

Proceedings of Conference on Engineering Research, Innovation and Education (CERIE - 2011)

January 11 - 13, 2011



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Sylhet-3114, Bangladesh***

ISBN: 978-984-33-2140-4

PREFACE

The School of Applied Sciences and Technology, Shahjalal University of Science and Technology, Sylhet, organized a Conference on Engineering Education, Research and Innovation (CERIE), which held on January 11-13, 2011. The organization of the conference was a result of whole-hearted and devoted labor of the teachers, officers and employees of all the departments under the school. This conference provided a platform for exchanging ideas, knowledge, experiences and research works in various areas of engineering and technology among academicians, scientists, technologists and engineers.

Around 200 research papers were presented in different sessions. The subject-matter of the papers cover vast area of engineering research and education including computer science and engineering, electrical and electronics engineering, telecommunications, industrial management, architecture, different branches of civil, environmental and chemical engineering. Besides delegates from different institutions in the country, representatives from different education and research institutions from Australia, Japan, Korea and UAE participated in the conference with technical papers.

Within the program-schedule of the conference, two round table discussions were arranged. The discussion brought forth fruitful suggestions for improving engineering education and research in the country.

The conference closed on January 13, 2011 successfully with high ambition and determination for organizing it after every two years with massive participation from home and abroad.

With the publication of the papers presented in the proceedings, the organizing committee is finally reaching the 'Finish'. We strongly believe that through the proceedings, the readers will have access to recent development in engineering research and education.

We would like to thank for their spirit, enthusiasm and efforts, with which they brought the publication of the proceedings to a successful end. We are also indebted to sponsors for their help in the conference.

CERIE will be held every year regularly and proceedings will appear with updated information in various fields of engineering.



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Designing Engineering Education for the 21st Century

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Introduction

Engineering is an art and science of using natural resources for the benefit of mankind. Human civilization has now reached a stage where *rapid change has become the principal constant* in the economic and social life of societies. Behind these changes is the colossal growth of knowledge that is taking place every day replacing old ideas and practices. Universities as knowledge providers are finding it hard to restrict them to typical teaching culture for their students to be useful in the society. A present day engineer while solving a problem may find a number of solutions to it. Selection of the most appropriate one would usually require knowledge from other disciplines such as commerce, economics, sociology, psychology, political science, management etc. Currently these are included in the engineering education in a rudimentary form. Perhaps this is the reason why our engineers are not proactive or taking the leadership in the development work, the country needs. This may also explain why the engineers are not in the position of leadership but have to work under people who are inferior to them intellectually or otherwise. Their work though essentially consumed by the society, is not recognized. Our engineers are too much engrossed in the technical details of engineering work thrust on them and have little time to advocate their story to the people. Our engineering education is biased heavily towards development of technical skill. Perhaps this is built on the maxim that:

“If a doctor fails then a patient dies but if an engineer fails then it becomes a catastrophe and many people die”.

Because of this bias, the present culture of our education gives more emphasis on technical skill rather than more indulgence on social issues. The engineer is a part of the society in which he is serving. Failure of a project is not necessarily due to its technical contents but may be due to social issues neglected by the designers. We are in an era when we have to look critically how we are educating our engineers to meet the challenges of development. We need to change the culture of our engineering education.

Culture of Engineering Education

Culture is defined in the dictionary as “*advanced development of human powers: development of body, mind, and spirit by training and experience*”. It is also defined as “*evidence of intellectual development (of arts, science etc.) in human society*” (Hornby, et. al., 1963). To a sociologist, culture is how a society behaves and works. Therefore, culture of engineering education implies how engineers are trained in a society to accomplish their task. Presently the engineering education focuses on the excellence of the technical content of knowledge. However, it has been now recognized that technical excellence in the traditional disciplines on its own is not enough, and it will not be able to meet the needs of the engineering graduates themselves and the expectations of the employers and the community at large. Ignoring this fact will continue to lead to a declining role for engineers in project

involvement and decision making and will reduce the role of engineers relative to non-engineering business managers, creative designers, administrators and politicians.

Constraints to Engineering Education

There is a contradictory situation prevailing regarding who should pay for higher education including engineering. Society demands more and more on the quality and versatility of its professionals. Enhancing education quality means more expenditure. Unfortunately, there is a worldwide trend for a decrease in funding and an apparent lack of commitment by society for higher education. Universities and other knowledge providers find themselves under increasing pressure to do more with less. Never before was there a need to work smarter, as well as working harder. This is also reflected by our government attitude. In 2003 one of our Education Ministers in a meeting mentioned that:

“The Govt. would cut spending for public universities in phases to reduce the tax payers burden.” — *The Daily Star, April 30, 2003.*

It is not known if he included technical universities in the above categories especially when the Government upgraded four Bangladesh Institutes of Technologies (BITs) to the status of university. If it is so then we have to rethink about effectiveness of the decision. Education, once perceived as an investment in the future of the nation, is now seen as a cost.

One eminent educationist suggested ‘***If you think education is expensive, try ignorance***’. Nevertheless, ***user pays*** principles now apply in many countries, as government seeks to share the cost of education with other stakeholders: business, society and students themselves. Perhaps this has given a surge of growth of Private Universities mostly within Dhaka city. Unfortunately, very few of these universities offer courses in engineering except related to computer and information technology. May be this is because of large investment required in setting up workshops and laboratories for the engineering programs and ease with which other programs can be run. Most of these universities run courses with part-time teachers from public universities. Student intake is virtually restricted by the financial capability of their parents. Even with high course fee, there is a doubt about the effectiveness of the programs run by these private universities. Concern about these universities is raised by many and it is said that:

“Many private universities do not have their own campus and sufficient teaching staff to ensure quality of education.”

The quality of teachers makes a great difference in the quality of engineering education. In a country where political rivalry supersede rational judgment, involvement of teachers and students in political grouping results in indiscipline and violence with a devastating effect on the peaceful academic atmosphere for learning and program schedule. Teachers teaching style, knowledge background, and understanding of the Society, all affect the student’s maturity and understanding of the world in which they live. The saying that, “***Any institution is as good as its teachers***” seems to be forgotten by us. We should have more transparency

and fairness in selecting teachers without government interference. This includes selection of institution heads based on proven honesty and quality rather than their political bias.

Availability of physical facilities in most engineering institutions is very poor by world standard and perhaps lacking in private universities.

Basis for Engineering Education

Table 1 show what are the expectations of an engineering graduate, his employer and the society (after Moore, 1974). To fulfill the expectations of the society and the employer an engineering graduate has to be a little short of a superman, but his own expectations may fall short due to the compensation package he is likely to receive in a poor society. This is the reality and his education should gracefully give him the message. At the same time, the Society should be told to show the recognition he deserves. Otherwise, it would fail to draw the most talented students to the engineering profession in Bangladesh. Table 1 also means that engineering education can not be limited to technical knowledge only because beside engineering solutions, he has to understand political situation, human relations, conflict resolution, environmental needs and implementation issues. His curriculum should therefore address all these issues.

Table 1. What Engineers, Society and the Employer want? (after Moore, 1974).

What Engineers Want	What Society Needs	What Employer Want
1. Money (economic security} 2. Recognition (Social status) 3. Management by Engineers (of engineering functions)	1. Solve conflicting demands between: Functional needs Economic impacts Human relations Environmental needs Political decisions 2. Effectively communicate facts (about decisions made) 3. Be effective in implementation (application of knowledge)	1. Technical ability 2. Integrity 3. Initiative and creativity 4. Sensitivity to conflicting factors 5. Communicate effectively with Others on team Clients Regulatory bodies Public 6. Cooperate with others 7. Good judgment 8. Ability to take responsibility

Science or Engineering?

To meet the challenges our profession will face in the future for a sustainable development in this country, our engineers must be good at problem solving. One however, must recognize the difference between how a solution by an engineer may differ from that of a scientist as eloquently expressed by Golder (1948):

“There are two approaches to a natural problem. They are the approaches of the pure scientist and that of the engineer. The pure scientist is interested only in the truth. For him there is only one answer - the right answer - no matter how long it takes to get it. For the engineer, on the other hand, there are many possible

answers, all of which are compromises between truth and time, for the engineer must have an answer now; his answer must be sufficient for a given purpose, even if not true. For this reason an engineer must make assumptions which in some cases he knows to be not strictly correct- but which will enable him to arrive at an answer which is sufficiently true for the immediate purpose.”

We would do our society and ourselves as educators and employers a big favor by having this in mind and instilling this attitude in our engineering students.

Engineers should essentially be skilled in synthesizing. Engineering is the conceptualization, design, construction, and administration of products and projects. Hence engineering education must find a balance between analysis and synthesis and find ways to promote creativity and risk taking (Steenfelt, 2001).

Educational Objective

Based on what has been mentioned, educational objective of engineering should be (after Poulos, 2000):

1. Engineers must be trained to do competent technical work.
2. They should be trained to have appreciation of experience or empirical knowledge based on what has been found to work in the past.
3. They should be trained to recognize the need for imagination, judgment and ingenuity in solving problems.
4. They should be trained to recognize the importance of human relations and political factors.
5. They should have an appreciation of peripheral sciences such as biology, chemistry and psychology.
6. They should be trained to communicate, both in writing and orally.
7. They should learn the need to make decisions from alternative choices.
8. They must learn the importance of implementation and completing a job.

Thus, we must pay more attention to the development of personal qualities in our future engineers for their survival in our competitive world.

Teaching Styles, Learning Methods and Aids

The Boyer Commission on Educating Undergraduates in the Research University (Boyer Commission, 1998) recommends the following “*ten ways to change undergraduate education*”.

1. Make research-based learning standard
2. Build on the freshman foundation
3. Link communication skills and coursework
4. Culminate with capstone experience
5. Change faculty reward systems

6. Construct an inquiry-based freshman year
7. Remove barriers to interdisciplinary education
8. Use information technology creatively
9. Educate graduate students as apprentice teachers
10. Cultivate a sense of community

Further the Commission asserts the '*students' bill of rights*' as follows:

1. Opportunity to learn through inquiry rather than simple transmission of knowledge
2. Training in skills necessary for oral and written communications
3. Appreciation of arts, humanities, sciences and social sciences
4. Preparation for graduate school, professional school or first professional position

Although the above is based on American experience and educational system, the advice has universal application.

Need for a Change

The position of an engineer in the Society has changed so has the need for change in engineering education. Increasing pressure of globalization has put more demand on engineer's quality and capability. He has now to compete beyond his national boundary. Lack of employment within the country, cost of higher education, and declining support for public education has brought new challenges for engineering educators.

Competition from other disciplines and the declining role of engineers and increasing role of business professionals in high ranking management is likely to discourage high academic achievers to take up engineering profession.

Increased involvement of applied scientists in designing and implementing engineering projects and accessibility of engineering knowledge and scientific software to non-engineers has reduced the need for services of engineering professionals nationally and globally. Emergence of information and service based economies and associated diverse, flexible and non-traditional educational and career opportunities has also added to the this because in a market driven economy investors compromise between investment and profit sometimes ignoring quality.

In order to remedy the situation, the engineers must play a model role of leaders with significant contribution to the society other than engineering projects.

Direction for Change

Shanableh (2003) identified aspects of engineering education that need to be changed in the context of emerging situations described above. His proposal for change in the culture of engineering education is shown in Table 2.

Table 2. Two Approaches to Engineering Education (Shanableh, 2003).

The Traditional	The Progressive
Maximize technical content and do not worry about generic skill	Balance technical content and generic skills
Excellence in engineering is all about finding numerical solutions to formulated project problems	Engineers involvement in projects involves more than finding numerical solutions to formulated project problems
Formalizing the development of social and environmental concerns is nonsense and wasteful	The profession is about serving the community
Given the data are supplied in full, there is a 'right' technique to use in solving problems, and there is clear-cut, 'right' engineering answer	The problem must be defined from incomplete and uncertain data, various solution techniques may apply, and several answers are possible depending on weight given to factors
Deferring some technical skills to continuing professional education and graduate studies is not satisfactory	Deferring some technical skills to continuing professional education and graduate studies is necessary
The engineer is the center of the project universe and the solution he/she provides is the backbone of project development and implementation	The engineer is a member of a project team and should be able to get involved in diverse roles in projects development and implementation
Engineering education should only be open to the academically high achieving competitive students	Excellence in engineering requires a variety of skills and abilities of which creativity and collaboration are essential

It is important to note several points that bring departure from the traditional education:

1. Balance between technical and generic knowledge and skill.
2. Imparting skill in formulating the problem. Solution is in formulating the problem.
3. Emphasis on the services to the community, leadership, development of mental and moral growth.
4. Motivating graduates towards self-education and continuing education goals.
5. Developing creativity and collaboration with other professionals as a part of a team.
6. Develop an appreciation for innovative developments and new disciplines.

Conclusions

Our graduates are high academic achievers, well educated persons in the Society but have been unable to take leadership in the decision making process. Our goal should be to lead and not just survive.

Our aim should be to lead the community in service and not merely serve the industry.

Our educational program needs to be changed in a way that it helps our graduates grow and develop morally, mentally, personally and knowledge-wise being able to take up the leadership in serving the community.

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3R Options in Industries

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Industrial Waste

Before substantial government regulation began in the late 1970s, most industrial waste was disposed of in landfills, stored in surface impoundments such as lagoons or pits, discharged into surface waters with little or no treatment or burned. Mismanagement of industrial as well as "hazardous" waste has resulted in polluted groundwater, streams, lakes and rivers as well as damage to wildlife and vegetation. Meanwhile, high levels of toxic contaminants have been found in animals and humans, particularly those, like farm workers and oil and gas workers, who are continually exposed to such waste streams.

Industrial waste management generally refers to a set of strategies and approaches that aim to eliminate, reduce, reprocess or dispose of waste produced in an industrial setting. Some of the common approaches to industrial waste management include emphasis on recycling programs, incineration, and landfills. Whatever method is employed, the focus is in complying with the relevant government laws. Some of these laws propose penalties in the forms of fines or increased taxes.

There are many different approaches to industrial waste management. Waste may be collected and transported for disposal at another location, or it might be disposed of on site. Recycling and reusing are other solutions that industrial companies are implementing. All these solutions can help reduce the amount of industrial waste a company has to dispose. Industrial wastes are best classified into three types based on their state as follows.

1. Gaseous emissions (from stack and fugitive emissions)
2. Liquid effluent (from process and cleaning)
3. Solid discharge (from process and from effluent treatment plant)

The most common gaseous emission is flue gas from the combustion of fossil fuels. Along with CO₂, oxides of sulfur, oxides of nitrogen, volatile organic compounds and other harmful gases in trace quantities can be found. In chemical industries where many types of chemicals are burned/roasted/reacted, a variety of gaseous compounds many of which are hazardous may be emitted. Most chemical industries tend to have leaks and vents. Through these leaks volatile compounds are continuously leaking out. If the concentrations of these compounds go beyond a certain level, then the health and safety of workers may be jeopardized.

Liquid effluents are also very common in chemical industries. Some examples are paper and pulp, food and beverage, textile dyeing plants. Liquid effluents are usually discharged into rivers, large bodies of water, and sometimes as runoff into low lands. All kinds of pollutants including hazardous ones can be present in liquid effluents. The non hazardous ones can usually be discharged into rivers provided their BOD and COD are within acceptable limits. With hazardous wastes sophisticated techniques must be applied to collect the pollutant in a solid form or in a concentrated form for safe disposal in a designated landfill.

Solid effluents can also be classified into two types – hazardous and ordinary. The hazardous type must be disposed off following strict guidelines. Usually it is given away to a third party

for disposal for a fee. The ordinary waste is usually dealt with by deep burial. If the material is safe it can even go to a municipal solid waste landfill. Gaseous emissions and liquid discharges are treated to meet environmental standards set by the pollution control board. These treatment processes usually result in the creation of solid pollutants that must be disposed off. Two examples are solid discharges from electrostatic precipitator for gaseous emissions and sludge from a liquid effluent treatment plant.

Two of the most common methods of waste disposal are the use of landfills and incineration devices. Depending on the type of waste, it can be disposed of or buried underground at a landfill site. This approach, however, is limited to materials which are not dangerous. Chemical waste or other types of toxic waste are not to be dumped at landfills because it can seep into the groundwater and present a health concern to nearby populations. Incinerators are also used to burn waste materials in appropriate cases. Environmental groups, however, typically do not favor this approach because of the related emission of hazardous gases.

The manner in which industries deal with wastes is best summarized in Figure 1. Historically, the tendency was to ignore the problem. As environmental regulations started being tightened, the tendency was to tackle the problem by *Dilute and Disperse*. As pollution started to build up in surface water, land and air, the dispersion technique was no longer acceptable, and *Treatment* was the preferred approach. Eventually the higher concepts of waste management, such as *3R and Cleaner Production* started taking root, and industries started moving towards **Prevention**. Many different names have been used to describe industrial waste management. Figure 2 shows how different approaches deal with waste, while Figure 3 shows the evolution of industrial waste management over the years.

Historically industries, for complying with environmental regulations, have opted for the *End-of-Pipe Treatment*. Industries have searched for devices or processes to reduce emission just to the point that it can meet the environmental regulations. Recent advances in industrial technology, materials and newer chemicals have made many processes available which can dramatically reduce waste. Industrialists usually shy away from any new process. The preventive approaches will not only help industries to meet all environmental regulations, it will enhance their performance under CSR, and in most cases be no more expensive than the End-of-Pipe Treatment. In many cases, the new process can actually save the industry money.

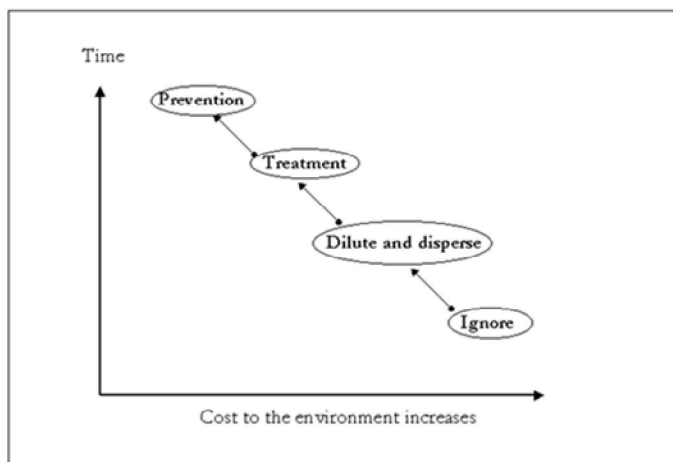


Figure 1: Response of industries to waste treatment¹

¹ UNIDO/UNEP

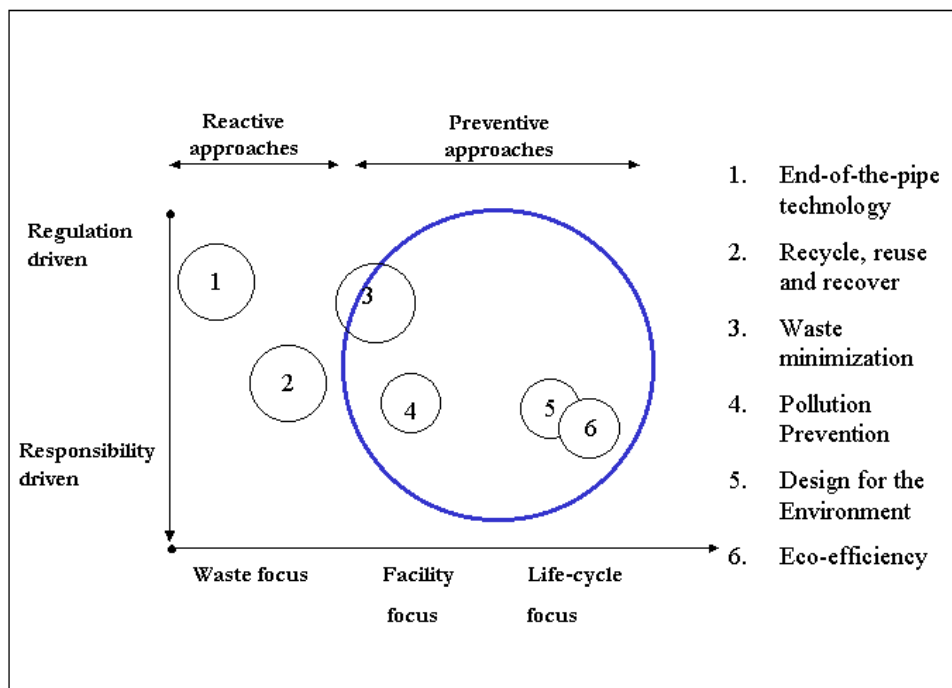


Figure 2: Different approaches for dealing with industrial waste²

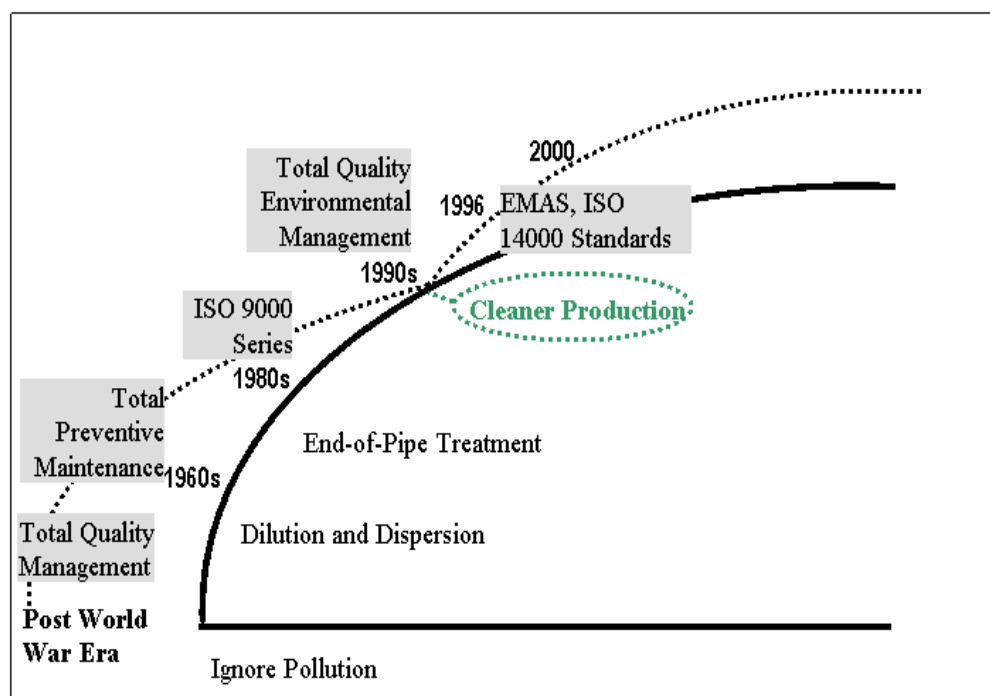


Figure 3: Evolution of waste treatment by industries³

² UNIDO/UNEP; Modified from: Berkel, R. Van & J.V.D. Meer (1997), Training Course for Future Trainers on Environmentally Sound Technology Transfer. IVAM Environmental Research, University of Amsterdam.

³ UNIDO/UNEP

What is 3R?

3R stands for, **Reduce, Reuse and Recycle**. In the different approaches to environmental management 3R is one of the newer ones along with Cleaner Production (CP) for managing wastes. The meanings of the 3Rs are elaborated in the following paragraphs.

Reduce – This is the highest form of managing wastes. The idea is that if the industrial operation can be done in such a way that it produces no or very little waste then that is the ideal situation.

Reuse – It is not always possible to produce zero waste from an industrial process however hard one may try. In that case, the next best management option is to reuse the waste. If 100% of the waste can be reused then that is the second best option.

Recycle – In practice it is not possible to get rid of all waste through only reduce and reuse. In that case the minimum must-do option is recycle. As the term implies wastes are treated in a variety of ways, sometimes in very complex and complicated manner to produce either zero waste or completely harmless wastes as determined by meeting some international standard.

In the 3R philosophy, the real focus is on the first R, i.e., **REDUCE**. As one move down the hierarchy from Reduce to Recycle the value of 3R diminishes. It must be appreciated that industries have been practicing Recycle for a long time, especially when the recycling operation is profitable. Bangladesh is replete with excellent examples (recycling of plastics, steel and glass are good examples). In other cases the need to comply with the environmental regulations has forced industries to recycle.

Fundamental concept is SOURCE REDUCTION. Prevent the creation of the waste by:

1. Using a better process and plant
2. Using high quality raw materials
3. Cleaner operation and regular maintenance

Some examples of source reduction are shown in the Box below.

EXAMPLES OF SOURCE REDUCTION

Textile (use of less dye)

Increase fixation levels for reactive dyes (better process)

Use appropriate recipe and follow recipe properly (better process)

Coal Fired Boiler (less ash)

Use low ash coal (better raw material)

Glass and Ceramics (less breakage)

Use of better sand and chemicals (better raw materials)

Use of high quality annealing chamber (better process and plant)

Instrumentation and control (better plant and operation)

Sógard and Madsen (2007)⁴ have analyzed the environmental performance and financial performance of industries with respect to the type of production as illustrated in Figure 4. They show that “Sustainable Production” results when both financial and environmental performances are strong; whereas when both the indicators are weak, the operation is “Unstable Production”. There are instances of “Shortsighted Production” where despite having a strong financial performance the industry displays a weak environmental performance, and there are instances of “Philanthropic Production” where an industry tries to have a strong environmental performance with a weak financial performance.

The fundamental concept of 3R is that it is a preventive approach rather than a reactive approach. In the reactive approach, as the name implies, industries are forced to take action because the waste has already been created. The reactive approach is the End-of-Pipe Treatment. In the preventive approach, which goes by the name Cleaner Production or 3R, the idea is to prevent the formation of the waste in the first place. Therefore, it is imperative that action is taken beforehand. The distinction between the reactive and preventive approach is best illustrated (see Box below) with an example from the Textile Dyeing industry, which is a large polluter in Bangladesh. In the reactive approach there are four levels of treatment possible. As one moves from dilution to flocculation to activated sludge to membrane separation one achieves better and better recovery of materials and cleanup of waste, but the cost increases correspondingly. It is worth noting here that even though Membrane Separation is a very high level and expensive operation, it is still a reactive approach. It is supported by the 3R approach only at the lowest level, i.e., in recycle. To achieve Cleaner Production or the higher Rs of the 3R process, one must go to the preventive approach. In this approach after auditing and housekeeping, one needs to search for a better process in terms of operation and raw material so that a minimum of waste is created. If possible the highest form of 3R, i.e., industrial ecology through better product design may be sought.

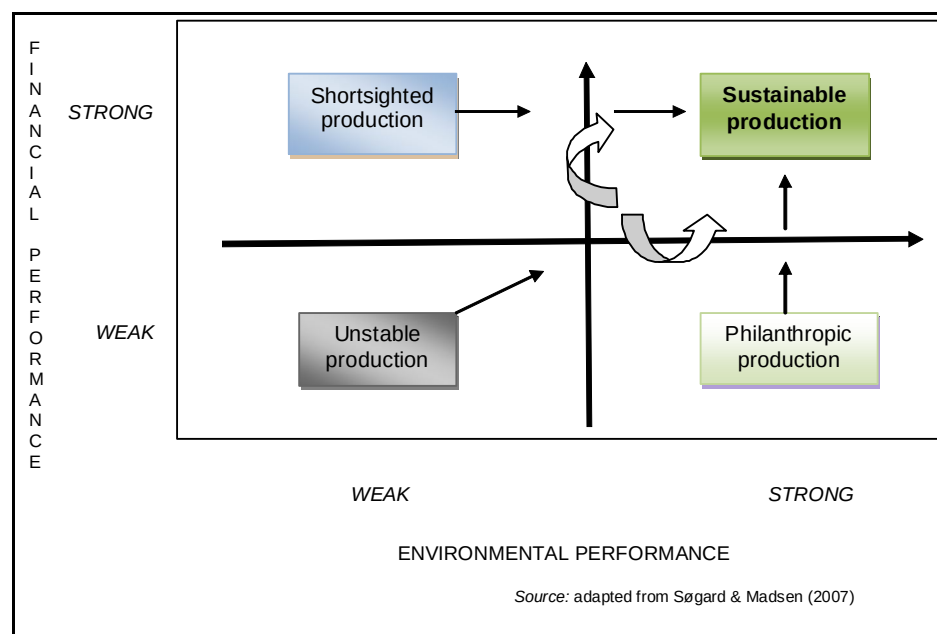


Figure 4: Production based on financial and environmental performances

⁴ Sógard and Madsen (2007): Adapted by: Centre for Enterprise and Economic Development Research, Middlesex University Business School. Ian Vickers, Prashant Vaze, Leah Corr, Eva Kasparova, Fergus Lyon.

Textile Dyeing: 2 Basic Approaches

- REACTIVE – End-of-pipe treatment (ETP)
 - Dilution
 - Flocculation
 - Activated Sludge
 - Membrane Separation
 - PREVENTIVE – Cleaner Production / 3R
 - Auditing and Housekeeping
 - Improved recipes followed accurately
 - Better Process
- ↓ **Cost Increases**

Industries are a major source of pollution. Industries emit all types of wastes – gaseous, liquid and solid. In addition, industries are a source of noise pollution and even radioactive pollution. In the early days of industrialization pollution and environmental degradation were of little concern because of the low level of industrialization worldwide, but the pace of industrialization has become so great that even developing countries have to come to terms with the enormous dangers of environmental degradation.

Today we see the visible signs of industrial pollution in rivers that can no longer sustain life. There are many industries that dispose off their wastes in a haphazard and unsafe manner in low lying area around the factories, nearby wetland and river. The following are some major sources of industrial pollution in Bangladesh.

1. Brick Kilns – Gaseous and solid (both air borne particulates and ash)
2. Leather – Gaseous (H_2S), Liquid (chromium laden water), solid (shavings)
3. Textile – Liquid effluent containing salts, alkalis and dyes
4. Ceramic – Solid (broken fired materials)
5. Pulp and Paper – Liquid effluent containing chemicals and pulp

3R Options for Industry

The following is a hierarchy of steps that can be followed to achieve 3R in industries.

1. Waste Audit and Housekeeping
2. Change Raw Materials
3. Existing Process Modification
4. Processes that Produce Less Waste
5. Product Design: to produce less waste

Waste audit (material and energy balance) is the first step for achieving waste reduction. When a well performed waste audit is combined with housekeeping 10-20% waste reduction is possible. This is sometimes no or low cost option. But often it is found that industries haven't even taken this first step in waste minimization. To perform a good audit professional auditor must be engaged.

There is a strong tendency of industrialists in developing countries to use cheap raw materials. The quality of raw material is a big factor in the amount of waste a process will create. If the raw material contains undesired product it will have to be removed thus creating

waste. Often bad raw materials consume excessive amounts of other processing chemicals and aids thus creating more waste. A good example (see Figure 5) is the use of low-sulfur, low-ash coal instead of high-sulfur, high-ash coal. The process will produce less SO₂ emission, less fly ash and less bottom ash. In addition the combustion process will be better and the vessel internals will be less corroded. In this case the benefits will more than pay for the extra cost of the high quality raw material.

Process modification or retrofit as it is commonly called in industry is a standard method of enhancing performance and reducing emissions. Many old plants have been fitted with electrostatic precipitators and NO_x control units after many years of operation of the plant. Often it is found changing one or two units can dramatically reduce pollution.

When a new plant is being built, the option to build a plant which will produce less waste is a ready option. In the present industrial scenario there are many processes available to produce the same product. Of course the decision is made on a financial basis, but more often than not a process that will produce less waste is ignored because it is perceived to be expensive, even though on the long run it will be cheaper especially if environmental regulations get tightened (see Figure 6). There are standard technologies, state-of-the-art technologies and advanced technologies, and in fact there are sub-standard technologies available in the market. Careful considerations to the aspect of waste creation can lead to a proper choice of technology.

Product Design is an entirely new concept that is taking root. Through computer modeling one can arrive at a product that will have the same function as a given product and produce minimal waste. Even though this is still in the realm of research, one or two products are creeping into practice, and numerous others are being tested in laboratories.

EMS to Life-cycle Analysis to Industrial Ecology

The following are the steps leading to sustainable industrial waste management.

- ◆ First, meet all environmental standards
- ◆ After that, establish an Environmental Management System (EMS)
- ◆ Get ISO 14001 certification for factory and operations
- ◆ Conduct Life Cycle Analysis (LCA) to decide on waste management options
- ◆ Move towards Industrial Ecology

EMS is a set of procedures that an establishment follows to achieve progressively higher and higher levels of environmental compliance, safe working conditions and sustainable development. **LCA** compares alternatives from cradle to grave and usually the criterion is economic cost using a suitable discount rate. But better criteria is material and/or energy use. The life cycle methodology advocates opting for the option which is cheaper (or uses less material/energy in the long run).

Industrial Ecology is the highest form of industrial operation that essentially achieves sustainable development through the following.

- ◆ Dematerialization (by a factor of 10)
- ◆ Minimization of energy use (by a factor of 5)
- ◆ 100% renewable energy
- ◆ Zero waste – 100% material recycling thus closing the material LOOP

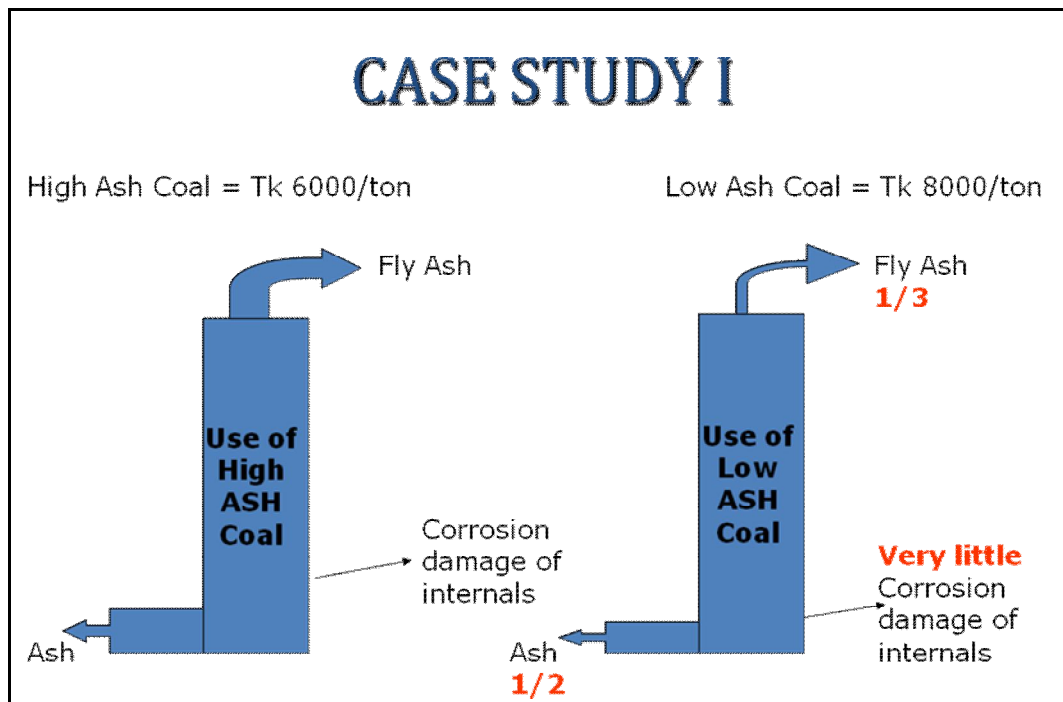


Figure 5: Use of low ash coal to generate less waste in a combustor

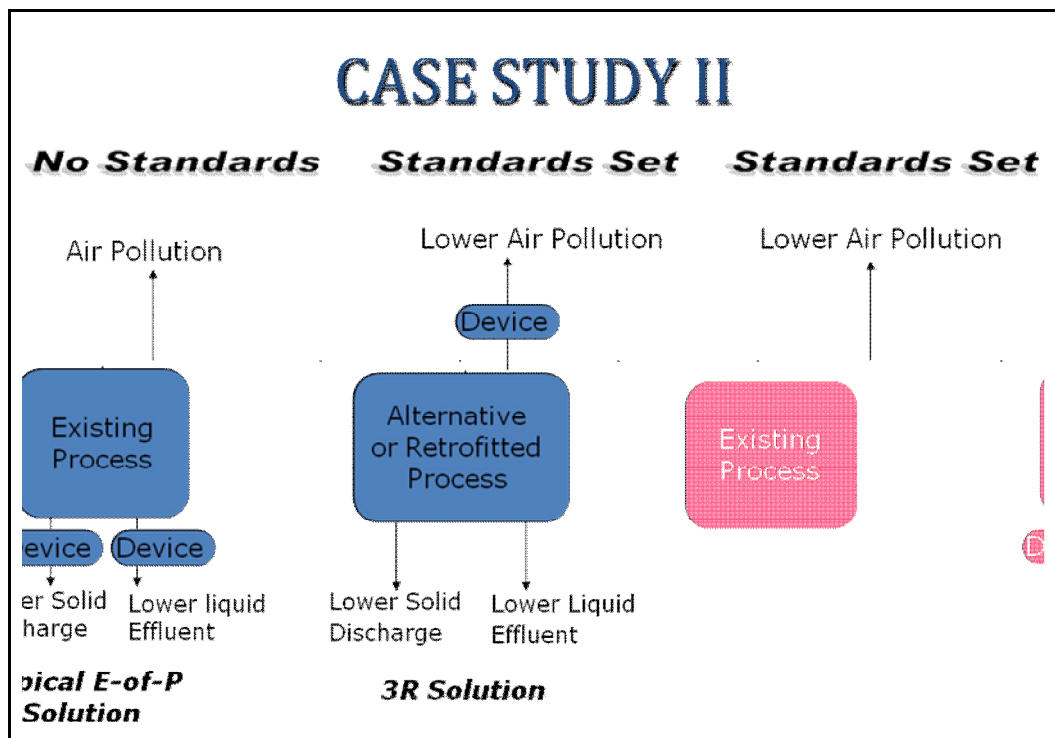


Figure 6: Effect of environmental standards on type of waste management used

Rational Use of Waste Biomass Energy: Potential of Carbon Sink Development

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Abstract

Biomass energy is playing an important role in the energy sector in developing countries. At present the biomass is used in a very traditional primitive conversion technologies and causing wastage a lot of energy. There is extra pressure on the forest due the growth of extra million of population every year. Rice husk briquetting is getting popularity in some areas where, scarcity of fuel wood. The rice husk briquette fuel is very good alternative of fuel wood both in terms price and the performance of fuel. In case of Bangladesh where the fuel wood comes from non-sustainable source, the briquette fuel can easily enter the carbon market. The forest area developed after replacing the wood fuel is 20.39 thousand hectare in 2000 and this forest land is increased to 40.92 thousand hectare in 2030. The carbon dioxide reduction is 6.29 million tonne in 2000 and this value is increased to 12.62 million tonne in 2030. By reducing deforestation the forest area is increased to 2.22 million hectare which is equivalent to the forest area that was in 1971. Rational use of waste biomass energy can substitute a significant amount of wood fuel that could reduce extra pressure on our environment. Hence reduction of deforestation would develop a carbon sink in the existing forest thus would led to sustainable development of forest resources in developing countries.

1. Introduction

Energy, the basic ingredients to alleviate poverty and socio - economic development. Worldwide, there is a major transition underway in the energy sector due to decline in fossil fuel availability, reduction of global emissions for mitigating climate change and energy security. About 2.5 billion people depend on traditional biomass energy [1]. Agro-residue is one of the main sources of traditional biomass. Biomass fuels from forest are using beyond their regenerative limits due to high pressure of population. There is severe shortage cooking fuel requirement in developing countries. There is a limitation of expansion of the forest area for wood fuel. Developing countries are facing problem with the deforesting process due to lack of fuel in small cities, public centers, small entrepreneur, tea stall, restaurants and rural areas. Biomass briquetting process is one of the process that can transform the loose biomass into solid, woody, high bulk density, regular shape which can be easily stored and transported [2]. The briquette fuel is getting popularity as alternative to wood fuel in different countries like Thailand, Vietnam, Bangladesh, India, Myanmar etc. Therefore, conversion of loose biomass into wood fuel is important to meet the demand of cooking fuel. The waste biomass like husk, straws,

municipal waste, that account for a substantial share in total energy consumption of many developing countries. The main problem of this waste biomass is its low bulk density that creates transportation and storage problem. Since the fuel wood comes from non-sustainable source of forest in developing countries, the use of fuelwood causes emission of greenhouse gas. The greenhouse gas emitted from the use of non-sustainable forest can be omitted by using any other fuel from sustainable source like agro-residues. In that case the waste biomass briquette can play a vital role to reduce the consumption of fuel wood from non-sustainable forest as well as to reduce the greenhouse gas emission.

2. Is Biomass renewable?

Biomass is part of the carbon cycle. Carbon from the atmosphere is converted into biological matter by photosynthesis. On death or combustion of the biomass material, the carbon goes back into the atmosphere as carbon dioxide (CO₂). This happens over a relatively short timescale. Biomass used as a fuel can be constantly replaced by planting for new growth. Therefore, a reasonably stable level of atmospheric carbon results from the use of biomass as a fuel. The carbon cycle of biomass fuel is shown in Fig. 1.

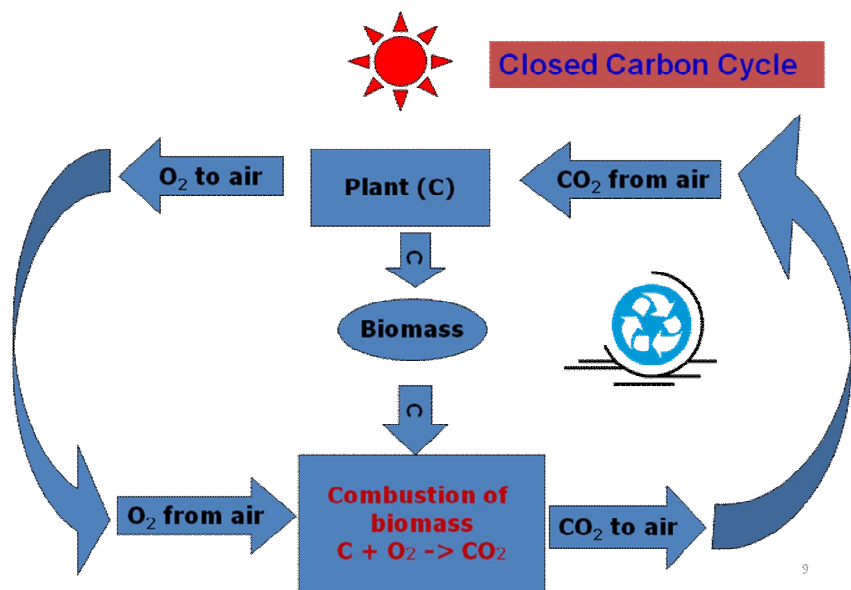


Fig.1: Life cycle of biomass carbon

Though biomass is a renewable fuel, and is sometimes called a "carbon neutral" fuel, its use can still contribute to global warming. This happens when the natural carbon equilibrium is disturbed: by deforestation and by urbanization of green sites.

3. Source of Biomass

The main sources of biomass are forest product, agro-waste, animal waste, municipal waste and energy crops etc. These biomass sources include jute stick, straws, husk, bagasse, firewood, twigs leaves, household wastes etc. Share of renewable energy is 18% globally and biomass contributes 13% of total energy consumption in the world [3]. Installed power capacity for electricity generation is 52 GW globally whereas hot water and heating capacity is 250 GW_{th} [4]. Global productions of selected biomass viz. firewood, bagasse and rice husk production are 835, 211 and 132 million tonne, respectively [4, 5].

In Bangladesh, different types of biomass are produced viz. rice straw, cowdung, rice husk, firewood, jute stick, bagasse, twigs and leaves etc. There are significant amounts of waste biomass produced in country (Fig. 2). Agro-waste biomass dominates the traditional energy sector in the country. Agro waste production is increased in trends with an annual growth rate of 2.35%.

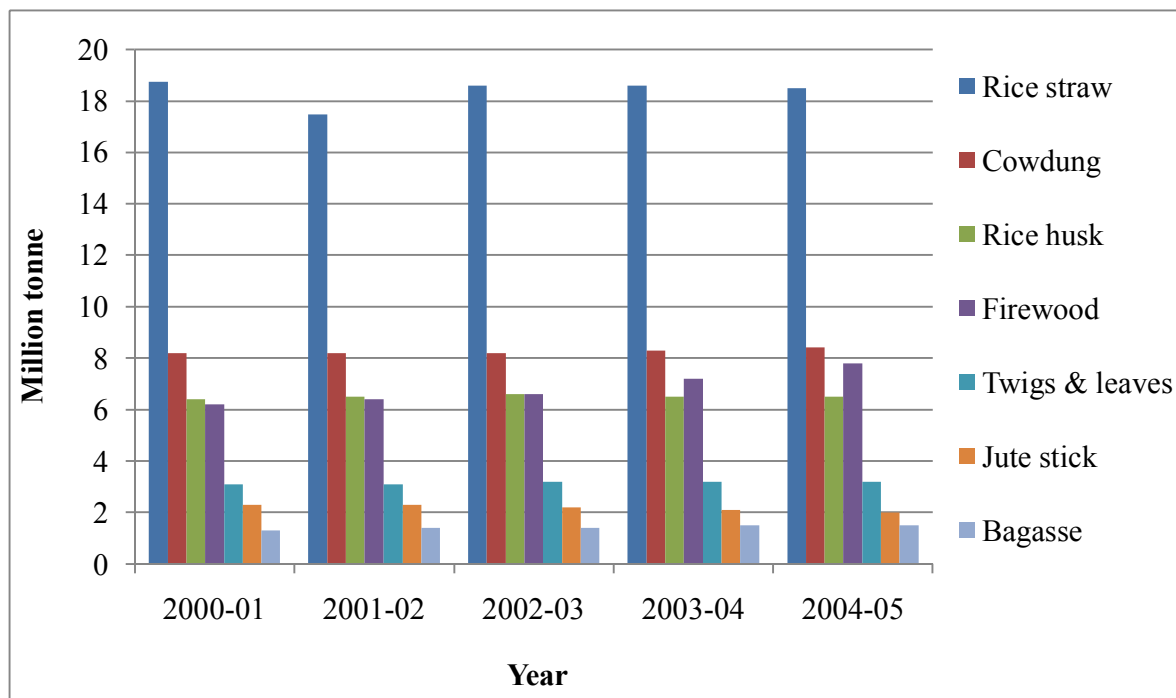


Fig.2: Different types of traditional biomass production in Bangladesh [6]

4. Consumption of biomass energy

Biomass is the main primary energy source for the people of developing countries. About 52% of world population relies on the traditional biomass energy. About 80% of total population of Bangladesh lives in rural area, where biomass is the only available energy source and it is estimated that 88% of energy demand is for household cooking, this being almost completely supplied by biomass resources [7]. Biomass is consumed in the form of as it is available. The conversion technology of biomass energy is very much traditional having very low thermal efficiency. The thermal efficiency of traditional biomass cook stove ranges 6 to 10%. Improved cook stove is the alternate option for saving of the biomass energy by 50% of traditionally consumed.

Rice husk biomass is obtained as byproduct of agro-processing centers. The rice husk is dumped and open fired in many countries. In Bangladesh, rice husk is mainly consumed for producing process heat of parboiling in the rice milling industries. About 5 million tonne of rice husk consumed in Bangladesh for rice parboiling. The boiler used in rice mills is very much inefficient and it can utilize only 20% of thermal energy [8]. Huge amount rice husk can be saved simply by replacing the traditional boiler with improved one. About 2 million ton of rice husk could be saved every year in Bangladesh if the rice millers would adopt this improved rice parboiling system. Therefore, there is a scope to save biomass energy without scarifying the net energy demand by using the biomass energy rationally.

5. Woody biomass fuel from waste loose biomass

The waste biomass like rice husk, rice straw, sawdust, bagasse, jute stick etc. account for a substantial share in total energy consumption of Bangladesh. The main problems of this energy are their low bulk densities and high moisture content as well as this traditional energy is not in an organized form. People have to spent time to gathering and drying of a bulk volume before using. Biomass densification process can transform this biomass into solid, high bulk densities, regular shape. This densified biomass (briquette) fuel can be easily stored and transported. After densification it looks like dry woody material (Fig. 3) and its calorific value ranges from 14.2 to 17.5 MJ/kg and it is equivalent to “B” grade coal in terms of calorific value [9]. It burns slowly with less smoke than wood fuel. The biomass briquette has very high bulk density and size and shape is comparable with fire wood (Table 1). Therefore, there is a potential to replace the wood fuel with this biomass briquette fuel from wastes.

In recent years the use and production of rice husk briquette fuel have been increased in certain areas of Bangladesh. A majority of tea stall and small food shops in Sylhet and Chittagong district of Bangladesh has shifted from using fuelwood to rice husk briquettes [10, 11]. In Mymensing town , most of tea stall, street food stall and restaurant have been shifted from wood fuel to rice husk briquette fuel. The consumption pattern widely varied among the users. The highest consumption rate was found to be 114 kg/day per restaurant. The average consumption rate of tea stall, street food stall and household were found to be 16 kg/day and 12 kg/day and 2.5

kg/day per household, respectively (Fig. 4). The wood consumption rate was higher than the briquette fuel (130 kg/day for restaurant and 30 kg/day for tea stalls) [12]. The consumers of briquette fuel reported that on an average 1 kg of densified biofuel could provide same service of 1.63 kg of wood fuel. However, this ratio differed when it was calculated based on consumption data (1.48 kg of wood fuel is equal to 1 kg of briquette fuel) and laboratory test data (1.21 kg of wood fuel is equivalent to 1 kg of briquette fuel). Use of rice husk briquette fuel instead of wood fuel has been increased in several areas of Bangladesh, that ensures that loose waste biomass could be a viable option to reduce pressure on the forest wood fuel.



(a) Dumping of loose rice husk



(b) Rice husk briquette

Fig. 3: Loose rice husk (a) and rice husk briquette fuel (b) after densification looks like woody biomass

Table 1. Properties of loose rice husk and compact briquette fuel

Fuel properties	Loose rice husk	Briquette fuel
Bulk density, kg/m ³	117	825
Length	length : 6- 8 mm	length : 60- 100 cm
Width/Diameter	width: 2-3 mm	diameter = 5.6 – 6.0 cm Inner hole diameter = 1.8 – 2.4 cm
Calorific value, MJ/kg	12.70	14.67



Fig. 4: Photograph of different type of rice husk briquette fuel users and their daily consumption

6. Deforestation

Many households in Africa and South Asia still do not have access to modern fuels and have to rely on fuel wood and waste for cooking. This represents a heavy burden in terms of time and money spent to obtain these fuels. In addition, reliance on fuel wood contributes to deforestation. Widespread use of natural forests as a source of wood for fuel this could cause deforestation, with serious ecological and social results. This is currently occurring in Nepal, parts of India, South America and in sub-Saharan Africa. In many Asian countries much of the wood used for energy purposes comes from natural forest areas, which could become deforested if overused. Net forest loss was estimate to be 8.3 million ha per year during 1990s. However the forest loss during the period of 2000-2010 is 5.2 million ha per year globally [14]. Bangladesh is facing problems with severe deforestation. According to the different reports the deforestation rate for Bangladesh ranges from 2.86 to 3.3% annually [15, 16]. The deforestation rate is reported to be 4 hectare per hour in Bangladesh [17]. The total deforested land is estimated to be 1.442 to 2.228 million hectare during the period of 1971 to 2006 (Table 2) [18].

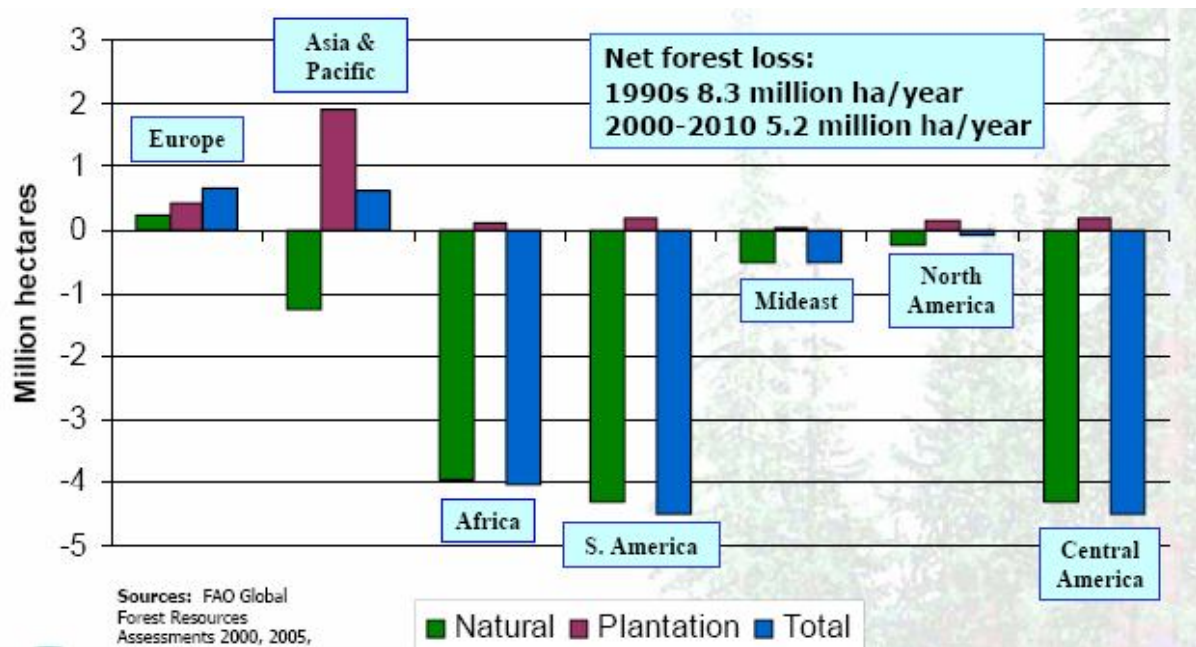


Fig. 5: Annual changes of forest area globally

Table 2. Deforestation rate in Bangladesh [15, 16, 17, 18]

Source of reporting	Deforestation
M.A.L. Mia 2009 (XIII World forest congress, Argentina)	3.3%
FAO 2000, NFA 2007	2.86%
Janakantha 2005	4 ha per hour
Forest area decrease during 1971 to 2006, million ha (FRA 2000, NFA 2007)	2.228 to 1.442

7. Reduced pressure on forest wood fuel

CASE STUDY: Replacement of fire wood with rice husk briquette fuel in Mymensingh town

- Total demand of briquette = 600 tonne/month
- Local production = 97 tonne/month
- Supply from surrounding = 503 tonne/month

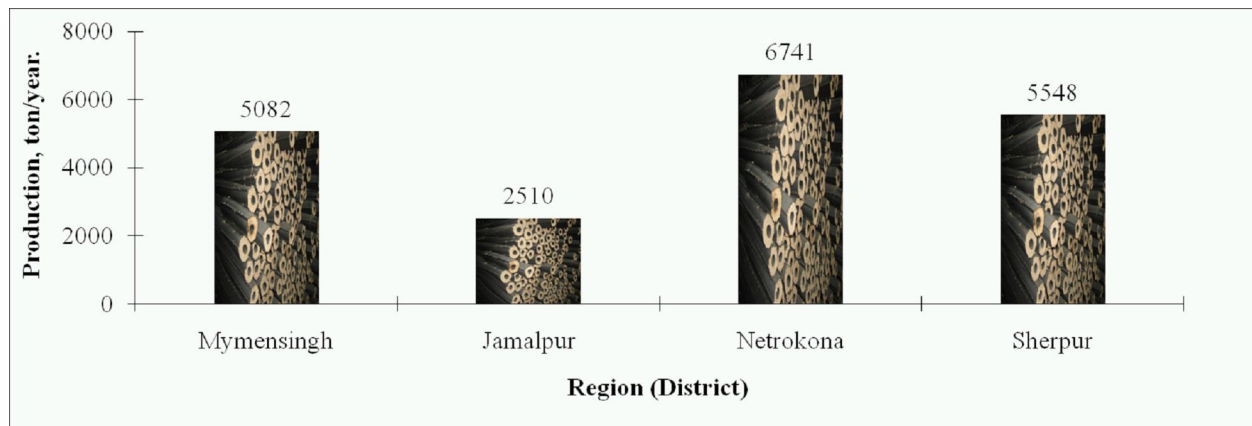


Fig. 6: Rice husk briquette production in greater Mymensingh region [12]

Use of rice husk briquette in Mymensingh

- Tea stalls, small retailers and poor household are the users of rice husk briquette.
- The main reason for this shift is that firewood is becoming scarce
- Briquette exerts less smoke and uniform quality compared to wood
- The households who could not avail the gas grid connection are using rice husk briquette fuel

Reduction of CO₂ emission

CO₂ equivalent emission results for wood fuel and rice husk briquette fuel options are calculated. The results are shown in Table 3. the CO₂ emission amounting 17370 tonne per year was obtained from wood fuel use from non-sustainable forest and the lowest CO₂ emission amounting 954 tonne was obtained from rice husk briquette fuel use option. The annual saving of CO₂ emission is 16.42 thousand tonne per year in Mymensingh town due to the use of briquette fuel instead of wood fuel. The annual return from CO₂ emission saving by using 100% briquette fuel instead of wood fuel in the study area would be equivalent to US\$197.04×10³ annual worth. Therefore, there is great potential to reduce global emission by using waste biomass energy instead of wood fuel [2].

Table 3. Reduction of CO₂ emission by using rice husk briquette fuel over wood fuel

Option	Annual demand $\times 10^6$	CO ₂ equivalent $\times 10^3$ ton/annum	Net CO ₂ saving over 100% wood system, $\times 10^3$ ton/annum	Return from CO ₂ abatement $\times 10^3$ US\$/annum
Wood fuel	14.244 kg	17.370	-	-
Rice husk briquette fuel	9.039 kg	0.954	16.42	197.04

[CO₂ reduction trade, US\$ 12.00/ton]

7. Potential of carbon sink development

Waste biomass energy needs to conversion into usable form to replace the wood fuel. Rice husk briquette fuel can replace wood fuel successfully as discussed in previous section. Rational use of rice husk energy can develop carbon sink by increasing the carbon storage in forest through reducing the deforestation of non-sustainable forest as described in the following block diagram. The potential production o briquette fuel and replacement of wood by briquette are shown in Fig.7.

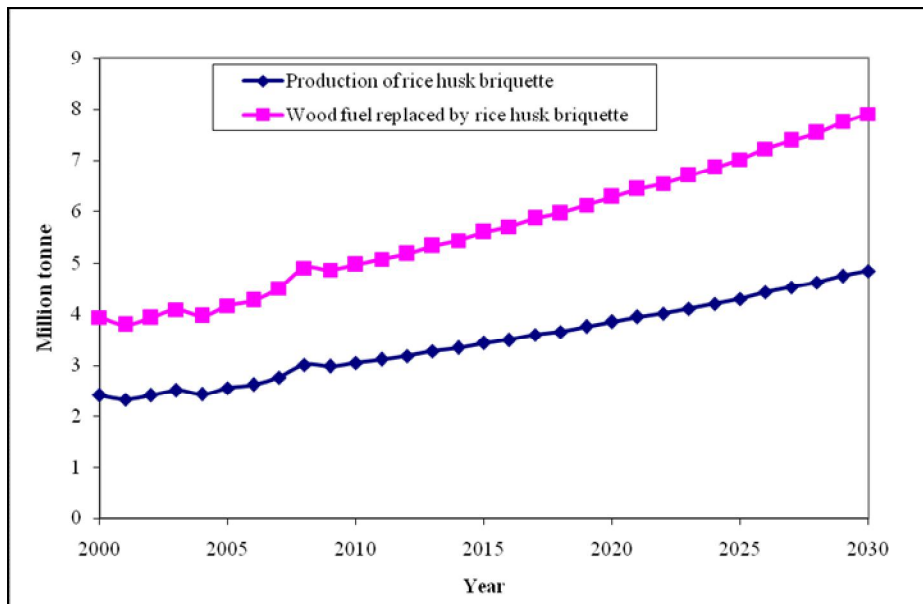
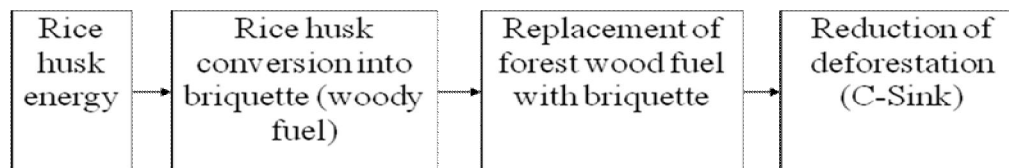


Fig. 7: Scenario for production of rice husk briquette and replacement of wood fuel

Rice husk briquette replaces the wood fuel coming from non-sustainable sources or deforestation processes. When the potential equivalent of wood fuel from rice husk briquette is added with wood fuel from sustainable source, it reaches the total present consumption of wood fuel. It reveals that if the rice husk briquette can be introduced in the wood fuel market then intrusion of wood fuel from deforestation process can be prevented. The scenario of total wood fuel equivalent i.e. combination of rice husk briquette and wood fuel from sustainable source seems to be increase in trends and sustainable (Fig. 8).

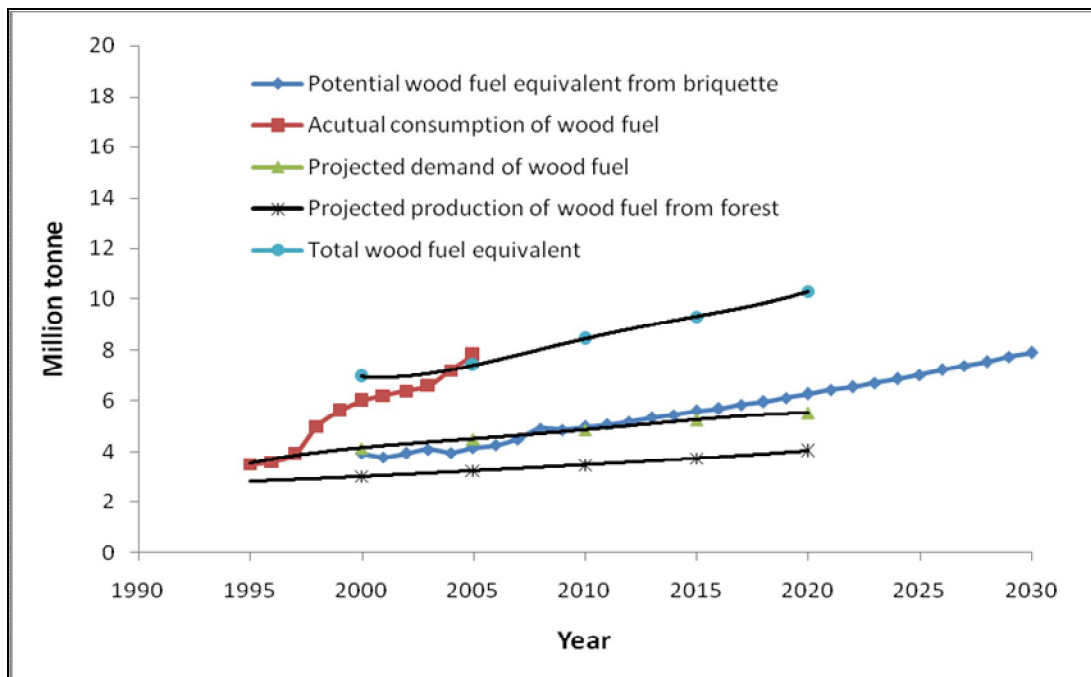


Fig. 8: Scenario of impact of rice husk briquette on total wood fuel equivalent

The forest area developed under the proposed model is 20.39 thousand hectare in 2000 and this forest land is increased to 40.92 thousand hectare in 2030. The carbon dioxide reduction is 6.29 million tonne in 2000 and this value is increased to 12.62 million tonne in 2030. The forest area saved each year is cumulated with present forest area then scenario of forest area in future is found. The scenario of total forest area shows that the forest area is increased to 2.22 million hectare which is equivalent to the forest area that was in 1971 (Fig. 9). Therefore, a sustainable forest growth could be achieved if the proposed model of rice husk energy use is executed.

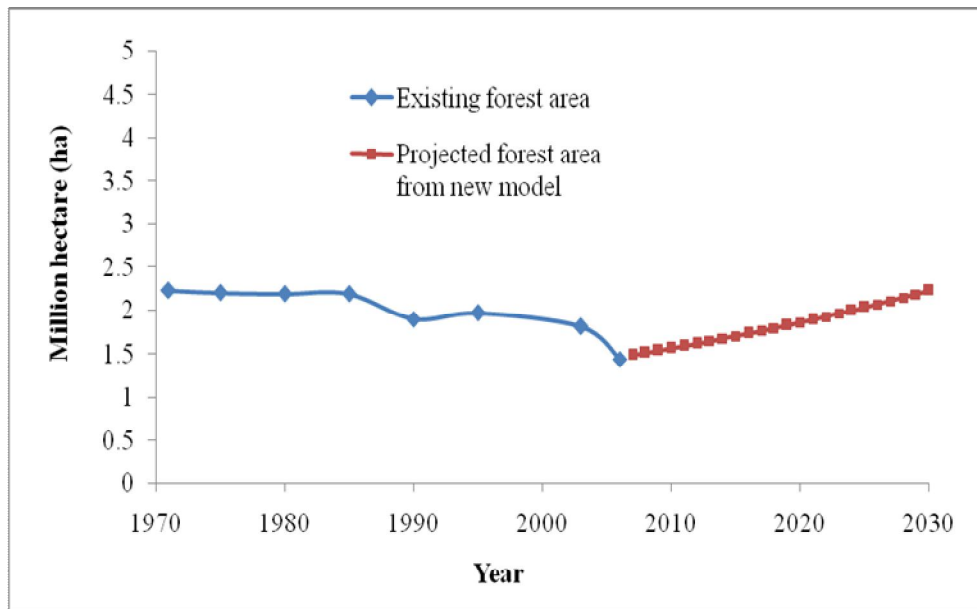


Fig. 9: Potential increase of forest area in Bangladesh

8. Conclusion

Biomass energy is playing an important role in the energy sector in developing countries. At present the biomass is used in a very traditional primitive conversion technologies and causing wastage a lot of energy. There is extra pressure on the forest due the growth of extra million of population every year. Rice husk briquetting is getting popularity in some areas where, scarcity of fuel wood. Rice husk and rice husk ask a product gifted by nature, they are environment friendly with local habitat. The rice husk briquette fuel is very good alternative of fuel wood both in terms price and the performance of fuel. In case of Bangladesh where the fuel wood comes from non-sustainable source, the briquette fuel can easily enter the carbon market. Rational use of waste biomass energy can substitute a significant amount of wood fuel that could reduce extra pressure on our environment. Hence reduction of deforestation would develop a carbon sink in the existing forest thus would led to sustainable development of forest resources in developing countries.

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THERMOMECHANICALLY TREATED ADVANCED STRUCTURAL STEELS TO IMPROVE THE EARTHQUAKE RESISTANCE OF BUILDINGS

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Earthquake is a part of natural activity similar to typhoon or ocean wave. However, it is very difficult to anyone around the world to predict the exact time, location and right magnitude of an earthquake. As a result, earthquake related damages are more uncertain and threatful for mankind. Although the occurrence of earthquake is very unpredictable, but the earthquake related damages to life and property can still be minimized by proper structural designs and using better materials for the structures. For modern taller multi-story buildings a large volume of steel bar is used to reinforce the concrete. The quantity, quality and properties of these steel bars used play the pioneer role for the safety of the buildings. Materials scientists have developed several advanced structural steels through various thermomechanical treatment routes. In this papers, production routes and various essential mechanical properties of two different thermomechanically treated advanced structural steels having high earthquake resistance (quenched and tempered; QT steel and transformation induced plasticity steel; TRIP) will be compared with conventional steels of similar chemical compositions and/or strengths. Initiative will also be taken to discuss the benefits of these advanced structural steels, if they are used as reinforcing bars in multistory buildings, especially in the earthquake sensitive areas.

Keywords: Earthquake, High-rise buildings, Reinforcing steel bars, Thermomechanically treated steels.

1. INTRODUCTION

Earthquakes cause the ground to shake violently in the form of wave (Fig. 1) there by triggering the landslides, creating floods, causing the ground along with its various manmade or natural structures to heave and crack with subsequent destruction to life and property. The study of why and where earthquakes might occur is the subject matter of geology. The study of the characteristics of the earthquake ground motion and its effects on engineered structures are the subjects of earthquake engineering. In particular, the effect of earthquakes on structures and design of structures to withstand earthquakes with no or minimum damage is the subject of earthquake resistant structural design.

Here it is to be realized that without materials there is no engineering. Material is the most vital factor for any engineering field. As a result, the success or failure in any engineering and/or design mostly depends on the performance of the materials utilized for that. Because, if worst material is used in the case of any structure where the best design criteria have been followed, the structure will not be sustainable accordingly. So, design engineers in any field must consider the performance of materials used or to be used for any targeted work.

For any structure to be earthquake resistant, the ductility of reinforcing materials used for the structure plays an important role [1-3]. Here it is to be mentioned that, the qualities of compressive load

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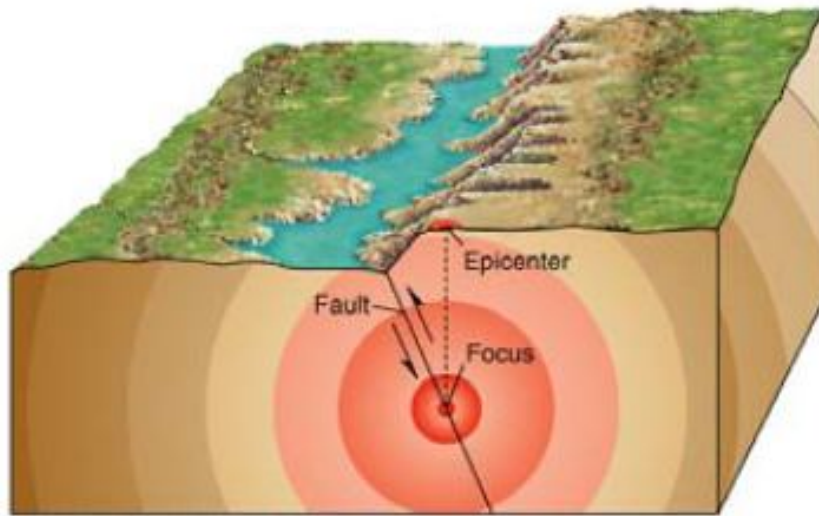


Fig. 1: Wave pattern ground shaking created by earthquake.

bearing materials as cement, gravel, sand, etc. are also very important [4,5]. Ductility is the property, which allows the structure to undergo large plastic deformations without significant loss of strength, Fig. 2a. On the other hand, hysteretic energy is the energy dissipated by inelastic cyclic deformations and is given by the area within the load-deformation curve, which is also known as hysteretic curve, Figs. 2b and c. Structures having low hysteretic energy dissipation capacities, even if the deformations are well below the ultimate deformation, are likely to collapse due to low cycle fatigue effect. Because all fatigue failures are of brittle nature [6,7], which take place under stress levels below of the respective yield stresses of the materials used. Here it is mentioned that earthquake loading produces a large deformation as well as cyclic loading depending on intensity and duration of the earthquake [1], Fig. 3. Higher energy dissipation means better earthquake resistance, which is controlled by the level of ductility of materials. On the other hand, resistance of the structures to repeated shocks caused by a single or several earthquakes depends on the low cycle fatigue resistance of the materials used for the structures [1,2]. As a result, both ductility and low cycle fatigue resistance are very important for making any material to be earthquake resistant.

In many countries, especially in vulnerable areas of Japan and U.S.A., there has been a tremendous progress in earthquake resistant buildings. For overall success, materials scientists have also contributed a lot towards making the engineered structures to be safer under earthquake through the development of various heavy duty materials essential for structural building such as cement, mortars, bricks, reinforcing

bars, etc. In any modern earthquake resistant multi-story building, a large volume of reinforcing bar is used, which is very clear from Fig. 4. It has been observed that the degree of earthquake related damage is proportional to the overall weight as well as the height of the building. In order to reduce the total weight of structural buildings, design engineers are suggesting high strength steel bars for high-rise buildings. Through the addition of various alloying elements, such as chromium, nickel, molybdenum, vanadium, etc. the strength of the structural steel can be increased. But the key problem concerning this steel strengthening route is that it reduces the ductility of the steel as well as the bendability [8-11], which is the key property for earthquake resistant reinforcing steel bar. In order to avoid problem related to inferior ductility, materials scientists have developed various advanced structural steels by proper control of microstructures of steels through thermomechanical treatments. Thermomechanically treated steels might be plain carbon as well as alloy steels. The latter group of steels (alloy steels) are designed to achieve further higher strength along with other functional property requirements depending on service conditions [12,13].

The main objective of this paper is to present and discuss various types of advanced structural steels, especially QT and TRIP steels and their benefits if they are used as reinforcing steel bars in the place of conventional steel bars for making earthquake resistant buildings and other structures where steel reinforced concretes are used.

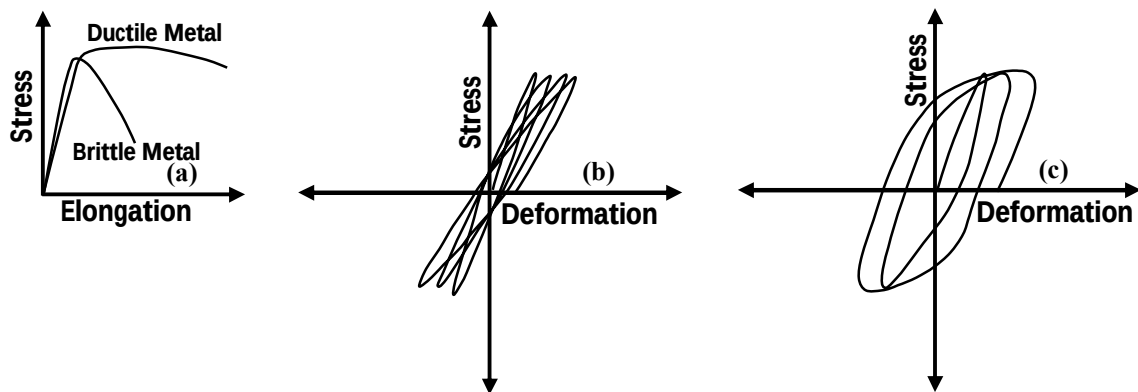


Fig. 2: (a) Stress-elongation curves of brittle and ductile materials, (b) and (c) are, respectively, hysteretic diagrams of brittle and ductile materials.

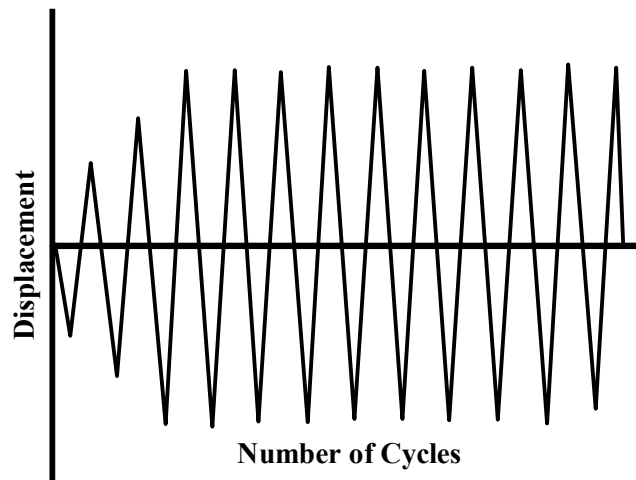


Fig. 3: Cyclic displacement caused by an earthquake.



Fig. 4: Use of reinforcing steel bars in a modern earthquake resistant building.

2. RESULTS AND DISCUSSION

In this paper production processes of several thermomechanically treated high strength steels and their microstructures along with mechanical properties (strength, ductility and fatigue resistance) will be compared to that of conventional steels of similar chemical compositions and/or strengths.

2.1 Production and Microstructures of Thermomechanically Treated High Strength Structural Steels

For conventional reinforcing structural steels, the hot rolled steel bars are cooled naturally in air after final rolling. So, the microstructure of this steel becomes to be composed of normalized ferrite-pearlite, Fig. 5. Here it is important to mention that the white and black grains of the microstructure, respectively, are ferrite and pearlite. Conventional plain carbon hot rolled structural steel results a very high level of ductility, however, its yield strength is relatively low. Although this steel shows high earthquake resistance, but it is not wise to use it for high rise buildings because of higher proportion of steel consumption, which increases the overall weight of buildings. In order to reduce the proportion of steel consumption, steel producers are trying to increase the strength of the conventional hot rolled steels by adding more carbon or alloying elements. This initiative helped in reducing the steel consumption. However, the ductility level of the steel decreases, which means reduction in earthquake resistance of the steel bars.

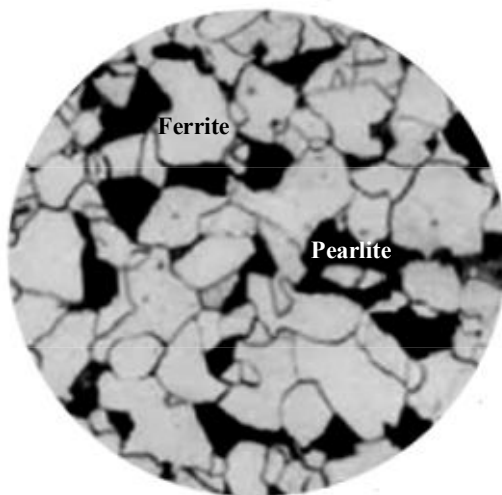


Fig. 5: Ferrite-pearlite structures of conventional structural steel.

For strengthening steel bars, there are various thermomechanical treatment options. One of these options is quenching and tempering (QT steel). For QT steel, after final pass of rolling, the hot rolled steel bars are quickly passed through a chamber with water flow from different directions. Finally, the dynamically quenched bar is naturally cooled in air on specially made cooling bed, Fig. 6. So, the microstructure of outer layers of the bars become tempered martensite because of quick quenching action on surface layers and the core remains to be normal ferrite-pearlite, Fig. 7. However, there might be a zone with microstructures in between ferrite-pearlite (at core) and tempered martensite (outer case), which is popularly known as transition zone. Recently, several local industries have started to produce this grade of steel.

Another option of increasing the strength of structural steel is by reducing the ferrite and pearlite grains to a very fine level (ultra fine grain; UFG steel) through drastic deformation during rolling process. Typical microstructure of UFG steel is shown in Fig. 8. Latest thermomechanically treated high strength structural steel is the transformation induced plasticity; TRIP steel. The production of TRIP steel is little bit difficult. Because it needs very close control on chemical compositions, hot rolling temperature, deformation in each pass, holding time and temperature after each pass of rolling, etc. As a result, the production cost of this steel is very high and that this steel is not commercially produced in many countries. The final structure of this steel is composed of several different phases like ferrite (F), retained austenite (RA), bainite (B) and martensite (M) of varying proportions, Fig. 9. So, TRIP steel is occasionally named as multiphase high strength steel.

2.2 Tensile Behaviours of Conventional and Thermomechanically Treated Steels

It has been mentioned that the microstructure of conventional structural steel is composed of ferrite and pearlite. Having similar carbon equivalent (CE) and carbon (e.g. 0.4 CE and 0.2% C), the conventional structural steel will result lower yield and ultimate tensile strength along with a very high elongation (more than 25% in general). Here it is important to note that yield strength of the reinforcing steel bar is a very important parameter as it is directly considered for any structural design. If low yield strength structural steels are used in buildings, the consumption of steel will be high, which means overall weight of the structure will be

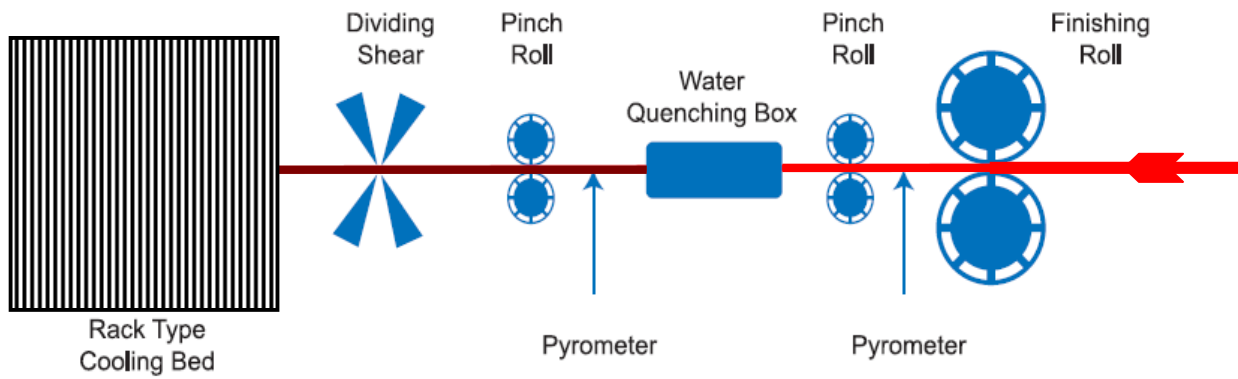


Fig. 6: Production of QT steel.

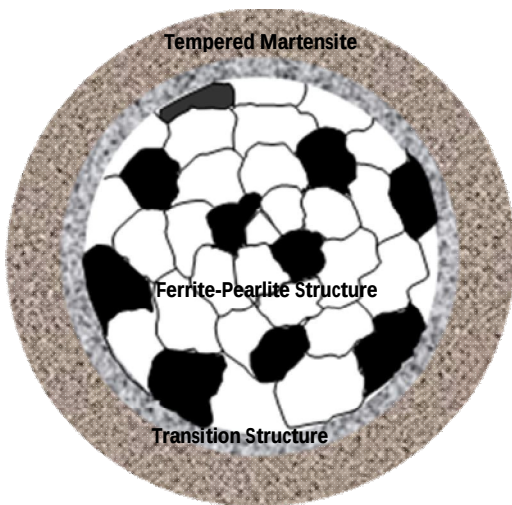


Fig. 7: Microstructures of QT steel.



Fig. 8: Ferrite-pearlite microstructures of an ultra fine grain (UFG) structural steel.

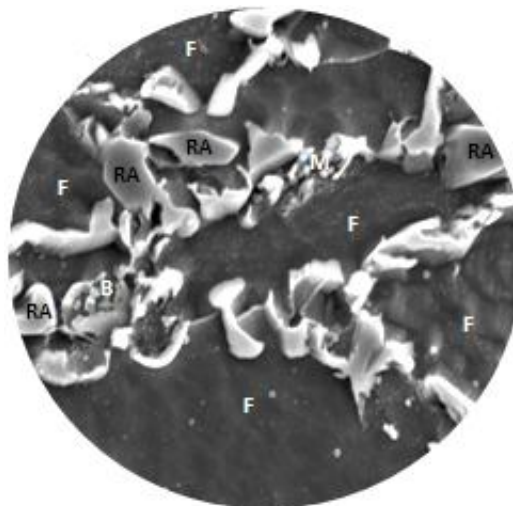


Fig. 9: Microstructures of transformation induced plasticity (TRIP) steel.

relatively high. If insufficient amount of low strength and high ductility bars are used to reduce the steel consumption as well as the weight of the structures, then there might be ductile failure under earthquake as shown in Fig. 10. On the other hand, from earthquake point of view, it is wise to reduce the total weight of the structure as minimum as possible without compromising the safety of the building. Because, in general, the degree of earthquake related damage of any structure is proportional to its overall weight. If high strength ductile steel bars are used in the place of conventional low strength steel bars then steel consumption will be lower. At the same time, the structure will also be safer.

Another option to increase the strength of steel bars by thermomechanical treatment route is by cold working. But, cold working severely reduces the ductility of reinforcing bar, which should not be compromised at all for the construction of earthquake resistant buildings. Moreover, the corrosion resistance of the cold worked steels becomes very poor. So, within a very short period of time the reinforcing steel bars become severely rusted and the plaster along with the part of reinforced concrete collapses causing the steel bars to be exposed to the atmosphere, Fig. 11. This phenomena decrease the total safe service life of buildings.

Addition of more carbon (note: in Bangladesh up to 0.4% carbon is found in structural steel bar) increases the strength, however, both ductility (Fig. 12) and corrosion resistance of the steel bar become inferior. So, it is also not wise to produce structural steel bars with carbon content more than 0.32%.

Another option of strengthening steel bar that is widely practiced in Bangladesh is the addition of various alloying elements such as manganese, chromium, nickel, copper, etc. There is no doubt that addition of chromium, nickel and copper increases the corrosion resistance of the steel bar. But, the ductility level and bending property decrease drastically, which is an important reason of more frequent structural failure in Bangladesh. The reason of drastic decrease in ductility and bendability is that local industries are producing reinforcing alloy grade of steel bars by melting various types of ferrous scraps in induction furnace, which is a very bad practice. Because in induction furnace, no refining, degassing or elimination of slag inclusions is possible. So, the levels of porosity, gas pockets, inclusion particles, etc. remain to a very high level. If these defective steel bars are used in structures, they will face high level of damage during earthquake

because of stress concentration at the defective areas. On the other hand, QT, UFG and TRIP steels show very high strengths, Fig. 13. Except for UFG steel, the ductility levels of other two (QT and TRIP) thermomechanically treated steels are also very high. In this respect, TRIP steel shows exceptionally a very high elongation (in general it is more than 30%).



Fig: 10. Column failure due to insufficient proportion of low strength highly ductile reinforcing steel bars.



Fig. 11: Rusted and exposed concrete reinforcing steel bars because of severe corrosion.

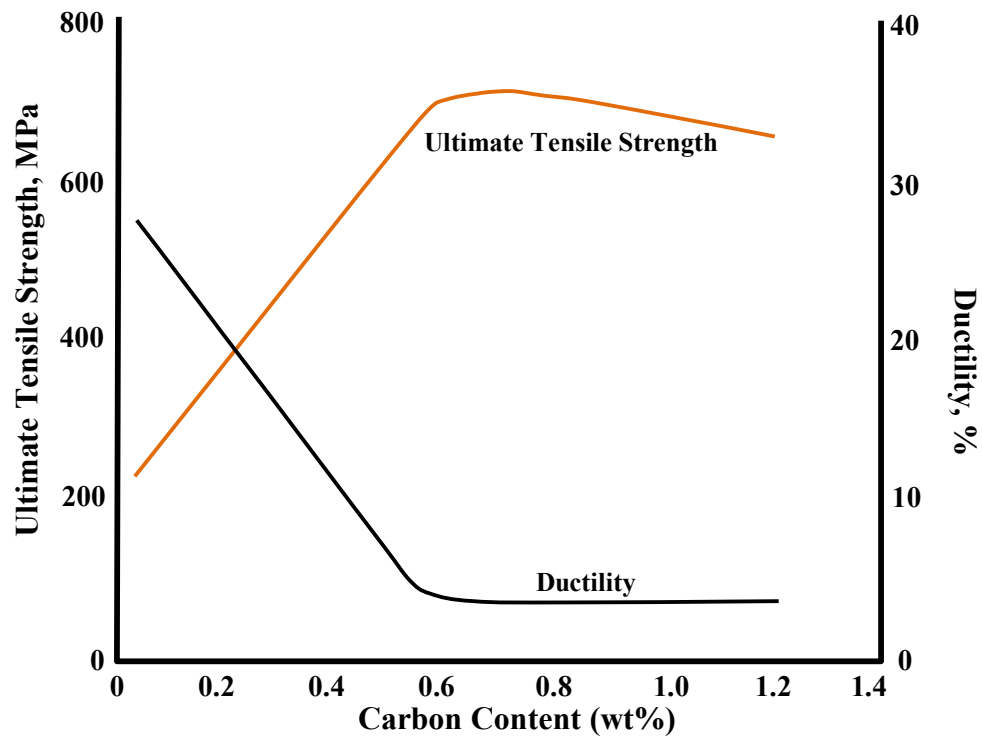


Fig. 12: Effect of carbon content on the strength and ductility of plain carbon structural steel.

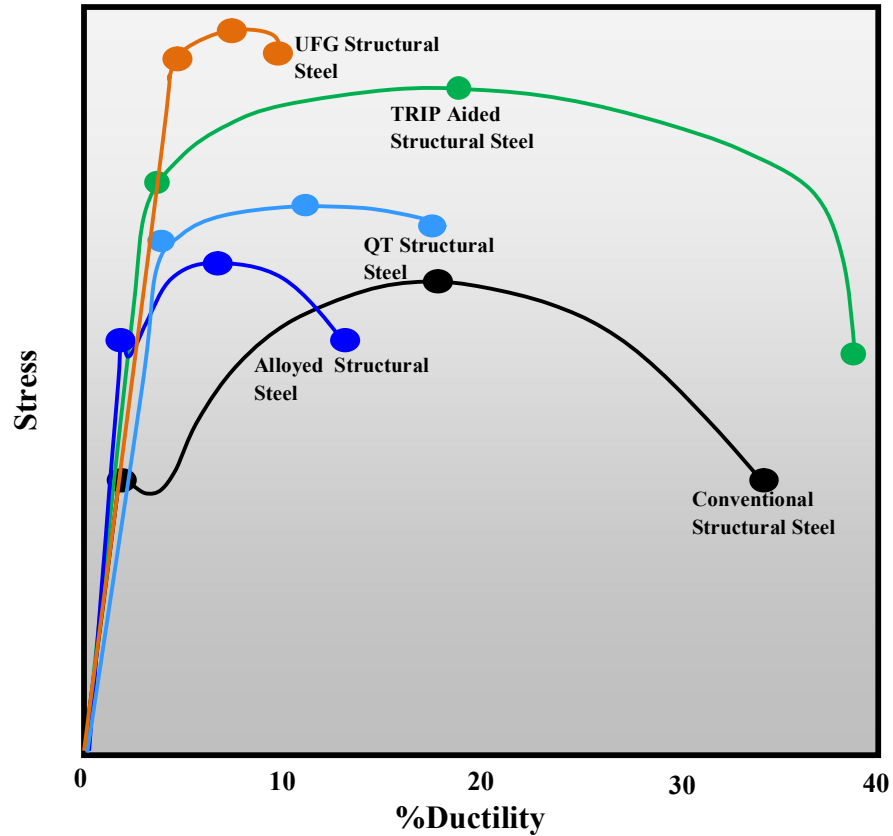


Fig. 13: Stress-ductility diagram of various structural steels.

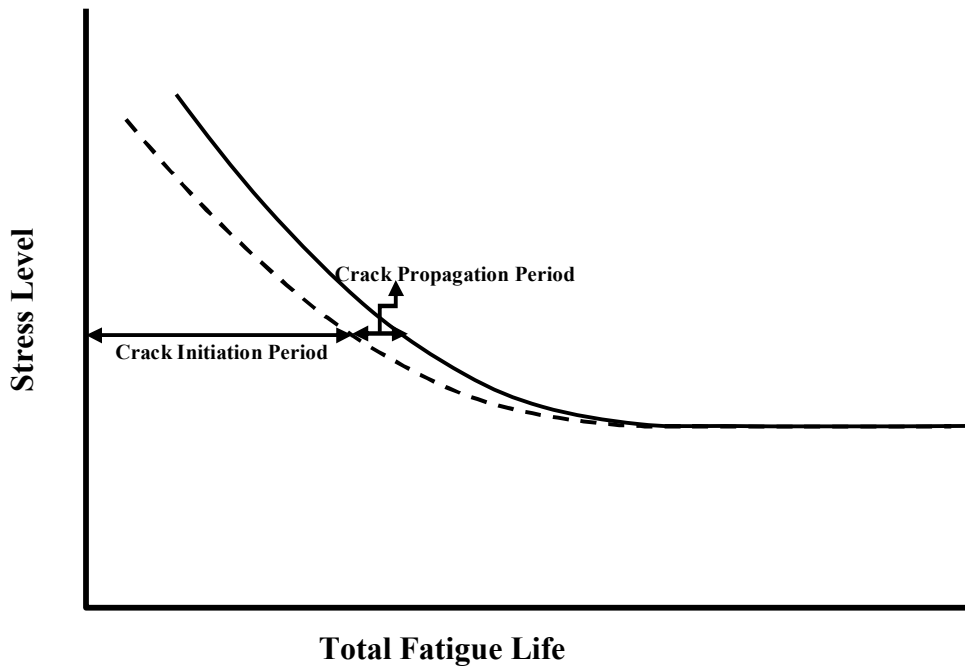


Fig. 14: Effect of applied cyclic stress level on the total fatigue life of a component.

2.3 Fatigue Behaviours of Conventional and Thermomechanically Treated Steels

It has been proved that the total fatigue life of a component is composed of two different periods, namely crack initiation period and crack propagation period, Fig. 14. In general, total fatigue life is dominated by crack initiation period, which is also clear in the figure. Longer the crack initiation period, higher will be the total fatigue life. It is also proved that higher the yield strength of material means longer crack nucleation period, Fig. 15. In the case of cyclic or fatigue loading, maximum tensile stress is induced at surface areas. Here it is important to mention that, during cyclic loading, fatigue crack initiates from surface having highest level of effective tensile stress. So, better surface finish as well as the yield strength of surface material plays important role to control the total fatigue life. In this case, QT steel shows unique combination of surface finish along with higher surface strength. It has been mentioned that after final pass of rolling, QT steel bars are quenched by controlled water flow. Due to this controlled water flow the material at the surface layer is only selectively quenched and subsequently tempered resulting tempered martensitic structure there. As a result, surface layer of QT steel bars becomes very strong, which is also a pre-requisite condition to resist early crack formation. So, QT steel

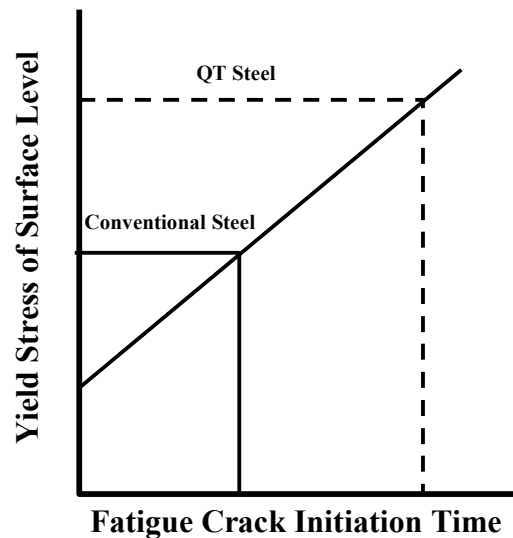


Fig. 15: Effect of surface yield strength on fatigue crack initiation time of a component.

bars show unparallel fatigue life compared to any other conventional structural steel having similar chemical compositions and/or average strength level.

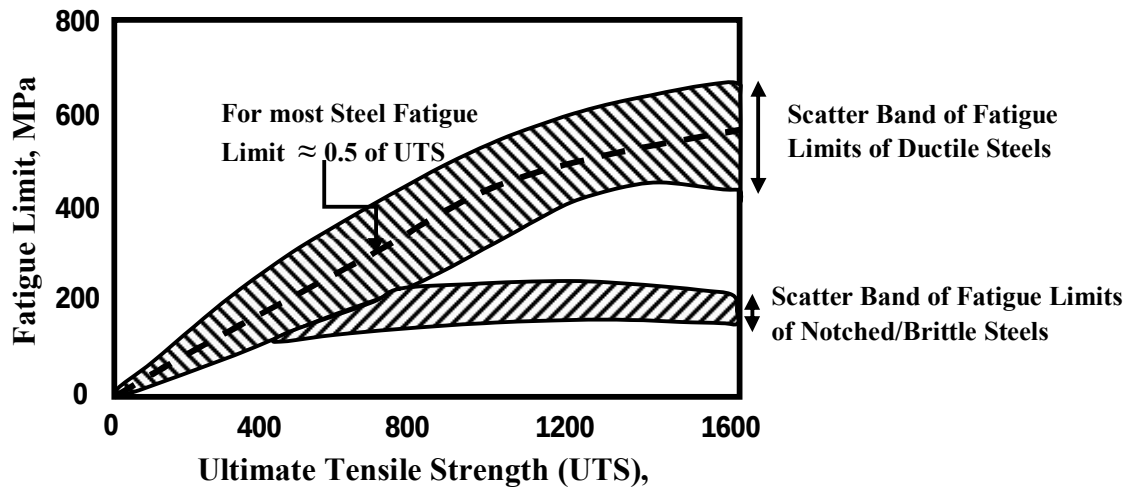


Fig. 16: UTS and fatigue limit relationship of ductile and brittle steel.

In general, the fatigue fracture is a brittle type of failure and it initiates below the yield strength of the material, which has already been mentioned. For ductile material, fatigue limit is also controlled by its ultimate tensile strength (UTS) which is 50% of the UTS, Fig. 16. Here it is to be mentioned that for ductile material, the yield strength (YS) is about 55 to 65% of its UTS, which means fatigue limit is well below the YS of the ductile materials. However, this rough assumption is not true for notched (materials with rough surface) or brittle materials. For structural applications, reinforcing steel bars must show more than 12% ductility. In our country, for many cases, ductility level is frequently found to be below 10%. At the same time, bend test samples frequently break below 45° angle of bend, which is not expected for any good quality structural steel bar. This observation is mostly for alloy grade and/or high carbon grade of structural steel. In brief, we can say that this steel is too brittle for reinforcing concrete. Even though this steel shows higher YS or UTS, their fatigue limit is very low, which also means low fatigue property. To be earthquake resistant, the steel must have high ductility. As a result, structures reinforced by conventional high strength steel bars of lower ductility level are unable to give proper safety of the building during the period of earthquake.

Here it is to be noted that thermomechanically treated UFG steel is a grade of high strength steel. However, this grade of steel is not good for earthquake resistant building because of its insufficient ductility, Fig. 13.

It has been mentioned that thermomechanically treated QT steel has a very high earthquake resistance. In terms of earthquake resistance, TRIP steel is one step ahead compared to that of QT group. The reasons of this superiority of TRIP steel over QT will be discussed now. QT steel is produced by dynamically quenched in water, which results tempered martensite. This tempered martensite is not completely residual stress free. So, having similar chemical compositions, corrosion resistance of TRIP steel is better than that of QT steel. Improper quenching and tempering might cause brittle zone on the surface areas of QT steel. In such case, if there is any surface imperfection, then QT steel might behave as a notched or brittle material and subsequently result lower fatigue limit as shown in Fig. 16. But TRIP steel, from surface to core, has uniform microstructures with higher ductility level having no particular zone with residual stress. Moreover, for conventional or QT steel total applied load is absorbed by elastic and plastic deformations. As a result, continuously, dislocation pile-up causes easy and early necking with subsequent failures in the case these steels. On the other hand, TRIP steel is not very soft like conventional carbon steel or very hard like conventional alloy steel bars or tempered martensite of surface layer of QT steel. As a result, total elongation related to elastic and inelastic deformation of TRIP steel is expected to be of moderate type. In the case of TRIP steel, another source of elongation is due to its strain-induced plasticity. During monotonic (e.g. like uniaxial Fig. 17) or cyclic

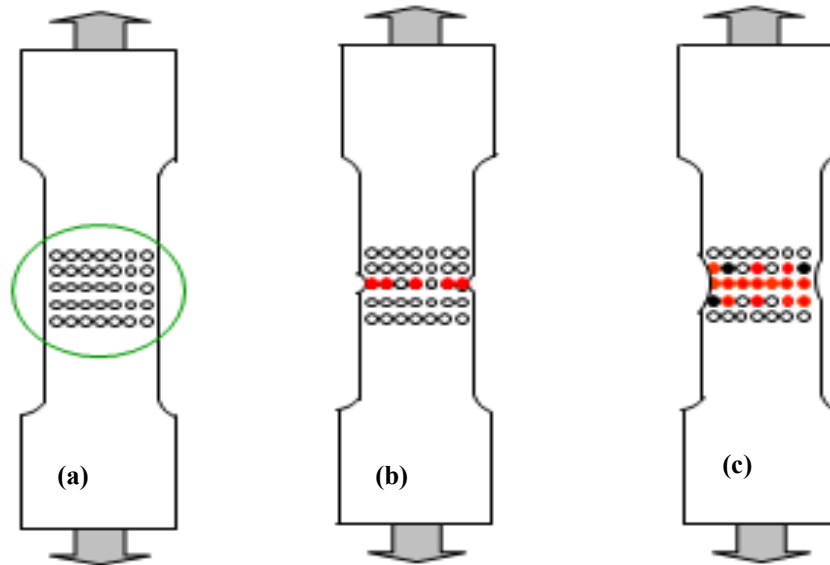


Fig. 17: Transformation of retained austenite (empty or filled black circles) to martensite (red filled circles) under tensile loading of TRIP steel (a) initial stage, (b) just after necking and (c) after a significant amount of necking.

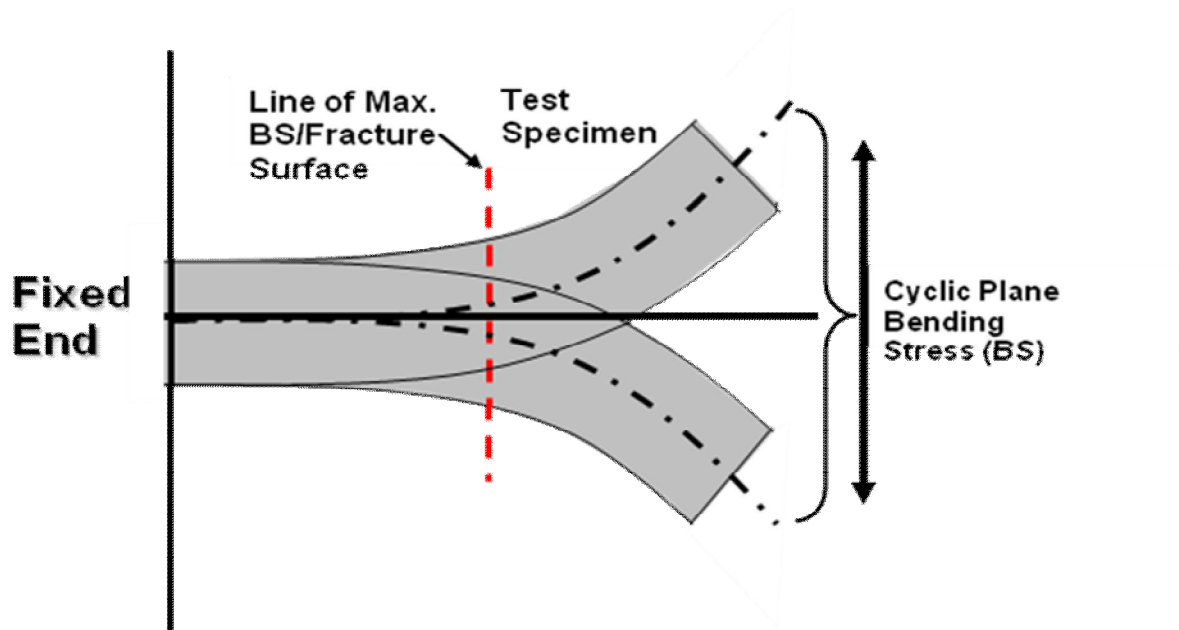


Fig. 18: Cyclic bending stress on TRIP steel sheet.

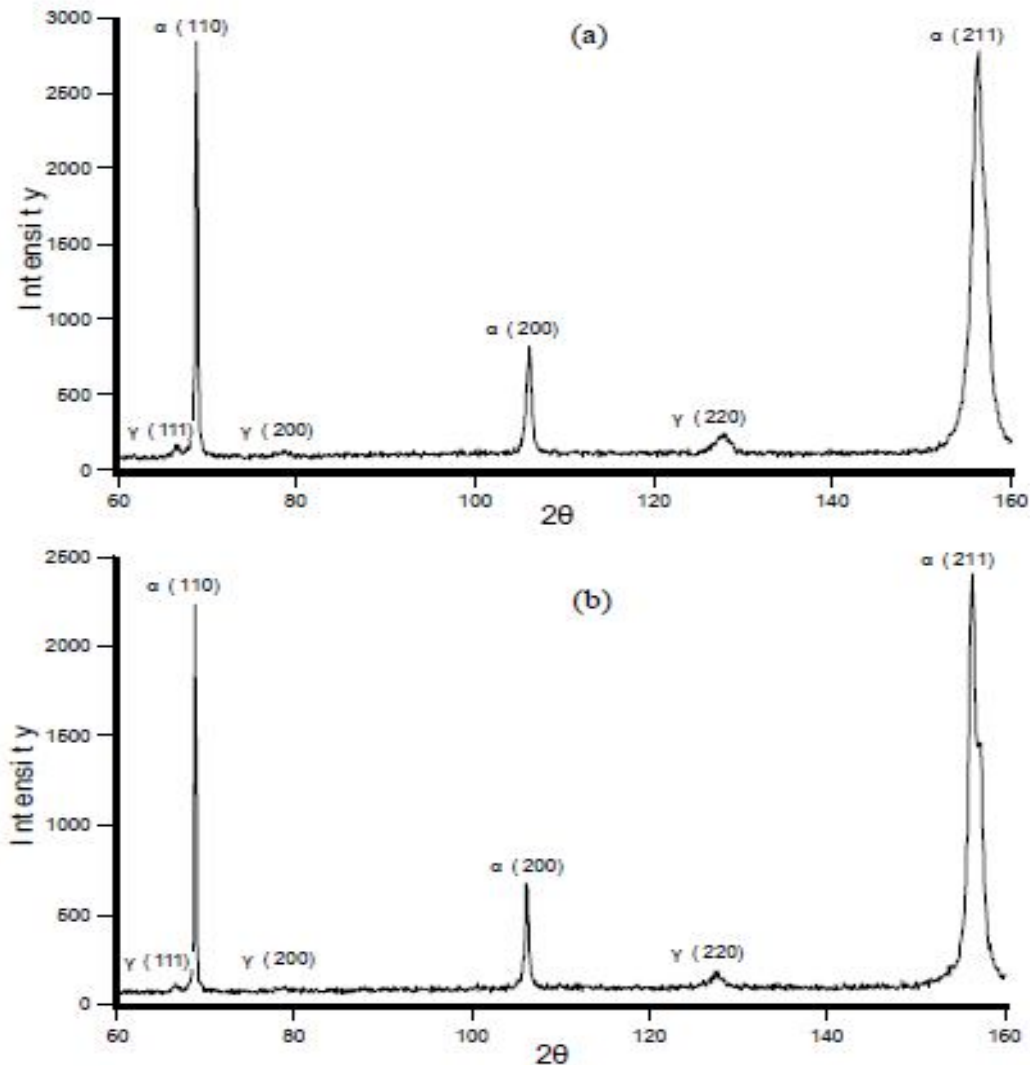


Fig. 19: XRD spectra showing the retained austenite transformation in TRIP steel (a) before fatigue test and (b) after fatigue test.

loading (e.g. cyclic bending, Fig. 18), when the applied load causes effective stress beyond the yield strength of any zone of the TRIP steel, retained austenite in this steel starts to transform, which is clear from XRD spectra presented in Fig. 19. This transformation of austenite (γ 200 and 220 peaks) to bainite/martensite (α 110, 200 and 211 peaks) is an endothermic process, which needs some external energy. If the earthquake related strain causes sufficient stress on the TRIP steel bars and retained austenite is transformed to bainite by absorbing

fraction of shock energy of earthquake. As a result, effective shock energy to damage any structure will be somewhat lower. This behaviour of TRIP steel provides double guard for the buildings; I. by absorbing certain fraction of earthquake related stress, which will ultimately reduce the effective intensity of earthquake and II. transformation of austenite to bainite strengthens the steel (14-16). Altogether, the fatigue property of TRIP steel is really excellent. As a result, TRIP type structural steel shows better fatigue life, which is many times higher than that of the conventional steel having similar level of tensile strength, Fig. 20.

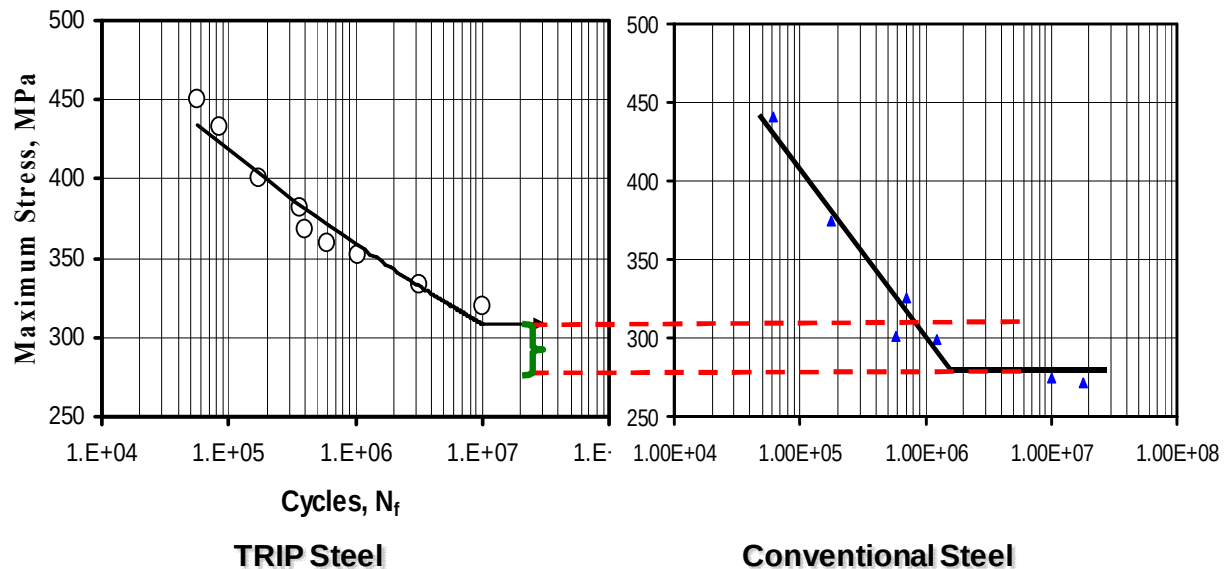


Fig. 20: Comparison of fatigue lives of TRIP and conventional structural steels having similar level of strength.

From Fig. 20 it is clear that TRIP steel provides approximately ten times of fatigue life compared to that of conventional steel and that the fatigue limit of the TRIP steel is also nearly double.

3. CONCLUSIONS

Reinforcing steel bars play the vital role for the safety of the structural buildings. In the case of earthquake resistant structural buildings, a large amount of reinforcing steel bars is used. If conventional hot rolled steel bars are used, the steel consumption will be rather high, which is not good from earthquake point of view. Because, heavy consumption of steel bars makes the structure to be relatively bulky and that earthquake related damage is proportional to the overall weight of the structure. High strength low alloy steel bars made from secondary steel are also not good because of their low ductility and poor bendability levels. In this situation, use of thermomechanically treated high strength and high ductility steel bars might provide necessary solution. Use of QT type thermomechanically steel bars will reduce the overall weight of the structure and risk of earthquake related damage. In this regard, TRIP type thermomechanically treated steels provide extra benefit as it absorbs a certain fraction of the earthquake energy when they experiences deformation by endothermic phase transformation and causes reduction in the intensity of the earthquake.

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TEA INDUSTRY OF BANGLADESH – PAST PRESENT AND FUTURE

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1.0 Introduction

History of tea as a beverage for human traces back to the Chinese civilization as well as to the monks who were preaching Buddhism from India to China. Its botany had its first natural footholds in China and India - rather Indo-China. During its thousands of years of drinking history from dynastic royal people to the down-to-earth common people, it is not only the cheapest beverage but also an established health drink based on scientific supports. At present, this crop is grown in more than 50 countries around the world from Georgia 43° N latitude to Nelson (South Island) in New Zealand 42° S latitude and from sea level to 2300 m above mean sea level. Tea's journey of commercial cultivation in Bangladesh started only in one and a half centuries ago flourishing to its present status.

The geographical location of growing tea in Bangladesh is only restricted to some green specks between 21°30' and 25°10' north latitude and between 91°10' and 92°41' east longitude. Tea is an important commodity of international trade. It is a major cash crops as well as an export item of Bangladesh. The industry and related trade is providing employment for about 0.2 million people. An overview of the world tea *vis-a-vis* Bangladesh tea is presented in Table.1

Table 1. World Tea vis-a-vis Bangladesh tea – an overview

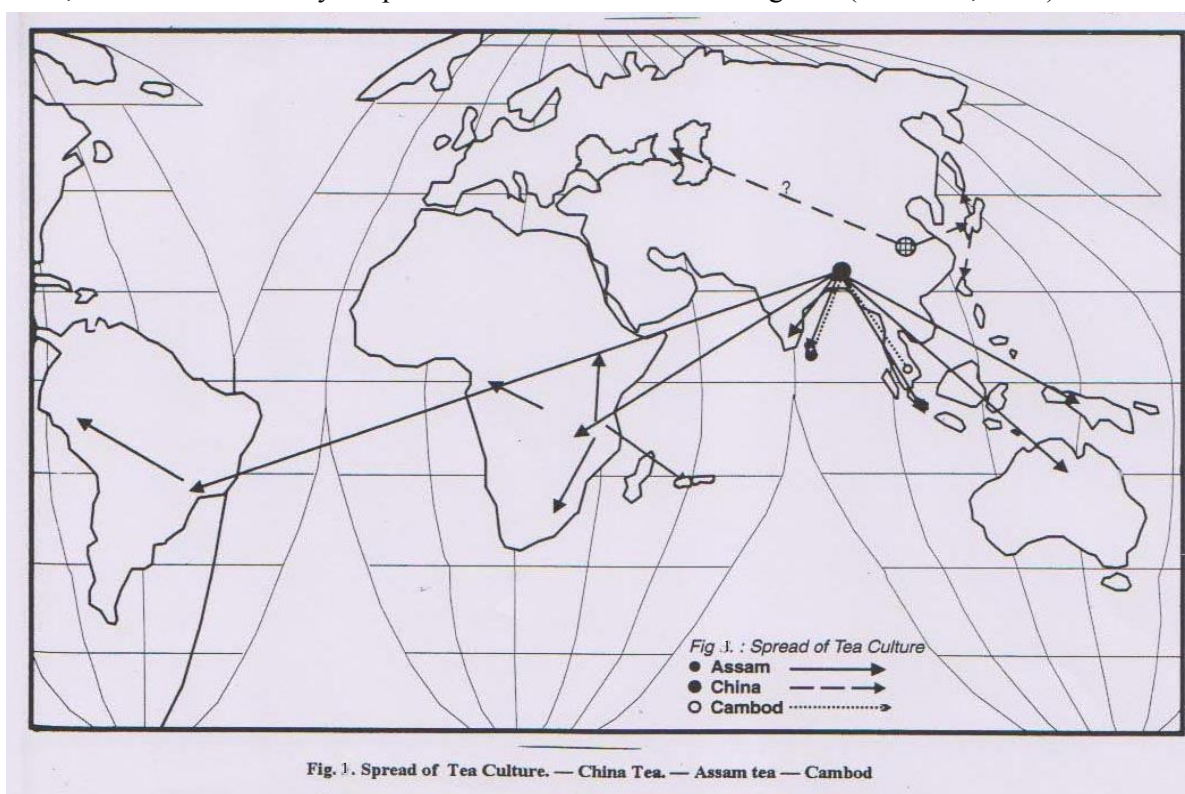
Country	Area			Production			Export			Yield (kg/ha)
	000ha	%	Position	mkg	%	Position	mkg	%	Position	
China	11613	50	1st	1200	31.5	1st	297	18	2nd	700
India	575	16.8	2nd	981	26	2nd	193	12	3rd	1707
Kenya	149	5	4th	370	10	3rd	383	23.4	1st	2190
Sri Lanka	189	6	3rd	305	8	4th	297	18	2nd	1697
Turkey	79	2	7th	178	5	5th	4.5	0.3	11th	1987
Indonesia	134	4	5th	150	4	6th	96	5.9	5th	1038
Vietnam	93	3	6th	148	4	7th	104	6.3	4th	1237
Japan	47	1	9th	100	3	8th	1.8	0.1	12th	1938
Argentina	37	1	10th	90	2	9th	77	4.7	6th	1895
Bangladesh	54	2	8th	58	1.5	10th	8.4	0.5	10th	1236
Malawi	19	1	13th	48	1	11th	47	3	7th	2581
Uganda	23	1	11th	45	1	12th	42	2.6	8th	1792
Tanzania	23	1	12th	35	1	13th	24.8	1.5	9th	1391
Others	241	1	-	158	4	-	109.5	6.7	-	771
Total	3276	100	-	3795	-	-	1549	100	-	-

2.0 Historical perspectives

2.1 Origin of tea

Like many other crop plants, it is believed that tea plants originated somewhere in North of China, probably in Central Mongolia and disperse two directions. The China variety *Camelia sinensis* (L.) var. *snensis* O. Kuntze spread towards the South-East direction of China along the river Mekong while the *Assamica* variety dispersed in South-West direction along the river Irrawady from secondary point in South China (Fig.1).

From there it migrated southwards to Central China. Tea was used as early as 3500 B.C. in China mainly as a medicinal drink. Later it became a common beverage. With the spread of Buddhism tea was introduced in Japan around 600 A.D. Its use, however, remained confined to these two countries for a long time. Tea was introduced to the West only in 1700 A.D. The generic name of *Camellia* was given after George Joseph Kamel, a German missionary in the Philippines from 1661 to 1706, who wrote on plants in Asia. Robert Sweet (1818) united both the genera *Thea* and *Camellia* in to one genus *Camellia*. In Sixth International Botanic Congress held at Amsterdam in 1935, *Camellia* was finally adopted as the correct name for the genus (Bezbaru, 1999).



The increasing popularity of tea all over the world induced countries like India and Indonesia to try tea cultivation with the “china” variety, which made little success. But another variety “assamica” was known to the people of North-East India and Northern Myanmar (Burma) since pre-historical times. Only in early eighteenth century it became known to the outside world and later this variety was successfully grown in other countries.

Another variety known as “*cambod*” from South-East Asia was also known for a long time and was introduced to the outside world in the beginning of 19th century. Upper Burma, Northern part of Thailand together with Southern part of Yunnan province of China, are considered to be the original home of tea and the people of the region had been using tea for a long time. However, organized cultivation in Burma and Thailand was not done.

In India, the British tried to introduce tea from the middle of the 18th century. In 1780, seeds from China were brought by a captain of East India Company and were tried at Sibpur Botanical Garden in Calcutta by Lt. Kyd. On the basis of the results obtained at Sibpur, the first practical step introduced tea in India taken by Sir Joseph Banks in 1788. However, it took a considerably long time to take final decision on the matter ultimately in 1834, a Tea Committee was appointed by Sir William Bentinck, the Governor General of India, to organize a tea cultivation in India. George James Gordon, who was appointed as the secretary to the committee was sent to China to procure tea seeds and plants. He brought back some seeds in 1835. These seeds and later consignments from China by different collectors were grown in Assam, the Kumaon Hills and in the Nilgiris. This process of seed consignments from China continued till the middle of sixties, in spite of the discovery of indigenous Assam tea in 1823.

Major Robert Bruce reported about the “Assam” tea plant presented to him by a Singpho Chief. Lt. Charlton, raised these plants and sends some specimen to the Agri-Horticultural Society of Calcutta in 1831. C.A. Bruce, who was maintaining the nurseries for the Tea Committee, also maintained the nursery of the “Assam” plants, an extension of the original started in 1825 by Robert Bruce. In 1836, a small sample of tea prepared from these “Assam” plants was sent to Calcutta for evaluation and was “Pronounced good”. A year later, a large sample of “Assam” tea was prepared and sent to the Govt. of India. The Governor General was pleased to observe that the tea would be considered as a marketable quality. In March 1838, the Tea Committee despatched 12 boxes of tea to London. The tea was first put up to auction in London in January 1839, and the Court of Directors commented the samples of “Assam” tea were satisfactory.

During the early years, when tea was first introduced to India most people associated with tea cultivation, were under the impression that only China tea bush could produce real tea and believed that “Assam” variety will never be able to compete with the “China” tea. This incidence, therefore, marked the turning point for the tea industry in India as well the whole world. The indigenous “Assam” plants came to the forefront as equally good source of commercial tea as its competitor from China and plantations were successfully established in different parts of Asia, Europe, Africa, America and Australia (Fig. 1).

2.2 Gamut of Bangladesh Tea

Tea plantation started in Bangladesh in the early 1840's. The early history of our tea is the history of tea in North-East India, to be more precise the Surma valley. The period 1827-1857 is very important in terms of beginning of tea in this Sub-continent in general and in present Bangladesh region in particular. The end of the period marks the beginning of extensive tea cultivation both in greater Chittagong and Sylhet districts. The introduction of tea in Chittagong dates from 1839-40.

The plant types were mainly hybrids but there were some Assam indigenous as well as China types. Mr. Sconce, the collector of the district, first received some tea seeds from Assam and some plants from China from the Calcutta Botanical Garden and planted them. The first tea plantation in Chittagong was rightly named ‘Pioneer’. The first tea plantation established in Sylhet was at Malnicherra in 1854 and it still exists as an estate. This was the beginning of tea plantations in Sylhet (Zaman, 1989).

3.0 Bangladesh tea at present

Bangladesh tea has undergone a radical metamorphosis since founding of a tea estate in the British period to the present day status of the whole industry. Towards the close of the nineteenth century, the development was directed to the creation of many limited liability companies dominated by the British entrepreneurs. It is important to analyze the growth of Bangladesh tea industry in respect of area, production and yield against in time of retrospect for rational future planning for increase in area, production and yield (Table 2).

Table 2. Area, production and yield of tea in Bangladesh at different periods

Year	Area (ha)		Production (mKg)		Yield (Kg/ha)		Remark
	Total	Increase/ Decrease*	Total	Increase/ Decrease*	Total	Increase/ Decrease*	
1947	30353	-	18.88	-	622	-	At partition of India
1957	31287	+ 934	25.55	+ 6665	817	+ 195	Pre-mandatory extension period
1970	42688	+ 11401	31.38	+ 5832	735	- 82	Upto Pre-liberation period
1980	43732	+ 1044	40.04	+ 8657	916	+ 181	Pre-BTRP status
1992	47781	+ 4049	48.93	+ 8892	1040	+ 124	Closing of BTRP status
1998	48735*	+ 954	55.82	+ 6894	1145	+ 105	BTRP Impact
2001	50974	+ 2239	56.82	+ 996	1115	- 30	
2003	52202	+ 1228	59.21	+ 2390	1247	+ 132	
2006	53350	+ 100	53.10	- 6510	1001	- 284	Drought Year
2007	53500	+ 150	57.25	+ 4152	1109	+ 235	
2008	53570	+ 70	58.65	+ 1398	1236	+ 75	Drought Year
2009	53000	- 570	60.00	+ 1340	1300	+ 64	Drought Year

Source: Bangladesh Tea Board, PDU and BCS (2009), (Area in Hectare, production in million kilogram, Yield in kg/ha)

3.1 Ecological Zones

Bangladesh tea grows in three fairly divergent ecological zones- namely Surma valley in greater Sylhet, Halda valley in Chittagong and Karatoa valley in Panchagarh (extreme north-west of Bangladesh).

3.2 Management category

Tea gardens in Bangladesh are under diverse management ownership. 27 tea estates are managed by Sterling companies consisting of Messers James Finlay, Duncun Brothers (Bangladesh) Ltd., and Deundi Tea Co. Ltd., 13 TEs run by the National Tea Co. (NTC) which is a public limited

company where the government owned institutions have the majority of shares. There are 120 TEs which are either proprietary or owned by local companies and 3 estates are managed by Bangladesh Tea Board under Ministry of Commerce.

3.3 Agroclimatic conditions

Bangladesh is situated in the tropical monsoon climatic zone with three distinct seasons. Warm season (mid-February to mid-May), Monsoon season (mid-May to mid-October) and Cold season (mid-October to mid-February). The year begins and ends with dry periods. The climate of Bangladesh tea area can be classified regime-wise under four important parameters: rainfall, temperature, humidity and sunshine which are responsible for successful tea culture (Sana, 1989).

3.3.1 Rainfall

The quantitative and qualitative rainfall pattern in Bangladesh is zonal. The annual rainfall ranges from 1400mm to 4500mm. Chittagong and Hill districts receive rainfall not exceeding 3000mm. The tea growing area of Sylhet and Chittagong fall in the wet area. Tea zones experience dry season from Nov. to April while the rainy season continues from May to October and above 80 percent of annual rainfall is obtained during June-September. The quantity of annual rainfall is higher in North Sylhet circle and is reduced in the lower western valley, the Luskergpur circle.

Reliable meteorological data can be utilized in the prediction of a crop like tea which can be understood from an example of a statistically analytical work at the Institute using information on rainfall. A crop forecast model based on rainfall pattern for the valleys in Sylhet has been developed from available data from 1978-87 (BTRI Biennial Rept. 1993-94). The models that have been derived under this study for forecasting the annual production of tea are not permanent ones, but are subject to change, when data of more consistent production contributory factors over a period of considerable years are included in the model under changed circumstances.

3.3.2 Temperature

In Bangladesh, temperature becomes generally highest in April or May, drops slightly during monsoon period and gradually falls after September or October. Prolonged drought occasionally occurs after November or December when rain is meager. In the tea areas of Sylhet, Chittagong and Panchagarh, temperature reaches up to a maximum of 40°C. On the other hand, the extreme minimum in Chittagong zone drops to the extent of 7.8°C to 8.9°C.

3.3.3 Humidity-Evaporation

Relative humidity is generally the highest during night, eases in the morning and is lowest during midday. Average monthly humidity approaches 90% during the monsoon months of June through October falling to 65% for March. An overall relative humidity in Sylhet and Chittagong Tea zone varies from 56 to 80% and 68 to 80%, respectively. It is also known that the rainfall in tea zones exceeds evaporation during the greater part of the year. A deficit of water balance occurs normally from October end until April. Water-stress usually develops after January and lasts up to the first week of March. The overall picture of evaporation regime of Bangladesh shows a primary maximum between April and May when temperature conditions over the country are at the highest.

A secondary maximum appears at random, even during the period of high rainfall or after it has began to recede. In December -January evaporation is the lowest when temperature is also lowest. Sylhet and Chittagong tea zones, however, experience less evaporation than the northern districts of Bangladesh.

3.3.4 Sunshine

The intensity and duration of sunshine has also an important influence on the growth of tea plants. It appears that winter dormancy in tea occurs only in those tea areas that are at higher latitudes as tea is sensitive to the day length (photoperiod). Day length is the shortest in December, the average lowest being 10.6 hrs to average longest in June, being 13.7 hrs. The hours of bright sunshine are fewer in the rainy season of Bangladesh due to the overcast clouds.

3.4 Characteristics of Bangladesh Tea Soil

Tea may be grown on soil of diverse geological origin. In Bangladesh most soils are quaternary and recent alluvia. There are many soils, formed *in situ* from the genesis and sandstone below. Tea soils are highly weathered, extremely acidic and low fertility status. Furthermore these soils do not receive deposits of fertile silt by flooding, rather they suffer from erosion. The soils are medium textured with low contents of organic matter and nitrogen. Mineralogical studies of Bangladesh tea soil have shown that it consists of kaolinite, quartz, hematite, goethite and gibbsite types minerals. Besides, Bangladesh tea soils contain over 85% aluminum in the exchangeable sites (Ahsan, 1984) and its high concentration is known to interfere in the uptake of essential nutrients such as Ca, P, Mg and Fe and produce some deficiency symptoms and aluminum toxicity. In tea soils of Bangladesh, an overall content of nitrogen and organic matter varies respectively from 0.07 to 0.09 per cent and 1.0 to 1.2 per cent. The critical values have been fixed at 0.1% for nitrogen and 1% for organic matter. The amount of available phosphorus, magnesium and base-saturation is low. The minimum level (critical level) of nutrient status of tea soil should be 10µg/g for P, 80µg/g for K, 25µg/g for Mg and 90µg/g for Ca. The C-N ratio should be 10. The most suitable tea soil is thought to be light friable, well drained having soil pH ranging from 4.5 to 5.8.

3.5 Tea populations and plant type

Since the British era, the plantations raised here, had some common ancestry as those in N.E. Due to local adaptation and selection pressure, only a few types particularly dark to semi-dark green and medium to large leaf plants become preponderant. In course of time, many seed orchards were established which mothered the seedling populations. Dark leaf hardy *Assamica* variety with intermediate leaf size and early flushing habit was the specialty of many seed jats in Bangladesh. In recent assessment, it has been calculated that out of the total tea plantation at least 80% are still seedling tea, the rest 20% being clonal plantation comprising largely of eighteen high yielding and quality clones and four biclonal seed stock released by BTRI, some garden clones and a few introduced clones. Thus seedling tea has been and will continue to play a dominating role in limiting the tea production in near future too (Alam, 1994).

3.6 Fertilizer use in tea

The use of fertilizer in Bangladesh tea is indispensable where deficiencies of major and minor nutrients are easily recognized. A huge amount of nutrients are being lost from the soil due to high rainfall, leaching fixation, crop removal, volatilization, evapo-transpiration etc. So the different essential nutrients in the form of inorganic fertilizer must be added to the soil in order to enrich the soil with balanced nutrients and make up the deficiencies of nutrients in the plant.

During Nineteen sixties ammonium sulphate alone had been used in tea as the only source of nitrogen as inorganic fertilizer. Later on different tests and trials on tea soils proved beyond doubt that the pH of tea soil has dropped drastically to a point, where no sulphate of ammonia should be used any further (Choudhury, 1983) because, this acid forming fertilizer sulphate of ammonia is responsible for strong acidity of soil. Then from 1978 onwards, the other source of nitrogen from urea was searched out. Different trials on the use of urea and singly or in combination with sulphate of ammonia were conducted in Bangladesh tea soils. Significant increase in yield had been obtained on the use of urea alone and in combination with sulphate of ammonia than sulphate of ammonia alone.

3.7 Tea Agro-techniques

Tea production-technology involves various agro-techniques which may be broadly put under two management components, viz. Nursery Management and Crop Management. The methods of propagation and multiplication of tea seeds, cuttings, saplings etc are included under the nursery management, while the crop management embraces various field techniques of bringing up tea, ancillary crops that are intended to exploit the highest possible productivity from a tea plantation.

In the sixties with the spacing of 120 cm x 75 cm to 120 cm x 60 cm depending on topography, population range of 11,000 to 14,000 plants/ha and three and four year pruning cycle were the conventional recommendations. With the change of time, like many other tea growing countries, from long term results, spacing from 120 cm x 75 cm to 90 cm x 60 cm with a population load of 15,500 to 18,000 and four-year pruning cycle have been adopted to increase the productivity of tea (BTRI Annual Report, 1992).

3.8 Tea Pest Management

Tea crop protection is an essential component of tea husbandry to safeguard tea plants from the ravages of a multitude of pests, diseases and other maladies. Pest management implies the regulation of pest-activity by adopting suitable methods so as to minimize their effects and maximize the activities of benefactors.

Bangladesh tea eco-system comprises tea, shade trees, green crops, forest etc. The intensive monoculture over 150 years had formed a stable eco-system which provided unlimited opportunity for perpetuation and spread of endemic or introduced pests. Therefore, management of tea pests posed a more complex challenge than any other crop in Bangladesh. So far 25 insects, 4 mites, 12 nematodes, 18 fungal and 1 algal diseases and 37 preponderant weed species have been recorded (Ahmed, 2005). Crop loss caused by pest attack is reported to be about 15% annually (Ahmed,

1991). The overall pest spectrum of Bangladesh tea is similar to that of the Brahmaputra valley, Assam. It seems that most of the major pests and diseases of tea have been introduced initially from the contiguous areas of Cachar, Assam or from the legacy of forest trees and wild or cultivated plants in this area. Red spider mite, Tea mosquito bug and Termite predominate and are widely distributed in all valley circles. Other pests like Flushworm, Jassid, Aphid, Scarlet mite, Blister blight disease are found to be restricted in localized areas or ecological zones.

Looking back into the early records of tea pest control history, natural product e.g. tobacco extract, liquid cowdung, muddy water and lime sulphur were the principal materials for pest control. With no exception in other tea growing countries, in Bangladesh also chemical control has been a dominating feature in pest control of tea and passed through three generations of pesticides. The first generation chemicals-DDT and its other analogues dominated till 1970. Now they are banned. Only Endosulfan is permitted on plucking tea whose MRL of 30 ppm is approved by EPA, Codex Alimentarius and FAO/WHO. Second generation of organo-phosphorus compounds (Ethion, Malathion etc.) and Carbamate (Carbaryl and Carbofuran) introduced since 1960 were only used where the pest became resistant to organo-chlorine compounds. Synthetic pyrethroids, the third generation pesticides, were introduced in 1980. Besides these three generations of pesticides, a fourth generation is in the process of coming up which consists of bio-pesticides like neem or its derivatives and other indigenous plant extracts; *Bacillus thuringiensis* (BT), insect juvenile hormone, etc., but they are yet to be introduced on a commercial scale in Bangladesh tea (Ahmed, 1991). BTRI underscores adoption of IPM with cultural practice and biological control as much as possible within the purview of decision analysis techniques.

3.9 Bio-chemical

Biochemistry refers to the chemical reactions initiated due to synthesis and burning of foods for live process. The biochemistry of tea is started during soaking a tea seed for germination and ceased during firing of tea. Tea leaves and made tea contain several chemical compounds having nutritional and medicinal values, such as, caffeine, polyphenol and alkaloids- catechins (Table 3). This is the caffeine that acts as a mild stimulant, while polyphenols contribute to colour and strength of the liquor. Other non-addictive drugs, such as theobromine, theophylline, useful fluorides, volatile oils and vitamins are also present. Quality of black tea depends on mainly the polyphenolic compounds obviously it is great interest of black tea manufactures to search and exploit for the quality production.

Table 3: Chemical components of black tea of nutritional and pharmacological importance

Chemical components	Approximate quantity in a cup mg (3g/150ml)
Unoxidised catechins (epigallocatechins, purins)	25-50
Theaflavins	12-60
Thearubigins	200-500
Caffeine	60-120
Lysine	0.7
Threonine	0.7
Leucine/ Isoleucine	3.0
Phynilalanine	3.0
Valine	3.6
Potassium	50
Phosphorus	3.0
Calcium	< 1

3.10 Tea Processing

In any food production process, the quality of the final product depends largely on the quality of the input material and the processes involved in obtaining the final product. Tea is not an exception. With the evaluation of newer generations of tea machinery, at different times and its revolutionary impact on tea processing with inevitable influence on tea trades elsewhere, Bangladesh is no exception. The age old orthodox process of manufacture showed a declining trend in the early sixties with the introduction of Legg-cut and CTC (Crush, Tear and Curl) process of manufacture. However, the Legg-cut process was very short lived, so the orthodox process rose up to 60% in the mid seventies, whereas the CTC process of manufacture continued to gain popularity at a faster rate until it reached a peak of about 99% of the total manufacture today. The starting material in black tea processing is the young shoot, the terminal bud and the two adjacent leaves. The salient features of black tea manufacture involve following operations, viz. plucking and handling of tea shoots, Withering, Processing, Fermentation, Drying/Firing, Sorting and Packaging. All these operations call for the necessary of meticulous care and technology maneuvers to produce a better quality tea. Amongst the steps, fermentation is the most important to be considered upon which quality of tea and hence the earnings of the factory depends. The flush is processed in distinct stages. Each stage involves characteristics changes in the physical and biochemical composition of the leaves and the cumulative effects of these changes are ultimately reflected the quality of the finished product, namely, the black tea. Today's Bangladesh tea production and trade both domestic and export are determined by CTC teas. But the prospect of Bangladesh tea in next millennium will depend on the capacity and timely adoption of advanced manufacturing technology of better performance and economy.

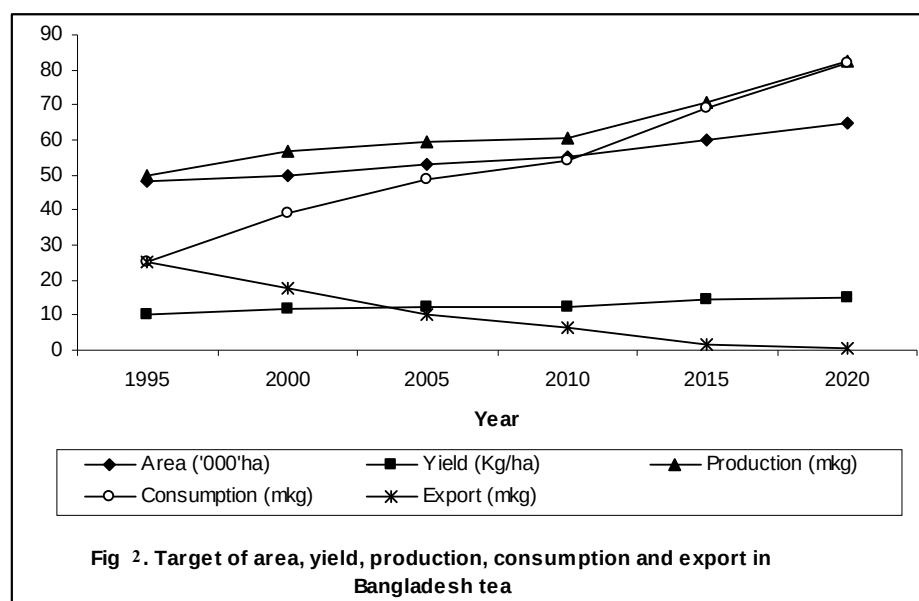
3.11 Trends in production, consumption, export and projections up to 2010

Tea in Bangladesh had been an export oriented product with domestic consumption having a minor share. Now because of population growth and rapid urbanization, the internal consumption is increasing faster and by 2020 will far supersede the export share. At present land utilization for tea is about 42% of the allotted land for tea estates.

Past progress and trend of land coverage and growth in yield, production, consumption and export have been reviewed. On this basis a conservative and easily achievable target of 58,000 ha covering 50% cultivation with tea has been set which will produce about 94 million kg of tea by 2020. The national average in yield is expected to rise over 1600 kg/ha although a few organized management units have already exceeded, or are about to reach the mark. The projections in area, production, consumption and export up to 2020 have been furnished in Table 4 and trend thereof in Fig. 2. There should be two dimensional thrusts i.e. horizontally by increasing plantation area and vertically by increasing per hectare production through introduction of high yielding quality clones and seeds, efficient use of recommended fertilizer, improving agronomic practices, control of pest and diseases, etc.

Table 4. Target plantation area, yield, consumption and export up to 2020

Year	Area (ha)	Yield (Kg/ha)	Production (mkg)	Consumption (mkg)	Export (mkg)
1995	48,000	10.42	50.00	25	25
2000	50,000	11.75	56.82	39	17.82
2005	53,000	12.47	59.21	49	10.21
2010	55,000	12.45	60.65	54	6.65
2015	60,000	14.50	70.62	69	1.62
2020	65,000	15.20	82.34	82	0.34



4.0 Tea Industry Related Organizations

4.1 Government Organizations

4.1.1 Bangladesh Tea Board (BTB)

Bangladesh Tea Board is a statutory body constituted under the Tea Ordinance 1977 to regulate, control and promote the cultivation and sale of Tea in Bangladesh. Tea industry in this part of the sub-continent was controlled by the Indian Tea Cess Act, 1903 till partition in 1947. An eleven

member Pakistan Tea Board with a five member Pakistan Tea Licensing Committee was constituted in 1951 under the Pakistan Tea Act, 1950. This Act was repealed by the Tea Ordinance 1959 and an eleven member Tea Board with the provision of a five member Tea Development Committee was constituted. After the independence of Bangladesh, Tea Ordinance, 1977 was promulgated constituting Bangladesh Tea Board of three whole time members with the provision of an Advisory Committee to be formed by the Government with not more than twenty five members. Later the members of the Board were raised to eleven by the Tea (Amendment) Ordinance, 1986. The Head Office of the Board was in Dhaka till it had been transferred to Chittagong in 1984.

The Board consists of the following members

- A Chairman to be appointed by the Government
- Two full time members to be appointed by the Government
- Chairman, Bangladeshiyo Cha Sangsad, ex-officio
- Chairman, Tea Traders Association of Bangladesh, ex-officio
- Joint Secretary (Export), Ministry of Commerce, ex-officio
- Commissioner, Chittagong Division, ex-officio
- Chief Conservator of Forests, ex-officio
- One member to be appointed by the Government from among tea brokers
- Two members to be appointed by the Government from among tea planters.

The main functions of the Board

- To regulate, control and promote the cultivation, sale and export of tea.
- To control and improve the quality of tea.
- To conduct comprehensive scientific and technological research to raise productivity of tea and improve its quality.
- To register tea estates with the Board and grant licenses to the planters, manufacturers and other dealers engaged in the business of tea.
- To assist establishing new tea gardens and improving productivity of existing tea gardens.
- To undertake welfare measures for tea garden laborers and employees.
- To undertake, acquire or manage any tea concern or to take such measures in the interest of the tea industry as directed by the Government, from time to time.

4.1.1.1 Bangladesh Tea Research Institute (BTRI)

Bangladesh Tea Research Institute (BTRI) is the research wing of Bangladesh Tea Board engaged in conducting comprehensive scientific, technological and economic research for the Tea Industry. It has provision for 182 personnel including research and technical staffs. It was initially established by the Board in 1957 at its present location in Srimangal as Research Station to provide technical support to the Tea Industry and subsequently was converted into a full-fledged Research Institute in 1973. Now it has three major research departments with 6 divisions as under Department of Chemistry comprising Soil Science and Biochemistry Divisions, Department of Crop Production comprising Botany and Agronomy Divisions, Department of Pest Management -comprising Entomology and Plant Pathology Divisions. It has two more research divisions namely, Tea Technology Division and Statistics-Economics Division.

4.1.1.1.1 Mandate

- Conducting research – strategic and basic
- Conserve gene resources
- Man power development
- Advisory & extension services
- Scientific linkage – national and international
- Develop information and communication

4.1.1.1.2 Objectives

- To increase yield and improve quality of our tea
- To render advisory service to tea industry
- To transfer technologies to the tea industry

4.1.1.1.3 Some research innovations**4.1.1.1.3.1 Varietal Improvement**

- Eighteen clones of high yield and quality evolved and released.
- Four hybrid tea seed of biclonal stocks developed.
- General seed stocks re-evaluated and ten good seed orchards registered.
- Gene bank being established for germplasm conservation.

4.1.1.1.3.2 VP Techniques

- Standardized vegetative propagation (VP) techniques for tea.
- Nucleus clone plot establishment and management determined.

4.1.1.1.3.3 Tea Soil Management

- Fertilizer policy for mature tea and young tea upgraded on yield basis.
- Management of soil properties like texture, structure, organic matter, ph, nutrients, etc. established.
- Critical values of nutrients in tea soil determined.
- Replacement of SOA by urea as a cheap nitrogenous fertilizer.
- Rock phosphate as economy fertilizer substitutes for other phosphatic fertilizers.
- Soil rehabilitation methods recommended.
- Proper soil mapping initiated.
- Possible new areas surveyed.

4.1.1.1.3.4 Agronomical Practices

- Pruning cycle for optimum crop production determined.
- Crop harvesting methods to optimize yield and quality of crop determined.
- Ideal plant population, planting methods, pre-and post – planting practices determined
- Grafting method for rapid mother bush establishment determined.

4.1.1.1.3.5 Tea Pest Management

- Tea pest complex surveyed and major pests identified (insects, mites, nematodes, diseases and weeds).
- Bio-ecology of major pests studied.
- Biotic potential for three major pests determined.
- Crop loss assessment for four major pests assessed (insects, mites, nematodes, diseases and weed).
- Integrated pest management method optimized and decision.
- Appropriate spraying technique and schedule determined.
- Awareness on MRL of pesticides created.
- Resistant agro types and vars. of tea to termite pest identified.
- Compatibility of pesticides determined.
- Few bio - control agents identified

4.1.1.1.3.1.6 Tea Processing

- Performance of different preconditioning methods for CTC processing determined.

4.1.1.1.3.1.7 Biochemical

- Correlation between theaflavin level and temperature during processing and fermentation established.

4.1.1.1.3.1.8 Statistics & Economics

- Annual crop forecasting method determined.
- Production cost of tea analyzed.
- Economic size of a tea estate determined.

4.1.1.1.4 Sub-stations

BTRI has four sub-stations located at-

1. Kality (Moulvibazar), 2. Sylhet, 3. Oodaleah (Fatikchari, Chittagong), and 4. Panchagarh

4.1.1.1.4 Activities of Sub stations

- Demonstration of zonal field experiments
- Multiplication of improved planting
- Materials and distribution
- Zonal information and training venue

4.1.1.1.5 Technology transfer to T,Es.

Research is a complex process and involves trained scientists, technical assistants, equipments and materials. The output includes knowledge and technology packages. Productivity and cost effectiveness depend mainly on the effective dissemination of technology to the end users. Following are the official fora through which technologies are disseminated to the industry by BTRI. Annual courses, Routine visit, Request visit, Special visit and training.

4.1.1.2. Project Development Unit (PDU)

Project Development Unit is a wing of the Tea Board acting in the field of development with a separate office at Srimangal. It was established in 1980 as a component of the Bangladesh Tea Rehabilitation Project (1980-92) implemented with financial and technical assistance of Overseas Development Agency (ODA) & European Economic Committee (EEC). Its manpower with 51 posts was absorbed in the revenue budget of the Board in 1988. The Board undertakes various development activities such as, preparation and implementation of development projects, assisting the tea estates in preparation and implementation of development schemes, monitoring of development activities of the tea estates, providing advisory services to the estates for dissemination of improved technology, imparting training to the management personnel of the tea estate, implementation of various labor welfare programs etc through PDU.

4.1.2 Bangladesh Krishi Bank (BKB)

Bangladesh Krishi Bank (BKB) is the only designated bank to provide both crop and along term development loan to tea industry. All grants/loans that had been provided by the UK Government and Bangladesh Government were channeled and continue to be channeled through BKB. BKB provides annually **180-220 crore** taka as crop loan @ 10% interest to the tea industry. It has also provided long term development loan of around **200 crore** taka to the tea industry from its own source. Re-payment of loans by the industry is well over 98% a credit to both the tea owners and the bank.

4.2 Non Government Organizations

4.2.1 Bangladesh Tea Association (BTA)

Bangladesh Tea Association is only the representing all owners of Tea Gardens of Bangladesh. The Association elects every two years a central committee from amongst its members who run its members who run the business of the Association. Its Head Office is in Chittagong. BTA interacts with the Government in such diverse issues as bank loans to land lease. BTA undertakes to negotiate wages for the staffs and workers of the entire tea industry with their respective unions. These wage agreements are negotiated every two years. It also settles disputes between tea companies and Labour Unions. BTA has two regional committees- Sylhet and Chittagong to after the interest of its members.

4.2.2 Tea Traders Association of Bangladesh (TTAB)

TTAB is the Association that represents the buyers of tea. Producers can also be its member. It has its Head office at Chittagong. TTAB along with BTB conduct and regulate the weekly Tea Auctions that is held every Tuesday at the Port City of Chittagong. TTAB and BTA maintain a close liaison and work jointly on many issues related to marketing of tea.

5.0 Bangladesh Tea Rehabilitation Project (BTRP)

During the war of liberation in 1971 the industry was severely damaged since most of the tea estates are on the international boundary between Bangladesh and India. As such the industry suffered a serious set-back after the liberation war due to high production cost, poor quality tea, competitive world market, low sale price etc. A number of studies were carried out to find out the ways and means to rehabilitate the war torn tea industry by various national and international committees and missions after the independence. On the basis of their recommendations the Govt. of Bangladesh took a massive development program in 1980 in the name of Bangladesh Tea Rehabilitation Project (BTRP) with the financial and technical assistance from British ODA, EEC & GOB.

5.1 Effect of Bangladesh Tea Rehabilitation Project (BTRP) on tea industry

This project has made a very positive contribution to the industry, which brought the present per hectare yield of Bangladesh tea to 1145 kg with the total production of 55.82 m. kg in 1998. The cost of production (COP) could be kept under control reasonably although the price of various inputs increased manifolds over the years. But the quality of tea attained a radical improvement and could easily be compared with the lower Assam tea. As a result of this achievement, Bangladesh tea now could find its way in the export market with remunerative price. Labour productivity has also been improved to a great extent and less absenteeism was observed. Health and education facilities in tea estates were improved reasonably. These altogether made tea industry more sustainable while the jute industry followed the path of peril.

5.2 Small holding tea cultivation concepts

In most of the major tea producing countries viz. India, Indonesia, Kenya and Sri Lanka, the small holding tea cultivation co-exist along with the large estates and contribute significantly to the national tea production. The ideas of establishing small holding tea cultivation in Bangladesh were firstly formulated in the Tea policy for 1984-85. Thereafter few tea professional of the country took certain positive steps to promote small holding tea cultivation in Tetulia, Panchagarh district by forming a company titled Tetulia Tea Company Limited (TTCL) which is a private initiative (TTCL, 2000). A joint project of Bangladesh Tea Board and Rajshahi Krishi Unnayan Bank entitled “**Development of Small Holding Tea Cultivation in Northern Bangladesh**” with an estimated cost of Tk. 1096.70 lakh has been initiated in 600 ha area of Thakurgaon, Nilphamari, Lalmonirhat and Dinajpur districts within 8 years (2002-2009). Furthermore another project entitled “**Small Holding Tea Cultivation at Chittagong Hill Tracts**” with an estimated cost of Tk. 1070.21 lakh has been approved by the Government. The objective of the project is to plant tea 100 ha in Rangamati, 300 ha in Bandarban and 100 ha in Khagrachherri by organizing farmers to grow tea in small holding. Furthermore a development project entitled “**Expansion of tea export by raising and distributing HYV clonal tea plants to the poor ethnic small growers of Bandarban hill districts**” with an estimated cost of Tk. 93.60 lakh has been undertaken. It is mentionable that BTB has drawn up a 20 year Strategic Plan (2004-2023) for development of Bangladesh Tea Industry (Ahammed, 2007). Now there are 8 registered tea estates in Panchagarh district. The tea planters of Panchagarh produced 4 million kg of made tea from 908.90 ha area in 2009.

5.3 New tea area surveyed

The feasibility study for growing tea in Small Holding at Jamalpur, Sherpur, Mymensingh and Thakurgaon has been done by BTB in 2004. It is found that **8522** ha of land are suitable for in these areas. These lands are unused now, which can be effectively used for tea maximizing incomes of the families. Besides, an area of 7822 ha is suitable in Lahagara to Cox’s Bazar, Satkania to Banskhali and Sitakunda to Mirsharai areas. These lands can also be brought under Small holding tea cultivation.

6.0 Pesticide Residue Analytical Laboratory: An Institutional Development

Pesticide residue in made tea means what is left over or remains of a pesticide in the made tea after the application of a pesticide to tea bushes in the field prior to plucking and subsequent manufacturing. As tea is a consumable commodity, the effect of residue of pesticides in made tea is harmful to human health. Tea produced in Bangladesh is exported to different countries of the world particularly West and East European as well as Middle Eastern countries. The consumers of these countries have become more conscious about the residue of the pesticides. In this perspective, EPA/ Codex Alimentarius/ FAO/WHO, German Law etc. have given restrictions on producing and procuring tea having pesticide residue.

Bangladesh Tea Research Institute at Srimangal has established a well-equipped sophisticated pesticide residue analytical laboratory at its own premise and is run by trained personnel since

January 2003. All sorts of precision analyses of international standard of different groups of pesticides like Organochlorine, Organophosphate, Carbamate, synthetic Pyrethroid and some unclassified groups are done successfully. Standards of Good Agricultural Practices (GAP) and Good Laboratory Practices (GLP) are strictly followed. The facilities are now open to the tea industry and they have already started deriving benefit out of it. So the producers and traders should start scrutinizing their teas on regular basis at field, factory and trade points without delay. They should contact BTRI and harness the full advantage of the available facilities. The laboratory has already selected as one of the 11 laboratory by Intergovernmental Group (IGG) of FAO for ring tests to fix MRL in black tea globally (FAO, 2009). Pesticide residue analytical laboratory is equipped with Gas Chromatograph (Shimadzu GC-14B) with other necessary equipments.

6.1 Role of Bangladesh tea producers and traders

As tea is a consumable commodity, tea drinkers in advanced countries are quite conscious of health hazards out of pesticides in their food and drinks and tea is no exception. Even our domestic consumers are elevating their choice for such toxicity free food products. Choice for organic food has been getting momentum. A substantial portion of our tea is exported to western and middle-eastern countries. We should be aware of these conscious markets. So our producers and traders should start scrutinising their teas at field, factory and trade points now. They should contact BTRI and harness the full advantage of the available facilities.

6.2 How the tea industry will benefit

The Residue Laboratory at BTRI is at the doorstep of the tea industry. They can easily take reliable as well as economic service within a short time which would involve more money, time and longer process to get samples tested from any other laboratory in the country or outside. At present the Institute can analyze about 200 tea samples per annum at different levels e.g. field application, made tea at factory, experimental samples, auction point, export point and random samples in the market point. The volume of analyses will be extended further. Thus the Institute plans to ensure MRL safe tea for the consumers home and abroad.

6.3 Running residue project

“Determination of residue level of different pesticides at different days after spraying” Core Research Programme/Project implemented during the year 2007-10 under “Research Grant” of BARC

Table 5. Safe harvest intervals for some common chemicals

Chemical	Dose /ha	Residue level* (ppm)	Safe harvest interval (days)
Endosulfan	1.5 lit.	1.40	7
Propargite	1.0 lit.	3.52	7
Ethion	1.0 lit.	4.66	8
Bifenthrin	500 ml	0.043	7
Cypermethrin	500 ml	0.85	7
Dimethoate	2.25 lit.	ND	7
Sulphur	2.25 Kg	ND	7

* at 7 days after spraying

The residue level of above mentioned pesticides at 7 days after plucking is below the MRL fixed by EPA, Codex Commission, EEC/EU and German Law (Ahmed *et al.*, 2009).

7.0 Major research thrust areas

- HYV & quality clone
- Raising organic matter status
- Biotechnology for plant improvement
- Drainage, irrigation & drought management
- Integrated pest management (IPM) with special emphasis on biocontrol
- Pesticide residue in tea
- Crop diversification
- Socio-economic study
- R & D management

The success of BTRI in the past to render scientific support to the tea industry was quite considerable. Innovations and adoption of newer technologies are expected from the future thrust areas. Their efficient management is expected to meet the challenges of future consolidating Bangladesh tea industry to play its due role in the economic development of Bangladesh.

8.0 Collaborative Research

The research group at the Tea Biochemistry Cell at the University of Cambridge in England in collaboration with Tocklai Experimental Station at Assam in British India in early 1940's, may be cited as a very good example of a pioneering work of Dr. E.A.H. Roberts & team on tea biochemistry which unveiled the contributions of Theaflavins (TF) and Thearubigins (TR) towards colour, strength, briskness and creaming properties of the brew, the role of chlorophyll in appearance, and volatile components like linalool for flavour and quality have been established.

9.0 Some suggested researches in the academic institutions like SUST

BTRI is engaged mainly in adaptive researches on tea by which the tea industry could benefit immediately but much remains to be done on basic research where higher academic institutions like SUST and other universities may come forward and complement the gap to generate adaptive technologies to improve our tea.

Some proposed fields may be as follows:

- The pharmacological values of tea
- Pharmacokinetics of tea
- Heavy metals in made tea and tea soils
- Applied physiology of tea plant
- Tissue culture, Genetic mapping and engineering to evolve transgenic tea
- Remote Sensing Technology to be utilized to identify the geomorphic units to formulate drainage planning based on topography and geomorphology
- Advanced studies on the ground water potential in some selective tea areas
- Catchments planning at estate level to be practiced to tackle the drainage problem
- Biodegradable jute geo-textiles as effective in reducing soil erosion in tea uplands

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A STUDY OF THE INTERNAL DEFECTS OF VARIOUS TYPES OF CONSTRUCTION MATERIALS BY USING DIRECT FILM NEUTRON RADIOGRAPHY TECHNIQUE

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Summary: Neutron radiography technique has been utilized in the work for studying internal defects of various types of construction materials through optical density measurements of the samples. Two kinds of locally developed construction materials have been used as samples in our experiment. They are Terrazzo and Engraved construction materials. Tangential Neutron Radiography Facility of 3 MW TRIGA Mark-II research reactor is used here to find out the internal defects of the samples. From the observation of neutron radiographic images of the samples and variation of optical density at different positions, it revealed that the associated composites of Terrazzo construction material are uniformly distributed. No voids or any inclusions in the materials have been observed in the radiograph. The neutron radiographic image of engraved construction material shows that the optical density values at different reference positions are different. The density at the central position of the image is different from its neighboring reference positions. Moreover, some voids are observed in the neutron radiograph of the material. This confirms that in this material the associated composites are not uniformly mixed and distributed during its fabrication. So, the fabrication of this construction material is relatively faulty. This faulty material may have several bad impacts while it is used as a construction material. It can absorb rainwater and thus may be damaged. Due to its structural disorder, its strength is deteriorated and may be damaged easily from even a very minor environmental turmoil.

Keywords: Neutron Radiography, Non-destructive testing, Optical density

Introduction

Neutron Radiography (NR) is an imaging technique, which provides images similar to X-ray and Gamma-ray radiography. Interactions of neutron with matter can be divided into scattering and absorption. Neutrons can detect light elements, which have large neutron absorption cross-sections like hydrogen and boron. The information provided by spatial and temporal beam attenuation is recorded on magnetic media via analogy or digital signals.

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All radiographic methods, whether making use of X-rays, γ -rays or neutron beams are based on the same general principle that, radiation is attenuated on passing through an object (sample). The object under examination is placed in the incident radiation beam. The beam, which remains after passing through, enters a detector that registers the fraction of the initial radiation intensity that has been transmitted through each point of the object. Any inhomogeneity in the object or an internal defect (such as voids, cracks, porosity, inclusion, corrosion etc.) will show up as change in radiation intensity reaching the detector.

Neutron Radiography [1] is a non-destructive testing (NDT) technique of testing the nuclear and non-nuclear materials as well as industrial products. It concerns neutrons and radiography using neutron beam.

Recently NR method has been applied to detect faults and to study water absorption properties of building materials [2]. A neutron radiography standard testing method for the moisture analysis was introduced by Peterka et al. [3] to the building industries in order to evaluate the properties, functions and the efficiency of their water protective agents against the penetration of water, water solution etc. In another study [4] quality of leather and ceramics has been studied. Study of corrosion in aluminium has been reported by M.N. Islam et al. [5]. In the present study, the NR set up at the tangential beam port of the 3.0 MW TRIGA Mark-II research reactor of AERE, Savar, Dhaka, Bangladesh has been used. Details of the NR facility of AERE, Savar, Dhaka can be found in reference [6]. Details of the parameters of the facility has been given in [7]. A study of defects and water absorption behaviour of jute products was reported by A.K.M. Azad Rahman et al. [8].

The following experiments have been carried out in the present study using direct film neutron radiography technique:

- A. Determination of optimum irradiation time for the present sample.
- B. Determination of defects in the samples through optical density variation measurements.

Any inhomogeneity in the object or an internal defect e.g. void, crack, porosity or inclusion will show up as a change in radiation intensity reaching the detector, Irradiation intensity varies after passing through an object under examination. This intensity variation obeys the general attenuation law applicable for X-rays, gamma rays or neutrons

$$I = I_0 e^{-\mu x} \quad \dots\dots\dots (1)$$

where,

- I_0 = initial intensity of the incident beam,
- I = intensity of the emergent beam from the object,
- μ = attenuation coefficient,
- x = thickness of the object.

When the radiation beam is neutron, the above equation can be written as

$$\phi_s = \phi_0 e^{-N\sigma x} \quad \dots\dots\dots (2)$$

where,

- ϕ_s = number of neutrons transmitted through the sample, $\text{n cm}^{-2} \text{ sec}^{-1}$,
- ϕ_0 = number of neutrons incident upon the sample $\text{cm}^{-2} \text{ sec}^{-1}$,
- N = number of nuclei per cm^3 ,
- σ = microscopic cross-section, cm^2 ,

x = thickness of the sample, cm.

The attenuated neutron beam enters a detector that registers the fraction of the initial radiation intensity reaching the detector and is then recorded in the X-ray film. This is the principle of NR. The rate of depletion of the control rod material can also be detected by taking regular neutron radiographs. Irradiated TRIGA fuel elements could be used as object for all these experiments.

Experimental Procedure

Pre-Irradiation Procedure

Before performing the irradiation of the experimental objects, the following steps were undertaken in the present experiment:

1. Sample collection/preparation
2. Loading the film and converter foil in the NR cassette
3. Setting the sample in the neutron beam

Sample preparation/collection

Some locally developed construction materials have been collected from the Concord Ready-Mix and Concrete Products Ltd, Gulshan, Dhaka. The names of these products are terrazzo construction product and engraved construction product. Terrazzo building product is made from marble chips, marble dust and white cement. Engraved product is made from cement, sand and pigment.

Loading the Film and Foil in the NR Cassette

Gadolinium (Gd) metal foil of 25 μ m thickness was used as converter in the NR cassette and Agfa structruix D4pDW industrial X-ray films were used as detector in our experiment. The films have emulsions in single side only. The sample and the NR camera were placed on their respective tables across the neutron beam. In this position the camera was placed just after the sample. The sample holder table was set at the optimum sample position from the reactor biological shielding assembly.

Irradiation of the Sample

To find out the optimum irradiation time of the sample a series of experiments were performed with different exposure time. To do these experiments the reactor was operated at 250 kW power level. Finally, we found the optimum irradiation/exposure time for the sample. From the observation of the final radiograph we found out the internal details such as cracks, voids, homogeneity of their compositions etc. of the sample.

Post Irradiation

After irradiation of the sample, the irradiated film was separated from the NR camera in the dark room and then following procedures have been carried out to make the radiographic image of the irradiated samples:

a. Developing

Developing ensures latent image, which was produced during irradiation to visual one. The film was then immersed into the developer for some time and was then agitated into the developer horizontally without touching the beaker (which contains the developer chemicals).

b. Washing

For cleaning the developing chemicals, the film was washed in cool water for a few minutes.

c. Fixing

The developed film was immersed in the fixative chemicals to obtain the clear image.

d. Final washing

The silver compounds, which were formed during the fixing stage, must be removed, since they can affect the silver image at the later stage. For this reason the film must be washed thoroughly in running water.

e. Drying

After the final washing, the films were dried by clipping it in a hanger and simultaneously flowing fresh air from the air cooler.

The neutron radiographic images of the sample show that the region in which the sample was at close contact on neutron radiography cassette were light whereas, the backgrounds were comparatively dark. This is because more neutrons were attenuated by the test sample and allowing more neutrons to pass freely through the rest.

Basic Principle of the Study for the Sample

The quality/homogeneity of an object depends on the proper distribution of the composite materials. In the present work we have studied the quality of the test samples by the densitometric measurements the neutron radiographic images of the sample.

When neutron beam hit an absorber, some of them are absorbed and scattered while the rest pass through it. Attenuation of radiation in the object is the difference between the radiation intensity before and after passing through this object. It can be expressed as [9]:

$$I = I_0 e^{-\mu x} \quad (3)$$

where e =base of natural logarithms, x = thickness of the test object, μ = linear neutron attenuation coefficient, which depends on the atomic number and the density of the material. I and I_0 is the neutron intensity after passing the object and the neutron incident on the object.

In this work, the term homogeneity means the uniformity in the distribution of the composite materials. The homogeneity of a material depends of the proper distribution of the composite materials. Measuring the optical density of the radiographic film background (with out image), the optical density of the center point of the sample image, and at different reference levels of the radiographic image of the sample, one can comment about its homogeneity/inhomogeneity. The best homogeneity is ensured would constant optical density values at all places/levels.

The mathematical expression [10] for the optical density, D , at a point of the film/image is given by:

$$D = \ln \left(\frac{A_0}{A} \right) \quad (4)$$

Here, A_0 = response of densitometer without the image and A = response of densitometer with the image.

Fractional change in image density of neutron radiograph can be represented by ΔD and the expression can be written as,

$$\Delta D = \left(\frac{D_c - D_n}{D_c} \right) \quad (5)$$

where D_c = Average optical density of the total radiographic image and D_n = Optical density at different positions of the radiographic image.

We have measured the optical density, of the neutron radiographic images of the sample by a digital densitometer (Model – 07 -424, S - 23285 Victorian Inc., USA). Densitometric data of optical density of the radiographic image of the sample is shown in Table below.

Result and Discussion

Table - 1 Optimum irradiation/exposure time of the objects

Samples	Irradiation time (minute)	Optimum irradiation time (minute)
Terrazzo construction material	60	45
	50	
	40	
	45	
Engraved construction material	60	45
	50	
	40	
	45	

Neutron Radiographic images of Terrazzo and Engraved construction materials are shown below:



Fig. 1a : Neutron Radiographic Image of Terrazzo

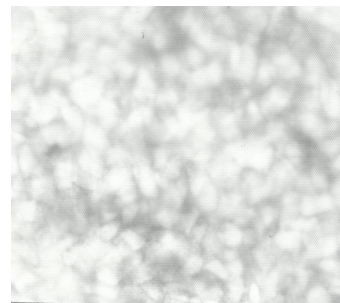


Fig. 1b : Neutron Radiographic Image Of Engraved

Table - 2 Densitometric data for Terrazzo and Engraved building materials.

Samples	Optical density at the centre	Average density (D_c)	Optical density at the different positions (D_n)	Fractional change in image density $\Delta D = (D_c - D_n) / D_c$
Terrazzo construction material	2.54	2.54	2.54	0.000
	2.54		2.54	0.000
	2.54		2.54	0.000
	2.54		2.55	0.004
	2.53		2.54	0.000
	2.53		2.54	0.000
	2.54		2.54	0.000
			2.55	0.004
			2.54	0.000
Engraved construction material	2.48	2.48	2.48	0.000
	2.48		2.50	0.008
	2.48		2.47	0.004
	2.48		2.52	0.016
	2.48		2.49	0.004
	2.48		2.44	0.016
	2.47		2.50	0.008
			2.44	0.016

Conclusion

We have seen that, the mixture of the constituent elements of the sample of Terrazzo construction materials was uniform. Because the radiographs we have found, are approximately clear. In the case of Engraved construction materials the sample was not perfectly homogeneous as the radiograph has been found, not clear and cannot be said uniform at all.

Acknowledgement

The authors would like to thank Bangladesh Atomic Energy Commission and Scientists of the Institute of Nuclear Science and Technology, AERE, Savar, Dhaka and the Bangladesh Research Reactor administration for allowing the reactor facility and other laboratory facilities for the research work. The authors also like to acknowledge Shahjalal University authority for funding the research project.

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A GIS BASED STUDY ON URBAN RAINWATER HARVESTING OPTION USING ROOF CATCHMENT

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Depletion of groundwater of the last few decades has led to a serious problem of scarcity of drinking water in Dhaka. In the urban areas, specially in Dhaka city application of standard technologies for extracting and delivering drinking water have become difficult and expensive. In this situation, the development of alternative sources of drinking water has become important. Rainwater harvesting is one of the alternative technologies for delivering drinking water. The primary objective of the study is to investigate possibility of using rainwater as an alternative source in Dhanmondi, one of the most densely populated thana in Dhaka. The roof top area has been considered as catchment area in the study zone and rainfall data from 2004 to 2009 has been considered for rainwater harvesting possibility. GIS has been used to extract effective catchment area in the study area. The amount of rainwater obtainable is calculated by rational method and compared with water demand in Dhanmondi in 2010 for analyzing feasibility. Since rainwater in Dhaka is predominant in Monsoon Rainwater Harvesting has been found to be more effective in this period. Due to the unavailability of rainwater from November to April Rainwater harvesting does not seem feasible in this time of year. The % of water available through rainwater harvesting is little compared to the demand. However, considering cost and water quality, rainwater may be used as a supplementary source to minimize ever increasing pressure on groundwater. Rainwater harvesting may also have positive impact on water logging which is common in Dhanmondi during Monsoon. Considering all the aspects, this paper suggests introduction of rainwater harvesting as an alternate water source in the city.

Key words: Rainwater Harvesting, GIS, Dhaka, water supply, rational method

1. INTRODUCTION

Fresh water, a renewable but limited resource, is scarce in many areas of the developing world because of unplanned withdrawal of waters from rivers and underground aquifers causing severe environmental problems like arsenic contamination (Rahman et al. 2003). In many countries, the amount of water being consumed has exceeded the annual amount of renewal creating an unsustainable situation (Choudhury & Vasudevan, 2003). In addition to that, rainwater run-off during rainfall from roofs and other paved and impermeable surfaces during heavy rain are leading to accumulated flooding in the urban areas of many countries like Bangladesh where the drainage system was not designed including the volume of rainwater runoff. In the early days of civilization, rainwater harvesting, the system of collecting and using the precipitation from a catchment area is

considered as an alternative option for water supply in Bangladesh (Yusuf, 1999). Unless it comes into contact with a surface or collection system, the quality of rainwater meets Environmental Protection Agency standards (Choudhury & Vasudevan, 2003) and the independent characteristic of its harvesting system has made it suitable for scattered settlement and individual operation (Rahman & Yusuf, 2000).

2. BACKGROUND STUDY

2.1 Historical Background

Rainwater harvesting (RWH) is a common practice in the countries and areas where the annual precipitation is high and pure drinking and usable water is scarce. All over the world, economical condition has prompted the low-income groups to

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harvest the rainwater for household and essential uses. Several countries of the world in different regions have showed the popularity of this method. Originated almost 5000 years ago in Iraq, rainwater harvesting is practiced throughout the Middle East, the Indian subcontinent, in Mexico, Africa as well as in Australia and United States. As the population of the world increased, irrigation, the most water consuming human activity, as well as domestic water usage increased, leading to a consequence of crisis of water supply in different region. Among other available alternative sources for water supply, rainwater harvesting has become the most economic solution for the water crisis (Boers and Ben-Asher,1982).

2.2 RWH: context of urban Dhaka city

The present water supply system of Dhaka almost entirely depends on groundwater. But exploitation of groundwater has its limit and depends on how much water is replenished during the monsoon of every year. At present, DWASA is operating 520 deep tube wells and four water treatment plants on the bank of surrounding Rivers. The contribution of four treatment plants in total water supply is insignificant and most of the water supply comes from exploitation of groundwater. The excessive groundwater extraction has led to lowering of water table. Figure 1 shows change of groundwater table over time.

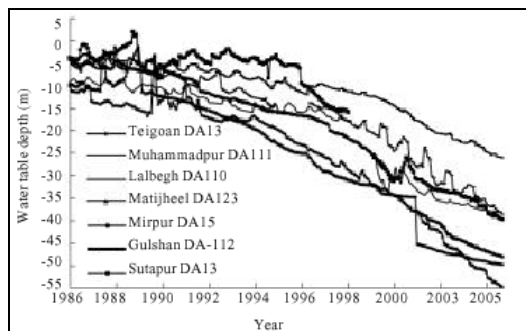


Fig1: Groundwater hydrograph of seven observation wells of Dhaka city from 1986 to 2005

With the ever increasing water demand, urban authority has long been looking for increasing supply of water to the consumers. With respect to the physical alternatives to fulfill sustainable management of freshwater, there are two solutions: finding alternate or additional water resources using conventional centralized approaches; or better utilizing the limited amount of water resources available in a more efficient way. To date in Bangladesh, much attention has been given to the first option and only limited attention has been given to optimizing water management systems.

Among the various alternative technologies to augment freshwater resources, rainwater harvesting (RWH) and utilization is a decentralized, environmentally sound solution, which can avoid many environmental problems often caused in conventional large-scale projects using centralized approaches. Rainwater harvesting, in its broadest sense, is a technology used for collecting and storing rainwater for human use from rooftops, land surfaces or rock catchments using simple techniques such as jars and pots as well as engineered techniques. Harvesting rainwater on the rooftop can be a possible alternative solution to acute water crisis in Dhaka city.

3. METHODOLOGY

3.1 Study Area

Dhanmondi has been chosen as the study area (Fig-2) as it is one of the most crowded and planned areas in Dhaka city. Its origins can be traced back to the late 1950s. Dhanmondi began as an affluent residential area, and over the decades it has evolved into a miniature city, where one can find everything from hospitals to malls, schools, banks, offices and universities. Water supply in Dhanmondi is facilitated entirely with ground water based pump system. In the peak demand hours Dhanmondi suffers from deficiency of supply water which can be pacified by adopting suitable rainwater harvesting technique. Cluster distribution pattern of buildings has been found in the study area

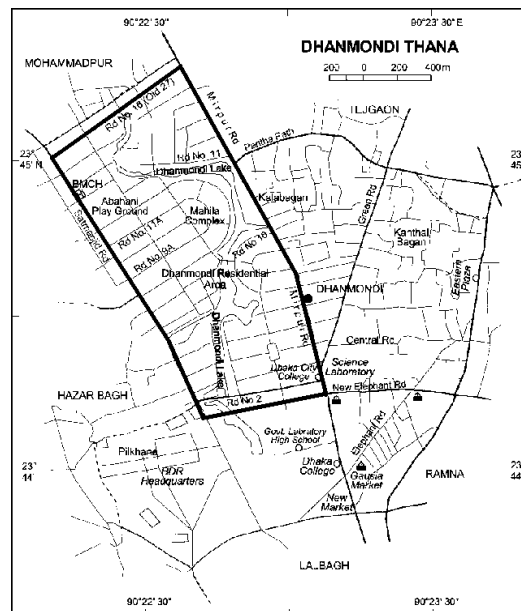


Fig 2: Study area for rainwater harvesting analysis

3.2 Estimation of Rainwater Harvesting

3.2.1 Runoff Coefficient

Rational Method has been adopted to calculate amount of water harvestable by utilizing roof top area. The runoff coefficient depends on the rooftop material. General values are tabulated in table 1, which may be utilized for assessing the runoff availability (Pacey & Cullis, 1989). A runoff coefficient value of 0.65 has been used.

Table 1: Runoff Coefficient for different catchment

Type of catchment		Runoff coefficient
Roof Catchments	• Tiles	0.8-0.9
	• Corrugated Metal Sheets	0.7-0.9
Ground surface coverings	• Concrete	0.6 - 0.8
	• Brick Pavement	0.5 – 0.6
Untreated ground catchments	• Rocky natural catchments	0.2 – 0.5
	• Green area	0.05 - 0.10

3.2.2 Rainfall Intensity

Rainfall data from 2004 to 2009 has been used for calculating rainfall intensity. Rainfall data used in this paper is collected from secondary sources like Bangladesh Meterological Department & Bangladesh Water Development Board.

3.2.3 Catchment Area

Catchment area has been calculated using GIS for the specified zone. ArcGIS 9.2 has been used for this purpose. Roof top area has been extracted from the foor top map of the study area. For simplification, roof top characteristics has been considered same for the whole area. 30 percent area of the roof top is assumed to be used for rainwater harvesting.

3.2.4 Water Demand

Estimated population data of 2010 has been taken from Dhaka Water Supply Project (Carl Bro, 2007). For demand calculation, water demand is taken as 220 lpd following DWASA design approach. Population density and concentration of demand are assumed to be uniformly distributed. For the rainwater available from 2004 to 2009, demand supplimented by rainwater available has been investigated.

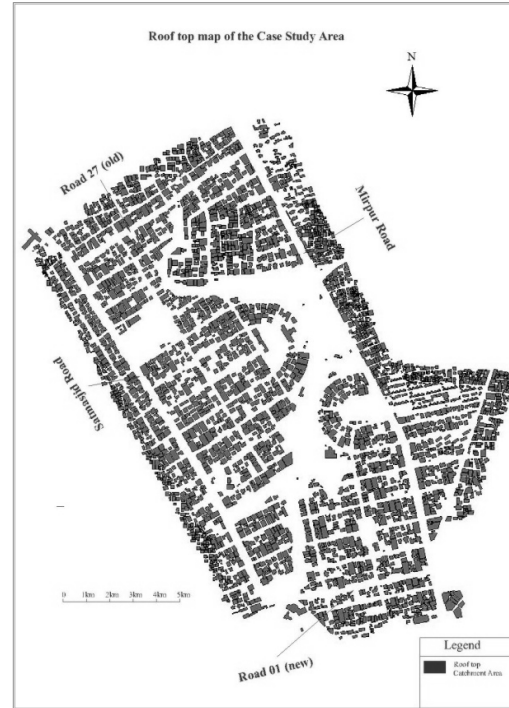


Fig 2: Roof top Catchment area in Dhanmondi

4. ILLUSTRATIONS

4.1 Availability of Rainfall

Rainfall in Bangladesh is predominant in monsoon. Average normal rainfall is recorded higher from May to September. Rainwater harvesting is, therefore, found to be more feasible during monsoon season. Figure 3 shows average normal rainfall in Dhaka.

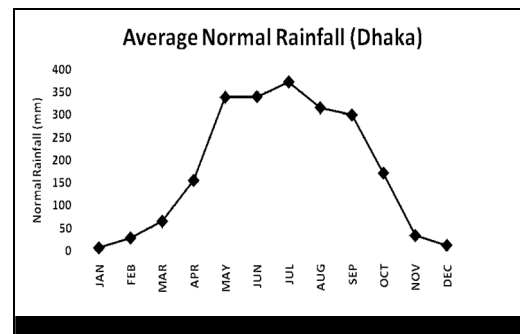


Fig 3: Average Normal Rainfall in Dhaka.

Figure 4 shows net rainfall harvestable in months, which is compared with water demand for 2009. The water available through rainwater harvesting has been found to supplement 2.8% in September where as rainwater harvesting from October to April seems difficult due to lower rainfall.

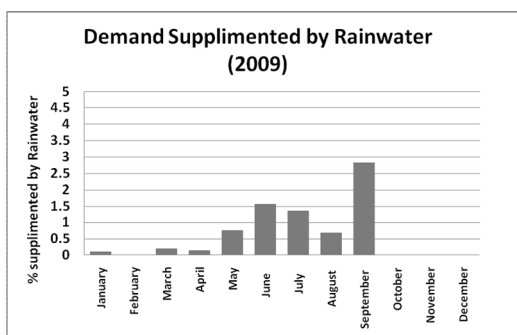


Figure 4: Demand supplimented by Rainwater

4.2 Rainwater available in Monsoon

Table 2 shows net harvestable rainfall in monsoon, which is compared with water demand for the time period from 2004 to 2008.

Table 2:supplimentary water available byRWH

Month	Net Rainfall Harvestable (lpd)	Supplementary water (%)
June,2004	928023.642	2.02437398
July,2004	556587.7766	1.214130505
August,2004	360367.0011	0.786098056
September,2004	1635739.151	3.568171785
Monsoon,2004	863430.1794	1.88347097
June,2005	504954.0405	1.101497607
July,2005	1022612.118	2.230707571
August,2005	681112.4995	1.485766482
September,2005	1002109.563	2.185983668
Monsoon,2005	803503.0431	1.752746999
June,2006	635579.217	1.386441003
July,2006	624510.3527	1.362295583
August,2006	315085.2837	0.687321337
September,2006	1292604.359	2.819663759
Monsoon,2006	712893.2131	1.555092356
June,2007	1224367.326	2.670812731
July,2007	1420713.884	3.099119559
August,2007	952802.804	2.078426796
September,2007	348983.6805	0.761266686
Monsoon,2007	989996.2912	2.159559996
June,2008	1124936.222	2.453915518
July,2008	1062233.621	2.3171372
August,2008	601869.494	1.312907224
September,2008	543946.6305	1.186555337
Monsoon,2008	833226.9027	1.817586089

The water available through rainwater harvesting has been found to supplement around 2% of water demand in the study area. Figure 5 shows contribution of rainwater harvesting as a supplementary water source compared to water demand in the study area.

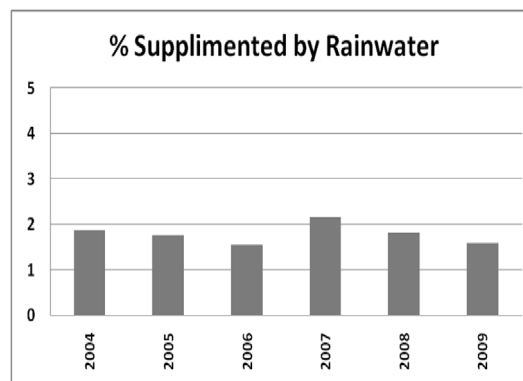


Figure 5: Contribution of Rainwater Harvesting as a Supplementary Water Source

The contribution of rainwater useable is not enormous compared to ever increasing water demand. But, since water available in this manner is less costly compared to ground water supplied, rainwater harvesting should be treated as a potential water source. The usual use of rainwater in household activities as practiced globally is mostly for flushing, cloth washing and car washing. Water used in this purposes require minimum water treatment which avails the minimum running cost of rainwater harvesting practice. The possible positive affect of RWH on water clogging problem, which is severe during monsoon should also be taken in consideration.

4.3 Rainwater Chemistry

Rainwater is the purest form of water in the nature, but only problem is the possibilities of bacteriological contamination during collection and use; if not done in a hygienic way. Several studies have been undertaken by researchers on rainwater chemistry for obtaining potable water. Considering the cost, availability and effectiveness, chlorination seems to be the most appropriate one to use for this purpose (Sultana, 2007). Contamination with bird droppings or solid particles is common in rainwater harvesting and constitutes the major water quality concern unless the roof catchment area and other system components are kept clean before each rainfall event (Al Muyeed, 2004). However analysis of rainwater collected in urban Dhaka must be undertaken for understanding complete scenario.

7. CONCLUSIONS

Rainwater harvesting can effectively be utilized as a supplementary source for water supply in Dhaka during monsoon. For sustainable urban growth and replenishment of groundwater RWH can be a very significant tool. Considering the cluster distribution pattern of housing in Dhaka, community based rainwater harvesting can be more effective and needs further study. The rainwater chemistry of Dhaka should also be analyzed to decide appropriate treatment technique.

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A LOW COST TEMPERATURE CONTROL UNIT FOR WASTEWATER RESPIROMETER

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A device for maintaining constant temperature in the reaction and control flask of wastewater respirometer is described. It consists of a water bath having a temperature control over 18⁰C to 32⁰C and a reverse mode peristaltic pump operated at the capacity of 100 ml per min. The water bath is incorporated with an automatic aquarium water heater. A thermometer is provided to monitor the temperature profile. The peristaltic pump can reverse the fluid circulation between the respirometer and water bath. The pump head devised with a replaceable silicon tube of 8 mm dia which is operated by a 9V DC motor.

Keywords: Water bath; Peristaltic pump; Reverse mode; Low cost; Respirometer

1. INTRODUCTION

Temperature control unit is a device or a vessel for regulating the temperature of any experimental vessel subjected to heat, by surrounding it with another larger tank containing water which can be kept at a desired temperature. It is extensively used in different types of laboratory experiments related to Chemical Engineering, Environmental Engineering, Biochemistry, Microbiology etc. A number of commercial temperature control units are available in the market [1]. But the facilities are offered to a certain extent. The BIOSCAN temperature control unit is a specially designed device in accordance with the requirement of BIOSCAN respirometer for the study of biodegradation process of wastewater and biosolids [2].

2. DESCRIPTION

Fig. 1 shows the major components of the temperature control unit which mainly consists of 1) a water bath with an automatic aquarium heater and 2) a reverse mode peristaltic pump.

2.1 Water bath unit

The main tank is made of 20 gauge metal sheet which is insulated with Styrofoam. One wooden platform is provided to hold the device on it. A normal thermometer is incorporated for monitoring temperature profile during the experiment. A fully

submersible automatic aquarium heater is placed inside the water tank. The typical components as well as the technical specifications are provided in the table 1.

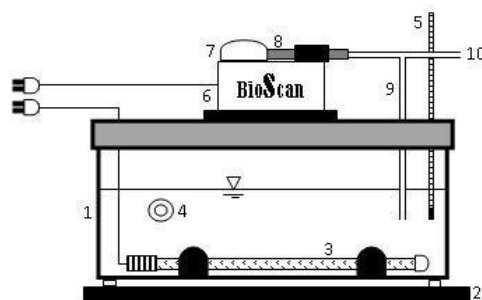


Fig. 1: BIOSCAN Water Bath (1.Water tank with lid, 2.Platform, 3.Automatic aquarium heater, 4.Outlet Pipe, 5.Thermometer, 6.Peristaltic pump, 7.Pump head, 8.Silicon tube, 9. Pump Inlet pipe and 10.Pump outlet pipe).

2.2 Peristaltic pump unit

The Bioscan peristaltic pump can alter the water flow from water tank to experimental reactor of the attached respirometer. Fig. 2 shows the pump head assembly with silicon tube. A DPDT (Double Pole, Double Throw) switch wired up as reverse circuit for the operation of the motor is shown in fig. 3.

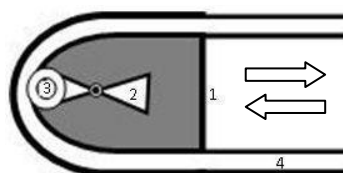


Fig. 2: Peristaltic Pump Head (1.Head chamber, 2.Shaft, 3.Roller, 4.Silicon tube).

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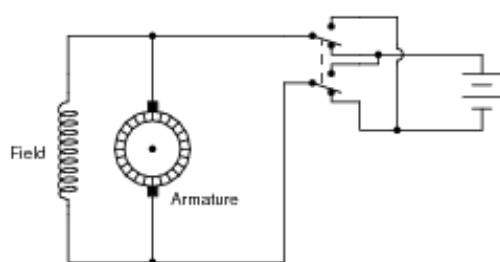


Fig. 3: Circuit Diagram of a Reverse Mode DC Motor.

Table 1: Technical Specifications

N o.	Item		Description
(1) Water bath unit	1. Water tank	Dimensions	360 x 190 x 270 mm
		Weight	3.5 kg
		Thermal insulator	Styrofoam of 10 mm thickness
		Capacity	9 liter
	2. Automatic aquarium heater	Brand Name	Weipro
		Model no	HA-200w
		Type	Submersible
		Watt	200 w
		Volt	AC 230V/50Hz
		Materials	Borosilicate glass
		Length	21 cm
		Temperature range	18-32°C ±1°C
3. Platform	Dimensions	Wooden frame (350 x 200 x 35 mm)	
(2) Peristaltic pump unit	1. Single head reverse mode peristaltic pump	Dimensions	130 x 100 x 110 mm
		Weight	1 kg
		Pump head	single roller mounted on an eccentric portion of a drive shaft
		Motor type	DC 9 volt Motor (input voltage 220-240 V AC)
		Discharge rate	100 ml/min
	2. Silicon Tube	Tube size	Inner dia 6mm outer dia- 8mm
		Tube matter	Silicone
	3. Inlet/outlet pipe	Pipe size	Inner dia- 6mm Outer dia- 8mm
Pipe matter		Plastic	

3. PERFORMANCE TEST

3.1 Water bath unit

Any small change of temperature in the reactor may greatly influence the biodegradation kinetics of wastewater microbes [3]. Therefore, it is utmost important to maintain the surrounding temperature of the reactor constant during the experiment. In this regard, peristaltic pump plays a significant role to ensure quick thermal diffusion of water by reversing the flow time to time between the tank and respirometer. Fig. 4 represents the prolong temperature profile against time interval. It is quite apparent that the water bath can maintain constant thermal environment over a desire period of time.

However a temperature lag of 2.5⁰C is observed in the reactor vessel which can be minimized by setting the heater temperature value at 2.5⁰C higher than the target temperature.

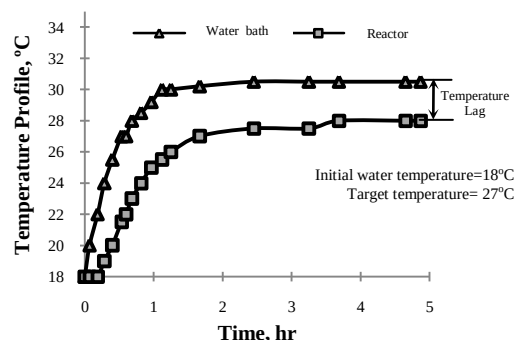


Fig. 4: Performance Test Curve for the **Bioscan** Water Bath.

3.2 Peristaltic pump unit

Fig. 5 shows the discharge capacity of the peristaltic pump in both clockwise and anticlockwise rotation. It is quite clear from the result that the discharge trend is almost typical in both the condition which ensures good reversing operation of the pump.

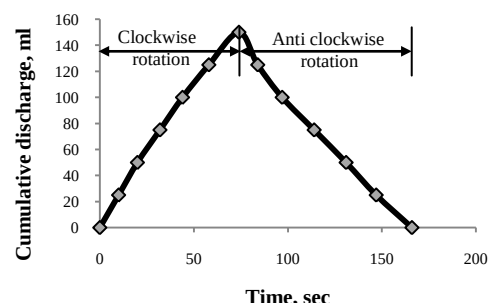


Fig. 5: Performance Test Curve for the **Bioscan** Peristaltic Pump

4. CONCLUSION

The study revealed that the low cost temperature control unit facilitated with the reverse mode peristaltic pump can be successfully used to maintain constant thermal background for the biodegradation kinetics study of wastewater using the **Bioscan** respirometers which were locally fabricated at SUST.

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AN OBSERVATION ON THE ACOUSTICAL ENVIRONMENTS OF AUDITORIUMS IN DHAKA

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This paper reports the findings of a study of existing acoustical condition of several auditoriums in Dhaka aimed at an understanding of their sonic environments. Good acoustical design is a pre-requisite for a hearty musical performance, which is badly ignored in the cases of auditoriums in Bangladesh. Ignorance about acoustics and also lack of expertise are responsible for this. Acoustic measurements have been carried out in four auditoriums in Dhaka, and the study was focused on the evaluation of musical performance there. These halls with capacity ranging from about 600 to 800 people are all frequented by major musical concerts and dramas. Measurements of Reverberation Time (RT) were done and feedbacks are taken from the performers and audience about the existing conditions prevailing in the widely known auditoriums.

The major objective of the study is to know about the existing acoustical condition of these auditoriums and compare their conditions. The analysis of data was focused on finding possible relationships between objective and subjective parameters of the acoustics of these halls. This may act as a basis for further study in this specific field for designing better acoustical environment in these auditoriums.

Key words: Acoustics, musical performance, Reverberation Time (RT), auditoriums, subjective parameters

1. INTRODUCTION

Among audience and performers alike it is a well known fact that to a large degree bad acoustics can ruin the joy of a musical performance. As a matter of fact both performers and audience sometimes choose not to go to a venue because of unsatisfactory acoustical conditions. Considerations for acoustics are seldom taken in Bangladesh while designing of auditoriums. Architects are more conscious about the form and massing of the auditoriums and as such most often ignore the requirements of good acoustical design for better functioning of auditoriums as places where musical concerts are held.

Knowledge about acoustics is a must for designing a well performing auditorium. The acoustics must be considered during the design phase which makes the installation of different acoustical materials easy and can be adjusted with the aesthetics and functions of the halls. In the auditoriums where acoustics not considered in the design phase may need expertise in acoustics for better functioning based on the existing conditions. This paper aims to explore the existing acoustical condition of several auditoriums in Dhaka city and create a basis for further study in the specific field.

2. OBJECTIVES

This study seeks to have a clear idea about the present acoustical condition of the places for musical performance in Bangladesh. This paper is outlined to reach the specific objectives i.e.

- a. To take the measurements of the objective parameters (RT) of the auditoriums.
- b. To know about the subjective parameters (intimacy, clarity etc).
- c. To find possible relationships between objective and subjective parameters of the acoustics of these halls.
- d. To compare the existing conditions of the halls which may act as a base for the up gradation of poorly performed halls.

This study is more concentrated on the evaluation of the halls in terms of overall musical performance and the survey was limited in four auditoriums in Dhaka city (Khan: 2010).

3. RESEARCH METHODS

The Case studies depend on direct observations, acoustical measurements, sketches and photographs and questionnaire survey of musicians and audiences which are used to trace the present status

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of the halls. The literature reviews served the purpose of making the knowledge base about the criteria of a good room for music. The auditoriums surveyed were selected from the standpoints of

- a) They should be widely known as venues for programs
- b) The capacity of audience ranges from 600 to 800.

It must be emphasized that the regular subscribers to performances in all of these houses spoke favorably for their acoustics.

4. OBJECTIVE & SUBJECTIVE ATTRIBUTES OF A ROOM FOR MUSIC

4.1 Objective acoustical attributes of a room for music

The objective acoustical attributes of a room for music in db are RT (Reverberation Time), EDT (Early Decay Time), ITDG (Initial Time Delay Gap), strength factor G (average sound pressure level for 500 hz and 1000 hz bands) etc. only RT is calculated in this particular study which objectively describes the echoic quality of the room. It is the time that takes for a sound level in a room to be reduced by 60 decibels after turning off the sound source. It is vital in establishing quality of music (long RT) and speech intelligibility (short RT). It is different for different music types and speech. Reverberation Time is calculated using Sabine Formula :

$$RT = .05 V/A \text{ (FPS)}$$

Or, $RT = .161 V/A \text{ (MKS)}$ where V= Volume of Space and A= total Absorption

Music requires high RT than speech, a reasonable degree of blurring and overlapping in musical sounds is often considered acceptable and even desirable. For various styles of music it is found that (Hong Kong Academy for Performing Arts: 1986),

Table 1. Different RT for different type of music

RT in sec	Type of Music
1.0	Baroque Music
1.5	Classical and Modern Music
2.0	Romantic Music

4.2 Subjective acoustical attributes of a room for music

Leo Leroy Beranek subjectively analyzed 54 concert halls and devised a set of 18 design

attributes incorporating the subjective qualities and the physical attributes of the auditorium. The attributes are (Beranek: 1996) :

1. Intimacy (presence, familiarity, closeness, relationship)
2. Liveness (fullness of Tone or how long a sound is heard, Reverberation)
3. Warmth (affection, hospitality, long lower frequency RT)
4. Loudness of the direct sound
5. Loudness of the reverberant sound
6. Definition, clarity- how well an individual sound can be heard within a performance
 - a) Horizontal Definition- how distinguishable sounds following each other are
 - b) Vertical Definition- how distinguishable sounds that occur at the same time (chords) are from other sounds
7. Brilliance (vividness)
8. Diffusion (spreading, dissemination)
9. Balance (symmetry, equilibrium)
10. Blend (mix, merge)
11. Ensemble (as a whole, as a group)
12. Response, Attack
13. Texture (feel, grain)
14. No echo
15. Quiet (soft)
16. Dynamic Range (vibrant)
17. No distortion
18. Uniformity (homogeny)

If the music gives the impression of being performed in a small intimate hall, the auditorium is said to have '*acoustical intimacy*'. When an auditorium has a large volume relative to the audience capacity, with predominant sound reflective enclosures, it is said to be '*live*'. A live hall has a relatively long reverberation time, giving a long sustaining tone. When the hall has a relatively long RT at lower frequencies, it has the acoustical quality of '*warmth*'. If the RT is adequately controlled, a pleasant '*fullness of tone*' is noticeable. If the sounds of different musical instruments are easily distinguishable and if the sounds within a rapid passage are heard separately, the room is said to possess '*definition*' or '*clarity*'. If the reflected sound waves approaching the listener from every direction are equal in amount, the result is '*diffusion*'. There are some other important qualities like balance, blend, ensemble etc. freedom from noise that is the reduction of exterior and interior noise to inaudibility is one of the most important characteristic of a place for music.

5. OBSERVATIONS AND FINDINGS

The four auditoriums surveyed for this research are-

1. BUET Auditorium
2. National Museum Auditorium
3. Bangladesh Shishu Academy Auditorium
4. Main Auditorium of Jatiyo Natyoshala

5.1 Objective acoustical attributes of the surveyed auditoriums

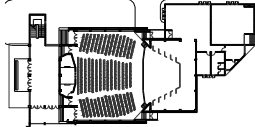


Fig. 1: plan of BUET Auditorium



Fig. 2: section of BUET Auditorium



Fig. 3: view of the stage of BUET Auditorium



Fig. 4: View of Auditorium from stage

Table 2: Calculation of RT of BUET Auditorium (from field survey conducted by author in 2010)

Calculation of absorption of materials					
Wall surface	Area/Volume/Number	Surface treatment	Designed Surface Area	Absorption Co-efficient	Absorption by surfaces sft.sabins
North wall	1620 sft	Wooden door	308	0.15	46.2
		Brick with plaster	1312	0.02	26.24
Balcony railing	180 sft	Brick with plaster	180	0.02	3.6
South side	1890 sft	wood	625	0.15	93.75
		Proscenium opening	1265		0
East wall	2676sft	1/2 wood	1488	0.15	223.2
		1/2 drapery	1488	0.49	729.12
West wall	2676sft	1/2 wood	1488	0.15	223.2
		1/2 drapery	1488	0.49	729.12
Ceiling	5616 sft	Plywood	5616	0.17	954.72
Floor Main	5616 sft	Net cement finish	5616	0.02	112.32
Floor Mezzanine	1770 sft	Net cement finish	1770	0.02	35.4
Audience in upholstered seats	700 nos		700	0.4	280
Air	199290 cft		199290	0.003	597.87
A, Designed total absorption					4054.74
V, volume in cft					199290
Therefore, RT					2.4574941

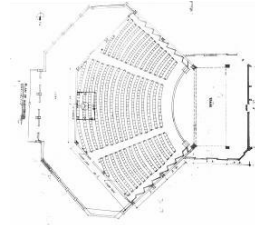


Fig. 5: plan of National Museum Auditorium

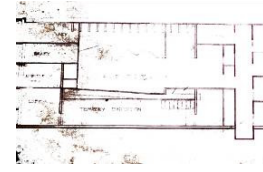


Fig. 6: Section through National Museum Auditorium



Fig. 7: view of the stage of BUET Auditorium



Fig. 8: View of Auditorium from stage

Table 3: Calculation of RT of Main Auditorium, Bangladesh National Museum (from field survey conducted by author in 2010)

Calculation of absorption of materials					
Wall surface	Area/Volume/Number	Surface treatment	Designed Surface Area	Absorption Co-efficient	Absorption by surfaces sft.sabins
South wall	1425 sft	Brick	1248	0.02	24.96
North side	1425 sft	Brick	1248	0.02	24.96
East wall	3168 sft	Wood on coir foam	3084	0.7	2158.8
		Wooden doors	4	0.15	12.6
West wall	1195 sft	Proscenium opening	855		0
		wood	40	0.15	51
Ceiling	4284 sft	wood	4284	0.15	642.6
Floor	4284 sft	Net cement finish	3940	0.05	197
		Carpeted	344	0.5	172
Audience in upholstered seats	725 nos		725	0.4	290
Air	111384 cft		111384	0.003	334.152
A, Designed total absorption					3908.072
V, volume in cft					111384
Therefore, RT					1.42505051

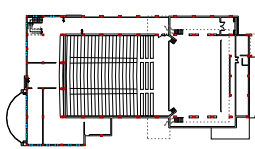


Fig. 9: plan of Bangladesh Shishu Academy Auditorium



Fig. 10: View from stage

Table 4: Calculation of RT of Main Auditorium, Bangladesh Shishu Academy (from field survey conducted by author in 2010)

Calculation of absorption of materials					
Wall surface	Area/Volume/Number	Surface treatment	Designed Surface Area	Absorption Co-efficient	Absorption by surfaces sft.sabins
South wall	1425 sft	Absorptive surface	1197	0.7	837.9
North side	2280 sft	Proscenium opening	1295		0
		Wood	598.5	0.15	89.775
		plaster	390	0.02	7.8
East wall	2920 sft	¼ reflective	730	0.02	14.6
		¾ absorptive	2190	0.7	1533
West wall	2920 sft	¼ reflective	730	0.02	14.6
		¾ absorptive	2190	0.7	1533
Ceiling	4360 sft	Plywood	4360	0.17	741.2
Floor	4360 sft	Net cement finish	4360	0.02	87.2
Audience in upholstered seats	650 nos		650	0.4	260
Air	130800 cft		130800	0.003	392.4
A, Designed total absorption					5511.475
V, volume in cft					130800
Therefore, RT					1.186615198

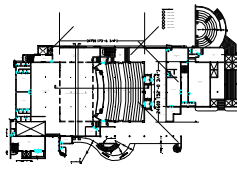


Fig. 11: First Floor Plan of Jatiyo Natyoshala

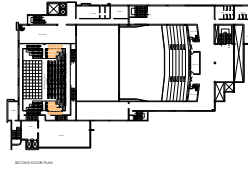


Fig. 12 2nd Floor Plan of Jatiyo Natyoshala



Fig. 13: Section of Jatiyo Natyoshala



Fig. 14: View of stage of Jatiyo Natyoshala

Table 5: Calculation of RT of Main Auditorium, Jatiyo Natyoshala (from field survey conducted by author in 2010)

Calculation of absorption of materials					
Wall surface	Area/Volume/Number	Surface treatment	Designed Surface Area	Absorption Co-efficient	Absorption by surfaces sft.sabins
North wall 79x22-2(4.9x8.8)	1652 sft	Absorptive surface	1652	0.7	1156.4
Balcony railing 79x2.5	198 sft	Wood paneling	198	0.15	29.7
South side 79x40	3160 sft	Proscenium opening	1280		0
		Reflective surface	1880	0.02	37.6
East wall	2165 sft	¼ reflective	541.25	0.02	10.825
69x32-1(4.9x8.8)		¾ absorptive	1623.75	0.7	1136.625
West wall	2165 sft	¼ reflective	541.25	0.02	10.825
69x32-1(4.9x8.8)		¾ absorptive	1623.75	0.7	1136.625
Ceiling 69x79	5451 sft	¼ wood paneling	1362.75	0.15	204.4125
		¾ reflective	4088.25	0.01	40.8825
Soffit 23x79	1817 sft	15% reflective	272.55	0.02	5.451
		85% absorptive	1544.45	0.7	1081.115
Floor main 69x79	5451 sft	¼ carpeted	1362.75	0.5	681.375
Floor balcony 79x23	1817 sft	¼ carpeted	454.25	0.5	227.125
Audience in upholstered seats	750 nos		750	0.4	300
Air	174432 cft		174432	0.003	523.296
A, Designed total absorption					6582.257
V, volume in cft					174432
Therefore, RT					1.32501663

It is seen from the graph (Figure 15) that the RT of BUET auditorium is highest and 2.45 sec and the RT of Shishu Academy Auditorium is the lowest and 1.18.

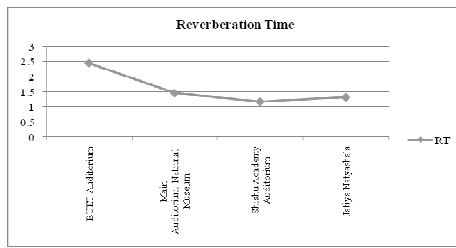


Fig.15 Reverberation Time of different auditoriums

5.2 Subjective acoustical attributes of the surveyed auditoriums

10 performers and 10 listeners for each auditorium are surveyed. They were asked for the ratings of acoustics of the auditoriums that they know well. They evaluated different criteria of the acoustic of a hall for music such as intimacy, spaciousness etc and rated on a scale from poor to good conditions which are assigned the numbers 1 to 10. They were asked for the ratings of the overall impression about the auditoriums on scale that had five steps- very poor, poor, passable, good, very good which were assigned the numbers 1 to 5.

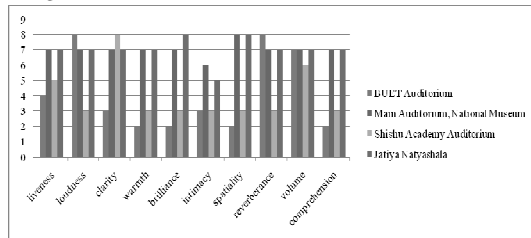


Fig.16 Subjective qualities of different auditoriums

A comparative evaluation of the subjective criteria of acoustic of auditoriums is seen in Figure 16. The National Theatre (Jatiya Natyashala) is the most live and the National Museum Auditorium is the most intimate one. The strength of sound is the most in BUET Auditorium but clarity is poor. Spatiality, reverberance, volume and comprehension are most in Jatiya Natyashala and National Museum Auditorium. Background sound is perceptible in BUET Auditorium and National Museum Auditorium is perceptible but uncomfortable in the rest two (Figure 17). The overall rating shows that Jatiya Natyashala and National Museum Auditorium are good, Shishu Academy is poor but BUET auditorium is very poor (Figure 18)

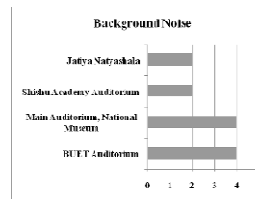


Fig.17 Background sound when the music is off

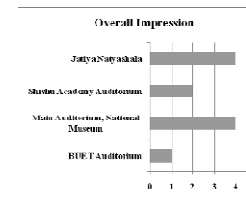


Fig.18 Overall impression rated by people for different auditoriums

5.3 Findings from the objective measurements and relation to the questionnaire

There is a parallel relationship of Reverberation time with liveness of a hall, the more the RT, the more live the hall is and vice versa. Again if it exceeds an acceptable level, the hall is no longer live. In BUET Auditorium, RT is more than 2 which makes the hall no longer live. Again we can see that, longer RT of it enhanced the loudness. The lower RT in the other 3 halls has impact on the comparatively weak sound there, but overall sound is strong in those auditoriums. The RT is less in the other 3 auditoriums and as such clarity is more there than BUET Auditorium.

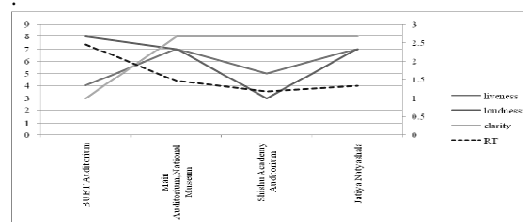


Fig.19 Correlation between objective and subjective parameters of auditorium acoustics

6. PROBLEM IDENTIFICATION & DISCUSSION

The overall acoustical environment in the National Theatre and National Museum Auditorium is good but poor in the other two. In case of BUET Auditorium, loudness is higher but the other parameters like intimacy, spatiality, clarity are lower. Loudness is the outcome of longer RT, but intimacy, spatiality depends on some other factors. But though in Shishu Academy Auditorium the RT is within acceptable range but the performance is poor, its due to other factors like EDT, ITDG. Due to poor performance, mechanical sound system is always used in BUET Auditorium and Shishu Academy Auditorium. With the use of external sound system the performance is better, but the

volume of the auditoriums are below 300000 cft which means that the acoustic design must perform well without any mechanical aid. The RT of BUET Auditorium must be reduced to below 1.5 sec either by the use of absorptive materials or reducing the volume. Again, in case of well performed auditorium it is seen that the background sound becomes uncomfortable which need to be controlled. The auditoriums must be acoustically treated by experts in acoustic design.

In our country awareness about acoustics is very rare among people. They are not bothered even by tremendous noise pollution by traffic or continuous loud music in speakers. People attending different musical concerts are also less concerned about the acoustics of the hall, so its also tough to get the true response from questionnaire survey from the people without acoustical knowledge. There is tremendous scope to improve upon the situation. Extensive research work is required to scientifically

- i) Establish the problem
- ii) Identify which groups(occupation/gender/age) are effected most and how
- iii) Ascertain the reasons behind the problems
- iv) Evolve low cost corrective measures (design, equipment, job description) (Ahmed: 2010)
- v) Discover the potentiality of local materials
- vi) Find out the required RT for different type of music of our country

From the above discussion it can be stated that for the design of musical auditoriums the following things need to be considered-

- Since no music hall is built for a specific type of music, RT must always be a compromise. But it must not exceed the acceptable range.
- Echo will be particularly noticeable if the RT is short and diffusion is inadequate. Longer RT of the room provides less trouble from echo.
- Many music (Bhaoaiya, Bhatiali, Rabindra Sangeet) of our country are lyric based i.e. the complete enjoyment depend on the understanding of every word, so intelligibility is an important acoustic criteria which must be considered.
- Particular attention is required to control noises and vibrations originating from the heating, ventilating and air conditioning systems and coming from external noise sources like traffic.
- Intimacy, clarity, spatiality, comprehension, definition, warmth, brilliance, loudness, liveness need to be achieved considering the other factors.
- Proper positioning of absorptive and reflective materials is important. Acoustic design does not mean to cover the surfaces with absorptive materials, reflective materials need to be used at proper locations to enhance the strength of sound.

- Acoustical design must merge with the overall architectural expression and for such it need to be considered during design phase.

7. CONCLUDING REMARKS

Acoustics is an important aspect that an architect has to encounter, knowingly or otherwise, to attain a building that is functionally effective. Generally very few architects or engineers in our country think of sound as a design element or an issue of concern at the design stage i.e. when they are drawing up the detail plans consulting with the building owner. It is commonly believed and wrongly so that with all other elements put into their respective slots, sound will be a natural and positive outcome. If an auditorium designed for music does not perform well, the main purpose of that space is not served though that can be a good architecture. It is the common case in most of the auditoriums in Dhaka. As to serve the function is the prime purpose of a good architecture, an auditorium must be acoustically sound. So the ill performed auditoriums must be treated properly by experts in the specific field. This study (performed within limited scope) works as a basis for further study and research in this specific field.

ACKNOWLEDGEMENT

The research work for this paper has been conducted in M. Arch Course ARCH 6102(Sonic Environment and Built Form) in Department of Architecture, Bangladesh University of Engineering & Technology, Dhaka, Bangladesh.

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BUILDING CONSTRUCTION WORKERS' QUALITY AND SAFETY: A CASE STUDY ON SYLHET CITY

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Sylhet is a densely populated city with approximately half million inhabitants living in an area of 26.5 sq.km where growth rate of population is high. Due to rapid urbanization process, a number of high rise buildings are constructing here. Since Sylhet city is vulnerable to earthquake, proper guideline and building codes should be followed for structurally sound construction. A huge number of people are involved with the building construction process. Most of the workers' are from poor level of the society and are illiterate. They have no institutional training and are not conscious about the safety during construction. As a result, accident at construction site has become a very common phenomenon of this city. This project is done by field visit report which is focused on ten high rise buildings at different locations in Sylhet city where various types of data were collected from field visit report, such as project areas, structural methods of those projects, number of workers, materials mixing ratios, construction safety measures, quality control of materials etc. the present condition of the construction workers' quality and their safety at the time of construction is evaluated here. Some other problems related to construction process are addressed in this study and some guideline is given as the solution of it.

Key words: construction worker, quality, Sylhet city, training, safety

1. INTRODUCTION

Work at construction sites is one of the most dangerous occupations in both developing and industrialized countries. According to the International Labor Organization (ILO), 337 million occupational accidents occur on the job annually, while the number of people dying of different work-related diseases is close to 2 million (1). According to the Building and Workers International (BWI) report, at least 108,000 workers are killed on the spot every year at construction sites. The report also states that construction sites account for 30 percent of all fatal injuries. This means that one person dies every five minutes due to poor and/or illegal working conditions (2). Construction is one of the important labor intensive industries in Bangladesh which plays a significant role in the domestic economy. It provides direct employment for 1.5 million people, which is equivalent to 3% of the total economically active working population (aged 15 years and above). This estimate comprises 1.4 million men and 104,000 women. Almost all of them are illiterate and don't have any educational

qualification on construction. As a result, sometimes, it becomes tough to control the soundness of the structure and maintain the cost. Injury and death of workers, due to ignorance of safety measures at the time of construction, is also a very common phenomenon in this country. Construction management is essential for achieving any pre-determined objective. It is, however, seen that in spite of construction management, majority of the project do not keep up their original time schedule and their completion cost is also higher as compared with the estimated cost. Quality control and safety represent increasingly important concerns for project managers.

2. STUDY AREA:

Sylhet is one of the rapidly growing metropolitan areas, located in the northeast region of Bangladesh and situated at 24.85° latitude and 91.80° longitudes. Sylhet was changed to a city corporation from a municipal board in 2001 and in 2002 the city was administrated by the Sylhet City Corporation (SCC) and finally was granted metropolitan city status in 31st March 2009(3). SCC occupies a total area of

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26.5 sq. km with a population of around 0.5 million. Population density is 17,479/km². For Sylhet historical background, fine climatic condition, most of the divisional head office, better quality of life, better job opportunities and for higher educational facilities; migration of population towards Sylhet city increases results elevated population density. Nowadays, a lots of high rise building is constructed in this reason. This study is performed to analyze the present condition of the management sector regarding construction workers' quality and their safety.

3. METHODOLOGY:

This project is done by field visit report. Ten high rises building at different location in Sylhet city were focused for the study. All types of data were collected from field visit report and questionnaire survey related on project area, structural method, number of workers, educational qualification of workers, materials mixing ratios, construction safety measures, quality control of materials etc. A questionnaire consisting of 13 questions which are directly related to the safety of the workers has been carried out. Finally, by analyzing the collected data and considering some other parameters related to the

surveyed area, some recommendations has been given which can be followed for ensuring better quality and safety of workers'.

4. DATA COLLECTION AND ANALYSIS

Construction workers' safety is widely related to the construction method, construction site, construction materials and equipments etc. workers' qualification and awareness about safety is also a matter of it. It is seen that the educated and qualified workers are more conscious about their safety then the less qualified workers. The structural data were collected from the constructors, site engineers and construction firms. The questionnaire survey was carried out over more than 110 construction workers who were involved with the construction work of the ten buildings. Table: 1 is showing the structural data of the ten buildings that has been surveyed. Table: 2 is representation the present workers' safety condition of that construction site. Educational qualification and sex of the workers' also play a vital rule in the construction sector.

Table 1: Structural Data

Serial No.	Name of Project (Location)	Square area	Floor	Foundation Type	Laborer (Minimum)	Design Method	Construction Period(Year)
1	Sylcoo Tower (Jail Road)	4500	10	Pile	15-20	WSD	3
2	Karim Tower (Jail Road)	4000	10	Pile	30-35	WSD	2
3	Safic Tower (Bondor)	4500	10	Pile	25-30	WSD	2.5
4	Rong Mohal Tower (Bondor)	8000	10	Pile	30-35	WSD	2.5
5	Silver Star Tower (Subid bazar)	7650	12	Pile + semi Mat	30-35	USD	3
6	Indiana Height (Subid bazar)	4000	12	Raft	20-25	WSD	2.5
7	M. Ahamed Tower (Dorshondeuri)	12000	17	Mat	40-45	USD	4
8	W Tower (Naiorpul)	4000	10	Pile	20-25	WSD	2.5
9	Shajalal Tower (Mira bazar)	6000	12	Pile	30-35	WSD	2
10	Star Plaza (Zindabazar)	16000	17	Pile	45-50	WSD	4

Table 2: Safety related questionnaire survey

Question	Yes(percentage)	No(percentage)
Chance that a person may fall from any dangerous height?	100	0
Chance that a person may fall on the working level?	60	40
Is there any chance that a person may fall through hollow shafts, ducts or chutes?	30	70
Is there any chance that a person may be struck by any falling material?	100	0
Is there any chance that a person may be struck by moving vehicles or machineries?	10	90
Is there any chance that a person may be pierced by any sharp edge or any hard object?	70	30
Is there any chance that a person can get electric shock?	80	20
Is there anything that can cause fire related accidents?	50	50
Is there any chance of accidents from mechanical failure?	80	20
Are the workers well equipped with their personal safety devices against accidents?	10	90
Is there adequate facility of first aid treatment?	70	30
Are the workers willing to use safety devices?	65	35
Do the workers have any institutional training?	0	100

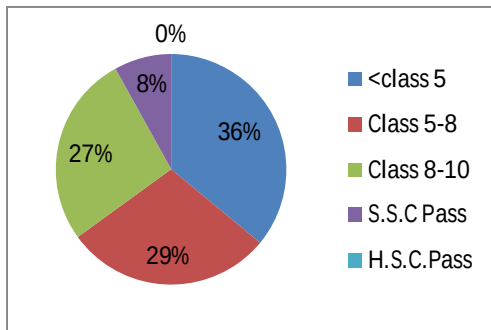


Figure1: Educational Qualification of workers'

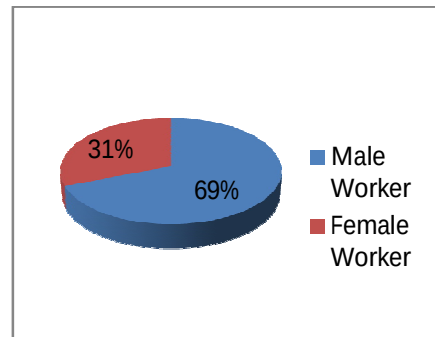


Figure1: Sex of workers'

5. RESULTS AND DISCUSSION:

From the data analysis, it is very clear that the construction workers' are working with a high risk of injury, even death. Almost in 70 percent cases, safety measures are not taken by the workers', even some of them are not willing to use the safety equipments. Use of hamlet, groves and safety goggles is almost zero. The Owner and supervisor are not also aware about the safety. As a result of it, workers' physical injury has become a very common phenomenon. Since the workers are not institutionally trained, the quality of the structures can't be ensured all the time. So sometimes the cost of construction is to be increased and the construction period is become higher.

6. CONCLUSION:

The construction sector in Bangladesh is widely known as a 'death trap' due to its poor health and safety record and the high rate of occupational accidents occurring in the country each year.(5) And the rate is increasing in every year. At Bangladeshi construction sites, ordinary workers normally do their job according to the instructions given by the contractors or subcontractors who employ them. As a result it may affect on the quality of the construction. Sylhet is a developing city where building construction is increasing day by day. So it is the high time to increase the quality of the workers' and safety measures of the workers'. Some recommendations which are the outcome of the study is given below that should be

followed to minimize/neutralize the amount of injury at the construction site

- regular inspection of safety situation should be ensured
- the records of all accidents should be to keep compulsorily
- The owner, contractor and workers should be aware about safety issues through awareness programme.
- formal institutional training on safety precautions to the workers and contractors is to be ensured

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CHLORIDE PENETRATION RESISTANCE OF FLY ASH CEMENT MORTAR

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ABSTRACT: Durability is an important issue for concrete in aggressive environment. Concrete structures are often deteriorated due to chloride and sulfate attack in marine environment. This paper investigates the performance of fly ash mortar regarding chloride penetration resistance and compressive strength development up to the curing period of 90 days. Cement was partially replaced with six percentages (10%, 20%, 30%, 40%, 50% and 60%) of Class F fly ash by weight. Ordinary Portland cement (OPC) mortar was also prepared as reference mortar. A total of 200 specimen of 50 mm cube were cast for compressive strength test and other 30 cylindrical specimen of size 100 mm diameter and 50 mm height to determine the chloride ion penetration resistance. Among the six fly ash mortars, the optimum amount of cement replacement is reported to about 40%, which provides around 16% higher compressive strength and also 51% higher chloride penetration resistance compared to OPC mortar. Fly ash mortar also shows better resistance against chloride ion penetration. The study reveals that fly ash may improve the durability characteristics of concrete in aggressive environment due to its high fineness, which after hydration markedly reduces the permeability of concrete that limits the penetration of aggressive species and also improve the strength characteristics.

Keywords: Cement; Chloride Penetration Resistance; Compressive Strength; Durability; Fly Ash.

1. INTRODUCTION

The seas and oceans make up of about 80% of the total surface of the earth. Apart from their use for navigation purposes, seas and their beds are being widely used as the space for both onshore and offshore structure throughout the world. The reinforced concrete structures constructed in marine environment have to face the sea salt loadings apart from the normal loading. In a marine environment, chloride ion penetrating into the concrete from sea water reacts with Ca(OH)_2 liberated from cement hydration and form calcium chloroaluminate (Friedels Salt). On the other hand, sulfate that penetrates inside concrete from seawater forms gypsum and a complex compound namely calcium sulphoaluminate (Ettringite). Both the products occupy a greater volume after crystallization in the pores of concrete than the compounds they replace. The formation of gypsum hydrate causes an increase in volume of 17.7% in concrete (Bougue, 1971). Thus, the durability of structural concrete has received increasing attention in modern concrete technology and pozzolanic cementitious materials are known for their beneficial effect on durability of concrete structures (Swamy, 2000). When used as a concrete additive, these materials react with calcium hydroxide liberated during the

hydration of cement to form additional cementitious compound, namely calcium silicate hydrate (CSH) and is more chemically resistant, mainly by virtue of its more refined microscopic pore structure (Roy et. al., 2001).

The resistance to chloride penetration of mortar and concrete is one of the most important issues concerning the durability of concrete structures. When the chloride concentration of mortar or concrete exceeds a certain threshold value, depassivation of steel occurs and reinforced steel starts to corrode (Alonso et. al., 2000). It is generally accepted that incorporation of a pozzolan improves the resistance to chloride penetration and reduces chloride-induced corrosion initiation period of steel reinforcement. This is mainly due to the reduction of permeability/diffusivity, particularly to chloride ion transportation properties of the blended cement concrete (Tomas et. al., 1999).

Most cement plants consume large amounts of energy and produce a number of undesirable products which provide negative impact to environment. Production of every tone of cement emits carbon dioxide to the tune of about 0.87 ton (Shetty, 2002) and around 7% of the world's carbon dioxide emission is attributable to Portland cement industry. Because of significant contribution to the environmental pollution and to the high

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consumption of natural resources like limestone etc., it would not be wise to produce more and more cement without thinking the proper substitute for it. Now a days, cement manufacturers are blending or intergrinding mineral additives such as fly ash, slag and natural pozzolana into the cement. The main objectives of using these materials are to reduce heat generation and the permeability characteristics, which lead to improve the durability properties of concrete (Detwiler et. al., 1991).

An industry by-product which is now being used quite extensively as pozzolan in blended cements is fly ash. The incorporation of fly ash enhances the performance of concrete by imparting proper resistance to chloride and sulfate induced deterioration after modifying the chemistry of pore characteristics of the hardened concrete (Zichao et. al., 2003). Fineness of fly ash is higher than ordinary Portland cement particles (Tarun et. al., 2006). As a result, it makes concrete more impermeable, which may greatly reduce penetration of chloride and sulfate ions, thereby increasing the durability of concrete (Oner et. al., 2003). Fly ash reacts with the product liberated at early ages during hydration and form secondary C-S-H gel which is less dense and has more volume than primary C-S-H gel. Therefore it fills all the pores inside concrete and makes the concrete more impermeable. The use of fly ash usually leads to a less permeable paste, denser interfacial zone between aggregate and the matrix (Chindaprasirt et. al., 2005). It has been shown that the use of fine fly ash results in better mechanical properties of concrete than those with the coarser fly ash. It increases strength, resistance to sulfate solution and resistance to chloride penetration of concrete (Chindaprasirt et. al., 2004). Fly ash, when used in mortar/concrete, contributes to the strength of mortar/concrete due to its pozzolanic reactivity. However, since the pozzolanic reaction proceeds slowly, the initial strength of fly ash concrete tends to be lower than that of concrete without fly ash (Aydin et al., 2007). Due to continued pozzolanic reactivity, such concrete develops strength at later age, which may exceed the strength of the concrete without fly ash.

The objective of this research is to study the strength and chloride ion penetration resistance of blended cement mortar containing fly ash. The results of the study will be beneficial for future applications of such material for increasing the durability of concrete in chloride based environment.

2. EXPERIMENTAL PROGRAM

The experimental program was planed to study the compressive strength and chloride ion penetration

resistance of mortars using fly ash as replacement of cement. Cement replacement at various percentage levels were used in this investigation to observe the effects of different fly ash levels in mortar in contributing the compressive strength at different curing ages and chloride ion penetration resistance.

(a) Materials:

(i) **Cement:** ASTM Type I Portland Cement was used as binding material. The physical properties and chemical compositions of cement are given in Table-1.

(ii) **Fly ash:** A low calcium ASTM Class F fly ash was used in this investigation. Physical properties and chemical compositions of the used fly ash are given in Table-1.

Table 1. Physical properties and chemical analysis of ordinary Portland cement and fly ash

Physical properties	ASTM Type-I Cement	ASTM Class F Fly ash
Fineness		
Passing #200 Sieve, %	95%	99%
Blains, m ² /kg	340	400
Vicat Setting Time, min		
Initial	145	--
Final	190	--
Compressive Strength, MPa		
3 days	15.4	--
7 days	19.9	--
28 days	30.2	--
Specific gravity	3.15	--
Chemical analysis, %		
Calcium oxide, CaO	65.18	8.6
Silicon dioxide, SiO ₂	20.80	59.3
Aluminum oxide, Al ₂ O ₃	5.22	23.4
Ferric oxide, Fe ₂ O ₃	3.15	4.8
Magnesium oxide, MgO	1.16	0.6
Sulfur trioxide, SO ₃	2.19	0.1
Sodium Oxide, Na ₂ O	--	3.2
Loss on ignition	1.70	--
Insoluble residue	0.6	--

(iii) **Sand:** Locally available natural sand passing through 4.75 mm sieve and retained on 0.015 mm sieve was used for this program. Gradation of this sand is given in Table-2.

Table 2. Grading of fine aggregate

Sieve size	Cumulative % Passing
1.18 mm (No. 16)	100
600 µm (No. 30)	97
425 µm (No. 40)	73
300 µm (No. 50)	28
150 µm (No. 100)	3

(b) Mortar quality: Six different mix proportions of cement fly ash (90:10, 80:20, 70:30, 60:40, 50:50, 40:60) were used as cementitious material. The mortar mixes are designated as 10%, 20%, 30%, 40%, 50% and 60% fly ash mortar. Cement fly ash mix ratio of 100:0 i.e. plain cement mortar specimens were also cast as reference mortar for comparing the properties of fly ash mortars. The fly ash mortar means the mortar made by using cement and fly ash as cementitious material with sand and water.

(c) Mix proportions and curing: Sand to cementitious material ratio of 2.75 by weight and water to cementitious material ratio of 0.485 were used in making mortar specimens for compressive strength and chloride ion penetration resistance test. Super plasticizer was incorporated in order to obtain mortar mixes with a similar flow of $110 \pm 5\%$ in accordance with ASTM C109. The cast specimens were covered with polythene sheet and damped cloth and placed in $27 \pm 2^\circ\text{C}$ Chamber. They were demoulded at the age of one day and cured in water at $27 \pm 2^\circ\text{C}$.

(d) Compressive strength: The 50 mm cube specimens were prepared in accordance with ASTM C109. They were tested at the age of 3, 7, 28, 60 and 90 days. The reported results for each test variables are taken as the average of three sample test readings.

(e) Rapid chloride penetration resistance: The 100 x 200 mm cylinders were prepared for chloride penetration resistance in accordance with ASTM C39. After being cured in water for the age of 27 days, they were cut into 50 mm slices with the 50 mm ends discarded. The 50 mm slices were epoxy-coated around the cylindrical surface. The 100 mm dia. x 50 mm epoxy-coated specimens were tested at the age of 28 days for rapid chloride penetration test (RCPT) in accordance with the method described in ASTM C1202. The reported results are taken as the average of three samples. The test setup for determination of chloride ion penetration resistance is shown in Fig.1 to 4. The ASTM guidelines concerning the chloride ion penetrability are given in Table-3.



Fig. 1: Sealing of the sample with in the cell

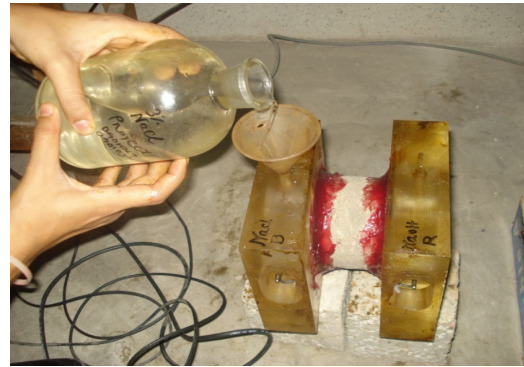


Fig. 2: Pouring 3% NaCl and NaOH solution in the cells



Fig. 3: Test arrangement for resistance to chloride ion penetration

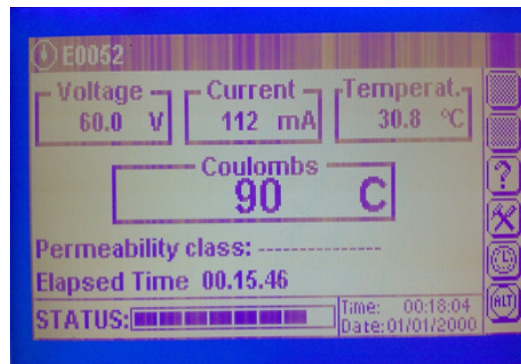


Fig. 4: Display unit for chloride ion penetration resistant equipment

Table 3. Guidelines for Chloride-ion penetrability based on charge passed (ASTM C 1202)

Charge passed, Coulombs	Chloride ion penetrability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very Low
<100	Negligible

3. RESULTS AND DISCUSSION

Various types of specimens made from different proportion of OPC and fly ash mortar were exposed to plain water to determine compressive strength and resistance to chloride ion penetration for various exposure periods. OPC mortar is considered as datum and used to compare the effect of fly ash in strength gaining and against chloride ion penetration.

3.1. Compressive Strength

The compressive strength of OPC and fly ash mortars as listed in Table-4, has been graphically represented in Fig.5. Also for the ease of comparison, the relative compressive strengths are plotted in Fig.6. Among all the mixes, for 3 days and 7 days compressive strength, no fly ash mortar achieves as much strength as that of OPC mortar. Test results showed that the 3 days compressive strength for OPC mortar is 9%, 15%, 23%, 29%, 45% and 59% higher than 10%, 20%, 30%, 40%, 50% and 60% fly ash mortar respectively. Up to curing period of 7 days, compressive strength is seen to decrease with the increase in fly ash content when compared with no fly ash mortar.

specimens with an increase in strength of 13% and 16% respectively as compared to OPC mortar. Also 10%, 20% and 50% replacement level provided an increase in strength of 7%, 10% and 9% respectively as compared with no fly ash mortar. Cement normally gains its maximum strength within 28 days. During that period, lime produced from cement hydration remains within the hydration product. Generally, this lime reacts with fly ash and imparts more strength. For this reason, mortar made with fly ash will have almost same strength as that of OPC mortar up to 28 days and substantially higher strength within 90 days. Fly ash retards the hydration of C_3S in the early stages but accelerates it at later stages (Jawed and Skalny, 1981). Conversely in cement mortar, this lime would remain intact and with time it would be susceptible to the effects of weathering and loss of strength and durability. Yamato and Sugita (1983) found that the later age strength of fly ash concrete was higher than that of the control concrete and that the modulus of elasticity was comparable to that of concrete made with moderate heat Portland cement.

Table 4. Compressive strength (MPa) of cement : fly ash mortars for various replacement level

Replacement Level	Ce:FA	Ce:FA	Ce:FA	Ce:FA	Ce:FA	Ce:FA	Ce:FA
Curing Period (days)	100:0	90:10	80:20	70:30	60:40	50:50	40:60
3	14.3	13.0	12.2	11.0	10.1	7.8	5.9
7	20.3	19.1	18.4	17.0	16.2	13.0	10.9
28	28.0	27.2	27.7	28.4	29.1	27.7	25.5
60	30.9	32.3	33.8	34.4	35.5	33.1	28.9
90	33.3	35.7	36.5	37.8	38.7	36.2	31.2

Ce : Cement ; FA: Fly Ash

28 days compressive strength of the specimens up to 50% replacement level was reported to be similar with OPC mortar strength. Compressive strength are slightly lower by 3%,1%, 1% and 9% for fly ash mortar of cement fly ash ratio 90:10, 80:20, 50:50 and 40:60 respectively when compared with OPC mortar. 28 days strength for the 30% and 40% fly ash mortar was observed to be 2% and 4% higher when compared with no fly ash mortar. 60 days compressive strength data obtained for 10%, 20%, 30%, 40% and 50% fly ash mortar were respectively 5%, 9%, 11%, 15% and 7% higher than no fly ash mortar, whereas 60% fly ash mortar strength was lower than OPC mortar by 7%. After 90 days, maximum compressive strength was obtained for 30% and 40% fly ash mortar

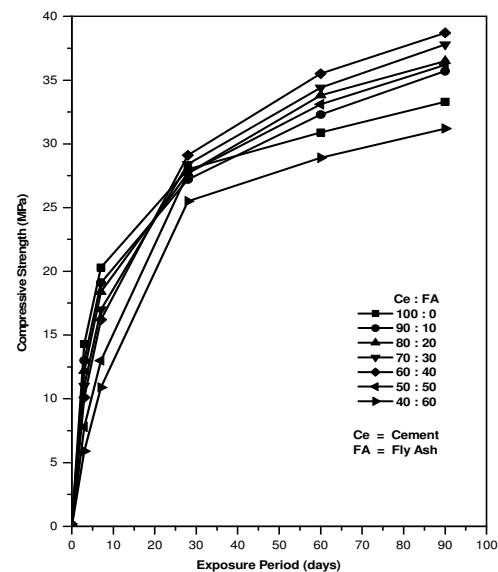


Fig. 5: Compressive strength- exposure time relation for

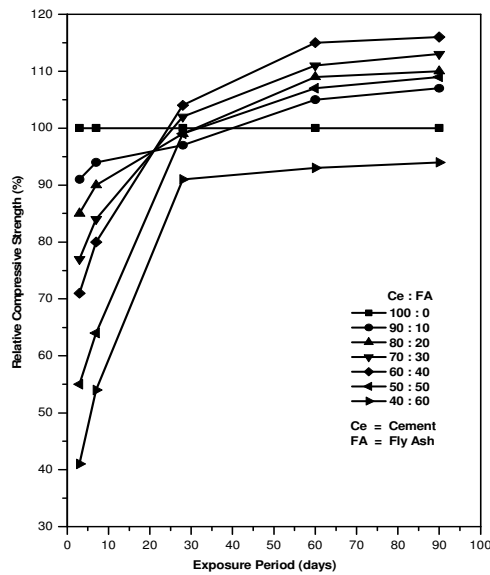


Fig. 6: Relative compressive strength-exposure time relation for cement:fly ash mortars

3.2. Resistance to Chloride Ion Penetration

Chloride ion penetration resistance value for OPC and fly ash mortar cured for 28 days period are shown in Table-5 as well as graphically presented in Fig.7.

Table 5. Chloride ion penetration Resistance (Coulombs)

Type of Mortar	Charge Passed	Curing Period
OPC Mortar	6900	28 Days
Fly ash Mortar (10% Fly ash)	4300	
Fly ash Mortar (20% Fly ash)	3900	
Fly ash Mortar (30% Fly ash)	3400	
Fly ash Mortar (40% Fly ash)	2700	
Fly ash Mortar (50% Fly ash)	2300	
Fly ash Mortar (60% Fly ash)	2000	

In case of OPC mortar, amount of passing charge is 6900 coulombs whereas the similar value for fly ash mortars are 4300, 3900, 3400, 2700, 2300 and 2000 coulombs for 10%, 20%, 30%, 40%, 50% and 60% fly ash mortars respectively. The incorporation of pozzolanic materials improves the resistance to chloride penetration of mortar as confirmed by other researchers (Janotka and Krajci, 2000). A close observation of the data shows that fly ash mortar has relatively better resistance against chloride ion penetration. Fly ash has high fineness

and can react with the products liberated during hydration. It forms secondary C-S-H gel that fills all the pores inside concrete and makes it more impermeable (Yalbot et. al., 1995). So it reduces the amount of charge passed thorough the concrete. Experimental result shows that as the amount of fly ash used in mortar is increased, charge flow through the mortar sample is decreased. This is due to the reduction of the pore spaces inside the mortar specimen that makes the mortar dense and compact and as a result the amount of charge flow is decreased.

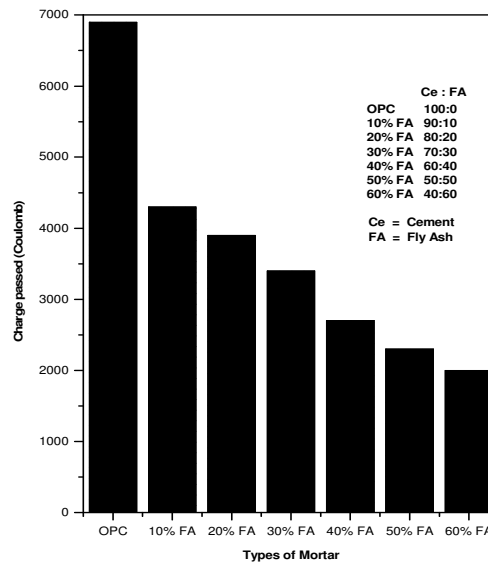


Fig. 7: Charge passed of rapid chloride penetration test (RCI)

Overall observation shows that after 90 days curing compressive strength values obtained for 20%, 30%, 40% and 50% fly ash mortar were 10%, 13%, 16% and 9% higher than OPC mortar respectively, whereas chloride penetration resistance is 43%, 51%, 61% and 67% higher as compared to OPC mortar. From both strength and chloride penetration resistance point of view, these four types of mortar are comparable. Among them 20%, 30% and 40% fly ash mortar are better from strength consideration. Again from the three mortar mix 40% fly ash mortar has better resistance against chloride ion penetration. Also all the values lie in the moderate range as per ASTM guidelines. 60% fly ash mortar shows best result against chloride ion penetration which is 71% better as compared to OPC mortar but strength is 6% lower as compared to OPC mortar. So this mortar is not good from strength point of view. After analyzing all the experimental result, it may be concluded that 40% fly ash mortar is best from durability as well as strength point of view.

4. CONCLUSION

Based on limited number of test variables studied and the results of the investigation conducted on different types of mortars, the following conclusions are drawn.

- (1) The rate of gain in strength of fly ash mortar specimens is observed to be lower than the corresponding OPC mortar at early ages of curing.
- (2) Fly ash mortar mix having various cement replacement level up to 50% exhibited satisfactory results for both compressive strength and chloride ion penetration resistance.
- (3) Fly ash blended mortar of replacement level 40% to 60% exhibited moderate penetrability to chloride ions diffusion as per ASTM guideline, whereas OPC mortar falls within the high range of chloride penetrability.
- (4) From both strength and chloride resistance consideration, the optimum fly ash content is observed to be 40% of cement. After 90 days curing, fly ash mortars with 40% cement replacement shows around 16% higher compressive strength compared to OPC mortar. Also, it shows around 51% higher resistance against chloride ion penetration.
- (5) In addition to lower chloride penetrability, use of fly ash as a partial replacement of cement in any construction work, provides lower impact on environment (reduce CO₂ emission) and judicious use of resources (energy conservation, use of by-product)

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CHALLENGES AND OPPORTUNITIES OF ECO-TOILET FOR LOW INCOME COMMUNITIES OF SYLHET CITY

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ABSTRACT

Eco-sanitation technology has been implemented in various part of the world, including both developed and developing countries as a sustainable sanitation option. Eco sanitation is good for environment, inexpensive and provides the only sustainable solutions available to problems of water shortage and sanitation problems. Eco toilet as a sustainable option can play an important rule to human waste disposal, retrieve and reuse the nutrients from human waste, and reduces use of water. Recycling of human excreta as fertilizer is the main reason to be appreciated by the users. Eco-toilet is new to Bangladesh. Some of NGOs implemented eco toilet in some areas of the country. This study focuses on the challenges and opportunities of eco toilet installation. In Sylhet city a huge number of slum people exist. Due to lack of fund and people awareness eco toilet are becoming very difficult to install. People have very short opportunity to use the fertilizers produced from the eco toilet by them. People have also superstition in having the vegetable produced by using the fertilizers from eco toilet. A family of 5 members produces the waste which has a value of BDT 5292.5. If government and other nongovernmental organization come forward the challenges can be removed.

Keywords: Eco-sanitation, human waste, eco-toilet, challenges etc.

1. INTRODUCTION

Sylhet is a tea producing area of Bangladesh situated in north eastern part of the country, where a huge amount of migrated people live in slums [1]. Open defecation is a very common practice in the slums. Children practice open defecation more than adults. In maximum number of slums there are unhealthy sanitary latrines and proper disposal facilities. About 70% children in slums practice open defecation. It is evident that about 27.8% slum people practices open defecation in average and about 39% slum people uses unsanitary latrine and 27% uses low cost sanitary latrines. Only 6.2% people have paka (RCC structure) latrines available to use [3].

Eco-sanitation is a new way of looking at sanitation. It treats human waste as a resource, and seeks to reintegrate sanitation with agriculture in a safe way, in order to reduce disease and improve low-income farmers' access to high-quality fertilizer [2]. It also looks at reducing waste of water, recharging ground water, and ensuring that people's need for water is met in a sustainable manner.

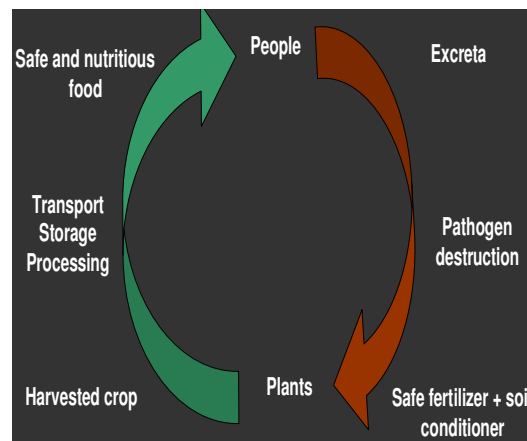


Fig. 1: Safe, green and valuable ecological sanitation

Eco-sanitation offers important solutions to many of the pressing and related problems of water and sanitation. Eco-sanitation involves extensive systems with multiple components. It can include systems for rainwater collection and use. It can

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involve reuse of grey water (the water from sinks and showers that otherwise goes down drains) to flush toilets or water plants or for agriculture. It can involve separation and composting of human waste in such a way as to benefit agriculture by providing needed fertilizer while also increasing access to clean and odor-free toilets for the poor. Eco toilet is a helpful tool for eco- friendly sanitation practice. It is designed to establish a way of sanitation practice which will enable fair waste management through collection and recycling. In an eco-toilet the human feces, urines and water used in latrine are collected separately. The basic function of eco toilet is collecting human feces as a dry waste. To do so eco toilet contains a heat panel. Figure 2 shows the internal model of eco toilet.

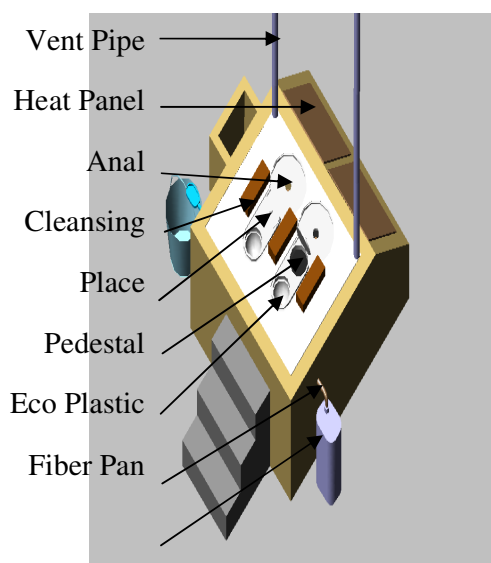


Fig. 2: Internal portion of Eco-toilet

Benefits of eco toilet:

Eco toilet is environmental friendly and it provides so many facilities to manage the human excreta in a sustainable ways such as-

- It reduces water pollution; indirectly prevent the water born diseases which exist in Bangladesh at a huge rate.
- Since eco toilet needs no flushing water hence it reduces the consumption of water.
- In Bangladesh and many other agricultural country scarcity of fertilizer hampers agricultural production. By using eco toilet big amount of fertilizer can be produce, which is environment friendly.
- The life cycle of human excreta in the eco toilet system starts from the people and ends to the people, which maintain the ecological balance. Figure 2 shows the

cycle involved in disposing of human excreta through eco toilet.

- In eco toilet system there is no smell problem, no fly nuisance and no insect breeding.
- Young children can use it safely.
- Poor people can be free of the scarcity of fertilizer.
- Reduce the rate of diseases suffered by the people.

Cost of installation & price of recycled products:

In installation of an eco toilet the involved costs are

- Land cost
- Construction cost
- Cost of ash

Cost of ash and the land is not considered in this study. The main cost is the construction cost is about BDT 12500-1500. In a family of 5 members the total solid component from urine and feces is about 529.25 kg. The price of the waste is about BDT 5292.5; assuming the price of the fertilizer is about BDT 10. Additionally, the water consumption is reduced by 5475 liters/year in eco toilet practice by a family of 5 members.

Table 1: Solid materials produced from the urine and feces and their value.

Human Waste	Component	HH Members	Yearly Production (Kg)	Value (Tk)
Feces	Solid	5	91.25	912.5
Urine	Solid	5	438	4380

Challenges:

The main challenges to introduce the eco toilet are

- Cost
- Low awareness level
- Proper maintenance

Most of the people become interested in seeing the opportunity of eco toilet. But due to lack of funds they cannot take the steps to introduce it. In Bangladesh the open defecation and unsanitary sanitation practice is common among the low income people. They are even not educated and aware. To ensure the effective practice of eco toilet training is essential to teach the maintenance procedure of eco toilet.

To overcome the challenges of the eco toilet installation and practice the parties which can be very effective are as follows-

- Local organizations and NGOs.
- Government and official bodies.
- Commercial and private sectors.

- International development organizations and donors.
- Educational and research institutions.
- Technical schools and technology centers.
- Professional association and bodies.

2. METHODOLOGY

This study has done mainly to assess the challenges and opportunities to introduce the eco-toilet as a sustainable sanitation option to the low income people. For this reason 6 slums were selected from the different area of Sylhet city. Two slums were selected from village area (Mirerchar, Kamal Bazar); two were selected from town (Mejortila, Subhanighat) and two from tea garden area (Malnicherra, Lakkatura).

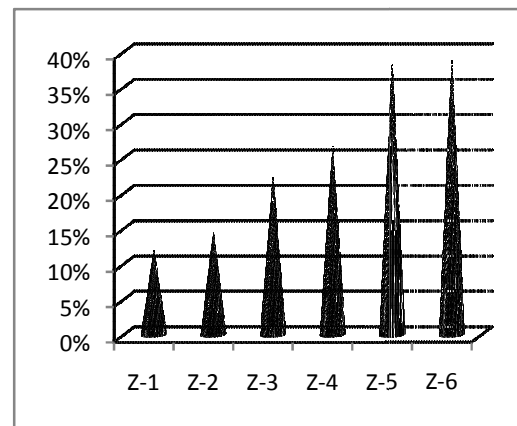


Figure 1: Rate of people have economic problem to install eco-toilet.

Table 1: Name, Location and identity of the study area

Identity	Name of the slum	Catagory	Location
Z-1	Mejortila	Town slum	North eastern part of Sylhet, outside the City Corporation (Near to Ward No. 25)
Z-2	Subhanighat	Town slum	Southeast part of Sylhet city (Ward No. 15)
Z-3	Mirerchar	Village slum	Near Biswanath Upozila
Z-4	Kamal bazaar	Village slum	Southwestern part of Sylhet, outside the City Corporation. (Near to Ward No. 20)
Z-5	Malnicherra	Tea estate slum	Northern portion of the city (Ward No. 17)
Z-6	Lakkatura	Tea estate Slum	Northern portion of the city (Ward No. 17)

Relevant data from each zone were collected that included socio-economic conditions of the slum dwellers, rate of people have problem in installing toilet, access to quantity and quality of water, access to basic sanitation services and sanitation behavior of the people. The awareness level and educational attainment of the people were also taken into account. Several approaches to data collection were used that included household survey, key informants' interviews and case studies.

3. RESULT

In case of eco toilet installation in the place of existing toilet an initial investment is needed. Since the slum people are very low income people hence they cannot provide the fund for establishing eco toilet. Figure-1 shows the rate of people considered they have economic problem to install the eco toilet. It is found that in Z-4 89.5% people have economic problem to introduce the eco toilet.

Practice of the eco toilet is different from the existing toilet to ensure the separation of urine, feces and water. In Z-6 61.7% and in Z-2 36.2% slum people think that that there have problem in eco toilet practice. Figure-2 shows the rate of people think that eco toilet have problems in use.

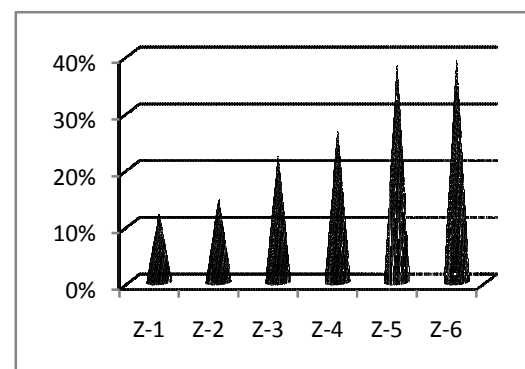


Figure 2: Rate of people have problem in eco toilet practice.

The slum people are not educated enough and they have very low level of awareness and knowledge about eco toilet practice. It is determined that in Z-1 13% people are aware and in Z-6 only 5.4% people are aware about the eco toilet practice and its benefits. Figure-3 shows the rate of people aware about the eco toilet. Mentionable there have few program undertaken to increase the awareness level of the people of the study area.

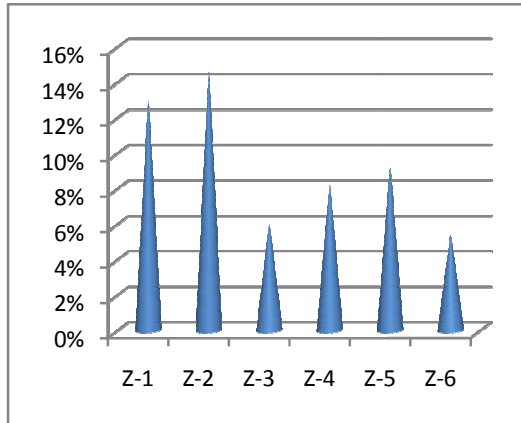


Figure 3: Rate of awareness of the people.

The slums in the village area have more opportunity to use the produced fertilizer from the eco toilet than the slums in town area. This is because the village slums have more open place for farming than town slums. In Z-1 and Z-2 only 10% and 6% people have this opportunity respectively. In Z-4 27% people have this opportunity. In Z-5 and Z-6 above 40% people have opportunity to use the fertilizers by themselves. Figure 4 shows the rate people have opportunity to use the fertilizer by themselves.

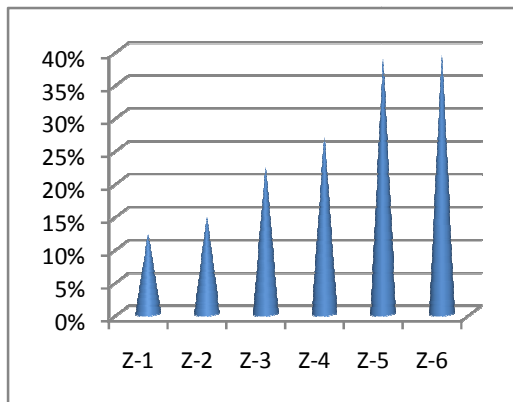


Figure 4: Rate of people has fertilizer using opportunity produced from the eco toilet by them.

Though there are problems involved in eco-toilet installation and practice, but still now people have good motivation to the benefits of eco toilet. In case of tea garden slum motivation level is mentionable. In Z-5 and Z-6 above 37% people are motivated to the eco toilet. Figure 5 shows the rate of people motivated to the eco toilet.

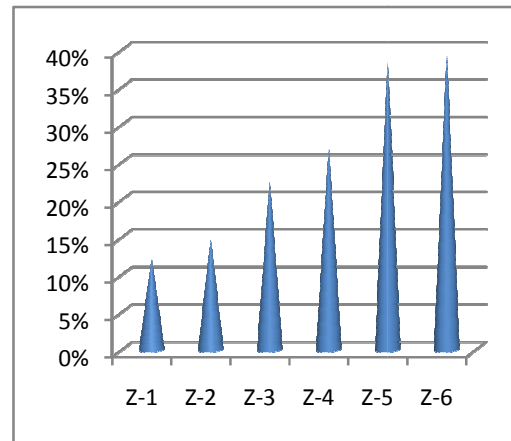


Figure 5: Motivation rate of the people to use the eco toilet.

As we know that the slum peoples are not educated enough they have superstition in having the vegetables produced by using the fertilizers from eco toilet. The superstition is high in case of village slum and tea garden slum people. In Z-3 42.5% people disagree to have the vegetable and in Z-5 47.1 % people have disagreed to have these vegetables.

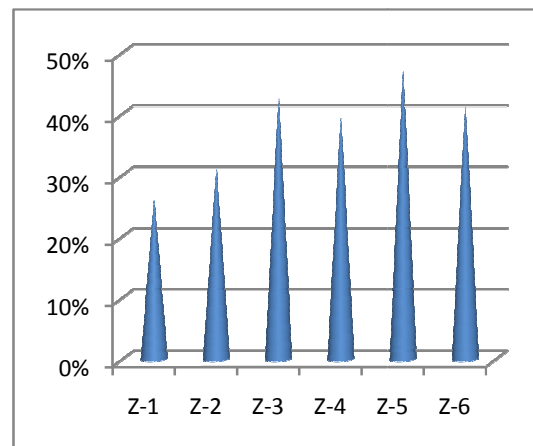


Figure 6: Rate of people disagree to have the vegetable produced from the fertilizers of eco toilet.

4. CONCLUSION

Installation of eco toilet is very much challenging in case of low income people. It is shown that the low income people are not able to provide the fund needed for the eco toilet installation. They are not aware also. But there have many mentionable benefits of eco toilet. To install the eco toilet the following steps are recommended-

- Government organization should provide the funds and organize programs to increase the awareness and knowledge of the people.
- Micro credit can be provided for the eco toilet installation.
- Scientific explanation about the healthy consumption of the vegetable produced by the fertilizers from the eco toilet needed to be established and communicated.
- Benefits of eco toilet should be communicated with mass people.
- The produced fertilizers can be manufactured and launched at the market.

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CLIMATE CHANGE AND CLIMATE REFUGEE NEXUS IN BANGLADESH CONTEXT

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Due to the climate change and consequent sea level rise (SLR), extreme environmental phenomena are presumed to occur more frequently and more intensely in Bangladesh. It is feared that this will result in huge population exodus. Dhaka being the capital city and most desired destination for most migrants (Climate Refugees-CR), will put great pressure on it. Dhaka is already burdened with many problems including; overcrowding, environmental degradation, lack of infrastructure and services, poor governance etc. and has limited physical and managerial capacity to cope with such problems and the CRs would be an added pressure on it. The objective of his paper is discuss SLR scenario and explore for a range of adaptive measures to respond to SLR induced situation. It is believed that the proposed measures will prevent large scale migrations and Dhaka would be saved from further deterioration due to CR induced overcrowding whilst helping them to avoid the misery of urban life in the slums of Dhaka.

Keywords: Environment; Climate Change; Climate Refugee; Adaptation; Urban.

1. INTRODUCTION

The global climate is changing due to both anthropogenic and natural process. The United Nations Development Programme reiterates that the scientific evidence supporting climate change is clear and that climate change is now a reality (UNDP, 2007/2008). In its 2007 report, the UN Intergovernmental Panel on Climate Change¹ (IPCC) provides convincing evidence of the ongoing processes of climate change and the contributing factors.

The impact of climate change is vast and complex. One of the significant impacts is the increased population displacements. The IPCC (2007) report estimated that by 2050, 150 million people could be displaced by climate change related phenomenon. Bangladesh, with its low-lying deltaic environment, will be severely affected by the climate change. According to UNDP (2010), by the year 2050, Bangladesh could lose 18 % of its land due to rising sea levels (SLR), resulting in 30 million

displaced people or climate refugees (CR). The displacement of people to new and existing settlements will put additional pressure on infrastructure and other services (IPCC, 2007). Factors like resources to move, livelihoods and social networks are regarded as the cause of migration. For social networking and secured livelihood reasons, options to migrate to Dhaka are most probable for CRs (Sirajee, 2010).

Dhaka is already burdened by many problems such as overpopulation, unplanned and inadequate services and infrastructure, poor governance, severe traffic congestion and environmental degradation. Additionally, when migrants end up invariably in the slums of Dhaka, the situation will further worsen. According to Begum (1999) more than 90% of migrants admitted to being influenced by the capital city status of Dhaka and nearly two thirds had over-estimated the facilities available in Dhaka. As a result, Dhaka has become long established and ultimate destination for most internal migrants, whether they are CRs or not (Courier, 2009). "Migrants to the city of Dhaka are not all single minded individuals who possess transferable skills; many tend to be illiterate, unskilled, old, and ill equipped for the city" (Begum, 1999, p4). As such, migration to Dhaka

¹ The intergovernmental PANEL ON Climate Change (IPCC) formed in 1988 is a scientific intergovernmental body tasked with evaluating the risk of climate change caused by human activity. The IPCC shared the 2007 Nobel Peace Prize.

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places an additional burden to already fragile urban infrastructure and population.

2. STUDY FRAMEWORK

2.1. Study Issues:

The paper aims to see various scenarios of adaptive measures to accommodate the CRs. Research on SLR, CR and adaptation measures in the human settlement is almost non-existent. Courier (2009) thinks that enough reliable, holistic research simply doesn't exist on CRs. It can be suggested that a planned migration process can be undertaken which could be proposed under the scope of National level and Regional level adaptive measures. These need to be undertaken in a process where first option is to retain people within the effected areas and the 2nd option could be to encourage them to move to regional cities and gradually to bigger cities. This paper is concerned with the first option ie, retaining people in their place through local level adaptive measures.

2.2. Understanding the Context:

Climate change refers to a change of climate that is caused by human activity directly or indirectly, thus resulting in change in global atmosphere in addition to that climate variability observed over comparable time periods (IPCC, 2007). As early as 1990 the IPCC also noted that “The greatest single impact of climate change might be on human migration - with millions of people displaced by shoreline erosion, coastal flooding and agricultural disruption”. Salehyan (2005) stated - “Environmental pressures have shaped human migration and settlement patterns for the millennia”. In general, the International Organization for Migration (IOM) proposes the following definition of such migrants.

“Environmental migrants are persons or groups of persons, who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or chose to do so, either temporarily or permanently, and who move either within their country or abroad”. (IOM,2008,p1-2)

The problems generated from CR induced ethnic tension, distrust and other conditions may destabilize host areas. “Conflict may erupt in receiving areas in response to *competition*, as CRs may burden the economic and resource base of the receiving area and competing for the resources.” (Mowla & Zareen, 2005; Mowla, 2008). Often conflict in some cases may erupt due to resource scarcity and competition and this conflict can lead

to greater migration. (Salehyan,2005). Dhaka being already burdened with social tension is extremely susceptible to such conflict.

3. CLIMATE CHANGE AND CLIMATE REFUGEE NEXUS IN BANGLADESH CONTEXT

The victims of climate change may be affected by four different phenomenon such as Deluge of a large part of the country; Intrusion of Salinity; Destabilization of rivers; Increase in extreme weather event (Islam, S. 2010). All such phenomenon is already contributing to the cause of CRs to Dhaka of both temporary and permanent type (Shafi, 2010). Severe conditions already prevail in Southern part of Bangladesh and will continue hitting the area more frequently in near future. Drought will also have some impact on the western part of the country. Flood will have adverse impact especially on the Gangetic plain. At present CRs gets displaced from these regions.

Adaptation can be defined as a method of adjustment or coping mechanism with its surrounding that helps improve the quality of life under strenuous circumstances (Mowla & Zareen, 2005). The proposed adaptive measures at the local level will mostly fall under the category of:

- a) Shared losses (providing subsidies to people),
- b) Modifying the threat (e.g. switching to alternate means and pattern etc),
- c) Preventing the impact (Building of protective infrastructure etc.),
- d) Change use (livelihood change etc.) etc. (Ahmed et al., 1999).

The planned measures will bolster the performance of spontaneous adaptive measure which the people of Bangladesh have practiced and developed over centuries. According to Ahmed et al (1999) “Adaptation at the micro (local) level often takes place spontaneously. People at grassroots often adjust to a given situation on a short term basis and as such; adaptation often follows the cycle of act-learn-act”. If liveability can be increased at the effected level, migration can be brought under control (Mowla, 2000&2005). People participation and feedback is a necessary component to enhance the performance of adaptive measure at local level.

3.1 Shared losses

3.1.1 Subsidy: If people are provided with grants, soft loans and other form of financial help during the time of dire need, it is assumed that they will deter from migrating. It is an accepted notion that most people tend to fight back (Mowla,2000) and this spirit can be enhanced by financial support. As

Kulsum (2010) states “It is proved that coastal vulnerable communities are positive to adapt themselves to changing environment but the major challenges are their limited financial resources.”

3.1.2 Insurance: Insurance against climatic events is expected to help people to retain life after devastation. According to the UNFCCC (2008) Convention (Article 4.8), insurance related actions constitute one of the three main means of response to the adverse effects of climate change, alongside funding and technology transfer. UNFCCC (2008) opines, “[insurance] can enhance financial resilience to external shocks and provide a unique opportunity to spread and transfer risk’. For private enterprise, such measure could be a challenge and opportunity at the same time. It is expected that insurance related to housing will reduce CRs significantly.

3.1.3 Disaster Relief Management: Through proper disaster relief and recovery management CR could be reduced. Depending on the nature and scale of climate change, these type of management continue from several month to several year. Government, N.G.O (Non Govt. Organisation) and C.B.O (Community Based Organisation) could play a pivotal role in such operations.

3.2. Modifying the Threat

Such measures require a comprehensive environmental rehabilitation approach linked to agriculture fisheries and livestock, as these sectors provide bulk of food required (Ketel,2008). Proper water harvesting will also lessen displacement and increase liveability in the effected areas.

3.2.1 Agriculture: Adaptation of agriculture systems in SLR areas can increase food security. In this context, floating agriculture in the water logged area could be a solution. Diversification of agriculture and change in crop calendar, use of paddy fields with irrigation and mulching/green manuring, change of fertiliser use and application can be implemented. For salinity intrusion, saline tolerant crop varieties could be introduced (Islam, S. 2010). Major problems of rice production relate to different kinds of stresses such as abiotic stress (submergence, salinity intrusion, drought, low/cold temp, high temp, and soil fertility), biotic stress (disease, insect, and weed) and socio-economic stress (Islam,2010). Such stress resistant rice should be cultivated in local area prone to extreme climatic events to solve food shortage. In the field of agriculture, scientists have already succeeded in developing many varieties suitable for particular agro-ecological zones (Ahmed et al, 1999).

3.2.2 Water Resources Management: Fresh Water is an essential element in retaining people within

area. In this context protection of water catchment areas and ground water, rainwater harvesting and desalination is important at the local level. Water policy reform including pricing and irrigation policies can be developed at national level to address the problem of water at local level (UNFCCC,2008). The heavy seasonal rain fall in Bangladesh makes rainwater harvesting a possible option for storage of drinking water. Due to unfavourable geo-physical condition of coastal areas some people have already been practicing this for storage of water. This may be further improved.

3.3. Preventing the Impact

Ketel (2008) suggests that with a better understanding of what causes displacement, pre emptive measures can be applied which will help people overcome their difficulties at an early stage, thereby enabling them to remain in their home area. Such activities occur in the pre-disaster phase, and include among others preparedness and mitigation in the following ways (Shaw, K, 2009):

3.3.1 Structural:

i. Infrastructure: The Construction of roads, Water retention ponds, culvert, embankment improves communication and at the same time protect area from natural disaster that devastate houses and render people homeless. Infrastructures like cyclone shelter, flood shelter also provides refuge during the extreme weather event.

ii. Housing: People mainly migrate due to homelessness. House and settlement pattern may need modification to better cope with the changing conditions and reduce homelessness. Roofs should be properly designed and tied with base or main structure (Kulsum,2010). Flood and cyclone responsive shelter may be built in the worst affected areas.

iii. Renewable Energy: The provision of alternate energy will increase liveability, enabling villagers to use it for productive and social activities. Renewable energy is sustainable and enhances liveability (Mowla, 2007 & 2008). With an increase in liveability it is expected that the tendency of people to migrate will decrease. Alternate energy sources could be Solar, wind, bio-gas etc.

3.3.2 Non Structural:

i. Forestry, Natural Resources and Terrestrial Ecosystem: Reduction of climate change hazards through coastal afforestation with community participation is a priority issue (Mowla, 2000). Coastal mangrove afforestation, tall trees next to tidal free zone, bamboo and cane cultivation as windbreaker, cultivation of horticulture species, agro forestry, and coast specific wood trees are also required to combat climatic events (Islam,S. 2010).

Besides material from trees such as thatch, leaves, woods will help people to undertake alternate livelihood after disaster. Other anticipatory adaptive measure like creation of parks/reserves, protected areas and biodiversity corridors, Identification / development of species resistant to climate change, better assessment of the vulnerability of ecosystems, monitoring of species, development and maintenance of seed banks etc need to be adopted (UNFCCC,2008). All these measure will enhance environmental performance that will motivate people to stay in their own area instead of migrating.

ii. Health: Due to climate change events, there will be a propensity of post traumatic stress and other sort of psychological and physical stress. In the absence of proper health support many people would migrate from affected areas. Reactive health measure such as emergency response and anticipatory adaptive measures such as better and /or improved disease/vector surveillance should be undertaken to help victims of climatic events (UNFCCC,2008).

3.3.3 Community Based Adaptation:

i. Motivation: Community level motivation programme could be more effective in combating climate change impacts (Maarten, van Aalst, 2008). Community-level adaptation strategies and implementation management plans like excavation to reduce water logging, raising of embankment to prevent intrusion of saline tidal water; pond sand-filter for safe drinking water, construction of new multipurpose cyclone shelters etc. to reinforce liveability in rural area (Islam, A. 2010) may be developed and implemented. This type of community level adaptation strategy will enhance community feeling and sense of belonging to the local area and will deter people from migrating because of such feeling and support. The local community's views and experience on climate change impact, adaptation through programmes like community consultation, group meeting, youth group activation and capacity building, the idea of out- migration can be stalled.

ii. Public Awareness: Through public awareness and dissemination of ideas related to grim future of Dhaka bound migration, a major breakthrough can be achieved. Improving public awareness and developing overall communications strategies at local level could make information related to climate change induced migration available to the average citizen and can reduce out migration (UNFCCC, 2008).

iii. Knowledge Base Education: Inclusion of climate change related issues in the curriculum could discourage people to migrate out particularly to Dhaka. Knowledge should be made available as

such and shared at the local level facing difficulties that leads migration towards Dhaka. In support to this initiative, there is a need to establish mechanisms for accessing and analysing current knowledge on migration and address priority gaps in current knowledge (Ahmed et al,1999).

3.4. Change Use

3.4.1 Fisheries: Adaptation of fisheries in areas prone to enhanced flooding in North East and Central Regions through adaptive and diversified fish culture practice can increase food security. Promoting adaptation to coastal fisheries through culture of salt tolerant fish especially in the coastal areas of Bangladesh will help increase liveability by increasing livelihood and food security. (Islam,A.2010)

3.4.2 Livelihood diversification: Livelihood diversification is essential element to adaptive resilience to climatic disasters. When people loose their livelihood from agriculture and fisheries, alternative livelihood provides them a means to survive within their area. The alternative livelihoods supplementary to their main livelihoods can be crab fattening, livestock rearing and non-farm activities. The non farm activities may include cottage industry such as weaving, articles, baskets and mat making from bamboo, local reed variety (Kulsum, 2010). All these will help local people resort to a new life instead of migrating to Dhaka.

4. DISCUSSION AND RECOMMENDATION

4.1. Discussion:

The concept of anthropogenic (human induced) climate change migration is relatively new as the phenomenon started to appear since industrial revolution with the emission of GHG (Green House Gas) mainly by industrial activities. Globally, CR surfaced with the inception of IPCC in 1988. As Haq (2007, p11) opines, "Climate change is a fairly new issue and that adaptation is even younger. We are learning by doing".

The mitigation measures for CR's towards Dhaka at the root level are subsidy, insurance, disaster relief management, innovative agriculture, water resource harvesting, building infrastructure, building houses, enhancing natural resources, improving health, community base adaptation, raising public awareness etc as discussed. The priority issues in implementing such solutions are funding, development of a knowledge base, capacity building, public awareness and finally Government commitment and will. To develop a knowledge base and capacity building with civil society,

universities, NGOs and other international and national body can contribute significantly. Ultimately it is the government with community support who should initiate and monitor all activities.

The constraints of implementing the adaptive measures at local level are huge and pose a major challenge. In terms of funding, it will be difficult to arrange extensive funds from Government's own resource, when the government is grappling with the problems like poverty, high unemployment, low literacy rate, insufficient basic health care issues for people of Bangladesh. The chance of obtaining substantial funds from foreign sources appears remote which was evident from last global conference on climate change in Copenhagen. Limited institutional capacity, limited technical capacity is also major deterrents for smooth operation of such adaptive measures. Moreover corruption and extreme level of politicization of administration are also a major deterrent from implementing such adaptive measures. Despite all constraints, Government has initiated some sign in positive direction by formulating Climate Change Strategy and Action Plan and National Adaptation Program of Action (NAPA).

The successful implementation of adaptive measures at the local level will increase the liveability in those areas and will contribute significantly in reducing out migration. Each of the proposed adaptive measures at the local level should be regarded as 'guideline solution'. People are responding well in the hostile climatic effect situations (like Sidr, Aila, or Beel Dakatia), their experience may be shared in the SLR and CR management. More research should be initiated on each of the adaptive measure by specialists and related experts.

4.2 Recommendations

1. A National Policy (Bangladesh) should be formulated addressing environmental migrant (CR) issues.
2. National Policies (Bangladesh) need be formulated related to adaptive measures at different level (local, regional and national) to minimize migrant flow to Dhaka.
3. A separate fund should be allocated from 'Climate Change Fund' for the specific purpose to address adaptive measures to minimize migrant flow to urban areas like Dhaka.
4. NGOs and CBOs and international agencies should be given enough support and freedom from all levels of administration to undertake and facilitate these adaptive measures.
5. Climate Change Strategy and Action Plan and National Adaptation Program of Action (NAPA) should be revised in order to provide more importance and significance to issues related to environmental migrants (CR) issue, specifically migrants to Dhaka.
6. As environmental migrants are innocent victim of situation caused by GHG emission mainly by developed nations, a 'Multi-Donor Trust Fund' need to be formulated comprising compensation from foreign countries.
7. Slum policy for Dhaka should be formulated in order to ameliorate the suffering of slum dwellers, which is the ultimate abode of such environmental rural migrants.
8. Climate change migration issue should be included in the curriculum at secondary and tertiary educational institution, discouraging people to migrate out especially to Dhaka.
9. National media should provide due coverage underscoring the need to retain environmentally affected people within local area or migrate to regional growth centres instead of migrating to Dhaka.

5. CONCLUSION

In implementing such adaptive measures local government need collaboration with National level administration. In addition, local government administration with the help of NGO (Non Government Organization), CBO (Community Based Organisations) and people's representatives can develop programs for implementing such adaptive measures. NGOs and CBOs should be given enough support and freedom from all levels of administration to undertake and facilitate these adaptive measures.

IOM's (International Organisation of Migration) policy and notion in general opposes migration towards urban areas and thinks migration hinders development in at least four ways; by increasing pressure on urban infrastructure and services, by undermining economic growth, by increasing the risk of conflict and by leading to worsening health, educational and social indicators among migrants themselves. (IOM, 2008). It can be argued that local level adaptive measure would not only reduce migration to Dhaka but also to other cities.

In nutshell, the climate change induced migration should be given due priority and importance nationally as a major new field of inquiry. As Ketel (2008) suggests, human migration caused by climate change might well be one of the major development problems of the third millennium. As such, utmost importance should be provided from

the part of governments and international humanitarian, development, and environmental agencies to this pressing issue.

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CRISIS IN THE BUILT ENVIRONMENT OF DHAKA: AN OVERVIEW

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Dhaka has grown from a small settlement to a sprawling metropolis of about fifteen million people. Traditional physical development in this region offered the best and integrated solutions towards human needs, in their relation with the nature and the community but contemporary development has ignored living with nature. Studies show that much greater environmental as well as socio-economic advantages can be achieved through design with ecological principles in mind than without it. This paper aims at understanding the development trend in Dhaka, the crises it is facing and the possible strategies to overcome the problem. It is concluded that fragmented approach of planning must be avoided and that the development taking care of geomorphology and hydrological behaviour of the place would result in a sustainable environment.

Keywords: Crisis; Built-environment; Ecology; urban design; Dhaka.

1. INTRODUCTION

Dhaka is located in the midst of an active delta – the largest in the world. Siltation process is going on for ages in both water channels as well as in the flood plains thereby their relative depth remains almost constant and the shore line moves south ward with the accretion of new lands. In his context, Dhaka has grown from a small trading settlement to a sprawling metropolis of about fifteen million people. The spatial development followed the prong of flood free terrace originating from the old nucleus along Bouriganga River towards north as a part of Madhupur terrace (Dhaka Terrace). The Dhaka Terrace sloped towards eastern and western flood plains, marshes and Rivers. The Dhaka terrace was also crisscrossed by numerous water channels that drained the city as well as served as a main source of service and communication line.

In this setting, after independence in 1971, tremendous population pressure has put Dhaka's built-environment in a crisis situation. The objective of this paper is to understand the nature of the crisis and to explore for possible strategies to overcome the crisis.

2. DHAKA'S URBAN GROWHT SCENARIO:

Traditional settlement pattern in this region offered the best and integrated solutions towards human

needs, in their relation with the nature, ecosystems and the community but contemporary development has ignored living with nature. The physiographic effect of water and land can be seen on the traditional settlement pattern, which sited on available ground or on artificial mounds created on the flood plains (Mowla,2008).



Figure-1: Water bodies are illegally encroached upon creating drainage and water logging problems.

In forties, about 50% of present Dhaka was low laying flood plain and wetlands. Many of the roads in Dhaka are developed by filling the water bodies or by making box-culverts, thus shrinking the water carrying capacity as well as reducing ground water replenishment. Destruction of these water channels and depressions has resulted in the disruption and alteration of the natural process of land accretion, land formation and ecosystems. Water logging (Fig-1) is an inherent problem associated with

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uncontrolled urbanization and lack of holistic planning in Dhaka.

3. POPULATION GROWTH, MIGRATION AND HOUSING

The population density in the slums is about 531,000 persons per square mile which is still growing and occupy an area of only 4% of the total Dhaka Metropolitan Area (DMA), whereas the urban poor population is about one-third. It has been reported that only 30% people of this city shares 80% of the total residential area and the rest 70% shares only 20% of residential area. Around 3000 slums and squatters exist in the city in which almost 3 million people live with very little utility facilities (Fig-2).



Figure-2: Uncontrolled Development at Koril

The population growth in Dhaka is due to natural growth and huge in-migration. Currently, the population is estimated to be about 15 million people (about half of which live below the poverty line) live in about 340sq.km area of Dhaka. The existing overall, gross urban development density is 89 persons per acre (ppa). In the inner zones, densities average 179 ppa, reaching a high density of 323 ppa in the older quarters. Statistics show that the housing demand of the residents in Dhaka city increases by around 10 percent each year. It is estimated that about five lakh people migrate to Dhaka every year requiring about one lakh housing units and 95 percent of such people are poor. Public and private sectors combined together build around 15,000-20,000 housing units a year to meet the staggering demand of about 100,000 units/year, of

which real estate developers contribute only about 5% of units in Dhaka each year that too for mostly higher income segment of the population. Approximately, 56 percent of the Dhaka city's population lives in informal housing.

Huge majority of migrants to Dhaka choose Dhaka because of centralized opportunities and central location. Migrants to the city of Dhaka are not all single minded individuals who possess transferable skills; many tend to be illiterate, unskilled, old, and ill equipped for the city. As such, migration to Dhaka places an additional burden to already fragile urban infrastructure and population. A study in 1987 revealed that 2.8 million of the poorest people lived on just 7 sq km of land and most of the residential development is unplanned. Motijheel is the Central Business District (CBD) of Dhaka city where 85% of housing is unplanned. The interesting case is Mirpur residential area where 90% of housing is unplanned. According to same investigation about 75 % of the housing stock in Dhaka is unauthorized. The residential density in Old Dhaka is 313 persons to an acre. A conservative estimate of the person / room ratio in the residential quarters of old Dhaka is 7.5. Though this seems very dense, the average Floor Area Ratio (FAR) in Choukbazar was found to be only 0.85. There are only 17 acres of open space for over 600,000 people.

The gender composition of Dhaka's population is balanced, but a significant portion of population is not stable. Most of the economically lower class people are single with their families in rural areas. UNCHS attributed this factor to the growing garment sector industries, which alone employ over 700,000 women. Centralization of urban amenities and activities in Dhaka has resulted in population explosion. The rapid increase in urban population has made a tremendous claim on the already over-utilized civic facilities and has created a state of disequilibria in the urban environment.



Figure-3: Concrete Jungle in Motijheel Area.

Decentralization of facilities and amenities is therefore essential for Dhaka to survive (Fig-3&4).

Establishment of New Satellite towns around Dhaka to reduce pressure from it are however not suitable proposition in Bangladesh context where land is scarce and cultivatable land, wetland and open spaces are meagre. Existing urban centres around Dhaka (Savar, Narayanganj, Tongi, Gazipur etc. or across Bouriganga River) may be consolidated, controlled and planned to shift / neutralize some of Dhaka's functions, particularly the activities that don't need to be at the centre. However, these centres must have rapid, efficient and cheap communication connectivity with Dhaka.

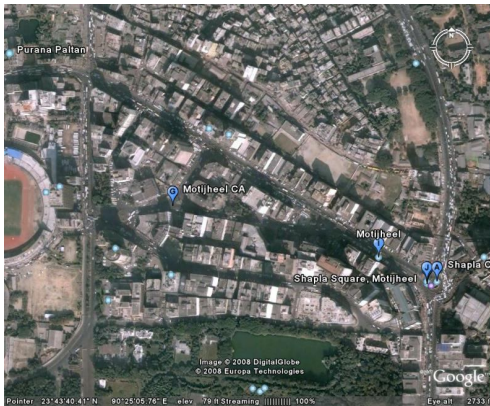


Figure-4: Traffic Congestion in Motijheel Area.

4. TRAFFIC AND TRANSPORTATION

Increase in population and number of automobiles without matching development of traffic and transportation infrastructure has almost resulted in a system break down (Fig-4&5). At present about 2500km of road in Dhaka have to carry about 8 lakh vehicles. Land use and traffic and transportation depend on each other. Land use distribution giving rise to the propensity to travel is one of the problems. For example, concentration of numerous ghats along Bouriganga river generates huge traffic that has to move to and fro through the city. If transportation cost and time spent in travel is considered, the relocation of some of the ghats to (say) Mirpur or Tongi where they are more needed would be more economical. Dispersal of warehouses, transport agencies and other relevant activities will automatically follow to newer location. Therefore, planned relocation of some strategic land use will have positive effect on the traffic and transportation situation.

Mass transit is essential for any mega city, as an economic first step towards this end in Dhaka context, initially Narayanganj – Dhaka – Tongi railway tract may be used as high frequency shuttle trains (mass transit spine) and important stations hooked up with the city's road transportation grid. 'Bus only' lanes or segregated right-of-way for

public transport vehicles in the major routes may have a positive effect on the otherwise precarious traffic and transportation situation of Dhaka. Efficient traffic management and efficient use of road space may substantially reduce the traffic problem of Dhaka in the short term. Alternate mode of traffic and transportation is needed, as such; fast moving water taxi may be introduced around Dhaka that will reduce much of the through traffic from Dhaka. Development of Western embankment road and eastern by pass road integrated with the city's grid will complement circular water way. Water-route and by-pass route must also be adequately hooked up with the city's road transportation grid.



Figure-5: Unbalanced Development: Panthapath

Pedestrian traffic makes up the lion share of the total traffic (in terms of persons moving) but it is surprising to note that almost no provision of pedestrian traffic is present in any level of planning and design – that contribute significantly towards overall traffic problem of the city. Other approaches that can be adopted simultaneously to tackle the problem are: a) Area licensing whereby low-occupancy vehicles pay to enter the designated congested areas; b) Road pricing, where by vehicles are charged for using certain roads. c) Physical restraints to discourage the movement of private cars across certain areas. d) Adequate parking facilities and parking Controls to prevent long term parking in busy areas. e) Staggered timing of city's traffic generating activities; f) restricted entry to certain types of vehicles to certain areas; g) Pedestrian amenities, efficient footpath and pedestrian routes, and h) land use control to influence the magnitude and type of transport demand.

5. OPEN-SPACE, WATER BODIES AND URBAN ENVIRONMENT

Dhaka being encircled by a river system provides relief to otherwise congested metropolis. Fringe areas are generally low, flood plains, depressions etc. Filling up of water bodies poses two prong

problem of unsuitability of construction and reduced water retention capacity. But the scenario is that, in old Dhaka only 5% and new Dhaka 12% of land is green and open. The total amount of open space in greater Dhaka is about 17%-18% of city area. The total stock of public open space in Dhaka City is hardly over 5000 acres.

5.1 Traditional Response:

Traditional response to the context gave rise to a richly woven urban fabric at the human scale. The rivers spilling over the flood plains and into canals / khals or connecting inland depressions or lakes together provided a hierarchy and network of water bodies and navigation routes giving rise to settlements alongside. There were flights of steps, locally known as ghats at intervals rising up to the lanes or community spaces. The ghats on the bigger water bodies or rivers were major community spaces where the daily activities take place. (Mowla, 2000 & 2010). The trend of ignoring channels and ponds so vital to the city's life line has caused social, health, sanitation and water logging problems.

5.2 Water based Urbanism:

5.2.1 Water Retention and Drainage: A tendency of filling of water bodies and flood plains resulting in the reduction of water retention capacity, diminishing public spaces and increasing water logging or flooding. In this respect the localities situated inside the city suffers most. Degradation, obstruction, filling and demolition of natural drainage systems are causes of flood's severity in some parts of the city.

5.2.2 Ground water extraction: Being one of the mega cities in the world and without any hydrological planning and remaining surface water being excessively polluted or destroyed, Dhaka is facing continuous potable water-related problems over the last few decades. Ground water extraction poses a great threat to the sustainability of the city itself. There is no strategy for planned replenishment of ground water, and that is in a place that receives one of the highest rates of rain fall in the world. Flood water retention and rainwater harvesting could be a better alternative to ground water extraction. Surface water complement and supplement underground water. The ground water replenishment rate is much slower than the extraction rate. Dhaka Water and Sewerage Authority (WASA) extract about 1200MI / day for urban water supply from about 423 deep tube wells. In 2001, underground water table in Dhaka was at a depth of between 200-300 feet. In 2010, this has deepened to 1,000 -1200 feet. This is not a matter of concern only with respect to diminishing water supply source but because a large vacuum between

surface and under-groundwater has developed which might trigger land slide or subsidence particularly in the event of earth quakes.

5.3 Mismanagement of Urban Water:

Dhaka WASA utilizes the existing canals and sewerage pipes to collect the waste water from different residential areas, carry the effluent to dispose, most of it, into surrounding river systems without any treatment. Many canals are cut off and transformed into lakes. Even these lakes are getting highly polluted due to disposal of waste waters collected from the municipal sewages.

In terms of utility services, a few key points are important. The lower the density, the higher the cost of providing services. Second, drainage cannot happen when all available space is paved over and built on. Third, as with transport, so is with utilities: attempting to meet constantly expanding demand with supply is an expensive and impossible proposition, therefore a holistic and long term planning is needed.

6. DHAKA'S WATER SCENARIO IN DMDP AND DAP

Patrick Geddes plan of in 1917 was a good concept for Dhaka's development but was never given a trial. First formal Master plan for Dhaka was prepared in 1958 for an anticipated population of 2 million. The Dhaka Metropolitan Area Development Plan (DMDP'95) was quite comprehensive, but could not be adopted due to mysterious reasons. Detail Area Plan (DAP'2010) supposed to have evolved from DMDP'95 is under serious public scrutiny because of its deviation from DMDP'95 and present reality.

A formal holistic policy and plan at national level sets priorities identifying major areas and quantities of uses. Urban structure plan (SP such as Fig. 6: DMDP, 95) is the second level plan within broad urbanization policy guidelines of national vision. The third level planning and designing is the detail area plan (DAP) within the guidelines set in SP. In the fourth level is small area and plot level designing. Such a sequential plan is not evident in the DAP, 2010, which rather than setting aside adequate space for water retention ponds and for green surfaces, focuses instead on roads and buildings, embankment and pump oriented flood control approach which further intensifies the suffering of Dhaka residents due to flooding. Considering the geo-morphology of Dhaka, flood management and a detention reservoir-based gravity drainage system is expected to be more reliable and appropriate for storm water drainage system in a floodplain landscape like Dhaka with rivers encircling the city (Mowla, 2010). Some

sporadic attempts to integrate water bodies with the settlement pattern are observed in Dhaka without any link with upper and lower level planning and design framework.

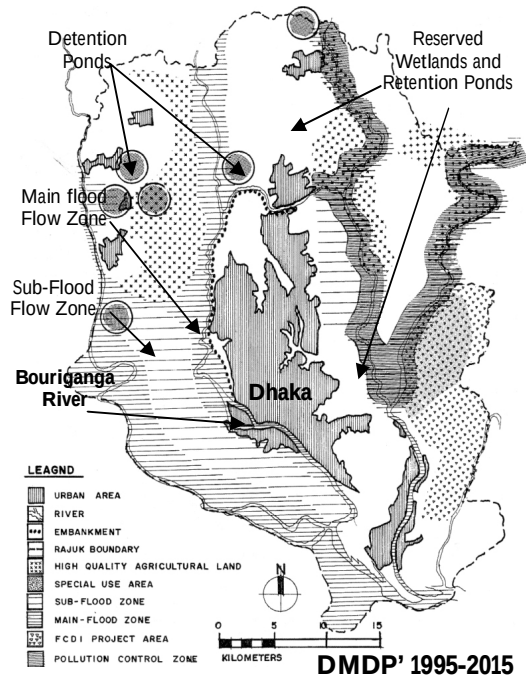


Figure-6: DMDP' 95 - Structure Plan Policy Areas i.e. built and natural areas for Dhaka.

6.1 Contextual Brief:

Dhaka Metropolitan Development Plan (DMDP, 1995) considered retaining at least eight flood-flow zones undisturbed. It is said that Dhaka must have at least 20 retention ponds of Hatirjheel size to tackle the storm water (Bangladeshnews, 2009). Transparency International Bangladesh - TIB informed that around 1,000 ponds, which were in the city, have now been totally destroyed (Bangladeshnews, 2009). TIB reports that 800 acres of land in 5 rivers including Bouriganga and Sitalakkhya were illegally grabbed violating the Wetland Protection Act, 2000. The fact is that the contemporary planning process never took water systems as the driving force in any physical planning in this delta. IRS images of 1996 and 2000 clearly shows that water bodies measuring about 2300sq.m were filled in by the Bashundhara and Bashumoti housing estates and 66 acres filled by Aftabnagar Housing. In 1996 there were 211 acres of water bodies in the Mohamadia Housing Estate and Adabor area of which 91 acres disappeared between 1996 and 2006 and 68 acres from 2006 to 2009. RAJUK, the main planning body for Dhaka is the major violator of its own plans. RAJUK initiated a residential project in the southern part of Bouriganga River covering an area of 381 acres –

over the last two years 3000sq.m of natural water bodies has already disappeared. Purbachal housing is another recent example of many such violations of DMDP, 95.

6.2 Crisis and Mitigation Approach:

Bangladesh is a deltaic country and has abundant rainfall, but due to the absence of clear policy-guidelines and regulatory laws, useable water quantity is declining fast. Wetland Protection Act, 2000 in Bangladesh restricts change in the wetland areas but doesn't regulate the use of water. In fact none of the rules calls for integrating natural water bodies or channels into the urban planning and design frame work.

Studies show that around 40% of the wetlands of Dhaka city has disappeared in 20 years due to indiscriminate filling up of lowland and flood flow zones that also has reduces its drainage capacity. It says that the temporary wetland area in DMDP, 1995 was 1,528 sq.km. this was 40,765 hectare in 1989 and came down to 35,740 hectare in 1999 and 24,208 hectare in 2005 (Bangladeshnews, 2010). Same study informs that to protect eastern Dhaka from floods, at least 40% (66 sq.km) of the drainage catchment area must be delineated and protected as wetlands and water bodies considering this as an 'ecologically critical area'. Of the recommended 40% drainage area, a minimum of 12% (about 20 sq.km) can be made available as reserved ponds or lakes and another 38% (about 46 sq.km) protected as natural wet lands for retention of storm water. A Dhaka University study reveals that the government owns about 33 lakh acres of khas (Government) land of which about a quarter is water bodies. DAP (2010) covers the area of DMDP, 1995 but did not follow the planning guidelines provided in it. Against the 40% requirement, DAP, 2010 recommends 21% of Dhaka's land as water bodies where no development would be permitted. DAP recommends 50m land from riverbanks to be earmarked for walkway or driveway; enlisting parks, playgrounds and open spaces; and marking existing canals in the maps (DAP, 2010). Though no basis of this recommendation is given, it seems better than none.

Considering the geo-morphology of Dhaka, it seems essential that if and when needed the earth cutting to fill / raise lands must be judiciously planned and invariably done on the channel ward side that would get rapidly filled up by the natural process of sedimentation / accretion. The western embankment of Dhaka is a response to the floods. The attitude of zero tolerance for floods amounts to demanding equal protection from floods along different stretches of rivers irrespective of the

geographical difference found there, which in practice is not possible. It increases the ferocity of flood flow in the lower reaches. Embankments saves some areas at the expense of some other areas but have a long term effect of higher river beds than their surrounding, insufficient percolation and diminishing soil fertility.

Traditional approach of planning and design of living with nature is still valid without sacrificing contemporary needs and that natural areas may be strictly controlled by regulations. It is also suggested that the Planning and regulatory agencies like RAJUK must not indulge in (real estate) development since monitoring and execution are conflicting roles with conflict of interest (like judiciary and bureaucracy).

7. DISCUSSIONS AND RECOMMENDATIONS

Review of Dhaka's geomorphology reveals that for the sake of sustainability needs, natural systems must be protected. Studies show that much greater environmental as well as socio-economic success can be achieved through design with ecological principles in mind than without it. Planning must be holistic in nature and piecemeal solutions be avoided. Mass housing and mass transit with ecological imperatives should get priority in the Dhaka's development process in the present context to minimize crisis.

Considering Dhaka's geomorphology and hydrological profile, finger shaped open ended dykes may be constructed for settlements, particularly in the fringe areas to allow free flow of flood water in and out of the urban areas. Lower elevation plains may be used as vegetation areas (parks or open spaces) during lean seasons. Restoration of natural (gravity) drainage system and creation of adequate water bodies is needed for a sustainable ecosystem in Dhaka.

Houses with elevated floors built on earth mounds created by adjacent excavation thus having similar storage capacity and evacuation boats kept available for emergency were the traditional concept of settlements in the flood plains. It is considered a highly developed form of culture born out of necessity to live with hydraulic dynamics.

8. CONCLUSION

Traditional Architecture, Urban Design and planning in this region offered the best and integrated solutions towards human needs, in their relation with the nature, ecosystems and the

community but contemporary development ignored living with nature.

Urban development with natural context as focus was not given a trial during rapid urbanization over the last 100 years. Review of Dhaka's geomorphology reveals that for the sake of ecological, hydrological integrity and development sustainability, natural systems must be protected and can be protected. DAP, 2010, though quite conservative and has compromised, if strictly followed is still expected to improve this situation. Studies show that much greater environmental as well as socio-economic advantages can be achieved through design with ecological principles in mind than without it. Fragmented approach of planning must be avoided, and further compromise with DAP will be suicidal in the long run.

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EARTHQUAKE VULNERABILITY ASSESSMENT OF SCHOOLS AND COLLEGES OF SYLHET, A NORTH EASTERN CITY OF BANGLADESH

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In this paper, seismic safety of the school and college buildings of the Sylhet city, the north-eastern divisional city of Bangladesh, has been discussed. This study is an outcome of the combination of Rapid Visual Screening (RVS) survey and Modified Turkish Method carried out to evaluate the existing school and college building stock of Sylhet City Corporation area. More than fifty school and college have been surveyed with an objective to evaluate the present condition and to identify the retrofit buildings in future earthquake. The field observation regarding soil condition, zone type, apparent quality and structural state has been reported. After the work down evaluation, preliminary assessment is done as it is essential for final structural and non-structural evaluation. 7.55%, 9.31% and 11.36% school and/or college building has been found highly vulnerable to earthquake when the distance of fault is within 9-15km, 5-8km and less than 4km respectively. Some recommendations have been provided that might be followed to avoid or minimize structural damage of the school and college buildings.

Key words: earthquake, vulnerability assessment, Sylhet city, school, college

1. INTRODUCTION

In earthquake prone areas there is a need for the assessment of the capacities of large numbers of existing buildings. The results of such assessment are essential for rational planning of retrofit programs for existing buildings before the occurrence of a strong earthquake, for the allocation of rescue forces and equipment to optimally deal with the forecasted damage, etc. (1) the seismic evaluation and retrofitting of school buildings laying in high seismic zones is important towards initiation of disaster mitigation as the damage of a house kills a family but damage to a school creates panic to many families and more importantly next generation. Sylhet, a divisional city of north-eastern region of Bangladesh, is one of the most vulnerable cities of Bangladesh. Literacy rate is more than 70 percent (2) and it is increasing day by day. More than one hundred educational institutions are located in this area. But lots of school and college in this historic city are very old. Most of the existing school and college buildings are 2 or 3 storied reinforced concrete frame buildings with infill brick walls and 1 storied brick masonry buildings with reinforced concrete roofs and using

cement mortar in most of the cases. Just A moderate level earthquake may create a huge damage to property and valuable lives. That is why this earthquake risk assessment is done to evaluate the existing condition of the school and college of this region.

2. STUDY AREA:

Sylhet is one of the rapidly growing metropolitan areas, located in the northeast region of Bangladesh and situated at 24.85° latitude and 91.80° longitudes. Sylhet was changed to a city corporation from a municipal board in 2001 and in 2002 the city was administrated by the Sylhet City Corporation (SCC) and finally was granted metropolitan city status in 31st March 2009(4). SCC occupies a total area of 26.5 sq. km with a population of around 0.5 million. Population density is 17,479/km². There are 22 intermediate college, 36 high schools, 11 English medium school, 7 madrasahs in this city (5). we have collected data from 53 schools and colleges which are located in different Wards of the City Corporations. Here, only the 7 or less than 7 storied reinforced concrete frame buildings are considered

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for the assessment .Figure:1 is showing the locations of the evaluated schools and colleges.

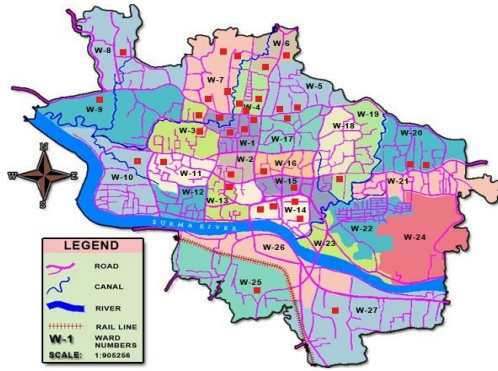


Fig. 1: Location of the surveyed Schools and colleges in Sylhet City Corporation

2. METHODOLOGY:

Different techniques are usually employed to assess the vulnerability of existing buildings which are usually considered as the most vulnerable. These methods were developed for area-wide data collection. Many of them are based on the inventory of structural parameters of the design collected by visual inspections and related to observational data of damage during past earthquakes [6]. Generally seismic vulnerability evaluation follows three main stages: walk-down, preliminary and final evaluations (ozcebe et al, 2003) The masonry buildings, structures more than seven story and those schools that have no permanent educational building are excluded from this assessment. Most of the data were collected from field visit and structural plan of the school and colleges were collected from district education office of Sylhet.

3.1. Walk down evaluation:

The parameters that are surveyed for the walk down evaluation are as follows:

- Number of Stories:
- Existence of a soft Story:
- Existence of heavy Overhangs:
- Apparent Building Quality:
- Existence of short Columns:
- Pounding Effect:
- Topographic Effects:
- Local Soil Conditions:

Based on their number of stories and the seismic hazard level at the site buildings are assigned different base scores as shown in Table 1.

3.1.1. Building Seismic Performance:

Once the vulnerability parameters of a building are obtained from walk down surveys and its location is determined, the seismic performance score PS can be calculated by using Eq. 1. The base scores, BS, the vulnerability scores, VS, and the vulnerability score multiplies, VSM, to be used in Eq. 1 are defined in Tables 4.2 and 4.3, respectively

$$PS = (BS) - \sum (VSM) \times (VS) \quad (1)$$

The weight of each building vulnerability parameter is evaluated by statistical procedures, based on the Duzce database. The results are then smoothed, and the weights of the parameters for which there was no available data (soft story, pounding, topography) are assigned by using engineering judgment.

Table 1: Vulnerability Parameters, (VSM)

Soft story	Does not exist = 0; Exists = 1
Heavy overhangs	Does not exist = 0; Exists = 1
Apparent quality	Good =0;Moderate =1;Poor =2
Short columns	Does not exist = 0; Exists = 1
Pounding effect	Does not exist = 0; Exists = 1
Topographic effects	Does not exist = 0; Exists = 1

3.2 Preliminary Assessment

In many instances statistical analysis based on the observed damage and significant building attributes would provide reliable and accurate results for regional assessments. Yucemen et al. 2004, Ozcebe et al. (2003) and Yakut et al. (2003) employed the discriminate analysis technique to develop a preliminary evaluation methodology for assessing seismic vulnerability of existing low- to medium-rise RC buildings in Turkey. The main objective of the procedure is to identify the buildings that are highly vulnerable to damage. The procedure is applicable to RC frames and frame-wall structures, having up to seven stories. Definition of the discriminating parameters and the procedure to be followed are introduced below. Further details of the proposed method can be reached in the references mentioned above.

Evaluated Parameters for preliminary assessment are as follows

The following parameters were chosen as the basic estimation parameters.

(a) *Number of stories (n)*: This is the total number of individual floor systems above the ground level.

(b) *Minimum normalized lateral stiffness index (mnlstfi)*: The mnlstfi parameter shall be computed based on the following relationship:

$$mnlstfi = \min (I_x, I_y) \quad (2)$$

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Where;

$$I_{nx} = \frac{\sum (I_{col})_x + \sum (I_{sw})_x}{\sum A_f} \times 1000, \quad (3)$$

$$I_{ny} = \frac{\sum (I_{col})_y + \sum (I_{sw})_y}{\sum A_f} \times 1000$$

Where, $\sum (I_{col})_x$ and $\sum (I_{col})_y$ are the summation of the moment of inertias of all columns about their centroidal x and y axes, respectively. $\sum (I_{sw})_x$ and $\sum (I_{sw})_y$ are the summation of the moment of inertias of all structural walls about their centroidal x and y axes, respectively. I_{nx} and I_{ny} are the total normalized moment of inertia of all members about x and y axes, respectively. $\sum A_f$ is the total floor area above ground level.

(c) *Minimum normalized lateral strength index (mnlsi)*: The mnlsi parameter shall be calculated by using the following equation:

$$mnlsi = \min (A_{nx}, A_{ny}) \quad (4)$$

where:

$$A_{nx} = \frac{\sum (A_{col})_x + \sum (A_{sw})_x + 0.1 \sum (A_{mw})_x}{\sum A_f} \times 1000$$

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$$A_{ny} = \frac{\sum (A_{col})_y + \sum (A_{sw})_y + 0.1 \sum (A_{mw})_y}{\sum A_f} \times 1000$$

For each column with a cross-sectional area denoted by A_{col} :

$$(A_{col})_x = k_x \cdot A_{col}, \quad (A_{col})_y = k_y \cdot A_{col} \quad (5)$$

Where; $k_x = 1/2$ for square and circular columns; $k_x = 2/3$ for rectangular columns with $b_x > b_y$; $k_x = 1/3$ for rectangular columns with $b_x < b_y$; and $k_y = 1 - k_x$. For each shear wall with cross-sectional area denoted by A_{sw} :

$$(A_{sw})_x = k_x \cdot A_{sw}, \quad (A_{sw})_y = k_y \cdot A_{sw} \quad (6)$$

Where; $k_x = 1$ for structural walls in the direction of x-axis; $k_x = 0$ for structural walls in the direction of y-axis; and $k_y = 1 - k_x$.

For each unreinforced masonry filler wall with no window or door opening and having a cross-sectional area denoted by A_{mw} :

$$(A_{mw})_x = k_x \cdot A_{mw}, \quad (A_{mw})_y = k_y \cdot A_{mw} \quad (7)$$

Where; $k_x = 1.0$ for masonry walls in the direction of x-axis; $k_x = 0$ for masonry walls in the direction of y-axis; and $k_y = 1 - k_x$.

(d) *Normalized redundancy score (nrs)*: The normalized redundancy ratio (nrr) of a frame structure is calculated by using the following expression:

$$nrr = \frac{A_{tr} (nf_x - 1)(nf_y - 1)}{A_{gf}} \quad (8)$$

Where; A_{tr} is the tributary area for a typical column. A_{tr} shall be taken as 25 m^2 if nf_x and nf_y are both greater than and equal to 3. In all other cases, A_{tr} shall be taken as 12.5 m^2 . nf_x , nf_y are the number of continuous frame lines in the critical story (usually the ground story) in x and y directions, respectively. A_{gf} is the area of the ground story, i.e. the footprint area of the building. Depending on the value of nrr computed from Eq. 8, the following discrete values are assigned to the normalized redundancy score (nrs):

nrs = 0 for ≤ 0

nrs = 1 for $0 < nrr \leq 0.5$

nrs = 2 for $0.5 < nrr \leq 1.0$

nrs = 3 for $1.0 < nrr$

(e) *Soft Story Index (ssi)*: On the ground story, there are usually fewer partition walls than in the upper stories. This situation is one of the main reasons for the soft story formations. soft story index is defined as the ratio of the height of first story (i.e. the ground story), H_1 , to the height of the second story, H_2 .

$$ssi = \frac{H_1}{H_2} \quad (9)$$

(f) *Overhang ratio (or)*: The summation of the overhang area of each story, $A_{overhang}$, divided by the area of the ground story, A_{gf} , is defined as the overhang ratio.

$$or = \frac{A_{overhang}}{A_{gf}} \quad (10)$$

3.2.1 Performance Classification:

The damage index or the damage score corresponding to the life safety performance classification (DI_{LS}) shall be computed from the discriminate function given in Eq. 11.

$$DI_{LS} = 0.620n - 0.246mnlsfi - 0.182mnlsi - 0.699nrs + 3.269ssi + 2.728or - 4.905 \quad (11)$$

In the case of Immediate Occupancy Performance Classification (IOPC), the discriminate function, where DI_{IO} is the damage score corresponding to IOPC, based on these variables is:

$$DI_{IO} = 0.808n - 0.334mnlsfi - 0.107mnlsi - 0.687nrs + 0.508ssi + 3.884or - 2.868 \quad (12)$$

In the proposed classification methodology, buildings are evaluated according to both Performance levels. The steps to be followed are listed below.

(1) Calculate DI_{LS} and DI_{IO} scores by using Eq. 11 and Eq. 10, respectively.

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Table 2: Base Scores and Vulnerability Scores for Concrete Buildings

Number of Stories	Base Scores (BS)			Vulnerability Scores (VS)					
	Zone I (60<PGV<80)	Zone II (40<PGV<60)	Zone III (20<PGV<40)	Soft Story	Heavy Overhang	Apparent Quality	Short Column	Pounding	Topography Effects
1 or 2	100	130	150	0	-5	-5	-5	0	0
3	90	120	140	-15	-10	-10	-5	-2	0
4	75	100	120	-20	-10	-10	-5	-3	-2
5	65	85	100	-25	-15	-15	-5	-3	-2
6 or 7	60	80	90	-30	-15	-15	-5	-3	-2

Table-3: Variation of CMC Values with Soil Type and Distance to Fault

Soil Type	Site class description	Shear Wave Velocity (m/s)	Distance to Fault (km)				
			0-4	5-8	9-15	16-25	>26
B	Rock	>360	0.778	0.824	0.928	1.128	1.538
C	Very dense soil and soft rock	360-760	0.864	1.000	1.240	1.642	2.414
D	Stiff soil	180-360	0.970	1.180	1.530	2.099	3.177
E	Soft soil, profile with >3m of soft clay defined as soil with plasticity index PI>20, moisture content >40%	<180	1.082	1.360	1.810	2.534	3.900

(2) Determine the cutoff values for each performance classification by using Eq. 13.

The LS_{CVR} and IO_{CVR} values in Eqs. 11 and 12 shall be obtained from Table 4.4 based on the number of stories above the ground level. The cutoff modification coefficients CMC values are adjustment factors, which introduce the spatial variation of the ground motion in the evaluation process. These values shall be taken from Table-4.5 based on the building location relative to the fault and the soil type at the site.

$$\begin{aligned} CV_{LS} &= LS_{CVR} + \left| LS_{CVR} \right| \times (CMC - 1); \\ CV_{IO} &= IO_{CVR} + \left| IO_{CVR} \right| \times (CMC - 1) \end{aligned} \quad (13)$$

Table -4: Variation of LS_{CVR} and IO_{CVR} Values with Number of Stories

n	LS_{CVR}	IO_{CVR}
3 or less	0.383	-0.425
4	0.430	-0.609
5	0.495	-0.001
6	1.265	0.889
7	1.791	1.551

(3) By comparing the CV values with associated DI value calculate performance grouping of the building for life safety performance classification (LSPC) and immediate occupancy performance classification (IOPC) as follows:

If $DI_{LS} > CV_{LS}$ take $PGLS=1$

If $DI_{LS} < CV_{LS}$ take $PGLS=0$

If $DI_{IO} > CV_{IO}$ take $PGIO=1$

If $DI_{IO} < CV_{IO}$ take $PGIO=0$

To decide the probable expected performance level of the building the damage scores obtained from Eqs. 11 and 12 should be compared with the story dependent cutoff values obtained from Eq. 13. In each case, the building under evaluation is assigned an indicator variable of “0” or “1”. The indicator variable “0” corresponds to “none, light or moderate damage” in the case of LSPC and “none or light damage” in the case of IOPC. Similarly, the indicator variable “1” corresponds to “severe damage or collapse” in the case of LSPC and “moderate or severe damage or collapse” in the case of IOPC. In the final stage, the building is rated in the “low risk group” if both indicator values are zero or in the “high risk group” when both indicator values are equal to unity. In all other cases buildings are classified as the cases “requiring further study.” Further investigations have indicated that these buildings generally lie in the “moderate risk group.”

4. RESULTS AND DISCUSSION:

Table-1 represents the result of walk down assessment (seismic performance score). Seismic performance score below 40, between 41 to 70 and between 71 to 100 indicates the high risk group, moderate risk group and low risk group respectively. Table-6, table-7, table-8, table-9 and table-10 represents the number of schools and/or

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colleges laid in these categories when the distance to fault is more than 26km, between 16km to 25 km, 9km to 15km, 5km to 8km and less than 4 km. Figure-2 represents the overall scenario quite clearly.

Table-5: Calculated performance scores of the studied school and colleges

No. of Stories	Performance Score(PS)			Total
	PS≤40	40<PS≤70	70<PS≤100	
1&2	0(0)	1(3.2)	30(96.8)	31(100)
3	0(0)	3(23.1)	10(76.9)	13(100)
4	1(11.1)	5(55.6)	3(33.3)	9(100)
Total	1(1.87)	8(15.1)	44(83.2)	53(100)

Table-6: Results of the Preliminary Assessment Method when distance to fault > 26.km.

No. of Stories	High Risk Group	Moderate Risk Group	Low Risk Group	Total
≤2	0(0)	0(0)	31(100)	31(100)
3	0(0)	1(7.69)	12(92.3)	13(100)
4	0(0)	2(22.22)	7(77.7)	9(100)
Total	0(0)	3(5.56)	50(94.3)	53(100)

Table-7: Results of the Preliminary Assessment Method when distance to fault is between 16 to 25km.

No. of Stories	High Risk Group	Moderate Risk Group	Low Risk Group	Total
≤2	0(0)	1(3.23)	30(96.7)	31(100)
3	0(0)	2(15.38)	11(84.6)	13(100)
4	0(0)	2(22.22)	7(77.8)	9(100)
Total	0(0)	5(9.43)	48(90.6)	53(100)

Table-8: Results of the Preliminary Assessment Method when distance to fault is between 9 to 15km.

No. of Stories	High Risk Group	Moderate Risk Group	Low Risk Group	Total
≤2	0(0)	5(16.13)	26(83.8)	31(100)
3	1(7.69)	3(23.1)	9(69.2)	13(100)
4	3(33.3)	2(22.2)	4(44.4)	9(100)
Total	4(7.55)	10(18.9)	39(73.6)	53(100)

Table-9: Results of the Preliminary Assessment Method when distance to fault is between 5 to 8km.

No. of Stories	High Risk Group	Moderate Risk Group	Low Risk Group	Total
≤2	1(3.22)	6(19.3)	24(77.4)	31(100)
3	1(7.69)	3(23.1)	9(69.2)	13(100)
4	3(33.3)	3(33.3)	3(33.3)	9(100)
Total	5(9.43)	14(24.2)	33(62.3)	53(100)

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Table-10: Results of the Preliminary Assessment Method when distance to fault is <4km

No. of Stories	High Risk Group	Moderate Risk Group	Low Risk Group	Total
≤2	2(6.45)	9(29.03)	20(64.5)	31(100)
3	1(7.69)	6(46.2)	6(46.2)	13(100)
4	3(33.3)	2(22.2)	4(44.4)	9(100)
Total	6(11.3)	17(32.1)	30(56.6)	53(100)

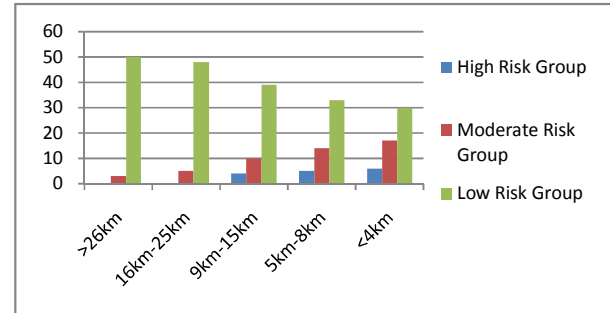


Fig-2: Change of vulnerability with distance to fault

5. CONCLUSION:

In Bangladesh, one of the major work tasks consists in the identification of the structural seismic vulnerability of schools and college. The integrity of schools and college buildings during an earthquake disaster is of utmost importance. Since the sylhet region is located near the Dauki fault zone, an earthquake of moderate level may cause a heavy damage to life and property. Some recommendations which are the outcome of the study is given below that should be followed to minimize the vulnerability of the school and/or college building:

- Structural assessment should be carried out for the schools and college building which are in most seismic vulnerable group.
- Rapid measures should be taken to repair the buildings which are in low and moderate seismic assessment group.
- Proper earthquake guideline should be followed at the time of constructing new educational buildings.
- Some buildings ,which are in very high risk as well, should not be used any longer

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ECO-HOUSING: MATERIAL TECHNOLOGIES FOR A SUSTAINABLE BUILT ENVIRONMENT

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Eco-Housing is an environmentally and economically optimized designed environment with the objective to deliver resource efficient built infrastructure through improved energy and material performance. Material efficiency can contribute to the economic, environmental and social benefits of a country. The two most common materials used in indigenous construction in Bangladesh are clay and bamboo. However, with growing population the availability of these materials, particularly bamboo, is decreasing and their prices are increasing. The structures built with clay and bamboo are also proving to be vulnerable to natural damages and destruction such as by seasonal flooding, cyclones and time borne decay, leading to short life spans and adding to the burden of scarce supply. Currently the trend towards replacing traditional building materials to better withstand flood, cyclone and other natural agents of destruction is by the use of CI sheets. But this is not a positive development. CI sheets have a much higher embodied energy, their recycle is not very convenient and their thermal performance is very poor. The HBRI eco-housing project demonstrates better and cheaper material alternatives and technologies that can be replicated all over the country delivering much better environmental and economic performance of housing materials.

Key words: Eco-housing, sustainability, materials, green technology, appropriate technology

1. INTRODUCTION

The United Nations has used the term “Eco-Settlement” since 1972 to define sustainable built-infrastructure. From 2004, the United Nation’s Environment Program (UNEP) and UN HABITAT have been setting up guidelines to implement examples of Eco-Settlements in the Asia Pacific region, identifying it as a flexible, bottoms-up approach that can reduce the negative trends of the construction sector and release environmental and energy-saving benefits (UNEP, 2006). With emphasis in four key areas: knowledge building, educational initiatives, networking and demonstration projects, these organizations have realized that despite the wide acceptance of the concept, a lack of demonstration projects is preventing the political decision making process. As a result, the UNEP and UN-HABITAT have implemented several eco-housing demonstration projects in countries of Asia, including Indonesia, the Maldives, Sri Lanka, Thailand, China and Bhutan. As a result of these developments, in 2006, the HBRI submitted a proposal to the Government of Bangladesh (GOB) for a project titled: Study on Eco-Housing, Ferro-cement Floating House and Polymer in Cement Concrete Using Indigenous Materials with a view to create an eco-housing

demonstration project in the country which would provide an illustrative example of how the building sector can contribute to give a relief pressure on the material and energy sector (electricity, fuel, and other resources) of Bangladesh as well as provide large scale environmental benefits. The project was approved for the 2007-2008 financial year – its execution started in July 2007 and was completed in December 2008.

2. BUILDING MATERIAL – AN IMPORTANT COMPONENT OF SUSTAINABLE SETTLEMENT

The guidelines of the United Nations Environment Program, UNEP (2006, pp.26-27) and UN-HABITAT on eco-housing laid emphasis on eight key areas, the selection and use of proper building materials is one very significant part of them. The guidelines, in particular, laid emphasis on using natural and rapidly renewable materials as below:

“Use naturally available materials, especially organic renewable materials like timber, trees, straw, grass, bamboo etc. Even non-renewable inorganic materials like stone and clay are useful, since they can be reused or recycled.” (UNEP-IETC, 2004, p.27-29)

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The guidelines of the US Green Building Council (USGBC) in its eco-labeling tool, Leadership in Energy and Environmental Design (LEED) has put similar emphasis on eight major areas of which the selection and use of building materials is one of them. According to LEED a green construction earns point in the material and resources category by following the criteria below:

“Reuse building materials and products to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources. Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation. Reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials.” (USGBC, 2010, pp. 51-54)

From the above discussion, it is clear that eco-friendly materials are in general characterized by those that are locally available, that can be easily recycled, reused or rapidly renewed (for short life cycle natural materials such as bamboo); in addition having properties of low-embodied energies, low emissions and low cost. Some of these building materials are mostly made from naturally available materials like clay, stone, sand or biomass.

3. HOUSING TYPES & MATERIAL USE IN BANGLADESH:

In Bangladesh, 82% households in the rural and 47% households in the urban areas are made from non-permanent (*kutch*a) building materials (table 1) making them vulnerable to flood, cyclone, weathering and natural decay. Increasing the longevity of these structures could not only provide economic benefits, but can also reduce the need for new construction materials.

Structure	Urban		Rural	
	Nos.	%	Nos.	%
Jhupri	420	7.58	1767	9.15
Kutch	26.11	47.15	15873	82.19
Semi-pucca	1288	23.26	1222	6.33
Pucca	1219	22.01	450	2.33
Total	5538	100	19312	100

Table 1. Dwelling households by the type of structure (BBS, 2001)

According to general longevity of the construction material, traditional houses in Bangladesh are

popularly classified into four main groups – *jhupri* or informal house, *kutch*a or impermanent house and *pucca* or permanent house. A sub-group *semi-pucca* denotes a combination of permanent and impermanent materials. Following is a categorization of the main construction materials used in traditional house forms in Bangladesh (Ahmed, 2005):

<i>Kutch</i> a House	Semi <i>Pucca</i> House	<i>Pucca</i> House
Foundation		
Earthen plinths with bamboo and sometimes timber posts	Earthen plinths; Brick perimeter wall with earth infill; Brick and concrete.	Brick and concrete.
Wall		
Organic materials – jute stick, catkin grass, straw, bamboo mats, etc. Split bamboo framing. Earthen walls in some areas	Bamboo mats; CI sheet; Timber (sometimes split bamboo) framing. Earthen walls in some areas. Sometimes part or full brick.	Brick
Roof		
Thatch rice or wheat or maize straw, catkin grass, etc with split bamboo or sometimes reed stalk framing.	CI sheet with timber framing (sometimes split bamboo)	Reinforced concrete

Table 2. Major house building materials in Bangladesh (Ahmed, 2005)

According to material used in construction, traditional houses in Bangladesh can also be categorized as follows (Murshed, 2006):

3.4 Mud Houses:

One-third in this country live in mud houses because of its widespread availability, relatively permanent nature and cheaper construction cost. In the Rajshahi region, double storied mud houses are common, and in the Jessore single storied mud house are predominant. In some regions, houses are made with mud blocks mixed with rice husk while in others layers of clay are used directly for construction. The wall thicknesses typically vary from 10" to 24". Mud houses are primarily available in the western part and hilly area of less flood prone regions of the country. Thatch, clay tiles and CI sheeting are typically used in roofing these houses.

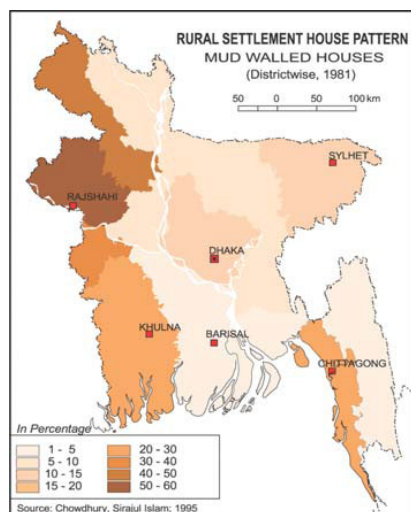


Figure 1: Prevalence of Mud Walled Houses in Bangladesh (Chowdhury, 1988; 1995)

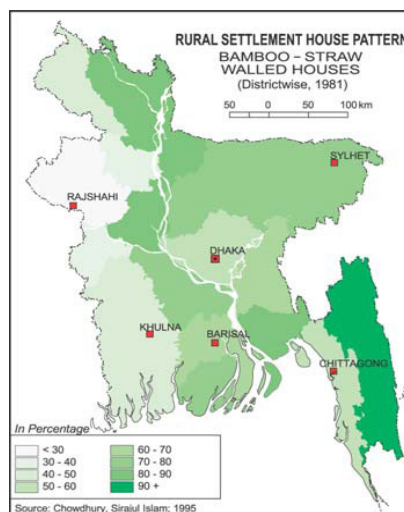


Figure 3: Prevalence of Bamboo Structures in Bangladesh (Chowdhury, 1988; 1995)

3.5 CGI Sheet House:

Corrugated galvanized Iron (CGI) sheet houses are available all over the country. Local NGOs provide loan of about 10,000/- (Taka ten thousand) to 20,000/- (Taka twenty thousand) to use in the improvement of the house – a mechanism that has rapidly transformed the indigenous house into CGI houses. A CGI sheet house carries considerable social prestige in the rural areas. Variations in the design, size and height of the houses are related to the status and wealth of the family. In Faridpur, Madaripur, Barisal, Patuakhali and Bhola CI sheet houses are also common where the material is used for both roofing and wall construction. In the central part of the country, as in Dhaka, Comilla and Mymensingh CI sheets are mainly used for roofing with mud or mud block walls.

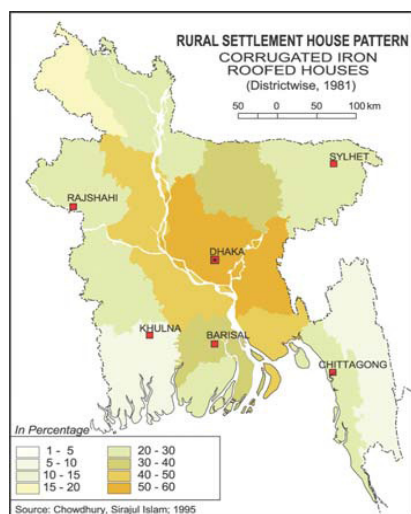


Figure 2: Prevalence of CI Sheet Houses in Bangladesh (Chowdhury, 1988; 1995)

3.6 Bamboo House:

Bamboo structures commonly found all over the country are relatively richer in the north-eastern and south-eastern parts. The Tribal house is an excellent example of indigenous bamboo house where the roof, the walls and even the floors are made with bamboo, raised on a platform to keep away wild animals, flash flood and landslide. Bamboo structures by virtue of flexibility of the material are typically more resistant to natural disasters like high wind and flood. Besides being low cost, bamboo is strong, durable and flexible which can sustain the structure under high wind.

3.7 Wooden House:

Wooden houses are common in the Madhupur Tracts and in the Chittagong Region because of the nearby forests. Timber houses in Chittagong are typically two storied, exceptions being those in the south. The houses of the Rakhain and Moghs are also of timber, but they are built on stilts. The prosperous Moghs have double-storied houses with curved balconies and lintels. The timber house in Sylhet usually have the floor and sometimes part of the lower walls made out of brick, while the walls are constructed of reeds called Ikra (*Erianthus ravaneae*) or bamboo matting plastered over with cement or mud on both sides and painted white; a frame of timber, painted black holds these up. The roof is usually of CI sheet, and sometimes of straw.

Houses located in the flood plains of the major rivers are subject to various hazards, like riverbank erosion, so people are compelled to invest as little as possible in housing. In a majority of the cases these houses have walls of jute sticks with mud dubbed on and thatching of paddy straw. In the marshy and low lands (Haor basin, Chalan Beel)

and in the islands (char lands), cheap construction materials like locally available reeds, long grass, jute sticks etc. are widely used both for roofing and wall construction. Kitchens, cowsheds, poultry coops, etc are typically built separate and usually with poorer materials. Except in the north-western and central regions where the cowsheds are thatched well and stand higher; poor sheds are rather more common.

4.0 TRADITIONAL HOUSE – ITS VULNERABILITY TO DISASTERS:

4.1 Flood

Due to its geographical location, natural disasters are a common phenomenon in Bangladesh, the most significant being flood (Hossain, 2002); almost every year the country is flooded once, even twice or sometimes more. According to Ahmed (2005, p. 3) damage to house forms caused by flood are primarily due to: (a) Direct flood hazard: which are closely related to (i) Flood depth, (ii) Flood duration, (iii) Uplift due to soil saturation and (iv) Horizontal force created by flood waves or currents; (b) Indirect flood hazard: secondary hazards such as high winds or storms, lightning, slope instability, ground settlement, etc.; and (c) Sustained flood hazard: floodwater can submerge buildings and cause various degrees of damage from staining of walls to structural collapse depending on flood depth and/ or duration and type of building. Brick and concrete (pucca) foundations are relatively stable under the affects of flood. In semi-pucca houses, the infill earth floor may settle and in prolonged flood can become muddy, unstable and the mud can escape from below. In kutchha houses both low and high intensity flood tend to wash off the mud plinth. In kutchha houses prolonged or recurring flood tend to rot the base of the bamboo or timber posts in saturated soil of the plinth. Rotting of the base weakens the entire structure making it vulnerable to strong winds, differential settlement, sagging of roofing elements and doors, windows and wall elements developing cracks and losing alignment (Ahmed, 2005).

Organic jute stick and catkin grass walls have a lifespan of 2-3 years and bamboo mat 4-5 years (Ahmed, 2005). Corrugated Iron (CI) sheet on timber framing corrodes due to contact with water and gets aggravated in flood. If not sufficiently above flood level the lower parts of walls are the most vulnerable. Monolithic earth wall construction can get seriously damaged by flood once the base gets affected, the entire structure may collapse. Brick walls are relatively durable. Roofs in kutchha houses are typically made from catkin grass, rice, wheat or maize straw usually on bamboo and

sometimes reed stalk framing. Normally these have to be renewed every 2-3 years (Ahmed, 2005). Decay occurs if thatch comes into contact with flood water or gets washed off in strong driving rain. Roofs in semi-pucca house are typically made from CI sheet with timber or bamboo framing. CI sheets are vulnerable to corrosion in damp atmosphere. A greater hazard occurs in strong wind when CI sheets are crumpled and blown off. Reinforced concrete (RC) roof is relatively durable.

4.2 Other Natural Disasters

Riverbank erosion is most common and a regular hazard in Bangladesh and rural housing is directly affected by it. About 10,000 hectares of agricultural land erodes every year and bank erosion ranges from 250-800 meters every year (BWDB, 2010). The three major rivers Padma, Jamuna and Meghna bank erosion happen frequently and the most vulnerable districts are Sherajgonj, Chandpur, Faridpur. People become land and homeless and take shelter on the sides of major roads and highways.

Traditionally cyclones of varying intensity hit parts of Bangladesh almost every year and super cyclones typically occur after every 10 years; but due to global warming and climate change the frequency of cyclones has increased. In the last few years super cyclones Sidr and Aila hit the coastal regions of the country causing large scale death of humans and cattle and damage to households and crops. Particularly Cyclone Sidr (15-16 November, 2008) damaged 565,000 households fully and 957,000 partly. On the other hand, cyclone Aila (25- 26 November 2009) damaged 243,000 households fully and 371,000 households partly (CDMP, 2008).

According to Lewis and Chisholm (1996) efforts to improve traditional houses to withstand cyclone has not gained popularity primarily because:

- High storm surges accompanying cyclones have tended to sweep away kutchha and semi-pucca structures regardless of their quality
- Poorly maintained or absence of embankments have failed to protect households in their places
- A general tendency to invest little in improved construction exists because villagers feel their investments would get washed away in the next storm

However, improved construction can deliver several possible benefits as below:

- Continued occupation of homes during cyclones
- Reduction in need of safe heavens (cyclone shelters)

- Avoidance of dangers of travelling between homes and safe heavens
 - Reduction of time away from home and attendant risk of theft
 - Greater ability to use roofs for both kutchra and pucca dwellings as refuge during floods
 - Reduction of the recurrent costs of dwelling reconstruction/replacement, enabling people to stay safely in their own homes, relieve over-crowding in safe heavens
- (Lewis & Chisholm, 1996)

5. HBRI ECO-HOUSING - SOLUTION FOR SUSTAINABLE HOUSING

Ahmed (1996, p. 39) has shown that contrary to popular belief traditional local building materials are no longer so widely available nor are they always cheaper. The standard recommendations of “eco-settlement” guidelines (paragraph 2) therefore, need to be revisited in terms of the use of bio-mass and availability of the most common building material in Bangladesh which is bamboo. Bangladesh Bureau of Statistics census of 1981 indicates that the majority of the houses use bamboo in construction whose prices are rising due to a growing scarcity (Ahmed I., 1996). Moreover, various Non Governmental Organizations (NGOs) such as the Grameen Bank and BRAC are providing loans to build improved housing which can help significantly in overcoming technical and cost constraints in selecting house building materials.

With a scenario as such the HBRI Eco-Housing demonstration project has researched and developed eight prototype dwelling units that show examples of improved material and technological performance. The project is located within the HBRI campus in Mirpur, Dhaka spread over 40 Kathas of land. It consists of eight rural type units each 480 square feet in plan and one urban type unit 1230 square feet in floor space. The units are for residential use and incorporate renewable energy technologies – bio-gas, wind and solar power and improved building materials.

The flood resistant properties of the dwelling units have been enhanced by adopting several design parameters. These are described below:

Plinth: A brick perimeter wall has been used in the construction of the plinth and filled with compacted sand to prevent the washing away and damaging impacts of recurrent and prolonged flood water. Sand fill prevents the seepage of dampness through capillary action that rots organic structural members – bamboo frames in typical mud plinths.

Wall & Roof: the most vulnerable part of traditional non-permanent wall construction is the lower edge which is recommended to be protected from the affects of water. Rural unit 2 made from bamboo mat and golpata (nipa palm) thatch roof most closely resembles the traditional impermanent rural structures. The wall has been protected from rain by a large overhang of the roof. Further, the gopata offers additional protection against rain by its inherent property; it does not easily decay in contact with water. Furthermore, to provide additional strength, chemically treated bamboo frame has been used. The lower parts have been dipped in tar and the whole bamboo and thatching material have been treated chemically to prevent decay. Firm anchoring of the frame has been ensured with the plinth, thereby, ensuring that extra strength is imparted to the roof and frame to withstand cyclonic conditions.



Figure 4: Prototype 4 Ekraw wall construction

Similar structural features have been followed in rural unit type 4 built with a stabilized brick perimeter wall, neat cement finish and compacted sand fill construction of the plinth. The wall has been constructed using bamboo mat wall, but water proofing has been achieved by plastering the wall surface – an indigenous construction technique called Ikra wall popular in the Sylhet region. The plastering process greatly enhances the longevity of the structure by keeping out dampness and makes it very much flood resistant.

The structural frame has been made with reinforced cement concrete (RCC) pillars of 4” by 4” square section supporting a mild steel framing anchored firmly on the RCC pillars and covered with corrugated iron (CI) sheeting. The strong structural frame greatly enhances the flood, cyclone and

weathering resistant properties of the materials used. Instead of a gabled roof, hipped gabled roof has been designed which offers greater protection from cyclonic wind (Lewis & Chisholm, 1996) (Ahmed K. I., 2005). Roof overhand and gutter to collect rainwater further prevents dampening of the wall material and prevents water borne decay of wall material.

The CI roof has been properly ventilated by leaving an air gap between the wall and the roof to allow convective cooling by air flow. However the hip gable traps the hot air which can only escape through the leaks, causing a heat build-up inside. A proposal has been forwarded to provide heat insulation by installing styro-foam false ceiling which has not been executed yet.



Figure 5: Rural type unit 3

Rural type unit 3 uses concrete hollow block walls and ferro-cement roof material on a stabilized brick walled plinth. Ferro-cement materials have the advantage of high crack resistance and impermeability to water. The basic raw materials are widely available and construction skills can be easily acquired. These also require little maintenance and do not involve complex equipment in construction (Ahmed K. I., 2005). Furthermore, nowadays with micro-credit or loans provided by NGOs, these materials have come within the affordability of the rural people. The unit presents an attractive alternative for building rural structures which would be much more resistant to flood and cyclonic damages. The dead weight of the roof gives the added advantage of being a stabilizing agent in strong cyclonic wind.

Rural type unit 6 has a similar ground plan and layout, with the exception of the wall structure which is made with Rat-trap bonding. The bonding saves the number of bricks required to construct a similar area of 10" wall, but gives much better thermal insulation and moisture protection. The space between two rooms in plan has been provided to allow women to engage in income generation activities. The gable angle of the roofs has been kept from 30 to 40 degrees which has been shown by prior research to offer greater resistance to

cyclonic wind (Lewis & Chisholm, 1996). Once again, the dead weight of the structure gives considerable anchoring.



Figure 6: Rural type unit 2

Rural type 2 has four dwelling units and is designed to serve as a dwelling in semi-urban areas. The wall material has been derived from recycled demolished concrete blocks. Demolished concrete from a pulled down building in the city (Rangs Bhaban) was transported to the site where the blocks were crushed using a motor operated crushing machine to yield a mixture of coarse and fine aggregates. Cement and water was mixed with the latter and cast into blocks to create concrete bricks. To allow easy workability, a 10" by 10" square block was used as traditional masons are habituated to working in brick modules. Any larger size makes the blocks too heavy for workability. The use of recycled demolished material reduces landfill and need for pristine materials, which produces saving and useful recycling of construction waste. The use of *pucca* or permanent materials makes the dwelling units much more stable under flood and cyclone conditions; therefore, they provide examples of improved housing solutions for the rural areas of Bangladesh.

The two units made from bamboo mat walls and traditional roofing also use improved technology of plinth construction, strong frame construction, treated bamboo, wall and roofing which make them much more durable and resistant to common flooding and cyclone related damages as compared to traditional rural structures made from similar materials. The following tables provide a summary of the relative advantages of each type of construction over similar conventional buildings:

Unit 2: Demolished concrete construction	Conventional concrete construction
Recycled material	New material
Concrete ratio 1:4:7 in which only cement and ¼ of course sand required additionally	Concrete ratio 1:4:7 (cement: sand: course aggregate). All new materials required
9.5"×9.5"×2.75" block	9.5"×9.5"×2.75" block

size costing Tk. 23/- per block	size costing Tk. 40 /- per block
Only crushing energy required	Requires manufacturing energy of raw materials
Ferro cement roof	R.C.C. roof
Pre cast	Cast in situ
Requires less time in construction	Requires more time in construction
Cost Tk. 150-170/ sft	Tk. 200-250/ sft

Table 3: Studied benefits in Unit 2

Unit 3: Hollow block wall	Conventional brick wall
7.5"x17"x4" block size costing Tk. 25/- per piece	9.5"x4.5"x2.75" bricks size costing Tk.5/- per piece
Per cubic feet wall construction cost less	Construction cost more
No need for plaster	Plaster needed
Ferro cement roof	R.C.C. roof
Pre cast	Cast in situ
Requires less time in construction	Requires more time in construction
Costs Tk. 100/ sft	Costs Tk. 200-250/ sft

Table 4: Studied benefits of Unit 3

Unit 4: Treated Bamboo & Nipa Palm	Ordinary Bamboo Construction
Treated bamboo pillar average life time is about 10-15 years	Ordinary bamboo pillar life span about 2-3 years
Designed to be stable under strong wind	Roof tend to blow away in cyclone
Golpata roof effective under suction wind effect (better able to withstand cyclone)	CI sheet roof is venerable under suction wind effect

Table 5: Studied benefits of Unit 4

Unit 5: Hollow brick wall construction	Typical 10" thick brick wall construction
10" brick hollow wall (Rat-trap bonding)	10" brick solid wall (English/Flemish bond)
30% brick saving	-
Ferro cement corrugated sheet roof	Ordinary R.C.C. roof
Pre cast	Cast in situ
Requires less time in construction	Requires more time in construction
Construction cost Tk. 100/ sft	Tk. 200-250/ sft

Table 6: Studied benefits of Unit 5

Unit 6: Ekra wall	Ordinary 5" brick wall
Economical	Less economical
Durable (life time more)	Durable

than 50 years)	
Wall thickness 2"-2.5", space saver	Thickness 5"
Construction cost Tk.52/ sft	Cost Tk.60-70/ sft

Table 7: Studied benefits of Unit 6

6. RECOMMENDATIONS

Materials chosen for construction play an important role in determining the longevity and hazard resistant properties of the overall dwelling unit. Bangladesh, due to its geographic location, is vulnerable to flood, cyclone, river erosion and other water related disasters. Making structures capable of withstanding water borne damages is a challenge. Even though common wisdom to sustainable built structure suggest that fast growing organic materials such as bamboo is most appropriate for rural home construction, and even though it is being used as such, studies suggest that such organic materials are increasingly becoming scarce and expensive (Ahmed I. , 1996). The incentive in disaster prone areas to build more robust housing is also less as rural population in these areas feel their investments on their housing units vulnerable that would be lost in the next flood or cyclone (Lewis & Chisholm, 1996). If cyclone and flood resistant structures can be shown to survive in these areas, the people would be willing to spend on building more permanent infrastructure. Simple technology such as the construction of brick walled plinths and concrete pillars are now becoming available in the rural areas. With a little training and economic support in terms of micro-credits and loans that are increasingly becoming available through various NGOs and foreign aid agencies, the modern structures demonstrated in the eco-housing project can become easily replicable ones.

The replacement of traditional materials – clay and bamboo, is already taking place by CI sheets. NGOs and various foreign aid agencies are providing CI sheets to disaster affected areas and the ability to sell CI sheets during financial difficulty is making it a liquid asset. But the thermal and material properties (embodied energy, recycle value etc.) of CI sheet make it a non-sustainable building material. If replacements must be made of bamboo and clay as base material for rural housing, the eco-housing units show several much more effective alternatives than CI sheet houses. It is desirable that the transition of rural housing from traditional materials to modern ones be guided towards much more environmentally positive and better performing alternatives as demonstrated by the eco-housing units.

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EFFECT OF SOFT STOREY IN REINFORCED CONCRETE FRAME STRUCTURES

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The present study was aimed at findings out the effect of soft storey on frame structures due to lateral loading. The masonry infill was modeled by equivalent struts and finite element package ANSYS 5.6 was used for the development of the model. Two different theories for modeling the equivalent struts i.e. Mainstone and Saneinejad theory were used. Deflections of building frame having soft storey at the ground floor were 1.4 to 2.0 times greater than that observed excluding the soft storey effect. The effect of soft story was more significant in case of less stiffer Reinforced Concrete (R.C.) frame structures. Storey level had a great influence on the deflection of a soft storey building frame due to additional lateral loads on added floors. Deflections of R.C. frames with 5 inch wall thickness having soft storey were observed 1.15 times greater than that with 10 inch wall thickness. As the beam and column size increases, deflection pattern decreases with increased stiffness. Deflections of R.C. frame using Saneinejad Theory of Equivalent Strut Modeling were slightly larger than that by Mainstone Theory.

Key words: Infill; Soft Storey; Equivalent Struts; Saneinejad Theory; Mainstone Theory.

1. INTRODUCTION

Usually in structural analysis only the bare reinforced concrete (R.C.) frame is modeled ignoring the effect of infills with the assumption that such modeling is rather conservative and computationally more efficient. However such assumption may lead to substantial inaccuracy in predicting the lateral stiffness, strength and ductility of a structure. When an infill frame is subjected to lateral loading, the infills behave effectively as strut along its compression diagonals to brace the frames. The behavior of masonry infilled frame structures has been studied in the last four

decades in attempts to develop a rational approach for design of such frames. Present code of practice does not include provision of taking into consideration the effect of infill. It can be understood that if the effect of infill is taken into account in the analysis and design of frame, the resulting structures may be significantly different. Therefore, a study is undertaken which will involve the finite element analysis of the behavior of High-Rise R.C. frame with brick masonry infill. Again when a sudden change in stiffness takes place along the building height, the storey at which this drastic change of stiffness occurs is called a

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soft storey. A soft storey is the one in which the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average stiffness of the three stores above (BNBC, 1993). The infill components increase the lateral stiffness and serve as a transfer medium of horizontal inertia forces. From this conception the floors that have no infill component has less stiffness regarding other floors.

The major objectives of the research work were as follows:

- To find out the influence of masonry infill wall panel in Reinforced Concrete framed Structures in terms of deformation.
- To study the behavior of frame with brick masonry infill by modeling masonry infill as a diagonal strut. The Finite Element package ANSYS 5.6 (Manual of ANSYS 5.6) is to be used for the development of the model.
- The present study was aimed at findings out the effects of wall thickness on frame structures due to horizontal loading.
- Two different theories (Mainstone and Saneinejad theory) of developing equivalent strut model were analyzed in this work and comparisons of these models were also made.

2. METHODOLOGY OF THE WORK

Finite element technique is a powerful and versatile tool for the analysis of problems of structural and continuum mechanics. In this study a linear finite element analysis was performed using the package ANSYS to predict the inelastic behavior of R.C. high-rise frame with brick masonry infill. The finite element analysis of infilled frames includes modeling of beams and columns, modeling of masonry infill, calculations of wind and earthquake load according to BNBC code, generation of finite element mesh with infill.

2.1 Finite Element Discretization

The ultimate purpose of finite element analysis is to predict mathematically the behavior of actual engineering system. In complete modeling, BEAM44 3-D Elastic Beam element was used to represent beams and columns. LINK10 3-D spar element was used to model masonry infill as a diagonal strut against lateral load. This model comprises all nodes, elements, material properties, geometrical properties, boundary conditions and other features that were used to represent the physical system. 2-D analysis was performed in this study. Since the

analysis was based on nonlinear elastic material response, it provides the information about the nature of stress distribution and deformation rather than the ultimate behavior of the structure.

For appropriate modeling of R.C member two types of elements, one for concrete and other for reinforcement are required and two types of material properties are also required for both these elements but in this analysis, reinforced cement concrete frame was assumed as a homogeneous and isotropic material. To model the R.C frame, Beam44 3-D elastic beam was selected from ANSYS element library. For Beam44 3-D elastic beam, reinforced concrete properties were used. In R.C high-rise frame, in addition to the use as partition walls, the infill can also be used for increasing stability and reducing displacement against lateral load. To model brick masonry infill, it was considered masonry infill to be act as a diagonal strut against lateral load according to the equivalent strut method. Since the tensile strength of masonry is negligible, only compression diagonal strut is liable to resist the lateral load. In this analysis the element LINK10 3-D spar was used to represent equivalent diagonal strut.

First to model the equivalent diagonal strut in this study, the width of the equivalent strut was calculated by taking into accounts the formulations developed by Stamford-Smith and Carter (1969) and Mainstone (1971). Also in another method of equivalent strut formulation, where the area of diagonal strut was found 66450 mm^2 by Saneinejad and Hobbs (1995) formula. In this study a 10 storied building frame was analyzed. The cross section of columns and beams were taken $305 \text{ mm} \times 305 \text{ mm}$. For analysis, 3.0 and 2.0 percent reinforcement were considered in columns and beams respectively.

3. DATA TABULATION

In modeling Plane frame, the following material properties and geometrical properties have been used for beam, columns, masonry infill.

3.1 Beam and Columns

3.1.1 Material properties: The following material properties of normal weight concrete have been provided for finite element analysis of building frames:

- Density, $w_c = 8.68 \text{e-}^2 \text{ lb/in}^3$
- Compressive strength, $f_c = 4000 \text{ psi}$

- Young's modulus of elasticity, $E_c = 3e6$ psi
- Poisson's ratio, $\nu_c = 0.15$

3.1.2 Geometrical properties: The following sectional properties have been used for beams and columns:

Column: Cross-section = 12 in x 12 in

Beam: Cross-section = 12 in x 12 in

3.2 Masonry infill:

3.2.1 Material properties: The following material properties have been used for masonry infill:

- Density, $w_c = 6.94e^{-2}$ lb/in³
- Compressive strength, $f_c = 1740$ psi
- Young's modulus of elasticity, $E_c = 1.2e6$ psi
- Poisson's ratio, $\nu_c = 0.16$

3.2.2 Geometrical properties: Thickness of infill = 5 in

3.3 Loads

In the present investigation, wind load and earthquake load has been chosen as the source of lateral loading on the building frame as set forth by the provision of Bangladesh National Building Code (BNBC, 1993). A 10-storied building has been selected to carry out this study. Fig. 1 shows the plan of the building. The structure is 48ft x 36ft in plan dimension and per floor storey height of the building has considered as 10ft. Loads are shown in Fig. 2 and Fig. 3.

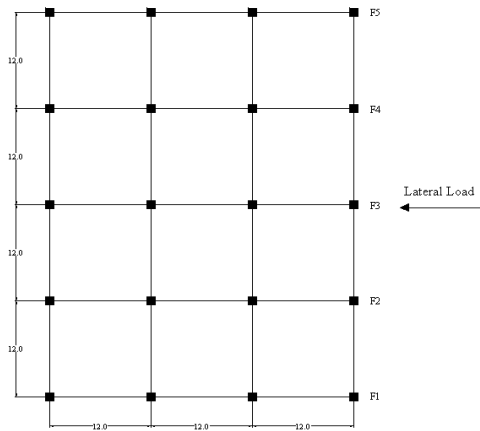


Fig. 1: Plan of the building

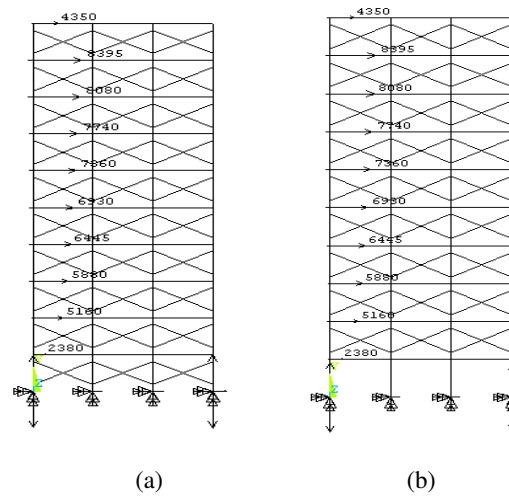


Fig. 2: Elevation of 10-story building frame (F2) with calculated wind load at each floor level (a) without soft story effect, (b) with soft story effect (Loads are in kips)

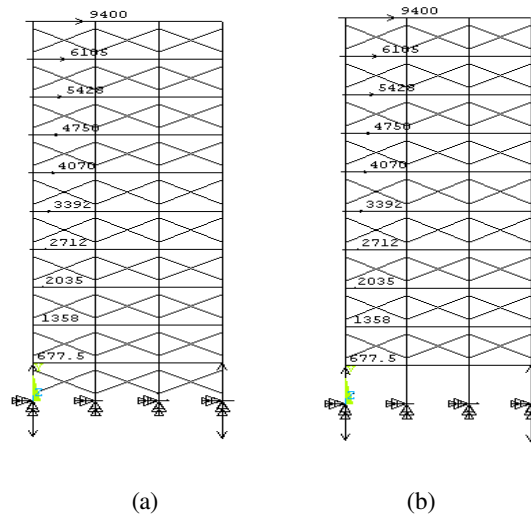


Fig. 3: Elevation of 10-story building frame (F2) with calculated earthquake load at each floor level (a) without soft story effect, (b) with soft story effect (Loads are in kips)

4. RESULTS AND DISCUSSIONS

The main objective of this investigation is to study the effect of horizontal loading on reinforced concrete frame with brick masonry infill for soft storey conditions. In this analysis the frame was assumed to be restrained at ground floor level. Deflections are one of the most important parameter to be considered in the design and analysis of a tall building. Therefore deflections for lateral loads (wind and earthquake loads) was studied according to Mainstone theory of equivalent strut method for different cases and

comparisons were also made. The different cases are: deflections for various no. of bay, deflections for variable storey frame and deflections for various spans of bay. In this study comparison of deflections of a 10-storey 3-bay building frame for different geometrical properties of beams, columns and infill walls were made. Also deflections were measured for two different theories of equivalent strut method (Mainstone theory and Saneinejad theory) and comparisons were also made.

4.1 Effect of Number of Bay

By using a 10-storey building frame of 12 ft bay length analysis was done for both wind and earthquake loads. Comparisons of deflections of the frame for different soft storey conditions and for different no. of bay have been graphically shown in Fig. 4. Due to the incorporation of soft storey at ground floor, the top deflections of a 10-storey building frame turned into 1.6 to 1.8 times than the usual deflections having no soft storey in case of lateral loads. Also the top deflections became 2.2 to 2.4 times higher as no. of bay reduces from 8 to 4. Because for different no. of bay parallel to wind direction, the wind load at every storey level remains same but as the no. of bay increases, the stiffness of the frame for resisting this load increases. As a result, the maximum top deflection of the frame decreases as no. of bay increases in case of wind load. But for earthquake loading, as no. of bay increases both the load and stiffness increases; and the rate of increase of stiffness is higher than that of load. As a result, similar bar chart for the maximum top deflection of the frame was found for earthquake loading.

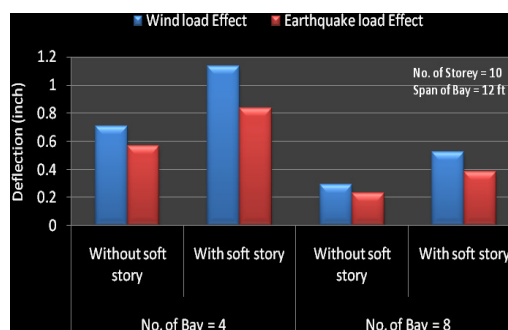


Fig. 4: Maximum top deflection of R.C. frame due to lateral loads for various no. of bay parallel to load direction

4.2 Effect of Number of Storey

By using a 3-bay building frame of 12 ft bay length analysis was done for both wind and earthquake loads. Comparisons of deflections of the frame for different soft storey conditions and for different no. of storey have been graphically shown in Fig. 5.

Due to the incorporation of soft storey at ground floor, the top deflections of the R.C. frame turn into 1.4 to 2.0 times than the usual deflections having no soft storey in case of lateral loads. Also the top deflections became 3.2 to 4.4 times higher as no. of storey increases from 6 to 10. As the no. of storey level increases, there are additional lateral loads added for increased storey level. As a result, the maximum top deflection of the frame amplifies rapidly with increased storey level.

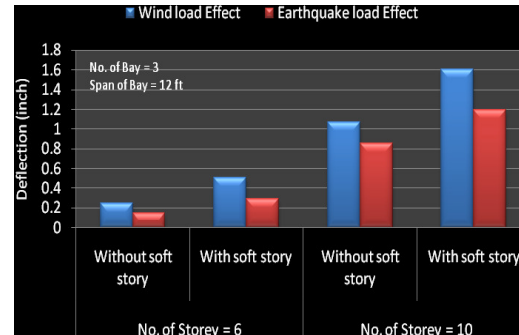


Fig. 5: Maximum top deflection of R.C. frame due to lateral loads for various no. of storey

4.3 Effect of Various Geometrical Properties of Infill Wall

By using a 10-storey 3-bay building frame having span of bay 12 ft, analysis was done for both wind and earthquake loads and according to Mainstone theory of equivalent strut method. Comparisons of deflections of the frame for different soft story conditions and for different thickness of infill have been graphically shown in Fig. 6. Due to the incorporation of soft storey, the top deflections of a 10-storey building frame turn into 1.4 to 1.7 times than the usual deflections having no soft storey in case of lateral loads. Deflections decrease 10 to 20% for 10 inch wall thickness than that for 5 inch wall thickness.

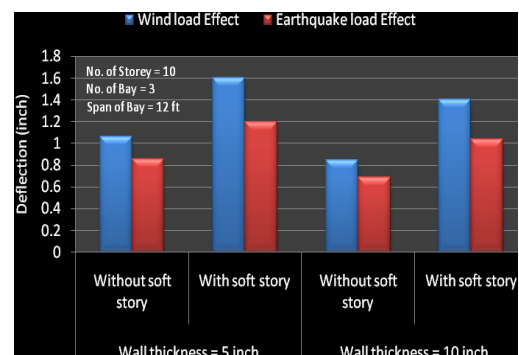


Fig. 6: Maximum top deflection of R.C. frame due to lateral loads for various wall thicknesses

4.4 Effect of Various Geometrical Properties of Beams and Columns

By using a 10-story 3-bay building frame having span of bay 12 ft, analysis was done for both wind and earthquake loads. Comparisons of deflections of the frame for different soft story conditions and for different geometrical properties of beams and columns have been graphically shown in Fig. 7. With 10 square inch beam and column section, the top deflections of a 10-storey building frame become 1.7 times for soft story than the usual deflections having no soft story. But this variation reduced to 1.2 times with 16 square inch beam and column section due to the stiffer section used in the R.C. frame structure. Also with the increasing cross-section of beams and columns the deflections were also decrease because of increased stiffness of the resisting frame.

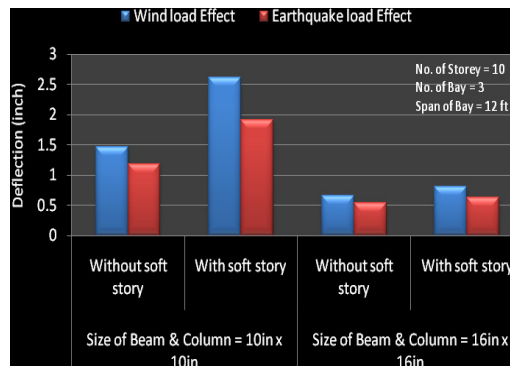


Fig. 7: Maximum top deflection of R.C. frame due to lateral loads for various beam and column sizes

4.5 Comparison of Deflections for Two Different Theories of Equivalent Strut Method

In this analysis, a 10-story of 3@20 ft bay span building frame was used. In this case, two different theories of equivalent strut method that is Mainstone theory and Saneinejad theory were applied. Comparison of deflections of the frame for different conditions (without soft story effect/ with soft story effect) and for different theories has been graphically shown in Fig. 8. The maximum top deflections of the frame for these two different methods were quite similar.

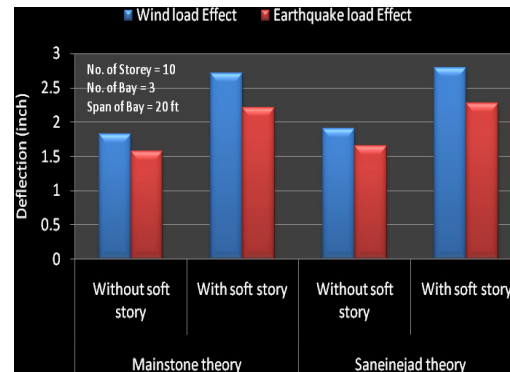


Fig. 8: Maximum top deflection of R.C. frame due to lateral loads for different theories of equivalent strut method

5. CONCLUSIONS

The following conclusions may be drawn from the current investigation:

- Deflections for a soft story building frame were as much as 1.2~2.0 times greater than that observed excluding the soft story effect. The lower range was for stiffer frame structures. So the effect of soft story was more significant in case of less rigid R.C. frames.
- In both cases of wind and earthquake loads, if number of bay increases, then the deflection eventually decreases.
- As the story level of a building frame increases, deflection due to lateral loads naturally increases due to additional lateral loads.
- Deflections of R.C. frames with 5 inch wall thickness having soft storey were observed 1.15 times greater than that with 10 inch wall thickness.
- As the beam and column cross sectional area was increased by 2.54 times, maximum deflection of the frame reduced to 3.1 times with amplified stiffness of the frame.
- Deflection for Saneinejad Theory of Equivalent Strut Method is slightly larger than that for Mainstone Theory. So, the two different theories of Equivalent Strut Method have little bearing on the variations of results.

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EFFECT OF FINNESS MODULUS OF SAND ON CONCRETE PROPERTIES

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The size of aggregates particularly grading is one of the important parameters that affect relative proportions in a concrete mix for strength, workability, economy, porosity and shrinkage etc. The main objective of this study is to evaluate the effect of fineness modulus (FM) of sand on concrete strength. A series of tests with cylindrical specimens were carried out for different FM of sand to investigate the variation of concrete compressive strength and other relevant properties of normal weight concrete. Concrete has its own strength composition according to FM of sand. When these relations are combined, the ultimate strength of concrete has great effect due to change of FM of sand. The results indicate that every 10% increase in FM of sand from 2.0 to 2.8, compressive strength increases almost from 2% to 8%. The rate of increase of concrete strength is faster towards coarser side for FM of sand equivalent to 2.5 or more. The effect of other properties such as density, unit weight, modulus of elasticity on concrete properties also reported herein with the different FM of sand.

Key words: compressive strength, fineness modulus, workability, modulus of elasticity and density of concrete

1. INTRODUCTION

Fineness Modulus is a term used as an index to the fineness or coarseness of aggregate. This is the summation of cumulative percentage of materials retained on the standard sieves divided by 100. It is well-known that aggregate plays an important role in achieving the desired properties of concrete. Though, aggregate constitute 80 to 90% of the total volume of concrete, yet very little attention is given in controlling the grading and surface texture of aggregate to optimize the properties of concrete. Improper blend of aggregate influences the cement and water demand for a given concrete mix and affects workability, compactibility, and cohesion characteristics of concrete mix. It also influences the compressive strength, flexural strength and other properties like permeability & durability of concrete.

In general, the grading of aggregates, which do not have a deficiency or excess of any size of aggregate and give a smooth grading curve, produce the most suitable concrete mix. The coarser fine aggregate has a smaller surface area and will not compete with the finer binding constituents of concrete,

such as cement, fly ash and blast furnace slag, to consume water during the hydration stage. Meanwhile, it is unanimously understood that fine aggregate with a higher fineness modulus is beneficial to the workability and strength of concrete.

Compressive strength remains the most important property of structural concrete, from an engineering point of view. The relationship between concrete composition and compressive strength has long been a matter of interest for researchers. The quality and durability of concrete mostly depend on the quality and properties of ingredients. Fine aggregate affects many concrete properties, including workability and finishability. Experience has shown that very coarse sand or very fine sand produces poor concrete mixes. Coarse sand results in harsh concrete mixes prone to bleeding and segregation. Fine sand requires a comparatively large amount of water to achieve the desired concrete workability, is prone to segregation, and may require higher cement contents. The decreasing FM for sand used in mortar requires considerably more cement content when the water-cement ratio and slump are held constant. However,

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a changing FM has little influence on the cement content required in concrete. Generally, a lower FM results in more paste making concrete easier to finish. For the high cement contents used in the production of high-strength concrete, coarse sand with an FM around 3.0 produces concrete with the best workability and highest compressive strength. In general, manufactured sands require more fines than natural sands for equal workability.

Some studies are carried in the literature. Ta-Peng Chang, etl. (2001) considered the effect of various fineness moduli (FM) of fine aggregate on the engineering properties of high – performance concrete were studied. Two kinds of coarse aggregate and three kinds of fine aggregate were used to evaluate the engineering properties of concrete. This studies showed that for the same concrete mixture, the coarsest fine aggregate (FM=3.24) has better positive effects on the properties of the fresh and hardened HPC. Kronlof (1994) considered the effect of fine aggregate, which consists of 63.3% by weight of 0.5 - 6.0 mm aggregate particles and 36.7% of 0.0001- 0.5 mm quartz powders, on the water requirement and strength evolution of the superplasticized concrete. The water requirement for constant workability fell sharply with the increasing amount and fineness of the very fine aggregate, and the concrete strength increased with the increase of quartz powders. Ahmed and El Kourd (1989) reported that water demand increased rapidly with increase of the very fine sand (VFS), which denoted the sand passing a No. 200 (75 μ m) sieve. But the compressive strength of concrete also decreased linearly with the increase of VFS at a constant slump of 100 mm.

The present study reports primarily to evaluate the effect of concrete compressive for same concrete mix using various graded sand as fine aggregate. The other properties such as, density, unit weight, modulus of elasticity also affects on concrete properties due to change of Fineness Modulus of sand.

2. REVIEW OF CODE PROVIIONS

ASTM Designation: C33-93- standard specification for concrete aggregates”–The fine aggregate shall have not more than 45% passing any sieve and retained on the next consecutive sieve and its fineness modulus will not be less than 2.3 and not more than 3.1. Rest is the same as for AASTHO M6-93.

U.S.B.R: The code has specified that the fineness modulus of sand shall not be less than 2.50 and not more 3.0.

AASTHO Designation: M6-93- “Standard Specification for Fine Aggregate For Portland Cement Concrete”- It indicates that the fineness modulus of sand will not be less than 2.3 and nor more than 3.1.

IS 383: “Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete.” This publication deals with specifications for Coarse and Fine aggregates from natural sources for Concrete. These specifications do not specify any limit for fineness modulus to be used in concrete. It divides the sand in four zones i.e. from Zone I to Zone IV. Zone I–Sand being very coarse and Zone 4 sand is very fine. It is generally recommended by code to use sands of zones I to Zone III for Structural concrete works.

3. EXPERIMENTAL DETAILS

3.1 Materials and mix proportions

The natural stone were used as coarse aggregate. Three different types of natural sand (Two types obtained from Sylhet and one type of locally available river sand) were used to prepare various type of fineness modulus of sand (range of FM 1.2 – 2.8) in this experiment. Ordinary Portland cement (ASTM Type-I) was used as binder in experiment. The required material properties, such as specific gravity (ASTM C127 and ASTM C128), unit weight (ASTM C29), fineness modulus of coarse and fine aggregate (ASTM C136) were used to design the concrete mix. These properties of the coarse and fine aggregates are summarized in Table 1.1 and 1.2

Table 1.1: Physical characteristics of coarse aggregates

Property	Stone (¾ in down grade)
Specific gravity (SSD)	2.63
Absorption capacity, %	5%
Unit weight, lb/ft ³	98
Fineness modulus	5.69

Table 1.2: Physical characteristics of Sand

Property	Sand Type		
	I	II	III
Specific gravity (SSD)	2.47	2.65	2.67
Absorption capacity, %	2.7	2.8%	3.1%
Unit weight, lb/ft ³	83	90	93
Fineness modulus	1.20	2.70	2.80

3.2 Preparation of Cylinder Specimens

Based on predefined mix proportions (weight basis), the required quantities of the materials were calculated and measured on SSD condition. The coarse aggregate, fine aggregate and cement were then spread evenly on the mixing surface, mixed thoroughly and continuously and water was gradually added. At the time of mixing uniform quality of concrete were maintained until to prepare proper mix. Then, the slump of the every mix proportion was measured according to the standard method (ASTM C31). This concrete was poured in reusable cylindrical moulds (size 6" X 12") and compacted properly conforming the ASTM procedure.

3.3 Curing and Testing of Cylinder

After casting of concrete, the cylinders were stored in moulds for 24 hours in moist condition at room temperature and the moulds were carefully removed. Then the concrete cylinders were sunk in the potable water for 28 days. All the cylinders were tested in wet condition at 28 days to determine the concrete compressive strength. The top surfaces of the cylinders were capped with sulphur mortar in accordance with standard specification (ASTM C617) before testing.

4. EXPERIMENTAL RESULT

In this study water-cement ratio (W/C) of mix is kept constant for all mixes with sand of different fineness modulus. Workability of mix is also fixed in range of 1.5 inch to 2.5 inch slump. Since mix with so different fineness modulus of sand, will result in different water demands, so water - cement ratio is kept constant and to adjust workability slight adjustments in admixture dosages has been made. Effect of varying FM of sand is studied on concrete density, workability, compressive strength, and modulus elasticity of concrete

4.1 Workability of Concrete Mix

The workability of concrete mix was measured with the help of 12 inch standard size slump cone. A little amount of admixture dose was added to concrete mix. Each time concrete mix was examined for the behavior in slump, segregation and Bleeding etc. Total 18 cylinders were prepared to observe slump, segregation and bleeding etc. The slump observed was about 2 inch in all cases. No segregation or bleeding was observed in the mix. The results indicate that with the increase in fineness modulus of sand, water demand in the mix

got affected consequently workability gets affected. Since water-cement ratio is kept constant, so to keep workability in the same range of 2 inch, admixture dosages were varied. The admixture dosages reduced considerably as fineness of sand increases as. Admixture dosage reduced from 1.0 percent to 0.2 percent as sand fineness modulus increases from 1.2 to 2.8. For Every 5% increase in FM of sand, admixture dosage reduced by 0.1%.

4.2 Effect of Fineness of Sand on Density of Concrete

After measuring the slump, several 150 mm cylinders were filled. These were cured in water tank for 28 days. After curing, each cylinder was weighed using electronic balance and density of concrete was calculated. The variation of density, unit weight and slump range with FM of sand is shown below for different cases. Since water cement fixed, Slumps (range 2-3) were varied due to change of fineness modulus of sand. It is evident that there is slight increase in density i.e. 1.0 to 2.15 percent, when fineness modulus increases from 1.2 to 2.8. According to ACI code requirements, the range of normal concrete weight is 90 pcf to 155 pcf. It is also shown that the range of unit weight of concrete is about 142 pcf – 147 pcf.

4.3 Effect of Fineness of Sand on Compressive Strength of Concrete

The effect of fineness modulus (FM) of sand on the compressive strength of concrete measured at 28 – days on is shown in Fig 1. From this figure it is shown that the compressive strength of concrete is increased drastically with the increase of fineness modulus of sand. A regression analysis shows the following relationship between concrete compressive strength and fineness modulus of sand-

$$f_c = 1128 (FM)^2 - 280 (FM) + 5093$$
$$R^2 = 0.9841$$

Where

f_c = concrete compressive strength at 28 days in psi
FM = fineness modulus of sand

The experimental investigation indicates that- As fineness modulus of sand changes from 1.2 to 1.8 there is an increase in compressive strength from 3236psi to 3743. i.e. strength increases by 15.7%, Fineness Modulus from 1.8 to 2.4, Compressive strength increases from 3743psi to 4742 resulting in 26.7% increase in strength. On the other hand by increasing Fineness Modulus from 2.4 to 2.8, Compressive strength increases from

4742psi to 6380 resulting in 34.5% increase in strength. For 10% increase in FM of sand from 2.0 to 2.8, compressive strength increases almost from 2% to 8%. The rate of increase of concrete compressive strength is faster towards coarser side of sand.

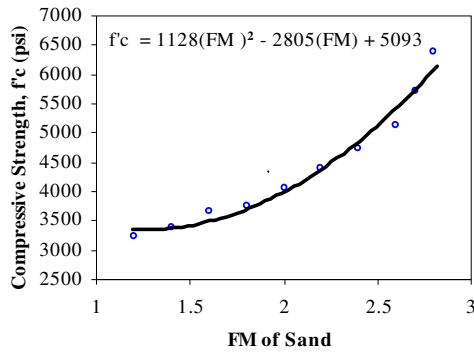


Fig.1: Relation between concrete compressive strength and Fineness Modulus of Sand

4.4 Modulus Elasticity of Concrete

There is no doubt that the modulus of elasticity increases with an increase in the compressive strength of concrete, but there is no agreement on the precise form of the relationship. This is not surprising, given the fact that the modulus of elasticity of concrete is affected by the modulus of elasticity of the aggregate and by the volumetric proportion of aggregate in the concrete. The former is rarely known so that some expressions, for example that of ACI 318-95 allow for the modulus of elasticity of aggregate by a coefficient which is a function of the density of the concrete, usually density raised to power 1.5. The figure 2 shows the relationship between concrete compressive strength, modulus elasticity of concrete and fineness modulus of sand. A regression analysis shows the following relationship between modulus elasticity of concrete and fineness modulus of sand-

$$E_c = 0.55(FM)^2 - 1.38(FM) + 4.11$$

Where

E_c = Modulus Elasticity of Concrete in 106 psi
FM = fineness modulus of sand

The observed result shows that the static modulus of elasticity of concrete has great influence due to change of Fineness Modulus of sand on concrete compressive strength. As Fineness Modulus of sand changes from 1.2 to 1.8 the static modulus of elasticity of concrete is increase by 8.2%. Fineness

Modulus of sand changes from 1.8 to 2.8 the static modulus of elasticity of concrete is increase by 35.2% according to ACI 318-19

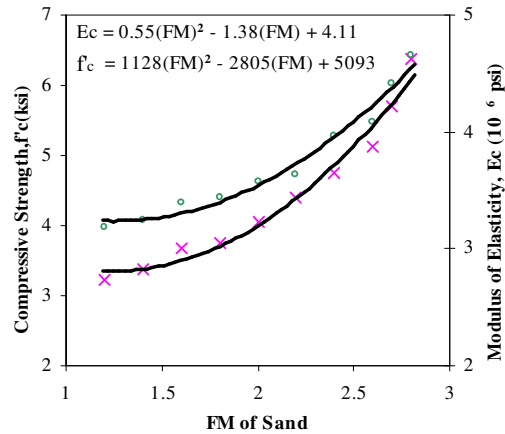


Fig.2: Relation between concrete compressive strength and Modulus of elasticity with respect to Fineness Modulus of Sand

4.5 Effect of Sand – Cement Ration on Concrete Compressive Strength

Stock et al (1979) published a comprehensive review concerning the effect of aggregate volume on concrete compressive strength. Most of the cited references tend to support the fact that the strength decreases when the paste content increases, at least in the range of usual structural concrete. Stock et al (1979) also performed some original experiments, in which they produce a series of concretes having different aggregate contents, keeping the same grading and matrix and avoiding segregation in fluid mixtures by continuously rotating the specimens before setting. Note that the aggregate volume effect, which is not monotonic, can be marked by the increase of entrapped air when workability decreases. The obtained result showed that lower compressive strength for higher content of coarse aggregate - cement ratio in Figure 3. The relation between compressive strength and other properties of concrete i.e. water – cement ratio, aggregate size, aggregate volume, and cement paste are observed graphically nearly exponential shape. The experimental result showed same behavior like as effect of aggregate – cement ratio. The total surface area is greater, more mixing water is required to produce the desired slump, and for given cement contents, the water cement ratio is higher for the higher sand content mix of concrete. Generally, compressive strength is lower for higher water – cement ratio. As sand – cement ratio

changes from 0.5 to 2.0 there is decrease in compressive strength from 4850psi to 3900. i.e. strength increases by 19.6%. Sand – cement ratio changes from 2.0 to 4.5 there is decrease in compressive strength from 3900psi to 1700. i.e. strength increases by 54.6% for fixed fineness modulus of sand .

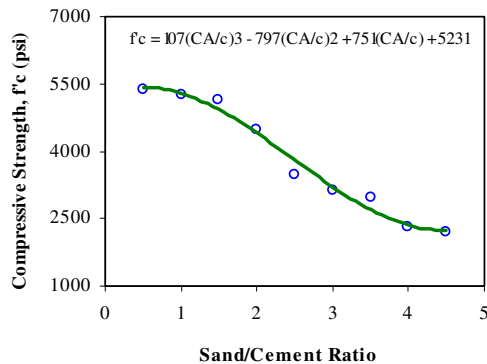


Fig.3: Relation between concrete compressive strength and Sand – cement ratio (coarse aggregate – cement ratio is 2 and FM of Sand 2.60)

5. CONCLUSION

Fineness Modulus of Sand affects Compressive as well as the other engineering properties of concrete. Sand, with higher FM, results in higher strength of concrete. The results indicate that with the increase in FM, workability gets affected considerably. The cement demand also gets modified. Some of the concluding observations are given below-

- Fineness Modulus has larger impact on 28 days Compressive Strength of Concrete. For every 10% increase in FM of sand from 2.0 to 2.8, compressive strength increases almost from 2% to 8% and the rate of increase of concrete compressive strength is faster towards coarser side of sand.
- Fineness Modulus also affects the density of concrete. It increases by about 2.15% as the FM increases from 2.0 to 2.8. Optimum value of density and other parameters are obtained when FM is 2.7.
- The observed result also shows that the static modulus of elasticity of concrete has great influence due to change of Fineness Modulus of sand on concrete compressive strength. As Fineness Modulus of sand changes from 1.2 to 2.8 the static modulus of elasticity of concrete is increase by 35.2% according to ACI 318-19

- The optimum value of strength can be taken when workability of concrete is also good. It is obtained when Fineness Modulus is about 2.7.
- The sand – cement ration has great impact on concrete compressive strength. As sand – cement ratio changes from 0.5 to 4.5 there is decrease in compressive strength from 4850psi to 3900. i.e. strength increases by 54.6%

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EFFECT OF AGGREGATE GRADING ON CONCRETE COMPRESSIVE STRENGTH

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Compressive strength is the major properties of concrete which depends on mainly aggregate size, shape, grading, mix ratio, presence of admixture etc. In this research work, effect of aggregate fineness modulus (both fine and coarse) and maximum coarse aggregate size on the compressive strength of aggregate has been studied. Others variable like water cement ratio, aggregate cement ratios were kept constant and only 28 days compressive strength was measured to evaluate the result. Mixture of Sylhet sand and local sand was used as fine aggregate to get desired fineness modulus and stone chips were used as coarse aggregate. Twelve set of cylinders were crushed in this study with different combination of fine aggregate having fineness modulus of 2.0, 2.5 and 3.0 and coarse aggregate having fineness modulus of 6.0, 6.5, 7.0 and 7.5. Maximum size of coarse aggregate was 1.5 inch. From this study it is observed that compressive strength of concrete increases with the increase of both the fine and coarse aggregate fineness modulus. Maximum compressive strength was found 3873 psi for concrete having fineness modulus of fine and coarse aggregate 3.0 and 7.5 respectively with mix ratio 1:2:4. Compressive strength of concrete increases up to the maximum aggregate size of 1.5 inch. It is also found that compressive strength has no linear relationship with the combine fineness modulus of aggregate.

Key Words: Grading, Fineness Modulus, Aggregate, Compressive Strength, Mix Ratio

1. INTRODUCTION

Compressive strength is the main qualitative measure of concrete. The 28 days strength is the most common practices employed to determine the concrete compressive strength. To ensure the strength of hardened concrete testing of 6 in $\times$ 12 in cylinder is the normal practices since long. It has been generally accepted that if the aggregate volumes are so chosen that the packing density of the combined aggregates is maximum then the amount of cementations paste volume required for a given amount of workability (i.e. slump) is reduced to a minimum. Maximum aggregate packing density can be achieved using the well graded aggregate

Grading of aggregate means particle size distribution of the aggregate Principle of grading is that the smaller size particles fill up the voids left in larger size particles. By adopting proper percentages, of various size aggregates, composite aggregate mix can be developed which will be thoroughly graded. Properly graded aggregate

produces dense concrete and needs smaller quantities of fine aggregate and cement. The grading of aggregate is expressed in terms of percentages by weight retained on a series of sieves, 40 mm, 20mm, 10 mm, 4.75 mm, 2.36mm coarse are used for grading of coarse aggregate, where as 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 micro, 300 micro, and 150 micro are used for aggregate.

2 OBJECTIVES OF THE STUDY:

- i) To evaluate the change of concrete compressive strength due to changing of aggregate grading.
- ii) To evaluate the response of concrete compressive strength due to changing of coarse aggregate maximum size.
- iii) To evaluate the change of concrete compressive strength due to changing of aggregate combine fineness modulus.

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3. PROPERTIES OF CONCRETE INGREDIENTS

The ingredients of concrete mix was cement, fine aggregate, coarse aggregate and water. No admixture was used for this study.

Cement is a binder, a substance which sets and hardens independently and can bind other materials together. Ordinary Portland cement was used as binder materials for the preparation of fresh concrete.

The aggregate most of which passes through No. 4(4.75 mm) sieve is classified as fine aggregate. Fine aggregate used in this study is prepared artificially to obtain predefined fineness modulus and grading. The fine aggregate is washed with water and dried in air before use. At the beginning of the use of the aggregate, their properties were measured in laboratory. Three different samples were prepared with fineness modulus 2.0, 2.5 and 3.0.

The objective of determining the fineness modulus was to plot there grading curves, and to use assigned combined grading limits to determine the amount of each of the aggregate of produce quality concrete. Gradations of three samples are given in the Table 1. Gradation curve of each sample are shown in Fig 1 to 3 and compared with the standard gradation curve. Gradation of sample having fineness modulus 2.0 and 3.0 slightly deviated from the standard gradation zone.

Table: 1 Gradation of fine aggregate.

Sieve size	Cumulative percent passing		
	FM=2.0	FM=2.5	FM=3.0
#4	100	98	95
#8	95	92	88
#16	90	80	75
#30	75	60	42
#50	40	20	0
#100	0	0	0

The aggregate usually occupies about 70 to 75 percent of the total volume of the mass of concrete, in which the coarse aggregate takes the major part. As such its selection and proportioning should be given carefully attention in order to control the quality of the concrete structures.

Different size coarse aggregate was used in this study. 1.5 in downgrade, 0.75 in downgrade and 0.5 in downgrade aggregate was used in this study with fineness modulus of 6.0, 6.5, 7.0 and 7.5. Properties

of these aggregate were determined in the laboratory.

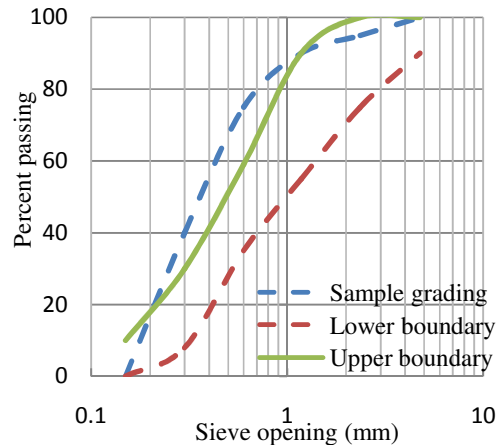


Fig 1: Gradation Curve of Sample having FM-2.0

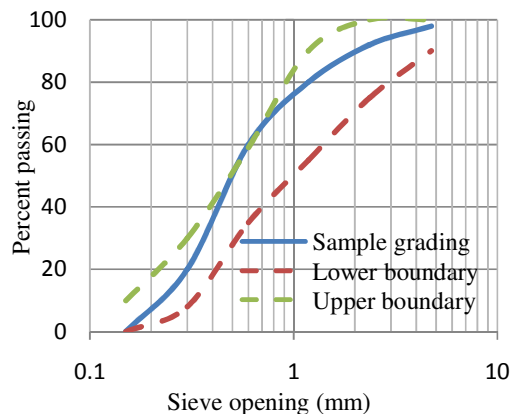


Fig 2: Gradation Curve of Sample having FM-2.5

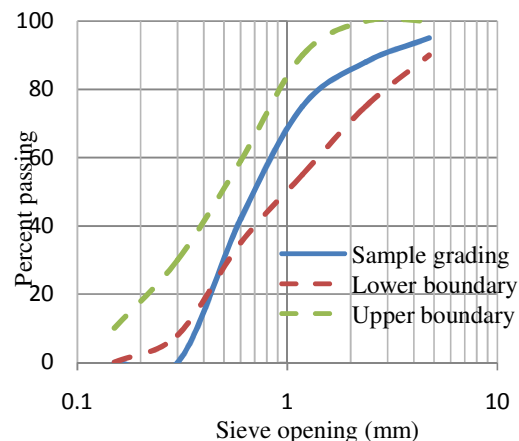


Fig 3: Gradation Curve of Sample having FM-3.0

The maximum size of coarse aggregate depends upon the nature of work for which the concrete is used. From a stand point of minimum void space round aggregate are more desirable that irregular.

From the stand point of ability to bond with the mortar, the rounded aggregate may be inferior, however so that in general the shape of the particles will be found to be much less important than their size and hardness. Thin flat pieces should be discarded.

Sample aggregate were prepared artificially to obtain the predefined grading. Gradation of these samples were given in the Table 2 and corresponding gradation curve is given in Figure 4 to 7

Table: 2 Gradation of coarse aggregate

Sieve size	Cumulative percent passing			
	1.5 in down grade	1.5 in down grade	3/4 in down grade	1/2 in down grade
	FM=7.5	FM=7.0	FM=6.5	FM=6.0
1.5"	95	100	100	100
0.75"	40	70	95	100
3/8"	15	30	50	80
3/16"	0	0	5	20
#8	0	0	0	0

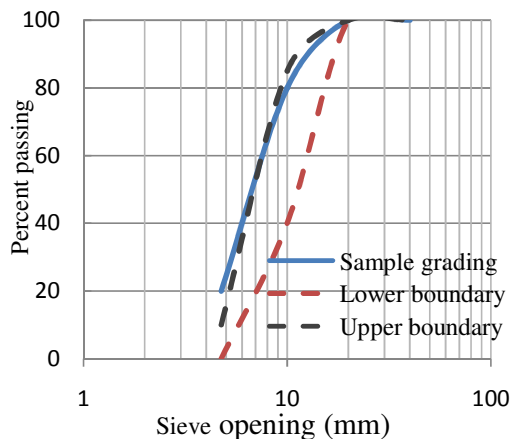


Fig: 4 Gradation Curve of Sample having FM-6.0

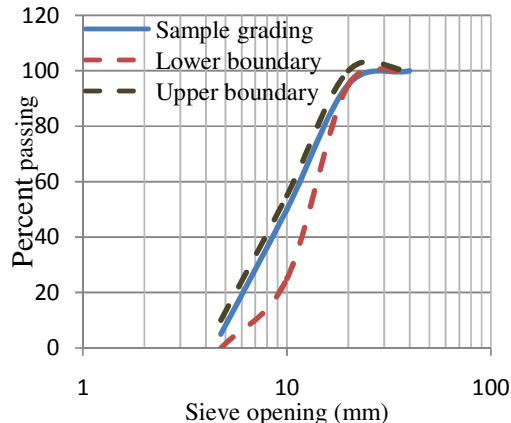


Fig: 5 Gradation Curve of Sample having FM-6.5

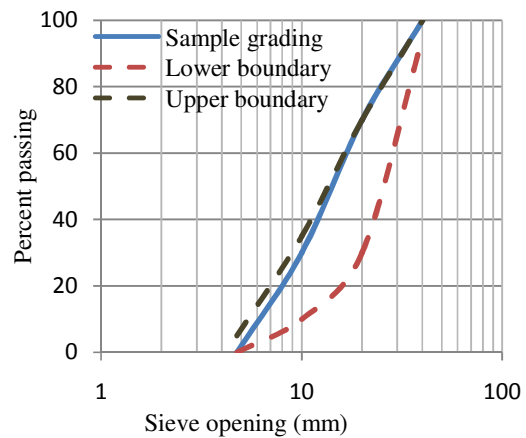


Fig: 6 Gradation Curve of Sample having FM-7.0

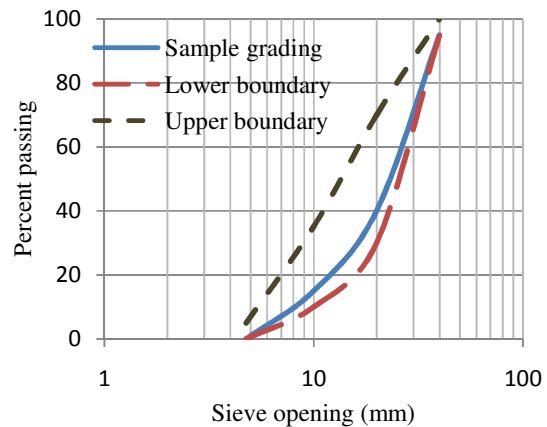


Fig: 7 Gradation Curve of Sample having FM-6.0

4 PREPARATION OF CONCRETE CYLINDER

Twelve set of Cylinder were cast with different grading of aggregate. Water cement ratio was same for all the concrete which was 0.5. Cement, sand, aggregate ratio was also uniform with ratio of 1:2:4. At beginning, aggregate of predefined fineness modulus was prepared by sieving of raw aggregate. To prepare specific concrete mix, aggregate with corresponding fineness modulus was taken then concrete mixture was prepared with ratio 1:2:4. All mixture was conducted on weight basis. Mixing of concrete was done by hand.

5. RESULTS AND DISCUSSION

28 days compressive strength was evaluated in this study due to different aggregate grading. Laboratory test results were examined and explained in both tabular form and graphically which is shown below

Higher fineness modulus of aggregate represents higher aggregate size. Compressive strength of aggregate is closely related with the aggregate grading as well as size also. Generally concrete compressive strength increases with the increase of aggregate fineness modulus size of aggregate. If aggregate size of concrete increases with reducing surface area then quantity of cementing materials per unit surface area is increases which increase bond stress with resulting increase of concrete compressive strength.

The relation of concrete compressive strength with variation of fineness modulus of coarse aggregate is shown in Fig 8. From figure it is clear that compressive strength increases with the increases of coarse aggregate fineness modulus. Concrete with lower fineness modulus of both fine aggregate and coarse aggregate show comparatively low compressive strength. Maximum compressive strength was archived when fineness modulus of both coarse and fine aggregate was higher and well graded.

Fine aggregate having fineness modulus 2.0 is not well graded as compared to ASTM grading requirement which is shown in Fig 3.1 that's why it gives low compressive strength.

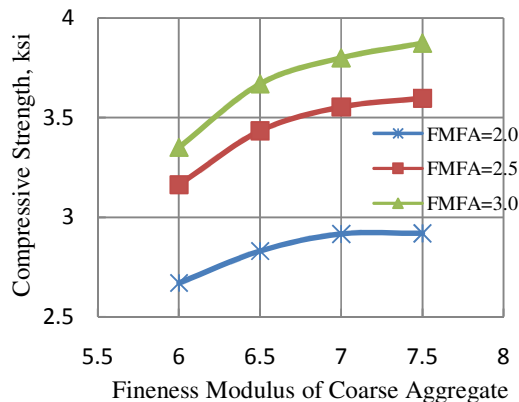


Fig 8: Relation of concrete compressive strength with the variation of fineness modulus of coarse aggregate

The change of concrete compressive strength with variation of fineness modulus of fine aggregate is shown in Fig 9. This figure also represent that compressive strength increases with the increases of fine aggregate fineness modulus.

Coarse aggregate having fineness modulus 6.0 is not well graded according to ASTM C 33-93 grading requirement which is shown in Fig 4 that's why it gives low compressive strength. Maximum compressive strength of 3800 psi was archived in

the concrete having fineness modulus of fine aggregate and coarse aggregate 3.0 and 7.5 respectively.

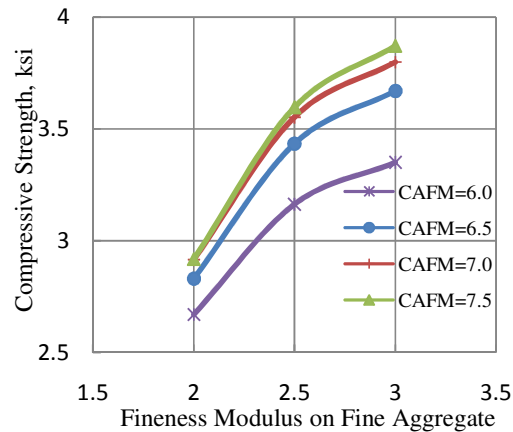


Fig 9: Relation of concrete compressive strength with the variation of fineness modulus of fine aggregate

Aggregate up to 1.5 in maximum size, concrete compressive strength increases. Aggregate above 1.5 in maximum size the gain in strength due to the reduced water requirement is offset by the detrimental effect of lower bond area and of discontinuities introduced by the very large particles [Neville A. M. 1995].

From Fig 10 concrete compressive strength increases rapidly due change of maximum aggregate size up to 0.75 in. Above 0.75 in maximum size, rate of increasing concrete compressive strength becomes lower up to 1.5 in down grade.

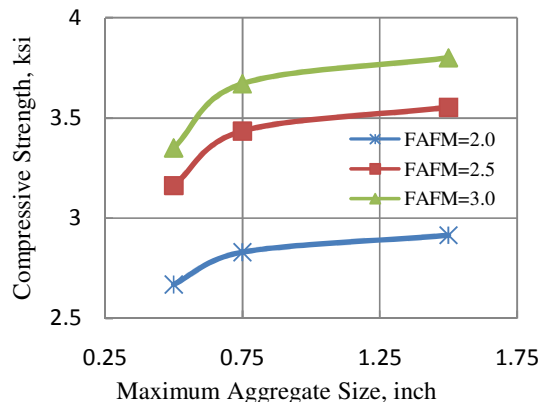


Fig 10: Influence of maximum size of aggregate on compressive strength of concrete

Response of concrete compressive strength with combined fineness modulus of aggregate is focused in the Fig 11. From figure, there is no linear

relationship of concrete compressive strength with the combine fineness modulus of aggregate.

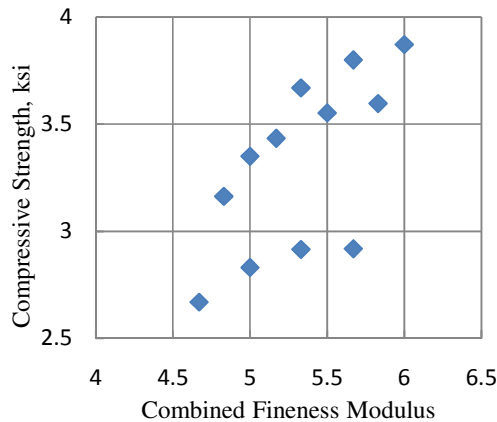


Fig 4.4 : Relation of concrete compressive strength with the variation of combine fineness modulus of aggregate.

6. CONCLUSION:

The main objectives of the study was to find the relation of concrete properties specially compressive strength with the both fine and coarse aggregate grading, maximum size of coarse aggregate and combined fineness modulus of aggregate. On the basis of this study following conclusions can be drawn:

- Compressive strength of concrete has been greatly influenced by the fine and coarse aggregate grading as well as fineness modulus. Due to the increase of the fineness modulus of aggregate, compressive strength increases considerably. Maximum compressive was achieved 3873 psi for the concrete with fineness modulus of fine and coarse aggregate 3.0 and 7.5 respectively. Minimum strength was found 2669 psi for the concrete with fineness modulus of fine and coarse aggregate 2.0 and 6.0 respectively.
- Compressive strength increases with the increases of maximum aggregate size up to 1.5 inch
- There is no linear relationship of concrete compressive strength with the combined fineness modulus of aggregate.

5.2 RECOMMENDATION:

This is a short scale research work due to the limitation of time and resource. To get the more accurate result large scale research should conduct changing various parameters. Few guidelines are suggested below for future study on this topic.

- Mix ratio was constant in this study; this research should be revised for different mix ratio.
- With the increases of aggregate size required water cement ratio become lower. So this study should be conducted with different water cement ratio.
- This study should be performed for brick aggregate and it is necessary to prepare standard grading requirement for both fine and coarse aggregate (brick).

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FIRE HAZARD SCENARIO IN CHITTAGONG: A CASE STUDY

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Abstract: Fire hazard estimation is a daunting task because of the huge number of factors involved in it. Such factors are number of vulnerable population, availability of escape ways, accessibility to fire cars, active and passive fire suppression equipments etc. In case of high-rise buildings (above 6 storeys) some of these parameters are more significant; like accessibility to fire trucks with high-reach ladders and active fire suppressing system. To get a realistic picture on the present hazard scenario of the second largest city of Bangladesh, Chittagong, a study was undertaken during May, 2010 to September, 2010. Study area was Nasirabad Housing Society, Sugandha, Khulshi, Mehediabag and O.R. Nizam Road. Data was collected for above mentioned parameters for high-rise buildings and represented and analysed in semi graphical method. Some of the major findings include that only 8.7% building has wide enough road for Turntable ladder appliances (require 30feet road), about 90% buildings has two or more fire extinguishers but sadly water reservoir size (over head and underground) do not comply with required sizes and also they do not keep 50% of their reserve for fire fighting according to Bangladesh National Building Code, 2007.

Key words: fire, accessibility, Chittagong, high-rise, BNBC

1. INTRODUCTION

A fire hazard is any situation in which there is a greater than normal risk of harm to people or property due to fire. Fire hazards can take the form of ways that fires can easily start, such as a blocked cooling vent, or overloaded electrical system, ways fires can spread rapidly, such as an insufficiently protected fuel store or areas with high oxygen concentrations, or things which, in a fire, pose a hazard to people, such as materials that produce toxic fumes when heated or blocked fire exits. Fire can cause

disasters and loss of lives in buildings such as residential apartments, offices, hotels, shopping centers, hospitals and schools.

As with most problems in this country, lack of awareness is one of the major impediments in making our buildings safe from fire related accidents. The difference here is that instead of going by the cliché of developing consciousness among the public, it is the professionals (architects, planners, and engineers) who have to first understand the emerging and growing need to be

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knowledgeable about fire, its dangers, causes and consequences, and then evolve design solutions that make a safe living environment.

Chittagong City has been experiencing high rate of urbanization since the last few decades. Presently, more than 4 million people are living in Chittagong City. The development trend of Chittagong City is deliberately shifting vertical direction to cope with the extensive population pressure.

High-rise buildings are being constructed in every parts of the city but in most cases dwellings are being constructed without maintaining the planning rules and regulations. Fire hazard vulnerability of Chittagong City dwellers has been increased due to reckless building construction and non conformation of Fire Protection Act, 2003.

Chittagong City has been experiencing many fire accidents at present and in most cases lack of proper precautionary measures along with the institutional inefficiency, insufficient equipment support and lack of public awareness are causing this situation more complex. As most of the dwellers do not know how to use the fire fighting equipments, in most cases all precautionary measures for combating fire generally go into vein. Therefore, institutional reform, strengthening of capacity at individual and institutional level is needed in order to reduce fire hazard risks of Chittagong City.

2. Background of the Study

Fire hazards occur frequently in our country because of different reasons such as unplanned urbanization and lack of public awareness of fire, according to the statistics available with the Fire Service and Civil Defense. The statistics showed the number of fire incidents was 6,289 in 2003, 7,140 in 2004, 7,475 in 2005, 9,542 in 2006, 9,196 in 2007 and 9,310 in 2008. Fire causes huge loss of lives and properties every year. Although termed as ‘fire accident’, most fire events are far from being accidental. Indeed, most fires are preventable.

The officials of Fire Service and Civil Defense (FSCD) established the number of fire hazards and extent of losses in fire incidents are as follows:

Table 2.1: Total number of fire hazards and extent of losses due to fire hazards in Bangladesh

Year	Number of Fire Hazards	Extent of Loss in Tk (crore)
2002	5404	112.21
2003	6289	110.59
2004	7140	213.78
2005	7475	272.64
2006	9542	238.76
2007	9196	309.00
2008	9310	231.00

Source: Bangladesh Fire Service and Civil Defense, 2009

From the table it is apparent that the fire incident and the economic loss is increasing gradually. A developing country like us cannot afford the huge amount of loss caused by fire accidents every year.

In the port City Chittagong, every year devastating fire causes huge loss of property and human lives. The number of fire incidents is higher than another region of the country. This is due to total environment and circumstances are not in favor to prevent fire. The officials of FSCD established the number of fire hazards, death toll and extent of losses in fire incidents of Chittagong are as follows:

Table 2.2: Total number of fire hazards, death toll and extent of losses due to fire hazards in Chittagong Division

Time Period	No. of Fire Hazard	Death Toll (Human)	Extent of Loss (Tk.)
2007	778	29	141383600
2008	836	33	393360066
2009	1053	11	341671500

Source: FSCD, Agrabad 2010

From the table it evident that fire hazards and economic loss is increasing gradually. Records showed that electric short-circuits have topped the list of reasons of fire incidents. Burner posses second position to generate fire hazard.

Besides, the poor fire fighting equipments of the Fire Service and absence of infrastructure supports like street hydrants and construction of fire-lanes in busy cities are the reasons that tackling such emergency situations. There are only 5,000 fire fighters in Bangladesh. There are 11 fire stations in the city. Chittagong fire fighters are unable to douse flames beyond

sixth floor of a high rise building. There is no turntable ladder.

Table 2.3: Total No. of fire disaster and economic loss in dwelling-house in Chittagong division

Year	Total No. of Fire in Dwelling House	Economic Loss (Taka)
2007	347	67003200
2008	419	77615400
2009	496	84730400

Source: FSCD, Agrabad 2010

Table 2.3 reveals that number of fire incidents in dwelling-house is increasing in Chittagong day by day. Lack of residents' awareness of electric wiring and burner fire are also the reasons for fire, especially in dwelling-house. The fire incidents are on an increase due to lack of awareness and practicing fire fighting drills, violation of building codes and non-compliance with the Fire Checking and Extinguishing Law, 2003.

3. Methodology

To carry out the study resourcefully, four sets of questionnaire have been developed. Each questionnaire has several variables and several natures (Table 2). These questionnaires have been developed on the basis of objectives to assessing the fire hazard prevention system in high-rise apartments of residential areas in Chittagong City. Questionnaire on expert group mainly higher officials on FSCD, CDA, are emphasis on suggestions and recommendations for the best approaches of fire hazards prevention in high-rise apartments. A total of 104 samples were collected:

Sl. No	Study Area	No. of Apartment
01	Nasirabad Hosing Society	32
02	Sugandha Housing Society	08
03	Khulshi Residential Area	31
04	O.R Nizam Road Residential Area	18
05	Mehedibag Residential Area	15
	Total	104

4. RESULTS

Following results were obtained from the field survey:

4.1 Number of Storey of the Apartments

A floor is any level part of an apartment that has a permanent roof and could be used by people (for living, work, storage, recreation, etc.). The number of floors of an apartment has been counted by observation technique. In the study area 30.8% apartments consist of seven floor and second highest 26.9% consist of eight floor. The following fig.4.1 represents the percentage of apartments consist with floor:

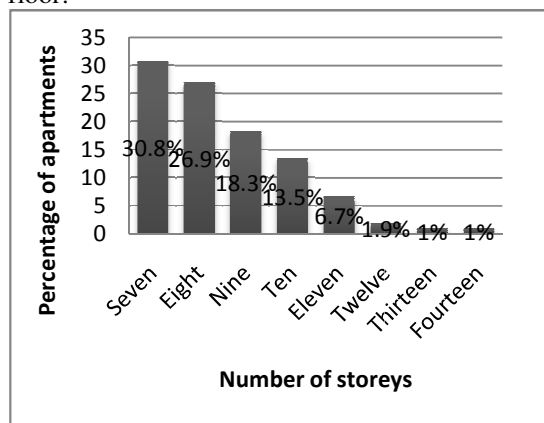


Fig 4.1: No of floors with percentage of apartments

4.2 Residents of the Apartments

It is an important factor to estimate fire safety of high-rise apartments because fixed installation to safe from fire should be taken on the basis of total residents of the apartment. According to apartments survey it was found that 22.1% apartments resident size was around 120 and the second highest 21.2% apartments resident size was around 141. In the fig 4.2 shows the resident size of the apartments.

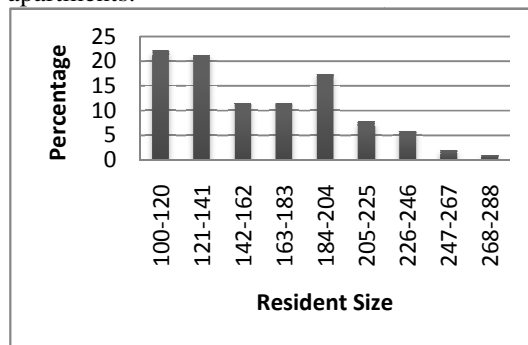


Fig 4.2: Percentage of Resident Size in an Apartment Building

In the high-rise apartment, if the fire fighting factors and escape routes are insufficient in compare with population then it has great chance to increase the fatality of residents in case of fire accidents.

4.3 Access way

Access way shall be provided for accessibility of site to firefighting appliances. Snorkel or Turntable Ladder appliances need to firefighting and rescue in high-rise apartment. To allowing access of that appliances need 30 feet wide road.



Fig 4.3: Road width below 30 feet in Nasirabad residential area.

Accessibility data has been collected through field survey. In the study area, above 30 feet wide access road has been found only 9.6 % apartments. The highest 36.5% apartment's road accessibility has been found above 15 feet. The access way of the apartments is presented below:

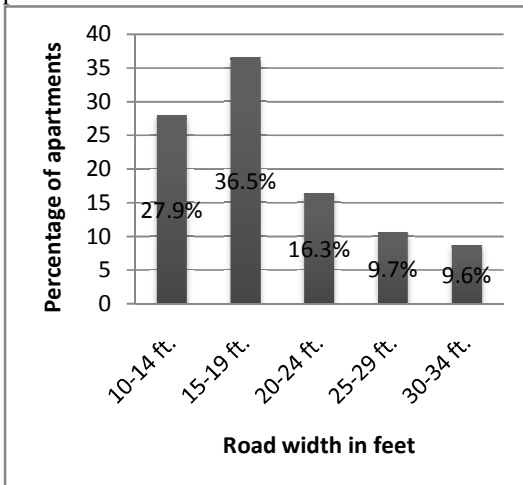


Fig 4.4: Apartments with Specific Road Width

4.4 Emergency Exit and General Stairwell

Emergency exit related information have been collected from the apartments of study area by the field survey. It has been found that only 13.5% apartments have emergency exit and others have no fire escape route except general stairwell. In the study area a large number of apartments (82.7%) are with one stairwell and others (17.3%) are with two stairwell.

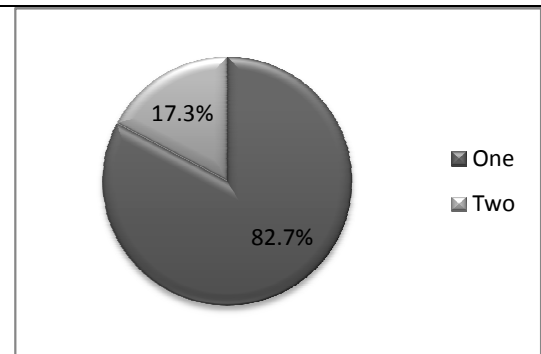


Fig 4.5: Percentage of Apartments with one or Two Stairwells

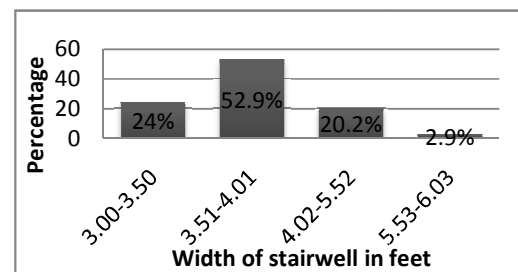


Fig 4.6: Percentage of Building vs. Width of Stairwell

According to firefighter expert, six feet wide stairwell needs for high-rise apartment to safe from fire but in the study area only 2.9% apartment's stairwell wide is near to six feet. So in the study area's apartments are not safe from fire.

4.5 Fire Extinguisher

A fire extinguisher is an absolute necessity in high-rise apartment. At the initial stage of fire accidents fire extinguisher used to extinguish or control fires. According to field survey it has been found that 38.5% floors of the apartments are with two fire extinguishers and 33.7% floors of the apartments are with three fire extinguishers. It is notable that 4.8% apartments are without fire extinguisher. In the following Fig 4.7 shows the number of fire

extinguishers numbers in the percentage of floors of the apartments:

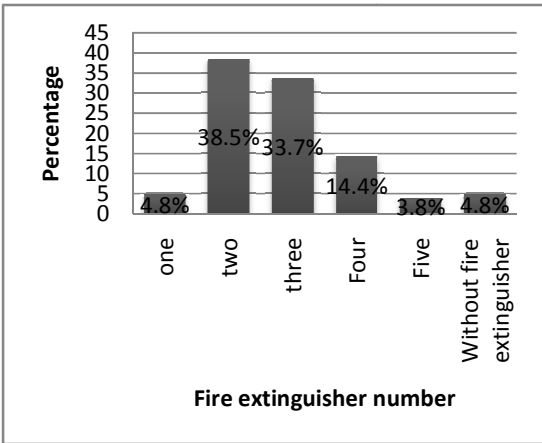


Fig 4.7: No of Fire extinguisher

Although it is also remarkable that fire extinguisher should be laid in different places but in the study area where we found the extinguishers all are in the corridor and beside the door.

4.6 Fire Alarm

Fire alarm is a device, such as a siren, used in announcing the outbreak of a fire. This study finds out the apartments with and without fire alarm.



Fig 4.8: Fire alarm in an apartment of Nasirabad residential area.

In the study area it has been found that 64.4% apartments are without fire alarm and rest 35.6% apartments having fire alarm (Fig 49).

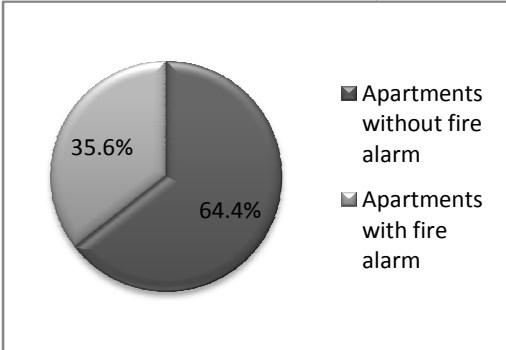


Fig 4.9: Availability of Fire Alarm

5. Conclusion

Obvious upgrading is essential in both fire safety design and fire fighting. Fire safety design can be improved by strict enforcement of fixed installation of fire fighting equipments and fire escape routes in the apartments. Proper fire inspection can reduce the vulnerability of high-rise apartments considering fire hazard. To improve the fire fighting aspect, indiscriminate filling up of water bodies must be prevented and adequate right- of- ways should be ensured. It is particularly important in the new development areas. Public awareness campaigns, including fire drills, may be conducted. Also careful planning of the number and locations of fire stations with adequate fire engines and equipments are considered necessary.

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INFORMAL SECTOR WATER UTILITY MANAGEMENT: POTENTIAL URBAN-SLUM UPGRADATION POLICIES IN BANGLADESH

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The unplanned water sector of slum settlements in many developing countries has an enormous backlog in the provision of reliable water supplies and sanitation services to its population, which is further exacerbated by the growing number of informal settlements. Development policy agendas are needed to be reshaped in ways that de-emphasize central state control and that shift responsibilities to local government, NGOs and the market. With some extensive literature review and using the outcomes of some studies on slum upgradation and its infrastructure development, this paper shows a range of practices and policies in accessing water and sanitation to urban slum settlements. The paper also summarizes the findings of the effectiveness of different policies and also discusses the difficulties and limitations of implementing government and private organizations' initiations. It identifies the changes needed to make slum upgrading more effective and capable of reaching a much larger scale. It starts from the observation of supply and provision of water and sanitation of slum as well as various upgradation program and policies. This research is concluded outlining a conceptual statement of adaptable slum up gradation policies in the context of a developing country like Bangladesh.

Key words: Informal sector, water-utility management, urban-slum, adaptable, upgradation policies.

1. INTRODUCTION

As estimated one billion people worldwide live in urban slums, the majority of them are in the less developed world. These settlements are usually of temporary structures and lack upgraded modern facilities. These informal sector water utilities in developing countries are consistently criticized for failing to provide adequate water services to the urban poor. The growing recognition of the problem of water utility in slums coincides with public policy shifts among national governments, major supranational institutions and many smaller non-governmental, private organizations. Development policy agendas are needed to be reshaped in ways that de-emphasize central state control and that shift responsibilities to local government, NGOs and the market. These changes are in part needed to democratize development through the involvement of local agencies and communities.

This paper focuses on the urban slum and its water-utilities upgradation policies; questions asked are: what new opportunities are offered by the policies? What are the constraints imposed by these policies? How do these affect local agencies, communities and processes in specific slum water utility upgradation projects?

2. INFORMAL SECTOR HOUSING: URBAN-SLUM AND ITS LIVING CONDITION

The world is experiencing an unprecedented rate of urbanization. In the path-breaking UN- Habitat report *Challenge of the slums* (2003), Secretary General of the UN Kofi Anan warned that:

“Without concerted action on the part of municipal authorities, national governments, civil society actors and the international community, the number of slum dwellers is likely to increase in most

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developing countries. And if no serious action is taken, the number of slum dwellers world-wide is projected to rise over the next 30 years to about 2 billion. The UN – Habitat report is one of numerous publications in the past few years alerting us to the gravity of the situation (Davis, 2006; Neuwirth, 2004). If this situation continues along with the absence of effective policies, precarious living conditions in cities may well become the main challenge to human development in future decades.”

The planned urban land areas command high land price. Therefore, low income families are forced into government or private vacant land with unplanned accommodation and unhealthy condition. Approximately 15 to 20 percent of Bangalore’s residents are slum dwellers while it is more than 30 percent in Dhaka, Kolkata and Mumbai. The government of India defines slums as housing that is “unfit for human habitation or detrimental to safety, health and morals of the inhabitants” (Government of India, 1988). The Bangladesh bureau of Statistics defines a slum (basti in Bengali) as: “A cluster of compact settlements of five or more households that generally grow very unsystematically and haphazardly in an unhealthy condition and atmosphere on government and private vacant land”. These seem to be acceptable definitions. The bureau used some of the criteria to identify slums, which includes predominantly poor housing, poor quality or no sewerage and drainage, inadequate drinking water supplies and few or no paved streets or paths. (CSAFP, 1997) In many of the slums covered by this study were found to be located near polluted water bodies, swamps or putrid drainage canals. These slum dwellers who take the low level of jobs continue living under this terrible condition. They represent a fundamental transformation of physical and social environment of urban life and human health. They seldom have access to publicly provided services even though the water supply and sanitation. In most cases, they build rudimentary toilets or use nearby streams and swamps for waste disposal. Pollution takes severe due to open defecation by the slum dwellers. Waterborne diseases are inevitable outcome. Accordingly, standard of health is becoming worse due to the reduced access to safe water and sanitation.

3. PROVISION OF WATER AND UTILITIES IN SLUM AREA

The responsibility of the government organizations for water provision in slums is fuzzy; perhaps an important contributory factor behind the poor quality of water-service levels in slum area is

inadequate number of government organizations involved in water sectors. Generally, the intersection of the slum and water sectors has created a web of relations among government actors that confront a simple version of a public utility. Inadequate safe drinking water in slums causes many problems. Unsanitary lifestyles, lack of domestic water, increased health risks-all are interrelated to the water provision of slum area. As the slum population is continuously growing excessively, demand of water within the service area cannot be met through piped network connection. So some alternative to piped system like buying from informal tankers, rainwater collection, own individual wells (for some counties) are also options to provide them with water for their daily use. But still, long term or short term policies are needed to distribute the services to the slum dwellers adequately.

4. SLUM UPGRADATION AND POLICIES EVOLVED

4.1 Evolutions of slum upgradation policies

In reference to Mumbai and other places, the slum policies are evaluated with the period of time. The various trial programs organized by state government as well as private agencies are failed in the implementing stage for the reasons of affordability, service distribution to the actual poor, inadequacy of fund, secure cost-recovery and maintenance. The role of the government is transformed from implementer to facilitator. But still it remains the problem of uncertainty to identify the truly poor dwellers that need the services from the private and governmental organizations. The local organizations and banks draw changes to the slum improvement policies through proper feasibility study and allowing active community participation. Now, scaling up the financing and implementation procedure from small area-based projects to large infrastructure sector of slums is the main challenging issue for cities of developing countries.

4.2 Common upgradation principles

In the developing countries, the slum upgradation programs are continuously changing according to the extensive experiences gathered from small projects and studies. But there are some common principles that government and private organizations follow to develop the water utilities and services of slums.

- Development plan by the government to redevelop slum infrastructure in situ through local structured program,
- Some agencies start through qualitative research methods which include local community

development structure, group interviews, introspection of the possible stakeholders, workshops and develop an action plan for longtime development.

- Some pilot projects initially go through feasibility studies which cover poverty matrix, SWOT analysis, Micro planning and poor community identification.
- Slum maintenance work is carried out by ward – level or local engineers, alongside routine works for given area.
- Maintenance divisions are usually like water source development, corporate planning by the private organizations, capital works, auditing and finance.
- For further extension of the development of water utilizes for slum dwellers, local investors and developers carry out with Lump sum contracts with the government.
- At the implementation stage the community participation is organized through communicating with selected community representatives to avoid muddle.
- Ensuring improved services after the connection with reliable water supply and consistent billing.

These principles have various implementation and maintenance procedure that may vary in different context of the cities of developing countries.

4.3 Overview of Institutions and their mitigation plans

Service provision can involve a variety of different organizational arrangements in water utility upgradation for slum. Among them, state governments and government institutions are slum rehabilitation authority, Regional development authority, municipal organizations, and civil societies. Their initiations for developing the environment of the slums are slow in progress and the staffing of the organizations is not appropriate to deliver effective services to the urban poor. In support, other coordinating authorities which also act as multiple executing agencies are the private sector developers, private banks, NGOs, Cooperative housing societies of slum dwellers, foreign agencies etc. Some of these agencies work

as financial investor to the slum development pilot projects. Their financial interest is the additional revenue that is gained from both initial connection fees and monthly tariffs paid by the slum dwellers. But sometimes there are some unusual funding and the opportunities to provide the slum dwellers with piped water supply and proper sanitation. Actually it varies according to the context.

The common features of their action plans are to improve the delivery of service to the poor settlements through an overall improvement of performance as well as the provision of infrastructure development to the slums.

4.4 Community participation and observations

Self-help practices are sometimes effective while undertaking upgrading programs for local area slum. Shared water connection and toilet facilities are the common approaches that are initiated by local slum dwellers. In effect, the potential outcomes for slum dwellers can be shared metered connections of water, individual metered connection, disconnection of illegal supply and services or no improvement. There are always choices in community participations which may vary with context of the cities. So it is better to promote participatory governance with the encouraging citizens to get involved with their government and hold it to account. The result is always observed with improvement of the relationships and decision making, user satisfaction according to their choices. So the whole process can be shown as Figure 1.

4.5 Scaling up the initial financing

All small local area-based projects are always successful as they are easier to manage in perspective of financial as well as implementation process. It is not important how the pilot projects can be scaled up but, rather, how the governance process can progress within the public sector organizations to generate new forms of governance. If the continuous development process can be formalized with necessary documentation and analysis, the initial financing can be scaled up according to the improvement of the mitigation plans. and adopt new patterns of working with the poor. In short, it can be shown as Figure 2.

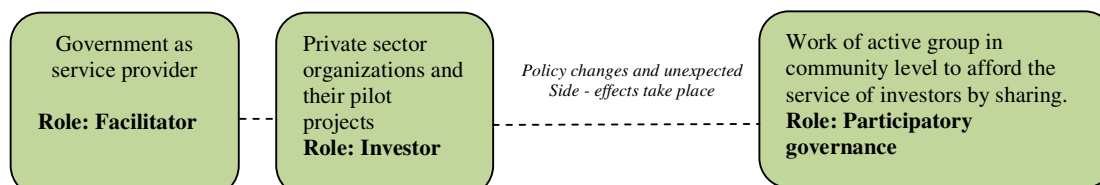


Figure 1: Overview of the evaluation of upgradation policies

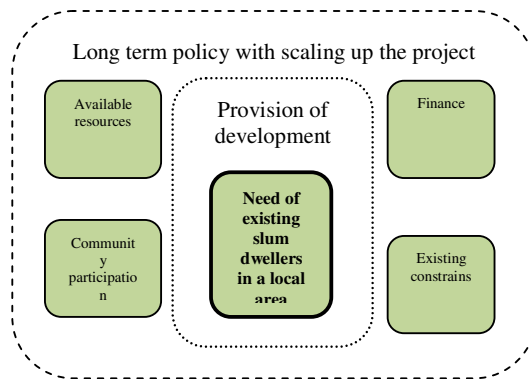


Figure 2: Long term mitigation plans

4.6 Limitations of the existing policies

If it is discussed about the effectiveness of the policies and difficulties of implementing government and private organizations' initiatives, the following common limitations can be monitored.

- In common, low number of social development experts work in the government organizations, rather these are staffed by engineers which is the main cause of limited interaction with slum dwellers.
- Political issues play a big role as the services provided by the agencies are misused by the powerful political persons who act as the community representatives. Public taps were provided, either legally by public agencies, or illegally by politicians, usually on the eve of elections.
- No consideration of capital investment associated with new growing slums and their infrastructure.
- Poorest people use to have very little involvement in community decision making in participatory governance.

4. ADAPTABLE UPGRADATION POLICIES FOR BANGLADESH

An estimated 3.4 million people live in slum (Figure 3) in Dhaka (Source: *Sustainable Development Networking Program (SDNP) website*). Some of them are involved in a variety of occupations in urban informal sectors. And due to a lack of education and employment training they usually do not gain entry into the more competitive formal sectors of urban employment. As a result their income is very low. So affordability of slum dwellers to meet the requirement of water and sanitation is an important issue. Whatever approach is taken for the upgradation of slums, it should be based on three simple concepts- "Affordability", "cost recovery" and "replicability".



Figure 3: Slum of Dhaka city (Source: Dhaka Satellite Image, Internet)

Affordability means adopting a realistic approach to the needed supply in terms of what urban poor can really afford. "Cost recovery" is related to the concept of "affordability", providing what can be afforded by consumers. "Replicability" means if costs are recovered as because they are affordable, then the successful repetition becomes likely. This would lead to an overall upgradation in slum settlements. In context of Bangladesh, the problems related to water utilities of urban slum are quite similar to other developing countries. But according to the available resources and public reactions some policies are adaptable for effective results.

5.1. Infrastructure and services

- House to house service connection is not feasible because of the huge gap between service to be provided and resource available. Therefore, privately supplied communal shared facilities can be provided.
- At the same way, clustered latrines (Figure 4) can be an affordable sanitation option since the cost is shared by many of the slum dwellers.
- Consumption of portable water can be reduced by providing alternative sources for other domestic purposes.

5.2 Finance

- Local government should play their subjective role because there is a substantial central government resource transfer component.
- Hence direct cost recovery is not feasible for slum area; improving land taxation can be a source for finance generation.
- Cost recovery is manageable for many poor households, but not for the poorest of the poor. In that case, some new cost-sharing arrangement is needed to be devised.
- Government subsidies and favorable loan agreements can also be introduced.



Figure 4: Community Clustered Latrines. (Source: Hanchett, S., Akhter, S., Khan, M.H., 2003)

5.3 Community participation

- Upgradation activity in any given slum starts with community mobilization. Developments have often emerged from the experiences of the local communities in trying to upgrade their own area, rather than a policy which has been superimposed from above
- In Dhaka city, while undertaking upgrading programs, community participation has to be ensured at all the strata of decision making and implementation as well.
- Community ownership should be developed instead of individual ownership.
- Communal activities like community mobilization and hygiene education can create a feeling for need for the infrastructure upgradation and their willingness to pay for those. It adds to people's ability to analyze and take control of their living environment. The local NGOs can play a progressive role here.
- Development and maintenance of infrastructure provision can be transferred to semi-autonomous public agencies from the routine municipal department, but cannot be to a complete autonomous body as it can obstruct overall coordination, long term planning and routine operational policies.

6. CONCLUDING REMARKS

Reviewing all the articles, mentioned in the reference, some general conclusion can be drawn regarding the upgradation of water utilities and services for urban slum. The overall experience of the pilot projects in other countries is very positive. Through the pilot projects, new working relationships are developed between slum dwellers, agency staff, NGO workers and others. But financial incentives were needed to ensure proper upgradation of water utilities and profitable for the developers or investors as well. Above all, the upgradation of urban slum is a continuous process which would be evaluated with the period of time, local context, existing needs, future needs and other

factors. So, the collaboration of the government, private organizations and community slum dwellers is necessary to reduce constraints of slum upgradation in Bangladesh. In broader sense the most important thing is the sustained reduction in vulnerability and poverty of urban poor.

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INTEGRATION OF PERFORMANCE BASED MODELING TECHNIQUES WITH BUILDING DESIGN METHOD (INDUSTRY/FACTORY) CONSIDERING ENERGY EFFICIENCY IN BANGLADESH

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Climate changing has been a debated issue during the last few years. Some institutes in different countries have worked on this subject. Several future climate predictions have been generated. Each future climate is based on some assumptions and consequently has some uncertainties. These uncertainties are dragged to the building simulation results by using the climate data for assessing the future performance of buildings. Bangladesh is newly a developing country. Many more construction is going on in full swing now days. This rapid construction is changing our earth surface very quickly. So that it increases heat on earth surface, energy consumption, decrease the comfort level. The answer to this challenging situation is the adoption of a holistic design approach, whereby the different disciplines required is brought together and interacts since the first steps of the design process. This study revealed the present implementation status of factory building sector energy standards in Bangladesh, implications for sustainable energy efficient designs in factory building and increasing demand for sustainable energy efficient industrial building.

Key words: Building Energy Use; Building Performance Modeling; Industrial Building

1. INTRODUCTION

Factories in Bangladesh have been heavily criticized over the last 30 years for the working conditions in which employees must labor. High internal gains from artificial lighting, poor natural lighting system and equipment produce an intolerably hot work environment and energy consumption is high. Bangladesh is one of the largest products exporters in the world. This factory building has been expanding rapidly since the late 1970s. Many purpose built factories have their own compliance to maintain the quality. Among the environmental compliances recommended Illumination condition, thermal comfort and reduce energy consumption are one of them that must be ensured. This paper consists 3 parts such as;

- (i) The status of energy standards for factory buildings in Bangladesh;
- (ii) Approaches to standards development in view of energy efficiency
- (iii) Implementation and energy simulation.

Energy saving did not happen in industrial sector in our country. Extra energy consumption (28.18 MTOE) in industry sector came from structural change (S-effect) and intensity change (I-effect) with amount of 16.39 and 11.79 MTOE, respectively.

This paper investigates the implementation status of factory building energy standards in developing countries and its implications for sustainable energy efficient designs in building. Important elements of the research that are described in the paper are:

- identifying the role factory building simulation can play at the different stages of design;
- developing a model description that evolves through the design process as the factory building design becomes more highly specified;
- simplifying the user interface at the early stage of the design where rapid feedback is required and where most impact can be made on the factory building's energy and environmental performance;

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- customizing results presentation to be appropriate for the particular stage of design; and
- implementing these simulation concepts, observing their acceptability, and addressing quality assurance and training issues.

In this Fig. 1, we can see the energy demand changing rapidly in our industrial sector. From 1970 to 2020 the energy demand of the industrial sector in Bangladesh will be almost 10 times increases.

So what can we do as professional bodies? There may have much kind of solutions. Building performance modeling while planning or designing a building may be one of the solutions to get rid of this kind of problem.

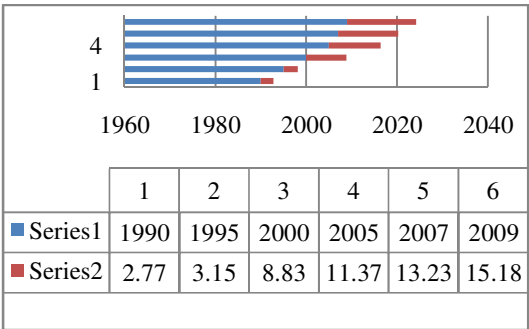


Fig. 1: energy consumption in the industrial sectors in Bangladesh Source: Research Journal of Applied Sciences

In Fig. 2 we can compare the ratio of energy demand increase day by day. And in 2010 it is highest. In the long run, we need more energy from the limited resources and it will cause a tremendous problem for our nation.

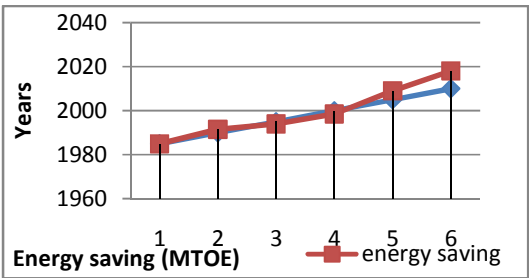


Fig.2: Energy demand of industrial sectors in Bangladesh Source: Research Journal of Applied Sciences; Year: 2010 | Volume: 5 | Issue: 2 | Page No.: 85-91

The overall building behavior will be influenced by numerous climate parameters, including sun, wind, water, and geotechnical factors. The sun influences shading, orientation, and views of the building. Wind introduces concepts of protection, shelter, and energy capture. Energy Conservation factory Buildings are very effective for restraint of global warming, because they can reduce CO2 emissions in building operation, which account for 70% of Life Cycle emissions.

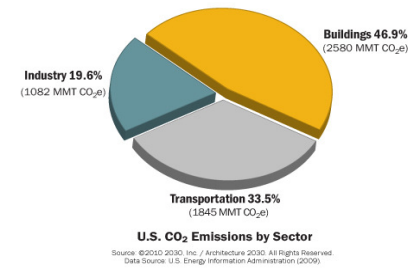


Fig. 3: US co2 emission by sector

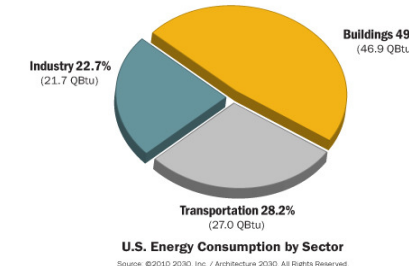


Fig. 4: US energy consumption by sector

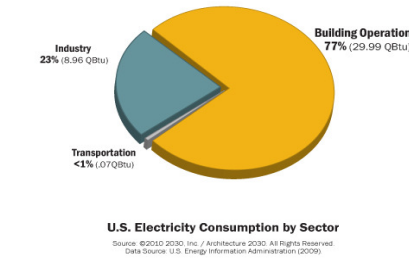


Fig. 5: US electricity consumption by sector sources: architecture 2030, energy international administration (2010)

From fig.3 – 5 we can notice that in US energy consumption is 22.7% in industrial sector and the whole building effect is almost 49% .the electricity consumption rate is about 23% and co2 emission is almost 19.6%. So now a day it is a big deal.

An essential condition for industrial development is uninterrupted supply of energy. Although the installed capacity for generation of electricity in

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the country is 2908 megawatt and energy consumption is about 25% in the industrial sector and takes the second position of energy consumption (Fig. 6), the actual production does not exceed 2160 megawatt as against the peak demand of 2200 megawatt. The average level of system loss is still as high as 33.3%. The demand for power will increase by 300 MW annually and an investment of about Tk 110 billion up to the turn of the century will be needed to meet it.

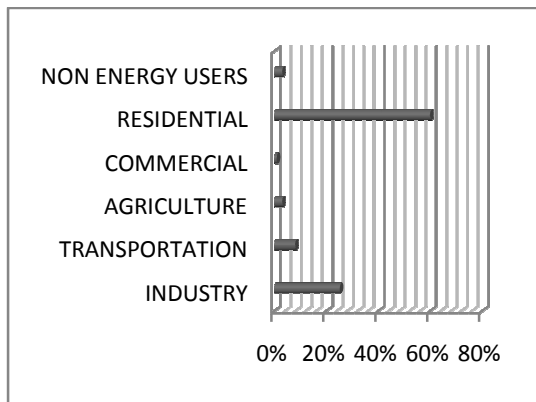


Fig. 6: Bangladesh electricity consumption by sector sources: power development authority, Bangladesh

2. IMPORTANCE OF ENERGY SIMULATION IN ARCHITECTURAL DESIGN

In early design stages, either in new or retrofit designs, one can estimate the energy consumption of the building being designed by using hand calculations. However, an energy simulation program can help the designer have more reliable predictions because it is able to simulate the building, the weather conditions that obviously influence the thermal behavior of the building, and the operating schedules of the building.

Energy simulations can then help the designer validate the preliminary estimation of the building's energy consumption and correct some of the architectural features of the building, and the mechanical systems, to improve the energy performance of the building. The building's form and thermal characteristics largely run the amount of energy consumed by a building. Thus, it is the building designer who has the primary control

over the building's energy use. When an architect starts to design a building, she or he is simultaneously starting the design of the heating, cooling, and lighting of the building. To avoid major flaws of the design, an architect needs to include the evaluation of the building's energy consumption in the earlier stages of the design process. If energy efficiency is not adequately considered during these stages, higher operating cost will accrue over the life of the building.

3. IMPACT ON ENVIRONMENT

Building performance modeling will create new knowledge and assist in capacity building by improving our understanding about energy efficiency on climatic adaptation and mitigation. This will create more awareness to take more effective actions for mitigating climate change, thereby making sustainable development feasible for green industry development in Bangladesh. It also Generate innovative knowledge. This knowledge will impact on national programs and strategies for climate change adaptation and mitigation.

4. GAPS FINDING IN DESIGN PROCESS (FACTORY BUILDING)

A worker's ability to do his/her job is affected by working in hot environments. One of the most important conditions for productive work is maintaining a comfortable temperature inside the workplace. Of course the temperature inside the factory varies according to the season and several methods can be used to address the problem.

Natural cross ventilation is another important factor for a factory building. Instead of natural cross ventilation extra cooling and heating load is needed for a factory building.

Most of the factory building in our country has no or less option of natural ventilation system, use of daylight, water efficiency techniques, no observation about indoor air quality and energy efficiency building envelop. On the other hand inside a typical factory, noise may come from a number of different sources such as the sewing machines, weaving looms, compressors, radios, background noise, etc. The noise, in the form of

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sound waves, is transmitted directly through the air and reflects off walls and ceilings as well as passing through the factory floor. It can be easily removed by the way of simulation process.

In Fig. 7 the diagram is presented the basic 3 gap of factory building design. In our country there is no consideration about local climate, building shape, orientation, no consideration about passive design process.

Most of the factory building owner want just make a floor for production and for this reason human being is like a machine nothing else here. Health hazardous condition and need extra energy for maintaining this factory is a common scenario in our country like Bangladesh.

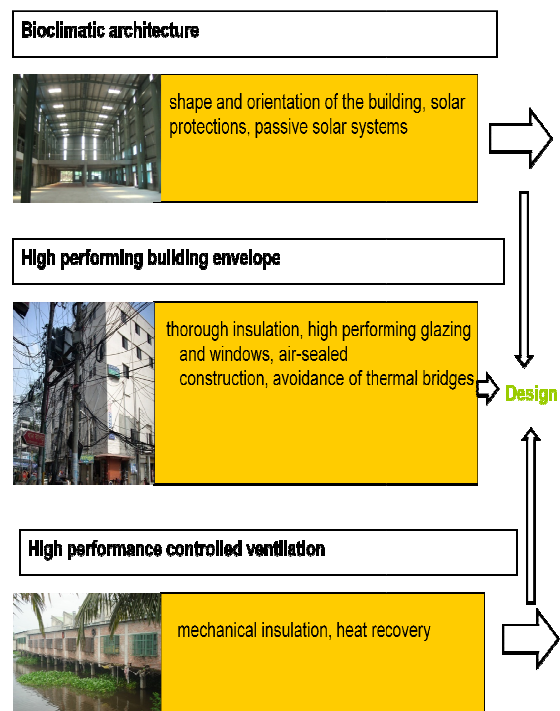


Fig. 7: the condition of present factory in Bangladesh and gaping element

5. SIMULATION IN THE DESIGN PROCESS

From Larry O. Degelman, Professor of Architecture, Texas A&M University we come to know to establish a holistic design approach

with simulation having an input at all stages it was necessary to determine the design approach of the architecture practice used as a analysis bed. The approach developed was also compared with related approaches in the published literature. The RIBA design plan of work (RIBA 1995) identifies three main building design stages: •Outline Design Stage • Scheme Design Stage • Detailed Design Stage. Different design objectives and scopes can be observed in the different factory building design stages.

At first in outline design stage a concept based on feasibility studies is prepared. It shows the design Analysis and options considered, it can include diagrammatic analysis of the requirements on the site, solutions to functional and circulation problems, relationships of spaces, massing, construction and environmental methods and a cost appraisal to enable an approximation of construction cost. This design stage is extremely time constrained. Elevation treatment, materials selection, construction and environmental analysis then are taken place in out line design stage.

In term of environmental analysis; Simulation will focus on problem areas or on typical factory building sections. Now the approved Scheme Design solution is worked through in detail. Detailed design drawings are produced for coordinating structure, services and specialist installation. Internal spaces may be detailed to include fittings, equipment and finishes.

At this design stage the application of simulation relates mainly to engineering issues and it will be experts using the tool. They will use simulation for purposes such as designing a natural ventilation strategy (sizing of openings, establishing control strategies, confirming minimum and maximum air flow) or to model other building services applications such as chilled construction systems or air conditioning systems.

In Fig. 8 a basic structure is shown for whole design evaluation process to see how simulation is used in design.

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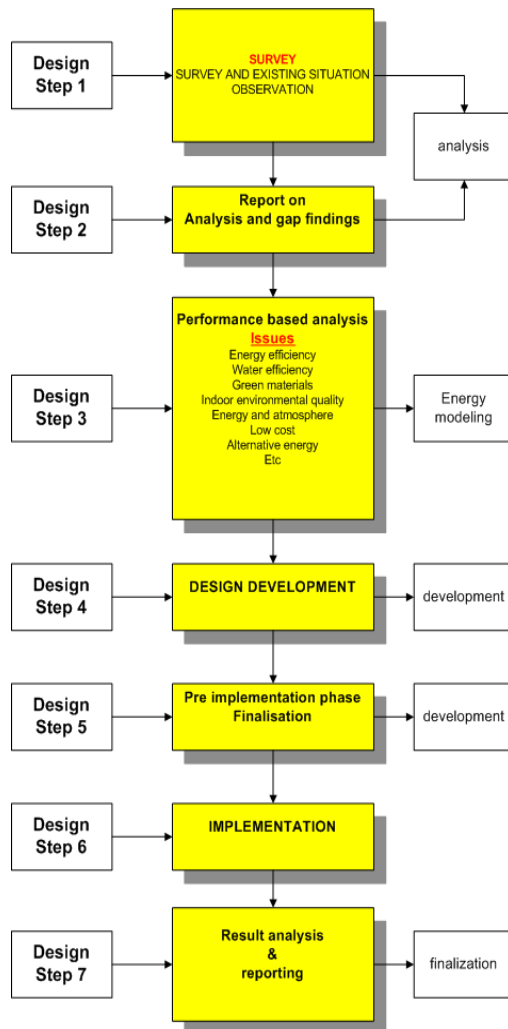


Fig. 8: structure of the design evaluation process BIM (Building Information Modeling) system

6. PARAMETERS EVALUATED BUILDING PERFORMANCE TOOLS

Simulation parameters also communicate more to the factory building envelope (glazing properties, ventilation rates) and whole building per year energy cost. The designer will be interested in an indication of the energy consumption that can be expected from the building. Simulation can also point out problem areas, identify parameters that cause the problem and assess the scale of the problem. Various types of simulation engine (tools) can be used for these purposes and using the same simulation tool throughout the design

process has additional advantages. It is possible to pass a model directly from one design stage to the next one. It is easier to tackle environmental issues in a holistic approach. Some energy simulation engine and their functions (applications) are mentioned here such as; Ecotect, Energy Plus, Dia lux, E-Spr, Radiance, Design Builder, etc. From Table. 1, it is noticed that various variables depends on the three design stages. And it comes one after another and need analysis for every component to make a factory green.

Design stage	Parametric consideration
Out line design stage	Orientation, U-values, Heat recovery systems, Air change rate
Scheme design stage	Detailed analysis, Material adjustment in overheating areas, Lighting strategy
Detailed design stage	Different heating systems Different cooling systems: Mechanical, ventilation

Table. 1: chart various design stage (Christoph Morbitzer, 2001)

7. MODEL CREATION

A number of key developments are part of the user Outline Design Stage (ODS) Interface. The program interface is structured to permit a step-by-step, rapid input procedure for the base case model and design options. 3D CAD software is used to define the model geometry. Detailed support databases are provided that distinguish building types, room function and zone location with the emphasis on rapid user selection (Joyce Carlo, 2003)

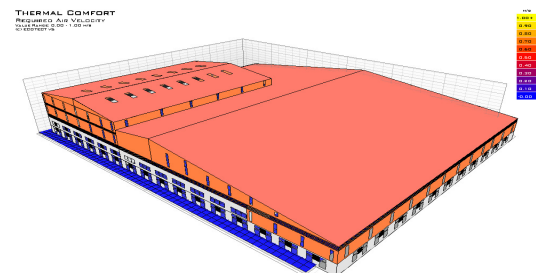


Fig. 9: a physical factory building computer generated model by Ecotect

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8. RESULTS ANALYSIS

Presentation of performance data is another vital element of building simulation interface design. This should help the designer to judge the environmental performance of the design and point out potential problems in the building. This includes the following key components:

- Ranking of the results against benchmarks.
- Identifying areas in the building that case poor performance.
- Identification of the reasons for unsatisfactory performance.

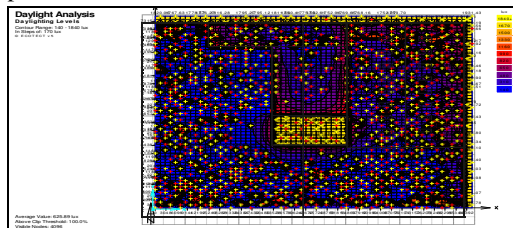


Fig. 10; daylight analysis model by Ecotect simulation tool

After performing the simulation, hourly result data is read into the database structure. The software then determines annual energy figures and compares them against benchmarks. It also View the energy flows in the building depending on, for example, time of day, external temperature, occupancy, only certain zone(s) etc.

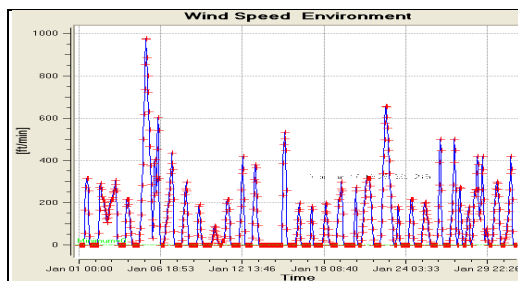


Fig. 11; win speed analysis 1 by Energy plus simulation tool

9. CONCLUSION

Building simulation is currently not an integrated element of the design process. Integrating modeling would raise awareness of energy and environmental issues and give it an adequate status in design decision making.

Finally it may be noted here Building performance simulation modeling has come a long way since the early seventies. In other developing countries, this type of integration is going on in full swing for their betterment of environmental aspect and them able to make the zero carbon community. We have to think about “plus o2 community” development instead of “zero carbon community” for our upcoming generation so that they can live in green space with the help of this kind of prediction techniques.

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LEARNING FROM ISLAMIC HERITAGE: AN ASSESSMENT OF CLIMATE CHANGE IMPACTS ON MUGHAL BUILDINGS IN DHAKA

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The Mughal built spaces of 400 years old city named Dhaka abridge the future with its ancient Islamic heritage and traditions. Every generation should be obliged to preserve the ancient buildings for learning. But due to impact of climates these Islamic buildings of Mughal times require repair every year. Moreover, climate change is becoming a matter of urgency for Bangladesh not only to mitigate the level of future change by reducing greenhouse gas emissions, but also to develop exclusive plans to adapt our ancient heritage to cope with the climate changes that will occur in future. As Dhaka is one of the most vulnerable to climate change effects, ancient heritage buildings must be considered with special care in respect to risks and adaptations. The objective of this paper is to identify and analyze the potential physical impacts of climate change on the built environment of the Mughal heritage building and possible mitigation strategies that should be considered for them in response to climate change risks in Dhaka city. The results shows that many decays of the old buildings is increasing with time due to the adverse effect of climate change and some particular means to be taken to sustain the historic heritage for future generations.

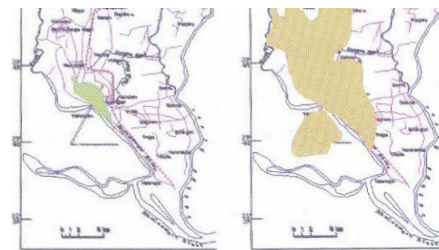
Key words: Islamic Heritage, Climate change impacts, Mughal building, Adaptation, mitigation strategies.

1. INTRODUCTION

The traditional architectural heritage and structures of Bengal are the reflection of bright and glorious past of Bengali nation. Dhaka is an indigenous city which was largely confined within Mughal forms till now. It is an old city with history of over 400 years. It has got political importance during Mughal Period (1608-1764) when Mughal Emperor Jahangir established it as the capital of Bengal (Hussain, A.B.M., 2007). But many of these Islamic heritages are in lack of maintenance. Bangladesh is recognized worldwide as one of the countries, most vulnerable to the impacts of global warming and climate change. The risk of survival of a particular building type and region will be largely dependent on the nature of that building and on climate changes (Roaf, S et al, 2005). This paper is aimed at all those comprehensive studies of climate change and those undertaking impact, risk and adaptation studies on heritage of Mughal period (figure 1) in Dhaka city.

2. OBJECTIVE

a) To identify and analyze the potential physical impacts of climate change on the built environment



Mughal Period Bangladesh Period
Figure 1: Development of Dhaka city in various
Periods (Source: Khan, F. 1997)

of the heritage building of Mughal period. b) To suggest possible mitigation strategies that should be considered for them in response to climate change risks in Dhaka city.

3. METHODOLOGY

Literature related to climate change and other aspect together with expert views from climate and heritage specialists were extensively reviewed and assessed. This integrated and broad methodology was made feasible by concentrating the study on the risks of Islamic heritage in four selected areas from the old and new part of Dhaka city: Lalbag and Begum Bazar areas from the Old Dhaka part as

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well as University and Mohammadpur areas from New Dhaka Part. The names of the Mughal structures that are analyzed are shown with figures 2, 3 and 4 as follows:



1. Lalbag fort: Tomb of Bibi Pari, 1678-78 AD



2. Khan Muhammad Mridha Mosque, Lalbagh, A.D. 1706



3. Kartalab Khan Mosque, Begum Bazaar, 1700-1704.



4. Bara Katra and Chhoto Katra, Old Dhaka, 1644

Figure 2: Mughal Structures of the Old Part of Dhaka: Lalbag and Begum Bazar area (Source: Photography by the authors)



5. Sat Gumbad Mosque, Mohammadpur, Late 17th A.D



6. Unknown tomb, Mohammadpur



7. Old Eid Gaah, Dhanmondi, A.D. 1640



8. Haji Khawaza Shahbaz Mosque and Tomb, 1679.

Figure 3: Mughal Structures of the New Part of Dhaka: Mohammadpur and University area (Source: Photography by the authors)

4. ISLAMIC HERITAGE IN BANGLADESH: MUGHAL BUILDINGS

The mughal rule in Bengal is over now, but it's memory still survives in large variety of buildings erected through a period of about two hundred years. Their expression of building activity through numerous mosques changes the skyline of Dhaka city. In Mughal buildings, there are secular buildings (Fort and fortifications, Palaces, Hammams, Katras, Bridges) and religious buildings (Mosques, Tombs, Qadam Rasuls, Eidgahs). In this great creative period rulers were sympathetic towards the local context and culture and mosque architecture went through extensive elaboration and perfection. It was recognized as brick-style

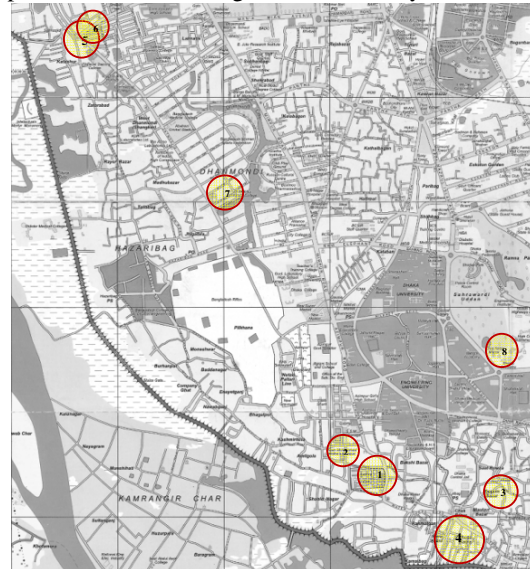


Figure 4: Surveyed Mughal structures of Old and New Dhaka (Source: drawn by the authors, Structures Numbers from figure 2 and 3)

They also invented chun-surki (lime powdered brick) to replicate the effect of sand stone. For an example, Sat Gumbag Masjid and Lalbagh Fort were the most tangible evidence of the past socio economic, cultural and religious activities. Therefore these heritages should be conserved and integrated to the life of contemporary society.

5. CLIMATE CHANGE IN CONTEXT OF DHAKA CITY

Currently, the most widely accepted climate change scenarios predict increases of between 1°C and 3.5°C for the global annual average temperatures (Cassar, M. 2005). Bangladesh is one of the worst affected among the countries that are facing the early impact of climate change. In Dhaka, the

capital of Bangladesh, the Key climate challenges for the historic buildings are: increasing rainfall, flooding, more extreme wet/dry cycles of weather or environment, coastal erosion and sea level rise. The notable direct impacts are: increased decay of stonework and organic growth due to higher rainfall in the rainy season. Indirect impacts are: increased demand for water elsewhere in Bangladesh could lead to develop the reservoirs or aqueducts; pressure at popular tourist sites due to increased tourism in warmer, drier summers; Upgrading of flood defences, drainage systems, changing patterns of cultivation and woodland expansion affects buried archaeology, renewable energy. In Bangladesh, average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during the 14 year period from 1985 to 1998. Highest hourly recorded rainfall 162 mm and recorded daily rainfall 300 mm. In some hot days of summer, temperature goes up to 40°C in the city and surrounding areas. Normally, rainfall cools down the weather (figure 5), but it is erratic.

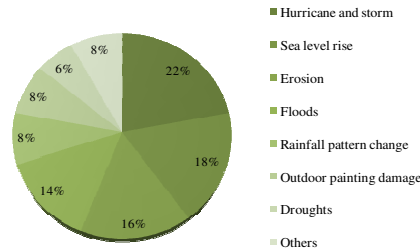


Figure 5: Threads of climate change reported for cultural World Heritage properties (Source: UNESCO World Heritage Centre, 2007)

According to IPCC in their recently published Fourth Assessment, the following changes have been observed in climatic trends, variability and extreme events:

- The annual mean rainfall exhibits increasing trends in Bangladesh. Decadal rain anomalies are above long term averages, since 1960s.
- Serious and recurring floods have taken place during 2002, 2003, and 2004. Cyclones originating from the Bay of Bengal have been noted to decrease since 1970 but the intensity has increased.
- Frequency of monsoon depressions.
- Water shortages has been attributed to rapid urbanization and industrialization, population growth and inefficient water use, which are aggravated by changing climate and its adverse impacts on demand, supply and water quality.
- The precipitation decline and droughts has resulted in the drying up of wetlands and severe degradation of ecosystems.

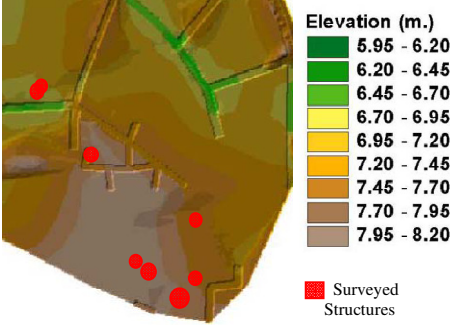


Figure 6: Interfered natural drainage system due to rapid expansion of the city (2004) and Digital Elevation Map of Dhaka City (Source: Internet)

Due to rapid expansion of the city, the natural drainage system was interfered with in some places and in some places destroyed (figure 6) and creates severe water logging problem. Thus, while considering the heritage of Dhaka city, climate change has its direct as well as indirect effect on the environment, economy and society and the impacts are also interrelated (figure 7) among them.

6. IMPACT ASSESSMENT

6.1 Environmental Impacts

The hot humid climate of Bangladesh supports prolific growth of vegetation and the burnt clay products. When the buildings loses its functional or economic use, the nature starts its process of destruction: vegetation grows, roots penetrate deep into the structure, dampness spreads all over the place, the wooden members rot, surface peels off with all its creative artistic works, roof system collapses and soon it turns into as earthen mound. The logged water at the site, damages the foundation and the building structure. To preserve the historical artefacts within Islamic heritage building, the indoor temperature should be 21°C, and relative humidity (RH) of 35% (dew-point 5°C) in the winter and 50% (dew-point 10°C) in the summer. It is also desirable that short-term (daily) variations in RH are no greater than 5%. But from the field survey, while considering all the desire situations, it is found that indoor-outdoor thermal difference (Table 1) is not so satisfactory. From the Damage survey (figure 7), it is found that the wall surface in Diwan-i-Am and Bibi Pari's Tomb showed damages due to saltpetre action and rising dampness.

Table 1: Comparative Analysis of the thermal condition of Mughal structures (Source: Field Survey)

Name of the Islamic heritage	Average indoor-outdoor Air Temperature Difference (deg Celsius)	Average indoor-outdoor Relative Humidity Difference (%)	Average indoor-outdoor Wind flow Difference (m/s)	Average indoor-outdoor Dew point Difference (deg Celsius)

Audience Hall (museum), Lalbagh fort	3.1	2%	0.2	0.4
Tomb of Bibi Pari, Lalbagh fort	1.1	9%	0.2	1.2
Lalbagh Fort Mosque	2.1	5%	0.5	1.6
Mridha Mosque, Lalbagh	0.2	4%	0.4	1.8
Kartalab Khan Mosque, Begum Bazaar	0.1	3%	0.1	0.4
Bara Katra and Chhoto Katra gateways	0.6	4%	0.2	1.2
Sat Gumbad Mosque, Mohammadpur	0.3	6%	0.1	2.2
Unknown tomb, Mohammadpur	1.9	8%	0.7	1.8
Old Eid Gaah, Dhanmondi	0.1	1%	0	0
Haji Khawaza Shahbaz Mosque and Tomb	2.5	6%	0.6	1.9

Though this has now been treated, transfusing silicon solution above the ground level, but the damages occurred again and again and it had to be renewed repeatedly. This old structures can stay warmer in winter and cooler in summer. Thatch in particular has a very high thermal insulation value. Terraces can also be more energy-efficient than detached houses which lose more heat through their larger surface area. Historic building materials are also often more durable than their modern replacements and can be more cost-effective in energy terms.

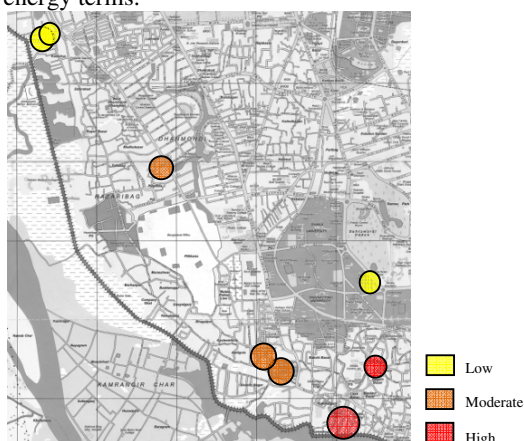


Figure 7: Damage map of the Existing Mughal structures (Source: field survey)

Wind: Wind driven rain and sand, transported salt, can give impacts like penetrative moisture into porous cultural heritage materials, structural damages, collapses, deterioration of surfaces due to erosion (UNESCO World Heritage Centre, 2007).

Climate and Pollution acting together: pH precipitation, changes in deposition of pollutants can make impacts such as brick recession by dissolution of carbonates, blackening of materials and corrosion of metals (Harris, D.J. 1999).

Changes in rainfall patterns: Increasing levels of rainfall pose a threat to semi-ruinous buildings. Rain water penetration to wall heads results in

disfiguring and damaging algal growth, staining and damage to brickworks.

Flooding: It presents a significant threat to the historic environment and causes irreversible effects such as damage to brick work from excessive wetting and contamination from flood water. All roads become blocked and thus cause inaccessibility.

6.1.1 Direct Impacts: Drier, warmer summers (more frequent drought conditions): Droughts can make risk to organic archaeological preservation, increased risk of fire in historic buildings. Maintenance of these historic buildings with parks and gardens will not be sustainable in water shortages (e.g. lawns, herbaceous borders).

Wetter rainy season (more periods of intense rain): It may cause flash flooding and erosion affecting archaeology and buildings and flooding of the river valley especially in old Dhaka part. Traditional drainage systems (roof and ground) may fail and renovating of rain water disposal system (figure 8) can damage the historic fabric or character of building.



Figure 8: Impact of wetter rainy season (Source: photography by the Author)



Figure 9: Impact of wetter rainy season (Source: photography by the Author)

Rising temperatures overall: New or increased insect pests and invasive plant species (fewer frosts) affect historic parks, gardens, buildings and landscapes such as the Lalbagh fort. Thus requires new installations of air-conditioning and climate control.

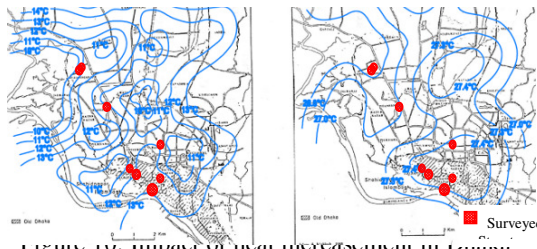


Figure 10. Impact of heat increment in Dhaka
(Source: Ahmed, K. A., 1996, newly drawn by author)

Increase in storm episodes: Damage to Mughal buildings as well as veteran trees may be caused by extremes of wind and rain. It also cause loss of and damage to ancient woodland.

6.1.2 Indirect Impacts: Switch to renewable energy sources or adaptations: Micro-generation installations adversely affect historic fabric and character.

Energy measures: Introduction of new building regulations like any changes of building elements require unnecessary or inappropriate changes to historic buildings. Inherent sustainability and embedded energy in historic buildings and infrastructure either is not recognised as contributing to the ‘carbon economy’ increasing pressure to demolish ‘inefficient’ older buildings and infrastructure.

6.2 Economic Impacts

Tourism, one of the most important and rapidly growing service industries, is an important part of economic sector in Bangladesh. Climate change has the potentiality to radically alter tourism patterns by inducing changes in destinations and seasonal demand structure (Scott *et al.*, 2008). The problems are twofold – a) how to integrate the complex climate science in economic models and b) how to develop economic models that will predict economic conditions in future. In order to predict the next 100 years, we need economic data from the previous 1000 years or so.

6.2.1 Direct Impact: Among the notable Mughal structure of this paper the Lalbagh Fort that have already been conserved and opened up for general public which is also a source of income for Bangladesh.

Table 2: Economic impacts in mughal structures
(Source: Scott, D., *et al.* 2008).

Name	Type	Location	Visitors/day	Income (tk)/week
Lalbagh Fort (Audience Hall, Tomb of Bibi Pari and other structures)	Mughal fort Complex	62 no ward, Lalbagh, Old Dhaka	6500-7000 (Friday, Saturday) 2000-2100 (Monday-	22,9462.5
Others seven mughal structures	Mughal heritage	Old and New Dhaka	Nil	Nil

Here ‘Table 2’ shows that there is economic loss if the heritages are conserved considering the climate change.

6.2.2 Indirect Impact: According to Nicholas Stern, from formal economic models, that if we do not act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more (Stern, 2006) which will be a nightmare for the government of Bangladesh to recover the total damage due to climate change. So, the historic buildings like mughal architectures could have negative impact with the economic crisis.

6.3 Social Impacts

The most obvious social scenarios relate to demographic changes, among which, changes in population size and distribution are probably the most commonly used. Future population changes of Dhaka city are likely to have a significant influence on the natural resources and heritages that are managed by local government in this capital city.

6.3.1 Direct Impact: Poorly designed or inappropriate energy-saving measures can seriously detract from the historic character and fabric of mughal buildings, whereas well designed measures can make considerable savings with little or no damage. Mughal Heritage welcomes the Government’s commitment to reduce the emissions that contribute to global warming, increase fuel efficiency and exploit renewable energy sources. Nevertheless, policies for adaptation and mitigation should be taken into account when policy is being formulated.

6.3.2 Indirect Impact

The informal situation of the whole sale shopping, especially at Borokatra and Chotokatra of old Dhaka (Hossain, M. S. 2008), may be beneficial to commerce both retail and wholesale, and local manufacturing. These uses make great demands on service infrastructure, traffic (trucking), dilapidated houses (ware-houses), cheap manual labour (migrants) etc (Asiatic Society of Bangladesh 1993). Changes of the historic sites to cope with the climate change may cause interruptions of the social structures of this part of the city.

7. RECOMMENDATIONS

The study of this paper shows that many decays of the old mughal buildings is increasing with time due to the adverse effect of climate change and some particular means to be taken to sustain the historic heritage for future generations.

The approach to improve the climatic environment in historical buildings in such conditions, was to raise the temperature in cooler areas of the building. Increasing temperature causes a necessary reduction of the RH level. The ideal is to maintain RH for the collection environment at less than 70%, slightly (5%) less than the threshold RH for significantly increased microbial activity (Shin M., Franciza T., 2001). Introducing secondary glazing, for example, can significantly improve thermal performance (English Heritage 2002). Lower heating levels could be adopted in some publicly accessible historic buildings, such as Lalbag fort or Kartalab Khan mosque and the use of humidistat controls rather than thermostats may in some cases reduce the demand for energy. New additions and amendment in Gadget or building construction act with considering climate change impact is a necessary step to save the mughal structures as well as other historic structures. All the mughal building should be enlisted with rating climate change impact on them. It is important to work with others to protect or, if not feasible, then record these significant historic sites that are at risk as a direct result of climate change. It is also needed to promote further research into the direct impact of climate change on the historic environment, including the development of impact indicators and adaptation strategies. We need to review the management of our own city as well as our country as a whole in terms of climate change, investigate low carbon and alternative energy systems that can be used in these historic buildings to reduce carbon emissions, ensure that buildings occupied or used by Mughal Heritage are maintained and operated to optimize their environmental performance and ensure that any new buildings constructed on our estate achieve 'excellent' energy performance ratings. Close coordination among BWDB, DWASA and DCC is necessary. Adequate human and organizational capacity is need to be developed with adequate technical, business, management, regulatory skills and appropriate enabling environment. Also, Participation of all stake holders – private actors, public agencies, NGOs, CSOs and grassroots organizations, can be the option of implementation strategies.

8. CONCLUSION

The rich heritage of old Dhaka, specially the mughal heritage, is under great danger and are being destroyed (Asiatic Society of Bangladesh, 1993, p.120). There are some challenges to mitigate the climate change impacts on Mughal structures. Identifying vulnerable sites and what to prioritize, 'how to treat old brick and other traditional materials affected by increased rainfall', 'are current conservation methods adequate?',

increased need for maintenance, 'where will resources be found?', decisions on the viability of certain mughal sites – these all are the possible challenges to implement sustainable and adaptable strategies for it. The Copenhagen negotiation in 2009 was focused on separate international funds for adaptation and innovation. These funding can be a support for mitigating the adaptations of mughal structures. In parallel with international negotiations initiatives at the domestic level are needed for improving the use of financial resources and quality of technology transfer (Climate Change Cell, 2007). Further research can be conducted on various issues of climate change impact upon historic building of Dhaka as well as Bangladesh to sustain these Islamic heritages with a scope of learning from these structures for future generations and maintain the presence of the past in the present.

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MODELING GROUNDWATER FLOW AND ADVECTIVE TRANSPORT OF SALINITY IN THE UNCONFINED AQUIFER OF SOUTHWEST BANGLADESH

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ABSTRACT

The southwest coastal region of Bangladesh is in a very difficult situation compared to other parts of the country due to direct interaction of the fresh groundwater with the saline surface water from coastal river and sea. A three-dimensional finite-difference groundwater flow model was employed to investigate the variety of hydrogeological conditions and to simulate the groundwater flow characteristics and dynamic flow exchanges between the rivers and the underlying aquifers in the southwest unconfined aquifer of Bangladesh. The MODFLOW modeling package in the framework of Groundwater Modeling System (GMS) was applied for this purpose. Stratigraphic modeling results of sub-surface lithology demonstrate that the upper unconfined aquifer of the region is extended up to a depth of 150m below the ground surface containing two distinct layers. Natural recharge from precipitation formed the main input to the aquifer system and abstraction from wells was the main output. The two-layer model was calibrated in two steps using observed groundwater levels: a steady state calibration against 1992 data, and a transient calibration and validation for 1992-2005 data. The simulation results show that the fluctuations of hydraulic heads are dependent on seasonal variation in recharge from precipitation. Advective transport of salinity was assessed by coupling the modeling package MT3DMS with MODFLOW in the framework of GMS. The model result reveals that the saline front lies close to the sea and has very little effect on groundwater. Also, the dynamic interaction simulation depicts that salinity intrusion from coastal rivers, in the form of recharge water, is the predominant factor affecting groundwater system rather than the intrusion directly from the sea side.

Keywords: Advective Transport, Conceptual Model, Dynamic Interaction, GMS, Groundwater Flow

1. INTRODUCTION

Worldwide, groundwater is usually the main source of freshwater in the coastal region because of limited potable freshwater supply, where saltwater intrusion is a frequent and widespread problem (Werner and Gallagher, 2006). Therefore, its development and management on a regional scale is essential for a developing country like Bangladesh, which often experiences the lack of surface water resources having adequate quality to meet the rising freshwater demand. But it is recognized that the most significant aspect of any water resources planning and management strategy is to ensure adequate supply of water with acceptable quality (Nobi and Das Gupta, 1997). The coastal belt surface water systems in the southwest region of

Bangladesh have already been affected by salinity due to the direct interactions of freshwater in the tidal rivers and saline water in the sea (Khan, 2002) which has direct impacts on the environmental sustainability in the region. Salinity concentrations in the tidal rivers of coastal belt vary seasonally depending on the upstream freshwater flows from the Ganges. Adel (2001) reported that the surface water availability in Bangladesh is reduced by 50% with a corresponding 60% upstream freshwater diversion (Farakka Barrage) in the Ganges, which causes a proportionate decrease in groundwater recharge in the downstream. Thus, salinity is one of the major causes of water quality degradation for both surface and groundwater resources in the region because of its geographical location as well as uncontrolled abstraction from underlying aquifers (Rahman *et al.*, 2000; Halcrow, 1993).

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It is widely accepted that both surface and groundwater systems are inherently linked to each other. Thus, uncontrolled development or contamination of one obviously affects the other (Sophocleous, 2002). So, the groundwater systems in this region may be affected by salinity intrusion from the sea due to over-exploitation from the aquifer. Study suggests that the underlying aquifer in this region is dynamically linked with the salinity affected rivers and surface water bodies (Nobi and Das Gupta, 1997; Halcrow, 1993) which may further degrades the groundwater quality through dynamic interaction mechanisms. In addition, further groundwater development and sea level changes may aggravate the situation (IPCC, 2007; Ranjan *et al.*, 2006). Finding solutions to such ubiquitous water resources problems need thorough investigations and analysis of the overall system in an integrated manner. So, the present study is an attempt to investigate the dynamic flow characteristics of groundwater systems and advective transport of salinity into the aquifer system in the southwest coastal region of Bangladesh by applying three-dimensional groundwater modeling technique.

2. MATERIALS AND METHODS

2.1 Hydrogeological characteristics of the study area

The study area is located in the south-west region of Bangladesh lying between 22.20° to 24.12° north latitudes and between 88.56° to 89.98° east longitudes. The area covers about a total area of about 16985 sq. km which is surrounded by the Ganges-Padma River in the north, the Gorai-Madhumati-Haringhata-Baleswar River system in the east, the international border between Bangladesh and India in the west and the Bay of Bengal in the south. The area is enclosed by 20 hydrological sub-catchments delineated by the Institute of Water Modeling (IWM), Bangladesh during regional model development phase (Fig. 1). The SRTM digital elevation model reveals that the area is dominated by flat topography, which varies from 18m to 2m above MSL with a gradual drop from northwest to southern coastal-belt directions. At extreme south, the coastal part has very low and flat topography varying between 0m to 2m above MSL. The annual average rainfall is 2000 mm of which approximately 75% occurs during the monsoon season (June to September) and almost 90% occurs in the wet period (April to September). The mean annual temperature is 26°C . The relative humidity also varies from 70% in March to 89% in July. Depending on these parameters, the average pan evaporation is also high and generally exceeds the rainfall rates in dry season (October to March).

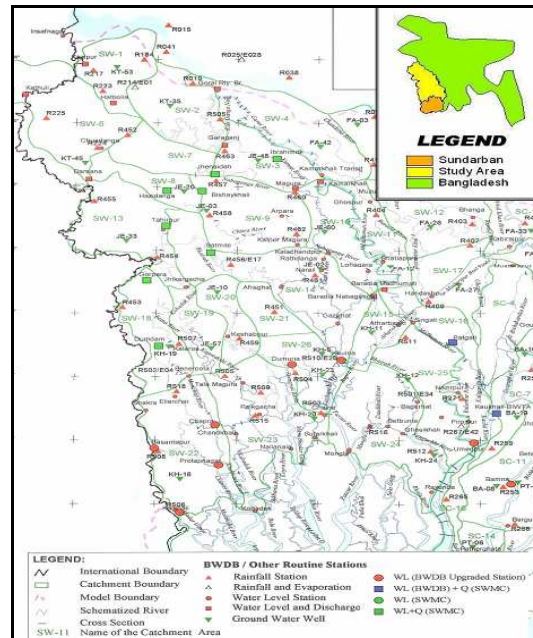


Fig. 1. Location of the Study Area in the Southwest Region of Bangladesh

The southwest region of Bangladesh is underlain by alluvial sediments of the Bengal Basin, laid down by the Ganges-Brahmaputra River system. The sediments become progressively older with depth and lithologically range from clay and silt, to fine, medium and coarse sand, which are unconsolidated or lightly compacted. Only those sediments down to 300m depth are of interest hydrogeologically. Previous studies reported that there are no faults or folds within these hydrogeologically significant sediments (Halcrow, 1993). In general, the upper clay layer is comparatively thick in the coastal part. In most of the areas, the composite and deep aquifer sequences are found in the 150-300 m depth range. The upper surface layer of mainly clay and silt characterized by high porosity but low permeability, which has poor aquifer properties and thus unsuitable for significant groundwater development. The intermediate layer has moderate to good aquifer properties and capable of producing reasonable amount of water. However, the main aquifer (lower unit) is the most important source of groundwater for irrigation, which is characterized by high porosity and moderate to high permeability and thus, it can provide large quantities of water to shallow and deep tube wells.

2.2 System conceptualization

The conceptual model helps to simplify the field problem and to organize the associated field data so that the system can be analyzed more readily (Elkrail and Ibrahim, 2008). A total of about 52 borelogs are available from the groundwater circle

of Bangladesh Water Development Board (BWDB) covering the whole study area containing individual layer lithology along the depth. This allows taking the full advantage of GMS[®] (Groundwater Modeling System) to build a conceptual model within its framework. GMS[®] is a graphical user interface (GUI) for using MODFLOW and MT3DMS and stratigraphic modeling of aquifer systems. It has a powerful GIS interface for use in different phases of groundwater modeling. Interpretations of individual lithology followed by semi-automatic preparation of cross-sections and automatic fence-diagram reveals that an unconfined aquifer exists up to 150 meter below the ground surface characterized by two distinct aquifer layers (Fig. 2). All sorts of spatially distributed data such as location of groundwater level observation well, recharge, aquifer hydraulic parameters, top and

bottom surface of two aquifer layers, bottom of riverbed etc. is mapped using GIS by digitizing point data, line or polygon features. The topography of the upper layer is spatially variable from north to south direction and is assigned into the model by integrating the digital elevation model (DEM) data of the area compiled from SRTM public domain database by kriging technique. The surface topography has influence on the head pattern of the upper aquifer layer and frequently receives rainfall recharge. The hydrogeological setting of the study area is characterized by large horizontal and vertical heterogeneity. Mainly three external sources of water influence the recharge conditions of the flow system such as rainfall recharge, later inflow from west boundary and river bed leakage in some sections.

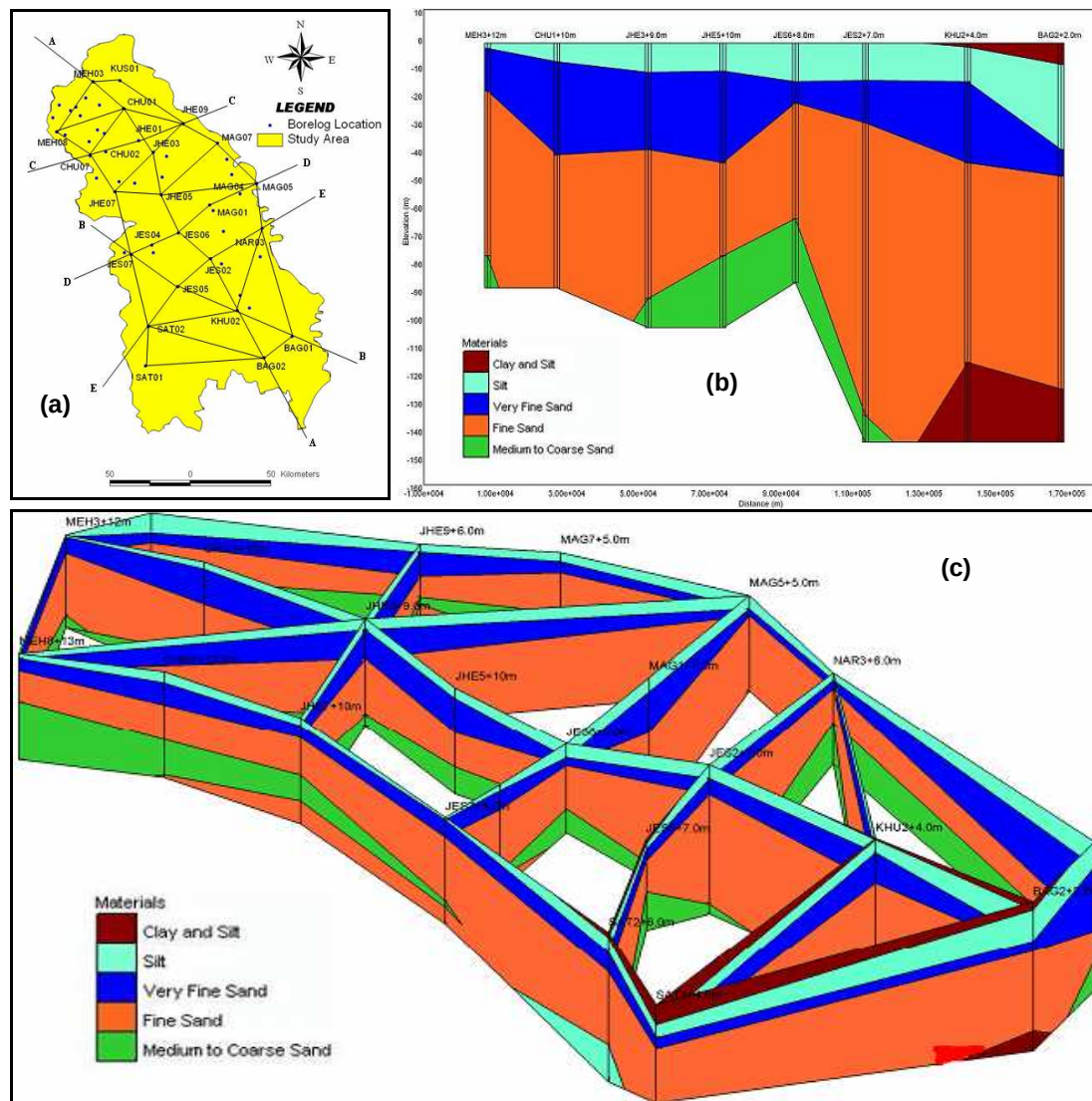


Fig. 2. (a) Location of Borelogs (b) Hydrogeological Profile along N-S direction (A-A) (c) Fence Diagram

2.3 Development of numerical model

The aims of the numerical model were to check and assess the validity of various interpretations regarding the flow system. These include (i) the location and type of flow-system boundaries, (ii) the location of recharge areas and (iii) variations in interpretation of hydrogeological framework. The three-dimensional groundwater flow model MODFLOW-2000 and three-dimensional solute transport model MT3DMS were used for simulating groundwater flow and salinity transport. Both models are applied in a two-step flow and transport simulation in the framework of GMS[®]. MODFLOW computes the hydraulic heads and cell-by-cell fluxes during the flow simulation, which is subsequently used by MT3DMS as the flow field for executing transport simulation. In order to prepare the finite-difference model grid, the aquifer system domain was divided into 232 rows and 162 columns and each cell having 1 km x 1 km grid size in the horizontal plane. The model consists of 2 layers (up to 150m depth) simulating the principal hydrostratigraphic units' presents the upper regional unconfined aquifers. The top layer (layer #1) is characterized by composite mixtures of clay, silt, very fine sand and fine to medium sand and lumped into one unit (0-60m). The bottom layer (layer #2) is represented by relatively coarser materials like fine, medium and coarse sand lumped into it (60-150m) (Fig. 2). Thus, both layers are hydraulically well-connected to each other (Nobi and Das Gupta, 1997). Surface and bottom elevations of both layers are interpolated from DEM and boreholes data. The model boundaries were represented by the available hydrological features adjacent to and within the model domain (Fig. 1). A time dependent specified head boundary is applied along the Ganges River in the north side and Gorai-Madhumati-Haringhata-Baleswar River systems in the eastern side of the study area using water level data of different gauging stations. In the south side, the model boundary is extended up to Hiron point to establish the sea boundary and a time dependent specified head boundary is provided using the Hiron Point water level measurement. The west boundary of the model domain is located along the international border between Bangladesh and India and a general head boundary is assigned along this side. For this purpose, the known hydraulic heads from the observed groundwater level of several monitoring wells located along the border is used. The river package of MODFLOW simulates the effects of flow between aquifer and rivers. Water levels in the rivers were used from the different gauging stations within it. The recharge rates as in (Halcrow, 1993) were assigned on the top layer only using the MODFLOW recharge package. There was a lack of enough pumping test

data in the area to be used as aquifer hydraulic property. So, the hydraulic conductivity is initially distributed on the basis of available pumping test data and lithological knowledge.

3. RESULTS AND DISCUSSIONS

3.1 Steady-state simulation and calibration of groundwater flow model

Initially, the developed groundwater flow model is simulated and calibrated under steady-state condition for the average base condition in 1992. The observation data used in the calibration process was the water table elevations from observation wells. Although, steady-state condition does not occur in the practical field situation, but it gives a very initial estimates of model parameters. It also helps to check the mass balance and to check the assigned boundary conditions in the model.

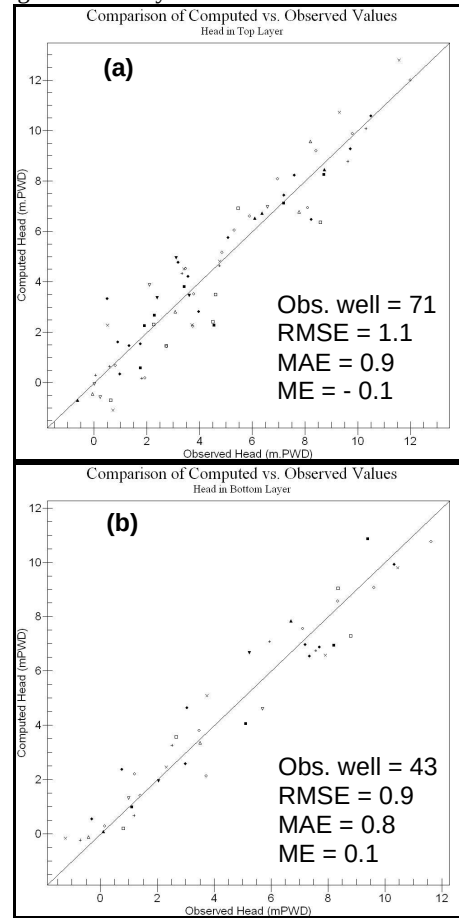


Fig. 3. Observed Vs. simulated heads in (a) top layer (b) bottom layer

Steady-state simulation was run to estimate the initial head distributions to be used in the transient simulation. Model calibration in groundwater modeling is often required because of the

unavailability of reliable field measured data to estimate the aquifer flow characteristics. During calibration, traditional trial and error technique is followed. GMS[®] has powerful graphical user interface (GUI) with strong GIS linkages for assigning model parameters either into cell-by-cell or zonal based approach. Parameters are assigned into the model by dividing the whole model domain into a number of zones for both layers assuming similar hydrogeological properties as the cell-by-cell input is a complicated task especially in a large groundwater model. In steady-state calibration, the initial values were adjusted within a reasonable limit to obtain a good agreement of the computed and observed water table in 1992 and quantified by statistical means. The calibrated hydraulic conductivities (20 zones) vary from 9 to 14 m/day for top layer and 18 to 40 m/day for bottom layer. To evaluate the calibration performance, scatter diagrams are prepared for each layer and a 45° line drawn to represent the perfect correspondence between observed and simulated values. For this model, the estimated RMSE for top and bottom layer was 1.1m and 0.9m respectively (Fig. 3), which is very small. Once these criteria were satisfied, the model was considered calibrated. It can be mentioned here that these criteria of calibration were met with the residual mean being close to zero.

3.2 Transient simulation and calibration

The transient simulation was run to replicate the flow characteristics in the aquifer by introducing the pumping well. The discharging through the pumping well was simulated as specified flow boundary using specified pumping rate. The pumping well is considered a sink and is represented in the model by a node. Initially, model calibration is performed using the available observed water table data for a period of 1992 to 2002. The remaining data from 2003 to 2005 is used for validation purpose. The whole simulation period is divided into 28 stress periods containing two periods (dry and wet) in a year. Recharge is assumed to occur only in wet period (May to October) and no recharge is considered in dry period (November to April) based on rainfall data analysis. Each stress periods are further divided into 6 time steps with a total of 168 time steps. Thus, each time step consists of 30 days with a total simulation time of 5113 days. In transient analysis, the head distributions or aquifer response at different simulation periods under existing stresses are found out. Also, the input required by the solute transport model (MT3DMS) is generated by simulating the flow model in transient condition. Transient calibration is carried out using the same model parameter structures and initial head

distributions computed in steady state calibration. During transient calibration, storage parameters are assigned in the same zone for both layers. The observed and simulated heads are then carefully compared and parameters are adjusted by trial and error method to obtain a good agreement between them. Initially, storage parameters are adjusted to obtain good match. Also, vertical conductivity is adjusted very little. The horizontal hydraulic conductivity was not changed. However, only one parameter is adjusted at a time because it facilitates to understand the effect produced by the change of each parameter. After modifying of parameters every time, the model is re-run. Several simulations have been carried until a good match between observed and simulated heads are obtained. From transient analysis, it is observed that without modifying the horizontal hydraulic conductivity values good match between observed and computed heads is obtained, which depicts that reasonable calibration was achieved in the transient-state. It is found that most of the observation wells show good agreement with the computed heads and the calibrated hydrograph follows the average trend of the observed hydrograph. The calibrated values of storage coefficient vary from 0.002 to 0.004 for both layers. However, there are some monitoring wells where poor agreement between observed and simulated heads is noticed. The study area constitutes a large number of small rivers and water bodies which have influence on groundwater level. But practically, it is quite impossible to incorporate all these in the model domain. It may also be due to aquifer anisotropy and heterogeneity. Sensitivity analysis shows that the response of the modeled system is more sensitive to variation in recharge than to hydraulic conductivity and storage parameters.

3.3 Simulations of salinity transport

In the present study, chloride concentration is considered as a proxy of salinity. The boundary conditions of the saltwater intrusion model depend on the boundary conditions used in the flow model. In salinity intrusion model, the specified head boundary in flow model is changed to specified concentration boundary based on the observed salinity measurements. As the salinity varies during dry and wet season, boundaries are also assigned accordingly in both periods. Along the general head boundary of flow model along the international border, a zero concentration boundary is assigned. Any inflow coming from the sea has a specified chloride concentration of 24000 mg/L which is established by the observed salinity data at Hiron point station. For Mongla, Chalna and Khulna points in Passur River, time dependent specified concentration boundary is established by the

observed salinity in those stations. The initial salinity concentration is assigned based on the groundwater salinity data from the very few observed stations. The specified concentration of recharge water is taken as 300 mg/L in the coastal part of the area where surface water bodies are already affected by salinity intrusion.

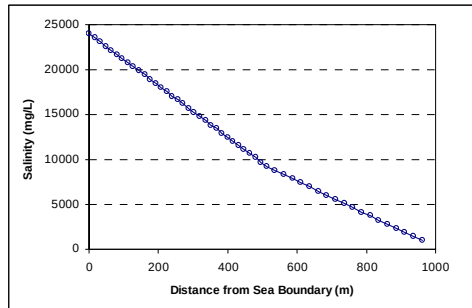


Fig. 4. Distance of saline front from Hiron Point

As MT3DMS is designed to be used in conjunction with any block-centered finite difference flow model, it facilitates to couple it with MODFLOW to develop solute transport model. Thus, the spatial discretization used by solute transport model is same as that of flow model. As the transport model uses the transient flow model, the stress periods of transport model is kept same but each time step (one month) of flow model is divided further into 60 transport steps in transport model. The smaller transport steps are taken to ensure the stability criteria of salinity intrusion model. Only advective transport is considered to simulate salinity transport into the groundwater system. In the advection process, salinity is transported at the same speed as the average linear velocity of groundwater. The simulation is carried out for the same period of flow model spanning over 1992 to 2005 (5113 days). The model results show that the saline front lies close to the sea boundary (Hiron Point) and the salinity is intruding by recharge water from affected surface water bodies through dynamic interaction.

4. CONCLUSIONS

A three-dimensional integrated river-aquifer model was developed to investigate the groundwater flow characteristics and salinity encroachment phenomena into the unconfined aquifer of southwest Bangladesh. For this a flow and transport model developed by MODFLOW and MT3DMS is coupled to develop a saltwater intrusion model. Only the advection process is considered for simulating saltwater intrusion. The results indicate that salinity intrusion from saline surface water bodies is found to be the predominant factor in affecting the groundwater system through recharge

water rather than the seawater intrusion directly from the sea side. The study conclusively proves that in the integrated river-aquifer systems in the coastal region, the interactions between the rivers and the underlying aquifer systems have significant influence on the flow and salinity intrusion into the overall system.

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MUNICIPAL WASTEWATER TREATMENT AND HEAVY METAL REMOVAL BY CONSTRUCTED WETLANDS

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In the world where life thrives on water, it is important to have methods that will secure the quality of water and provide the nourishment that the environment requires. The study assesses the performance of constructed wetlands to treat municipal wastewater and heavy metal removal efficiency for different plant species. For this study, ten small beds are constructed with locally available four different plant species and soil. Municipal wastewater and the synthetic water are treated by constructed wetlands and the pollution removal efficiency is estimated. Also to understand the settling behavior of the effluent water the Routine Water Test is performed in undisturbed state. The results of this study show that the constructed wetlands can be utilized to remove impurities as well as heavy metals from municipal wastewater and synthetic water efficiently. The impurities include Nitrogen (N), Phosphorus (P), Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Heavy metals such as Arsenic (As), Chromium (Cr), Lead (Pb). The values of pH, Color, Turbidity, Hardness, Chloride, Iron, TDS and TSS are found satisfactory to be disposed in Inland Surface Water, Public sewer at secondary treatment plant and Irrigated land. Particularly, the performance by the plant species Palm (*Light palm*) and Fern (*Pteris vittata*) are noteworthy.

Key words: Wetland, Wastewater, Heavy Metal, Efficiency, Plant Species

1. INTRODUCTION

Natural wetland systems have often been described as the "earth's kidneys" because they filter pollutants from water that flows through on its way to receiving lakes, streams and oceans. Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality. Constructed wetland can be considered as wetlands built to fulfill desired objectives. White (1998) defines a constructed wetland as "purpose built structures, utilizing the predominantly natural materials of soil water and biota, which perform the desired physical, chemical and biological processes and functions of natural wetlands to achieve desired objectives". Unlike natural wetlands, which are confined by availability and proximity of the wastewater source, constructed wetlands can be built almost everywhere, including lands with limited uses and other system components can be managed as required include vegetation (Reed *et al.*, 1988).

Wetland plants are an important component in constructed wetlands. The roles that they can fulfill or to which they can contribute to are numerous.

Wetland plants have adaptations that allow the transportation of oxygen to the roots and rhizomes (Brix, 1997). Not all plants are capable of removal of contaminants. There are some special plants such as *Canna lily*, *Light palm*, *Pteris vittata*, *Xanthosoma violaceum* etc plays important role in the removal of pollutants. For experiment local plants can be used in the constructed wetland just to compare the removal efficiencies.

Constructed wetlands are an innovative, biological solution to wastewater treatment. While offering a high degree of protection and reliability, they eliminate the need for discharging treated effluent into surface water that can adversely affect environment. Constructed wetlands were first initiated in Europe in the 1970s. Since then, the use of wetlands has evolved from a research concept to an accepted pollution control technology worldwide.

2. OBJECTIVES

In this study we observed the effects of pollution on a constructed wetland to determine the wetlands' ability to reduce pollution levels. In summary, the following objectives are observed:

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1. To determine the removal efficiencies of selected physical and chemical characteristics of Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrogen (N), Phosphorus (P) for wastewater.

2. To determine the removal efficiencies of the heavy metals such as Arsenic (As), Chromium (Cr) and Lead (Pb) for synthetic water.

3. To compare the removal efficiencies of different plant species.

4. To understand the behavior of the effluent water after treatment and when kept undisturbed.

3. RESEARCH METHODS

3.1 Introduction

The removal efficiencies of some locally available plants such as Palm (*Light palm*), Fern (*Pteris vittata*), Kalaboti (*Canna lily*), Kochu (*Xanthosoma violaceum*) for municipal wastewater and synthetic water were observed in this study. When the wastewater flows through the system, the suspended solids and trace matters are settled and filtered. Plants absorb the organic and trace matters also. These organic materials and nutrients absorbed by the wetland plants on the stems and roots are used as food. Plants provide much of the oxygen needed by the organisms to live and grow. Plant roots keep the rocks or soil loose so that water can flow through easily. The whole operation of the study was done by:

- ▶ Bed preparation
- ▶ Planting and Seeding
- ▶ Wastewater Collection
- ▶ Wastewater Testing
- ▶ Sample Collection
- ▶ Storage and Analysis

3.2 Construction of Wetlands

Constructed wetlands can serve as wastewater treatment systems and always consist of shallow ponds or channels planted with aquatic macrophytes. They can treat a variety of wastewaters by the microbial, biological, physical and chemical processes (Hamilton, *et al.*, 1997; Reed, 2000; USEPA, 2000a; García, *et al.*, 2004; Voeks and Rahmatian, 2004).

The pilot scale experiment is of subsurface flow system in which eight tubs with four different plants and two tubs with soil were used. Constructed wetland consists of three layers:

- a) Lower layer of crushed bricks
- b) Middle layer of sand
- c) Upper layer of soils

3.2.1 Bed Preparation: In total there were ten tubs used for the study having the same dimensions. All the tubs had the similar side slope of approximately 1H : 3V. Each plant type was planted in two different tubs to understand the standard deviation of removals. Only the Horizontal Flow Subsurface System was considered in this study. So the total removal efficiency of a wetland cannot be predicted from this study.

Dimension of the Tubs:

Diameter of the tubs

- ▶ Top: 9 inches
- ▶ Bottom: 6 inches

Height of the tubs (in total) = 10 inches

Height of Coarse aggregate (brick chips) = 1 inch

Height of Fine aggregate (sand) = 1 inch

Height of Soil = 7 inches

3.2.2 Plantation and Seeding: The two most popular methods of vegetating cells are planting and seeding. Both methods can be successful depending on the procedure undertaken. Prior to introducing vegetation to the wetland cells, the following preliminary steps should be taken (Tousignant *et al.* 1999).

- a) At least 10cm of topsoil (or wetland subsurface) should be placed, in an uncompacted condition, on the cell floor.
- b) The substrate of the wetland should be level.
- c) The substrate can be left prepared for some time prior to planting and/or seeding.
- d) However it should be protected from erosion and treated for weeds.
- e) Make sure that the wetland substrate is moist (not flooded) just prior to planting (or seeding).

Once the vegetation has started growing, care should be taken to ensure that weeds are controlled. Due to the lack of dense vegetation at the start of a wetland cell, weeds may invade the cell and become a major problem.

3.2.3 Tree Plantation: Plants were collected from a nursery situated in the Dhaka University area for this study. Matured plants were collected though they were taken care for about one month before the commencement of the study. There were two tubs for each of the plants.

Plant Species:

Palm (*Light palm*), Fern (*Pteris vittata*), Kalaboti (*Canna lily*), Kochu (*Xanthosoma violaceum*)

3.3 Raw Wastewater Collection

The removal efficiencies of the plants were studied for two different types of water sample. At first the raw sewage water was utilized to understand the removal behavior and then the synthetic water. The raw sewage water was collected from a gutter near the Farmgate Residential Area. The synthetic water was a mixture of three different effluents of heavy metal with the tap water of BUET. The heavy metal effluents were: Arsenic (100ppb), Chromium (100ppb), Lead (500ppb).

The first requirement for any sampling system is that it must provide a representative sample. Samples of waste collected from different sources fairly represent the whole waste from which they were collected. For each experimental time about 15 liters sample was collected in bucket.

3.4 Wastewater Treatment

After the collection of sample water each time it was treated step by step.

a) At first the opening of the tub was closed with plastic papers and clay soil and then the water was poured into the tubs for treatment.

b) The water was contained for about two hours in the tub.

c) Then the clogging materials were removed from the opening and the treated water was collected in containers.

d) The treated water was then collected and was taken to the laboratory.

3.5 Methods of Sampling

Water quality parameters measurement may be done either in their sources or in their laboratory. To measure the parameters in the laboratory requires sampling in an appropriate manner. Analysis through sophisticated equipment does not always ensure correct results because it only analyzes the sample that is brought into the laboratory. So, the acceptability of any laboratory test result depends on the sampling procedure. The sample must also be kept in such a manner so that the concentrations of different contaminants remain unchanged during transportation and storage. The analytical techniques to be used will affect the sample size taken, the type of sample bottle and also the method of storage.

3.6 Preservation and Storage of Samples

Preservation techniques retard chemical and biological changes that continue after sample collection. Sample preservation is difficult because almost all preservatives interfere with some of the tests. So the sample should be analyzed as quickly as possible without using any chemical preservatives. During storage certain constituents could be subjected to loss by adsorption on the sides of glass container walls. So, plastic bottles are preferred for storage of samples for analysis of metal ions as well as other parameters as plastic materials are less likely to contaminate the sample than glass bottles. Samples of different cells were than marked separately. All treated samples were kept in the refrigerator on which tests for determining different water quality parameters were performed.

3.7 Sample Analysis

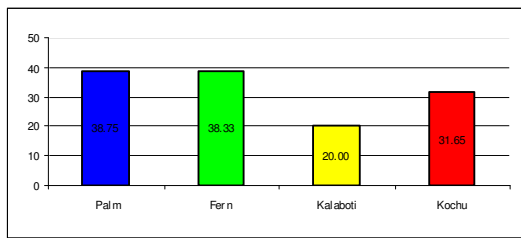
The sample analysis was performed in three different stages. At every stage the removal efficiency of different parameters were performed. The parameters observed in different stages are mentioned following:

- | | |
|-----------|--|
| 1st Stage | → Nitrogen (N), Phosphorus (P), Chromium (Cr), Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) |
| 2nd Stage | → Heavy Metal Removal for Arsenic (As), Chromium (Cr), Lead (Pb) |
| 3rd Stage | → Routine Water Test such as pH, Color, Turbidity, Hardness, Chloride, Iron, TDS, TSS |

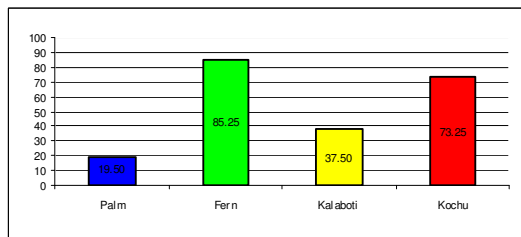
4. RESULTS AND DISCUSSION

4.1 Results

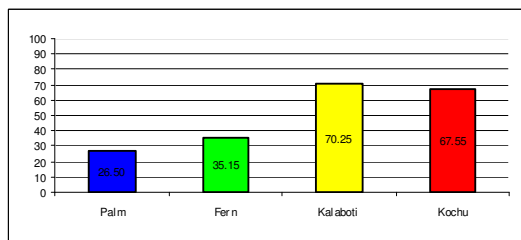
The performance observed for the raw wastewater treatment and the synthetic water treatment are both mentioned in the following pages by form histograms.



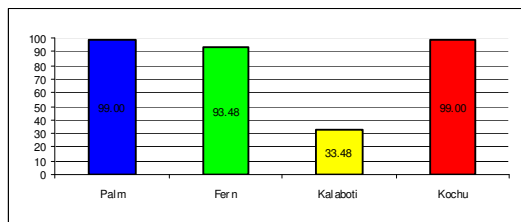
4.1: Efficiency of Nitrogen removal



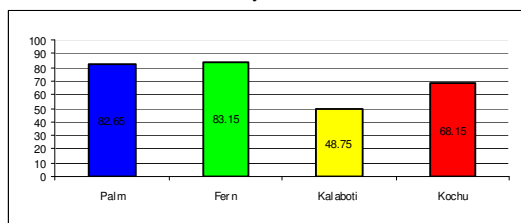
4.2: Efficiency of Phosphorus removal



4.3: Efficiency of TSS removal



4.4: Efficiency of Chromium removal



4.5: Efficiency of COD removal

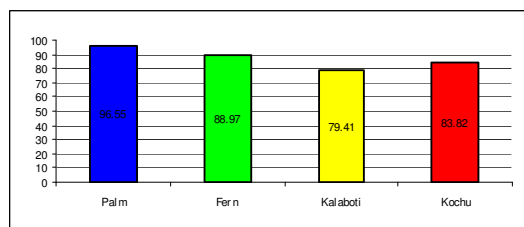


Figure 4.6: Efficiency of BOD removal

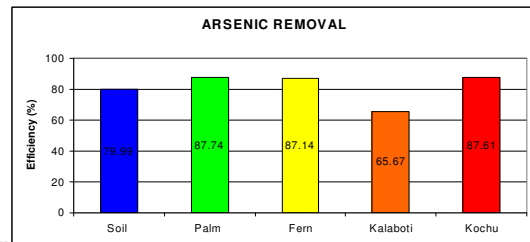


Figure 4.7: Average Arsenic Removal Efficiency

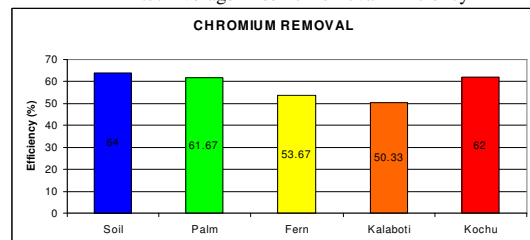


Figure 4.8: Average Chromium Removal Efficiency

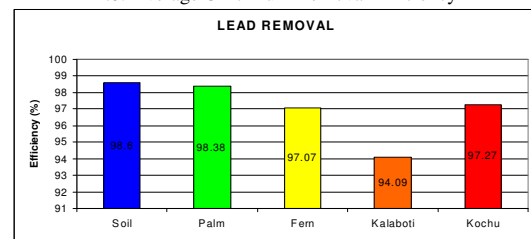


Figure 4.9: Average Lead Removal Efficiency

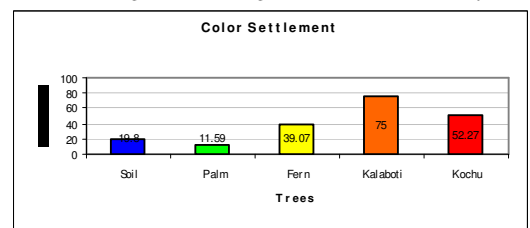


Figure: Color Settlement for undisturbed sample

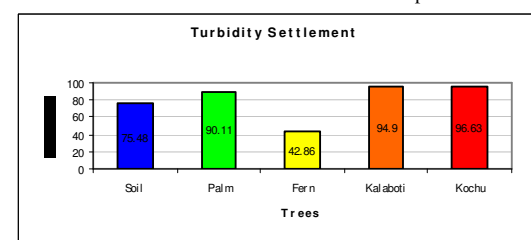


Figure: Turbidity Settlement for undisturbed sample

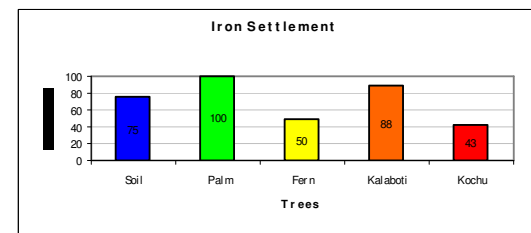


Figure: Iron Settlement for undisturbed sample

4.2 Discussions

Table 4.1: Summary of Removal Efficiencies in Percent (%)

Parameters	Palm	Fern	Kalaboti	Kochu
N	38.75	38.33	20.0	31.65
P	19.5	85.25	37.5	73.25
Cr	99	93.48	33.48	99
TSS	26.5	35.15	70.25	67.55
BOD	96.55	88.97	79.41	83.82
COD	82.65	83.15	48.75	68.15

From the results obtained the following decisions can be taken:

- Nitrogen removal is higher by Palm
- Phosphorus removal is higher by Fern
- Chromium removal is higher by both Palm and Kochu
- TSS removal is higher by Kalaboti
- BOD removal is higher by Palm
- COD removal is higher by both Palm and Fern

Table 4.2: Summary of Average Removal Efficiency for Heavy Metals (%)

Parameters	Soil	Palm	Fern	Kalaboti	Kochu
As	79.99	87.74	87.14	65.67	87.61
Cr	64	61.67	53.67	50.33	62
Pb	98.6	98.38	97.07	94.09	97.27

From the results obtained the following decisions can be taken:

- Arsenic removal is higher by Palm
- Chromium removal is similar for Soil, Palm and Kochu
- Lead removal is higher for all the plant species and Soil
- Soil has a very good removal capability for Heavy Metals

Table 4.3: Summary of Routine Water Test

Parameters	Soil	Palm	Fern	Kalaboti	Kochu
Chloride	50% removed	50% removed	50% removed	40% removed	30% removed
pH, Hardness	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Color, Turbidity, Iron, TDS, TSS	Increased	Increased	Increased	Increased	Increased

From the results obtained the following decision can be taken:

- Chloride can be removed by the plant species and Soil
- pH and Hardness remain unchanged
- Color, Turbidity, Iron, TDS, TSS values increase due to the presence of soil particles in the effluent water

Table 4.12: Summary of Settlement for Undisturbed Effluent Undisturbed Effluent

Parameters	Soil	Palm	Fern	Kalaboti	Kochu
Chloride, Hardness	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Color	Low	Low	Medium	High	Medium
Iron, Turbidity	High	High	High	High	High

From the above discussion the following decision can be taken:

- Chloride and Hardness do not settle when kept undisturbed
- Color has a Low to High range of settlement for the plant species and Soil
- Iron and Turbidity have a high settlement when kept undisturbed for the plant species and Soil

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The major findings of the study are mentioned briefly stage by stage following:

At First Stage:

- a) Palm (*Light palm*) has greater removal efficiency for Nitrogen, BOD and COD.
- b) Fern (*Pteris vittata*) has greater removal efficiency for Phosphorus and COD.
- c) TSS and Chromium removal is higher for Kalaboti (*Canna lily*) and Kochu (*Xanthosoma violaceum*) respectively.

At Second Stage:

- a) Palm (*Light palm*) has greater removal efficiency for Arsenic (As) and Chromium (Cr).
- b) Kochu (*Xanthosoma violaceum*) has greater removal efficiency for Chromium (Cr).
- c) Lead (Pb) removal is higher for all the plant species and soil.
- d) Vegetation has the ability to remove Arsenic but does not have the ability to remove Chromium and Lead.

At Third Stage:

- a) The chloride concentration is reduced by the vegetation and soil.
- b) pH and Iron concentration remain unchanged.
- c) Color, Turbidity, Iron, TDS and TSS values increase due to the presence of soil particles in the effluent water.

d) Chloride and Hardness do not settle when kept undisturbed.

e) Color has a Low to High range of settlement for the plant species and Soil.

f) Iron and Turbidity have a high settlement when kept undisturbed for the plant species and as well as Soil

5.2 Recommendations

The following recommendations can be made to extend the scope of present study:

1. The study can be conducted for at least one year to obtain seasonal variation in removal efficiency.

2. The study can be conducted to understand the behavior of sunlight and night.

3. The heavy metal removal efficiency can be further studied for Industrial wastewater.

4. Further study is recommended for removal of pollutants for flowing wastewater and standing wastewater in wetland that are not compared in this study.

5. This study can be further extended to remove pollutants from Industrial, Textile and Agricultural liquid waste.

6. The aggregate size and type can be varied to understand the effect of aggregate in removal of pollutants.

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NUMERICAL INVESTIGATION OF THE BEHAVIOR OF RETROFITTED FLEXURAL CRACKED BEAM WITH EXTERNAL PLATE BONDING

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The aim of this paper is to study the effectiveness of using “External Plate Bonding” in flexural retrofitting of reinforced concrete (RC) beam. A simply supported rectangular RC beam is considered for this study. The steel plate and the CFRP (Carbon Fiber Reinforced Polymer) sheet are taken into consideration as bonded plates for retrofitting of RC beam. General purpose finite element program (ANSYS 11.0) is used to carry out non-linear analysis of uncracked, cracked and retrofitted RC beam. Based on the results obtained from numerical investigation it is seen that cracking in RC beam reduces the load carrying capacity of the beam. When retrofitting technique using steel or CFRP plate bonding externally is applied, stresses at the crack tip reduce significantly. Therefore, external plate bonding could be effectively applied in retrofitting of RC beam.

Key words: CFRP sheet, Flexural crack, Plate bonding, Non-linear analysis, Retrofitting, Steel plate

1. INTRODUCTION

Reinforced concrete (RC) is one of the most widely used construction material in both the developing and developed countries since more than a century. RC structures are often suffering damage before reaching their intended design life. There are several factors responsible to this distress of these structures, such as improper design, faulty and quick construction, change in building usage, overloading, natural disasters (like earthquake, Tsunami, Cyclone, Flood etc.), various environmental effects like corrosion, fire, etc. Buildings, which are deteriorated due to such factors, need quick attention and scientific approach in finding the causes of distress and also need suitable remedial action to make the building functional.

Beam is one of the primary elements of the frame structure building and is mainly responsible for the lateral stiffness of the structure. A beam fails when the load acts on it is higher than the load for which it is designed (Kaish and Hassan, 2008). It may also

fail under service load due to loss of its stiffness caused by various deteriorating factors discussed above. To mitigate the unexpected failure various methods are proposed to retrofit the beam. External post tensioning, plate bonding, ferro-cement laminating and RCC jacketing are among them.

External plate bonding technique is one of the efficient and well-known method of repairing or retrofitting of beam (Devid et al., 1998). Steel plate is the traditional material used in the retrofitting of flexural beam member. But its low corrosion resistance and handling problem forced engineering community to look for alternatives (Gorji, 2009). Fiber Reinforced Polymer (FRP) emerges as an effective alternative of steel plate. It becomes a popular material for structural re-strengthening because of its high tensile strength, low weight and high corrosion resistance properties (Hollaway and Leeming, 1999).

Several experimental and analytical investigations have been conducted on the use of FRP sheets as flexural retrofitting/re-strengthening of RC beams

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(Shahawy et. al., 1996; Saadatmanesh et. al., 1997; Sharif et. al., 1994; Chajes et. al., 1995; Khaloo and Gharchorlou, 2005 and Panazopoulou et. at., 2001). The behavior of re-strengthened beam is also available in terms of load-deflection, load-strain, failure patterns and structural ductility (Gorji, 2009).

Laboratory and numerical studies show the efficacy of externally bonded FRP plates in enhancing the flexural capacity of RC beam. However, there are limited studies conducted on the behavior of flexural cracked RC beam retrofitted with external plate bonding using steel plate or FRP sheet. In this paper numerical investigation to the behavior of flexural cracked RC beam retrofitted with externally bonded steel plate or CFRP sheet are reported.

2. FINITE ELEMENT MODELING OF RC BEAM

Simply supported reinforced concrete beam of ten feet span was considered to carry out numerical analysis. Four beams were modeled for this purpose. One of which was an un-cracked beam (considered as benchmark specimen) denoted as UB. A cracked beam (denoted as CB) of crack depth of 20% of the full depth of beam was also modeled. The two beams were modeled as retrofitted cracked beams. One of which was retrofitted by steel plate (denoted as RS) and the other one was by CFRP sheet (denoted as RF). Simulations were carried out by using one of the most powerful finite element software ANSYS (11.0). Two-dimensional finite element model was developed for simplicity in analysis and reducing computational effort. Geometry, loading and boundary condition of uncracked, cracked and retrofitted beam are shown in Fig. 1.

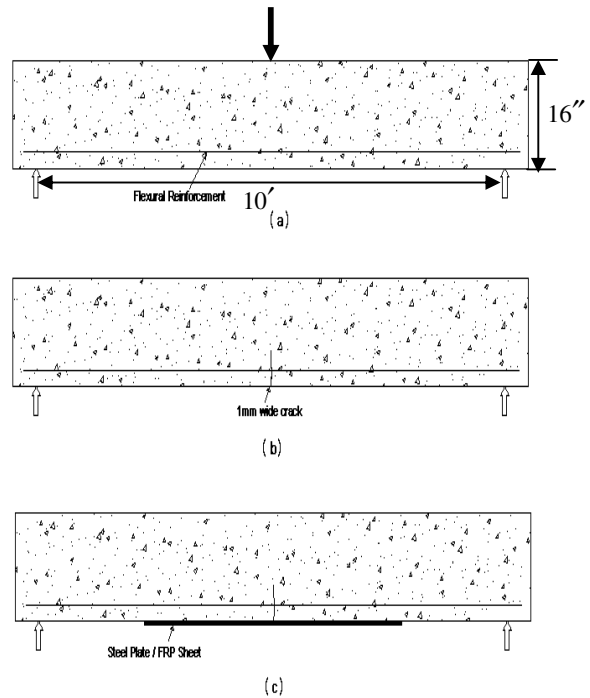


Fig. 1: RC beam; (a) Un-cracked beam, (b) Cracked beam and (c) Retrofitted beam.

2.1 Element Types

Eight-nodded quadratic plane stress element (PLANE82) having two degrees of freedom at each node (translation in the nodal x and y directions) available in ANSYS finite element program was used to model the concrete. This element has capability to model plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. Geometry of node numbering of PLANE82 element is shown in Fig. 2.

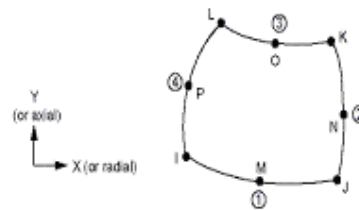


Figure 2: Geometry of PLANE82

One-dimensional (link1, 2-D spar) element was used to model the reinforcement. This element is a uniaxial tension-compression element with two degrees of freedom at each node (translations in the nodal x and y directions). Steel plate and CFRP sheet were also modeled using PLANE82 element.

2.2 Material Properties

2.2.1 Concrete: In the present study concrete was assumed as a homogeneous material. In usual practice, linearly elastic-perfectly plastic model is used for concrete crushing though many researchers have proposed piece-wise linear model. The linearly elastic-perfectly plastic model gives a good prediction of ultimate loading and displacement to the specimens (Zhang, 2004). Linearly elastic-perfectly plastic model of normal concrete is shown in Fig. 3.

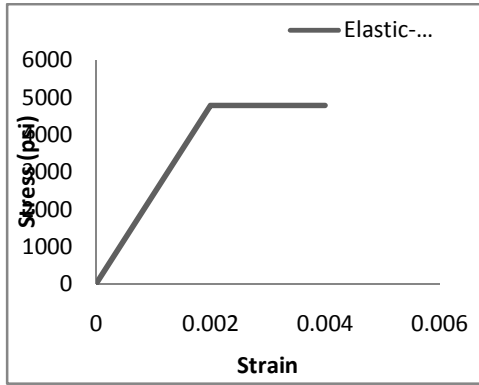


Fig. 3: Linearly elastic-perfectly plastic stress-strain relationship of normal concrete.

In the present study smeared cracking approach was used in modeling the concrete. Following properties were defined for concrete element:

- Elastic modulus ($E=3949075$ psi),
- Poisson's ratio ($\nu=0.2$),
- Shear transfer coefficients for an open crack (0.3),
- Shear transfer coefficients for a closed crack (0.9),
- Uniaxial tensile cracking stress ($f_t=520$ psi),
- Uniaxial crushing stress ($f_c=4800$ psi).

The shear transfer co-efficient represents the condition of cracked face. The shear transfer coefficient for a closed crack is widely accepted within 0.9 to 1.0. The value of shear transfer coefficients for an open crack used in many studies of reinforced concrete structures varies between 0.05 and 0.25 (Bangash, 1989; Huyse et. al., 1994 and Hemmaty, 1998). Convergence problems were encountered with shear transfer coefficients for an open crack dropped below 0.2 (Wolanski, 2004). Zhang (2004) mentioned that shear transfer value of magnitude 0.3 gives a good agreement with the change of stiffness of the specimen as well as the ultimate loading. Therefore, shear transfer value of

magnitude 0.3 was taken into consideration in this study

2.2.2 Steel Reinforcement and Steel Plate: For the finite element modeling, steel reinforcement is assumed as linearly elastic-perfectly plastic material and identical in both tension and compression. Elastic modulus and Poisson's ratio assumed for steel reinforcement were 29×10^6 psi and 0.3, respectively. Steel plate used in FEM was assumed as linearly elastic material with the same elastic modulus and Poisson's ratio of the steel reinforcement. Thickness of the steel plate was taken into consideration as 3mm. Linearly elastic-perfectly plastic model of steel is shown in Fig. 4.

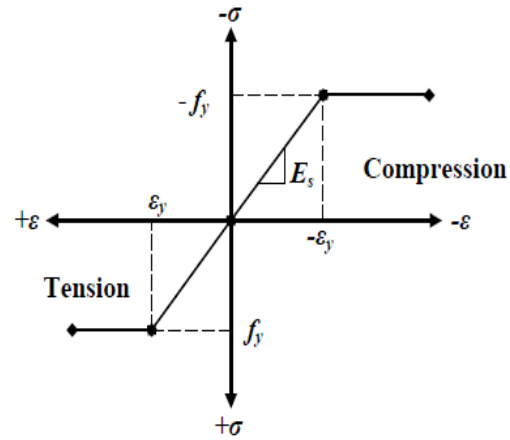
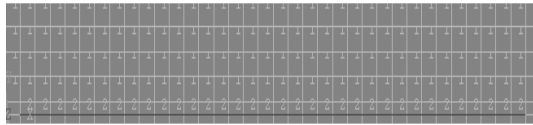


Fig. 4: Linearly elastic-perfectly plastic stress-strain relationship of steel.

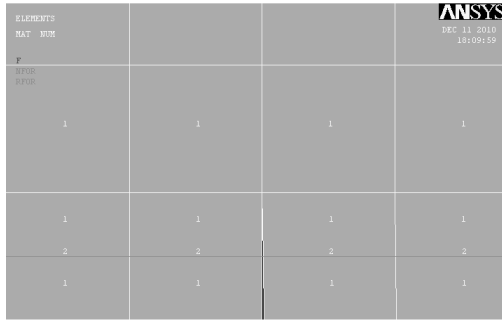
2.2.3 FRP Sheet: Carbon fiber reinforced polymer (CFRP) was used as FRP sheet. A linear elastic property was assumed for CFRP. Elastic modulus and Poisson's ratio used for CFRP were 21.75×10^6 psi and 0.25 respectively. Thickness of CFRP sheet was taken 3mm.

2.3 Finite Element Modeling Procedure

The entire beam was modeled first with simply supported boundary condition. In case of cracked beam, flexural pre-crack was introduced by creating a gap (1mm) between elements at the bottom of mid-section of beam. The steel reinforcement was simplified in the model. Only bottom (flexural) reinforcement was modeled for simplicity in modeling and analysis. Both the top and shear reinforcement was omitted in the model. Perfect compatibility between concrete and steel reinforcement was assumed in this study. Finite element modeling of uncracked beam and closed view of crack are shown in Figs. 5(a) and (b).



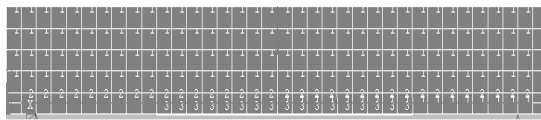
(a)



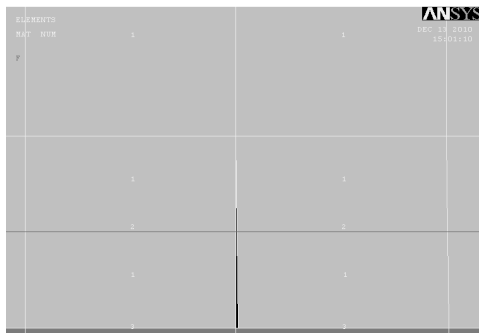
(b)

Fig. 5: Finite element meshing of beam; (a) Uncracked beam and (b) Closed view of crack.

Steel plate and CFRP sheet in retrofitted beam were modeled in the same way with consistent thickness but with different material properties. Epoxy bonding layer was omitted in the model. Usually epoxy is much stronger than concrete and therefore not a weak link exists in between concrete and steel plate or FRP sheet. Perfect bonding (concrete and epoxy strength are considered as same) between concrete and steel plate (or CFRP sheet) was assumed in the analysis. This was done by directly joining the nodes of steel plate (or CFRP sheet) with concrete elements. Finite element modeling of retrofitted beam is shown in Figs. 6(a) and (b).



(a)



(b)

Fig. 6: Finite element meshing of retrofitted beam; (a) Retrofitted beam and (b) Close view of crack location.

3. RESULTS AND DISCUSSION

Results obtained from the numerical analysis of four beams are summarized in Table 1 and discussed in the following subsection.

3.1 Load-Deflection Response

The load-deflection response of uncracked (UB), cracked (CB) and retrofitted beam (RS and RF) are shown in Table 1 and Fig. 7. It is seen that cracked beam shows a brittle mode of failure just after the yielding of reinforcement. Retrofitted beams show significant ductile behavior before failure. However, this ductility is not as much as the uncracked one.

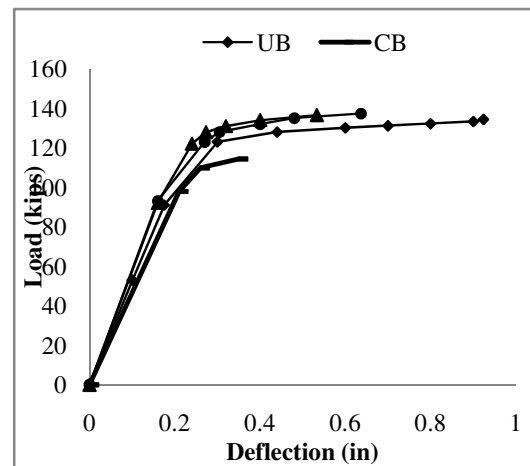


Fig. 7: Load-deflection response.

3.2 At the development of first crack

From Fig. 7 it is seen that first crack occurs in the cracked beam at higher load than un-cracked beam. This may be due to the energy absorbed by the pre-crack, which allows higher deflection at the same load. First crack occurs in both the retrofitted beam (Type RS and Type RF) also at slightly higher load than un-cracked beam. This is due to additional stiffness of steel plate or CFRP sheet.

3.3 At Failure

It is seen from Table 1 that a crack of 20% of full depth reduces the ultimate load carrying capacity approximately 18%. Pre-cracking also reduces the ultimate deflection. Table 1 also shows that, load carrying capacity of retrofitted beam increases at a

value slightly higher than the un-cracked beam. Both the retrofitted beams show a lower value of ultimate deflection than the un-cracked beam but higher than the cracked beam.

Table 1: Summary of numerical analyses results.

Type	At First Crack		At Failure	
	Load (kip)	Deflection (in)	Load (kip)	Deflection (in)
UB	91	0.175	134.42	0.924
CB	97.9	0.21	114.32	0.35
RS	92.2	0.16	136.66	0.532
RF	93	0.16	137.32	0.636

3.4 Stress Response

Table 2 shows the stress responses at different locations of beams. All stresses were calculated at a load of 91 kips, which was the lowest first cracking load (occurred in uncracked beam). It is seen from Table 2 that cracking in RC beam causes increased stress at crack tip. Stress, σ_y (stress in local y-direction) increases significantly than σ_x (stress in local x-direction) due to crack. However, for retrofitted beam stresses at the crack tip effectively reduces. At the point of stress transfer, an increased stress is noticed due to retrofitting. However this increased stress lies within allowable limit. Stress contour plot of local stresses (σ_x and σ_y) of cracked beam is shown in Figs. 8(a) and (b). It is seen that stresses concentrate at the tip of crack.

Table 2: Stresses (σ_x and σ_y)

Type	Stress, σ_x (psi)		Stress, σ_y (psi)	
	At crack tip	At transfer	At crack tip	At transfer
UB	4135	2233	-110.89	0.1824
CB	4265	2232	1636	0.1808
RS	4152	2466	386.94	35.14
RF	4184	2408	438.74	28.103

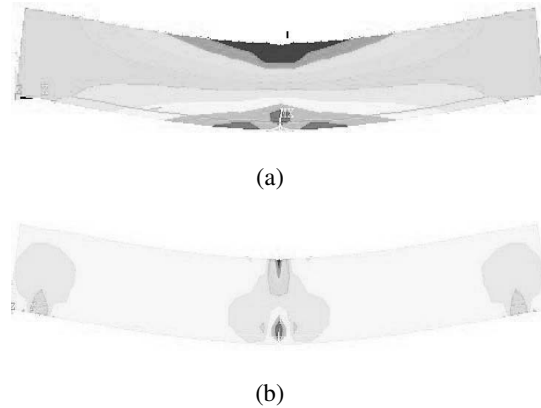


Fig. 8: Stress contour plot of cracked beam, (a) σ_x , (b) σ_y .

4. CONCLUSION

Based on the results obtained from numerical analysis, the following conclusions can be drawn:

- Cracking in RC beam reduces the load carrying capacity of the beam.
- Significant stress concentration occurs in the beam due to cracking.
- External plate bonding reduces the stress concentration at crack tip.
- External plate bonding causes an increased flexural stress in concrete at stress transfer zone. However, this increment in flexural stress lies within allowable limit.
- Plate bonding using both the steel plate and CFRP sheet could effectively retrofit cracked beam by increasing its load carrying capacity.

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RETHINKING THE FORM OF SUSTAINABLE CYCLONE SHELTER

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ABSTRACT

Geographically Bangladesh is a disaster-prone area. Throughout the years, this country has been exposed to several hazards such as: cyclone, *Gourkee* (high water tide) flood, drought, earthquake etc. Cyclone has always been a major threat to the coastal area of our country. Severe cyclones have affected this region and have cost us wealth and most importantly lives. Cyclone cannot be stopped but it is essential to carry out research and invent new technologies to protect lives during and after cyclone. It is inherent tendency of human being to look for shelter from any natural discomfort or hazard. Therefore, right from beginning of civilization the human race have been inventing protection, shelter and technology to adopt a shelter to protect them from above calamities.

This paper is an attempt to derive a form which is sustainable against cyclonic force but yet it is part-and-parcel of respective landscape.

KEYWORDS: Cyclone Shelter, Coastal area of Bangladesh, Architectural Form, Disaster, Landscape, Social icon.

1. INTRODUCTION

Cyclone is one of the most destructive natural hazards in our country. Several cyclones have caused casualties and economic loss which had large impact on our economy. Therefore, government and private agencies have been motivated to construct cyclone shelters. The concept for constructing cyclone shelter in the costal area of Bangladesh is to give shelter for the local people during the cyclone. But what is going to be the structure's use in the remaining days? That means when there is no cyclone what is the uses of these structures. In this study it has also been tried to rethink the cyclone shelters so that they become an icon that gives the locality strength and also integrity.

Bangladesh is situated to the north of Bay of Bengal. Its geographical location is between 20° 34' N and 26° 38' N latitude, it has 724 km long coast line which is highly vulnerable to tropical cyclones and associated storm surge (Islam and Peterson, 2008). The south and south-eastern zone of Bangladesh is more exposed to cyclones than the other areas (see Fig. 1). The districts included

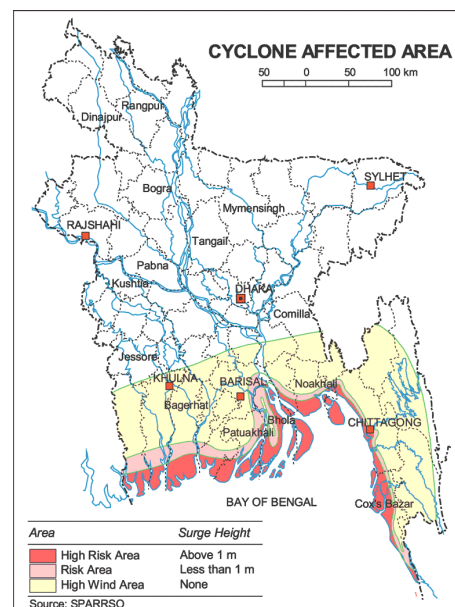


Fig 1: Cyclone affected areas of Bangladesh ([http:// banglapedia. search. com. Bd / Maps / MN_0131D.GIF/2008](http://banglapedia.search.com.Bd/Maps/MN_0131D.GIF/2008))

in these areas are Chittagong, Cox's Bazar, Patuakhali, Barguna, Jhalkathi, Barisal, Noakhali, Feni, Bhola, Satkhira, Khulna, etc.

Major cyclones that hit to the coast of Bangladesh in different times and its number of death are given in Table 1. It is seen that lost of human lives in 15th November 2007 cyclone's are much lower than 12th November 1970 and 29th April 1991 cyclones'' Preparedness against cyclones is the reason for this. Therefore, cyclone shelters like structure are more important in the coastal areas of Bangladesh to get significant preparedness against cyclone. Its routine maintenance is also important to keep it useable form.

Table 1: Major cyclones that hit Bangladesh in different time and their deaths ([http:// www.preventionweb.net/ english pro fessional /news / \(2010 \)](http://www.preventionweb.net/english/professional/news/)).

DATE	YEAR	STORM SURGE(ft)	DEATHS
09 May	1961	8-10	11466
11 May	1965	12	19279
12 Nov.	1970	20-30	500000
25 May	1985	10-15	11069
29-Apr	1991	20-25	138000
15 Nov.	2007	20-25	3400
25-May	2009	-	190

2. OBSERVATION ON EXISTING CYCLONE SHELTERS

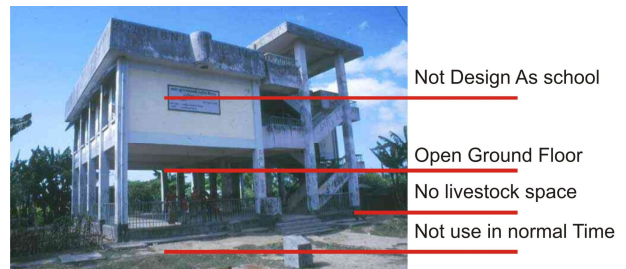
Existing cyclone shelters are mostly designed and constructed by the Government and NGOs. These structures are designed on focusing mainly to protect people from cyclone and water-surge. Livestock is an important part of our village life. Generally, people are not interested to go to the cyclone shelters without their important wealth such as livestock. This is our serious observation that most of the cyclone shelters have no consideration of space for saving live-stocks. In few cyclone shelters there is some space for livestock but this is not properly designed for that purpose. All cyclone shelters are opened in ground floor to allow flash flooding during the cyclone (see Figs. 2(a) and (b)). This space cannot be used in emergency or in general. Besides in the most critical cases appropriate access road is not there (see Fig. 2(b)). Most of the

existing cyclone shelters are designed only as structures just to shelters. It is the project of huge investment but focused only to protect people from cyclone, generally for 4-5 days. Rest of the days in a year it is used mostly as a school but not properly designed for that purpose. No structure can survive if it is meant to be used for only 10 days a year. So the structure should be designed for all the year considering the social, cultural, educational aspects and so on. In this paper it has been discussed how a cyclone shelter needs to be designed to get its maximum utility during cyclone as well as other time of the year. It also covers to protect people as well as other wealth such as live stocks.

(a)



(b)



Figs. 2(a) and (b): Typical Cyclone shelter

3. DESIGN CONCEPT FOR RETHINKING CYCLONE SHELTER

The form of structure needs to be built in the coastal area should have inherent criteria to withstand pressure of severe wind as well as to save from the storm water surge. The obvious answer is a circular shape in broad sense. Circular form is able to resist the severe wind pressure and storm water surge whenever they occur. On the other hand this creates a space for play ground in normal

time. Wind effect on circular form is shown in Fig. 3.

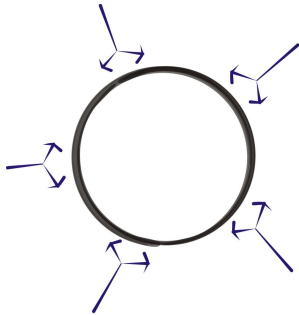


Fig. 3: Wind effect on circular form

It is seen that wind force gets component when it acts on the surface of circular shaped structure. Inside the circular area there will be a fixed space where people will live. During emergency definitive space and shape are to be provided for people and livestock, respectively. People will live in rectangular space and livestock will live in circular space. Proposed positions for people and livestock inside the circular area are shown Fig. 4. Rectangular shape is achieved from the class rooms' size and shape which is suitable for used as school in normal period. Both shapes together give the sense of safety and security.

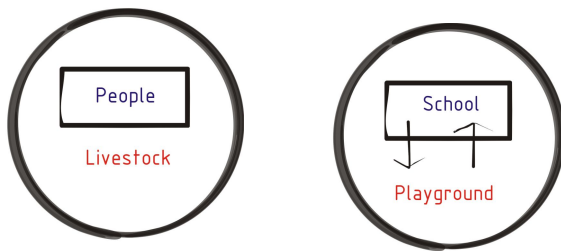


Fig. 4: Position of people and livestock within the form during emergency and the use of the same space in normal period

4. DESIGN CONSIDERATION FOR NEW FORM OF CYCLONE SHELTER

Criteria for the design of new form of cyclone shelter should be to provide a sense of safety and security to the people and the livestock. Circulation routes for people and livestock must be clearly defined to avoid clash and confusion during emergency. 'U' turn should be avoided in the access route of cyclone shelter. Because

it is difficult for a cow to take a 'U' turn in crowded situations. Fig. 5 shows a proper circulation route for people and livestock. Planning of proper circulation route must be taken into consideration during design of multipurpose use of cyclone shelter.

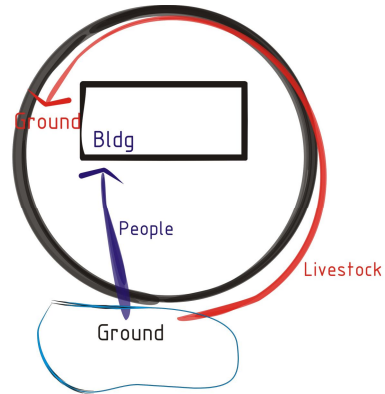


Fig. 5: Circulation of people and livestock within the form of shelter

The livestock should be visible by their respective owners even during emergency shelter. Thereby, the people will be more encouraged and willing, specially the woman folk, to come to the shelter. It is observed that only movable property of the coastal people is their livestock. They want to keep the property with them till the end of cyclone, if one can own one.

Normal time use of school, play ground, indoor and outdoor spaces should be integrated with the shelter. Therefore, the design is for a utilitarian building that stands boldly to resist cyclones and to protect the people and the livestock, but yet being functional, simple and free from any decoration.

5. SITE FOR THE CYCLONE SHELTER

Site is another factor that must be taken into consideration during construction of cyclone shelter. Cyclone shelter should be well access of the local people of the region where it to be constructed. The region must be flat and above the sea level of height of cyclone and tidal waves. Low flat terrain and funneling coastal part should be avoided.

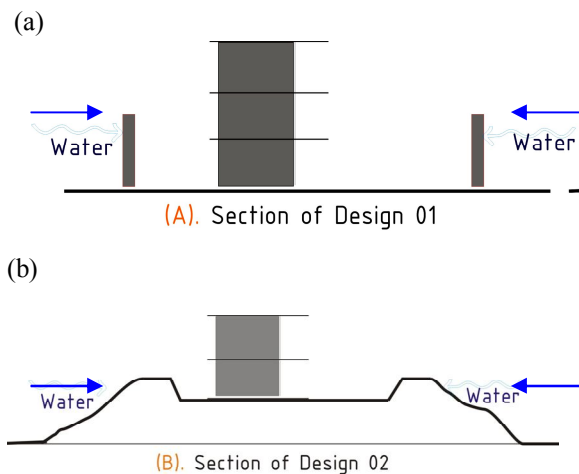
6. WATER SUPPLY, SANITATION AND ELECTRICITY FACILITIES

Water Supply and sanitation: Drinking water must be supplied from the tube well. Therefore, it has to be ensured to install few tube wells near the shelter. Facility must exist to store rain water which could be an alternate of tube well water. Septic tank and soak pit must have to be placed outside the peripheral wall of the shelter. Excess water collection inside the peripheral wall may be pump out from two swamp located at two ends.

Electricity: It has been observed that supply of electricity from national grid is often shutdown during cyclone due to damage of electric pole and wire. Therefore, an alternate arrangement for electricity must be kept in cyclone shelter. Solar energy equipment could be an option for this. Lightening arrestor must be provided to protect people and livestock from thundering.

7. PROPOSAL FOR NEW CYCLONE SHELTER

In this study two types of shelter namely DESIGN-01 and DESIGN-02 are proposed for 2000 people in multipurpose uses. However, the scheme can be scaled down for community of 1000 people. Cross section of these two types is shown in Fig. 6(a) and (b). Structure of both these design cases must be R.C.C structures.



Figs. 6(a) and (b): Sections showing the wall and embankment surrounding the building form

Basis of DESIGN 01 is considered as at ground level and for DESIGN 02 it is considered as on Plateau of reclaimed land.

Figs. 7 and 8 show the use of space for normal and emergency periods. Rectangular space could be used for the school of children and open space could be used as playground in normal time.

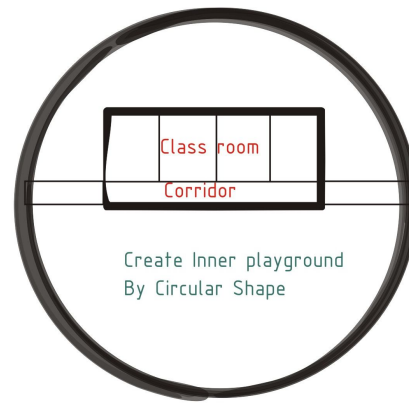


Fig. 7: Plan showing the use of space for normal period

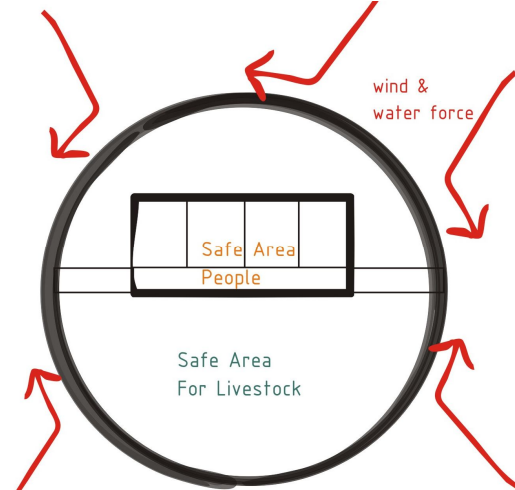


Fig. 8: Plan showing the use of space for emergency period

Enclosed open space on ground level is to protect livestock in emergency. This open space may also be used for different socio, cultural, and economic activities of the community beyond school hour.

Fig. 9 shows the plan of circulation for ramp and stair. Circulation needs to be very well defined for livestock and people to avoid chaos and confusion during emergency. A ramp climbing up and then down without any 'U' turn must be there for livestock and a stair must be there for people to use during emergency. In normal time these elements (ramp, stairs) would be used by all students, teachers and community people. Besides, ramp must be needed for handicap people during emergency and normal time.

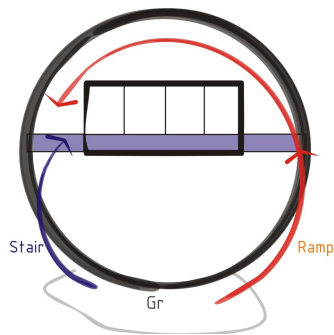


Fig. 9: Plan showing the circulation, ramp for livestock and stair for people

Orientation of the building depends on the climate condition, air flow, natural light, etc. Therefore, the orientation of the building should be fixed in respect of direction of air-movement and the sun path. Rationally, east and west sides of the building should be made with solid wall and north and south sides of the building should be made with enough shaded space and openings for natural ventilation. An ideal orientation of the building is shown in Fig. 10

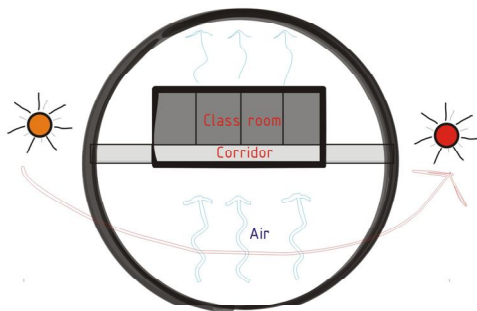


Fig. 10: Plan showing the orientation of the building considering climate condition and natural light.

8. GRAPHICAL PRESENTATION OF PROPOSED DESIGN 01 AND DESIGN 02

Floor plans at different levels, elevations, sections and perspective views of proposed design 01 are shown in Figs. 11-16. The peripheral wall around the shelter region is proposed to make for safety and security of the people and their livestock in the emergency situation. With the 6m high flood-water surge, of temporary stay (say 8 hrs), water may sip through the earth inside the ground space bounded by peripheral wall. Therefore ground level inside the peripheral wall is raised to +1.2 m.

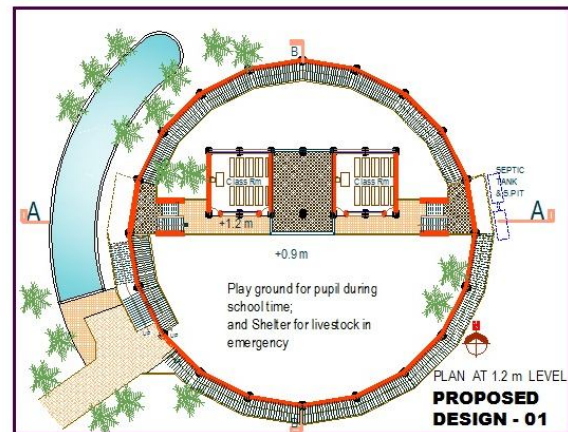


Fig. 11: Plan at +1.2m level of proposed design 01

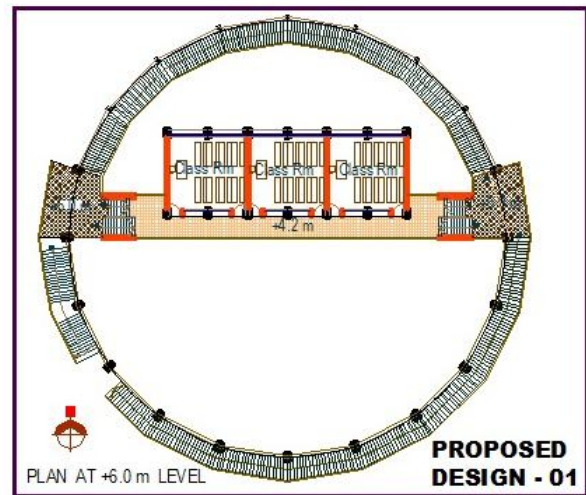


Fig. 12: Plan at +6.0m level of proposed design 01

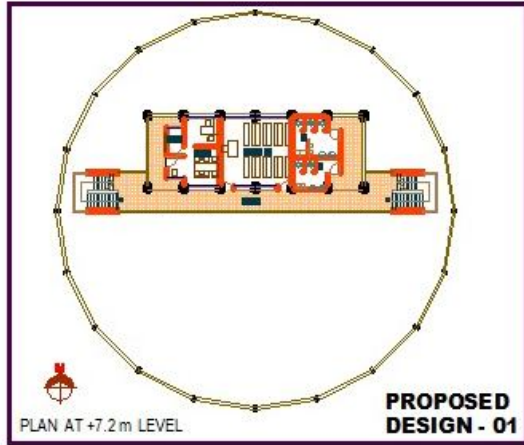


Fig. 13: Plan at +7.2m level of proposed design 01



Fig. 14: Elevations showing the vertical circulation



Fig. 15: Section showing the vertical circulation, ground open space for livestock and upper floor for people

(a)



(b)



Figs. 16(a) and (b): Perspective view of proposed design 01

Details graphical presentation of proposed design 02 is shown in Figs. 17 to 20. In this proposal of design, shelter place is raised from the normal ground level of region where shelter to be built. Earth filling for killa is done from the digging of canal (see Fig. 17) around the base of killa. The canal may be used for fishing, ducks cultivation and for irrigation purpose. The slope surface around the plateau may be used for herbal plantation. Cooperative ownership of the canal and the slope surface is to be decided by the community. During normal time, the rain water inside sunken platform will be soaked away by the semi soft surface and excess water if any, can be pumped out from the two swamps at two ends. This sunken plane at + 4.5 m level is the major place of activities. Floor plan of proposed design 02 at different levels is shown

in Figs. 16 and 17. It is seen that four connects roads (conceptual) from different villages and one circular circulation around the killa (Plateau) which leads to a common entry point at the west site of the killa are joined to the shelter. There is a stair for people and a ramp for livestock from entry point to the shelter at +4.5m level. Here the open space is for live stock and the class room is used as shelter for people at emergency.

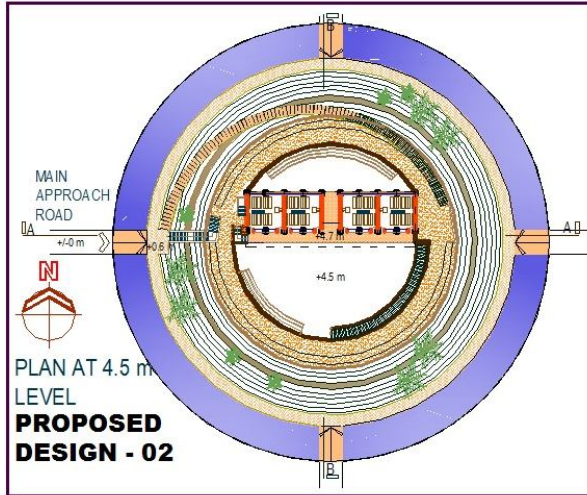


Fig. 17: Floor Plan of proposed design 02 at +4.5 level.

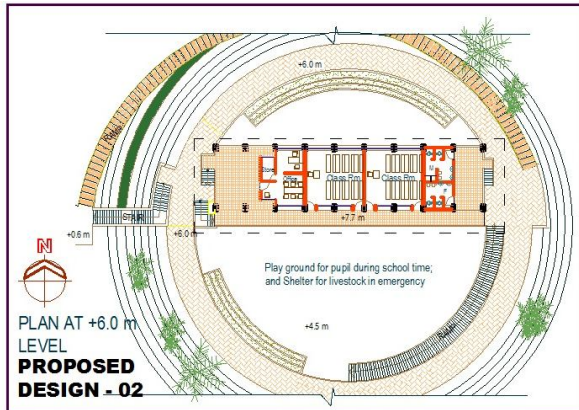


Fig. 18: Floor Plan of proposed design 02 at +6.0 level

Section and elevation of Proposed design 02, are given in Fig. 19. The sunken space which is partly open would be used as play ground in normal time. In cyclone period it would be used for safety for livestock

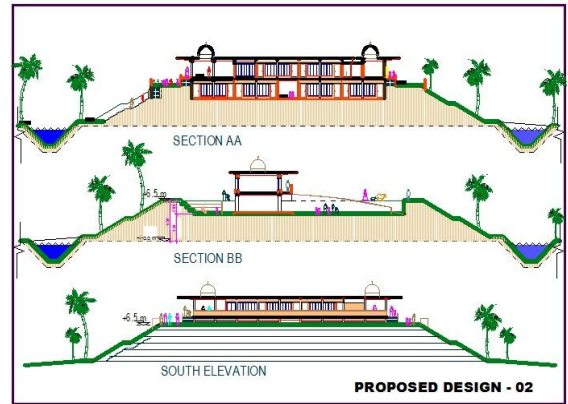


Fig. 19: Section and Elevation of design 02,

Various perspective views of proposed design 02 are shown in Figs. 20 (a)-(c). Circular ramp, stair, building form and detailing of surrounding landscape are shown in these figures.



Fig. 20(a): Perspective view showing ramp and stair of proposed design 02

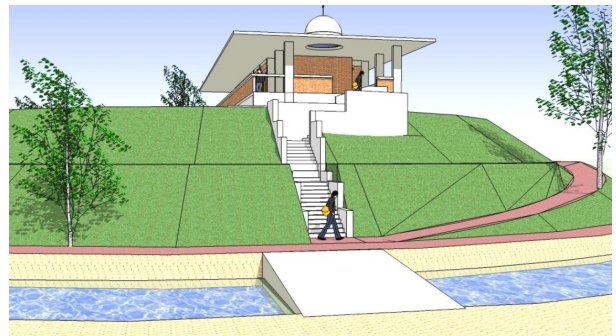
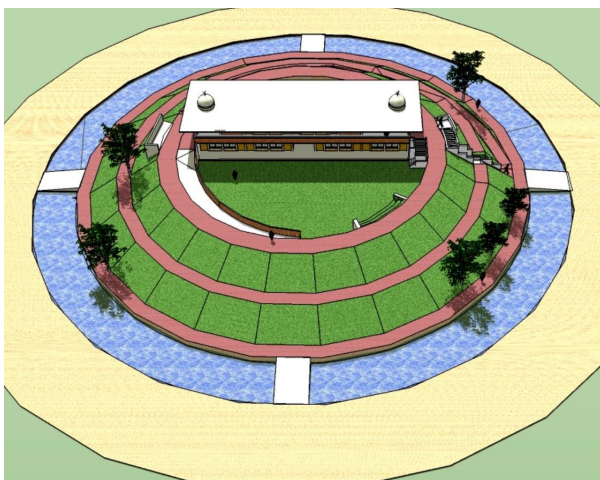


Fig. 20(b) (cont'd): Perspective view of proposed design 02 showing entry point



Figs. 20(c) (cont'd): Birds eye view of proposed design 02 showing whole killa with its surrounding landscape,

9. CONCLUSION

Both of the design proposal discussed above will be used all the year as school/ community space. The spaces are designed not only as a shelter but also as a place for social gathering or meeting place. Surrounding environment of the site can be used as agricultural land for grains, vegetables or for fishing. At the same time the open space can be considered as a playground and the whole project would be social icon for a village.

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RENEWABLE ENERGY SYSTEMS FOR RESIDENTIAL BUILDINGS IN NEW SATELLITE TOWNS OF DHAKA: BARRIERS AND PROBABLE SOLUTIONS

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Energy is essential to ensure quality of life and to underpin most of the services to our environment. Bangladesh faces unprecedented energy crisis due to high-energy demand and poor management. Low production results frequent disconnection; load shedding and most of the service sectors in the city are interrupted. Surprisingly residential sector consumes 45% electricity of Dhaka and the demand is increasing day by day. Another problem is that government introduced new satellite towns to keep pace of development and to accommodate people, which will further also increase the demand. Our country relies heavily on fossil fuels like natural gas and imported oil for its electricity production. Renewable sources can meet the demand only 4% though the zone is favorable for plentiful supply of renewable sources. Therefore the objective of the paper is to assess how renewable energy technologies (RETs) can be incorporated in the residential buildings of new satellite towns of Dhaka to supplement the existing electricity demand focusing more on technical and policy aspect. This paper also tries to find out the main barriers and probable solutions to incorporate the technologies in the residential buildings for its sustainability.

Key words: Renewable energy, residential buildings, satellite towns, sustainability, Dhaka.

1. INTRODUCTION

Energy is essential to ensure quality of life and to underpin most of the services to our environment. Dhaka the capital of Bangladesh faces an unprecedented energy crisis due to higher demand, country's small energy infrastructure, poor management and system loss. Now Dhaka city consumes around 1000-1200 MW electricity against the demand of 2000 MW, where country can only generate 4,162 MW (BPDB, 2010). Surprisingly residential buildings sector consumes 45% electricity of Dhaka (Rahman and Mallick in Ahsan 2009). This includes energy for heating, cooling, and lighting purpose. Moreover government introduced new satellite towns like "purbachal" in Dhaka to accommodate people, which will further increase the electricity demand.

Now the country's power is being generated mostly with indigenous natural gas (82%), 9% imported oil, 5% coal (Kabir *et al* 2009). Recently a remarkable decline of the natural gas takes place, which rapidly aggravates electricity generation. The initiative of new exploration and development of

natural gas has almost reduced to zero due to lack of capacity. Realizing the fact, government had stopped to permit electricity connections for all new buildings from April to October 2010 and since November they started conditional electricity connection like building must use solar energy if demand is more than 2 KW (KK, 2010). The development of renewable energy is insufficient. Renewable energy sources can meet the demand only 4%, though the zone is favorable for plentiful supply of renewable sources.

Given the city's power crisis, high energy prices or their rather unpredictable development, search for alternative source of energy in buildings for new satellite towns of Dhaka could be pragmatic to supplement existing power demand and to avoid a number of social economic and environmental problems. Renewable energy systems in buildings would be very effective in this regard.

2. OBJECTIVES:

As electricity situation posing the number one problem for all service sectors in Dhaka, residential

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buildings could play an important role by incorporating RETs to supplement the existing demand. This paper focuses on how RETs could be incorporated in the urban residential buildings focusing on new satellite towns of Dhaka with a view to

- What are the RETs that can be used in residential buildings of Dhaka?
- How different government policies can help to promote the RETs around the world?
- How it could be affordable at local level?
- What are the barriers and probable solutions to promote RETs for buildings in new satellite towns of Dhaka? And
- To prepare a basis for further study about RETs use in buildings of Dhaka

3. RESEARCH METHODS

The research consists of three main phases: desk study, field research and information analysis. Desk study helped to analyze different aspect to promote RETs in building sector around the world. Field research helped to produce some qualitative and quantitative descriptions of some aspects of the study area at Dhanmondi in Dhaka that helped to make some assumption about new satellite towns. The quantitative data from the questions has been grouped and put in tables and the results expressed in percentages and frequency distribution. Qualitative data that were collected through in depth interview with key respondents presented in graphs.

4. ENERGY AS AN URBAN ENVIRONMENTAL PROBLEM:

Energy uses are increasing significantly with increased supply of fossil fuels to maintain urban lifestyles that negatively affect to our environment. Realizing the fact ‘Winston Churchill’ expressed his emotion (Jowitt, 2009), “*We shape our buildings, and afterwards our buildings shape us*”.

4.1 Energy sources uses in building: As Dhaka electric supply authority cannot meet the current electricity demand in residential sector at dhanmondi shows, most of the building (90%) use diesel based generator and IPS as alternative sources (Table 1) which contribute to a number of social, economic & environmental problems like noise and air pollution, global warming etc. They spent huge additional cost to operate generators each year. Study confirms that people are interested about the technology but 70% mentioned it expensive.

Table 1: survey analysis of Dhanmondi

Questions	Answer	No. of Ans.	(%)
What are the alternative sources you currently use	Generator	9	90
	IPS	1	10
	RE	0	0
What do you prefer as alternatives	Generator	6	60
	IPS	0	0
	RE	4	40
Why you don't use RET	Expensive	7	70
	Lack of info.	3	30

Sources: author

4.2 New satellite towns of Dhaka: Dhaka, the capital of Bangladesh, has come to be known as a fast growing megacity (13 million) of South Asia in recent times. It is expected to grow at a rate of 3.6% annually and reach a total of 21.1 million in 2015 (UN, 1999). To accommodate the growing number of population, the city would need at least 10 million new residential apartments (units/flats) by the year 2015. Moreover buildings in new satellite towns like “purbachal” will further increase the energy demand. This is the right time to think about energy choice and sustainable pattern of residential building in new satellite towns for our future energy security.

4.3 Improving through energy choice and buildings design: Buildings are very important for our environment because of their lifetime (around 50-80 years) and most of the energy is used during their service life. Through the careful choice of environmental friendly energy sources, the use of an ecological design approach the building could reduce considerably the quantities of pollutants entering the environment. CABE (2007) believes that: “*No building, space or place can be considered well designed if it does not contribute to environmental social and economic sustainability, conversely, no building, space or place can be considered sustainable if it is not well designed*”.

To improve our environmental and its sustainability we need to thing alternative sources of energy for buildings. There is an urgent need to transition to energy options that are clean, affordable, secure, sustainable and peaceable (Kamal, 2010). RETs offer the promise of clean, abundant energy.

5. RENEWABLE ENERGY:

Renewable energy may be defined as energy from naturally available sources such as wind, solar, rain, tides, geothermal heat and biomass etc that can be constantly replenished and harnessed for human

benefit (IEA, 2009). These resources can be used to produce electricity for all economic sectors.

5.1 Renewable energy sources uses in building:

There is a wide range of renewable energy sources/technologies such as solar photovoltaic (PV), solar thermal (ST), wind power, combined heat and power (CHP), ground source cooling (GSC), ground sources heat pump (GSHP) and biomass varying in technical and commercial viability for building. It can be used in a number of ways, these include: extracted elsewhere and delivered via the conventional delivery channels and networks, it can be extracted locally, it can be extracted at the site of the building(s), or by the building envelop in integrated way. Without proper policy interventions and technological improvements these patterns of energy are not expected to achieve/change in the near future (UNEP, 2009).

Table 2: Overview of eight (8) different RE sources uses in building worldwide.

Sources	Energy type	Co2 savings	Cost	Factors
SPVs	Electricity	Low	Low	Solar radiation
ST	H* & C*	L*-M*	M	Solar radiation
DHC	H & C	M-H	M	Location & building type
CHP	H & C	M-H	M	Building type, occupation
GSC	Cooling	Depend	Depend	Ground Temp
GCHP	Heating	M	M	Ground Temp
Wind	Electricity	L-M	M	Wind speed
Biomass		High	M	Location & occupation

Source: CIBSE, 2006

H*=Heat, L*=Low, M*=Medium

The application of renewable systems for building depends on several determining factors; including geophysical (absolute location, global horizontal irradiance, temperature, cloud cover, sunshine duration, air flow, surface temperature, space availability and so on) economic and socio political (capital investment, technology support, social acceptability, political commitment, institutional support etc.) and environmental factors (Green house gas emission reduction, climate protection) (Kabir *at el*, 2009). This can substantially meet the energy demand for buildings.

6. RENEWABLE ENERGY POLICY IN BANGLADESH 2008:

'Bangladesh's Renewable Energy Policy 2008' approved with a vision for reducing dependence on traditional sources of energy and encouraging investment in this sector to generate electricity from renewable sources. It has been predicted that 5

percent demand for electricity would be met by 2015 through utilizing renewable energy while 10 percent demand by the year 2020 (GOB, 2008). According to the policy statement, an independent institution, sustainable energy development agency (SEDA), in co-operation with local government will provide benefits for installation of solar, wind, biomass or any other renewable/clean energy projects. There is no institution or local policy for building sectors in Dhaka to promote RETs yet.

6.1 Major renewable energy sources: RETs currently uses building in Dhaka and Bangladesh as well are as follows:

6.1.1 Solar Energy: Geographically Dhaka, the capital of Bangladesh is situated between 23°46' north and 90°23' east latitude. A subtropical region that is endowed with a plentiful supply of renewable energy sources. The monthly average sunshine hour varies 4.1 to 8.7h, which is significantly higher than Europe to use solar energy. Centre for energy studies (CES), BUET, recorded average solar radiation in Dhaka in a year 4.7 kWh/m²/day, which offer maximum benefit to use solar energy (electricity generation and hot water system). In Dhaka "prime minister office" and "Bangladesh bank bhaban" installed solar panel to supplement the existing electricity demand. Ministry directive also showed all government building must use solar energy in Dhaka by 2013.

6.1.2 Wind sources: Wind can be vital sources for electricity generation if it can be harness properly. Most of the wind speed data of Dhaka available in meteorological department are measured at lower heights (10m) that lack reliability and accuracy. According to Mahfuz *at el* (2002) above 25 m height the average wind speed is in Dhaka is 4.52 m/s. that could be useful to install a wind turbine for high-rise buildings. Vertical axis systems (wind turbine) can be installed that require minimum speeds of 3.5-5 m/s to operate and is easier to integrate with building structure. Currently wind energy potential is mainly limited to coastal areas and offshore islands with strong wind regimes.

7. DIFFUSION OF RENEWABLE ENERGY FOR BUILDING IN THE WORLD:

If the aim of the building sector is to make more sustainable in the long run, then renewable energies will have to play a bigger role. This can be achieved through two avenues: first, by substituting fossil fuels with renewable energy sources at the point of electricity generation; and second, through the use of renewable energy technologies at the

point of consumption when supported by favorable government policies (UNEP, 2009). Many countries are trying to speed up the diffusion of renewable energy provision through direct regulation. There are number of common policy mechanism used worldwide such as target setting, regulations, municipal operations, voluntary actions and guidance to promote RETs in building sectors at local level.

Table 3: Overview of RET'S policy in the world

City/ country	Target	Regulation				Municipal operation			Voluntary actions				Guidance
		Urban	Building	Taxes	Other	Purchase	Invest	Utility	Demo	Grants	Land	Other	
Kunming China	X	X		X			X			X		X	X
Nagpur India	X	X	X	X			X		X				X
Barcelona Spain	X	X	X				X					X	X

7.1 Kunming, China (population 4.7 million): Kunming aspires to be a “solar capital” of China. In 2008, the city adopted a policy framework “advice on renewable energy development and use” which calls for a 50% share of all buildings in the city to have solar hot water and solar PV by 2010. Other policies to promote renewable energy include low-interest loans, tax exemptions, and a special fund to encourage private investment. The city has also incorporated solar investments into its own procurement. And the city is providing support for R&D, industry development, university education, and a solar hot water equipment-testing center.

7.2 Nagpur, India (population 2.1 million): Nagpur participated in a local renewables “model communities” program from 2005–2008, paid partly through foreign donor assistance. The city also issued an ordinance mandating solar water heaters for all new residential buildings with more than 1500 m², with a 10% rebate on property tax as an incentive. A Renewable Energy Resource Center was established to facilitate dialogue with local stakeholders, to identify and collect various forms of information, and to publish newsletters and brochures. Awareness campaigns include a mobile

van, formation of “energy clubs” in schools, and training for students and schoolteachers. The city is targeting a 20% reduction in conventional energy consumption of municipal buildings and services by 2012.

7.3 Barcelona, Spain (population 1.6 million): Barcelona enacted a city ordinance in 2000 that required solar hot water in all new buildings and major renovations above a size threshold (typically all commercial buildings, and residential buildings of 16 or more households). In 2005, the city eliminated the size requirement so the ordinance now applies to all construction. The ordinance requires 60% of hot water energy to come from solar. Barcelona promotes renewable energy through its 2002–2010 “Plan for Energy Improvement in Barcelona,” which aims to reduce CO₂ emissions by 20% by 2010 (compared to 1999). The plan is being implemented and monitored by the Energy Agency of Barcelona. There are also informational and public awareness programs.

8. BARRIERS TO RENEWABLE ENERGY DEVELOPMENT:

There are plenty of barriers hindering widespread deployment of potential RETs in new satellite towns of Dhaka. The major impediments to use renewable energy sources in the building sector are policy and institutional barriers rather than technical problems. Different types of barriers experienced are discussed in the subsequent headings.

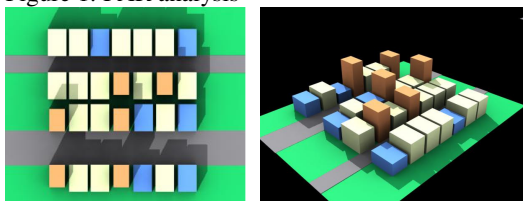
- Policy Barriers: Lack of renewable energy policy in building for local level at Dhaka is one of the main barriers. Unfavorable energy policies for building sector and unwieldy regulatory mechanisms
- Institutional barriers: Absence of a dedicated national agency like Renewable Energy Development Authority (REDA) to plan, co-ordinate and finance.
- Technical Barriers: Lack of access to the technology. Local manufacturing and/or assembly of renewable energy technology components and equipment are currently limited.
- Market Barriers: Small size of the market, limited access to international markets for modern RETs, limited involvement of the private sector, high upfront cost at the end user level.
- Economic, Financial and Financing Barriers: Unfavorable costs, taxes (local and import), subsidies and energy prices. Lack of

appropriate financing mechanisms for renewable energy in urban sector

- vi) Capacity/ Human Resource Barriers: Lack of skilled manpower for system design, installation, operation, maintenance and training facilities.
- vii) Environmental: Visual pollution, lack of valuation of social and environmental benefits
- viii) Information/ Awareness Barriers: Lack of information among the public and policy makers about renewable energy resources, technical/economic information about RETs.
- ix) Social acceptance: Lack of social acceptance and local participation.

8.1 FAR (Floor area ratio): RAJUK introduced “Dhaka building construction rule 2008” focusing more on FAR, creates some barrier to promote RET at residential building in Dhaka (figure 1).

Figure 1: FAR analysis



Source: Author

From the above illustration we can see most of the buildings at Dhanmondi residential area are typical six stories. FAR offers vertical extension (more than six) which creates shadow to adjacent lower height building, is one of the main barriers to promote solar energy in building at Dhaka.

Barriers would not be removed unless government takes actions.

9. RESULT AND DISCUSSIONS:

9.1 Technical aspect: On the basis of both the desk study and survey analysis we can see geophysical factors have been found fully supportive for solar energy (solar photovoltaic and solar thermal) application in urban residential building in new satellite towns of Dhaka to generate electricity and hot water system in winter and some cases wind speed to harness wind energy, depends on height of the buildings. It must be noted that this is the theoretical potential real achievements depend on the different and specific policy aspect, availability of cost-effective technology, affordability, building design guidelines, acceptability and effective planning and management.

9.2 Policy aspect: From the international energy

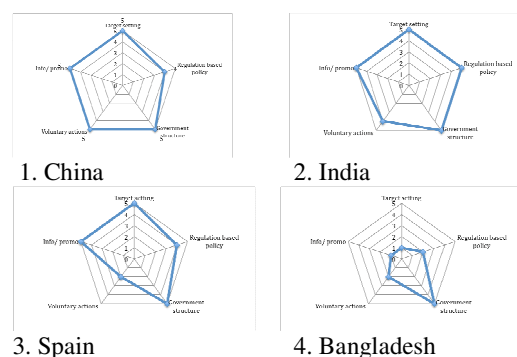
agency IEA (2009) and REN21 (2009), five different policy mechanism and activities, namely target setting, regulations, municipal operations, voluntary actions by government and guidance have been identified to promote renewable energy at the local level. Different aspects from International experiences have been analyzed to promote renewable energy in cities including Dhaka with the scale value 5

Table 4: values for five policy indicators in four different countries.

City/ country	Target	Regulation	Municipal operation	Voluntary actions	Guidance
Kunming China	5	4	5	5	5
Nagpur India	5	5	5	4	5
Barcelona Spain	5	4	5	2	5
Dhaka Bangladesh	1	2	5	2	1

Source: Author

Figure 2: shows the graphical comparison



Source: Author

In comparison with the China, India and Spain’s renewable energy policy development, from the figure we can see Bangladesh clearly lags behind in terms of local renewable energy policy in buildings, regulations, and proper financing mechanism for urban areas. Consequently current government

initiative to promote renewable energy technology in building sector in Dhaka cannot be called an integrated way of system due to absence of clear target, regulations like energy efficiency building codes. A study on the regulations in the national building code of Bangladesh (BNBC) shows that it does not address the issues of RETs in any building category. RAJUK introduced Dhaka building construction rule 2008, there is also no clear indication about energy consumption reduction from buildings or RE issues. Moreover FAR (floor area ration) creates some barrier to promote RETs in building as it casts shadow to adjacent lower height buildings due to no restriction on height. It is assumed that the introduction of specific renewable energy policy in building sector for new satellite towns of Dhaka will have a positive aspect to implement the government initiative and supplement the existing electric energy demand and for our future energy security.

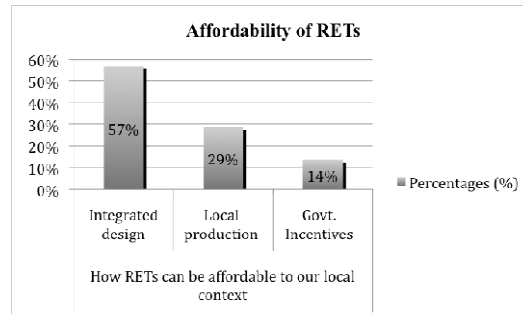
9.3 Affordability at local context: Although investment costs of RET's are generally higher compared to fossil fuel alternatives, this option becomes economically viable when all externalities (e.g. environmental cost, health hazards etc.) and lower operating cost are taken into consideration (GOB, 2008). We can carefully assess the following table 5

Energy	Sources	Cost	Positive aspects	Negative aspects
Conventional	Gas (82%)	Low	Environment friendly	Not enough reserve
	Oil (9%)			Import based/ Emit CO ₂ / Operating cost high
	Coal (5%)			Not decided yet
Generator	Diesel	High		Not environment Friendly/ Emit CO ₂ Operating cost high
IPS	Electricity			
Renewable	Solar	Very high	Environment friendly/ No operating cost	
	Wind			

Source: Author

According to some experts, 57% said cost could be minimized if we use RETs in building an integrated way. 29 % mentioned it would be systems would be affordable if we can produce it locally. Some of them also focused on government incentives.

Fig: 2 expert interview result.



Source: Author

In addition building design technique such as integrated renewable energy systems could play a big role to minimize the cost and system loss if it considered at the early stages of a project, before factors such as orientation, building form; numbers of storey's, heating and ventilation strategy etc have been established (CIBSE, 2006). From the Architectural, technical and financial perspectives:

- Reduction of investment costs by replacing facade/roof/-shading elements;
- When grid-connected, avoids the costs of batteries.
- Can be aesthetically appealing;
- Electricity is generated at the point of use, reducing costs of transmission and distribution.
- Suitable for un shaded roofs and facades in densely populated areas;
- No additional land area required, since building surfaces used;
- Can be designed to generate electricity at a building's peak usage times, thus reducing the building's peak grid electricity demand;
- Can act as shading devices
- Can form semi transparent elements of fenestration
- PV/T can provide part of the water or space-heating loads of the building BIPV can form part of a grid-failsafe antennae system for cellular communications.

Integrated design requires more emphasis on energy efficiency and systems in the early planning phase than traditional design that would be ideal for new satellite towns of Dhaka.

9.4 Probable solutions: From the above study we found barriers would be removed if government takes actions on followings.

- Policy Barriers: Strong policy target and regulations for buildings in new satellite towns of Dhaka to promote RETs

- ii) Institutional barriers: Setup strong national agency to plan, coordinate and finance to implement the policy target
- iii) Technical Barriers: Technology transfer mechanisms to make local people informed.
- iv) Market Barriers: Fiscal instruments and incentives, Product standards, Economic instruments to facilitate the market
- v) Economic, Financial and Financing Barriers: Fiscal and economic instruments such as tax rebates, Kyoto flexibility mechanisms, subsidized loans, regulatory instruments or increase energy price, remove energy price subsidies
- vi) Capacity/ Human Resource Barriers: Training of building professionals those are directly involved the building process
- vii) Environmental: Should include environmental cost and health issues
- viii) Information/ Awareness Barriers: Awareness raising campaigns
- ix) Social acceptance: Voluntary actions such as tax incentive, subsidy

FAR should be modified for specific locations like new buildings at “purbachal” in terms of height.

10. CONCLUSIONS:

Geophysical factor fully support solar energy development in Dhaka and some cases wind sources depends on building height and urban design guidelines. Knowing the current fact people is also interested to invest for RETs to generate electricity in Dhaka. Government has a lead role to play in the case of initial investment and there is a scope to manage big funds internationally through clean development mechanism (CDM). To promote RETs we need specific renewable energy policy target for building sectors and regulations to implement the policy. An integrated energy planning approach, and rational policy instrument to deal with technical, social, economical and political barriers are the prerequisite to promote the RETs for building sector in new satellite towns of Dhaka. Integrated renewable energy systems could play an important role to make it affordable at local level especially in new satellite towns of Dhaka.

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RISK ASSESSMENT OF MASONRY BUILDINGS IN HERITAGE AREA: A CASE STUDY FOR THE OLDER PART OF DHAKA CITY

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Being very close to the boundary of two active plates: the Indian plate in the west and the Eurasian plate in the east and north, earthquake risk of major urban centers including Dhaka are quite substantial. This study focuses on the seismic safety evaluation of masonry heritage buildings in Shakhari Bazar in the older part of Dhaka City. The major structural parameters in the classification of masonry buildings are considered as the number of stories, load-bearing wall material, regularity in plan and the arrangement of walls. It was revealed from the study that about 7% of the buildings fall under severe risk category, 36% of the buildings fall under high risk category and 41% of the buildings in moderate risk category.

Key words: assessment, heritage areas, masonry buildings, risk and Shakhari Bazar.

1. INTRODUCTION

The risk is growing with every passing moment because of the unabated growth of human settlement and industrial and other economic activities in and around Dhaka. It is generally believed that very high density development and existence of very old structures have made the older part of the city even more vulnerable to any impending earthquake situation. After the death of 19 people in 2004, due to collapse of an old building at Shakhari Bazar in old Dhaka (Observer, 2004), Town planning department of Dhaka City Corporation felt the necessity of undertaking initiative to assess the seismic vulnerability of buildings at Shakhari Bazar declared as heritage areas. Consequently, a consortium of Asian Disaster Preparedness Center and a consulting firm Datex were assigned to undertake seismic vulnerability assessment and prepare separate Structural Assessment Reports (SAR) for each of these selected buildings (Alam et al., 2010).

SAR also referred to as an Engineer's Report is a planning tool used to determine a historic building or structure's structural condition by analyzing and evaluating foundation, framing, other construction systems, and their associated construction details. This report also provides recommendations for corrective treatments, as applicable. SAR may be

commissioned for several reasons, including determining existing load capacity and identification of structural deficiencies that need to be addressed for an adaptive use, determining causes and the extent of existing or potential structural failures, and as documentation and justification of the need for demolition. The size and degree of detail in a SAR is dependent on the condition and complexity of the resource examined the amount of information available or attainable, and the resource's current or proposed use (Afsana, 2004). This paper presents the methodology used for assessing seismic vulnerability and a summary of the assessment being done for selected 82 old masonry buildings in Shakhari Bazar. Besides, the paper also puts forward some recommendations regarding future course action that needs to be undertaken for the buildings assessed.

2. STUDY AREA

Shakhari Bazar is located in old town. The old urban settlement is one of the high density areas of Dhaka city. The selected 82 buildings are situated in Shakhari Bazar falls within two wards viz. ward 72 and 73. The locations of the areas are shown in fig. 1.

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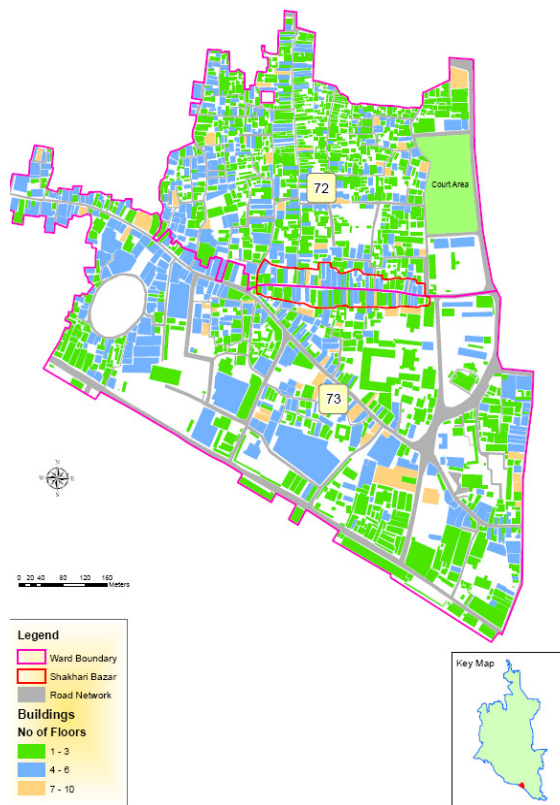


Fig. 1: Location of Shakhari Bazar

The rich architectural heritage at Shakhari Bazaar is also home to the Shakhari community, a community that has been living here and practicing the same craft of Shakha (conch-made bangles) making as their ancestors did over the last 500 years (Seraj and Alam, 1989). With their habitats, lifestyle and craft this community of Shakhari has become a living heritage of Old Dhaka. But, as the age-worn masonry buildings look dangerously close to falling down, it is not just the rich architectural heritage that is at risk, the Shakhari community and the craft they have carried on across centuries also face the threat of extinction. Hence, structural assessment of the buildings of these areas has been found to be necessary.

3. METHODOLOGY ADOPTED FOR ASSESSMENT

Several Protocols provided by Federal Emergency Management Authority were used for evaluating structural vulnerability of the buildings in this study (FEMA 310, 1998). First of all building structural as well as the architectural types had been identified. The load transfer mechanism of the buildings had been determined. Level I and level II

survey of the building were done to identify the basic vulnerability factors such as heavy overhang, pounding possibility etc. Then with the help of Rapid Visual Screening (RVS) method (ATC-21, 1988) the strength score of the building was generated. After that with the help of floor plan, structural check was done. From the RVS method detailed level of assessment requirements had been identified. Among the 82 buildings 74 buildings did not satisfy the score; hence most of the buildings were undertaken for the detailed assessment. For detailed assessment of buildings FEMA 310 and several critical structural checks were adopted (Rai, 2005).

Soil characteristics are one of the major factors to analyze earthquake vulnerability of buildings. The soil class D was used for seismic vulnerability score generation in RVS Method. The V_{s30} range is 180 to 360 m/sec for class D. It also gave the idea for ground base shear wave velocity of the study area (CDMP, 2009).

Initially RVS Score was done for the initial assessment of the buildings. A detailed survey proposed by FEMA 310 was done for each of the building for the in depth structural checking of the buildings. Fig. 2 shows the outline of the steps followed during the study.

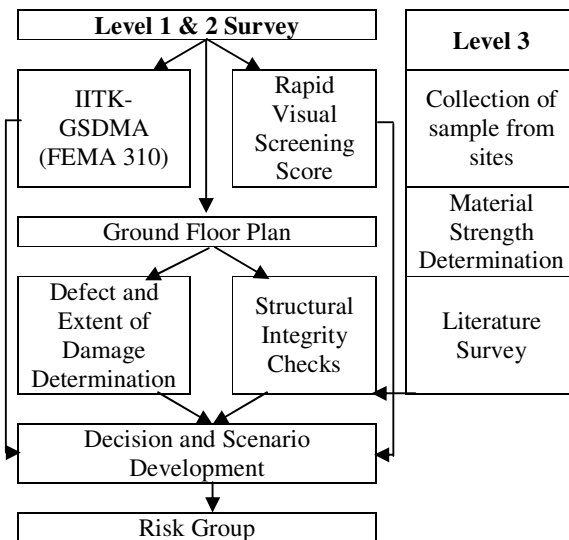


Fig. 2: Outline of the Methodology

3.1 Level I and Level II Survey

A pre set questionnaire was used for building survey. Side walk survey and questionnaire survey were carried out for each of the 82 buildings. The average time required for this survey by a 2-member team was about 2-3 hours per building.

The building attributes considered during level I survey were number of stories, occupancy class, structural type, number of occupants during the day and the night, age of the building, presence of heavy overhangs, shape of the building plan, shape of the building in elevation view, pounding possibility, building in slope land, visible ground settlement and visible physical condition .

Moreover, Architectural features which are the parameters defining geometry of buildings such as story height, span length, presence of open 1st-story, and etc may act as factors for the vulnerability assessment. These parameters primarily depend on functioning and aesthetic purposes of buildings. For masonry buildings, considered attributes were wall thickness, maximum unsupported length of wall, corner separation, anchorage of wall to floor, anchorage of roof with wall, wall to wall anchorage, bracing of flexible floor or roof, existence of gable wall, horizontal band (Alam et al., 2010).

In level II survey, detail of ground floor of a building was surveyed in addition to the features considered during level I survey.

3.2 Level III survey

The direct shear test for masonry load bearing buildings with the help of Hydraulic Jack operated machines had been conducted. After that some laboratory tests were done to determine the confined compressive strength of existing brick units, confined compressive strength of lime and cement mortar and shear strength of the lime mortar for the detailed assessment of the buildings. With the help of these tests each building was checked against the seismic load, height to thickness ratio, overhang ratio and old masonry building indices.

3.3 Design Seismic Base Shear

The design seismic base shear is the total design lateral force at the base of a structure. The total design lateral force or seismic base shear (V_B) (BNBC, 1993) along any principal direction shall be determined by the following expression:

$$V_B = ZICW/R$$

Where,

Z = Seismic Zone Coefficient

I = Structural Importance Coefficient

R = Response Modification Coefficient

W = Seismic weights of building.

C = Numerical Coefficient given by

$$C = 1.25S/T^{2/3}$$

S = Site coefficient for soil characteristics

T = Approximate fundamental natural period of vibration in second, is estimated by the empirical expression:

$$T = C_t (h_n)^{3/4}$$

$C_t = 0.049$ for masonry building

h_n = Height in metres above base level

The design base shear (V_B) is distributed along the height of the building as per the following expression:

$$Q_i = V_B (W_i h_i / \sum W_i h_i)$$

Where,

Q_i = Designed lateral force at floor i,

W_i = Seismic weight of floor i,

h_i = Height of floor i measured from base, and

n = Number of storey in the building is the number of levels at which the masses are located

3.4 Strength check for diaphragms

Floor and roof diaphragms should be able to resist diaphragm forces F_{px} as given below:

$$F_{px} = \frac{\sum_{i=x}^n Q_i}{\sum_{i=x}^n W_i} W_{px}$$

Where,

W_{px} = Weight of roof or floor diaphragm at the level x and

$Q_i = w_i$ are lateral loads the i-th floor

w_i = Seismic weights at the i-th floor

The force F_{px} determined from the above equation shall not be more than $0.75 ZI_{wpx}$ and less than $0.35 ZI_{wpx}$ (BNBC, 1993).

3.5 Shear Stress Check

Shear stress at any level for load bearing wall:

$$\tau_{wall} = (Q/A_w)$$

Where

Q_i = Storey shear for piers in the grid

A_w = Area of shear wall in the direction of loading.

For unreinforced masonry load bearing wall building, the average shear stress, τ_{wall} shall be less than 0.1Mpa (Rai, 2005).

3.6 Old Masonry Building Index

Following three indexes were used for old masonry building indices check (Lourenço and Roque, 2006):

Index 1: In-plan area ratio

$$\gamma_{1,i} = A_{wi} / S$$

Index 2: Area to weight ratio

$$\gamma_{2,i} = A_{wi} / G$$

Index 3: Base shear ratio

$$\gamma_{3,i} = V_{Rd,i} / V_{Sd}$$

Where,

V_{Sd} = Base Shear

$V_{Rd,i}$ = Shear Capacity in i direction

S = The total Plan area

A_{wi} = Plan area of earthquake resistant walls in direction “i”

A_w = Total in plan area of earthquake resistant walls

Table 1: Minimum recommended values for γ

Index	Allowable Value
In Plan Area ratio, γ_1	5%
Area to Weight ratio, γ_2	1.8 m ² /MN
Base Shear ratio, γ_3	1

3.7 Overhang Ratio

In a typical floor plan, the area beyond the outermost lines on all sides is defined as the overhang area. The summation of the overhang area of each story, $A_{overhang}$, divided by the area of the ground story, A_{gf} , is defined as the overhang ratio.

$$\text{Overhang Ratio} = \sum A_{overhang} / A_{gf}$$

3.8 Parapet Walls

Non-structural falling hazards such as chimneys, parapets, cornices, veneers, and overhangs can pose life safety hazards if not adequately anchored to the building. The maximum height of unbraced unreinforced masonry parapet above the roof should not exceed 1.5 times the thickness of parapet wall (Rai, 2005).

3.9 Height to Thickness Ratio

The bearing walls are judged for out-of-plane stability based on their height to thickness (h/t) ratios. The following allowable ratio must be considered for unreinforced masonry bearing wall buildings with stiff diaphragms (Rai, 2005).

Table 2: h/t ratio for risk zone (Z = 0.15)

Wall Type	Allowable h/t
Top storey of multi-storey building	14
First storey of multi-storey building	18
All other conditions	16

3.10 Direct Shear Test

Direct shear stress for bearing wall was conducted by using calibrated Hi force hydraulic jack, Pressure gauge reading = X

Applied force in Plane, $F = 0.0206 X + 0.169$

Contact surface area= A (2 face for 5 in wall and 3 face for 10 in wall)

Ultimate Shear Strength= F/A

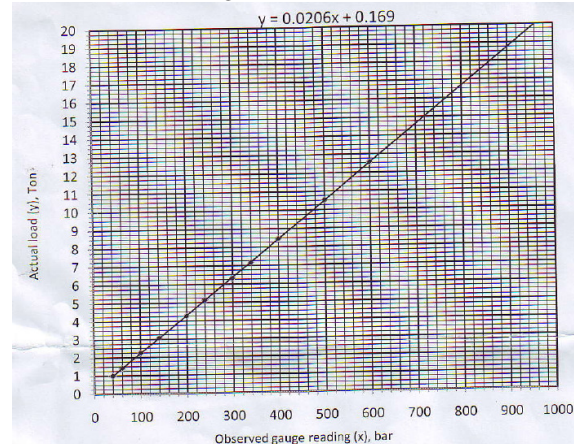


Fig. 3: Calibration curve for pressure gauge

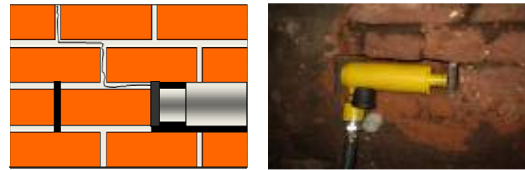


Fig. 4: Masonry unit failure (left) and Hydraulic Jack



Fig. 5: Defects and extent of damages in Shakhari Bazar.

3.11 Existing Damage

For the masonry buildings vulnerability assessment, existing damage factors are very important. The structural faults those are identified are deteriorated mortar, damaged lintel, corner separation, wall crack, poor condition of supports etc. These structural faults caused structural vulnerability of surveyed buildings. Fig. 5 shows different types of damage factors in study area.

3.12 Risk Scenario

Risk Scenario was developed for existing buildings considering all importance factors. An engineering judgment was applied to classify the buildings in different risk group. Fig. 6 shows the way to categorize the risk group and Table 3 shows risk classification (EMS-98, 1998).

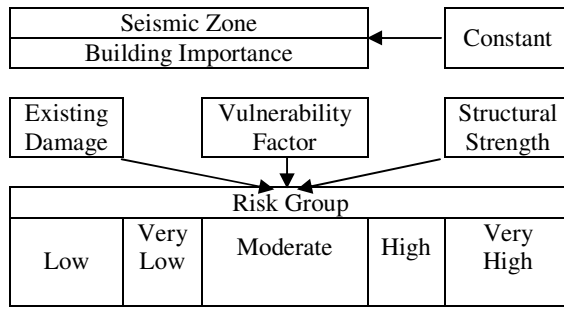


Fig. 6: Steps of Risk Scenario Development

Table3: Risk Group

Risk Group	Brief Description
Very High	Building is in near collapse position
High	Crack in walls, Corner separation, Structural Elements Poor Condition, Structural performance low
Moderate	Cracks in infill, Mortar condition Poor, Moderate Structural Performance
Low	Hair Crack in structural elements, No severe damage, with some vulnerability, Structural performance good
Very Low	Building in good shape, Vulnerability very low, Structural checks satisfied

4. RESULTS

Most of the buildings in Shakhari Bazar bear the symbol of ancient settlement of old Dhaka. About 20% of the surveyed buildings carry some symbols of architecture of 1600 A.D. Although many of these symbols have either been decay or modified over the time due to different interventions, still these holds the heritage of 400 years of Dhaka.

In Shakhari Bazar there is no recent construction due to government restriction. This has restricted the owners to construct existing house vertically. Among the surveyed buildings in Shakhari Bazar most of the buildings are 3 storied and above.

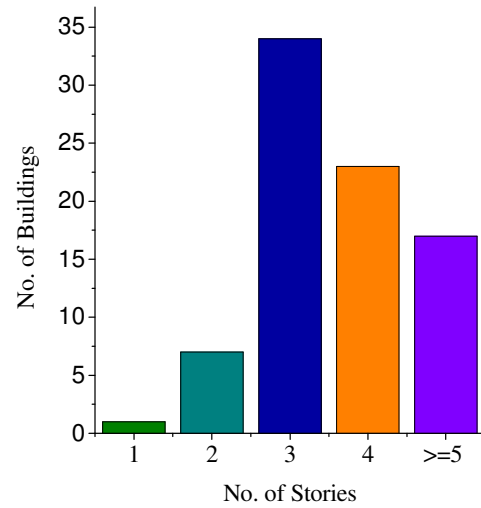


Fig.7: Building Storey Distribution

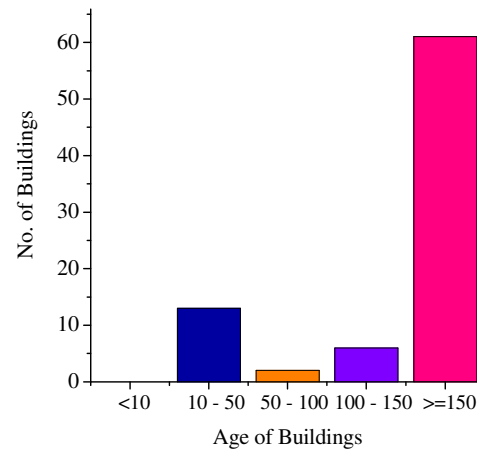


Fig.8: Relationship between building age and buildings age

About 61 of the surveyed buildings are more than 150 years old and owned by individual and these buildings are constructed on limited area. Moreover, ownership conflicts over the years, many of the buildings are not well maintained. As a result the apparent quality of buildings was found poor during this study. About 62% of the surveyed buildings appear to be poor in quality assessment. About 31% of the bindings are in average condition since these were repaired time to time by the owners.

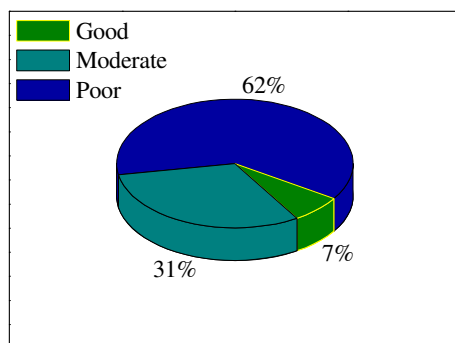


Fig.9: Apparent quality of buildings

Building shape and elevation are one of the major factors affecting buildings during an earthquake. From the experience of different earthquake, it is understood that the buildings with irregular shape are more damaged than the buildings that are of regular shape. Similarly elevation of building is also another important factor responsible for damages in buildings during an earthquake. Narrow tall buildings are more vulnerable during an earthquake. About 40% of the buildings have 'Setback' irregularities in elevation and 20% of the surveyed builds are of 'narrow tall' category. On the other hand, 12% buildings are irregular shape in building plan. Among the surveyed buildings about 10% of buildings found with heavy overhangs.

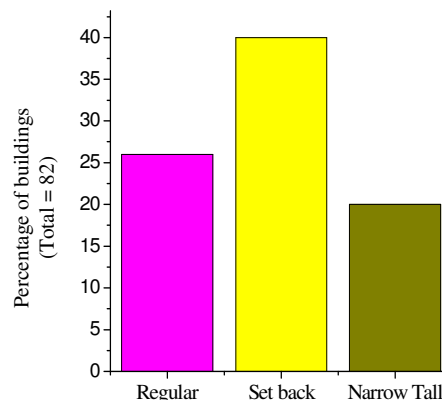


Fig10: Building Shape in Elevation

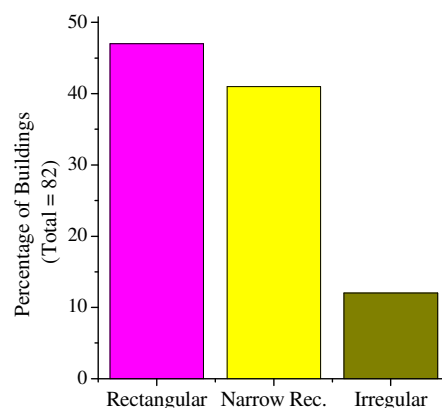


Fig11: Shape in Building Plan

Among the buildings, 89% were found with deteriorated mortar, 75% with damaged lintel, 47% corner separation, 85% crack in wall, 44% giant crack in bearing wall and 49% with poor cornices.

Considering the above stated results and with the help of Destructive and Laboratory tests, some structural checks had been conducted in the study, and the results are depicted in Table 4.

Table 4: Structural checks results

Structural Check	No. of Buildings	
	Satisfied	Not Satisfied
Shear Stress Check	35	47
Strength check for diaphragms	42	40
Old Masonry index	43	39
Overhang Ratio	68	14
h/t ratio	28	54

Parapet Walls	57	25
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5. CONCLUSIONS

The present study shows that among the surveyed buildings, about 36% were found to be in high risk category and 7% of the buildings were found to be in severe risk category and therefore, in a position to be collapsed. Serious lacks in maintenance of buildings by the owners were identified. Since these old masonry buildings have been declared as the heritage building, seismic retrofitting is the recommended technique to minimize the earthquake effects. Following are key recommendations from the study which could be taken into consideration for ensuring seismic safety of the surveyed buildings;

- Extra Stories of the building should be demolished and the building should be restored in original shape and storey.
- Some recent extensions constructed by the owners, such as, the heavy overhangs or cantilevers should be demolished.
- According to the assessment result, height to thickness ratio is the most governing issue to be addressed if retrofitting is opted.
- In cases when the height to thickness ratio of the walls exceeds the limits of stability, rehabilitation could be done by reducing the span between the walls.

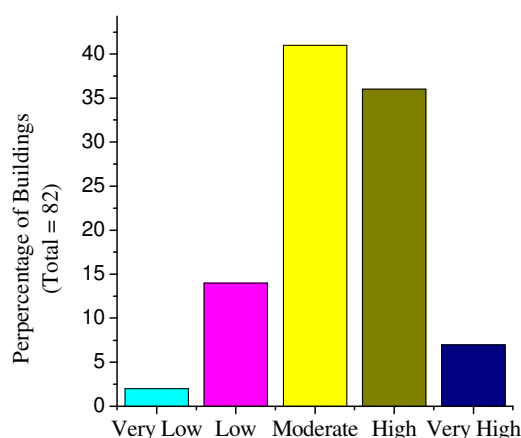


Fig. 12: Risk Group Distribution

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SEISMIC RISK ANALYSIS FOR THE SCHOOLS OF SYLHET CITY, BANGLADESH

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Bangladesh is one of the most earthquake prone countries in southern part of Asia, where Sylhet is the most risky region to an earthquake as it is situated in Dauki fault zone. The main objective of the study was to evaluate the structural safety of some renowned schools of Sylhet city due to earthquakes of different intensities. Engineering judgment from site visit, questionnaire survey, drawings and prevailing practices of building construction in this region was used as the methodology of the study. It was revealed from the study that at a probable intensity EMS IX, Damage Grade (DG) will be DG3, DG4 and DG5 with 60%, 26.7% and 13.3% buildings respectively. It was also found that the masonry schools are in most vulnerable condition (40% of the schools have DG5 and 40%- DG4) and the reinforced concrete schools are comparatively in less vulnerable condition (80%- DG4). The study also puts forward some recommendations regarding future course action that needs to be undertaken for the buildings assessed.

Key words: Schools, Seismic vulnerability, Sylhet city, Intensity, Damage Grade

1. INTRODUCTION

Bangladesh is one of the most earthquake prone countries in southern part of Asia. Sylhet, the north-eastern region of Bangladesh, is most risky to an earthquake as it is situated in Dauki fault zone. The schools are the places where hundreds of students, the future of the nation, get together every day for study purpose. So, school buildings must have enough structural safety to avoid mass injury and fatality during an earthquake. Unfortunately a significant number of the school buildings of the city are old and non- structured. So, there should be a thorough investigation to evaluate the vulnerability of the school buildings due to a probable earthquake and find individual solutions for strengthening each of the buildings to ensure its structural safety. In this context an attempt was taken to evaluate the structural safety of some renowned schools of the city due to earthquakes of different intensities.

million. It is one of the seven divisional cities of Bangladesh. There are about seventy schools in the city area. From them eight renowned schools were selected for the study (Figure 1). Among them there are four primary schools: Burhan Uddin Govt. Primary School, Durga Kumar Govt. Primary School, Ghashitula Govt. Primary School and Mendibag Govt. Primary School and four high schools: Dakshin Surma Nasiba Khatun Girls High School, Syed Hatim Ali Govt. High School, Sylhet Govt. Pilot High School and Sylhet Model High School.

The existing school buildings are of mainly two types: (1) reinforced concrete frame buildings with infill brick walls and (2) brick masonry buildings with reinforced concrete roofs and using cement mortar in most of the cases. These two categories fall under engineered construction in which assistance from qualified structural engineers are sought at each stage in most of the cases. Most of the buildings were constructed within last 30 years.

2. STUDY AREA

Sylhet City Corporation occupies a total area of 26.5 sq. km with a population of around 0.5

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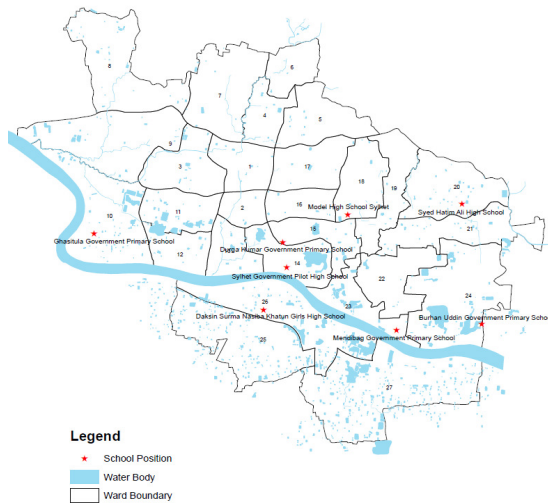


Fig. 1: Location of the Schools in Sylhet City Corporation

3. METHODOLOGY

Seismic vulnerability estimation is a complex process, which has to take into account not only the design of building but also the deterioration of the materials and damages of the building, if any. The difficulties faced in seismic vulnerability estimation of a building are manifold. There is no reliable information available for existing building stock, construction practices, in-situ strength of material and components of the building, and therefore, seismic vulnerability estimation mainly relies on set of general evaluation statements.

Engineering judgment from site visit, questionnaire survey, drawings and prevailing practices of building construction in this region was used as the methodology of the study. All possible efforts have been made to provide accurate and authoritative seismic vulnerability assessment of the buildings in the given circumstances of information provided by school administration. Qualitative and some quantitative structural assessment of the buildings are done based on visual observation and review of drawings, design details observed at site during field visit. The evaluation involves a set of checklist and identifies areas of potential weakness in the building. After analyzed, buildings are classified into different damage grades for different intensities using European Macroseismic Scale.

3.1 Identification of Vulnerability Factors

Prior to conducting a FEMA 310 Evaluation, All available documents collected and reviewed. Different Vulnerability factors associated with the particular type of building are checked with a set of appropriate checklists from FEMA 310, “Handbook

for the Seismic Evaluation of Buildings” and Indian Standard Guidelines for Seismic Evaluation and Strengthening of Existing Buildings. The basic vulnerability factors related to Building system, Lateral force resisting system, Connections, Diaphragms are evaluated based on visual inspection and review of drawings. Table 1 shows an evaluation form to identify the potential vulnerability factors (FEMA 310, 1998).

Table 1: Influences of Different Vulnerability Factors (FEMA 310)

Vulnerability Factors	
Building system	Number of storey
	Shape
	Proportion in plan
	Opening in wall
	Position of opening
	Load Path
	Adjacent buildings
	Mezzanines floors
	Deterioration of concrete
	Masonry units
	Masonry joints
	Cracks in infill walls
	Unsupported wall length
Plan irregularities	Torsion
	Diaphragm continuity
Vertical irregularities	Weak storey
	Soft storey
	Mass irregularity
	Vertical geometric irregularity
	Vertical discontinuities
Lateral load resisting system	Redundancy
	Height to thickness ratio
	Masonry lay up
	Vertical reinforcement
	Horizontal bands
	Corner stitch
	Gable band
	Diagonal bracing
Diaphragm	Diaphragm opening at walls
	Plan irregularities

	Diaphragm reinforcement at opening
Connections	Wall anchorage
	Transfer to walls
	Lateral restrainers
Geologic site	Area history
	Liquefaction
	Slope failure
Others	Non structural components

Vulnerability factors are identified by different parameters that may High, Medium, Low, N/A or not known.

3.2 Design Seismic Base Shear

The design seismic base shear is the total design lateral force at the base of a structure. The total design lateral force or seismic base shear (V_B) (BNBC, 1993) along any principal direction shall be determined by the following expression:

$$V_B = ZICW/R$$

Where,

Z = Seismic Zone Coefficient

I = Structural Importance Coefficient

R = Response Modification Coefficient

W = Seismic weights of building

C = Numerical Coefficient given by

$$C = 1.25S/T^{2/3}$$

S = Site coefficient for soil characteristics

The approximate fundamental natural period of vibration (T), in second for moment resisting frame buildings with brick infill panels may be estimated by the empirical expression:

$$T = Ct (h_n)^{3/4}$$

Ct = 0.083 for steel moment resisting frame,
= 0.073 for reinforced concrete moment resisting frames and eccentric braced steel frames,
= 0.049 for all other structural systems

h_n = Height in metres above base level

The design base shear (V_B) is distributed along the height of the building as per the following expression:

$$Q_i = V_B (W_i h_i / \sum W_i h_i)$$

Where,

Q_i = designed lateral force at floor i,

W_i = seismic weight of floor i,

h_i = height of floor i measured from base, and

n = number of storey in the building is the number of levels at which the masses are located

3.3 Calculation of Shear Stress

For Masonry; shear stress at any level for load bearing wall:

$$\tau_{wall} = (Q_i/A_w)$$

Where

Q_i = Storey shear for piers in the grid

A_w = Area of shear wall in the direction of loading.

For unreinforced masonry load bearing wall building, the average shear stress, τ_{wall} shall be less than 0.1Mpa (Rai, 2005). For Reinforced Concrete Structure; average shear stress in columns is given as (Rai, 2005):

$$\tau_{col} = (n_c/(n_c - n_f)) * (V_i/A_c) < \min \text{ of } 0.4\text{Mpa and } 0.1\sqrt{f_{ck}}$$

Where

n_c = Total no. of columns resisting lateral forces in the direction of loading

n_f = Total no. of frames in the direction of loading

A_c = Summation of the cross-section area of all columns in the storey under consideration

V_i = Maximum storey shear at storey level 'i'

f_{ck} = characteristic cube strength of concrete

3.4 Strength Check for Diaphragms

Floor and roof diaphragms should be able to resist diaphragm forces F_{px} as given below (Rai, 2005):

$$F_{px} = \frac{\sum_{i=x}^n Q_i}{\sum_{i=x}^n W_i} W_{px}$$

Where,

w_{px} = weight of roof or floor diaphragm at the level x

Q_i = w_i are lateral loads the i-th floor

w_i = seismic weights at the i-th floor

The force F_{px} determined from the above equation shall not be more than $0.75ZI_{wpx}$ and less than $0.35ZI_{wpx}$ (BNBC, 1993).

3.5 In-Plane Bending in Masonry Piers

Tension stress:

$$\sigma = -P/A + M/Z$$

Where,

M = Moment = Distributed Shear in one grid X Height of storey

A = Area = Total area of base of piers in one grid

P = Load = Total gravity load of piers in one grid

Z = Section Modulus = Sum of Section modulus of piers in one grid

Permissible tension stress for bending in the vertical direction where tension developed is normal to bed joints is 0.05 N/mm^2 (Rai, 2005).

3.6 Out-of-Plane Bending in Masonry Piers

$$\sigma = M/Z \text{ and } M = w \times L^2/10$$

Where,

M= Moment

w = Uniform dead load of wall

L = length of wall supported on cross wall

Z= Section Modulus

σ = Tension stress

Permissible tension stress for bending in the vertical direction where tension developed is 0.10 N/mm^2 (Rai, 2005).

3.7 Axial Stress Check

The axial stress due to gravity loads in column

$$\sigma = \text{Load on column } (F_o) / \text{Cross section Area of Column } (A)$$

Axial force in columns of moment frames at base due to overturning forces,

$$F_o = (2 V_B H) / (3 n_f L)$$

V_B = Base shear

n_f = Total no of frames in the direction of loading

H = Total height in meters

L = Length of the building in meters

Permissible axial stress shall be less than $0.25 f_{ck}$ (Rai, 2005).

3.8 Masonry Building Index

Following three indexes were used for old masonry building indices check (Lourenço and Roque, (2006) :

Index 1: In-plan area ratio

$$\gamma_{1,i} = A_{wi} / S$$

Index 2: Area to weight ratio

$$\gamma_{2,i} = A_{wi} / G$$

Index 3: Base shear ratio

$$\gamma_{3,i} = V_{Rd,i} / V_{Sd}$$

Where,

V_{Sd} = Base Shear

$V_{Rd,i}$ = Shear Capacity in i direction

S is the total Plan area

A_{wi} = Plan area of earthquake resistant walls in direction “i”

A_w = total in plan area of earthquake resistant walls

Table 2: Minimum recommended values for γ

Index	Allowable Value
In Plan Area ratio, γ_1	5%
Area to Weight ratio, γ_2	$1.8 \text{ m}^2/\text{MN}$
Base Shear ratio, γ_3	1

3.9 Overhang Ratio

In a typical floor plan, the area beyond the outermost frame lines on all sides is defined as the overhang area. The summation of the overhang area of each story, A_{overhang} , divided by the area of the ground story, A_{gf} , is defined as the overhang ratio.

$$\text{Overhang Ratio} = \sum A_{\text{overhang}} / A_{\text{gf}}$$

3.10 Parapet Walls

Non-structural falling hazards such as chimneys, parapets, cornices, veneers, and overhangs can pose life safety hazards if not adequately anchored to the building. The maximum height of unbraced unreinforced masonry parapet above the roof should not exceed 1.5 times the thickness of parapet wall (FEMA 310, 1998).

3.11 Height to Thickness Ratio

The bearing walls are judged for out-of-plane stability based on their height to thickness (h/t) ratios (Rai, 2005). The following allowable ratio must be considered for unreinforced masonry bearing wall buildings with stiff diaphragms.

Table 3: h/t ratio for risk zone (Z = 0.25)

Wall Type	Allowable h/t
Top storey of multi-storey building	14
First storey of multi-storey building	16
All other conditions	16

3.12 Damage Classification

The Damage grade of a building is the possible consequence to the building due to the probable earthquake shaking. The damage grade is expressed as the degree of severity of damage in a building during different earthquake intensities. Classification of damage according to the degree of severity is shown in table 4 (EMS-98, 1998). Normally, the buildings with similar structural systems and properties behave in similar pattern during the earthquakes. Hence, generalized fragility functions are available for different types of building. In Bangladesh case, fragility functions

from Nepal, India and Pakistan are utilized and verified with “European Macro-seismic Scale (EMS-98, 1998)”. Damage grades of different building typologies in different intensities of earthquakes are extracted from such fragility functions.

Table 4: Classification of damage to buildings

Damage Class	Damage Potential
Grade 1: Negligible to slight damage	Slight non-structural damage
Grade 2: Moderate damage	Slight structural damage and moderate non-structural damage
Grade 3: Substantial to heavy damage	Moderate structural damage and heavy non-structural damage
Grade 4: Very heavy damage	Heavy structural damage and very heavy non-structural damage
Grade 5: Destruction	Very heavy structural damage or collapse

Damage grades for the identified Masonry Buildings and Reinforced Concrete Ordinary Moment Resisting Frame Buildings are given below in tables 5 and 6 respectively.

The European Macroseismic Scale (EMS) is a unit to measure the intensity of earthquake in a particular area. The EMS is a qualitative measure of the actual shaking at a location during earthquake, and is assigned as Roman Capital Numerals. It ranges from I (least perceptive) to XII (most severe). The intensity scales are based on three features of shaking- perception by people and animals, performance of buildings, and changes to natural surroundings.

Table 5: Fragility of the Masonry Buildings on Brick in Cement Mortar

Shaking Intensity (EMS)		VII	VIII	IX
Damage Grades for Different Classes of Buildings	Weak	DG3	DG4	DG5
	Average	DG2	DG3	DG4
	Good	DG1	DG2	DG3

The table 5 shows that the weaker buildings of this category get damage degree of five (DG5) at intensity IX where as good buildings of this category will suffer damage degree of three (DG3) at the same intensity.

The minimum requirement of the building is to provide life safety for its occupants. It may not be obtain when the performance of building will be DG4 or DG5 during earthquake.

The table 6 shows that the weaker buildings of this category get damage degree of four (DG4) at intensity IX where as good buildings of this category will suffer damage degree of two (DG2) at the same intensity.

Table 6: Fragility of the Reinforced Concrete Ordinary Moment Resisting Frame

Shaking Intensity (EMS)		VII	VIII	IX
Damage Grades for Different Classes of Buildings	Weak	DG2	DG3	DG4
	Average	DG1	DG2	DG3
	Good	-	DG1	DG2

4. RESULTS AND DISCUSSION

Figure 2 represents the overall damage risk scenario for school buildings with respect to different intensity. Based on the assessment done above on the basis of the available information about the buildings, the architectural and structural information obtained from field visit, it is identified that the assessed buildings are likely to suffer moderate to very heavy structural damage at large earthquakes of intensity EMS IX.

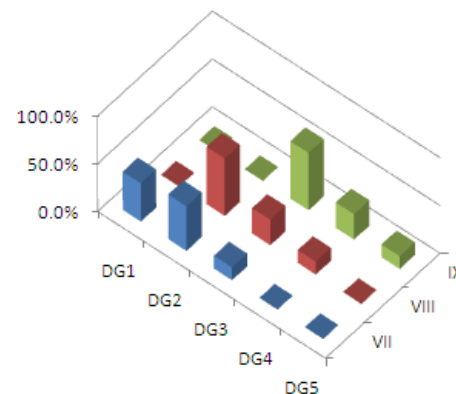


Fig. 2: Damage Risk Scenario for School in Sylhet

For intensity EMS VII, damage grade will DG1, DG2 and DG3 with 40%, 46.7% and 13.3%

buildings respectively. At intensity EMS VIII, damage grade will DG2, DG3 and DG4 with 60%, 26.7% and 13.3% buildings respectively. At intensity EMS IX, damage grade will DG3, DG4 and DG5 with 60%, 26.7% and 13.3% buildings respectively. Structural check results for 15 buildings represent in table 7. Table 8 and table 9 represent the risk percentage for masonry and reinforced concrete structure.

Table 7: Structural checks results

Structural Check	Percentage		Total Buildings
	Satisfied	Not Satisfied	
Shear Stress Check	73.3	26.7	15.0
Axial Stress check	70.0	30.0	10.0
Strength check for diaphragms	60.0	40.0	5.0
In-Plane bending	80.0	20.0	5.0
Out-of-Plane bending	40.0	60.0	5.0
Masonry index	40.0	60.0	3.0
Overhang Ratio	90.0	10.0	10.0
h/t ratio	60.0	40.0	5.0
Parapet Walls	80.0	20.0	5.0

Table 8: Damage grade for Masonry buildings in different Intensity

Intensity (EMS)	Damage Grade				
	DG1	DG2	DG3	DG4	DG5
VII	20%	40%	40%	0%	0%
VIII	0%	20%	40%	40%	0%
IX	0%	0%	20%	40%	40%

Table 9: Damage grade for Reinforced Concrete Frame buildings in different Intensity

Intensity (EMS)	Damage Grade				
	DG1	DG2	DG3	DG4	DG5
VII	50%	50%	0%	0%	0%
VIII	0%	80%	20%	0%	0%
IX	0%	0%	20%	80%	0%

5. CONCLUSIONS

From the assessment, it was evident that some school buildings in Sylhet fall under high to severe risk category. Serious lacks in maintenance of buildings were identified. Seismic retrofitting is the recommended technique to minimize the earthquake effects. Following are key recommendations from the study which could be taken into consideration for ensuring seismic safety of the surveyed buildings;

- Detail evaluation and retrofit design is recommended based on the identified weakness in this present study.
- Retrofitting of this building is feasible. However, before taking up any retrofitting program, a detailed study of building, its structural system and materials is recommended.
- In cases when the height to thickness ratio of the walls exceeds the limits of stability, rehabilitation could be done by reducing the span between the walls.
- Non-structural elements (partitions, false ceiling, furniture, equipment etc.) should be fixed properly for restricting their movement to prevent from overturning, sliding and impacting during an earthquake.

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STRENGTHENING OF SQUARE RC COLUMN USING LOW-COST SQUARE FERROCEMENT JACKETING TECHNIQUE

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This paper deals about the efficacy of low-cost square Ferrocement Jacketing technique in strengthening of square reinforced concrete column. Usually square jacketing technique can not effectively provide lateral confinement due to stress concentrations at the corners which results patterns of cracking. The study focuses on the limitations and consequent improvement of square jacketing technique. In order to achieve this, various square jacketing schemes (SL, RSL, SKSL, and SLTL) are taken into account. It is found from the test results that the benchmark specimen developed its design strength but a non-ductile mode of failure occurred when the peak load was reached. The jacketed specimen's exhibited an enhanced load carrying capacity. But only type SLTL showed excellent ductility performance. All other type of specimens showed a brittle mode of failure with enhanced load carrying capacity.

Key words: Strengthening, Column Jacketing, Ferrocement, Lateral confinement, Low-cost

1. INTRODUCTION

Strengthening of reinforced concrete structures are needed when their proper function is modified or they are used in a different manner than previously planned. It is also necessitated due to upgrading the seismic provisions of previous code suggesting better techniques. New strengthening techniques of RC structures have been suggested in recent years.

Strengthening of the reinforced concrete structures is one of the most difficult and important tasks to perform (Mieczyslaw and Tomasz, 2006). Structures must be carefully examined and analyzed their technical design in order to determine the structural conditions as well as to carry out suitable measures. The strengthening techniques applied should be effective but also a low cost one as cost effectiveness is the main concern for developing countries like Bangladesh.

Column is the structural element designed to support the vertical loads. It is the most important element of a frame-structure building providing a great portion of both vertical and lateral stability, especially in high rise building. Failure of column is very much catastrophic than failure of other elements. It may lead to total collapse of a building as it is the only structural element that transfers the load of the building to the ground (Kaish and Hassan, 2008).

Reinforced concrete columns require lateral confinement for enhanced performance against axial loads. Lateral confinement in a column is provided with lateral ties in the form of individual rings or in the form of continuous spirals running from top to bottom of the column (Rajasekaran, et. al., 2008). Lateral confinement is necessary in order to ensure large deformation under load hence ductility and provide adequate resistance capacity. In the case of a seismic event, energy dissipation allowed by a well confined concrete core can often save human lives. On the contrary, a poorly confined concrete column behaves in a brittle manner leading to sudden and catastrophic failures (Renato and Antonio). Inadequate axial load carrying capacity and axial ductility of column are the key factors among many other factors responsible for the collapse of many reinforced concrete buildings during 1999 Chi-Chi Taiwan earthquake (K. Chyuan and M. Lang, 2002). So, it is very important to develop low cost but efficient techniques to retrofit the columns to increase their axial ductility and axial load carrying capacity. However, conducted researches have shown, that the compressive strength of core concrete, ultimate concrete compressive strain and ductility of the strengthened column increased significantly if proper external confinement by means of jacketing were provided (Saadatmanesh, et. al., 1997, Masukawa, et. al., 1997, Xiao, et. al., 1999, Priestley, et. al., 1994).

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Ferrocement can be an ideal means of jacketing especially in developing countries. Material cost in this case is relatively low and thanks to its durability it spares the need for any special fire or corrosion protection. Its manufacturing is easy and needs no advanced techniques (Kazemi and Morshed, 2005). It being suitable for both pre-fabrication and self-help construction could lead Ferrocement to become one of the most inexpensive and attractive alternative techniques for strengthening and rehabilitation of existing and damage concrete columns for both axial & shear capacity.

Normally three types of jacketing technique is used to strengthen a square/rectangular RC column, such as: (a) Square/Rectangular Jacketing, (b) Circular Jacketing, (c) Octagonal Jacketing, etc. Among these types of jacketing technique, first one is the most time saving and a low cost solution because of its fabrication. Later two requires shape modification which is time consuming as well as costly with respect to the previous one. But the problem behind the square/rectangular type jacketing is, it only provides confinement pressure at the corner. It relies on arching action for confinement; thus, only a portion of the cross section is effectively confined.

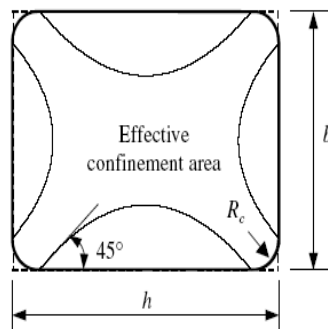


Fig. 1: Effectively confined concrete in a square/rectangular column.

In recent years researchers are trying both experimentally and analytically to overcome the drawbacks of square/rectangular jacketing technique. Investigations were carried out to reduce the stress concentration at the corner of FRP strengthened square columns. Published researches shows that, jacketing with rounded corner gives certain degrees of confinement by reducing stress concentration at corners (Al-Salloum, Y. A. 2006, Wang L., 2007).

Limited studies were reported for the similar work in case of Ferrocement strengthened RC column.

This research was carried out to overcome the drawbacks of square jacketing technique in case of Ferrocement strengthened RC column. Investigations were carried out on seventeen square columns under monotonic concentric load. Five columns were tested without any jacketing (considered as Benchmark, denoted as NJ), three with Ferrocement jacketing using single layer wire mesh (denoted as SL), two with Ferrocement jacketing using single layer wire mesh after rounding column corners (denoted as RSL), three with Ferrocement jacketing using single layer wire mesh with shear keys at the center of each faces (denoted as SKSL), three with Ferrocement jacketing using single layer wire mesh with two extra layer mesh at each corner (denoted as SLTL).

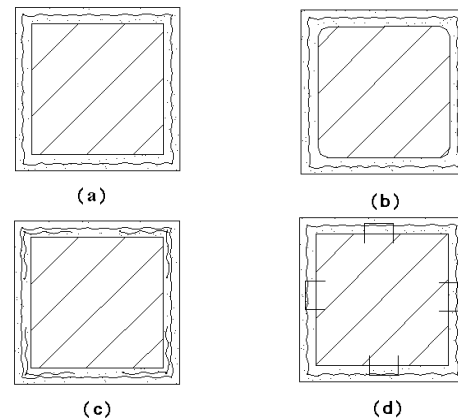


Fig. 2: Various jacketing schemes (a) SL, (b) RSL, (c) SLTL, (d) SKSL.

Experimental results and mode of failure confirms that, Type RSL, SLTL and SKSL jacketing scheme significantly reduces the stress concentrations at the corner which leads to enhanced carrying capacity.

2. EXPERIMENTAL STUDY

Reinforced concrete column specimens for the experimental study were of size 100 mm X 100 mm and 600 mm long, reinforced with 4-8 mm Grade 60 (414 MPa) longitudinal bar. Lateral reinforcement was providing by 6 mm Grade 60 (414 MPa) tie spaced at 100 mm on centre. The mix design for the concrete was determined for sand to aggregate volume ratio = 0.55, cement content = 360 kg/m³, air content = 2% and W/C=0.45. Coarse aggregate used for making concrete was 12 mm downgraded stone chips. The fineness modulus (FM) and specific gravity of sand used in this investigation were 2.7 and 2.61 respectively. Normal tap water was used as mixing water. Saturated and surface dry sand and coarse aggregate were used for making the concrete. After

mixing, the workability of concrete was measured by a slump cone. Column specimens were made and demoulded after one day of casting. Later the specimens were cured continuously under water.

2.1 Ferrocement jacketed specimen

Ferrocement jacketing was done after 7 days of column casting. All strengthened columns were jacketed by 12 mm Ferrocement jacket with 20 gages GI wire mesh of 12 mm opening. To avoid direct compressive load on Ferrocement jacket, 5 mm clear gap was provided at the top and bottom of column. Both the jacketed and non-jacketed specimens were cured for 28 days from the date of casting. Fig. 3 and Table 1 shows the details of both non-jacketed and jacketed RC column specimens.

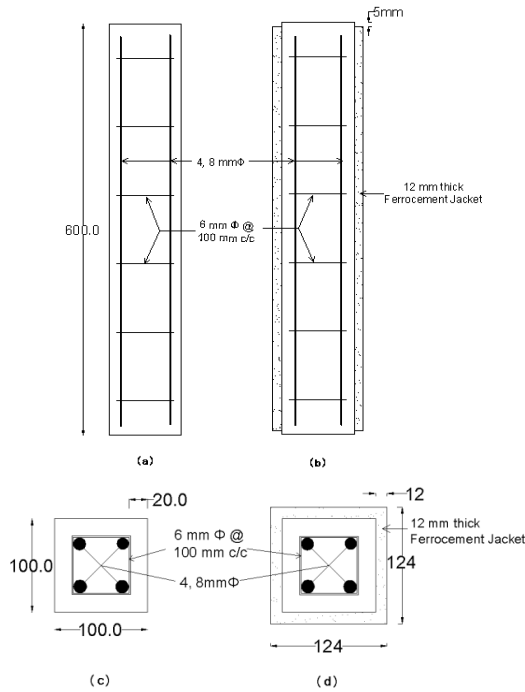


Fig. 3: Details of column, (a) Long section of non-jacketed column, (b) Long section of jacketed column, (c) Cross-section of non-jacketed column, (d) Cross section of jacketed column.

Table 1: Specimen details

Specimen	Height (mm)	Cross-section (mm)	Long Bar	Tie Bar	Jacket Thickness (mm)
NJ	600	100 X 100	4-Φ 8	6 mm @ 100 mm	-
1L					12 mm
R1L					12 mm
SK1L					12 mm
3L					12 mm

2.2 Test setup

After curing, all specimens were tested for monotonically increasing concentric load by a Compression Testing Machine of capacity 2000 kN. Load was applied to the top of the concrete column. The axial deformation of column specimens were measured by a strain measurement setup with a dial gauge.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Experimental results of tested specimens are summarized in Table 2. The increment in average ultimate load carrying capacity and average axial deformation of jacketed specimen are also shown in the table. The average load-axial deformation responses for the experimental columns are shown in Fig. 4. It can be seen from the Fig. 4, all types of specimen exhibits a brittle mode of failure except type SLTL. The ultimate loads of all the tested specimens are shown in Fig. 5. The percent increment in ultimate loads and ultimate axial deformations are shown in Fig. 6 and Fig. 7 respectively. The failure modes of the specimens after the tests are shown in Fig. 8.

Table 2: Ultimate axial load and deformation of tested specimens.

Specimen	Average Ultimate Load (kN)	% Increment of Ultimate Load (kN)	Avg. Ultimate Axial Deformation (mm)	% Increment of Ultimate Axial Deformation
NJ	268.8	0	2.68	0
SL	337.67	26	3.37	25.75
RSL	360.5	34	3.85	43.65
SKSL	304.33	13	3.52	31.34
SLTL	402	50	5.34	99.25

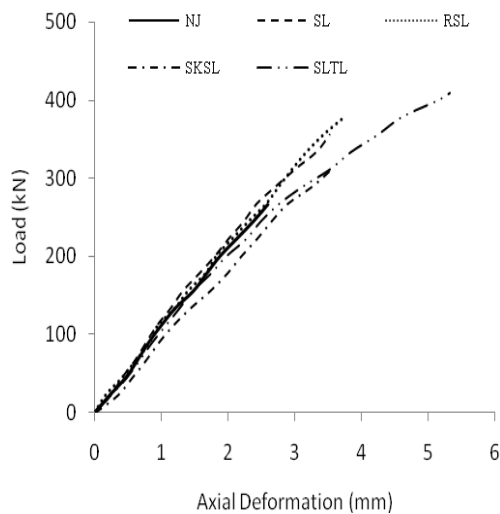


Fig. 4: Load-Axial deformation relationship.

3.1 Ultimate load response

The axial load carrying capacity of all jacketed specimens is increased than the non-jacketed specimens. Type SKSL specimen shows lower carrying capacity than type SL specimen though both types of specimens contain same layer of wire mesh. This may be due to the nailing of shear keys into the column that weakens the column. Type RSL specimen shows higher carrying capacity than type SL specimen due to rounding the corners. Type SLTL specimen shows the highest carrying capacity than all types of specimens as this specimen has two extra layer of wire mesh at each corner. This specimen shows fifty percent increased carrying capacity than the non-jacketed specimen.

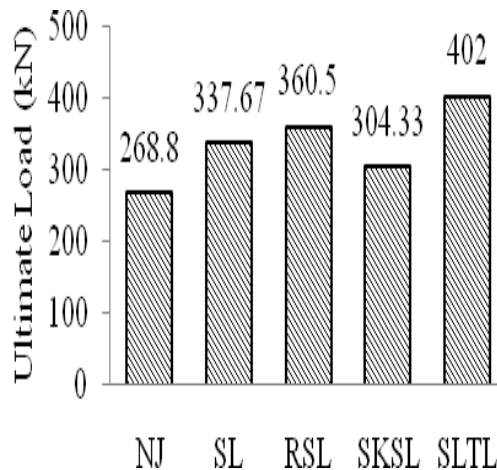


Fig. 5: Ultimate load of specimens

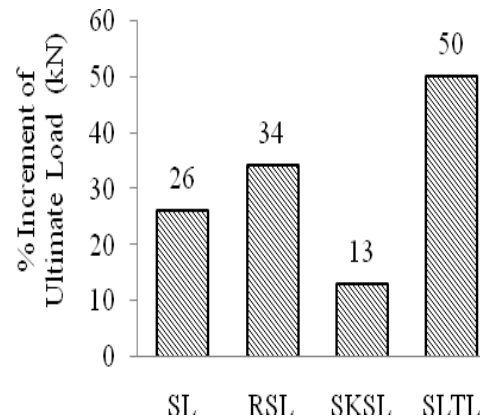


Fig. 6: Percent Increment of ultimate load

3.2 Axial deformation response

All jacketed specimens show higher axial deformation, i.e. axial ductility at ultimate load level. Type SLTL shows the highest axial deformation at failure. The increment in axial deformation of this type of specimen is 99.25% than non-jacketed specimen. This value for type SL, RSL and SKSL specimens are 25.75%, 43.65% and 31.34% respectively.

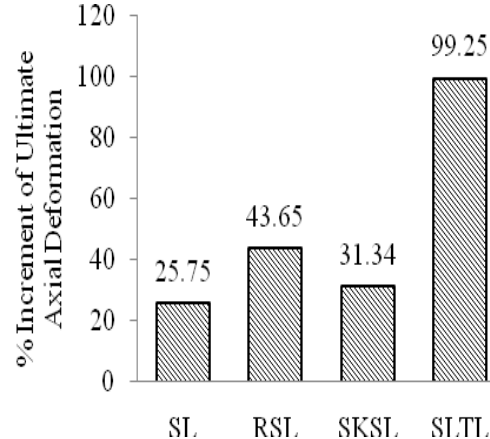


Fig. 7: Percent Increment of ultimate axial deformation

3.3 Failure mode

Failure mode of non-jacketed column (Type NJ) does not match with actual building column failure mode. Shear failure of concrete occurred at the top of the column due to load applied at the top. Whereas bursting failure occurs in actual building column. Failure mode of all the jacketed column is as it was expected. In type SL specimen, cracking of corner occurs due to stress concentration at corners. In type RSL specimens, cracking occurs at

the middle of each face as rounding the corner reduces the stress concentration at corners. For type SKSL specimen, cracking occurs at both the corner and the middle of each face. Shear keys were used in this type of specimens make the middle of each face effective stress transfer zone. For type SLTL specimen, cracking occurs at the middle of each face only. No corner cracking is occurred in this type of specimen as extra two layer wire mesh strengthens the corner.



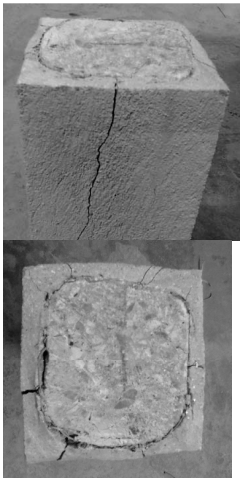
NJ



SL

NJ

SL



RSL

RSL



SKSL

SKSL



SLTL

SLTL

Fig. 8: Final appearance of tested specimens.

4. CONCLUSION

This paper investigates the effectiveness of low-cost square Ferrocement jacketing technique in strengthening of square building columns. Results

from experimental studies confirm that, square Ferrocement jacketing technique could be used effectively, if proper jacketing scheme is introduced. This is also clear from the experimental results that SLTL type jacketing scheme is the most effective jacketing scheme among other types used in the study. However, further research on full-scale columns is needed to warrant their application in strengthening of square building columns with high axial load risk.

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TRAND OF URBAN HEAT ISLAND (UHI) IN SYLHET CITY, BANGLADESH

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Abstract

Until recently, Sylhet City was known as the “green city” of Bangladesh due to its presence of green trees and hilly areas. Currently the city is known for its business boom; being one of the richest cities in Bangladesh, with new investments of hotels, shopping malls and luxury housing estates, brought mainly by expatriates living all over the world. METO (Metropolitan Environmental Temperature Observation) system was used to clarify the detailed temporal and spatial patterns of Urban Heat Island (UHI) in Sylhet City and meteorological equipments were installed on the rooftop of twelve buildings in the city comprising its rural surroundings as meteorological data acquisition stations from June to August, 2010. Analyzing the horizontal and vertical temperatures recorded in these stations, UHI indices of 1° - 3° C has been found for the City. The high-rise infrastructures and widespread asphalt roads comprises a wide range of dry and dark surfaces which absorbs rather than reflects more sunlight during day time and radiate heat after sunset resulting the temperature to rise. During the night, the warmer area has been appeared in the highly urbanized centers of the city in compare to its rural surroundings. Obviously, unplanned urbanization is the major cause of UHI in Sylhet City. The impact of UHI on energy use and public health was also highlighted. Finally the paper suggests some guidelines to mitigate the UHI effects in the city.

Keywords

UHI index, temperature, unplanned urbanization, energy use, green building

1. Introduction

The urban heat island phenomenon was first discovered in the early 1800s in London. As urban areas develop, changes occur in their landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist become impermeable and dry. These changes cause urban regions to become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape [Climate Change Cell (CCC). (2009a)].

So far, most of the Urban Heat Island (UHI) phenomena have been detected in high and mid-latitude mega cities of the northern hemisphere. But many of the cities of

developing countries are also associated with the effects of Urban Heat Island (UHI) where the urbanization is in progress.

This study selected Sylhet City, being urbanized with an alarming rate for one of the richest cities in Bangladesh, with new investments of hotels, shopping malls and luxury housing estates, brought mainly by expatriates living all over the world. The study aims to explain, first, the relationship between land-use changes and surface temperature to show clearly the horizontal and vertical distribution changes of daily temperature which are being altered with urbanization in Sylhet City.

2. Methodology

2.1 Horizontal Distribution Change of Daily Temperature

The study has been used METO (Metropolitan Environmental Temperature Observation) system to clarify the detailed temporal and spatial patterns of Urban Heat Island (UHI) in Sylhet City. Meteorological equipments were installed on the rooftop of 12 buildings as meteorological data

acquisition stations from June to August, 2010. These 12 stations were installed in and out of Sylhet City to show clearly the horizontal distribution change of daily temperature. Temperature data was collected daily at 6 am, 12 pm, 6 pm and 12 am from June to August, 2010 in each of the stations.

2.2 Vertical Temperature Profile

For acquisition of vertical temperature profile and surface temperature by different land cover 8 high-rise buildings (Station 13 to Station 20) were selected and air temperature in each of 10 feet height was recorded at 5pm to 8pm in an interval of 1 hour.

2.3 Annual Mean, Maximum and Minimum Temperature

An assessment of annual mean, maximum and minimum temperature of Sylhet using weather station data operated by Bangladesh Meteorological Department (BMD) and Climate Change Cell (CCC) shows

3. Results

3.1 Sylhet Climate

Temperature, rainfall, wind pattern and solar radiation mainly characterize the climate systems and determine the seasons. Brammer (2002) classified Bangladesh into four distinct climatic seasons. These are: (1) Pre-monsoon (March to May) with high temperatures and evaporation rates (2) Monsoon (June to September) with high intensity of rainfall occurrence (3) Post-monsoon (October to November) characterized as hot and humid period with decreasing rainfall (4) Dry or winter season

continuous warming of the region since 1961.

2.4 Application of Global Information System (GIS) and Remote Sensing (RS)

The difference of surface temperature between urban infrastructures (buildings, roads) and vegetation area was determined using GIS and RS. A thermo-graphic camera system can remotely measure the surface temperature of the materials through infrared radiation. It acquires the distribution of surface temperature of the materials, easily and instantly.

(December to February) portrayed as the coolest, driest and sunniest period of the year.

The climate of Sylhet is tropical monsoon with a predominantly hot and humid summer and a relatively cool winter. The city is within the monsoon climatic zone, with annual average highest temperatures of 31°C in June-August and average lowest temperature of 10°C in January (Tawhidul-2010). Rashid (1991) provides detail descriptions about the pattern of climate variables of Bangladesh and

characterizes the Sylhet climate as milder summer, heavy rainfall and cloudy cool winter.

3.2 Assessment of Temperature Fluctuations

Assessing meteorological data of 50 years (1960-2009), collected from the Sylhet Station of Bangladesh Meteorological Department (BMD) and Climate Change Cell (CCC), the average maximum and average minimum temperature from January to December has been determined (Figure - 3.1). Furthermore, a climate line has been determined by calculating the mean temperature for 50 years from 1960 to 2009.

Then yearly temperature deviations from that climate line have been determined.

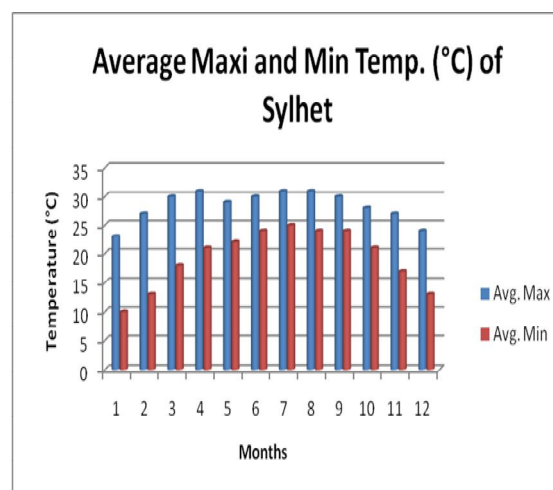


Figure 3.1: Average maxi and average min temperature from January to December

Table 3.1: Average maximum and minimum temperature fluctuations from 1960 to 2009

Season	Fluctuations	Climate Line ($^{\circ}\text{C}$)	Warmest Year (deviation from climate line) ($^{\circ}\text{C}$)	Cooltest Year (deviation from climate line) ($^{\circ}\text{C}$)
Winter Average Maximum (December. to January)	Increase	25.78	1997 (+1.97)	1964 (-1.08)
Winter Average Minimum (December. to January)	Increase	13.32	2002 (+1.38)	1962 (-1.27)
Summer Average Maximum (April to May)	No Change	30.98	1960 (+3.27)	1977 (-3.23)
Winter Average Minimum (April to May)	Slight increase	22.14	1979 (+1.11)	1986 (-1.89)

However, International Panel on Climate Change (IPCC) states in their Third (2001) and Fourth Assessment (2007) Reports that by 2030, a 0.7°C temperature rise in monsoon season and a 1.3°C rise in the winter season might take place in this region.

3.3 Results of Fixed Points Observation

Heat islands occur on the surface and in the atmosphere. On a hot, sunny summer day, the sun can heat dry, exposed urban surfaces, such as roofs and pavement, hotter than the air while shaded or moist surfaces—often in more rural surroundings—remain close to air temperatures. Surface urban heat islands are typically present day and night, but tend to be strongest during the day when the sun is shining. In contrast, atmospheric urban heat islands are often weak during the late morning and throughout the day and become more pronounced after sunset due to the slow release of heat from urban infrastructure.

In this study METO (Metropolitan Environmental Temperature Observation) system was used and meteorological equipments were installed on the rooftop of twelve buildings in the city (urbanized area)

comprising its rural surroundings (suburban area) as meteorological data acquisition stations from June to August, 2010. Station-01 to Station-05 is located in sub-urban area and Station-06 to Station-12 is located in the centre of build-up, urbanized area.

It is found that the Urban Heat Island (UHI) phenomena was clearly appeared in the urbanized area after sunset and kept through the night. Because the potential heat capacity in build-up area is larger than sub-urban, and heat from the building materials would be released through the night. Also a little or zero Urban Heat Island Intensity (UHII) was found in the daytime. The diurnal UHII was 0.3°C at 17:30 pm, because of lower solar radiation of Station -10 than Station-01 by sky view factor and air pollution. The nocturnal UHII was more than 2.5°C in the midnight. The maximum of UHII was 2.5°C . The daily extremes, 3.1°C appeared between Station-01 and Station-11 on July 14, 2010 at 12:00 am.

Figure 3.2 illustrates the average maximum temperature of 12 stations at different period of a day. However, Figure 3.3 shows the temperature profile of 12 stations on July 28, 2010 (summer) after sunset. Figure 3.4 shows the Urban Heat Island Intensity

(UHII) of fine day between Station-01 and Station-11 in July, 2010.

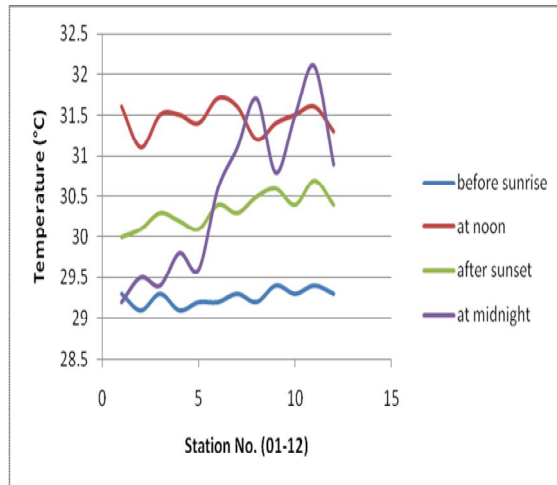


Figure 3.2: Average maximum temperature of 12 stations at different periods of a day

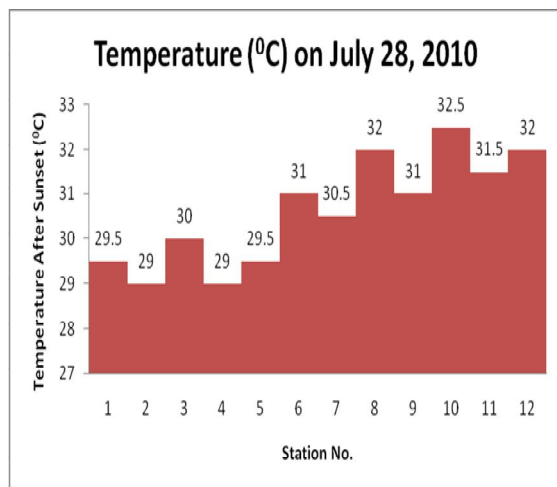


Figure 3.3: Temperature profile of 12 stations on July 28, 2010 (summer) after sunset

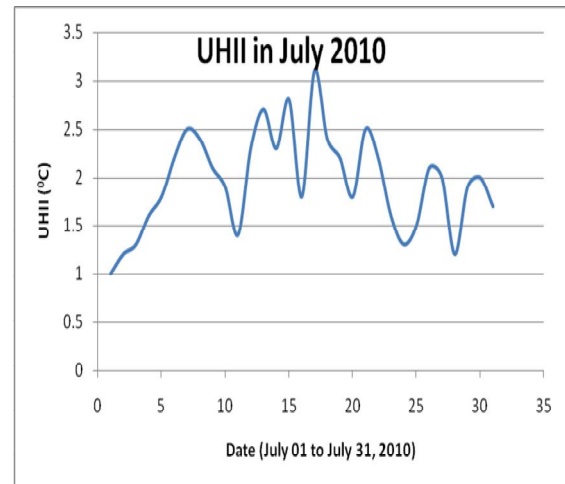


Figure 3.4: Urban Heat Island Intensity (UHII) between Station-01 and Station-11 in July, 2010 after sunset.

Thus, it is very interesting that UHII of Sylhet appears larger at night than in the day and the daily maximum of UHII was around 3.0°C, diurnal temperature in city center are not so much different from suburban by sky view factor and air pollution.

3.5 Thermo Graphic Observations

With process of urbanization, the city growth alters the urban fabric by man-made asphalt roads and tar roofs and other features substituting forest growth. These surfaces absorb-rather than reflect- the sun's heat, causing surface temperatures and overall ambient temperatures to rise, resulting the Sylhet City as an Urban Heat Island.

Thermal images detected by thermo-graphic camera according to different types of surface materials shown in Figure-3.7. The surface temperature of roads, buildings were more than 35⁰C. Especially, the surface temperature of the roofs was more than 40⁰C. Otherwise, vegetations were around 28⁰C.

4. Discussion

The study reveals that that the development of the Sylhet City is growing at an alarming rate without adequate planning. New skyscrapers are being built up all over the city. Moreover, the asphalt roads are also being elongated and expanded with the

5. Conclusion

Whoever has experienced the sweltering summer days of Sylhet City will agree that average temperature of the City has increased over the decades. The scorching heat during daytime and hot, see thing nights coupled with load shedding are the bane of the city dweller's life. And it is the unique feature of the urban climate known as Urban Heat Island (UHI) Effect why the temperature is so high in Sylhet.

Approximately half of the world's population currently lives in cities, and this value is expected to increase to 61% by

2 buildings, painted with brown and white were observed and it was found the surface temperature of these two was 33⁰C (brown) and 31⁰C (white). The reason why the surface temperature of 2 buildings were different was that the albedo of white paint is higher than brown.

increase in population and development pattern. Hence, the city comprises a wide range of dry and dark surfaces which absorb rather than reflect more sunlight, resulting in an Urban Heat Island.

2030 (U.S. Environmental Protection Agency -2009). The high rate of urbanization, in this regards, means that increasing numbers of people will be exposed to impacts resulting from heat islands in the future. Most policymakers and environmental activists concerned with the threat of global warming urge two strategies to combat it; cutting the use of fossil fuels and planting trees, which sequester carbon dioxide in their wood. The planting of trees in cities does both of these, and is far more effective than planting trees in forests.

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ULTIMATE LOAD CAPACITY OF AXIALLY LOADED VERTICAL PILES IN MID-SOUTHERN AND MID-NORTHERN DEPOSITS OF BANGLADESH

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Accurate evaluation of ultimate load capacity of pile is extremely complex and difficult. Capacity of pile is derived from the resistance developed by the soils surrounding the shaft and underneath the tip of the pile. Soil, by nature, inherits/exhibits non-homogeneity, anisotropy and in-elasticity. Prediction of accurate engineering properties of the surrounding particulate three-phase soil matrix becomes even more complex due to installation of piles. Thus, available semi-empirical/empirical methods for determination of ultimate resistance of pile pose un-reliability and, thereby, may significantly affect safety and economy of a project. Therefore, although expensive, conduction of limited number of full-scale pile load tests becomes inevitable prior to commencement of construction. Comparison of the actual capacity determined by load tests with predicted one may necessitate revision of pile design. This study aims at bridging this gap between prediction and reality. Six pile load tests performed in two different parts of Bangladesh were analyzed and compared with the capacities evaluated using static analysis incorporating various empirical methods of obtaining pile design parameters. With the aid of the comparative study, the authors' primary objective is carried out towards the estimation of the representative values of design parameters appropriate for local conditions within the geo-hydrologic environment of alluvial deposition of the Bengal basin.

Key words: Pile Capacity; Driven Pile; Shaft Friction; End Bearing; Pile Load Test.

1. INTRODUCTION

Piles are relatively long and generally slender structural foundation members that transmit superstructure loads to deep soil layers. In geotechnical engineering, piles usually serve as foundations when soil conditions are not suitable for the use of shallow foundations. Therefore, safety and stability of pile supported structures depend on the behavior of piles. Pile behavior is significantly dependent on the properties of soils surrounding and underlying the shaft and tip/end of the pile, respectively. Accurate evaluation of the properties of these soils is quite complex. Generally, soil is non-homogeneous, inelastic and anisotropic. Again, the behavior of these soils changes significantly during the driving process, in case of driven piles, depending upon the driving method, energy required, overburden pressure, pile geometry etc. As the dissipation of excess pore water pressure generated during the driving process is significantly affected by hydro-geologic condition and time, the properties of these soils become also time and hydro-geology dependent. Consequently, determination of the exact capacity of pile becomes almost impossible.

The prediction/estimation of load carrying capacity of driven pile can be achieved using different methods such as pile load test, dynamic analysis and static analysis based on soil properties from field and laboratory tests, and static analysis utilizing the results of in situ tests such as cone penetration. Due to the uncertainties associated with pile design, available semi-empirical/empirical methods for determination of ultimate resistance of pile may pose un-reliability and, thereby, may significantly affect safety and economy of a project. Therefore, although expensive, conduction of limited number of full-scale pile load tests becomes inevitable prior to commencement of construction. However, pile load tests are a verification tool for the pile design and they cannot be the substitute for the engineering analysis of the pile behavior. Comparison of the actual capacity determined by load tests with predicted one may necessitate revision of pile design. This study aims at bridging this gap between prediction and reality. The research effort is focused on the applicability of the most suitable pile design parameters for predicting the axial load carrying capacity of piles driven into the geo-hydrologic, cohesive and granulometric

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matrix of dominantly prevailing alluvial deposits of the Bengal basin.

This study considers the carrying capacity of driven piles only, having same size but different lengths. Data acquired includes geotechnical sub-surface investigation reports and six pile load test reports from three different project sites within the Bengal basin. Six pile load tests were performed on test piles (PTP1, PTP2, NTP1, NTP2, JTP1 and JTP2), two at each site, located at three different sites in three districts (Jhalokathi, Pirojpur and Netrokona) of Bangladesh. Hunt (1976) grouped various land systems of the country into six soils units. Accordingly, deposits of Jhalokathi and Pirojpur sites located in the mid-southern portion of the country are generally of Estuarine and Tidal Deposits type, whereas deposits of Netrokona site located in the mid-northern portion of the country straddles the boundary between Alluvial Floodplain Deposits and Depression Deposits type.

Geotechnical subsurface exploration revealed the subsurface stratigraphic condition at the site and the soils' parameter to aid in the estimation/evaluation of theoretical pile capacity, whereas interpreted results from the pile load test reports gave the actual (to a greater extent) capacity of the piles. This study aims to provide guidelines regarding the pile design parameters most appropriate or suitable for local conditions and the best procedure for estimating ultimate capacity from pile load tests in country's major alluvial deposit.

2. PILE CAPACITY FROM THEORETICAL ANALYSIS

Various field and laboratory tests have been carried out during the geotechnical investigations for evaluation of subsurface conditions and the pile design parameters. The subsurface soils of all the sites mostly consists of deposition of cohesionless non-plastic silts underlain with silty sand except at Pirojpur site where a cohesive low to medium plastic lean clay layer having thickness varying from 2.3 to 8.4 m is underlain with non-plastic silt and then silty sand up to the boring termination depth.

A site-specific correlation between SPT-N value and undrained cohesion has been developed for the cohesive deposit encountered at the Pirojpur site (Shamima et al, 2010). SPT-N values for cohesionless deposits have been corrected for overburden pressure according to Lio & Whitman (1986). Subsequently, in case of silt and very fine sand or silty sand, the overburden-corrected SPT-N values have further been corrected for dilatancy.

The correlation $\phi = 15 + \text{SQRT}(N/60)$, is used to determine angle of internal friction(ϕ) for cohesionless soils. For shaft friction of pile in cohesionless deposit, co-efficient of lateral earth pressure, K_s ($=1.5$) and angle of friction at the pile-soil interface, δ ($= 0.8\phi$) are used as recommended by Broms (1966).

A great deal of variation is found in the values of end bearing capacity factor, N_q for deep foundation provided by different researches. Theoretical pile end bearing capacity is estimated using the N_q - ϕ correlations provided by Terzaghi (1943), Berezantzev (1961) and Meyerhof (1953). Theoretical pile capacities obtained accordingly are summarized in Table 1.

3. PILE CAPACITY FROM LOAD TESTS

Six load tests were performed on piles having same x-sectional dimensions (300 mm x 300 mm) and lengths varying from 12.2 m to 18.3 m. The ASTM D 1143 test procedure was followed, in general, for pile load tests conducted on test piles designated as PTP1, PTP2, NTP1, NTP2, JTP1 and JTP2. The results of load tests are summarized in Table 2. Load-settlement curves were generated, as shown in Figure 1, in order to interpret the ultimate load carrying capacity of respective pile. The load test data are analyzed using ten interpretation methods in order to estimate the ultimate load carrying capacity of each pile. The ultimate loads determined from pile load tests using different interpretation methods are summarized in Table 3. This table implies that:

- Ultimate pile capacities obtained using all the interpretation methods are close to each other for all the test piles.

- Ultimate pile capacities obtained using Terzaghi method, method recommended by the Indian Code of Practice, Double Tangent Method on Arithmetic Plot, Double Tangent Method on Logarithmic Plot and Davisson's Method are even closer to each other for all the test piles.

- Ultimate pile capacities, having even the least length, obtained using all the methods are the highest at the Netrokona site that straddles the boundary between Alluvial Floodplain Deposits and Depression Deposits are the highest of all the test piles.

- Ultimate pile capacity (Q_u) for a particular load test can be estimated as the average of all the capacities obtained using all ten interpretation methods as mentioned in Table 3 and in this study the capacities, thus estimated, of six load tests

PTP1, PTP2, NTP1, NTP2, JTP1 and JTP2 are respectively.
estimated as 73, 64, 100, 98, 55 and 70 Ton,

Table 1: Summary of theoretical pile capacity (Q_u) using different method

Sl. No.	Methods	PTP1	PTP2	NTP1	NTP2	JTP1	JTP2
		$Q_u(\text{ton})$	$Q_u(\text{ton})$	$Q_u(\text{ton})$	$Q_u(\text{ton})$	$Q_u(\text{ton})$	$Q_u(\text{ton})$
1	Berezantzeb(1961)	85	75	109	95	57	58
2	Meyerhof(1953)	164	120	236	184	92	95
3	Terzaghi(1943)	75	70	92	85	53	54

Table 2: Summary of pile load test results

Sl. No.	Test Pile No.	Pile Dimension		Applied Load (maximum)	Total Settlement	Net Settlement
		Length m	X-Sectional Dimension mm			
1	PTP1	13.7	300 x 300	68.98	31.9	18.3
2	PTP2	13.7	300 x 300	79.56	30.175	15.6
3	NTP1	12.2	300 x 300	102.15	31.425	15.225
4	NTP2	12.2	300 x 300	102.42	22.37	15.07
5	JTP1	18.3	300 x 300	60.51	29.835	21.4
6	JTP2	18.3	300 x 300	79.56	31.3	19.46

Table 3: Summary of Ultimate loads (Q_u) determined from pile load test results using different methods

Sl. No.	Methods	PTP1	PTP2	NTP1	NTP2	JTP1	JTP2
		$Q_u(\text{ton})$	$Q_u(\text{ton})$	$Q_u(\text{ton})$	$Q_u(\text{ton})$	$Q_u(\text{ton})$	$Q_u(\text{ton})$
1	Terzaghi Method(British Standard Code)	78	66	100	102	58	76
2	Indian Standard Code of Practice	81	71	118	111	68	68
3	Double Tangent Method on an Arithmetic Plot	62	58	97	95	47	64
4	Double Tangent Method on Logarithmic Plot	80	61	88	91	50	69
5	Maximum Curvature Method	69	61	99	102	50	69
6	The Hansen 80% Criterion	86	76	103	105	65	80
7	Davissan's Method	78	68	102	102	57	74
8	Butler and Hoy's Method	62	56	90	86	50	61
9	Mzurkiewicz Method	74	66	109	91	52	77
10	DeBeer et al. (1979)	60	56	98	100	50	63

Table 4: Summary of ultimate pile capacity (Q_u) from pile load test and theoretical analysis

Sl. No.	Test Pile No.	Load test	Meyerhof(1953)	Berezantzeb(1961)	Terzaghi(1943)
		$Q_{u(avg)}$ (ton)	Q_u (ton)	Q_u (ton)	Q_u (ton)
1	PTP1	73	164	85	75
2	PTP2	64	120	75	70
3	NTP1	100	236	109	92
4	NTP2	98	184	95	85
5	JTP1	55	92	57	53
6	JTP2	70	95	58	54

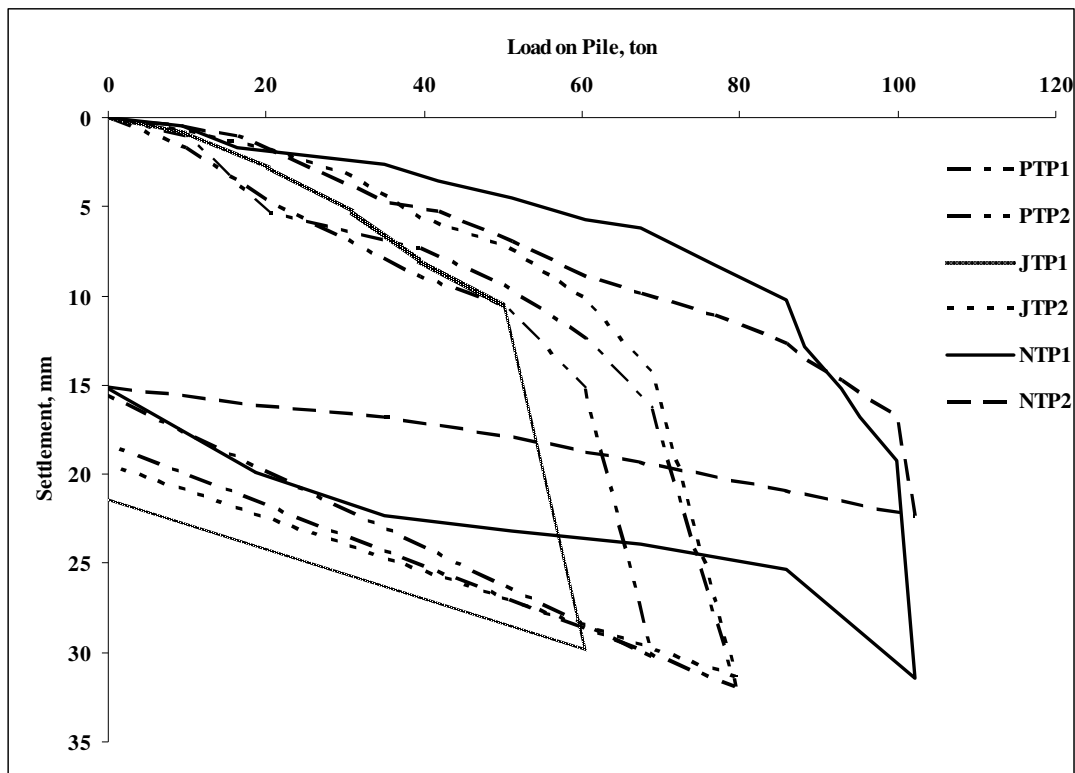


Fig 1. Load-settlement graphs for six pile load test

4. SUMMARY AND CONCLUSIONS

- Site specific correlation between SPT-N value and undrained cohesion can be generated to simulate local geological conditions in order to evaluate representative undrained cohesion for cohesive deposits.
- The ultimate loads determined from load/settlement curves of load tests by methods mentioned in Table 3 are in close compliance with each other.
- The best method of estimating ultimate load from pile load tests results is to use the average value of ultimate loads obtained from five methods (i.e., Terzaghi method, method recommended by the Indian Code of Practice, Double Tangent Method on Arithmetic Plot, Double Tangent Method on Logarithmic Plot and Davisson's Method).
- Theoretical pile capacities as determined using N_q - ϕ correlations suggested by Meyerhof (1953) are much higher than the capacities interpreted from pile load test results as shown in Table 4.

- Theoretical pile capacities as determined using N_q - ϕ correlations suggested by Terzaghi (1943) are conservative in comparison with the capacities interpreted from pile load test results.
- Theoretical pile capacities as determined using N_q - ϕ correlations suggested by Berezantsev (1961) are in very close compliance with the capacities interpreted from pile load test results and can be used as most suitable one to incorporate local geological conditions.

The above conclusions are based on load test data on six test piles only. There is a need to include several more pile load tests data in order to validate the above conclusions and express them in more general terms.

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URBAN HEAT ISLAND (UHI) DRIFT IN RAJSHAHI METROPOLITAN CITY

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ABSTRACT

Rajshahi Metropolitan City is being raised to high due to rural-urban migration and high population growth rate where migration is a result of the 'pull factors' of urban settlements-such as perceived job opportunities, and better infrastructure and housing-in addition to 'push factors' from rural areas such as shortage of land and declining returns from agriculture. The process of urbanization in Rajshahi Metropolitan City is being done through a much unplanned manner when the city growth alters the urban fabric by man-made asphalt roads and tar roofs and other features substituting forest growth. These surfaces absorb rather than reflect the sun's heat, causing surface temperatures and overall ambient temperatures to rise in compare to its rural surroundings, resulting the city as an Urban Heat Island (UHI). The study clarified the detailed temporal and spatial patterns of urban heat islands in Rajshahi Metropolitan City where METOS (Metropolitan Environmental Temperature Observation System) was used and installed meteorological equipments on the rooftop of twelve buildings in the city comprising its rural surroundings as meteorological data acquisition stations from July 01 to August 01, 2010. Analyzing the horizontal and vertical temperatures recorded in this stations, UHI indices of 2⁰-3⁰C has been found in Rajshahi Metropolitan City. Finally relevant mitigation measures to get rid of the UHI effects in the city is recommended with the subsequent conclusion.

KEYWORDS

UHI index, settlement, infrastructures, energy use, cooled roof

INTRODUCTION

A UHI is a metropolitan area which is significantly warmer than its surrounding rural areas. Heat islands of cities located in the mid latitudes usually are strongest in the summer or winter seasons. In tropical climates, the dry season may favor large heat island magnitudes. The temperature difference usually is larger at night than during the daytime and larger in winter than in summer, and is most apparent when winds are weak. The main cause of the urban heat island is modification of the land surface by urban development; waste heat generated by energy usage is a secondary contributor. Since we have covered most of the land surface of Rajshahi city with concrete and asphalt pavements, the city has become an oven with millions of people in it. Though the UHI air temperature is generally most apparent at night, urban heat islands exhibit significant and somewhat paradoxical diurnal behavior. The UHI air temperature is large at night and small during the day, while the opposite is true for the UHI surface temperature. Throughout the daytime, particularly when the skies are free of clouds, urban surfaces are warmed by the absorption of solar radiation. As described above, the surfaces in the urban areas tend to warm faster than those of the

surrounding rural areas. By virtue of their high heat capacities, these urban surfaces act as a giant reservoir of heat energy. (For example, concrete can hold roughly 2000 times as much heat as an equivalent volume of air). This daytime heating creates convective winds that minimize the surface temperature to a great extent. At night, however, the situation reverses. The absence of solar heating causes the atmospheric convection to decrease. This traps the urban air near the surface, and allows it to heat from the still-warm urban surfaces, forming the nighttime UHI air temperature.

Annual mean temperatures in central Rajshahi have increased 2-3 degrees Celsius for the last 50 years, which is around five times as fast as that of global warming. In summer, although daily minimum temperatures might be highest in central Rajshahi as a typical heat island pattern, daily maximum temperatures often appears in the southwestern residential area of Rajshahi Metropolitan City. We settled twelve monitoring station called METOS in Rajshahi Metropolitan area since July, 2010 with own finance. Only collected temperature data were acquired and analyzed. Here we show some results of

acquired data analysis in the last summer season.

SIGNIFICANCE

UHIs have the latent to directly influence the health and welfare of the urbanites. Compared to rural areas, cities experience higher rates of heat-related illness and death. The heat island effect is one factor among several that can raise summertime temperatures to levels that pose a threat to public health. The nighttime effect of UHIs can be particularly harmful during a heat wave, as it deprives urban residents of the cool relief found in rural areas during the night. Furthermore, the poor air quality that results from this increased energy usage can affect our health, aggravating asthma and other respiratory illnesses. People in Dhaka, especially the poor, suffer from various acute respiratory diseases during summer. In 1995, a heat wave in Chicago illustrated why excessive temperature and heat islands

METHODOLOGY

There are two parts to this study. The first part is data collection system and secondly collected data adjustments analysis. The study has been used METOS (Metropolitan Environmental Temperature Observation

are of concern. This episode of unusually hot weather resulted in the deaths of over 700 people.

Another consequence of urban heat islands is the increased energy required for air conditioning and refrigeration in cities that are in comparatively hot climates. The Heat Island Group, a research and advocacy organization that works to educate the public and policymakers about the heat island effect, estimates that the city of Los Angeles spends about \$100 million per year in extra energy costs to offset its heat island effect. Urban heat islands also can impact local weather, altering local wind patterns, spurring the development of clouds and fog, increasing the number of lightning strikes, and influencing the rates of precipitation as we are experiencing now in Dhaka. Sometimes it also affects growth of the trees. Using satellite images, researchers discovered that plants take more time to grow in UHIs than the rural areas.

System) to clarify the detailed temporal and spatial patterns of Urban Heat Island (UHI) in Rjshahi City. Meteorological equipments were installed on the rooftop of 12 buildings as meteorological data acquisition stations

from July 13 to September 9, 2010. There are 12 stations (Table-1) which are installed at Rural and Urban area among the City Corporation area to show clearly the horizontal distribution change of daily temperature. Temperature data was collected daily four times as Before Sun rise, Noon,

After Sun set and Mid Night. Here at the Map the YELLOW point has indicate

Suburban Station (SS) and BLUE point indicate Urban Station (US). Table-1 evaluates the Meteorological Data Acquirement Station with global position

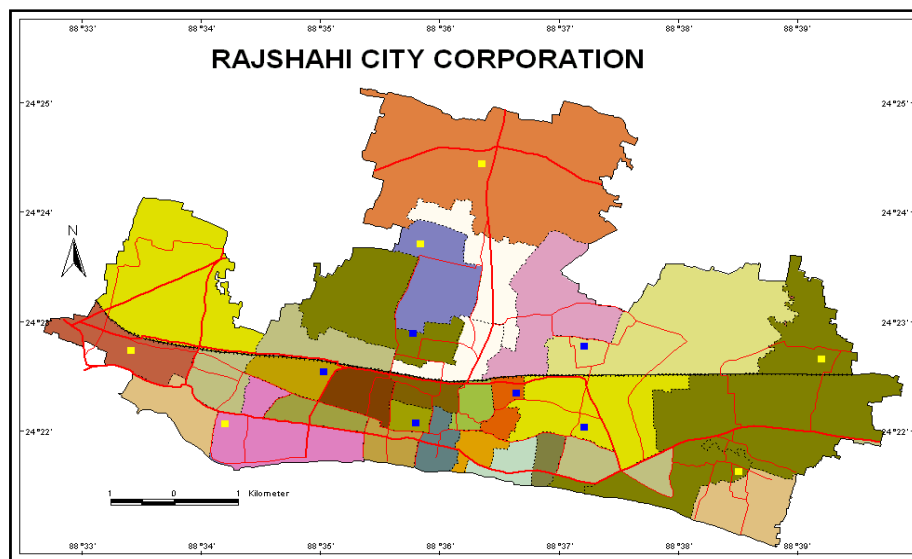


Fig-1: Twelve **METOS** station in Rajshahi City Corporation area (**YELLOW**: Suburban station & **BLUE**: Urban station)

Temperature Data from Bangladesh Meteorological Department (BMD):

An assessment of annual mean, maximum and minimum temperature of Rajshahi using weather station data operated by Bangladesh Meteorological Department (BMD) shows continuous warming of the region since 1964.

Global Information System (GIS) and Remote Sensing (RS):

An application of Global Information System (GIS) and Remote Sensing (RS) to the difference of surface temperature between urban infrastructures (buildings, roads) and vegetation area was determined using GIS and RS. A thermo-graphic camera system can remotely measure the surface

temperature of the materials through infrared radiation. It acquires the distribution of surface temperature of the materials, easily and instantly.

RESULT & DISCUSSION

Using the data collected from the Rajshahi Station of Bangladesh Meteorological Department (BMD), a climate line has been determined by calculating the Maximum temperature for years from 1964 to 2009. Then yearly temperature deviations from that climate line have been determined; distributions of the deviation points were plotted in to the graph (figure-2).

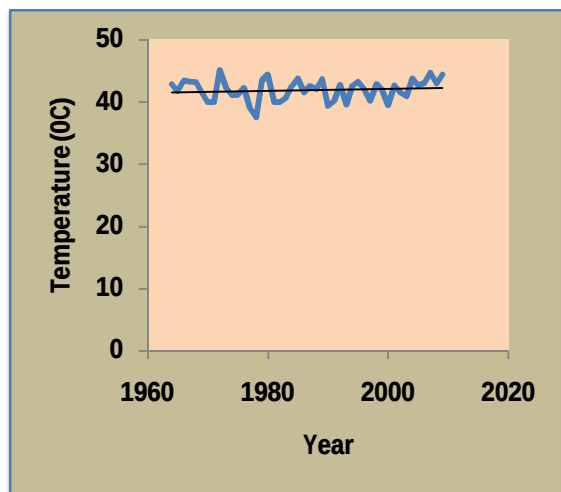


Figure-2: Annual Maximum Temperature profile for last 50 years. (Source: BMD)

Fixed Points Observation

It is clear that the Urban Heat Island (UHI) phenomena is undoubtedly appeared after sunset and reserved through the night. And

Urban Heat Island Intensity (UHII) was not found in the other times of the day. Station-1, 4, 5, 9, 10, 12 and Station-2, 3, 6, 7, 8, and 11 are located respectively in sub-urban area and urbanized area. Figure 4 shows the Urban Heat Island Intensity (UHII) at after sunset of 12 days between Station-1 and Station-6 in 12-23 August, 2010.

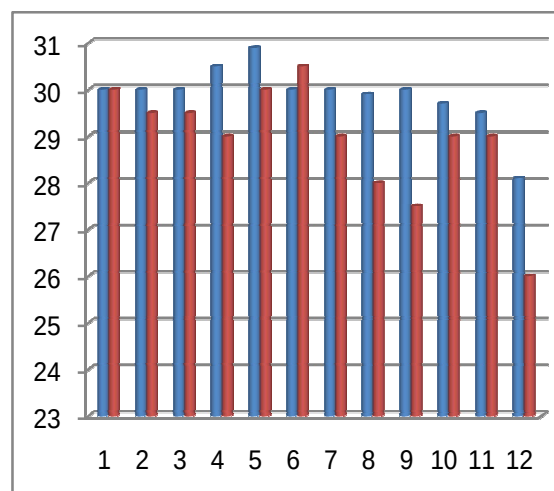


Figure 4: Urban Heat Island Intensity (UHII) of station-1 & station -2 for After sunset

Similarly other Urban & Suburban station show the UHII as mentioned previously. The diurnal UHII was minus, and the minimum was -1.2°C at 17:30 pm, because solar radiation of Station-06 was 15-20% lower than Station-01 by sky view factor and air pollution. The nocturnal UHII was plus, more than 2.0°C in the midnight. The maximum of UHII was 2.2°C . The daily

extremes, 2.5°C appeared between Station-6 and Station-1 on August 23, 2010 at 6:00 pm. The potential heat capacity in build-up area is larger than sub-urban, and heat from the building materials would be released through the night. Thus, it is very interesting that UHI of Rajshahi appears larger in summer season.

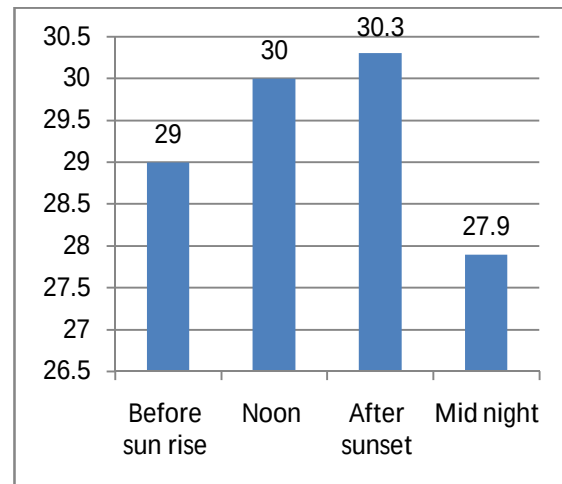


Figure-5: Daily Temperature profile of stations-6 in August 17, 2010

MITIGATION MEASURES

The heat island effect can be counteracted slightly by using white or reflective materials to build houses, pavements, and roads, thus increasing the overall albedo of the city. Using light-colored concrete has proven effective in reflecting up to 50% more light than asphalt and reducing ambient temperature. A low albedo value, characteristic of black asphalt, absorbs a large percentage of solar heat and contributes to the warming of cities. By paving with light colored concrete, in addition to replacing asphalt with light-colored concrete, communities can lower their average temperature. This is a long

established practice in many countries. A biologically related solution is to use vegetation to reduce urban heat. Vegetation provides important shading effects as well as cooling through evaporation. Some examples include:

- Planting trees around individual buildings to shade urban surfaces to reduce their temperature, especially roofs and south-, east-, and west-facing walls. The reduction in surface temperature also leads to substantial reductions in energy use for air conditioning. Trees and green spaces are other solutions.

- Trees can also be used to shade roads and parking lots, which would otherwise become very hot during the day and which store heat for later release at night. Shading of vehicles in parking lots can reduce evaporative emissions from gasoline, which contributes to increased levels of urban ozone.
- “Green roofs” use living vegetation on roofs in order to help reduce heat accumulation of buildings. For example, the city of Chicago has more than 80 municipal and private green roofs as of June 2004, including the first municipal green roof in the country, the City Hall rooftop garden. A green roof is much cooler than a traditional roof because a significant fraction of the absorbed energy is used to evaporate water rather than to heat the roof and the overlying air.
- Creation of green space such as parks can be used to assist in cooling

of neighborhoods, and an overall greening of the city can lead to a cooler urban atmosphere.

In addition, energy demand and costs also can be reduced by placing an air-conditioner in a shaded window, for example shaded by a strategically planted tree.

COST BENEFITS

These strategies can provide cost benefits. A building owner benefits from reduced energy consumption costs. Residents downwind of the urban area benefit from air quality improvements because:

- pollutants are deposited on trees
- greenhouse gas and pollutant emissions from air conditioning use are reduced
- emissions of volatile organic compounds that contribute to urban smog are lessened
- the rate of ozone formation is potentially reduced

LIMITATIONS & CONCLUSION:

Luckily, since we know what causes the urban heat island effect, we can control it to a significant extent. The fact is green trees and only trees can help us. Yes, to escape

the heat island effects, cities need a lot more vegetation and a lot fewer dark and hard surfaces. But the inconvenient truth is that some of our wise guys are plotting to cut

down hundreds of trees. But there must be something that we can do to ameliorate the existing condition. We cannot be apathetic any more regarding the apocalyptic effects of climate change. Our governments should also contemplate this matter seriously and more Environmental Engineers and urban planners are needed to attempt the situation.

In this study we used Hydrometer & Room Thermometer with required modified figure. However in this study are going to make a concern about the UHI effects in the Rajshahi City. There is no doubt about that the high rate of urbanization threatens the city for rising as an Urban Heat Island. Many problems already have beset our adored Rashahi City. Let's not contradict the situation and make it worse.

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- Geography & Environment Study department, Rajshahi University, Rajshahi.
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A COMPOSITE PHOTOCATALYST FOR METHYLENE BLUE DEGRADATION UNDER VISIBLE LIGHT IRRADIATION

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Abstract

The photocatalytic degradation of Methylene Blue (MB) under UV irradiation and even under ordinary visible light using a new composite photocatalyst $Mn_{1-x}Cd_xS$ ($x=0.18$) has been introduced. The order of reactivity, irrelevant to the nature of light, followed the order of $Mn_{1-x}Cd_xS$ ($x=0.18$) > TiO_2 > ZnO > CdS at neutral pH. The lower band gap energy (2.1 eV) of the catalyst $Mn_{1-x}Cd_xS$ ($x=0.18$) and dispersed nature of the photoinduced hole within the valence band, comprising the hybridized orbital of S and Cd valence shell orbital-rendering the prohibition of the recombination of the photo-induced electron and hole in the mechanistic path of direct photo-excitation of the catalyst- combined with the self-photosensitized degradation process of the dye molecules were identified as the reasons of the higher reactivity under visible light irradiation.

Key words: Composite catalyst, Degradation, Mineralization, Rate constant, Methylene Blue.

1. INTRODUCTION

Dyes are organic colored materials used in textile, pharmaceutical, cosmetic and food industries for imparting different shades of attractive colors. The wastewater discharged from a large number of industries, associated with dye stuff activities, contains high concentration of reactive dyes which causes a serious environmental problem. Some of these dyes have detrimental health effects (Neppolian et al., 2003). Their discharge as wastewater in the ecosystem is a dramatic source of esthetic pollution, eutrophication, and perturbations in aquatic life. Effluents discharged from textile and dyeing industries are characterized by low BOD, high COD and variation of pH in the range of 2-12 (Amin et al., 2009; Babu, et al., 2007). These dyes in water strongly absorb sunlight which decreases the intensity of light absorbed by water plants and phytoplankton, reducing photosynthesis and the oxygenation of water

reservoirs. The greatest number of the dyes are resistant's to biodegradation and direct photolysis.

In addition, many N-containing dyes such as methylene blue (MB) undergo natural reductive anaerobic degradation to yield carcinogenic aromatic amines. Therefore, the use of AOPs for effluent water treatment has been studied extensively and it has been affirmed that UV radiation by lights is expensive. So nowadays research is focusing innovative and novel on the two AOPs, which can be influenced by solar irradiation, i.e. light with a wavelength longer than 300 nm, homogeneous catalysis with photo-Fenton and heterogeneous catalysis with UV/ TiO_2 with and without accumulation of oxidants and solar radiation is as proficient as or even more resourceful than artificial radiation that also allows a decline in effluent treatment operational expenses. Moreover, in most of the industries the phenolic compounds are widely utilized and have become ordinary contaminants in waste water bodies. The photocatalytic degradation of

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phenol was found to be more effective under solar light in comparison to artificial visible light irradiation. There are various physicochemical and biological methods for the treatment of reactive dyes in wastewater (Neppolian et al., 2003). The conventional method of textile effluent water treatment comprises chemical coagulation, biological treatment and adsorption by activated carbon. However, these methods transfer dyes from the liquid to the solid phase which causes secondary pollution, requiring further treatment. The presence of higher molecular weight dyestuffs in wastewater results lower degradation efficiency when it is treated by biological method. The photocatalytic degradation of dyes is of growing interest for environmental remediation. Many organic and inorganic pollutants in water and air stream have been shown to be fully decomposed by means of photocatalysis (Li et al., 2007).

A large number of studies have been reported in the past decades on the photodegradation of organic compounds using semiconductor particles as photocatalysts. Semiconductor photo catalysts, such as TiO_2 and ZnO are employed extensively in the destruction of organic pollutants owing to their relatively high photocatalytic activity, biological and chemical stability, low costs, nonpoisonous and long life span. The appropriate position of their conduction bands allows oxygen to act as acceptor of photo-generated electrons which is more important in their usage (Yu et al., 2002). But several important scientific and technologic problems still remain to be solved in the application of photocatalysis technology of TiO_2 semiconductor for the treatment of industrial wastewater.

In our previous studies (Hasnat et al., 2005; Hasnat et al., 2007) have been investigated the photocatalytic degradation of several dyes using TiO_2 and ZnO dispersion under UV light. The main problem of using oxide photocatalyst TiO_2 and ZnO for dye degradation is their pitiable activity under visible light irradiation due to their higher band gap energy which hinders their photoexcitation. Some dyes could be degraded under visible light irradiation over TiO_2 or ZnO by a self-photosensitized process where the dye is the only light absorbing species. A brief of the mechanistic pathway is that at the excited state of the dye, an electron is injected into the conduction band of TiO_2 or ZnO where it is captured by the surface adsorbed O_2 to produce $\text{O}_2^{\cdot -}$, and active oxygen species decompose subsequently the dye cation radicals.

However, in such a case photo-efficiency is very low due to the much slower interfacial electron transfer to the oxidized sensitizer. Solar heterogeneous photocatalysis has emerged as a promissory technology to destroy toxic and/or bio-recalcitrant pollutants in water. Moreover, this technology has also shown the strongest potential in order to inactivate waterborne pathogen microorganisms. To obtain an acceptable response to visible light and to investigate the potential application of the photocatalytic technique under visible light irradiation, a number of new photocatalysts, with lower band gap energy capable of using visible light, have been developed. In the present studies, the efficiency of $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x=0.18$) in degrading an organic dye Methylene Blue (MB) has been explored under UV and visible light irradiation and also to evaluate the relative efficiency of three other common photocatalysts (TiO_2 , ZnO , CdS) for removal of color from effluent water.

2. EXPERIMENTAL

2.1. Materials

TiO_2 photocatalyst (P25, 90% anatase, specific surface area $50 \text{ m}^2 \text{ g}^{-1}$) ZnO and CdS were supplied by Wako Incorp. (Japan). The catalyst $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x=0.18$) was used as received. The cationic dye methylene blue (Fig. 1) was obtained from Waldeck-GmbH & Co. and was used as received. All other chemicals used in the experiments were reagent grade and were used without further purification. All solutions were prepared by using distilled and deionised water.

2.2. Reactor

Batch reactors were designed for the photodegradation study. For UV light induced degradation study three 10 W UV (Mercury) tube lights were placed parallel on the top inside of a wooden box, kept in a dark room. The walls, inside the box, were covered with aluminum foil to ensure the maximum light to fall on the reaction vessel by reflection. Pyrex glass reactor (200 ml) was used as reaction vessel, which along with the reacting solution was placed about 15 cm below the tube light on a magnetic stirrer. Samples were taken at a regular interval by raising the lid of the box. For visible light induced degradation study a 500 W crown bulb, the visible light source, was hung with a holder and a stand over wooden stage in the dark room, about 15

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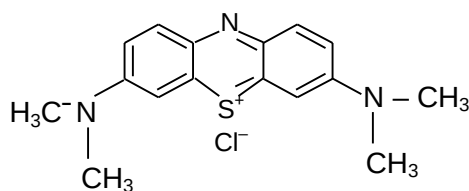


Fig. 1. The molecular structure of Methylene blue.

cm apart from the surface of the solution. The thermostatic state was maintained using a cooling fan.

2.3. Methods

Energy dispersive X-ray fluorescence (XRF, Horiba, MESA-500 W) analysis was used to determine chemical composition. The X-ray diffraction patterns (XRD) of the powder samples were measured at room temperature with a Rigaku powder diffractometer with Cu-K α radiation. The nitrogen adsorption isotherm at 77 K was measured using a Belsorp Mini, Japan instrument.

The UV-visible spectrum of methylene blue was obtained for 10 μ M solution in the range of 200 nm–700 nm using a UV-visible spectrophotometer (UV-1650PC, Shimadzu Corporation, Kyoto, Japan). The maximum absorbance was found at 664 nm ($\lambda_{\text{max}} = 664$ nm) and photometric measurements were carried out at 664 nm. For UV light irradiation assisted temporal absorption spectrum changes study a mixture of MB (15 μ M, 200 ml) was prepared by taking 0.2 g photocatalyst at pH 7.5. The as prepared mixture was stirred for 30 minutes in the dark to ensure its suspension behavior and then was subjected to UV irradiation for 125 minutes. In order to monitor the concentration changes, 3 ml of aliquot portions were withdrawn at a regular time interval; centrifuged and UV-visible spectra were taken. All the photocatalytic experiments were carried out under open air condition in a dark room.

3. Results and discussion

Fig. 2 shows the XRD pattern of the profiles of MnS (curve A) and CdS (curve B) along with composite material, prepared from the combination of γ MnS and CdS (curve C) using hydrothermal method. From these profiles, it is clear that γ MnS used in this study was a mixture cubic (R, rock salt structure) and hexagonal (γ ,

wurtzite structure) phases. However, the cubic phase of γ MnS was vanished and at the same time signals

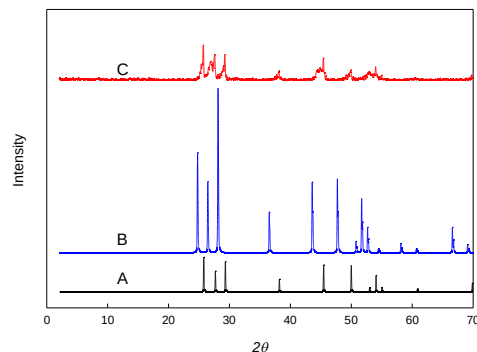


Fig.2. XRD patterns of (A) γ MnS (B) CdS and (C) $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x=0.18$).

due to cubic phase of CdS along with zincblend type structure was noticed as soon as the component CdS was hydrothermally combined to the MnS system. The newly developed composite material having zinc blend type structure was designated as $\text{Mn}_{1-x}\text{Cd}_x\text{S}$, where the value of x using XRF technique was determined to be 0.18. Using the as prepared material, photocatalytic degradation experiments of Methylene blue (MB) have been performed both under UV and visible light irradiation. Fig. 3 shows the spectral changes of MB

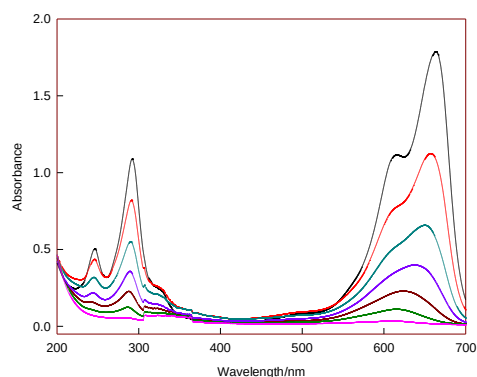


Fig.3. The temporal absorption spectrum changes of MB taking place under visible light irradiation. The lines indicate the change of decolorization /degradation every 25 min intervals. Initial concentration of MB: 15 μ M (200 ml), $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x = 0.18$): 0.2 g, pH: 7.5.

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molecules recorded at 25 min regular intervals under visible light condition. The absorption spectrum of MB shows two major peaks, one at 664 nm due to substitution of $>N(CH_3)_2$ group to heteroaromatic ring (responsible for color) and another at 292 nm associated with localized bands of the unsaturated heteroaromatic system (Wellington et al., 2006).

These peaks were decreased markedly in intensity and were almost completely disappeared after 125min irradiation. The disappearance of the peak at 664 nm

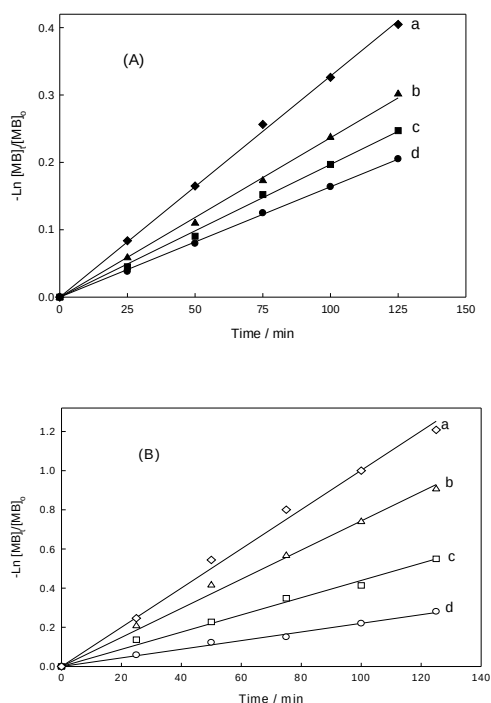


Fig. 4. Linear form of first order decolorization at 664 nm of Methylene Blue (200 ml, 15 μ M) in presence of (A) Visible light irradiation and in presence of (B) UV light irradiation. The lines a, b, c and d indicate the presence of 0.2 g $Mn_{1-x}Cd_xS$ ($x = 0.18$), TiO_2 , ZnO and CdS photocatalysts, respectively.

indicates decolorization (either due to functional groups removal or due to mineralization or due to both reasons). Meanwhile, the disappearance of the peak at 292 nm indicates the mineralization of MB molecules. Since the intensity of the peaks was decreased exponentially and so estimated the relative photocatalytic performances by evaluating first order

rate constant (k) at both 664 nm and 292 nm. The linear form of the first order decolorization has been shown in Fig. 4 measured at 664 nm both in presence of visible and UV light. It has been found that the value of k at 664 was $15.1 \times 10^{-3} \text{ min}^{-1}$, slightly higher than $13.3 \times 10^{-3} \text{ min}^{-1}$ which was observed at 292nm. This results indicate that mineralization of MB molecules took place followed by decolorization provably due to N-deethylation as was also observed by other researchers using oxide photocatalysts (Li et al., 2007, Hu et al., 2006). In order to confirm the mineralization, TOC was determined as below detection limit ($< 0.1\%$) after 150 min irradiation.

The main attractive feature to point out is the relative activity of the as prepared catalyst under visible light irradiation. In order to compare the relative activities, experiments were performed under same condition using TiO_2 , ZnO , most familiar semiconductor photocatalysts, CdS and as prepared $Mn_{1-x}Cd_xS$ catalyst.

Though the catalysts TiO_2 and ZnO were relatively active under UV light irradiation but they are deemed under visible light condition as is reported in Table 1.

Table-1: The temporal absorption spectrum change kinetic results of MB under UV and visible light irradiation

The activity of the as prepared $Mn_{1-x}Cd_xS$ under

Catalyst	Rate constant at UV light		Rate constant at Visible light	
	$k_{664 \text{ nm}}$ / 10^{-3} min^{-1}	$k_{292 \text{ nm}}$ / 10^{-3} min^{-1}	$k_{664 \text{ nm}}$ / 10^{-3} min^{-1}	$k_{292 \text{ nm}}$ / 10^{-3} min^{-1}
TiO_2	19.2	18.1	7.8	6.5
ZnO	10.9	8.2	2.1	1.9
CdS	4.1	2.3	1.6	1.0
$Mn_{1-x}Cd_xS$	22.3	19.1	15.1	13.3

visible light irradiation was found to be higher than that for TiO_2 and almost closer to that observed for TiO_2 under UV irradiation. In case of both peaks decolorization / mineralization followed the order of

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$\text{Mn}_{1-x}\text{Cd}_x\text{S} > \text{TiO}_2 > \text{ZnO} > \text{CdS}$, irrelevant to light used for photolysis. The reasons of such high activity of the as prepared $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ catalyst might be because either due to its larger surface area and or due to reasonable smaller band gap energy. Therefore, it is essential to investigate the surface area and band gap energy of the as prepared catalysts.

Fig. 5 shows the N_2 adsorption isotherm for $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x=0.18$). This is similar to type II isotherm defined in the IUPAC classification, indicating relatively strong interaction between sample surface and adsorbate. Adsorption isotherm is typical for non

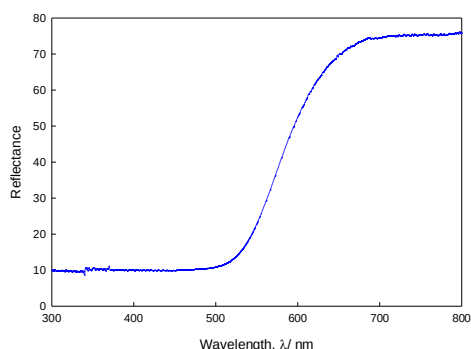


Fig. 6. The reflectance spectra of the as prepared $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x=0.18$).

porous material. It starts up taking N_2 homogeneously from relative pressure (p/p^0) zero then decreases apparently at higher pressure until at relative pressure 0.4. This signifies that adsorption in this nonporous material is generally accompanied by the formation of a monolayer followed by a multilayer and thereby lacking of capillary condensation.

The specific surface area was determined using BET method and found $31 \text{ m}^2\text{g}^{-1}$ with high correlation coefficient of the BET straight line, which is quite low compared to TiO_2 ($50 \text{ m}^2/\text{g}$) and ZnO ($100 \text{ m}^2/\text{g}$) (Hasnat et al., 2007). Therefore, the measurements of surface area did not support the noble activity of the composite $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ catalyst.

Finally, the band gap energy has been estimated by measuring the reflectance spectra of the composite catalyst. The diffused reflectance spectrum of the composite material $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x = 0.18$) is shown in Fig 6. As can be seen from figure, the band gap energy

of the catalyst $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x = 0.18$) was estimated to be 2.2 eV. This value is significantly smaller than oxide photocatalysts anatase TiO_2 (3.2 eV) and ZnO (3.4 eV) and also slightly lower than the sulfide photocatalyst CdS (2.4 eV). Therefore, lower band gap energy of the composite catalyst $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x=0.18$) might be a consistent reason of the activated photocatalytic performance MB molecules degradation under visible light condition. But, CdS show lower photodegradation efficiency than TiO_2 , despite of having lower band gap energy (2.4 eV) than that of TiO_2 (3.2 eV). Lower band gap energy of the composite catalyst is therefore not the only reason for its higher catalytic activity but also the photocatalytic oxidation of organic compounds is mainly considered to be controlled by the following processes: (1) the photoabsorption of the semiconductor catalyst, (2) the

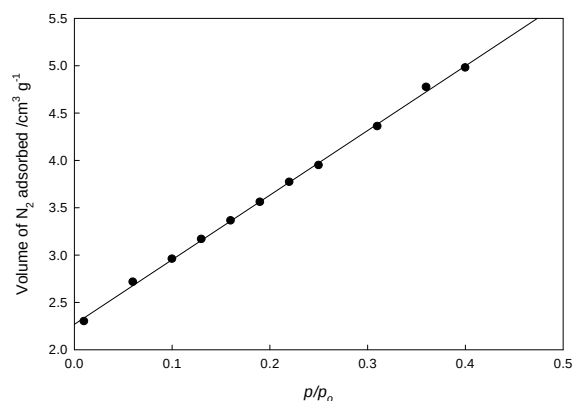


Fig. 5. BET isotherm of as prepared $\text{Mn}_{1-x}\text{Cd}_x\text{S}$ ($x=0.18$) catalyst.

generation of photogenerated electron and hole, (3) the transfer of charge carriers and (4) the utilization of the charge carriers by the reactants. In the photocatalytic processes using TiO_2 , ZnO or CdS , the recombination of the photogenerated electron and hole limits their degradation efficiency under UV irradiation. The lower band gap energy enabled the catalyst to be photoexcited resulting in the formation of photogenerated e^- and h^+ . Moreover, the hybridization of the S and Cd valence levels makes the VB largely dispersed, which favors the mobility of photoholes in the VB- preventing the recombination of e^- and h^+ and is beneficial to the oxidation reaction. In addition, the self-photosensitized degradation process of the dye

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molecules occurs concurrently, which is the main mechanism of degradation using oxide or sulfide catalyst, with the direct photocatalytic (e^- and h^+ generation) process. Therefore, superior photodegradation ability of the newly presented photocatalyst under visible light irradiation could be attributed to the combination of two process, namely, the enhanced direct e^- and h^+ generation process with increased lifetime of the photoproduced e^- and h^+ pairs and the self photosensitized degradation process of the dye molecules.

4. CONCLUSION

The new catalyst more efficiently degraded Methylene blue molecules compared to the broadly used TiO_2 or ZnO photocatalysts both under UV and visible light irradiation. Although, it showed slightly higher photocatalytic efficiency than TiO_2 under UV light irradiation, a considerably greater activity than that was found for it under visible light irradiation. The results of the present study suggest that the photocatalytic degradation of dye pollutants using the composite photocatalyst $Mn_{1-x}Cd_xS$ ($x = 0.18$) could be an efficient way of the remediation for substantial harmful effect created by these pollutants. Since the catalyst showed considerably higher photocatalytic performance under visible light irradiation, it could further be recommended that the cost effective visible light irradiation based dye treatment technology, utilizing $Mn_{1-x}Cd_xS$ ($x = 0.18$) should be preferred.

5. ACKNOWLEDGEMENTS

The authors express great gratitude to Prof. Masato Machida and Mr. Satoshi Shiba of Kumamoto University, Graduate School of Nano Science and Technology, Japan for supplying necessary photocatalysts to perform the experiments for this research paper.

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A MULTIVARIATE ANALYSIS OF BIODIESEL PRODUCTION FROM THE LIPID OF WASTEWATER SLUDGE

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Biodiesel is the most promising environment friendly green fuel produced from various renewable lipid sources. Wastewater sludge is a potential source of lipids that can be extracted using organic solvents and converted to biodiesel. A statistical multivariate analysis is a fast, economic, and effective way to systematically investigate the effect of several variables simultaneously. In this study, a half fraction 2^5 Plackett-Burman factorial design was used to investigate the influence of five different variables on the biodiesel production from the methanol extracted lipid. An empirical model was developed. The interaction of methanol to lipid ratio and reaction time was turned out to be the most significant factor. Reaction time, amount of natural zeolite, concentration of acid catalyst, methanol to lipid ratio and the some interactions among the variables were also found to be statistically significant. The maximum biodiesel yield of the H_2SO_4 catalyzed esterification-transesterification was 57.12% (on the basis of lipid) at the centre point run. The effect of reaction time and temperature were also studied for the biodiesel production from the lipid of wastewater sludge. The yield and quality of the FAME were determined by GC.

Keywords: Lipid, biodiesel, factorial design, wastewater sludge, fatty acid methyl ester (FAME)

1. INTRODUCTION

Biodiesel has worldwide attraction and growing interest as a renewable, biodegradable, clean fuel. It provides similar energy density to petro-diesel and can be used in most diesel engines in pure form (B100) or may be blended with petroleum diesel at any concentration. (Revellame et al., 2010; Knothe et al., 2005; Vyas et al., 2010; Siddiquee and Rohani, 2010; Xue et al., 2006]. However, the biodiesel production from pure vegetable oil is a major economic challenge as 70% and 85% of the overall biodiesel production cost is associated with the raw-materials (Revellame et al., 2010; Haas and Foglia, 2005; Mondala et al., 2009). Moreover, these raw-materials for biodiesel production compete with food materials. Extensive research is being conducted all over the world to produce biodiesel from alternative raw-materials like algae, waste cooking oil, non-edible oil like jatropha, castor, neem, karanja, pongamia, etc. But these are not the unique solution as cultivation of some of these requires huge lands. So the biodiesel production from a raw material that is readily

available in large quantities without any cost is very important.

Wastewater sludge generated after primary and secondary treatment processes is a source of various lipids which are being considered as potential feedstock for biodiesel production (Pokoo-Aikins et al., 2010; Uggetti et al., 2009; Jarde et al. 2005). Municipal wastewater treatment facilities produce large quantities of sludge that is available without any cost or even with an incentive. Wastewater treatment plant facilities in USA alone produced over 6.2 million metric tons of dry sludge every year (Dufreche et al., 2007). In 2008, six wastewater treatment plants in London, Canada produced 3.8×10^5 m³ wastewater sludge (http://www.london.ca/d.aspx?s=/Sewer_and_Wastewater/Sewagetreatment_index.htm). The generation of wastewater sludge is expected to increase in the future due to increasing urbanization and industrialization. The sludge management and disposal is a great challenge for any wastewater treatment facilities. Biodiesel production from sludge will reduce the costly disposal as well as management challenge and will promote the energy recovery from the waste. Lipids are usually

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extracted from the sludge with organic solvents to avoid the interference and subsequently, biodiesel is produced from the extracted lipid. Approximately 17–18 wt % lipids (on the basis of dry sludge) were extracted from dried sewage sludge by boiling solvent extraction using chloroform and toluene as solvents of which 65 wt % of the extracts were found to be free fatty acids and 7 wt % were glyceride fatty acids and 28 wt% were unsaponifiable material (Boocock et al., 1992). Pokoo-Aikins et al. separated the free fatty acids (FFA), triglycerides (oils) and the solvent from extracted lipids from sewage sludge by using toluene, hexane, ethanol, and methanol and found the yield of FFA was 24.8 wt%, 24.9 wt%, 25.5 wt%, 25.5 wt%, respectively. The maximum yield of triglyceride was 3.4 w% for all four solvents (Pokoo-Aikins et al., 2010).

Biodiesel, chemically known as fatty acid methyl ester (FAME), is produced via esterification and/or transesterification reaction (Fig. 1) of various lipid sources with alcohol in the presence of a base, acid, enzyme or heterogeneous catalyst. Base catalyst transesterification is widely used commercially due to very fast reaction rate compared to other catalysts. But, base catalyzed process is highly sensitive to the presence free fatty acids (FFA) as FFA reacts with catalyst and form soap that consume catalyst, inhibits glycerol separation and facilitate emulsion formation during washing step (Siddiquee and Rohani, 2010).

Acid catalyzed transesterification is slower than base catalyzed transesterification and requires high lipid to alcohol ratio (Demirbas, 2005). However, the

main advantage of acid catalyst is the ability to catalyze both the esterification and transesterification to produce more biodiesel. As the presence of water can stop the reaction (Fig. 2), this approach requires a water management technique.

Few researchers used acid-catalyzed in-situ transesterification process to produce biodiesel from freeze dried primary and secondary sludge process (Revellame et al., 2010; Mondala et al., 2009; Dufreche et al., 2007). However, the solvent and acid catalyst requirements were high. Moreover, freeze drying process to remove water from sludges was energy and time consuming. Additionally, water produced by in-situ esterification made the reaction rate slow. The use of commercial zeolite was reported in biodiesel production to absorb water produced by esterification reaction (Cao et al., 2008). However, there was no report about the use of natural zeolite as a dehydrating agent for the production of biodiesel. In this study, we used natural zeolite to absorb water produced during the esterification reaction of FFA.

The yield of biodiesel production depends on several factors including the type of catalyst (base, acid, enzyme or heterogeneous), alcohol/lipid ratio, temperature, and reaction time, water and free fatty acid content. Although several researchers have demonstrated biodiesel production from the lipid of wastewater sludge, the effects of various parameters have not investigated.

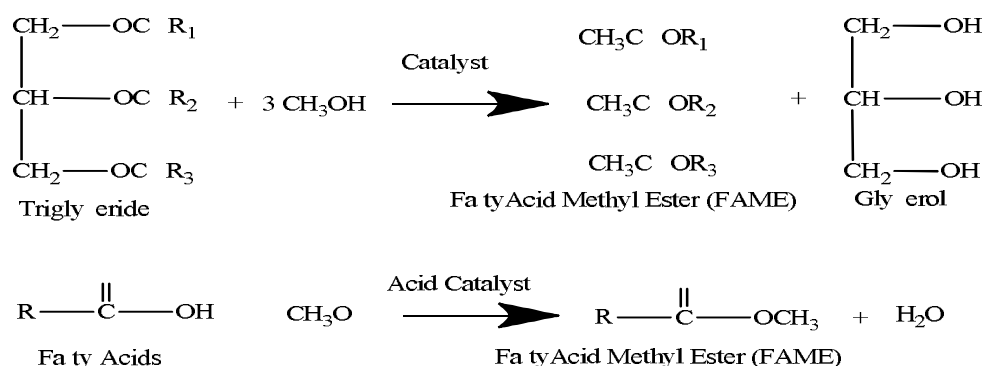


Fig. 1: Acid-catalyzed transesterification of triglycerides and esterification of fatty acids

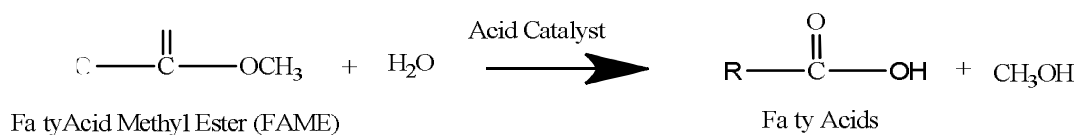


Fig. 2: Acid-catalyzed hydrolysis of FAME.

A statistical experimental design is a fast, economic, and effective way to investigate the effect of several variables simultaneously (multivariate data analysis). The objective of the multivariate data analysis is to develop an empirical model to describe the relation between a variable space (X) and response variable (Y) as well as possible (Jalbani et al., 2006; Karami and Rohani, 2009). In this study, a half fraction 2^5 Plackett-Burman factorial design was applied to study the effects of five factors namely methanol to lipid ratio (X_1), Reaction time (X_2), temperature (X_3), amount of acid catalyst (X_4), and amount of natural zeolite (X_5). Stirring rate was kept constant during the experiments.

2. MATERIALS AND METHODS

2.1. Materials

SuplecoTM standard 37component FAME mix- a 37 component reference mixture of fatty acid methyl ester in the range of C_4 to C_{24} including saturated, mono-unsaturated and poly unsaturated FAME were purchased from Supleco (Bellefonte, PA, USA) and used to calibrate the GC for FAME analysis. HPLC- grade methanol and hexane were purchased from Caledon Laboratories Ltd. (Georgetown, ON, Canada), sodium bicarbonate was purchased from Sigma-Aldrich Inc. (St. Louise, MO, USA), Sodium Chloride was purchased from EM Science (Gibbstown, NJ, USA), anhydrous sodium sulphate was purchased from BDH Inc. (Toronto, ON, Canada). All the chemicals were used without any treatment.

2.2 Sample Preparation

Natural zeolite was crushed, desalted and calcinated at 300 °C temperature using a Lindberg/Blue Mendel (Model: Box Furnace, Thermo Scientific, USA) prior to use as a dehydrating agents. The wastewater sludge was collected from Adelaide Pollution Control Plant, London, ON, Canada. After settling for 24 hours at 0°C and discarding the supernatant liquid, the resulting sludge was then centrifuged using IEC Centra-HN centrifuge (International Equipment Company, Needham Heights, USA) for further dewatering. Dewatered sludge was spread on tray and put in a fume hood to dry under vacuum at ambient temperature. Dried sludge was crushed in a mortar and pestle, homogenized and then stored in a freezer prior to use.

2.3 Extraction of lipid from sludge

The lipid was extracted from dried sludge by using methanol as a solvent. The dried sludge was weighed into a round bottom flask and methanol was added and then the resulting mixture was

heated to the 70°C temperature at ambient pressure. A magnetic stirring bar was used for mixing and the loss of methanol due to evaporation was minimized by using a condenser with water at 20 °C. After assigned extraction time, the resulting slurry was immediately filtered using VWR filter paper (size 5.5 cm) and a Buchner funnel attached to vacuum. Any residual particles were removed by centrifuging the lipid solution. The methanol was removed from the resulting supernatants under vacuum using a Büchi Rotavapor R-200 (Büchi Labortechnik, Switzerland) at 45°C and then flask was flushed with air to remove any remaining methanol in the gas phase. The resulting lipid was stored in refrigerator prior to use.

2.4 Experimental Design of Biodiesel Production

Five variables under investigation and their high and low experimental levels and center points are given in Table 1. Two replicates were done for all treatment combinations. The biodiesel productions from extracted lipid were performed according to the scheme stated in Minitab Software using the modified version of Christie's method in presence of an acid catalyst (H_2SO_4) (Christie, 2003).

Table 1. The experimental parameters and their high and low levels and center points

Factors	Low level (-1)	High Level (+1)	Centre Point (0)
A: Methanol to lipid ratio (ml/g)	50	200	125
B: Reaction time (h)	4	24	14
C: Temperature (°C)	45	75	60
D: % Acid catalyst (ml/ml)	1	5	3
E: Natural Zeolite (mg)	25	75	50

Two hundred milligram of extracted lipid was dissolved in 10 ml of hexane and transferred to a round bottom flask. Assigned amount of natural zeolite, H_2SO_4 and methanol were added to the flask and the resulting mixture was heated at assigned temperature for the time mentioned in Table 1. A magnetic stirring bar was used for mixing. The loss of methanol due to evaporation was minimized by using a condenser with water. After stopping the reaction, the mixture was allowed to cool and then centrifuged using IEC Centra-HN centrifuge (International Equipment Company, Needham Heights, USA) for 5 minutes to remove the natural zeolite. The supernatants

were transferred to a separatory funnel and then 10ml aliquot of 5% NaCl in water was added. Twenty ml of hexane was added to the separatory funnel and shaken for 3 minutes to extract biodiesel. Extraction procedure was repeated 3 times. Hexane layer was washed with 10 ml of 2 % NaHCO₃ followed by 10 ml of warm water and dried by passing through a Whatman filter paper (110 mm dia) containing anhydrous sodium sulphate and collected into a measuring flask. A 1.5 ml aliquot of hexane phase was pipetted into 2.0 ml Supelco PTFE lined capped vial (Supelco, Bellefonte, PA) for FAME analysis using GC equipped with FID (Flame Ionization Detector). The remaining hexane phase was transferred to a round bottom flask and the solvent was removed under vacuum using a Büchi R205 Rotary Evaporator (Büchi Labortechnik, Switzerland) at 40 °C to get biodiesel. The yield of FAME was determined from FAME analysis using GC.

2.5 FAME analysis

Varian CP-3800 gas chromatograph (Varian Inc., Lake Forest, CA) equipped with FID, and a 50m x 0.25 mm x 0.2 µm Varian CP-Wax 58 (FFAP) CB capillary Column (Varian Inc., Lake Forest, CA) was used to analyze the FAME. Helium was used as a carrier gas and the sample injection volume was 1.0 µl with a split ratio of 80:1. The column flow was constant at 1.2 ml/min and column oven temperature was programmed to maintain at 100 °C for 1.0 min, increase from 100 °C to 200 °C at 15 °C /min, then increased from 200 °C to 240 °C at 5 °C /min, and finally maintained at 240 °C for 24 min. The detector and injector temperature were set at 260 °C for the duration of the analysis.

3. RESULTS AND DISCUSSION

3.1 Statistical Analysis

Minitab software version15 (Minitab Inc, State College PA, USA) was used for the statistical analyses. The normal probability plot for effects of biodiesel production from extracted lipid is shown in Fig. 3. The response for the model is the amount of biodiesel Y expressed in terms of wt/wt% (on the basis of lipid). The underlying model for a half fraction 2⁵ Plackett-Burman factorial design is given by

$$Y = 45.31 - 1.94X_1 + 0.99X_2 + 0.20X_3 - 0.48X_4 - 0.68X_5 + 1.86X_1X_2 + 1.8X_1X_3 - 0.87X_1X_4 + 1.12X_1X_5 + 1.55X_2X_3 + 0.31X_2X_4 + 0.82X_3X_4 - 1.19X_4X_5 + \varepsilon$$

Here, X_i is the factors influencing the biodiesel production namely methanol to lipid ratio (X₁), reaction time (X₂), temperature (X₃), amount of acid catalyst (X₄), and amount of natural zeolite (X₅); X_iX_j is the interaction between the factors, and ε is the random error term having a normal distribution with mean zero and variance σ² (Montgomery and Runger, 2003). In the model, positive coefficients indicate that the high level of the variables increase the biodiesel yield. The interaction of methanol to lipid ratio(X₁) and reaction time (X₂) was turned out to be the most significant for the model. Reaction time, Temperature, amount of natural zeolite, concentration of acid catalyst, methanol to lipid ratio and the some interactions among the variables were also found to be statistically significant.

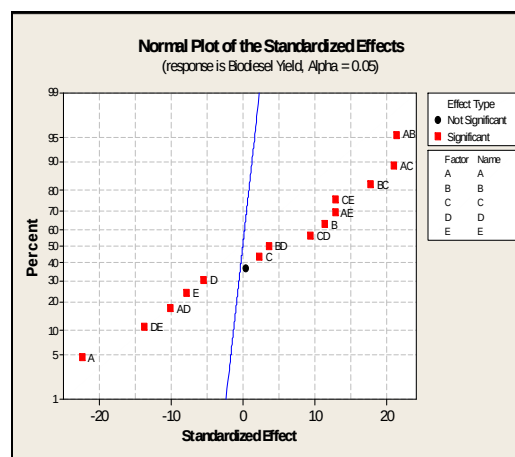


Fig. 3: The normal plot of standardized effects of various factors and their interaction.

3.2 FAME Analysis

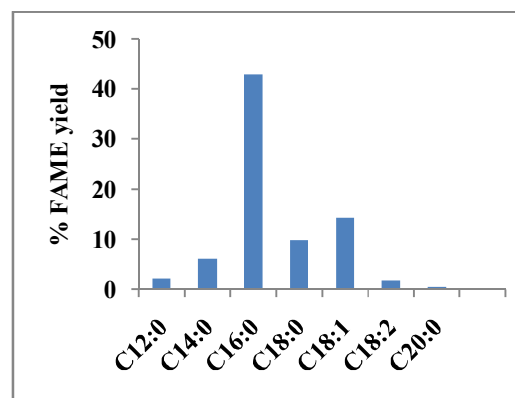


Fig. 4: FAME analysis of biodiesel obtained via acid catalyzed esterification-transesterification of lipid of the wastewater sludge.

The maximum FAME yield of half fraction 2⁵ Plackett-Burman factorial design was 57.12% (wt/wt) (on the basis of lipid). This yield was obtained for centre point run. As shown in Fig. 4, biodiesel contain mainly the methyl ester of myristic acid (C 14:0), palmitic acid (C16:0), palmitoleic acid (C 16:1) stearic acid (C18:0), oleic acid (C18:1) and linoleic acid (C 18:2). Methyl ester of palmitic acid (C 16:0) is present in greatest amount in the biodiesel produced from the extracted lipid. These results are found to be in agreement with the findings of Mondala et. al. by the in-situ transesterification of primary and secondary sludge (Mondala et. al., 2009).

3.3 Effect of time on biodiesel production

The effect of reactime time is shown in Fig. 5. The reaction was fast initially due to the esterification of the free fatty acid present in the lipid. However, the reaction was slow after 12 h that may be due to the slow acid catalyzed transesterification of lipid.

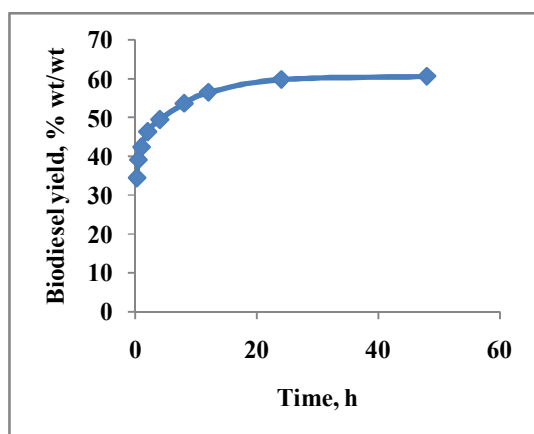


Fig. 5: The effect of time on biodiesel production via H_2SO_4 catalyzed esterification-transesterification of lipid of the wastewater sludge.

3.3 Effect of temperature on biodiesel production

The effect of temperature is shown in Fig. 6. The four temperature levels 40°C, 50°C, 60°C, and 70°C were used for the 24h reaction time. The yield of biodiesel production was increased with temperature upto 60°C. The maximum yield was obtained at 60°C that was approximately 60 wt/wt% (on the basis of extracted lipid). However, significant polymerization of unsaturated fatty acids and their derivatives might have caused the decrease of biodiesel yield at temperature above 60°C. Another, possible reason is the loss of methanol at higher temperature.

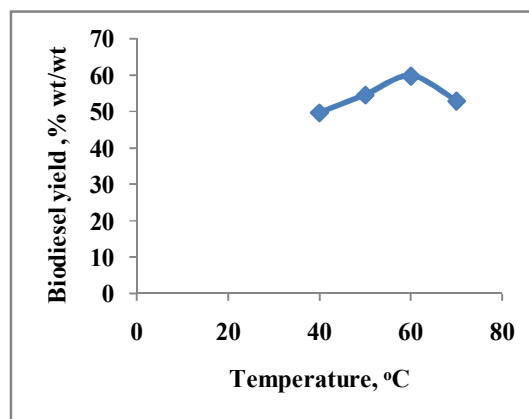


Fig. 6: The effect of temperature on biodiesel production via H_2SO_4 catalyzed esterification-transesterification of lipid of the wastewater sludge.

4. CONCLUSIONS

A model was developed for biodiesel production from the lipid of wastewater sludge. The interaction of methanol to lipid ratio(X_1) and reaction time (X_2) was turned out to be the most significant for the model. All the five factors and the some interactions among the variables were also found to be statistically significant. The maximum FAME yield of half fraction 2⁵ Plackett-Burman factorial design was 57.12% (wt/wt) (on the basis of lipid). The use natural zeolite as a dehydrating agent was increased the biodiesel yield. The biodiesel yield above 60°C was significantly decreased. This may be due to the acid catalyzed polymerization of unsaturated fatty acids and/ or their ester. Biodiesel produced from the lipid of wastewater sludge contain mainly the methyl ester of myristic acid (C 14:0), palmitic acid (C16:0), palmitoleic acid (C 16:1) stearic acid (C18:0), oleic acid (C18:1) and linoleic acid (C 18:2).

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Biogas from municipal solid waste

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Abstract

Energy crisis and environmental pollution is the best concerned of today's world. So that, research for renewable energy and getting friendly environment is middle task of all countries. Due to urbanization, many solid wastes are generated and the disposal of municipal solid waste is a great concern now a days. Municipal solid waste contains lot of organic composition which is one of the sources of biogas that's biogas can help to remove the energy crisis and keep environment friendly. In this work can represent the reactant preparation, reactor design, biogas production from municipal solid waste, component of biogas, CO₂ removing process, final component of biogas (in percentage), why needed to remove CO₂, how public can benefited from this biogas and how it can save the environment from environmental pollution

Keywords are: Solid waste, biogas, Absorption, co₂ removal.

Introduction

Energy is a vital input for economic growth in agriculture and industry. Fossil fuel are depleting fast due to over exploitation, besides increasing the environment al protection cost. Search for renewable energy source and their technology development is of paramount importance to have a balance and buoyant environment for better quality of life. Energy supply from renewable source is therefore an essential part of every country's strategy, especially when there is a serious threat of environment degradation and challenge for maintaining sustainability of fossil fuels. [D.P. Kothari, K.C. Singal, Rakesh Ranjan, Renewable energy sources, 2008, Preface xvll]

Biogas can be digestion of animal, plant and human waste. Digestion is a biological process that takes place in a digester with

anaerobic organism in absence of oxygen at a temperature of 35⁰ to 70⁰c. [D.P. Kothari, K.C. Singal, Rakesh Ranjan, Renewable energy sources, 2008, PP-287]

Municipal solid waste (MSW), also called urban solid waste, is a waste type that includes



Fig 1: Municipal Solid waste (Lalmaiya)

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predominantly household waste (domestic waste) with sometimes the addition of commercial waste collected by a municipality within a given area. They are in either solid or semisolid form and generally exclude industrial hazardous wastes. The term residual waste relates to waste left from household sources containing materials that have not been separated out or sent for reprocessing. Solid waste creates not only ground water pollution and soil pollution but is also play a vital role in urban air pollution. Due to the population growth and economic development, MSW generated is increasing with dramatically. the quantity of MSW in Sylhet is up to 120 tons/day. Among them maximum are disposed by landfill method. [Data From Sylhet City Corporation]

Material and Methodology- Biogas production from solid waste:

Waste Collection:

1. Municipal Solid waste from Lalmatia
2. From Police Line, Rekabibazar
3. From Electric Supply Road, Amborkhana

In the batch reactor there take place the anaerobic digestion process of the waste material for 60 days. After the digestion process completed we collected the Biogas to gas collector through the Brine Replacing method. Then in the Orchid apparatus we measure the percentage of CO₂. After that we have done water absorption of the collected gas. And again we measure the percentage of CO₂ at the same process. Comparing the measurement of carbon-dioxide in between before and after absorption process we seen that carbon-dioxide is reduced in great amount



Fig 2: Mechanism of organism

Pressure Swing Adsorption - PSA

Adsorption“ refers to the exit of molecules from fluids and their subsequent attachment to solid surfaces . This process is used in PSA to remove the CO₂ and any remaining traces of other gases from raw biogas. Before adsorption, sulfur and water vapor must be removed from the raw biogas, since these substances can damage the active carbon required in the process. As a rule, water separation succeeds when raw biogas is cooled nearly to the point of freezing. For the separation of sulfure from biogas, various other processes may be used.

Pressurized Water Scrubbing (PWS)

Pressure water washing is a matter of physical adsorption processes. Raw biogas is routed through a water-filled pressure tank, in which the gases present in the biogas are absorbed by the water through the application of physical force. Besides CO₂, this process can also remove some of the hydrogen sulfide (H₂S) and ammonia (NH₃) present in raw biogas. When biogas contains more hydrogen sulfide than can be removed through pressure water washing, this is an indication that an additional sulfur removal process should be implemented “upstream” of the pressure water wash. Following the completion of the pressure water wash, the gas must be dried and dehumidified before being fed into the natural gas grid.



Fig 3: setup for the process.



Fig 5: Reactor with agitator

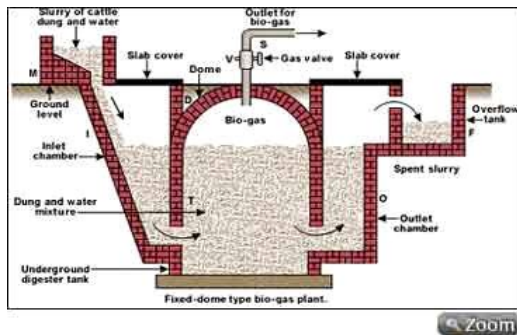


Fig 4: Schematic view of reactor



Fig 6: Burning of bigas



Fig 7: Gas collector

Table 1: Solid waste composition from Lalmatiya, Sylhet

Basis: 20 kg weight municipal solid waste

Element	1.Sample Weight(kg)	1. Sample(%)	2.Sample Weight(kg)	2. Sample(%)	3.Sample Weight(kg)	3. Sample(%)
Paper	1.00	5.00	1.00	5.00	1.50	7.50
Can	0.00	0.00	0.00	0.00	0.00	0.00
Plastic	1.50	7.50	2.00	10.00	1.50	7.50
Organic	16.80	84.00	16.90	84.50	16.85	84.25
Wire	0.20	1.00	0.00	0.00	0.00	0.00
Others	0.50	2.50	0.10	0.50	0.15	0.75

Table 2: Solid waste composition from Rikabibazar , Sylhet

Basis: 30 kg weight municipal solid waste

Element	1.Sample Weight(kg)	1. Sample(%)	2.Sample Weight(kg)	2. Sample(%)	3.Sample Weight(kg)	3. Sample(%)
Paper	1.50	5.00	2.00	6.6	1.00	3.33
Can	0.10	0.33	0.10	0.33	0.15	0.50
Plastic	2.00	6.60	2.00	3.33	2.00	6.60
Organic	25.9	86.47	25.4	88.14	25.75	85.83

Wire	0.00	0.00	0.00	0.00	0.10	0.33
Others	0.50	1.60	0.50	1.6	1.00	3.33

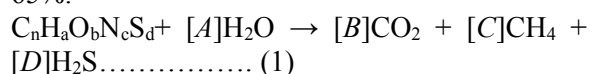
Table 4: Typical chemical composition of MSW which collect from the Sylhet City Corporation

Component	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur	Ash
Food waste	48.0	6.4	37.6	2.6	0.4	5.0
Paper	43.5	6.0	44.0	0.3	0.2	6.0
Cardboard	44.0	5.9	44.6	0.3	0.2	5.0
Plastic	60.0	7.2	22.8	-	-	10.0
Textile	55.0	6.6	31.2	4.6	0.15	2.5
Rubber	78.0	10.0	-	2.0	-	10.0
Leather	60.0	8.0	11.6	10.0	0.4	10.0
Garden trimming	47.8	6.0	38.0	3.4	0.3	4.5
Wood	49.5	6.0	42.7	0.2	0.1	1.5
Misc. organics	48.5	6.5	37.5	2.2	0.3	5.0
Dirt, ashes, brick etc	26.3	3.0	2.0	0.5	0.2	68.0

Theoretical Biogas yield

The exact expectation of the producible biogas amount and its methane content is One of the most important aspects of an anaerobic digester. The chemical Compositions of a feedstock determine the potential biogas yields, as well as the gas composition. The results of elemental analyses showed the chemical composition of feed used in this study to be C14.25H28.80O4.43NS0.03. An empirical equation, Eq. (1), was used to calculate the biogas production in the anaerobic digestion. As a result, the theoretical biogas and methane yields of feed fresh leachate at standard temperature and pressure (STP, i.e., 0°C, 760 mmHg) were 1.116 L biogas /g VSS destroyed and 0.72 L CH₄/g VSS destroyed, respectively.

The theoretical methane was estimated to be 65%.



Where

$$[A] = n - a/4 - b/2 + 3c/4 + d/2$$

$$[B] = n/2 - a/8 + b/4 + 3c/8 + d/4$$

$$[C] = n/2 + a/8 - b/4 - 3c/8 - b/4$$

[Muhammad Alamgir, Chris McDonald, Karl Ernst Roehl, Aminul Ashan. 2005, "Integrated Management and Safe Disposal of Municipal Solid Waste in Least Developed Asian Countries" Department of Civil Engineering, KUET, Khulna, Bangladesh]

Percentage of Methane:

Measured by the Orchid apparatus:
Before the absorption (Approximate)

Carbon dioxide (%)	Methane (%)
36	63
38	61
39	60

2. After the Absorption

Carbon dioxide (%)	Methane (%)
11	87
13	85
12	86



Fig 8: Overall setup for CO₂ absorption process.

Conclusion:

Solid wastes from domestic sources contribute to the processing environmental problems of the country like Bangladesh. In this paper attention has shifted to using organic waste material (Solid Waste) in the production of methane gas using a batch reactor production of biogas and the biogas contains around 60% of methane used as cooking, heating and lighting and as a source of electricity.

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Clinical Waste Management in Sylhet City

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Abstract:

The scenario of clinical waste disposal system is simply threatening to our environment. Due to increasing health facility, production of clinical waste is also increasing. It is therefore, becoming a matter of great concern to manage this waste properly. Here we studied the clinical waste management system of Sylhet City Corporation (SCC). The objective of our study is the analysis of current disposal system of clinical waste and provide some recommendation for the improvement of existing healthcare situation as well as reduction of environmental pollution. The existing system of waste disposal is to dump all types of wastes in low lying areas adjacent to the town. Mass people are not aware of the hazards of infectious clinical waste. The wastes are not categorically segregated. As a result, mixing of municipal solid wastes with hazardous clinical wastes led to high risk of public health and environment. Our study also identify the risk associated with health hazards of general people and people engaged in the existing management system. We also give guidelines to SCC for sustainable management of clinical wastes.

Key words : Waste, Clinical waste, Management, Health hazard.

Introduction:

Waste is defined as anything that you discard, intend to discard or are required to discard. This covers more than just objects and substances you have decided to dispose of. Material being recovered - eg. sent for recycling or prepared for reuse - also counts as waste. Waste includes all items that people no longer have any use for, which they either intend to get rid of or have already discarded. Additionally, wastes are such items which people are required to discard, for example by law because of their hazardous properties.

Clinical waste is any waste which poses a threat of infection to humans. The term also includes drugs or other pharmaceutical products.

Clinical waste is mainly produced by hospitals, health clinics, doctors' surgeries and veterinary practices, but also arises from residential homes, nursing homes and private households.

Examples of clinical waste are human or animal tissue, blood or other bodily fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, syringes, needles or other sharp instruments.

One estimate shows that some 5.2 million people (including 4 million children) die each year from waste-related diseases. Concerned with this situation Agenda 21, adopted in the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June, 1992, set the following goals and targets with regard to waste management in cities:

- All countries must establish waste treatment and disposal criteria and develop the ability to monitor the environmental impact of waste by the year 2000.
- By 2025, developing countries should ensure that at least half of the sewage, wastewater and solid waste are disposed according to national and international guidelines.
- By 2025, all countries shall dispose of all waste according to international quality guidelines (Nasima, 2000).

The unsafe disposal of health-care waste (for example, contaminated syringes and needles) poses public health risks. Contaminated needles and syringes represent a particular threat as the failure to dispose of them safely may lead to

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dangerous recycling and repackaging which lead to unsafe reuse. Contaminated injection equipment may be scavenged from waste areas and dumpsites and either be reused or sold to be used again. WHO estimated that, in 2000, contaminated injections with contaminated syringes caused:

21 million hepatitis B virus (HBV) infections (32% of all new infections); two million hepatitis C virus (HCV) infections (40% of all new infections); and at least 260 000 HIV infections (5% of all new infections)(WHO, 2000).

In 2002, the results of a WHO assessment conducted in 22 developing countries showed that the proportion of health-care facilities that do not use proper waste disposal methods ranges from 18% to 64%.

In addition to the public health risks, if not managed, direct reuse of contaminated injection equipment results in occupational hazards to health workers, waste handlers and scavengers. Where waste is dumped into areas without restricted access, children may come into contact with contaminated waste and play with used needles and syringes. Epidemiological studies indicate that a person who experiences one

needle stick injury from a needle used on an infected source patient has risks of 30%, 1.8%, and 0.3% respectively of becoming infected with HBV, HCV and HIV (Nasima, 2000).

Sylhet, the northeastern divisional city of Bangladesh, is located at 24°53'N latitude and 91°52'E longitude stands on the banks of river Surma. Considering the demand of huge increasing population, rapid and mushrooming growth of private clinics/hospitals is observed in the recent years in Sylhet city. And most of private clinics are housed in renovated residential building and do not have the facilities for adequate waste management systems. So clinical waste generated from government hospitals, private clinics, diagnostic centers and many other sources is a big problem in Sylhet City as there exists a very poor and unhygienic disposal system of that waste. Our study took an attempt to find out comparative analysis of clinical waste management in Sylhet City and to make some environmentally safe alternatives for better management.

Objectives:

- to categorize various types of clinical wastes in Sylhet City
- to see the total amount of clinical waste generated from different hospitals and clinics of Sylhet city.

- to note the existing management and discarding system of the clinical waste.
- to provide some guidelines for improved management and dumping system of this clinical waste.

Materials & Methods :

Our study is intended to focus on the mismanagement and possible threats of clinical waste in Sylhet City. Among 136 different health care centers available in Sylhet city we studied around 40 facility center. The study was conducted for the period of six month from March 2010 to August 2010. Both primary and secondary data have been collected for this study. Primary data collection involves preliminary survey, questionnaire survey, physical observation and survey for finding waste generation rates. The primary data have

been collected mainly on the basis of questionnaire through formal interview of the manager, matrons, cleaners, ward master and patients. The relevant secondary data for our study were mainly collected from the published and unpublished papers, journals etc. The collected data and information were critically analyzed to assess existing waste management system, its limitation and impacts. An integrated management plan was recommended for efficient disposal of clinical waste.

Result and Discussion :

To find out the generation rate of different categories of wastes, a weeklong survey at different hospitals, clinics, diagnostic center and outdoors clinics of SCC area has been carried out. The wastes were collected, weighed and

recorded three times a day from each health care center(HCC). The timing was morning, noon and evening. The data collection survey for each HCC was a continuous program i.e. without break for weekend and general holidays. In this

survey we found clinical wastes such as gauge; bandage, cotton, saline bag, chemical reagent, blood, urine, stools, test tube etc from pathological lab, plasters, foil or packet of medicine, any part of human body amputated in Operation Theater, abortion ambrio, syringes and needles, stool, urine, cough, spit, blood etc. We

categorize these wastes as Infectious and General waste, Sharp waste, Recyclable waste, Chemical and Radioactive waste. The average amount of generated waste in different categories from different clinics and hospitals, diagnostic centers is tabulated below.

Table : Amount of clinical waste generated in studied health care center

Sl. No	Name	No. of beds	No. of people involved in waste management	Daily generated waste(in Kg)/Day			
				Infectious & general	Sharp	Recyclable	Chemical & radioactive
1	Sylhet Osmani Medical College Hospital	900	130	400	10	20	04
2	Jalalabad Ragib Rabeya Medical College Hospital	500	110	150	8	10	2.5
3	North East Medical College Hospital	400	90	100	5	7	1.5
4	Sylhet Shahid Shamsuddin Hospital	100	24	25	2	5	0.5
5	General Shisu Hospital	75	20	18	1	5	0.5
6	T.B.Hospital	56	8	15	2	3	0.4
7	Noorjahan Hospital	60	25	15	2	4	0.3
8	Niramoy Poly Clinic	40	16	10	1	2	0.2
9	City Poly Clinic	50	20	12	1	2	0.4
10	Ayesha Medicare	35	15	10	1	2	0.5
11	Central Hospital	25	10	08	1	1	0.2
12	Mother care Clinic	18	8	06	0.5	2	-
13	Jalalabad Clinic	20	12	08	1	1	-
14	Al-Raiyan Hospital	24	04	07	1	3	0.2
15	Arroggy Poly Clinic	26	06	08	-	2	-
16	Friends Eye Hospital	20	04	06	-	-	-
17	Shahjalal Mental Health Hospital	50	10	10	0.5	2	0.5
18	Marie Stopes Clinic	14	06	08	-	2	-
19	United Poly Clinic	40	18	10	1	2	1
20	Royal Hospital	70	45	18	1	3	1
21	Metropolitan Hospital	25	14	08	-	2	-
22	Al-Banna General Hospital	24	07	06	0.5	2	-
23	Popular General Hospital	20	04	06	-	2	-
24	Fair Health Hospital	26	06	08	0.5	1	0.5
25	Ideal Clinic	24	06	06	0.5	2	0.2
26	Medinova Medical Services		04	04	1	2	2
27	Popular Medical Center		15	05	1	3	3
28	Medi Aid		03	03	1	1	1
29	Medi Lab		02	02	0.5	1	1
30	Marie Stopes		04	04	0.5	-	0.5
31	Lab Aid Diagnostic Center		08	04	1	2	1
32	Malik Compath		04	02	0.5	1	0.5
33	National Diagnostic Center		04	03	0.5	1	0.5
34	Family Health Clinics		03	02	0.8	1	0.4
	Total	2642	665	907	47.3	99	24.3



Figure: Photograph showing collection & dumping of clinical waste

The rate of waste generation differs due to geographical location, season of the year, collection frequency, availability of different treatment facilities, social status of the patient

(i.e. income, living standard, awareness about diseases), hospital management, legislation etc. Clinical waste generated from the daily activities of patients, cleaners, sweepers, nurses, doctors,

and administrators etc that are discarded as useless. Medical wastes are generated from wards, cabins, Operation Theater. Volume of waste mainly depends upon Number of beds and outdoor patients that represents the waste generation sources. It is observed that existing clinical waste collection, handling and disposal practices of all the clinics and hospitals of SCC involved transport of wastes by ward boys, maid nurses and other employees from the point of generation to initial storage points in each unit. Wastes are normally collected from small bowl or plastic bin provided for each bed in hospital

and stored either in a large size plastic bag or bucket. These plastic bags or wastes from buckets are then put in a pushcart and carried to the nearest municipal bins for dumping without any segregation or treatment. The municipal bins are normally placed either in hospital premises or outside the hospital. Wastes from operation theater, laboratory and hospital kitchen are also dumped into municipal bins. SCC trucks carried these wastes three times daily to the landfill area for final dumping. Following pie diagram categorically shows the amount of waste in percentage.

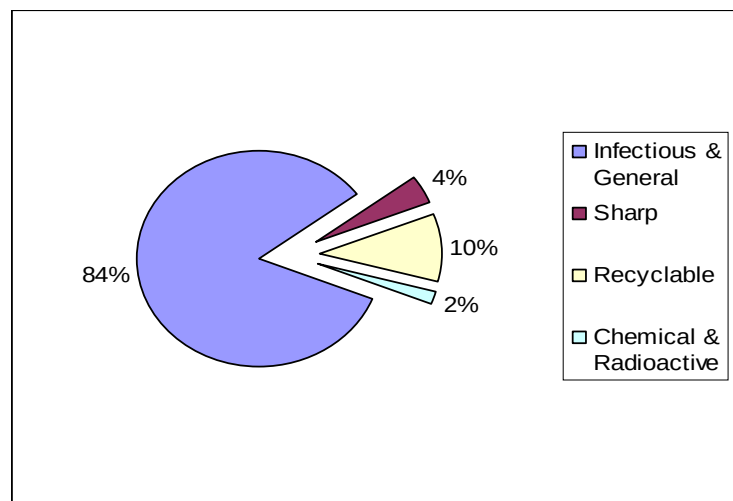


Figure: Percentage of different type of clinical waste

Risk associated with clinical waste :

Clinical waste is a reservoir of potentially harmful micro-organisms which can infect hospital patients, health-care workers and the general public. Other potential infectious risks include the spread of, sometimes resistant, micro-organisms from health-care establishments into the environment. These risks have so far been only poorly investigated. Wastes and by-products can also cause injuries, for example radiation burns or sharps-inflicted injuries; poisoning and pollution, whether through the release of pharmaceutical products, in particular, antibiotics and cytotoxic drugs, through the waste water or by toxic elements or compounds such as mercury or dioxins.

Throughout the world every year an estimated 12 000 million injections are administered. And not

all needles and syringes are properly disposed of, generating a considerable risk for injury and infection and opportunities for re-use.

Worldwide, 8-16 million hepatitis B, 2.3 to 4.7 million hepatitis C and 80 000 to 160 000 HIV infections are estimated to occur yearly from re-use of syringe needles without sterilization². Many of these infections could be avoided if syringes were disposed of safely. The re-use of disposable syringes and needles for injections is particularly common in certain African, Asian and Central and Eastern European countries.

In developing countries, additional hazards occur from scavenging on waste disposal sites and manual sorting of the waste recuperated at the back doors of health-care establishments. These practices are common in many regions of the world. The waste handlers are at immediate risk of needle-stick injuries and other exposures to toxic or infectious materials.

The use of radiation sources in medical and other applications is widespread throughout the world. Occasionally, the public is exposed to radioactive waste, usually originating from radiotherapy treatments, that has not been properly disposed of. Serious accidents have been documented in Goiânia, Brazil in 1988 in which four people died from acute radiation syndrome and 28 suffered serious radiation burns. Similar accidents happened in Mexico City in 1962, Algeria in 1978, Morocco in 1983 and Ciudad Juárez in Mexico in 1983.

Risks associated with other fractions of health-care wastes, in particular blood waste and chemicals, have been relatively poorly assessed, and need to be strengthened.

Recommendation :

Clinical waste management is one of the most neglected parts of the managerial process in Bangladesh. Neither the government nor the hospital authorities pay proper attention to this matter. There are no well-defined rules and regulations of clinical waste management in Sylhet City Corporation. That means no specific definition of clinical waste and no specific and separate regulation for disposal of clinical waste and also there is less priority for proper disposal of waste by the authorities and lack of accountability of concerned authorities. Since the existing solid waste management system of Sylhet City is neither satisfactory nor adequate and has been failed to keep pace with the vast amount of solid waste produced, the clinical waste doesn't get proper attention. Having this reality, some recommendations from us-

- The build-up of a comprehensive system, addressing responsibilities, resource allocation, handling and disposal. This is a long-term process, sustained by gradual improvements;
- Segregation and identification (color coding) of hazardous waste from non-risk clinical waste.
- Non-biodegradable portion of clinical waste should be separately collected and recycled.
- SCC should start a separate collection and disposal system for clinical waste.

Conclusion :

At present, clinical waste management has become a decisive issue around the world. For its hazardous nature it is very much harmful for the environment. Lately, the management of clinical wastes has received little attention despite their potential environmental hazards and public health risks. Using both the quantitative and qualitative approach, the report has attempted to put a figure on the mismanagement of clinical waste and the health hazard accompanying with it. The study reveals that medical wastes are not properly managed in almost all the clinics and hospitals, in the study area. It can be concluded that the existing system of clinical waste management of studied health care centers is neither satisfactory nor adequate. Human resource development, adequate logistic and technological support and above all political commitment are the basic needs for the development in the sector.

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COMPERATIVE STUDY OF BIODIESEL PREPARATION METHODS

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Biodiesel, which is a new, renewable and biological origin alternative diesel fuel, has been receiving more attention all over the world due to the energy needs and environmental consciousness. Biodiesel is usually produced from food-grade vegetable oils using transesterification process. Base catalyzed transesterification reaction is widely used for biodiesel production from vegetable oil due to its faster kinetics than that of acid catalyzed process. But if free fatty acid (FFA) content in the oil is more than 2%, the base catalyzed process is not feasible. Using food-grade vegetable oils is not economically feasible since they are more expensive than diesel fuel. Therefore, it is said that the main obstacle for commercialization of biodiesel is its high cost. Nonedible feed stocks are being studied in recent years for biodiesel production. The main problem for the nonedible sources is its high FFA content which limits the use of single step transesterification reaction. A two-step and three-step processes are developed recently for the biodiesel production from oil. In the present paper biodiesel is prepared from nonedible oils, such as rubber seed oil and nahor oil by different methods. The difficulties of each processes are discussed and the biodiesel properties are measured and compared.

Keywords: Biodiesel; Transesterification; Esterification; Saponification.

1. INTRODUCTION

The vast majority of motor vehicles used around the world rely on four-stroke internal combustion engines run on petroleum-based fuel or biodiesel. In comparison with petro-diesel, vegetable oils have their own advantages: first of all, they are renewable as the vegetables which produce oil seeds can be planted year after year; secondly, they are available everywhere in the world; thirdly, they are “greener” to the environment, as they seldom contain sulfur element in them. (Balat et. al., 2008). Use of biodiesel is catching up all over the world especially in the developed countries. Most developed countries are moving from voluntarily to obligatory legislations to increase the market share of biofuels within the transport sector (e.g. set up of a mandatory biofuel target of 10% by the European Commission for the European transport sector in 2020 (Directive 2009/28/EC of the Parliament and of the Council on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Brussels, 23 April 2009.))

The end cost of the biodiesel mainly depends on the price of feedstock. Although biodiesel is currently produced from high quality food-grade vegetable oils (in the USA, soybean oil; in Europe, rapeseed oil) using methanol and an alkaline catalyst, but it can be made from any plant oils with over 350 oil-bearing crops being identified for the production of biodiesel (Demirbas et. al., 2007). The predominant feedstock in the Europe is rapeseed, while soybean is the most widely used feedstock in the United States (US). Feedstocks such as palm, jatropha and coconut are common in Malaysia, India and the Philippines, respectively. (Demirbas, 2007). Gui et al made a thorough analysis on the production of biodiesel from edible and nonedible oils. Generally the cost of raw materials accounts about 70-80% of the total production cost of biodiesel.

Four major techniques (dilution, microemulsion, pyrolysis, and transesterification modification techniques) are used for biodiesel production, among them transesterification process has been widely used to reduce the high viscosity of the oil. Transesterification reaction can be catalyzed by both homogeneous (alkalies and acids) and

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ISBN: 978-984-33-2140-4

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heterogeneous catalysts. The most commonly used alkali catalysts are NaOH, CH₃ONa, and KOH (Gemma et. al., 2004). It has been found that the alkaline-catalyzed transesterification process is not suitable to produce esters from unrefined oils (Ramadhas et. al., 2005) where the FFA content is higher. In order to prevent saponification during the reaction, FFA and water content of the feed must be below 0.5 wt.% and 0.05 wt.%, respectively. Because of these limitations, only pure vegetable oil feeds are appropriate for alkali-catalyzed Transesterification without extensive pre-treatment (Freedman et. al., 1984). Homogeneous acid-catalyzed reaction is about 4000 times slower than the homogeneous base-catalyzed reaction and hence is not popular for industrial production of biodiesel.

A two-step process is developed recently for the biodiesel production from oil, where in the first step acid-catalyzed esterification is conducted to convert the FFA to FAME followed by the base catalyzed transesterification to convert the TG to FAME. Another approach was reported, where FFA was produced from oil by saponification-acidification reaction and FAME is produced by acid catalyzed esterification (Islam et. al., 2008). In the present paper biodiesel is prepared from nonedible oils, such as rubber seed oil and nahor oil by different methods. The difficulties of each processes are discussed and the biodiesel properties are measured and compared.

2. MATERIALS AND METHODS

2.1. Chemicals

Methanol (99-100%), ethanol (99-100%), sodium hydroxide pellets (96%), potassium hydroxide pellets (>84%), phenolphthalein (pH 8.2 - 9.8), starch, acetone (99%), n-Hexane(96%), hydrochloric acid(37%) , isopropanol, iodine, sodium iodide, glacial acetic acid, bromine, carbon tetrachloride, s-Diphenylcarbazide, Potassium Dichromate etc. were purchased from Merck. All the chemicals used were analytical reagent grade.

2.2 Extraction of oil

Different methods were used to extract oil from the seed (Morshed et. al., 2008). For mechanical press, a vertical, manual operated, cylindrical (4.3 cm ID) mechanical press spiral screw was used. For cold percolation process, hexane was used as a solvent. A Soxhlet Extraction unit was used for oil extraction where hexane was refluxed for 6 h for a given amount of karnel mass.

2.3. Biodiesel preparation from oil

2.3.1 Acid catalysed transesterification

Biodiesel from non-edible oil was prepared

by acid catalyzed transesterification reaction (De B.K. and Bhattacharyya, 1999). The reaction was carried out at 70 °C and atmospheric pressure under reflux for 18 hours with vigorous stirring. Typically 50 gm of oil sample were placed in a three-necked 250 ml round bottom flask equipped with a reflux condenser. The flask was placed in an electric heater with a temperature controller and magnetic stirrer. Concentrated sulfuric acid (2 wt % of oil) was mixed in required amount of methanol. Methanol was used 9:1 molar ratio to oil. The methanesulfonic acid solution was transferred into the reaction flask. After 18 hours, the contents were cooled to room temperature. After the reaction period, the reaction product was allowed to stand 2-3 hours in a separatory funnel. Two separate layers were observed. Upper layer was methyl ester (Biodiesel) and lower layer were a mixture of crude glycerin and lye catalyst. The Biodiesel layer was separated and this layer was opaque as it contained some catalyst, methanol and triglyceride. For purification of the biodiesel given water wash. For this purpose hot water and biodiesel mixed together in separatory funnel and shaking. Then allow stand for phase separation. Water is heavier than biodiesel and absorbs the excess alcohol, catalyst and impurities. After washing and settling, the water and the impurities in the water are drained from the bottom of the separatory funnel. Several wash cycle are generally needed. The first washed water drained from funnel will be milky, and the final washed water drained off will be clear. The washed biodiesel was then dried at 80-100 °C under vacuum.

2.3.2 Two step method

A two-step acid-catalyzed methanolysis of higher FFA containing oil was adopted for the conversion of FFA and TG to fatty acid methyl esters (Zullaikah et al 2005). In brief, in the first step esterification was carried out at 60 °C and atmospheric pressure with a molar ratio of methanol/FFA as 5/1. Sulfuric acid (2 wt% of oil) was used as catalyst and reaction was carried out for 2 h. After 2 h the contents were cooled to room temperature and reaction product was washed with hot water in a separatory funnel until clear water found and dried under vacuum at 100 °C for 20 min. In the second step acid catalyzed transesterification (2 wt% sulfuric acid) with oil/methanol molar ratio of 1/9. The methanolysis was performed under vigorous stirring at 100 °C. After 6 h the contents were cooled to room temperature, and reaction product was washed with hot water until clear water found. The organic phase was collected and dried under vacuum at 100 °C for 30 min.

2.3.3 Three-step method

In this method the raw seed oil was saponified, acidified and esterified sequentially. Saponification was carried out for 30 min with different stoichiometric amount of alcoholic sodium hydroxide solution at 60 °C (Islam et. al., 2008). In further study saponification of oil was done by aqueous calcium oxide solution. The reaction time and molar ratio of oil to calcium oxide were optimized.

After saponification, the soap solution were treated with different stoichiometric amount of concentrated hydrochloric acid at a temperature of 60 -70 °C with vigorous stirring. After dissolving the soap the fatty acid contents were separated in separatory funnel. The fatty acid content was determined by titrimetric method.

Esterification of FFA was carried out as similar the first step of the two-step method. The molar ratio of FFA to methanol, catalyst concentration and reaction temperature were optimised. The biodiesel was washed and dried under vacuum.

2.4. Analytical Methods for Oil and Biodiesel

FFA in the oil and biodiesel samples was analyzed by the method described in AOCS Aa 6-38. Saponification value (SV) was determined by the method described by Jeffery *et al.*. The iodine value (IV) were determined by titrating 0.01 N sodium thiosulfate to the mixture of tested fuel and chemical reagents until the disappearance of the blue color based on the analysis methods of American Oil Chemist's Society.

Physical properties such as color, moisture content, density and calorific value of the oil were determined by following ASTM D 1500, ASTM D 1744 (Karl fisher method), ASTM D 1480/81 and ASTM D 240 respectively. Boiling point was determined by using the variable heating instrument, Gallanclamp, Germany. Viscosity, flash point, pour point and cloud point were determined by standards ASTM D445, ASTM D 93 (Pensky-Martens Flashpoint Apparatus, Lazer Scientific Inc, Germany), ASTM D 2500 and ASTM D 97 respectively.

3. RESULT AND DISCUSSION:

3.1: Extraction of oil and Characterization:

The oil was extracted from the seed by different methods and the oil content in the seed presented in Table 1.

Table 1: Oil contents in nahor and rubber seed by different methods

Seed	Press	Cold percolation	Press with solvent	Sohxlet
	wt. %	wt. %	wt. %	wt. %
Nahor Seed	39	44	52	54
Rubber Seed	5	42	49	52

Properties of raw oil are given in Table 2.

Table 2: Properties of raw oil.

Properties	Nahor seed oil	Rubber seed oil
Physical state	Liquid	Liquid
Color	Brown	Brown
Specific gravity at 25°C	0.926	0.88
Viscosity, mm ² /s at 25°C	58.06	33
FFA wt. %	12.17	45
Average molecular weight of FFA (gm/mol)	275.5	278.12
Molecular weight of oil (gm/mol)	864.5	875.36
Saponification value (mg of KOH/gm of oil)	249.33	213
Iodine value, g I ₂ /100 g oil	77	132.6
Cetane Index	50.87	45.25
Moisture content, wt. %	0.51-0.52	0.93-0.98

3.2. Preparation of biodiesel:

3.2.1. Biodiesel preparation by single step (transesterification) and two-step methods:

The properties of biodiesel for acid catalyzed transesterification reaction and two-step method are presented in Table 3. The final viscosity of the biodiesel by two-step method is lower than the single step acid catalyzed process. RSO yields poor results than the Nahor oil due to its high FFA content in the oil. The acid catalyzed single step process is time consuming and even after 18 h the viscosity of the biodiesel is not comparable with the standard biodiesel viscosity. However, there are some drawbacks in two-step process also. The second step, transesterification requires 6 h instead of 2 h reported by Zullaikh et al. And the final biodiesel viscosity is higher than the standard value (Table 3)

Table 3: Properties of Acid catalyzed transesterification and two-step method products

Property	Transesterification		Two-step	
	NSO	RSO	NSO	RSO
Color	Black	Dark brown	Black	Dark brown
Viscosity (mm ² /s) at 22 °C	14.5	17.8	9.6	14.5

Saponification value (mg KOH/gm oil)	211	203	212	202
FFA (wt%)	2.12	14.5	0.65	6.2
Specific gravity	0.89	0.86	0.89	0.9

3.2.2. Three-step method for biodiesel Preparation:

FFA was prepared from oil by Saponification of oil followed by acidification mentioned above. The results are represented in Fig. 1. From Fig. 1, it can be seen that the optimum molar ratio of sodium hydroxide to oil was 1:6 for both nahor oil and RSO. Further increase in the molar ratio of NaOH to oil the conversion of oil to soap remain unchanged.

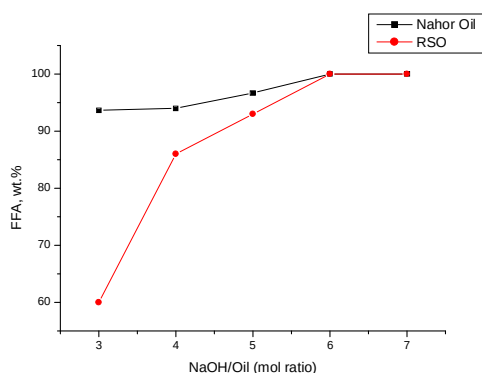


Fig.1: Preparation of Free Fatty Acid (FFA) from oil through saponification and acidification by different stoichiometric molar ratio of alcoholic NaOH solution [T = 60 °C, Time=30 min].

In further study, saponification was carried out by aqueous calcium oxide solution and FFA prepared from nahor oil. The results are shown in Fig 2.

As shown in Fig. 2, the optimum molar ratio of oil to calcium oxide was 1:2 for nahor oil and time was 1 hour.

FFA obtained from oil was subjected to esterification to convert biodiesel. The reaction was carried out with different FFA/methanol molar ratio in presence of catalyst (HCl). Effect of FFA/Methanol molar ratio was investigated at 60 C and 5 wt% of catalyst. The results are presented in Fig. 3. The maximum conversion of FFA to methyl ester was found for FFA/ methanol molar ratio of 1:6 after 120 minutes for both oil and for nahor oil conversions were 97.2% and 98.15% for nahor oil and RSO respectively. Further increase in molar ratio of alcohol to FFA the conversion of FFA and viscosity remain unchanged.

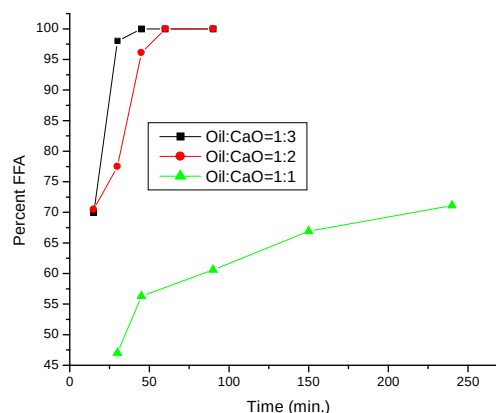


Fig 2: Preparation of FFA from nahor oil through saponification and acidification by different stoichiometric molar ratio of calcium oxide to oil in aqueous solution [T = 100°C, under reflux with vigorous stirring].

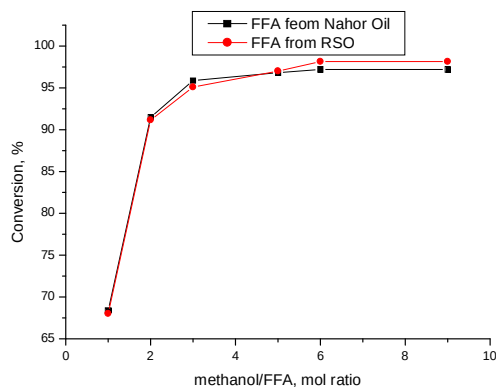


Fig. 3 : Conversion of FFA to biodiesel at different FFA/ methanol molar ratio for nahor oil derived FFA and RSO derived FFA [Reaction temp. 60°C, Catalyst concentration 5.0% wt of FFA, vigorous stirring, Reaction time 120 min].

Effect of Catalyst Concentration was studied at FFA/methanol molar ratio of 1:6 at 60 C and the results are presented in Fig. 4 a and b.

Fig 4 shows that around 98 % conversion of FFA can be achieved by 5 wt% catalyst concentration. Further increase in catalyst concentration has no impact on FFA conversion.

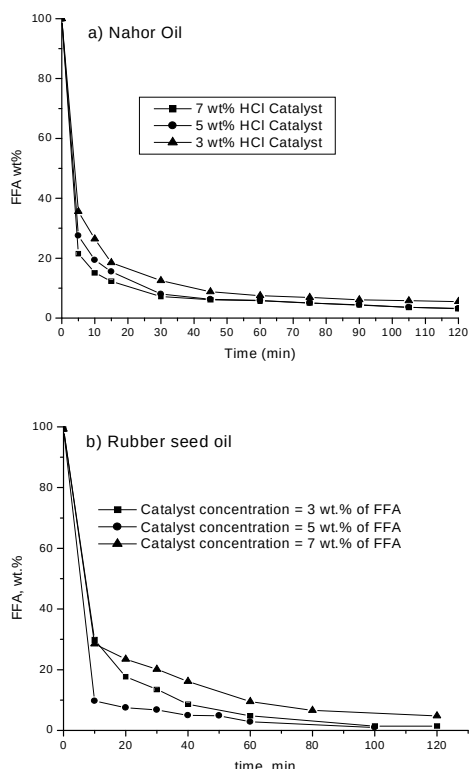


Fig 4: Effect of catalyst concentration on esterification reaction [T = 60°C, FFA / methanol ratio 1:6, vigorous stirring, Reaction time 120 min].

Effect of Temperature on esterification reaction was studied with Nahor oil derived FFA. The results are presented in Fig 5. It can be seen that the temperature has a significant effect on the conversion of esterification reaction. As the temperature increased, the conversion was also increased..

3.4 Properties of biodiesel:

Some of the important quality parameters of biodiesel (viscosity, density, flash point, cloud point, pour point, calorific value, FFA content, copper strip corrosion etc.) are shown in Table 4. Physical properties of biodiesel were compared with standard biodiesel properties. All of the measured values were in the range of standard biodiesel values except the FFA content which was found higher in the biodiesel prepared by three-step method. But as the copper strip corrosion test showed non corrosive nature of the biodiesel, it can be safely used in the diesel engine.

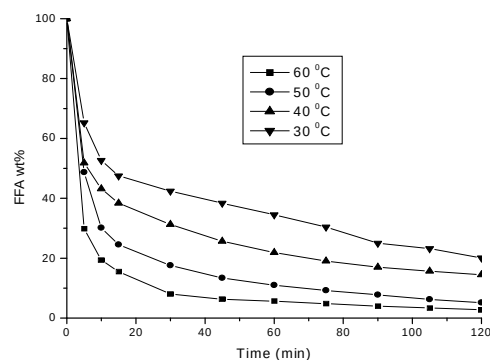


Fig. 3.5: Effect of Temperature on esterification reaction for nahor oil [FFA / methanol ratio 1:6, Catalyst (HCl) 5.0% wt of FFA, vigorous stirring, Reaction time 120 min]

4. CONCLUSION:

Biodiesel has been prepared from nahor oil and rubber seed oil by acid catalyzed transesterification reaction, two-step method and three-step methods. Among these methods transesterification is best because it requires fewer amounts of equipment and investment. But base catalyzed transesterification is not used for the preparation of biodiesel from Nahor and Rubber seed oil because of their high FFA content. Acid catalysed transesterification reaction was done for the preparation of biodiesel from both nahor oil and Rubber Seed oil. The viscosity of oil reduces from 58.06 mm²/s to 14.55 mm²/s and FFA reduces 12.17% to 2.12% for Nahor Oil and 33 mm²/s to 12.00 mm²/s and FFA 45% to 8.5% for Rubber Seed Oil after 18 h of reaction. The product was not used as biodiesel because of its higher viscosity and FFA and the process was time consuming. Acid catalysed two-step method was performed for the preparation of biodiesel from both oil. The viscosity of Nahor oil reduces from 58.06 mm²/s to 9.64 mm²/s which was slightly higher than biodiesel standard. FFA of the oil reduces from 12.17% to 0.64% and for Rubber Seed oil Viscosity changes from 33 mm²/s to 14.5 mm²/s and FFA 45% to 6.2%.

Three-step method, where FFA was produced by saponification and acidification of oil and thereafter Biodiesel was produced by esterification of FFA, showed comparable biodiesel properties and similar optimum conditions for both oil. Hence three-step method can be used for biodiesel production from nonedible mixed feed stocks.

Biodiesel properties was measured by standard methods and compared with the standard biodiesel properties.

Table 4: Properties of biodiesel produced by three-step method

Properties	Biodiesel from Nahor oil	Biodiesel from Rubber seed oil	Biodiesel Standard Value (Balat et. al)
Density at 15 °C (Kg/L)	0.89	0.85	0.878
Cetane Index (Calculated)	45.4	46.5	-
Pour point (°C)	9	6	-15 to 10
Copper Strip Corrosion (3 hours at 100 °C)	Non corrosive	Non corrosive	Non corrosive
Flash point (°C)	162	120	100-170
Fire point (°C)	200	180	-
Kinematic Viscosity (mm ² /s) at 38°C	6.64	4.5	1.9-6.0
FFA wt%	2.80	1.85	Trace
Water content, % vol.	0.10	0.08	0.05
Calorific value (Gross Kcal/Kg)	9364	8520	10156
Saponification value (mg KOH/gm oil)	204.7	202.3	-
Iodine value	81.29	75.2	-
Free glycerol, % wt.	Nil	Nil	0.02 max.
Total glycerol, % wt.	Nil	Nil	0.24 max.

5. ACKNOWLEDGEMENT

The financial support from the research grant of University Grants Commission (UGC) of Bangladesh for conducting this research work and ERL for providing their facility for biodiesel properties measurement.

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CRISPR MAY GIVE IMPORTANT INFORMATION WHICH CAN BE BENEFICIAL IN MOLECULAR BIOLOGY AND BIOTECHNOLOGY STUDY.

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CRISPRs (Clustered Regularly Interspaced Short Palindromic Repeats) are sites containing multiple short direct repeats found in the genomes of approximately 40% of bacteria and 90% of archaea. CRISPR functions as a prokaryotic immune system, in that it confers resistance to exogenous genetic elements, such as plasmids and phage. Here I found some interesting and important information by searching the CRISPR database (<http://crispr.u-psud.fr/crispr/>). I found high **CRISPR** ratio in thermo stable bacteria which may confer resistance from heat by these **CRISPRs** and some **CRISPR** found in plasmid DNA of bacteria which confer transformation to other bacteria, we can use these as a medium of transfer resistance to other bacteria which is needed in different biological process. I also found some info about different species of bacteria which have high **CRISPRs** is pathogenic in nature.

Keywords: CRISPR, Thermophile, Plasmid, Immune System, Phage

1. INTRODUCTION

The clusters of regularly interspaced short palindromic repeat (CRISPR)-based defense system protects many bacteria and archaea against invading conjugative plasmids transposable elements and viruses. Resistance is acquired by incorporating short stretches of invading DNA sequences in genomic CRISPR loci. These integrated sequences are thought to function as a genetic memory that prevents the host from being infected by viruses containing this recognition sequence (Fig 1).

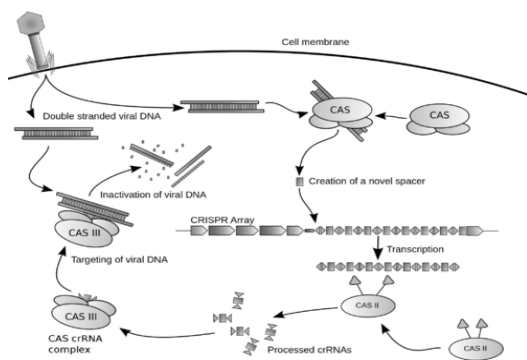


Fig 1: CRISPR possible mechanism.

CRISPR may give some important information about the bacteria and archaea. How this work against other organism. Here different CRISPR related info is analyzed.

This information can be used for further research on CRISPR and may be used in different purpose biotechnology.

2. METHODS AND MATERIALS

I access CRISPR database to do this work. The Web address is (<http://crispr.u-psud.fr/crispr/>). Then analyze my data.

3. RESULTS

I found some interesting information from CRISPR database.

3.1 CRISPR in *Clostridium* genus

Clostridium is a genus of Gram-positive bacteria, belonging to the Firmicutes.

Clostridium consists of around 100 species which include common free-living bacteria as well as important pathogens; there are four main species responsible for disease in humans:

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C. botulinum, an organism producing a toxin in food/wound that causes botulism. (Baron S et al., eds1996)

- *C. difficile*, can overgrow other bacteria in the gut during antibiotic therapy and cause pseudomembranous colitis.(Baron S et al., eds.1996)
- *C. perfringens*, formerly called *C. welchii*, causes a wide range of symptoms, from food poisoning to gas gangrene
- *C. tetani*, the causative organism of tetanus(Baron S et al., eds,1996). The name derives from "of a tension", referring to the tension (caused by tetanus) in the muscles
- *C. sordellii* has been linked to the deaths of more than a dozen women after childbirth

I found almost every organism belongs to this genus in database have CRISPR (Fig 2).

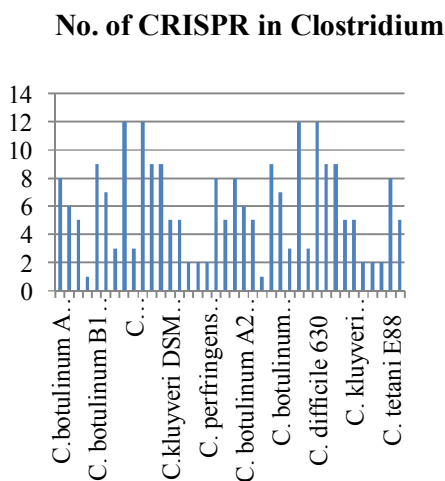


Fig 2: Different clostridium spp. is presented with its CRISPR

3.2 CRISPR in plasmids:

Mainly CRISPR is situated in chromosomal DNA but there are some bacteria whose plasmids have CRISPR in it (Table 1).

Table 1: CRISPR in plasmid

Plasmid	CRISPRs
Rhodothermus marinus DSM 4252 (plasmid pRMAR01)	7
Aquifex aeolicus VF5 (plasmid ece1)	1
Azoarcus sp. EbN1 (plasmid 1)	2
Clostridium botulinum B1 str. Okra (plasmid pCLD)	4
Clostridium botulinum Ba4 str. 657 (plasmid pCLJ)	1
Thermus thermophilus HB27 (plasmid pTT27)	8
Clostridium botulinum A3 str. Loch Maree(plasmid pCLK)	5
Thermus thermophilus HB8 (plasmid pTT27)	9
Clostridium botulinum B1 str. Okra (plasmid pCLD)	4
Clostridium botulinum Ba4 str. 657 (plasmid pCLJ)	1
Thioalkalivibrio sp. K90mix (plasmid pTK9001)	1

3.3 High CRISPR:

There are different bacteria which have high CRISPR. Here is some description about some bacteria and archaea which have high CRISPR.

1. **Methanocaldococcus** is a genus of the Methanocaldococcaceae-mesophile

2. **Pyrococcus**-*Pyrococcus* has similar characteristics of other archaea such as Archaeoglobus, Thermoautotrophican, and Methanococcus in the respect that they are all thermophile and anaerobic. *Pyrococcus* differs, however, because its optimal growth temperature is nearly 100 °C and dwells at a greater sea depth than the other archaea. Studying *Pyrococcus* helps give insight to possible mechanisms used to endure extreme environmental conditions like high temperatures and high pressure.

3. Thermobifida-*Thermobifida fusca*, formerly known as *Thermomonaspora fusca*, is a rod shaped; thermophilic organism found in decaying organic matter and is a major degrader of plant cell wall.

4. Thermotogales: Thermotogales are extremely thermostable and therefore useful for many industrial processes such as in chemical and food industries (R. Huber *et al.*, 2004).*Thermotoga* enzymes are known for being active at high temperatures.

Table 2: High CRISPR in different bacteria and archaea

Bacteria	No of CRISPR
Methanocaldococcus:	
Methanocaldococcus fervens AG86	8
Methanocaldococcus infernus ME	14
Methanocaldococcus jannaschii DSM 2661	20
Methanocaldococcus sp. FS406-22	23
Methanocaldococcus vulcanius M7	20
Pyrococcus:	
Pyrococcus abyssi GE5	4
Pyrococcus furiosus DSM 3638	7
Pyrococcus horikoshii OT3	6
Thermobifida	
Thermobifida fusca YX	14
Thermotoga	
Thermotoga maritima MSB8	8
Thermotoga naphthophila RKU-10	8
Thermotoga neapolitana DSM 4359	8
Thermotoga petrophila	8
Thermotoga sp. RQ2	8

Here is a graphical representation of *Methanocaldococcus* spp and it's CRISPR (Fig 3).

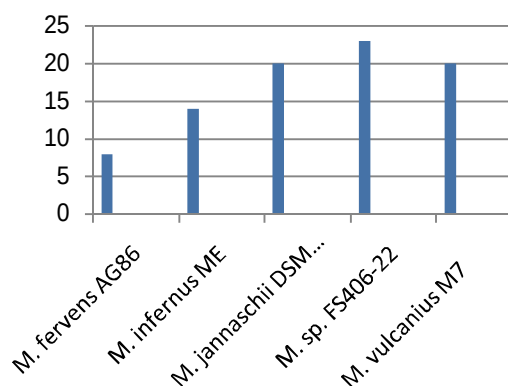


Fig 3: Some *Methanocaldococcus* spp. is shown with its CRISPR

3.4 Thermo stable bacteria also have CRISPRs in there sequence:

The bacteria states below are thermo stable bacteria and all have CRISPR on its sequence (Table 3).

Table 3: Thermo stable bacteria with its CRISPR

Bacteria	CRISPRs
Thermincola sp. JR	7
Thermoanaerobacter italicus Ab9	4
Thermoanaerobacter mathranii subsp. mathranii str. A3	3
Thermoanaerobacter pseudethanolicus ATCC 33223	7
Thermoanaerobacter sp. X514	4
Thermoanaerobacter tengcongensis MB4	3
Thermoanaerobacterium thermosaccharolyticum DSM 571	5
Thermobaculum terrenum ATCC BAA-798	5
Thermobispora bispora DSM 43833	6
Thermobifida fusca YX	14

Bacteria	CRISPRs
Thermodesulfovibrio yellowstonii DSM 11347	5
Thermocrinis albus DSM 14484	5
Thermomonospora curvata DSM 43183	15
Thermosediminibacter oceani DSM 16646	6
Thermosipho africanus TCF52B	12
Thermosipho melanesiensis BI429	5
Thermotoga maritima MSB8	8
Thermotoga naphthophila RKU-10	8
Thermotoga neapolitana DSM 4359	8
Thermotoga petrophila	8
Thermotoga sp. RQ2	8
Thermus thermophilus HB27	10
Thermus thermophilus HB8	11

4. DISCUSSION

Clostridium is a genus of Gram-positive bacteria. They are obligate anaerobes capable of producing endospores. Here I see this highly pathogenic bacteria have CRISPR which may give the organism much protection from being attack by other organism. This may confer the pathogenicity.

Here there are different bacteria which have CRISPR in their plasmid, which may use as a biotechnology tool. Because we can transfer this plasmid from one bacterium from another and can construct a novel bacteria which may give different function along with resistance against different phage.

High CRISPR level gives high versatility in bacteria. Here seen that the bacterium gives protection to itself by CRISPR.

The specific type of bacteria listed here which have high CRISPR mainly thermo stable. So we can use these bacteria in different important purpose where temperature does harm.

5. CONCLUTION

In conclusion it can be said that CRISPR is an important bioinformatics tool which can be used in different biotechnological application.

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DETERMINATION OF MASS TRANSFER COEFFICIENT: A LABORATORY DEMONSTRATION

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A laboratory demonstration of determination of mass transfer coefficient was developed using aeration of water. The demonstration was designed to provide both conceptual and practical insight of the mass transfer process. A bubble column fitted with a sieve tray was used to carry out the experiment. The air flow rate and hole size of the sieve tray were varied. Mass transfer coefficient was obtained from the initial and final oxygen concentrations of the aerated water. A dimensionless correlation for mass transfer coefficient in terms of the experimental variables was developed by dimensional analysis and regression of the experimental data.

Key words: Mass transfer coefficient; aeration; bubble column; dimensional analysis; Stanton number

1. INTRODUCTION

Although diffusional mass transfer is of common interest in physics, physical chemistry, biology etc., the concept of mass transfer coefficient is developed explicitly in chemical engineering. A chemical engineering graduate is expected not only to have clear understanding of the concept but also to be comfortable in applying it in diversified fields. Several mass transfer experiments are currently used in the unit operations laboratories of chemical engineering departments in different universities. It is unfortunate that undergraduate laboratories of chemical engineering all over the world is generally lacking in experimental facilities that demonstrates the concept of mass transfer coefficient adequately. A typical chemical engineering laboratory has either a distillation or an absorption column and a diffusion cell with membrane separator. The distillation/absorption column is used to demonstrate tray or packing efficiency and at times to exercise the column control. The diffusion cell, on the other hand, demonstrates diffusion phenomenon and measurement of diffusivity. The notion of mass transfer coefficient is missing from these experimental demonstrations.

Therefore, efforts to build customized experimental set-up are going on to meet the requirement. A number of inexpensive and simple experiments in mass transfer are reported in articles published in Chemical Engineering Education. Nirdosh and Baird (1996-2001)

described a series of low cost experiments in mass transfer exploring phenomena of liquid-liquid extraction, gas absorption, vapor diffusion and natural convection. Kwon et al (2002) and Mohammad (2000) have developed experiment to measure binary molecular diffusion and molecular diffusivity. Chawla and Pourhashemi (2004) reported an experimental set-up using both de-oxygenation and aeration to demonstrate the mass transfer phenomenon.

In the present paper our target is to set up a tailored experiment for undergraduate laboratory that can enable students to comprehend both theoretical and applied side of inter-phase mass transfer and mass transfer coefficient. This involves building a simple and easy to maintain experimental rig for demonstrating measurement of mass transfer co-efficient and effect of different parameters on it. A basic mass transfer correlation is also developed using the measured values and a method called dimensional analysis as an essential part of the experiment. The formulation of the experiment is inspired by the aeration set-up suggested by Cussler (1997). Aeration is a frequently used industrial process, particularly as fermentors and in sewage treatment; and is directly relevant to chemical engineering jobs.

This paper describes the experimental set-up, procedure and development of the dimensionless correlation in detail. It also discusses the limitations of the demonstration.

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2. EXPERIMENTAL SET-UP AND MEASUREMENT OF MASS TRANSFER COEFFICIENTS

The aeration process was studied by injecting air into water for a certain period of time and measuring the oxygen concentration of the water before and after the aeration. A glass column of 50.8 mm diameter and 600 mm height was built to carry out the aeration experiment. The column was fitted with a sieve tray at the bottom. A manometer was attached to one of the holes of the sieve tray to measure the clear liquid height on the tray. The schematic of the setup is shown in figure 1. At first, the column was filled with 500 ml water. Prior to the experiment, the dissolved oxygen of the feed water, denoted by c_{I0} , was measured by a DO meter.

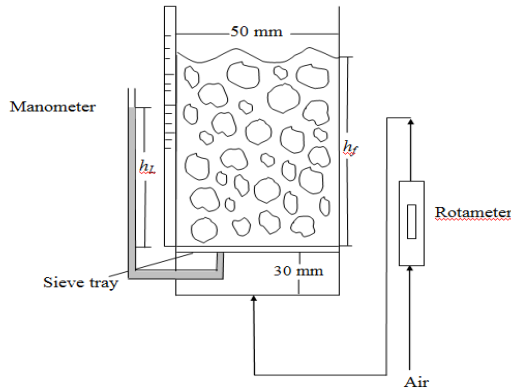


Fig. 1: Experimental arrangement for aeration

Air from a compressor was passed into the water through the sieve tray acting as a sparger. There is a 30 mm gap between the air inlet and the sieve tray to allow uniform distribution of air over the column cross sectional area. A Rota-meter was used to measure the air flow rate. The flow time was 5 minutes for each experiment. At the end of experiment the aerated water was collected by the drainage valve and concentration of dissolved oxygen of the water, denoted by c_{If} , was measured. The experiments were carried out at atmospheric condition (at 29°C and 1 atm). Table 1 summarizes different parameters of the experiment.

A mass balance on the aerated water was done to get the expression for mass transfer coefficient;

$$\frac{dVc_1}{dt} = AN_1 = k(c_{1,sat} - c_1) \quad (1)$$

$$\frac{dc_1}{dt} = k \frac{A}{V} (c_{1,sat} - c_1) = ka(c_{1,sat} - c_1) \quad (1a)$$

Here, A is the interfacial area of mass transfer i.e. total bubble ares, z is the clear liquid height, k is the mass transfer coefficient, a is the total bubble area per unit volume of liquid, c_1 is the concentration of the dissolved oxygen in water and $c_{1,sat}$ is the saturated concentration of the dissolved oxygen in water at atmospheric temperature.

The boundary conditions for equation (1) are

at $t = 0$ $c_1 = c_{I0}$ and

at $t = 5$ min $c_1 = c_{If}$

By integrating equation (1) between the boundaries we get

$$\int_0^5 kadt = \int_{c_{I0}}^{c_{If}} \left(\frac{dc_1}{c_{1,sat} - c_1} \right) \quad (2)$$

$$\Rightarrow ka = -\frac{1}{5} \ln \left(\frac{c_{1,sat} - c_{If}}{c_{1,sat} - c_{I0}} \right) \quad (3)$$

In present study different air velocities and sieve trays with different hole sizes were used and corresponding ka were calculated from c_{I0} and c_{If} data using equation (3).

Table 1. Experimental conditions for aeration

Diameter of the bubble column	50.8 mm
Volume of each solution	500 ml
Diameter of single orifice	3, 3.5 and 4 mm
Number of orifices	20
Air flow rate	4,6,8,10 and 12 lit/min
Aeration time	5 min
Initial oxygen content of the feed water	2.85 mg/lit at 25°C
Oxygen content of saturated water	8.38 mg/lit at 25°C

For better result, k and a should be measured independently. The product of ka is measured to avoid the uncertainty and difficulties arise in individual measurement of k and a .

3. DEVELOPMENT OF DIMENSIONLESS CORRELATION

The method dimensional analysis is frequently used in describing transport phenomena, i.e. mass transfer, momentum transfer, heat transfer etc and a useful tool for engineers in general. Mass transfer modeling is traditionally done by

dimensional analysis. The accuracy of a dimensional analysis is dependent on proper identification of the factors affecting the phenomenon. In this demonstration the main experimental variables are bubble velocity, v , bubble diameter, d , liquid density, ρ , liquid height, z and viscosity, μ . Thus, ka can be expressed as a function of five factors

$$ka = ka(v, \rho, \mu, d, z) \quad (4)$$

The function is assumed to have the following form

$$ka = C v^a \rho^\beta \mu^\gamma d^\delta z^\kappa \quad (5)$$

Here, the constant C and the exponents a, β, γ, δ and κ are dimensionless.

From dimensionless analysis the following equation is obtained

$$\frac{kad}{v} = C \left(\frac{dv\rho}{\mu} \right)^{-\gamma} \left(\frac{z}{d} \right)^\kappa \quad (6)$$

The left hand side of equation (6) is a type of Stanton number whereas the first term in parentheses on the right hand side is Reynolds number and the second term is a measure of column's depth. The next step of the correlation development is to determine the constant C and the exponents γ and κ . By taking $\ln$ on both sides of equation (6) we get

$$\ln \left(\frac{kad}{v} \right) = \ln C - \gamma \ln \left(\frac{dv\rho}{\mu} \right) + \kappa \ln \left(\frac{z}{d} \right) \quad (7)$$

In this demonstration the bubble diameter is considered to be independent of velocity. Therefore, if the sieve tray is kept fixed and air

flow rates were varied, the plot of $\ln \left(\frac{kad}{v} \right)$ vs

$\ln \left(\frac{dv\rho}{\mu} \right)$ will produce a straight line with slope -

γ and intercept $\left(\ln C + \kappa \ln \left(\frac{z}{d} \right) \right)$.

Furthermore, equation (7) can be rearranged to get the value of κ as follows

$$\ln \left[\left(\frac{kad}{v} \right) \times \left(\frac{dv\rho}{\mu} \right)^\gamma \right] = \ln C + \kappa \ln \left(\frac{z}{d} \right) \quad (8)$$

According to equation (8), a plot of

$\ln \left[\left(\frac{kad}{v} \right) \times \left(\frac{dv\rho}{\mu} \right)^\gamma \right]$ against $\ln \left(\frac{z}{d} \right)$ will form a

straight line with slope κ and intercept $\ln C$.

4. DETERMINATION OF THE EXPONENTS AND THE CONSTANT

In order to determine the exponents and constant C , aeration was done with sieve trays of three hole sizes and five air flow rates. The ka values were estimated with the initial and final concentrations of oxygen of the aerated water using equation (1). Table 2 presents the calculated values of ka for different runs.

Table 2. ka values for different operating conditions

Hole diameter (mm)	Air flow rate (lit/min)	ka (s ⁻¹)
3	4	2.0833×10^{-3}
	6	2.1631×10^{-3}
	8	2.3045×10^{-3}
	10	2.5028×10^{-3}
	12	2.0721×10^{-3}
3.3	4	1.1812×10^{-3}
	6	1.5439×10^{-3}
	8	1.5824×10^{-3}
	10	1.8866×10^{-3}
	12	1.6509×10^{-3}
4	4	1.1385×10^{-3}
	6	1.2506×10^{-3}
	8	1.3215×10^{-3}
	10	1.3667×10^{-3}
	12	1.2859×10^{-3}

The bubble diameter, d and bubble velocity, v were estimated by the following equations;

$$d = 1.27 \left(\frac{D_H \sigma}{g(\rho_l - \rho_g)} \right)^{1/3} \quad (9)$$

$$v = 25 V^{1/6} + U_s \quad (10)$$

Here, U_s is the superficial velocity of air, D_H is the hole diameter of the sieve tray, V is the bubble

volume and σ is the surface tension of water. The parameters $\left(\frac{kad}{v}\right), \left(\frac{dvp}{\mu}\right)$ were calculated using the ka, d and v values. Figure 2 and 3 present the plot of $\ln\left(\frac{kad}{v}\right)$ versus $\ln\left(\frac{dvp}{\mu}\right)$ and $\ln\left[\left(\frac{kad}{v}\right) \times \left(\frac{dvp}{\mu}\right)^\gamma\right]$ versus $\ln\left(\frac{z}{d}\right)$, respectively.

The linear regression lines are also shown in the figures. The constant and exponents of equation (6) obtained from the slope and intercepts of the regression lines are shown in Table 3.

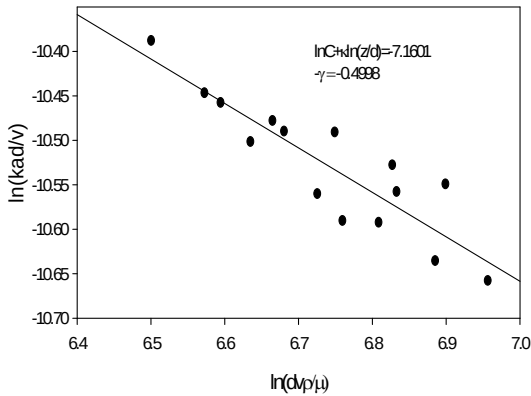


Fig. 2: Plot of $\ln\left(\frac{kad}{v}\right)$ versus $\ln\left(\frac{dvp}{\mu}\right)$

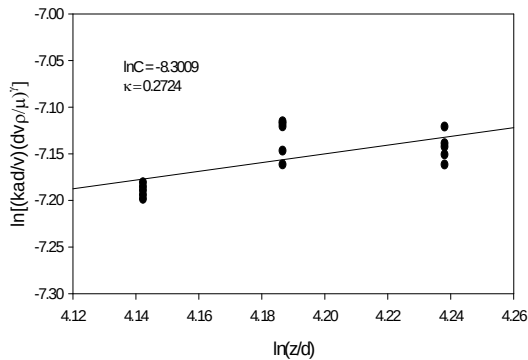


Fig. 3: Plot of $\ln\left[\left(\frac{kad}{v}\right) \times \left(\frac{dvp}{\mu}\right)^\gamma\right]$ versus $\ln\left(\frac{z}{d}\right)$

Table 3. Exponents and constant obtained from regression analysis

γ	κ	C
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0.4998	0.2724	2.5×10^{-4}
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5. RESULTS & DISCUSSION

The experimental values of ka varied from 1.1385×10^{-3} to 2.5×10^{-3} per sec, which are within the typical range of mass transfer coefficient in liquids. The correlation gives ka as a function $v^{0.5}$, which is also within the acceptable range as the exponent to v in the existing correlations of ka varies from 0.2 to 0.6 for liquid system (Cussler, 1997).

In this demonstration it is also important to appreciate the sources of error in the measurement as well as the shortcomings of dimensional analysis. For example, low airflow rate leads to weeping through the sieve tray. This affects the measurement of liquid height, z and dissolved oxygen of the aerated liquid, c1f. Furthermore, fluctuation in air flow introduces error in measurement by affecting the bubble diameter and bubble velocity. These can be minimized by keeping the flow rate high enough to avoid weeping and by introducing an intermediate storage tank between the compressor and the air inlet to the column to stabilize the fluctuation of air flow.

Furthermore, the variables considered in the dimensional analysis are not exhaustive. ka may vary with tank diameter, sparger shape or surface tension of the liquid. This will change the form of the correlation developed as equation (6). In this demonstration, the clear liquid height, z was kept fixed and z/d were varied by varying the hole diameter of the sieve tray. A better estimation may be obtained by varying the liquid height, z . Besides, equation (9) does not include effects of hole velocity on bubble diameter, which is not always the fact. Bubble diameter may be directly obtained by image processing instead of calculating from other parameters.

6. CONCLUSIONS

In this work, aeration of water was studied to demonstrate mass transfer coefficient measurement in the undergraduate laboratory of chemical engineering. The product of mass transfer coefficient and total bubble area per column volume, ka were measured experimentally. A correlation was developed by dimensional analysis to express ka in terms of the experimental variables. This demonstration is

unique as it offers a simple and easy to maintain experimental procedure at the same time provides both conceptual and practical understanding of mass transfer coefficient, its measurement and prediction. Lastly, the developed correlation i.e. equation (6a) may be used to optimize design and operating parameters of industrial aeration process.

NOMENCLATURE

a	total bubble area per liquid volume, cm^2/cm^3
A	cross sectional area of the column, cm^2
c_l	oxygen concentration of the aerated water mg/cc
$c_{l(sat)}$	saturation oxygen concentration of the water, mg/cc
C	Constant in equation (6)
d	bubble diameter, cm
D_H	sieve diameter, m
k	mass transfer coefficient, cm/s
U_s	superficial velocity, cm/s
v	superficial velocity of air, cm/s
V	volume of bubbles, cm^3
z	clear liquid height, cm

Symbols

γ, κ	exponents in equation (6)
μ	viscosity, g/cm-s
ρ_g	density of air, g/cc
ρ_l	density of water, g/cc
σ	surface tension of water, g/m-s

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DEVELOPMENT OF ACIDIC MESOPOROUS HETEROGENEOUS CATALYST FOR THE BIODIESEL PRODUCTION FROM THE LIPID OF WASTEWATER SLUDGE

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Biodiesel, an attractive alternative to diesel fuel, is produced from renewable lipid sources via catalytic transesterification and/or esterification reaction. Heterogeneous acid catalysts are promising for the esterification-transesterification reaction to produce biodiesel from high free fatty acid containing lipid sources. Unlike homogeneous catalyst, these catalysts are environmentally propitious and can be easily recovered, regenerated and reused. In this study, the production of biodiesel from the lipid of wastewater sludge was studied through usage of a mesoporous heterogeneous catalyst; namely a mesoporous ordered silica, SBA-15, impregnated with heteropolyacid $\text{H}_3\text{PO}_4 \cdot 12\text{WO}_3 \cdot x\text{H}_2\text{O}$ (PW_{12}). The mesoporous material was synthesized following a similar procedure reported in literature (Speybroeck et al, 2009); however, a different silica source was used. Upon synthesizing, calcining and impregnating the SBA-15 with different percentage of the heteropolyacid, different analytical techniques including X-RD, BET surface analysis and scanning electron microscopy (SEM) were applied to characterize the prepared catalysts. Catalytic performances of the prepared catalysts were evaluated in a micro-reactor setup (Autoclave Engineers, division of Snap-tite, Inc., USA) under several different experimental conditions. The biodiesel yield for sample impregnated with 25% PW_{12} was 10.63 wt/wt% (on the basis of lipid) at temperature of 135°C, and pressure of 135psi for 3hours of reaction. Gas chromatograph was used to determine the yield and the quality of biodiesel.

Keywords: Biodiesel, mesoporous heterogeneous catalyst, nano materials, zeolitic materials

1. INTRODUCTION

Energy is an integral part of the society and plays a pivotal role in its socio-economic development by raising the standard of living and the quality of life. However, the majority of energy consumed worldwide comes from fossil fuel sources. Fossil fuel sources are non-renewable, and will be exhausted in the near future (Shafiee et al., 2009). Presently, there is an urgent need for alternative cheap and renewable energy resources with little or no environmental impact.

Extensive research is being conducted all over the world to produce fuels from renewable biomass. Biodiesel, a renewable liquid fuel produced from lipid sources, is one of the most attractive among the options explored for alternative energy sources. Biodiesel is a renewable, biodegradable, clean fuel.

It provides similar energy density to petro-diesel and can be used in most diesel engines in pure form (B100) or may be blended with petroleum diesel at any concentration. (Revellame et al. 2010; Knothe et al., 2005; Vyas et al. 2010; Siddiquee and Rohani, 2010; Xue et al., 2006]. However, the biodiesel production from pure vegetable oil is a major economic challenge as 70% and 85% of the overall biodiesel production cost is associated with the raw-materials (Revellame et al., 2010; Haas and Foglia, 2005; Mondala et al., 2009). Moreover, these raw-materials for biodiesel production compete with food materials. Alternative raw-materials like algae, waste cooking oil, wastewater sludge, non-edible oil like jatropha, castor, neem, karanja, etc are also being used for biodiesel production. However, presence of large amount of free fatty acid (FFA) is an obstacle for biodiesel production from non-edible sources.

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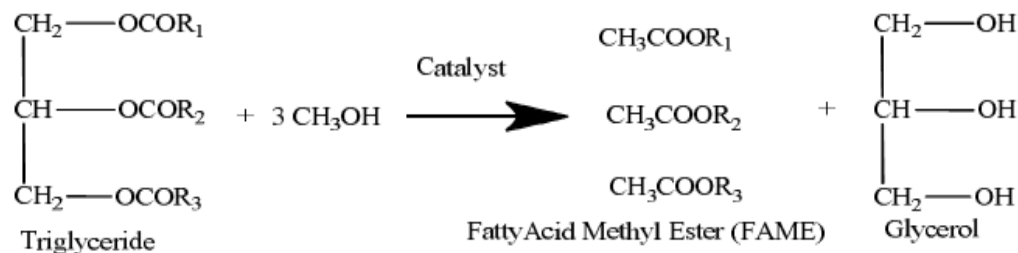


Fig. 1: Biodiesel production via transesterification of triglycerides

Chemically, biodiesel is fatty acid alkyl ester commonly known as fatty acid methyl ester (FAME), is mainly produced transesterification reaction (Fig. 1) of various lipid sources with alcohol in the presence of a base, acid, enzyme or heterogeneous catalyst. Base catalyst transesterification is very fast compared to other catalysts and widely used commercially. But, base catalyzed process is highly sensitive to the presence free fatty acids (FFA) as FFA reacts with catalyst and form soap that consume catalyst, inhibits glycerol separation and facilitate emulsion formation during washing step (Siddiquee and Rohani, 2010). Acid catalyzed transesterification requires high lipid to alcohol ratio and is slower than base catalyzed transesterification and (Demirbas, 2005). However, the main advantage of acid catalyst is the ability to catalyze both the esterification and transesterification to produce more biodiesel. As the presence of water can stop the reaction, this approach requires a water management technique.

Heterogeneous catalysts have shown greater promise toward transesterification to obtain biodiesel. The commonly used heterogeneous catalysts are Mg/La mixed oxide, S-ZrO₂ sulfated zirconia, KOH/Nax zeolite, Li/CaO, CaO, KI/Al₂O₃, (ZS/Si) zinc stearate immobilized on silicagel, KNO₃/ Al₂O₃, SO₄²⁻/TiO₂-SiO₂, etc. Heterogeneous catalysts can be recovered conveniently from reaction products (Vyas et al., 2010; Serio et al., 2008). The undesired saponification reactions can be avoided by using heterogeneous acid catalysts. This catalyst enables the transesterification of vegetable oils or animal fats with high contents of free fatty acid (FFA) (Garcia et al., 2008). Solid catalyst can be reused and provides the possibility for carrying out both transesterification and esterification reactions simultaneously (Lopez et al., 2005).

Wastewater sludge is being considered as potential feedstock for biodiesel production (Pokoo-Aikins et al., 2010; Uggetti et al., 2009; Jarde et al. 2005). Lipids are usually extracted from the sludge with organic solvents to avoid the interference and subsequently, biodiesel is produced from the extracted lipid. Approximately 17– 18 wt % lipids (on the basis of dry sludge) were extracted from dried sewage sludge by boiling solvent extraction using chloroform and toluene as solvents of which 65 wt % of the extracts were found to be free fatty acids and 7 wt % were glyceride fatty acids and 28 wt% were unsaponifiable material (Boocock et al., 1992). Pokoo-Aikins et al. separated the free fatty acids (FFA), triglycerides (oils) and the solvent from extracted lipids from sewage sludge by using toluene, hexane, ethanol, and methanol and found the yield of FFA was 24.8 wt%, 24.9 wt%, 25.5 wt%, 25.5 wt%, respectively. The maximum yield of triglyceride was 3.4 w% for all four solvents (Pokoo-Aikins et al., 2010).

In this study, the production of biodiesel from the lipid of wastewater sludge was studied through usage of a mesoporous heterogeneous catalyst; namely a mesoporous ordered silica, SBA-15, impregnated with different percentage of heteropolyacid H₃PO₄.12WO₃.xH₂O.

2. MATERIALS AND METHODS

2.1. Materials

P-123 and sodium bicarbonate were purchased from Sigma-Aldrich Inc. (St. Louise, MO, USA), sodium silicate was purchased from The PQ Corporation, USA. SuplecoTM standard 37component FAME mix- a 37 component reference mixture of fatty acid methyl ester in the range of C₄ to C₂₄ including saturated, mono-unsaturated and poly unsaturated FAME were purchased from Supleco (Bellefonte, PA, USA) and used to calibrate the GC for FAME analysis. HPLC- grade methanol and hexane were purchased from Caledon Laboratories Ltd. (Georgetown, ON,

Canada); sodium chloride was purchased from EM Science (Gibbstown, NJ, USA); anhydrous sodium sulphate was purchased from BDH Inc. (Toronto, ON, Canada). All the chemicals were used without any treatment.

2.2 Catalyst Preparation

Highly ordered mesoporous silica SBA-15, which was used as the catalyst substrate, was synthesized according to the procedure described in the literature (Speybroeck et al., 2009) with minor changes of the procedure. Briefly, 6 gram of triblock copolymer of Poly (ethylene glycol)-block-poly (propylene glycol)-block-poly(ethylene glycol) (i.e. PEG-PPG-PEG; P-123) with average molecular weight of $\sim 5,800$ was added to 180 ml of 2M HCl solution in a conical beaker. The mixture was vigorously mixed using a magnet stirrer at 35°C until all of the P-123 was dissolved (i.e. solution A). In another beaker, 15.5 g of sodium silicate solution (>27 wt.-% SiO₂) was diluted to 45 ml of deionized water (i.e. solution B). Then, solution B was added drop-wise to the solution A under vigorous stirring. Mixing of the resultant milky mixture was continued for 10 more minutes before switching to the static synthesis conditions of ageing at 35°C for 24 h. The SBA-15 mesoporous was crystallized at 100°C for 24 h under static condition. The SBA-15 product was

then cooled to ambient temperature and separated from supernatant by means of vacuum filter using appropriate filter paper, rinsed with extra amount of deionized water to remove unreacted silicon precursor, dried at 60°C in an electrical oven for 5 h. In order to remove the organic molecules of the p-13 surfactant from the SBA-15 pores, the product was calcined at 500°C for 5 h under a controlled heating and cooling rate. Schematic diagram of SBA-15 synthesis is illustrated in Fig. 2.

To prepare the solid acid as heterogeneous catalysts for biodiesel synthesis purposes, the mesoporous SBA-15 was loaded with different percentage of dodeca-tungstophosphoric acid (i.e. H₃PO₄.12WO₃.xH₂O) as a super-acid (i.e. heteropolyacid; HPA) by means of an “incipient wetness” impregnation method. To do this, appropriate amount of HPA (wt/wt%), which was corresponded to 5%, 15% and 25 % of HPA loading with respect to SBA-15 support, was dissolved in methanol to form a homogeneous solution. The HPA solution was then added the measured quantity of mesoporous substrate, while it was mixing using a magnet stirrer for 30 min. Later, the formed slurry was dried at 60°C and calcined at 170°C for 5 h under air atmosphere with controlled rate of heating and cooling.

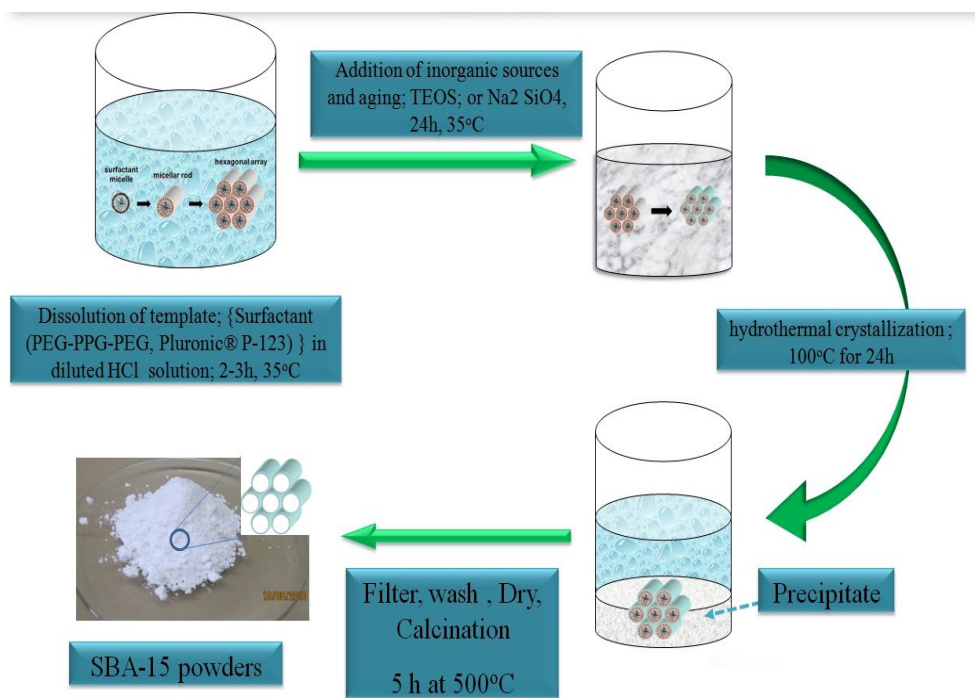


Fig. 2: General synthesis scheme for the ordered mesoporous silica SBA-15.

2.3 Extraction of lipid from sludge

The wastewater sludge, collected from Adelaide Pollution Control Plant, London, ON, Canada, was allowed to settle for 24 hours at 0°C and the supernatant liquid was discarded. The resulting sludge was then centrifuged using IEC Centra-HN centrifuge (International Equipment Company, Needham Heights, USA) for further dewatering. Dewatered sludge was spread on tray and put in a fume hood to dry under vacuum at ambient temperature. Dried sludge was crushed in a mortar and pestle, homogenized and then stored in a freezer prior to use.

The lipid was extracted from dried sludge by using methanol as a solvent. The dried sludge was weighed into a round bottom flask and methanol was added and then the resulting mixture was heated to the 70°C temperature at ambient pressure. A magnetic stirring bar was used for mixing and the loss of methanol due to evaporation was minimized by using a condenser with water at 20°C. After assigned extraction time (1 h), the resulting slurry was immediately filtered using VWR filter paper (size 5.5 cm) and a Buchner funnel attached to vacuum. Any residual particles were removed by centrifuging the lipid solution. The methanol was removed from the resulting supernatants under vacuum using a Büchi Rotavapor R-200 (Büchi Labortechnik, Switzerland) at 45°C and then flask was flushed with air to remove any remaining methanol in the gas phase. The resulting lipid was stored in refrigerator prior to use.

2.4 Biodiesel Production

Biodiesel was produced by using a micro-reactor (Autoclave Engineers, division of Snap-tite, Inc., USA) facilitated with a high temperature oil circulator (Julabo Labortechnik GMBH, D-77960, and Germany). Five hundred milligram of extracted lipid was mixed with 100 mL of methanol and assigned amount of acidic mesoporous heterogeneous catalyst namely, SBA-15 impregnated with different percentage of heteropolyacid. The resulting mixture was introduced into reactor and heated at 135°C (pressure was 135 psi) and allowed to react for 3h. After the reaction time, the mixture was allowed to cool and then centrifuged using IEC Centra-HN centrifuge (International Equipment Company, Needham Heights, USA) for 10 minutes at 3000 rpm to remove the solid materials. The supernatants were transferred to a separatory funnel and 50 ml of hexane was added to the separatory funnel and shaken to extract biodiesel. Extraction procedure was repeated 2 times. Hexane layer was passed through a Whatman filter paper (110 mm dia)

containing anhydrous sodium sulphate and collected into a measuring flask. A 1.5 ml aliquot of hexane phase was pipetted into 2.0 ml Supelco PTFE lined capped vial (Supelco, Bellefonte, PA) for FAME analysis using GC. The remaining hexane phase was transferred to a round bottom flask and the solvent was removed under vacuum using a Büchi R205 Rotary Evaporator (Büchi Labortechnik, Switzerland) at 40 °C to get biodiesel. The yield of FAME was determined from FAME analysis using GC.

2.5 FAME analysis

Varian CP-3800 gas chromatograph (Varian Inc., Lake Forest, CA) equipped with FID, and a 50m x 0.25 mm x 0.2 µm Varian CP-Wax 58 (FFAP) CB capillary Column (Varian Inc., Lake Forest, CA) was used to analyze the FAME. Helium was used as a carrier gas and the sample injection volume was 1.0 µl with a split ratio of 80:1. The column flow was constant at 1.2 ml/min and column oven temperature was programmed to maintain at 100 °C for 1.0 min, increase from 100 °C to 200 °C at 15 °C /min, then increased from 200 °C to 240 °C at 5 °C /min, and finally maintained at 240 °C for 24 min. The detector and injector temperature were set at 260 °C for the duration of the analysis.

3. RESULTS AND DISCUSSION

3.1 Catalyst Characterization

The as-synthesized SBA-15 was then characterized by means of various instrumental techniques. The SEM image, which is shown in Fig. 3, was taken by means of JSM 600F model, Joel, Japan operating at 10 keV of acceleration voltage. SEM image of the fabricated mesoporous SBA-15 exhibits hexagonal cylinder-like morphologies, which is one of the typical morphologies known for this type of highly ordered mesoporous silica materials.

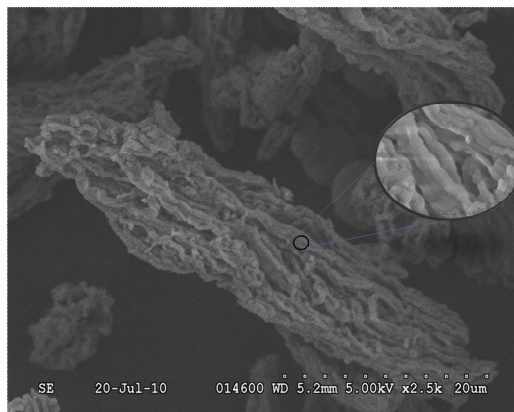


Fig. 3: SEM micrograph of a calcined SBA-15 sample

Surface area of the as-synthesized mesoporous was measured using a BET surface area and pore size analyzer (Micromeritics ASAP 2010) instrument. Prior to measurement of nitrogen adsorption-desorption isotherms, the sample was degassed under vacuum (10⁻⁵ Torr) at 125 °C for 6 h. BET surface area results for the calcined sample was higher than 605.2408m²/g, external surface area was 529.5621m²/g, and BET adsorption average pore diameter was 52.7748Å, which are in close agreement with those reported in the relevant literatures (Speybroeck et al., 2009).

3.2 FAME Analysis

A typical GC chromatogram of biodiesel produced from the lipid of wastewater sludge is shown in Fig. 4. According to the chromatogram, biodiesel contain mainly the methyl ester of myristic acid (C 14:0), palmitic acid (C16:0), palmitoleic acid (C 16:1) stearic acid (C18:0), oleic acid (C18:1) and linoleic acid (C 18:2). Methyl ester of palmitic acid (C 16:0) is present in greatest amount in the biodiesel produced from the extracted lipid. These results are found to be in agreement with the findings of Mondala et. al. by the in-situ transesterification of primary (Mondala et al., 2009).

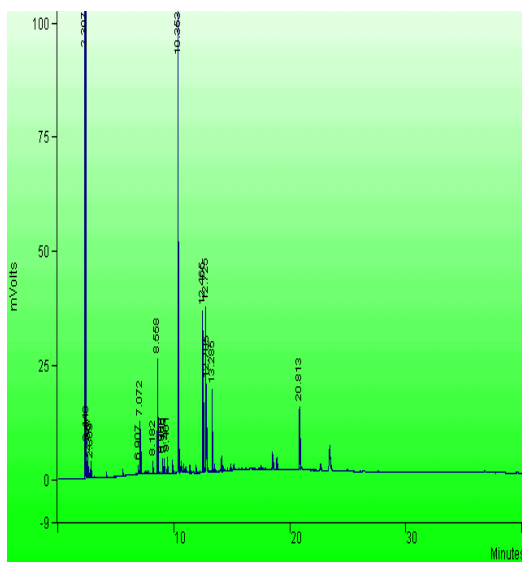


Fig. 4: GC chromatogram of FAME produced from the lipid of the wastewater sludge.

Based on the chromatogram, the maximum FAME yield was 10.63 % (wt/wt) (on the basis of lipid) that was obtained for 25% PW₁₂ at 135°C. The effect of PW₁₂ loading on the lipid conversion is illustrated in Fig. 5. As shown in Fig. 5, biodiesel yield was increased by increasing the loading of PW₁₂.

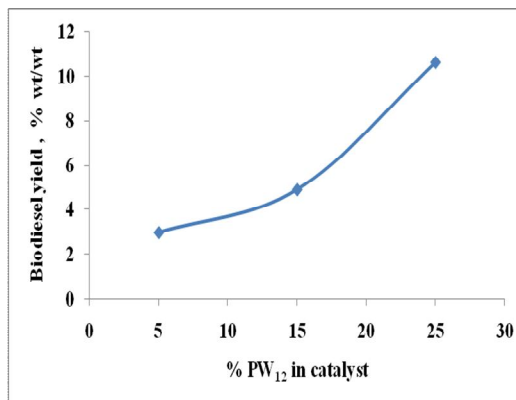


Fig-5: The effect of PW₁₂ loading on biodiesel production from the lipid of wastewater sludge

4. CONCLUSIONS

The conversion of the wastewater sludge lipid to biodiesel was studied through usage of a mesoporous ordered silica, SBA-15, impregnated with heteropolyacid H₃PO₄.12WO₃.xH₂O (PW₁₂). Different analytical techniques including scanning electron microscopy (SEM) and BET surface analysis were applied to characterize the prepared catalysts. The highest biodiesel yield at the examined conditions was 10.63 wt/wt% (on the basis of lipid) for the mesoporous catalyst impregnated with 25% PW₁₂. Biodiesel produced from the lipid of wastewater sludge contain mainly the methyl ester of myristic acid (C 14:0), palmitic acid (C16:0), palmitoleic acid (C 16:1) stearic acid (C18:0), oleic acid (C18:1) and linoleic acid (C 18:2).

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Dissimilar behavior of Ag modified Pt and Pd cathodes on the reduction mechanism of NO_3^- at H^+ -conducting solid polymer electrolyte reactor

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Abstract

In this paper, the relative electrochemical and catalytic hydrogenation responses of Ag modified Pt and Pd cathodes, deposited on H^+ conducting Nafion membrane for NO_3^- reduction, have been reported. Electrochemical investigation showed the order of reactivity as; $\text{Ag-Pt} > \text{Ag-Pt-Pd} > \text{Ag-Pd}$. Conversely, the catalytic hydrogenation reaction showed the reactivity sequence as; $\text{Ag-Pd} > \text{Ag-Pt-Pd} > \text{Ag-Pt}$. While both of these two processes were combined in the electrolyte reactor, the order of reactivity was turned out to be; $\text{Ag-Pt-Pd} > \text{Ag-Pt} > \text{Ag-Pd}$ in

reducing nitrate ions. In the present study, reasons of such dissimilar trends of cathodic reactivity have been discussed.

Key words: Nitrate reduction, Catalytic activity, Voltammetry, Electrolysis, Rate constant

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DOUBLE CHAMBER MICROBIAL FUEL CELL (MFC) FOR ELECTRICITY GENERATION

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Application of Microbial Fuel Cell (MFC) as a renewable source of energy for electricity generation is a promising technology. In this process, electricity generation from biodegradable organic substrate is accompanied by wastewater treatment, which reduces the cost of industrial effluent treatment. Current generation in laboratory scale mediated double chamber MFC has been studied in batch mode. The MFC was designed and fabricated using available local materials. The main objective was to investigate the current generation of MFC in different operating conditions, such as – initial substrate concentration, initial mediator concentration, initial pH and external load. Glucose was used as substrate, an azo dye (Cibacron Yellow – 2G) as mediator and potassium permanganate solution as oxidant. Domestic waste water was used as source inoculums. Current generation, current density, change in pH, change in COD and effect of polarization was studied. Polarization experiments were conducted to find the maximum power density. The study documented a maximum power density of 2.76mW/m² at current density of 8.17mA/m². A maximum 72% removal of COD is observed at optimized operating conditions.

Key Words: Microbial Fuel Cell, Mediated MFC, Wastewater treatment, Electricity generation, COD.

1. INTRODUCTION

Energy conversion and environment are interrelated. Environmental degradation has become a serious problem with the increase in electric power generation by conventional way of burning fossil fuel. The recent energy crisis and alarming environmental pollution has reinvigorated interests in MFCs among academic researchers as a way to generate electric power or hydrogen from biomass without a net carbon emission into the ecosystem. A microbial fuel cell (MFC) is a bioreactor that converts chemical energy in the chemical bonds in organic compounds to electrical energy through catalytic reactions of microorganisms under anaerobic conditions (Z. Du et al., 2007). MFCs can also be used in wastewater treatment facilities to break down organic matters (Liu et al., 2003). The real interest in MFCs has tremendously grown in recent years, both in terms of number of researchers as well as the applications for these systems (Pant, D., et al., 2009). Moreover, the reported electric current output from the MFCs has also increased tremendously over the recent years. In this study, MFC has been constructed for

simultaneous power generation and wastewater treatment. In the present study, Glucose has been used as substrate, an azo dye (Cibacron Yellow–2G) as mediator and potassium permanganate solution as oxidant. Different experiments have been done to find the optimum condition for current generation and COD removal. Polarization experiments were conducted to find the maximum power density.

2. MATERIALS & METHODS

2.1. Chemicals Used in Experiments

- Yellow Cibacron-2G (an industrial dye which was supplied from a local industry) was used as the mediator. The **IUPAC Name** is trisodium 4-[[4-chloro-6-[(4-sulphonatophenyl) amino]-1,3,5-triazin-2-yl]amino]-2-[[1-(2,5-dichloro-4-sulphonatophenyl)-4,5-dihydro-3-methyl-5-oxo-1H-pyrazol-4-yl] azo] benzenesulphonate.
- Anhydrous dextrose purified (MERCK, Germany) was used as the substrate.
- Potassium Permanganate (MERCK, Germany) was used as the oxidant.

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2.2 MFC Construction & Inoculation

Dual-chambered MFC was designed and fabricated in the laboratory using available local material. Total volume of both anode and cathode compartment was the same (0.5 L) and each chamber was provided with sample port, wire point inputs (top), inlet and outlet ports.

A Proton Exchange Membrane (PEM) membrane between two straight conduits was used to connect the two chambers. Two 1 cm long and 0.75 cm diameter plastic tubes were used.

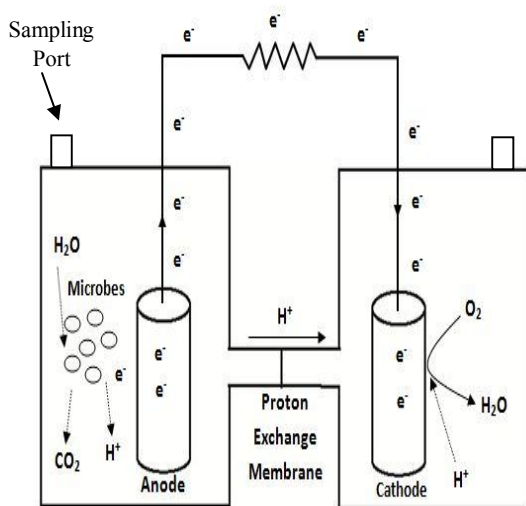


Fig 1. Schematic diagram of dual-chambered microbial fuel cell with schematic details.

The Proton Exchange Membrane used in the experiments was Nafion-212 (DuPont, Germany).

Both anode and cathode electrodes were made of graphite Rod (length 11 cm; diameter 0.8 cm) obtained from local dry cell factory and were positioned at a distance of 2 cm on either side of the membrane. Each electrode had a surface area of 28.65 sq. cm (both anode and cathode). Prior to use, the electrodes were soaked in de-ionized water for a period of 24 h. Contact between electrodes and copper wires was sealed with epoxy material.

Yellow Cebicron-2G (YC) was used as mediator and Glucose as substrate in the anodic chamber of the MFC. The mixture of substrate, mediator and sludge was stored in a jar with air bubbling. Glucose was the nutrient for microorganism. This mixture was used as the original anodic inoculums. The sludge was collected from Sylhet City Corporation's waste water drainage system. Before inoculation, the sludge was filtered through a sieve

of 0.25 mm pore size to remove the impurities. The cells were operated in batch mode at constant operating temperature ($30 \pm 2^\circ\text{C}$) and at dark environment.

2.3 MFC Operation

The performance of MFC with respect to electricity generation from organic carbon source was investigated by a series of experiments. The first experiment was conducted to investigate the steady current production of the MFC. The second experiment was conducted to investigate the effect of initial substrate concentration on electricity generation. To do so, solution of three different substrate (glucose) concentrations of 300, 600 and 900mg/L were taken with a fixed mediator (YC) concentration of 300mg/L. The anode chambers of three MFC were charged with the mixtures. The third experiment was conducted to investigate the effect of initial mediator concentration. In this experiment, anode chambers of three MFCs were filled with the mixtures of fixed concentration substrate (300mg/L glucose solution) and three different concentrations of mediator (300, 600 and 1200mg/L YC solution). All the results were plotted as current density vs. time. The change in pH with time was also recorded. In the fourth experiment, voltage vs. current density and power density vs. current density data were recorded for three MFCs running with three different substrate and mediator concentrations. Power density curves were used to obtain the maximum power density by varying the external resistance using a resistor box. The fifth experiment was done to investigate the water treatment performance of the MFCs. The anode chambers were charged with different substrate and mediator concentrations and the results were expressed as % COD removal vs. time. In all the experiments, the oxidant and the oxidant concentration were kept same (200mg/L KMnO_4 solution). All the experiments were done in closed circuit and the current generated was expressed as current density vs. time. 106Ω external resistance was used in the first experiment and 10Ω external resistances were used in the second, third and fourth experiment. Every experiment was conducted at least in duplicate at constant room temperature ($30 \pm 2^\circ\text{C}$) and the average value was reported for all the data. The anode chambers were inoculated with 15mL of sludge each time. The decolorization of mediator was observed regularly to investigate if the mediator was decomposing due to microbial action.

2.4 Analysis and Calculations

2.4.1 Current density: Current was recorded with a fixed resistance by a precise digital multimeter. Then the current density (A/m^2) was calculated by the following equation (1).

$$\text{Current Density, } J = I/A \quad (1)$$

Here, I= current and A= Projected cross sectional area of anode

2.4.2 Power Density: The voltage difference (V) between two points of a resistor connected with the anode & cathode was recorded using a precise multi-meter. Power density (mW/m^2) was calculated according to the following equation (2).

$$\text{Power Density, } P = IV/A \quad (2)$$

Where, I= current, V= voltage difference and A= projected cross-sectional area of the anode.

2.4.3 COD calculation: COD of a sample can be calculated by the following equation:

$$\text{COD (as mg O}_2\text{/L)} = \frac{8000(b-s)n}{\text{sample volume}} \times \text{dilution factor}$$

Where, b = ml FAS solution required for blank
s = ml FAS solution required for sample
n = normality of FAS solution

3. RESULTS AND DISCUSSION

3.1 Study the Performance of MFC

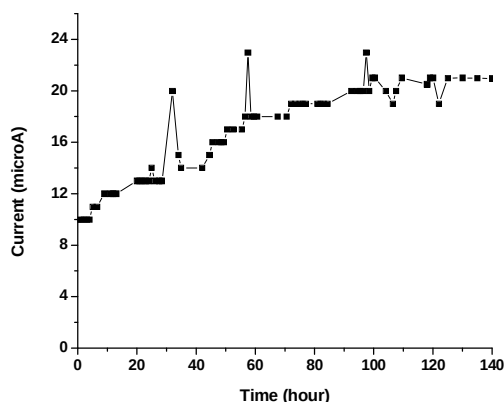


Fig. 2. Performance of a MFC. Anode chamber contains a mixture of 300mg/L glucose and 300mg/L YC. 200mg/L $KMnO_4$ is used in the cathode chamber. Current was measured in closed circuit with an external resistance of 100Ω .

Performance of the MFC at an external resistance of 100Ω was investigated at a substrate (glucose) concentration of 300mg/L and mediator (YC) concentration of 300mg/L. 200mg/L $KMnO_4$ is used in the cathode chamber.

Initially current and voltage were very low which was observed in **Fig.2.**, but with respect of time, it increased. After some time, the current started increasing. The current gained a highest value of 21 μA , and it decreased with the further increment of time (not showed in the plot). The current showed a nearly steady response from 99th hour to 140th hour. Current production increases as the bacteria grows exponentially. Current production decreases when bacterial growth reaches stationary/decay phase. Other reasons may be – ohmic losses, metabolic losses, concentration losses, activation losses.

3.2 Effect of initial Substrate (Glucose) concentration in MFC

To explore the effect of initial substrate concentration in the current production of MFC, anode chambers of three MFCs were charged with three different solutions having a fixed concentration of mediator and variable substrate concentrations. The mediator (YC) concentration was kept fixed at 300mg/L and the variable substrate (glucose) concentrations were 300, 600 and 900mg/L. The oxidant used in the all three cells

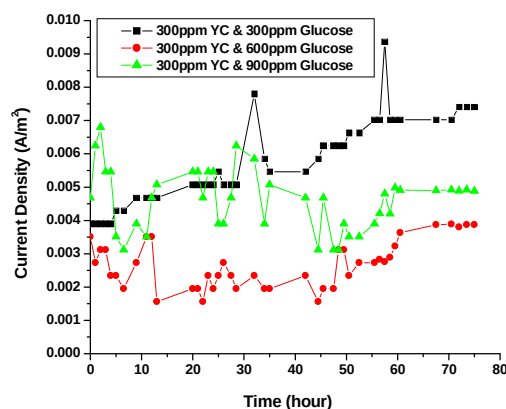


Fig. 3. Effect of the initial substrate concentration (mg/L) on the current production of MFC. 10Ω external resistances were used in each cells.

were $KMnO_4$ and the concentrations of the oxidant were kept constant at 200mg/L. All the currents

were measured in closed circuit and the cells were connected with external resistance of 10Ω . The cells were run for about 56 hours and the corresponding currents were recorded with respect to time. The results are shown as current density vs. time in the **Fig.3**.

The result shows that, the cell using 300mg/L YC and 300mg/L glucose at the anode chamber gave better current production then other two. Initially the current density of the 300, 600 and 900mg/L glucose cells were 0.0039, 0.00351 and 0.00468 A/m^2 respectively. As the time proceeds, the current density of the 600 and 900mg/L glucose cells were unsteady and showed a decreasing trend. But the 300mg/L glucose cell showed a steady current production with the increment of time.

At the end of 75 hours, the current density for the cells containing 300, 600 and 900mg/L glucose were 0.00741, 0.00387 and 0.00488 A/m^2 respectively. This clearly showed that, for a fix mediator concentration, there is a maximum level of substrate concentration that can be used to deliver maximum current density. Beyond that level, the production of current falls.

3.3 Effect of Initial Mediator (YC) Concentration in MFC

To investigate the effect of initial mediator concentration in the current production of MFC, anode chambers of three MFCs were charged with three different solutions having a fixed concentration of substrate and variable concentrations of mediator. The substrate (glucose) concentration was kept fixed at 300mg/L and the variable mediator (YC) concentrations were 300, 600 and 1200mg/L. The oxidant used in the all three cells was $KMnO_4$ and the concentrations of the oxidant were kept constant at 200mg/L. All the currents were measured in closed circuit and the cells were connected with external resistance of 10Ω . The cells were run for about 120 hours and the corresponding currents were recorded with respect to time. The results are shown as current density vs. time in the **Fig.4**.

From the data it can be seen that, initial current density of the cells containing 300, 600 and 1200mg/L YC were 0.0039, 0.00585 and 0.00702 A/m^2 . From 80th hour, all the cells were producing nearly steady current. At the end of the 120 hours, the current densities of the three cells were 0.00819, 0.013 and 0.01755 A/m^2 respectively. Throughout the time of the experiment, the cell contained 1200mg/L YC showed better result than

both the cell contained 300mg/L and 600mg/L YC. The graph clearly indicates that, for a fixed initial substrate concentration, the increment of mediator concentration increases the current production.

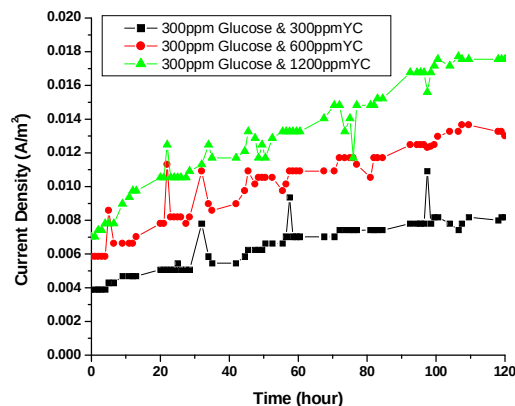


Fig.4. Effect of the initial mediator concentration (mg/L) on the current production of MFC. 10Ω external resistances were used in each cell.

The reason for this behavior can be explained by this: the metabolic processes in microbial cells generate reductive species which are isolated by a microbial membrane. Therefore, electron transfer between the cells and electrode are diminutive as they are separated by the membrane of the cells (David A. Katz, 2004). The electro-active groups which are required for the microbial redox activity of enzymes are kept deep inside their prosthetic groups which make electrical communication between electrode surface and microbial cells poor. The poor electrical communication can be solved by wiring the microbial cells to the electrode surface using mediators. There are different ways for a mediator to be coupled to the microbial (Rabaey, K. and Verstraete, W., 2005; J.H. Hirschenhofer et al., 1998). The mediators are used to shuttle electrons between the electrode and intracellular bacterial space. Thus, as the concentration of the mediator increased, the current production also increased.

3.4 Effect of Initial pH and Change in pH During MFC Operation

The pH of feed chamber (anode chamber) affects both anodic microbial activities and cathodic reaction, and thus is a very important factor (Z. He et al., 2008). **Fig.5.** shows the change of pH at anode chamber with time. Three MFCs were used in this experiment which had a fixed concentration

of substrate (300mg/L glucose) and variable concentration of mediator (300, 600 and 1200mg/L YC). 200mg/L KMnO_4 solution was used as oxidant in all three cells. The initial pH of the cells were 6.2, 6.0 and 5.7 respectively. The variation in initial pH is due to the different concentrations of mediator.

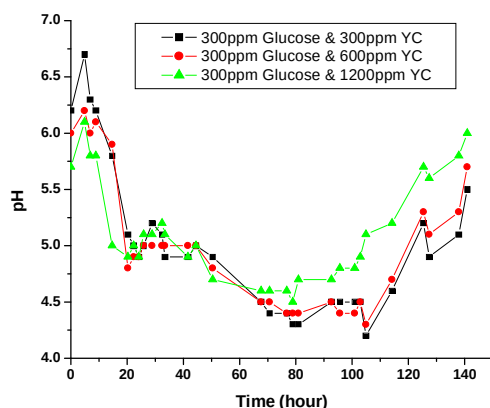


Fig.5. Change of pH in the anode chamber with time. The variation of the initial pH is due to the different mediator concentration. 10Ω external resistances were used in each cell.

The biological and electrochemical reactions in the double-chambered MFC had changed the pH of the anode chamber. From the plot, it can be observed that, the pH of the cells initially tend to decrease. But after reaching a lowest value, the pH of all three cells increased with time. Bacterial metabolism constantly produces weak acid compounds and maintains their intracellular pH (H. G. Schlegel, 1993), which explains the decreasing of pH in the first stage of the experiment. The increase of pH is due to proton consumption by the cathodic reactions (F. Zhao et al., 2006). Both proton consumption and generation occur at the same time, but a balance was established based on the initial pH.

Comparing this pH plot with Fig.4, it can be seen that, lower initial pH of the feed results higher current. The advantages of operating an MFC at low pH are the availability of protons at the cathode and the proton transfer process across the proton exchange membrane (PEM) separating the anode and cathode. Because of a higher driving force, the use of low pH at the anode side is expected to result in higher proton transfer rates and can alleviate proton limitations at the cathode. It should be noted that the present MFC is a batch-operated system. In a continuously operated MFC, the buffering effect via bacterial metabolism may not be as important as

that in a batch system, because a constant flux of high pH solution may overwhelm the proton generation.

3.5 Polarization Curve

The performance of the anode, cathode, cell and membrane were analyzed by $E-j$ curves. The voltages and potentials in an open circuit ($j=0 \text{ A/m}^2$) indicate the maximum voltage or potential which is feasible under the existing experimental conditions. After connecting the resistor, thus allowing an electrical current through the system, it can be seen to what extent this maximum voltage or potential is reached. Operation at peak power density can cause instability in control because the system will have a tendency to oscillate between lower and higher current densities at peak. Operation at the higher power densities will mean operation at lower cell voltages or lower cell efficiency.

In this experiment, the electrodes potential were measured at various current densities to investigate the effect of polarization on MFC operation. From the Fig.6, it is observed that, when the current density of the cells increased potential decreased. It can be also seen that, potential energy decreased with the concentration of the mediator used.

Fig.7. shows the polarization curve as a function of current density. Power densities were measured at variable external resistances. Current generation in different resistors was observed once the maximum voltage was attained. From the Fig.7, maximum power density was recorded 2.76 mW/m^2 at the current density 8.17 mA/m^2 for the cell containing

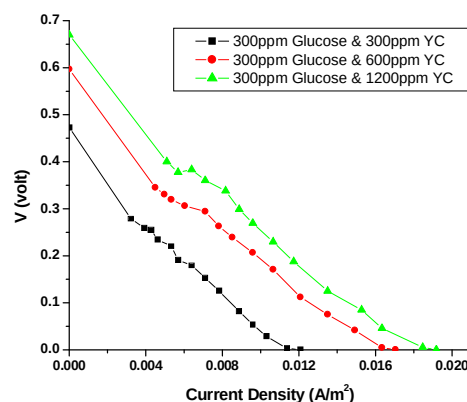


Fig. 6. Polarization curve for three MFCs using solution of fix conc. of substrate (300 mg/L glucose) and different conc. of mediator (300, 600 & 1200mg/L YC) in anode chamber and 200mg/L KMnO_4 solution in cathode

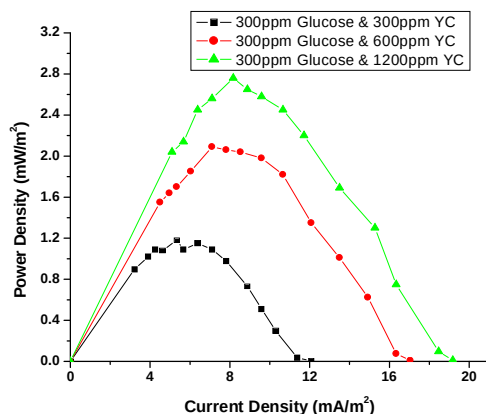


Fig. 7. Power Density vs. current density polarization curve for three MFCs using solution of fix conc. of substrate (300 mg/L glucose) and different conc. of mediator (300, 600 & 1200mg/L YC) in anode chamber and 200mg/L KMnO_4 solution in cathode

1200mg/L YC and 300mg/L glucose at the anode chamber. For 300mg/L and 600mg/L of YC, the maximum power densities were found to be 2.09mW/m^2 and 1.18mW/m^2 for current densities of 7.11mA/m^2 and 5.33mA/m^2 respectively.

At first, the power densities showed an incremental trend with increasing external resistance. But after reaching a peak value, the power densities begin to fall down with increasing resistance and current density. Current generation showed decreasing trend with increase in resistance and is consistent with the reported literature (Venkata Mohan et al, 2006., Min et al, 2004.), which indicated a typical fuel cell behavior. At higher resistance used, relatively less power density was observed. Relatively less voltage drop was observed at lower resistance indicating less potential drop. Voltage stabilization was comparatively rapid at higher resistances studied. Effective electron discharge observed at lower resistances might be the probable reason for further potential drop and slow stabilization of the voltage at lower resistances. Oxidation of substrates by microbes was observed to be more at lower resistance than at higher resistance, where microbes donated electrons to the anode as the electrons were discharged in a closed circuit (Britannica, Liu et al. 2005.). Relatively lower power observed in this study might be because of using graphite electrode without any coating.

3.6 Removal of COD in MFC

It has been reported that microorganisms can convert organic matter into electricity using MFCs

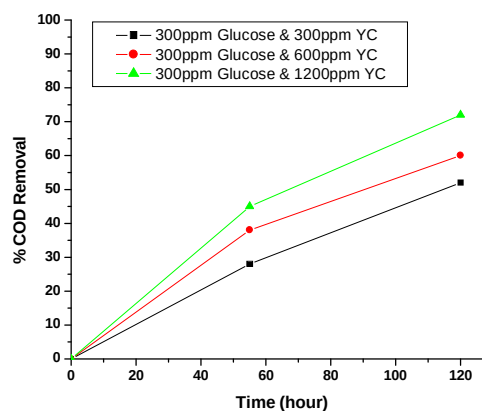


Fig. 8. Percent removal of COD in terms of time for three MFCs using solution of fix conc. of substrate (300 mg/L glucose) and different conc. of mediator (300, 600 & 1200mg/L YC) in anode chamber and 200mg/L KMnO_4 solution in cathode

while simultaneously accomplishing wastewater treatment (Venkata Mohan et al., 2008; Liu et al., 2004). During operation, fuel cells' anode chambers were continuously monitored for COD removal to enumerate the potential of fuel cell to act as wastewater treatment unit. In 120 hour operation, the cells showed a COD removal efficiency of 52%, 60% and 72% for the cells containing 300, 600 and 1200mg/L YC and 300mg/L glucose respectively. So, the removal of COD is found to be higher for the cell which showed higher current density.

4. CONCLUSION

- Microbial Fuel cell was fabricated and constructed with local materials.
- Effect of initial mediator and initial substrate concentration was investigated.
- It has been found that, current generation of a MFC increases for a given concentration substrate with the increment of mediator concentration.
- Effect of initial substrate concentration on electricity generation has been investigated and no specific trend was found.
- The polarization curve was plotted for particular MFC. Due to the ohmic resistances, sharp drop in the voltage was

observed with the increase of the current density. This indicates the external resistances in electrode, connecting weir, circuit etc were dominated in the MFC efficiency.

- The removal of COD is found to be higher for the cell which showed higher current density. The highest COD removal was found 72% for the cell containing 1200mg/L YC and 300mg/L glucose at the anode chamber.
- Maximum power density was recorded 2.76mW/m² at the current density 8.17 mA/m² for the cell containing 1200mg/L YC and 300mg/L glucose at the anode chamber.
- Further studies are necessary for the implementation of MFC in practical uses.

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EFFICIENT HYDROGEN PEROXIDE DECOMPOSITION ON BIMETALLIC Pt-Pd SURFACE

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ABSTRACT

Hydrogen peroxide was efficiently decomposed on Pt-Pd surface deposited on Nafion membrane. Comparing the activities for the different materials, the activity for the decomposition of hydrogen peroxide was found to decrease in the order of Pt-Pd surface > MnO_2 > $\text{K}_2\text{Cr}_2\text{O}_7$ > Au > Polycrystalline Pt plate. It was observed that the decomposition process followed bimolecular first order kinetics, which was well fitted with Eley-Rideal (L-R) model. The first order decomposition rate constant was $4.5 \times 10^{-4} \text{s}^{-1}$ and $5.4 \times 10^{-4} \text{s}^{-1}$ for A_1 and A_2 surfaces, respectively. The free energy of activation was evaluated as 34.0 kJmol^{-1} over Pt-Nafion and 36.3 kJmol^{-1} for Pd Nafion systems, respectively. In this paper, reason of efficient catalytic decomposition of hydrogen peroxide over bi-metallic Pt-Pd surface has been discussed.

Key words: Metal film, decomposition, hydrogen peroxide, efficiency, Nafion membrane.

1. INTRODUCTION

Hydrogen peroxide (H_2O_2) is a light blue liquid, to some extent more viscous than water and its dilute solution is almost colorless. It is a weak acid, has strong oxidizing properties and is a powerful bleaching agent. It is used as a disinfectant, antiseptic, oxidizer and in rocket as a propellant. The oxidizing capacity of hydrogen peroxide is so strong that it is considered as a highly reactive oxygen donating species. Its most recent intended use include as a fuel/propellant instead of carcinogenic hydrazines (Hurlbert et al.). Hydrogen peroxide is a well-established source of the hydroxyl radical ($\bullet\text{OH}$) in the so called oxidative destruction of organic wastes (Kwan et al.). Many efforts have been directed to destroy toxic organic compounds using H_2O_2 in presence of UV and visible light (Sedlak et al., and Hasnat et al.). In the previous report, we discussed the role of Fenton's reagent ($\text{Fe(II)/Fe(III)} + \text{H}_2\text{O}_2$), for attaining rapid degradation of some organic compounds. Although nearly all of the H_2O_2 was decomposed during the degradation process, nevertheless, it was necessary to remove the residual peroxide in the digest to avoid the secondary pollution. If the waste containing Fenton's reagent is discharged to the natural aquatic systems, it may cause harm to the living beings due to the action of

$\bullet\text{OH}$ radicals. By contrast, when analytical samples containing such oxidative materials are employed into sophisticated techniques like chromatography, the column materials might be degraded or damaged. It has been found that the self decomposition of hydrogen peroxide is fairly very slow. Therefore, prior to inserting the test samples through the column, it is necessary to remove all of the residual hydrogen peroxide. On top of showing destructive effects, hydrogen peroxide is a source of artificial oxygen. It is possible to be used for emergency patients and aquatic lives in the aquarium if a steady peroxide decomposing catalyst could be developed.

Concerning the above facts, there are so many metal oxides have been reported in the literature for hydrogen peroxide decomposition (H. Zhou et al., Baldi et al.). Among them, Fe_2O_3 , MnO_2 and $\text{K}_2\text{Cr}_2\text{O}_7$ are frequently used. Some reports have also been published based on noble metal (Pt and Pd) catalyzed decomposition of hydrogen peroxide. In addition, the Gold nanoparticles (Au NPs) were also used for, deposited directly on polymer beads, for H_2O_2 decomposition. However, because of chemical reactions; metal oxides are consumed proportional to the extent of hydrogen peroxide. This means that the metal oxides cannot spontaneously be regenerated and moreover, additional treatment is required to

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avoid the secondary pollution caused by the toxic metal ions. Conversely, noble metals seem to show pitiable catalytic performance. Recently, bi-metallic catalysts, originated from Pt and Pd, have been attracted by the researchers due to their robust catalytic properties for numerous reactions.

In this report, the effects of bi-metallic catalytic surfaces, consists of Pt and Pd particles, on catalytic hydrogen peroxide decomposition have discussed. In order to prove the validity of using such catalyst, the relative decomposition efficiencies have been compared with other conventional peroxide decomposing materials.

2. EXPERIMENTAL

2.1. Preparation of catalysts

The noble metal films were prepared by following the procedures described in the references [30-33]. Pt and Pd were chemically deposited on the each surface of the Nafion-117 membrane (DuPont, Inc.). The Nafion membrane was first sand blasted and dried at 110 °C then was immersed into 200 mL water containing 5mg of $H_2[PtCl_6]$ supplied by Walko Icorp. A mixed solution of 2.0 M $NaBH_4$ and 4.0 M $NaOH$ was added to the membrane-containing system at rate of $2.0\text{ mL}\cdot\text{h}^{-1}$. Meanwhile, the reaction mixture was heated from 35 °C at a rate of $5\text{ }^\circ\text{C}\cdot\text{h}^{-1}$. The Pt plating with an area of $2 \times 3\text{ cm}^2$ per side of the Nafion membrane was completed within 12 h. Using the same procedure, Pd coated membrane was prepared from 10.0 mg $PdCl_2$. Meanwhile, Gold particles with a 2 nm core surrounded by a decanethiolate monolayer shell (DT-Au_{2nm} nanoparticles) were synthesized by a conventional synthesis protocol [34]. The Au particles (4.2 mg) were than deposited on a plastic formed Carbon plate (6 cm^2) using the technique mentioned in the reference [35]. In the text, this catalyst has been designated as Au-CP. In the present research, we will be show the efficiency of mixed catalytic surfaces consisting of Pt and Pd particles. In this connection, two catalytic surfaces A₁ (76 mol % Pt + 24 mol % Pd) and A₂ (59 mol % Pt+ 41 mol % Pd) have been used for decomposition of H_2O_2 . The deposited amount of metallic particles for A₁ and A₂ surfaces were 2.1 mg and 3.3 mg respectively. The composition of surfaces was determined by the X-ray florescence technique.

2.2. H_2O_2 decomposition

Standard H_2O_2 solution was prepared by dilution and its concentrations was standardized by standard potassium dichromate solution. The catalytic competence of Pt-Pd film deposited on Nafion -117

membranes were measured with respect to H_2O_2 decomposition. The reactions of H_2O_2 decomposition was carried out at room temperature and at atmospheric pressure. Decomposition of H_2O_2 by A₁/Nafion or A₂/Nafion assembly and O_2 production were performed in a 250 ml Gas jar filled with 250 ml volume of solution. A graduated glass burette was used to measure the volume of O_2 at STP. Light was excluded by wrapping the Gas jar with aluminum foil. Similar, procedure was also maintained for the decomposition process studied by the other materials (MnO_2 and $K_2Cr_2O_7$). In each case 5.0 mg fine powder materials were added to the reactor to start the process.

3. RESULTS AND DISCUSSION

3.1. Surface Characterization

Before applying to the catalytic reaction process, it was necessary to ensure the deposition of the Pt. Fig. 1 shows the SEM (Scanning electron microscopy) micrograph of the Nafion surface after deposition of the Pt particles.

The relative view of the images indicates the

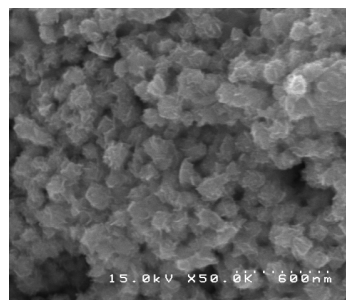


Fig.1. SEM (Scannaing electron microscopic) image of the after deposition of Pt-Pd particles.

deposition of Pt particles over the Nafion membrane. The depositions of the Pt particles were further confirmed by the electron probe micro analysis (EPMA) of the Pt-Nafion cross-section as shown in Fig. 2.

The dotted colored points clearly indicate the deposition of Pt particles over the Nafion surface. The average thickness of the metal deposits was estimated to be ca. 2 μm over the Nafion membrane. An ordinary Pt surface has several crystalline phases (100,110, 111 etc). Fig. 3 shows the XRD pattern of the as prepared A₁-Nafion assembly. The clear peaks at 2θ values 39.1 and 48 indicate 110 and 200 planes caused due to the formation of Pt-Pd film over Nafion surface. Estimating the intensity of the peaks,

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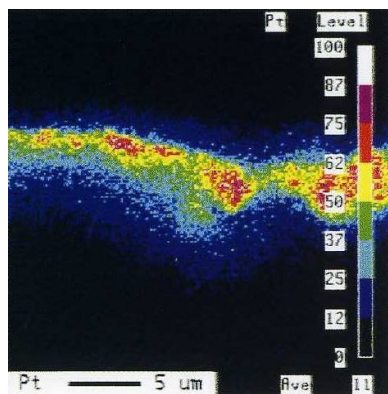


Fig.2. Electron probe micro analysis photograph of the Pt-Nafion cross-section. The upper black part indicates the Nafion membrane; the lower black part indicates the epoxy resin of the sample holder. The middle colored part indicates the deposited Pt particles.

it is apparent that the Pt-Pd particles, in A₁, showed 110 planes as the major component on the surface.

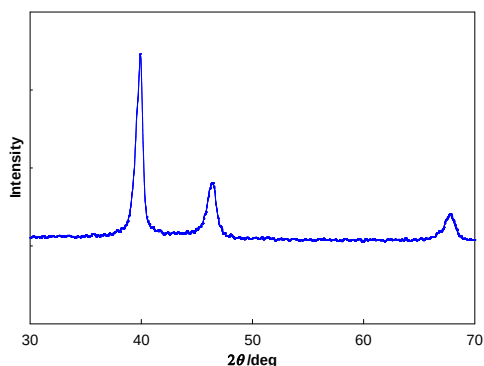


Fig. 3. X-ray diffraction pattern of the as prepared A₁ (Pt-Pd) surface recorded by 2KW Multiflex diffractometer .

3.2. Catalytic efficiency

Fig. 4 shows the evolved O₂ versus time profile due to decomposition of H₂O₂ using conventional materials and using the as prepared Pt-Pd (A₁ and A₂ surfaces) and Au films. From the tangents of the curves, the normalized initial reaction rates were evaluated, which are reported in Table 1. The decomposition efficiency of different materials for hydrogen peroxide destruction followed

the order of A₁ > A₂ > MnO₂ > K₂Cr₂O₇ > Au-PC > commercial Pt plate.

It is clear from the trends of the O₂ evolution curves that the as prepared A₁/ A₂ assembly was prolific by several times for hydrogen peroxide decomposition compared to MnO₂ and K₂Cr₂O₇, which in turn is more efficient than Au-PC plate and an ordinary Pt plate. The reason of such elevated performance of the

Table 1: Normalized decomposition rate using various catalysts

Catalyst	KMnO ₂	K ₂ Cr ₂ O ₇	Au-PC	Pt plate	A1	A2
O ₂ Evolution rate/10 ⁻⁹ mol L ⁻¹ g ⁻¹ s ⁻¹	2.8	2.1	1.2	0.91	10.0	5.4
Rate constant/ k, 10 ⁻⁴ s ⁻¹	2.3	1.2	0.5	0.3	5.4	4.5

as prepared Pt – Pd films on Nafion could be explained by the decomposition mechanism and properties of the bi-metallic Pt-Pd surfaces.

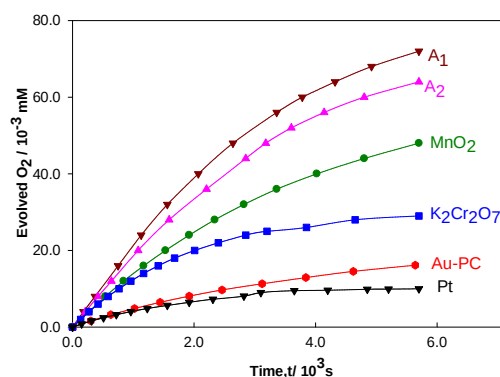
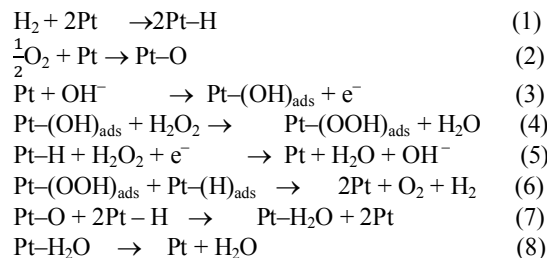


Fig.4. Comparisons of catalytic decomposition of H₂O₂ solution over A₁(Pt-Pd; 2.1 mg)/Nafion assembly, A₂(Pt-Pd; 3.3 mg) / Nafion assembly, MnO₂ (50 mg), K₂Cr₂O₇ (50 mg), Au-PC (4.2 mg) and Pt plate. [H₂O₂] = 0.50M; Volume of the reactor 250 ml. Geometric surface area of catalyst

Mededovic' et al., proposed the decomposition mechanism of H₂O₂ on Pt surface(Mededovic et al.,).

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The first steps in the surface catalyzed hydrogen peroxide decomposition are the adsorption of molecular hydrogen, molecular oxygen and hydroxyl ions. Hydrogen and oxygen are adsorbed through dissociative adsorption in which hydrogen and oxygen atoms are directly bonded to the platinum. Hydroxyl ions are involved in a simple charge transfer reaction. The surface bound species further react with hydrogen peroxide to form oxygen and water. By writing the species balance on hydrogen peroxide it is obvious that Pt-(OH) and Pt-(H) are directly involved in its decomposition kinetics. The concentrations of these two species are interdependent since both bind to free catalytic sites on the platinum surface. However, it has been reported that Pt and Pd particles become negatively and positively charged, respectively, when they are combined. Therefore, in the present case, presence of excessive negatively charged Pt particles in the assemblies of A₁, A₂ probably increased the negatively charged region within the whole surface area. Hence the creation of excessive negative surface area might have stimulated the reactions (3–5) by increasing the decomposition activity.

According to Nørskov's study the characteristics of d-bands of the surface metal, predominantly the weighted center of the d-band (ϵ_d), play a key function in determining surface reactivity. A higher lying d-band center tends to bind adsorbates more strongly, forming M-OH bond more easily, but it is unfavorable to OH formation by breaking the M-OH bond. On the other hand, a lower lying d-band tends to make easy O-H bond formation, but it binds the adsorbates more weakly. Therefore, the most active catalytic surface should have a ϵ_d with an intermediate value. The density functional theory (DFT) studies have shown that for pure Pt surface, Pt-OH is easily formed on the surface of Pt because of the higher ϵ_d of Pt. This means that a pure surface is favorable to accomplish reaction (3) but at the same time unfavorable for the reactions (4) and (5). But an efficient decomposition, all of these reactions should be taken place efficiently.

Several studies have reported that the existence of Pd in the Pd-Pt catalyst could lower the ϵ_d of Pt to a moderate ϵ_d value. Therefore, in comparison with that on pure Pt surface, all the reactions (3–5) were

probably facilitated by the bimetallic A₁ and A₂ surfaces, ultimately increasing the decomposition rate of hydrogen peroxide. In addition of the surface activation, as described above, the increased surface

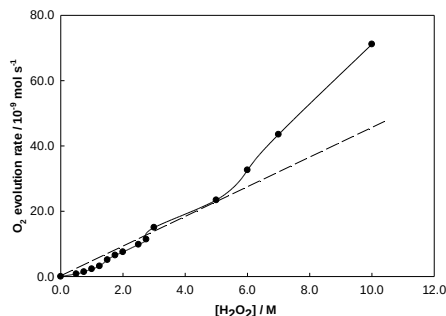


Fig.5. Dependency of O₂ evolution rate on initial peroxide concentration (0.05 M–10 M). Volume of the reactor 250 ml. Geometric surface area of the catalyst (A₁) was 12.0 cm².

area, which could be inferred from the SEM image (Fig. 1) of the catalytic surfaces, might be another reason of efficient decomposition rates by the A₁ and A₂ surfaces.

3.3. Reaction Kinetics

From the dependency of decomposition rate on the initial H₂O₂ concentration, the kinetics was investigated. Fig.5 shows the dependency of the oxygen evolution rate on the initial hydrogen peroxide concentration within the range of 0.05–10.0M over A₁-Nafion system. Up to 5.0M, the decomposition rate was increased linearly. Above this limit, constructive deviation is observed from the normal trend. This means that above this concentration limit, the number of oxygen molecules evolved were unexpectedly high. This can be explained by the enthalpy change (ΔH^0) of the decomposition reaction. The decomposition of peroxide is an exothermic process over the noble metal surfaces although the change in temperature rise during the process was not significant until the peroxide concentration was used as higher as 3.0M. By measuring the temperature rise at 5.0M H₂O₂ concentration, the change in ΔH^0 was determined to be $-12.45 \text{ kJmol}^{-1}$ in the present case.

At higher temperatures, hydrogen peroxide tends to show auto decomposition reaction and as the solubility of produced oxygen gas is very low at higher temperature, the reaction equilibrium shifts to forward direction. Hence, an excessive rise in the reaction rate is noticed at higher temperature.

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However, the reaction rate was always proportional to the initial peroxide concentration indicating that Pt–Pd surface had copious numbers of sites to decompose hydrogen peroxide. Since no restraining rate was observed within the mentioned concentration range, it is, therefore, suggested that the decomposition of H_2O_2 was occurred according to Eley–Rideal (E–R) model of surface, which was consistent with the reference. The rate law used for E–R model may be written for the decomposition of H_2O_2 as (9).

$$v = \frac{kK_a[H_2O_2]^2}{1+2K_a[H_2O_2]} \quad (9)$$

Where, v is the reaction rate, k the rate constant and K_a the adsorption equilibrium constant of H_2O_2 on Pt. At sufficiently high concentration of H_2O_2 , $K_a[H_2O_2] \gg 1$. Therefore, equation (9) can be written as

$$v = \frac{1}{2}k[H_2O_2] \quad (10)$$

This assumption was firmly matched with experimental data as shown in Fig.5. In our experiments, the decomposition rate was increased proportionally with the peroxide concentration. However, from the dependency of H_2O_2 decomposition on concentration, it was possible to determine the actual reaction kinetics. The evolution rate of O_2 is related to the initial concentration of H_2O_2 as the following rate law (eqⁿ. (11)).

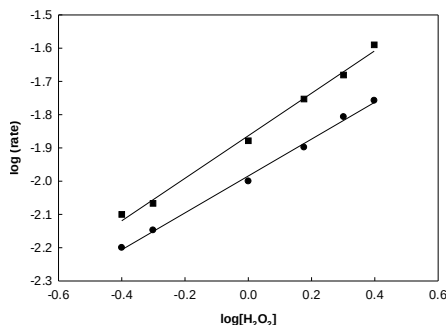


Fig.6. $\log(\text{rate})$ vs. $\log[H_2O_2]$ curves for peroxide decomposition over (●) A_1 surface and over A_2 surface (■).

$$\frac{-d[H_2O_2]}{dt} = k[H_2O_2]^\alpha \quad (11)$$

where, k is the rate constant and α is the order of reaction. Since one molecule of H_2O_2 is decomposed into one molecule of H_2O and one-half molecule of O_2 ($H_2O_2 \rightarrow H_2O + 1/2 O_2$), equation (11) may be written as:

$$\frac{d[O_2]}{dt} = \frac{1}{2}k[H_2O_2]^\alpha \quad (12)$$

Taking logarithm, the equation (6) may be linearized in the form of equation (13).

$$\log \frac{d[O_2]}{dt} = \log\left(\frac{1}{2}k\right) + \alpha \log[H_2O_2] \quad (13)$$

From the slope of $\log \frac{d[O_2]}{dt}$ vs. $\log[H_2O_2]$ (Fig.6), order (α) of the reaction was determined as 0.91 and 0.95 over A_1 and A_2 surfaces, respectively. The above discussion therefore, exhorts that H_2O_2 was decomposed over the noble metal films using first order kinetics. This conclusion is compatible with the nature of the evolution of the amount of O_2 evolution as is shown in Fig. 4. The oxygen molecules evolved exponentially indicating that H_2O_2 also decayed exponentially as like as first order reaction. In the present case, the exponential relation (equation 14) between H_2O_2 concentration and time t can be evaluated by integrating the differential equation (11).

$$[H_2O_2] = [H_2O_2]_0 e^{-kt} \quad (14)$$

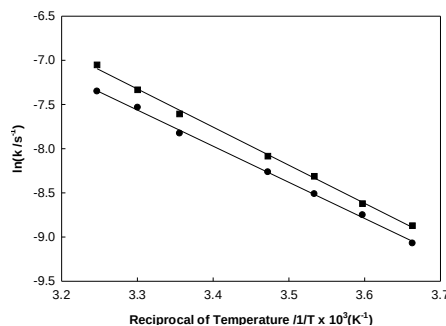


Fig.7. Arrhenius plot of $\ln k$ vs. $1/T$ for peroxide decomposition over (●) A_1 surface and over A_2 surface (■). $[H_2O_2] = 50 \mu M$, volume of the reactor 250 ml. Geometric area of the catalytic surface 12.0 cm^2 .

Applying equation (14), observed rate constant k was estimated as $5.4 \times 10^{-3} \text{ s}^{-1}$ using A_1 and $4.5 \times 10^{-3} \text{ s}^{-1}$ using A_2 surfaces. Finally, from the dependency of the rate constants on temperature (Fig. 7), energy of the activation, E_a was calculated by applying so called Ahrenius equation (15).

$$\ln k = \ln A - E_a/RT \quad (15)$$

where, $A = (kT/h)$, here k is Boltzman constant and h is Plank's constant.

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From this dependency E_a was calculated as 34.0 kJ mol^{-1} for A_1 and 36.3 kJ mol^{-1} for A_2 surfaces, respectively. The lower activation energy shown by the A_1 surface indicates that Pt content determined the activation of the surface.

3.4. Stability of the catalytic surfaces

The stability of the catalytic surface is very important prior to its use for the realistic purposes. In order to check the stability, in terms of longevity of the catalytic surfaces of as prepared A_1 and A_2 films, 10 separate experiments (each was 2h long) were

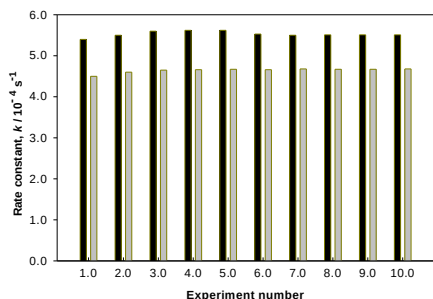


Fig.8. Catalytic efficiency of decomposition of H_2O_2 solution over A_1 assembly (black) and A_2 assembly (grey). $[\text{H}_2\text{O}_2] = 50 \text{ }\mu\text{M}$; Geometric surface area of the catalyst was 12.0 cm^2 . Volume of the reactor 250 ml .

conducted out under same condition. Fig.8 shows the O_2 evolution rate for H_2O_2 decomposition reaction in presence of A_1 and A_2 surfaces. The first order decomposition rate constant was $4.5 \times 10^{-4} \text{ s}^{-1}$ and $5.4 \times 10^{-4} \text{ s}^{-1}$ for A_1 and A_2 surfaces, respectively. In order to check the reproducibility, ten experiments were repeated. It is evident from Fig.8 that performance of the peroxide destruction rate constant was persistently invariable. In the first three experiments, the slight increase of the reaction rates might be because of surface cleaning effect due to removal of potential surface blocking particles (hydroxide, micro organics etc.). The constancy of the rates consequently proves that the novel metal films fabricated on the Nafion membrane were exclusively stable to decompose hydrogen peroxide and suitable for long term use.

4. CONCLUSION

Novel Pt–Pd catalyst was developed, which successfully could decompose H_2O_2 without adding any foreign materials. This catalyst is several times effective than an ordinary polycrystalline Pt surface.

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The altered electronic property and or enlarged surface area were the reason of enhanced catalytic ability. The decomposition mechanism followed Eley–Rideal model. Because of reproducible catalytic nature, the Pt–Pd catalytic surface may be used repeatedly for long time. Since Pt and Pd are highly expensive metal so considering the cost, MnO_2 and $\text{K}_2\text{Cr}_2\text{O}_7$ have to be preferred, however, permanganate and dichromate themselves are toxic. Thus, secondary contamination cannot be ignored after decomposition of hydrogen peroxide. But in case of platinum and palladium, the active form is metal itself, which provides active sites rather than entering into an oxidation–reduction scheme. Therefore, Pt–Pd surfaces are environmentally friendly for peroxide destruction.

4. ACKNOWLEDGEMENT

The authors acknowledge Prof. Masato Machida, Department of Nano Science and Technology, Kumamoto University, Japan for supplying required materials to prepare Pt films on Nafion membrane.

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ELECTROCATALYTIC NO_2^- REDUCTION USING Gc-Pt ELECTRODE

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ABSTRACT

Platinum particles were electrochemically deposited over glassy carbon (GC) to prepare GC-Pt electrodes. The electrocatalytic behaviors of this electrode have been compared with that of an ordinary polycrystalline (OPC) Pt and GC electrode in reducing NO_2^- at neutral medium. The as prepared GC-Pt electrode reduced NO_2^- , exhibiting double-peak reduction waves. The reduction performance of this electrode was noticed at least 7.8 times higher than that of an OPC Pt electrode. The sensitivity of the GC-Pt electrode was found to be enhanced by the temperature rise. A consecutive mechanism, $\text{NO}_2^- \rightarrow \text{NO} \rightarrow \text{NH}_4^+$, over the as prepared GC-Pt electrode has been investigated.

Keywords: Glassy carbon, Platinum, Nitrite, Mechanism, Efficiency.

1. INTRODUCTION

Drinking water, containing $\text{NO}_3^- > 50$ ppm, is deleterious for health and environment (Gray, 1994). Nitrite ions are essential precursors in the formation of nitrosamines, many of which have been recognized to be carcinogens and detrimental for our environment. Nitrite ions are usually used as food preservatives and are highly malicious to living bodies. Therefore, the elimination of nitrite from the liquid waste, foods and drinking water has received continued attention over the last couple of years (Hasnat et.al., 2009, Hasnat et. al. 2010). On the other hand, reduction of nitrite ions might be a route to synthesize numerous useful chemicals namely NH_4^+ , N_2 , NO , N_2O , HNO_2 , NH_2OH (Heckner, 1973). Direct electroreduction of nitrite ions requires high overpotential at most bare electrode surfaces (Lin and Li, 2007). Noble metal nanoparticles have been extensively utilized owing to their extraordinary catalytic activities (Bonnemann et.al., 2002, El-Deab et.al., 2003). Particularly, Pt nanoparticles have been attracted as an intensive research subject to fabrication of electrodes (Bard and Faulkner, 2001). It has been

reported by Dima et al., that the activity of a polycrystalline Pt electrode in reducing nitrite ions is very poor (Dima et al, 2003). The mesoporous materials, prepared by the surfactant template technique, have the large surface area (Hasnat et. al., 2008). Attard et al., reported that mesoporous Pt films, electro-deposited on Au from the mixture of octaethylene glycol monohexadecyl ether (C_{16}EO_8) and hexachloro platonium acid $\text{H}_2[\text{PtCl}_6]$, have large surface area (Attard et. al., 1997). Another surfactant, sodium dodecyl sulphate (SDS), has been proved to be an efficient templating reagent in chemical synthesis of large capacity oxygen storage mesoporous materials (Machida et. al., 2006). Recently, Ojani et al., reported a carbon paste electrode to reduce NO_2^- under acidic condition (Ojani et al, 2008). M. Duca et al., recently reported pH dependant dissimilar nitrite reduction mechanism at Pt electrode (Duca et al., 2010). In this study, Pt modified glassy carbon (GC-Pt) electrode was prepared by electro-deposition of Pt films, from a mixture of sodium dodecyl sulphate ($\text{C}_{12}\text{H}_{25}\text{OSO}_3\text{Na}$) and $\text{H}_2[\text{PtCl}_6]$. The as prepared GC-Pt electrode has been employed for electrocatalytic NO_2^- reduction under neutral pH condition.

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2. EXPERIMENTAL

All the glassware was boiled with deionized water and was sonicated to remove organic and inorganic contaminants. Solutions were prepared with analytical grade chemicals (Merck, Germany.) and Millipore Milli-Q water (resistivity $> 18 \text{ M}\Omega\text{cm}^{-1}$ and micro organic concentration $\leq 3 \text{ ppb}$). The volumes of the solutions to be examined in each independent experiment were 10mL. All the electrochemical experiments were performed three times with a Metrohm 797VA automatic electrochemical polarization system. A KCl saturated Ag/AgCl electrode was used as a reference electrode. The auxiliary electrode was a 4-cm^2 ordinary polycrystalline (OPC) Pt plate and the working electrode was primarily a glassy carbon (GC) electrode having a geometric area of 0.28cm^2 , which was then modified by depositing Pt particles. Prior to the surface modification, GC surface was cleaned smoothly by washing with deionized water followed by rubbing with alumina. Finally, the electrode was cleaned by cycling for 10–15 times in 0.5 M sulfuric acid solution between 0.6 and -0.6 V at 50mV s^{-1} scan rate. The cyclic voltammogram of 30 gL^{-1} SDS and $20\text{gL}^{-1} \text{ H}_2[\text{PtCl}_6]$ over GC showed Pt deposition wave at -0.75V and 25mVs^{-1} scan rate (Fig. 1). Therefore, the electroplating of the GC surface with Pt films was carried out at -0.7V for 300s using the same reaction mixture. The total deposition charge was

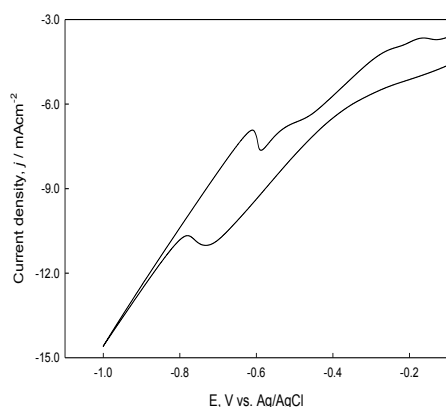


Fig.1. Cyclic voltammogram of Pt deposition over glassy carbon from a solution of 30 gL^{-1} SDS + $20\text{gL}^{-1} \text{ H}_2[\text{PtCl}_6]$ at a scan rate of 25mVs^{-1} .

determined to be 825 mC. This leaded formation of Pt films over GC surface. Before use, the as prepared GC–Pt electrode was rinsed with boiled

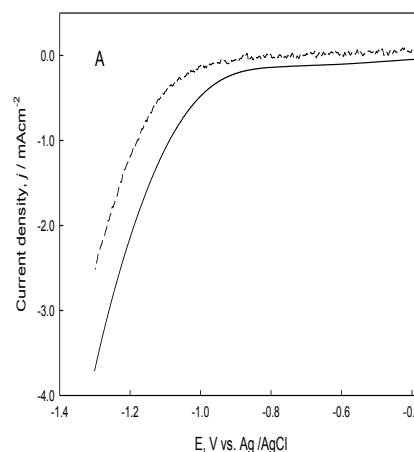
water for several times to remove the residual SDS. In order to avoid interference of O_2 , all the voltammetric experiments were carried out under N_2 atmosphere condition. The cathodic electrolysis was performed using a conventional cell divided by Nafion membrane (Walko Incorp. Japan). The concentration changes of NO_2^- and NH_4^+ ions as a function of time were evaluated by ion chromatographic technique. The XRD data was recorded using a multiflex 2KW diffractometer. The scanning electron microscope (SEM) image of the surface was taken with a JEOL model JSM–6060LV instrument.

3. RESULTS AND DISCUSSION

3.1. Cyclic Voltammetry

Figure 2 exhibits the comparison of the linear sweep voltammograms (LSVs, at a scan rate of 10mVs^{-1}) of 0.1M KNO_2 in 0.5M KCl recorded using a fresh GC electrode (Fig. 2A), OPC Pt electrode (Fig not shown) and as prepared GC–Pt electrode (Fig. 2C) at 293K . No characteristic feature for NO_2^- reduction is seen over the GC surface as shown in Fig. 2A. By contrast, the OPC Pt electrode shows a reductive wave (E1) at -0.80V having current density of -2.6 mAcm^{-2} . Meanwhile, E1 peak is shown to be appeared at -0.83V using the as prepared GC–Pt electrode having a current density of -8.1 mAcm^{-2} . The experiments were repeated using variable nitrite concentrations. Throughout the concentration range ($0.01\text{--}0.1\text{M}$), the peak current ratio ϕ ($J_{\text{E1(GC-Pt)}}/J_{\text{E1(ord.Pt)}}$) was 3.0 at 293K . This observation truly implied that the as prepared GC–Pt electrode was indigenously much reactive, compared to an OPC Pt electrode to reduce nitrite ions.

However, in order to evaluate the order of NO_2^-



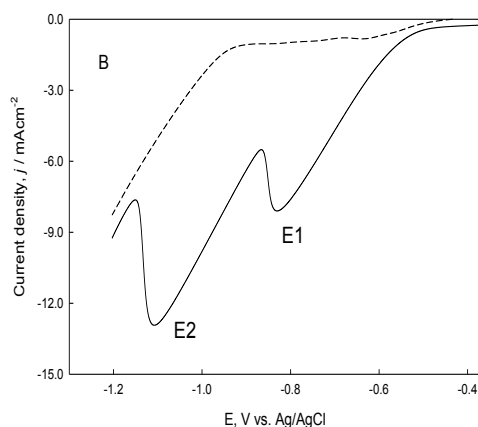


Fig. 2. LSV curves of 0.1M KNO_2 + 0.5M KCl over (A) Glassy carbon electrode and (B) Nano-structured GC-Pt electrode at 10mVs^{-1} and 293K.

reduction at peak potential (E1), $\log j$ was plotted against $\log[\text{NO}_2^-]$ in the concentration range as mentioned above. The slopes of the regression lines correspond to the respective order of reaction, which was 0.45 for OPC Pt electrode and 0.30 for the as prepared GC-Pt electrode, respectively. An interesting trait to underline is that the polarization curve of the GC-Pt electrode exhibited a second peak (E2) at -1.1V with a current density of -13.0mAcm^{-2} (Fig. 2B). This observation indicates that NO_2^- was reduced to an electro active intermediate (X) at E1, which was next converted into end product/s (P) at E2 wave following a consecutive reaction pathway (1).



Figure 3 illustrates how the E1 and E2 peaks, using GC-Pt electrode, were dependent on the scan rate at 293K. The E1 peak became saturated at scan rate of 50mVs^{-1} ; by contrast, the cathodic current associated to E2 peak was increased almost linearly as a function of scan rate. At all scan rates, E2 currents were larger than that of E1. Since either of the GC or OPC Pt electrode did not exhibit E2 peak (Fig. 2), it can be inferred that E2 peak was originated from the synergistic influence of GC and Pt particles. However, if the electro-active reactant was gaseous, the effect of temperature on the

reduction wave should be less important because of decreased solubility. In order to elucidate the nature of the intermediate (X) using GC-Pt electrode, temperature dependant experiments were next carried out between 290K and 333K. The OPC Pt electrode increased the current density of E1 wave having a rate of $0.12 \pm 0.005\text{mAcm}^{-2}\text{K}^{-1}$ without affecting the position of E1 (Fig. 4A). On the contrary, in case of GC-Pt electrode, E1 wave was shifted to negative potentials as the temperature was raised as shown in Figure 4B. At the same time, the current ratio (ϕ) at E1 wave was amplified from 3.0 ± 0.15 (at 290K) to 9.2 ± 0.52 (at 333K), confirming the stimulated performance of GC-Pt at higher temperatures. Here, it is to be noted that the E1 wave was distinctly influenced compared to the E2 wave with the temperature rise. At 290K, current associated to E1 was lower than that of E2; however, after 298K, current at E1 surmounted that of E2. Analytically, the E1 current density was boosted at a rate of $1.26 \pm 0.035\text{mAcm}^{-2}\text{K}^{-1}$; conversely, E2 current density was elevated at a rate of $0.76 \pm 0.015\text{mAcm}^{-2}\text{K}^{-1}$. This fact can be explained by the relative mass transfer rates of the electro-active species. The mass transfer rate of the ionic species NO_2^- , from the bulk to electrode surface, was positively influenced with the rise of temperature as has been reflected in the case of wave E1. At lower temperatures ($<298\text{K}$), $J_{E1} < J_{E2}$ implies that the intermediate X was strongly bonded to the electrode surface. The reverse effect ($J_{E1} > J_{E2}$), at higher temperatures ($>298\text{K}$), suggests that the intermediate generated at E1 was provably gaseous molecules, part of which was desorbed at the elevated temperatures exhibiting less momentous increase of current density at E2.

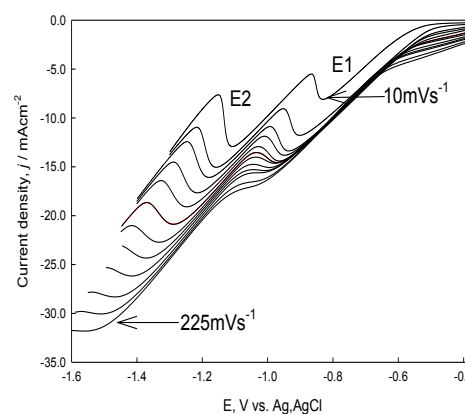


Fig. 3. Dependency of peak current and peaks positions of 0.1M KNO_2 reduction in 0.5MKCl on scan rate using as prepared GC-Pt electrode at 293K.

The appearance of E2 peak only by the GC-Pt electrode suggests that the gaseous intermediate (X) generated at E1, was most likely strongly adsorbed by the Pt particles in involvement of GC, which was consequently reduced at E2 potential. Meanwhile, the capability of Pt particles (on OPC surface) to adsorb the gaseous intermediates was not provably sufficient which ultimately can be reduced further on the same surface. This was

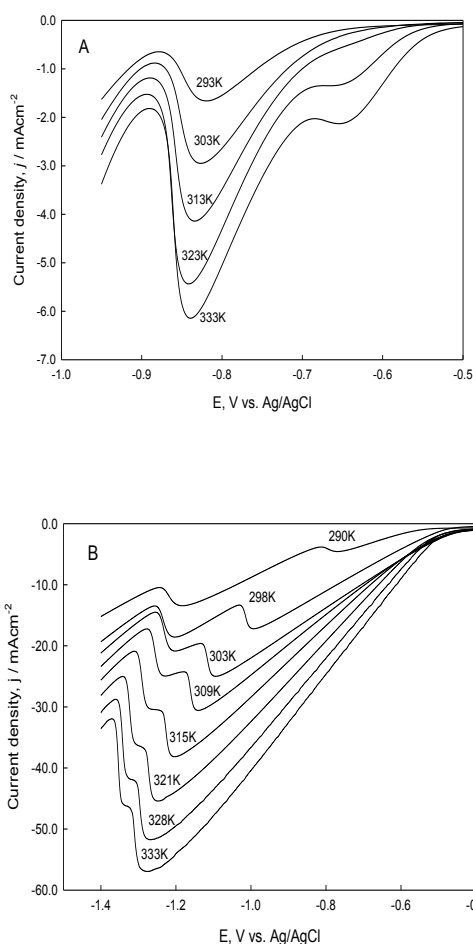


Fig. 4. Dependency of peak current on temperature for the reduction of 0.1M KNO_2 in 0.5M KCl over (A) ordinary Pt electrode and (B) GC-Pt electrode, at 25 mVs^{-1} scan rate.

might be the reason of the no-exhibition of the E2 wave by the OPC Pt electrode.

3.2. Rotating disk electrode

In order to identify the electron transfer reaction at peak E1, we employed Pt modified GC rotating disk electrode. The reciprocal of peak current, i at E1, versus reciprocal of square root of angular velocity, ω of the disk electrode yielded a straight line (Fig. 5) as per Koutecky–Levich equation (2) [16].

$$\frac{1}{i} = \frac{1}{i_K} + \frac{1}{0.62nFAD_0^{2/3}\sqrt{\omega}v^{-1/6}C_0} \quad (2)$$

Where, n is the number of electron transfer, D_0 ($2.0 \times 10^{-5} \text{ cm}^2 \text{ s}^{-1}$) the diffusion co-efficient of nitrite ions, ω the rotation frequency (rad/s), A the electrode area, F the faraday constant, i_K the current in absence of mass transfer and C_0 the nitrite concentration. From the slope, the value of n was obtained to be 0.83, which indicates that single electron transfer reaction might have taken place at E1. Therefore, this observation fairly suggests that NO was generated at E1 due to the following reaction (3).

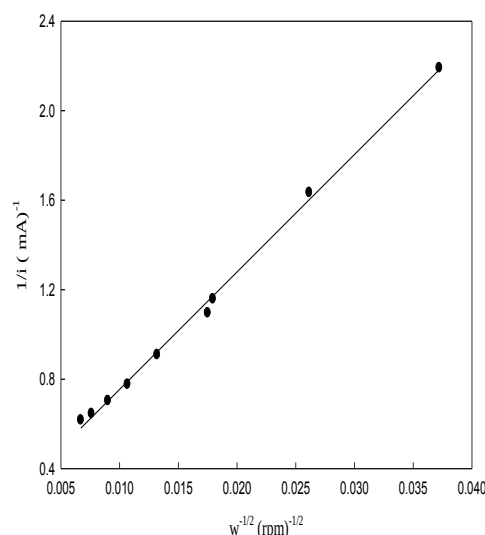
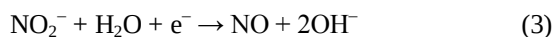


Fig. 5. Koutecky–Levich plot for NO_2^- reduction over GC-Pt rotating disk electrode at -0.85 V . $[\text{NO}_2^-] = 1.0 \times 10^{-3} \text{ M}$, supporting electrolyte: 0.5M KCl, electrode area: 0.2826 cm^2 , room temperature

The literatures also support this observation. Many researchers reported that Pt electrode can generate NO adlayers during NO_2^- reduction (Hasnat et.al., 2008).

3.3. Chronoamperometry

Double peak chronoamperometry were next employed to investigate electrochemical process by setting the electrode potential -0.85V and -1.15V respectively using GC–Pt electrode. Figure 6 represents the current transients of 0.5M KCl both in absence (a) and in presence (b) of 0.1M KNO_2 . In the second step, the net current due to reduction was larger than that was observed in the first step. This assessment is purely consistent with the CV results at room temperature as shown in Fig.2C. However, for an electroactive material, electrochemical reaction (under diffusion control) is described by Cottrell's equation (4) (Bard and Faulkner, 2001).

$$I = nFAD_o^{-1/2}C\pi t^{-1/2} \quad (4)$$

Where, C is the bulk concentration (mol cm^{-3}), D_o the diffusion co-efficient, n the number of electron transfer, F the Faraday constant, A the electrode area. From the plots of I vs. $t^{-1/2}$ vs. $t^{-1/2}$ the values of n was determined to be 0.91 at -0.85V , which literally validated the reaction (3). The value of n was also estimated at -1.15V assuming that all the NO species generated at -0.85V was electro-active at -1.15V . The value of n (3.8), determined for the second step, suggests that either NH_2OH or NH_3 might be the potential end product. According to the method describe in literature (Galus, 1976), the catalytic rate constant (k_o) due to heterogeneous electron transfer may be calculated using the following equation:

$$I_{\text{cat}}/I_d = \pi^{1/2}(k_o C_o t)^{1/2} \quad (5)$$

Where, I_{cat} is the catalytic current in presence of nitrite, I_d is the diffusion limited current in absence of nitrite and t the time. From the slopes of the I_{cat}/I_d vs. $t^{1/2}$ plot, the catalytic rate constant (k_o) was calculated as $1.0 \times 10^2 \text{ M}^{-1}\text{s}^{-1}$ for the process took place in the first step, which was raised to $4.4 \times 10^2 \text{ M}^{-1}\text{s}^{-1}$ in the second step. As mentioned previously, in the first step single electron transfer reaction (3) was identified by applying Koutecky–Levich and Cottrell's equations. Therefore, the 4.4 fold charge transfer in the second step compared to first step, points that around 4–electron transfer reaction was involved in the second step. This means that either of the following reactions (6 and or 7) might have taken place in the second step.

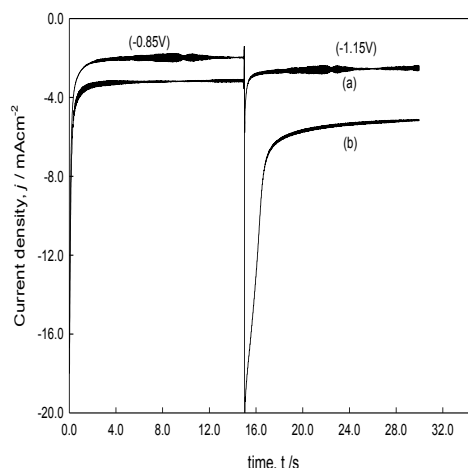
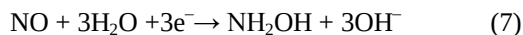


Fig. 6. Double step chronoamperograms of 0.5M KCl (a) and 0.5M KCl + 0.1M KNO_2 at 300K . Sampling pulse: 1ms ; First and second steps were -0.85V and -1.15V vs. Ag/AgCl respectively.



4. CONCLUSION

The present study unveils the higher reduction capability of SDS templated GC–Pt electrode for nitrite ions. This electrode showed an apparent view of consecutive mechanism; $\text{NO}_2^- \rightarrow \text{NO} \rightarrow \text{NH}_4^+$. This electrode might be used for ammonia synthesis as well as NO_2^- detection.

ACKNOWLEDGEMENT

The authors acknowledge the helps from Prof. I. Taniguchi, Prof. M. Machida and Dr. D.J. Zhang, Department of Nano Science and Technology, Kumamoto University, Japan. A special thanks to Dr. Rezwana Miah of Department of Chemistry, Shahjalal University of Science and Technology, Sylhet, Bangladesh for important counseling.

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ENTREPRENEURIAL MANAGEMENT: AN INTERNATIONAL STUDY

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Key words: entrepreneur, management, industry

INTRODUCTION

Entrepreneurship

The word *entrepreneur* originates from the French word, *entreprendre*, which means "to undertake." In a business context, it means to start a business. The Merriam-Webster Dictionary presents the definition of an entrepreneur as one who organizes, manages, and assumes the risks of a business or enterprise.

Entrepreneurship is the act of being an entrepreneur, which can be defined as "one who undertakes innovations, finance and business acumen in an effort to transform innovations into economic goods". This may result in new organizations or may be part of revitalizing mature organizations in response to a perceived opportunity. The most obvious form of entrepreneurship is that of starting new businesses however, in recent years, the term has been extended to include social and political forms of entrepreneurial activity. When entrepreneurship is describing activities within a firm or large organization it is referred to as intra-preneurship and may include corporate venturing, when large entities spin-off organizations. Entrepreneurial activities are substantially different depending on the type of organization that is being started.

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Austrian economist Joseph Schumpeter's definition of entrepreneurship placed an emphasis on innovation, such as:

- new products
- new production methods
- new markets
- new forms of organization

Any **entrepreneurial manager** is charged with the difficult task of turning a business idea into reality, either through starting a new business or injecting new life into an existing one. To help them along each step of the journey – from finding the idea in the first place through to its planning and implementation – the manager can draw inspiration from the experiences of others who have been on similar journeys before them.

As a means of **entrepreneurship development**, the footsteps of others can be followed and the entrepreneur can benefit from the wisdom of those who have found a route to success.

Entrepreneurship management demands innovation, as well as the marriage of profitability and growth.

History of Entrepreneurship

The entrepreneur is a factor in microeconomics, and the study of entrepreneurship reaches back to the work of Richard Cantillon and Adam Smith in the late 17th and early 18th centuries, but was largely ignored theoretically until the late

19th and early 20th centuries and empirically until a profound resurgence in business and economics in the last 40 years.

In the 20th century, the understanding of entrepreneurship owes much to the work of economist Joseph Schumpeter in the 1930s and other Austrian economists such as Carl Menger, Ludwig von Mises and Friedrich von Hayek. In Schumpeter, an entrepreneur is a person who is willing and able to convert a new idea or invention into a successful innovation. Entrepreneurship employs what Schumpeter called "the gale of creative destruction" to replace in whole or in part inferior innovations across markets and industries, simultaneously creating new products including new business models. In this way, creative destruction is largely responsible for the dynamism of industries and long-run economic growth.

For Schumpeter, entrepreneurship resulted in new industries but also in new combinations of currently existing inputs. Schumpeter's initial example of this was the combination of a steam engine and then current wagon making technologies to produce the horseless carriage. In this case the innovation, the car, was transformational but did not require the development of a new technology, merely the application of existing technologies in a novel manner. Despite Schumpeter's early 20th-century contributions, traditional microeconomic theory did not formally consider the entrepreneur in its theoretical frameworks (instead assuming that resources would find each other through a price system). In this treatment the entrepreneur was an implied but unspecified actor, but it is consistent with the concept of the entrepreneur being the agent of x-efficiency.

Different scholars have described entrepreneurs as, among other things, bearing risk. For Schumpeter, the entrepreneur did not bear risk the capitalist did.

For Frank H. Knight (1921) and Peter Drucker (1970) entrepreneurship is about taking risk. The behavior of the entrepreneur reflects a kind of person willing to put his or her career and financial security on the line and take risks in the

name of an idea, spending much time as well as capital on an uncertain venture. Knight classified three types of uncertainty.

- Risk, which is measurable statistically (such as the probability of drawing a red color ball from a jar containing 5 red balls and 5 white balls).
- Ambiguity, which is hard to measure statistically (such as the probability of drawing a red ball from a jar containing 5 red balls but with an unknown number of white balls).
- True Uncertainty or Knightian Uncertainty, which is impossible to estimate or predict statistically (such as the probability of drawing a red ball from a jar whose number of red balls is unknown as well as the number of other colored balls).

Management

Management in all business and organizational activities is the act of getting people together to accomplish desired goals and objectives efficiently and effectively. Management comprises planning, organizing, staffing, leading or directing and controlling an organization (a group of one or more people or entities) or effort for the purpose of accomplishing a goal. Resourcing encompasses the deployment and manipulation of human resources, financial resources, technological resources and natural resources

Basic functions/Roles-Management operates through various functions, often classified as planning, organizing, staffing, leading/directing, and controlling/monitoring.i.e

- **Planning:** Deciding what needs to happen in the future (today, next week, next month, next year, over the next 5 years, etc.) and generating plans for action.
- **Organizing:** (Implementation) making optimum use of the resources required to enable the successful carrying out of plans.
- **Staffing:** Job analyzing, recruitment, and hiring individuals for appropriate jobs.

- **Leading/Directing:** Determining what needs to be done in a situation and getting people to do it.
- **Controlling/Monitoring:** Checking progress against plans.
- **Motivation:** Motivation is also a kind of basic function of management, because without motivation, employees cannot work effectively. If motivation doesn't take place in an organization, then employees may not contribute to the other functions (which are usually set by top level management).

Managers vs. Entrepreneurs

A manager is someone who directs a team and an entrepreneur is someone who organizes, manages, and assumes the risks of a business or enterprise. An entrepreneur can be a manager but a manager cannot be an entrepreneur. A manager is someone who is what is known as a micro-manager. They like to control all aspects of their workplace. Each person is given their assigned tasks and a manager will look over your shoulder until you finish it. An entrepreneur is generally considered a leader versus a manager. They will give people tasks and a deadline and generally leave them alone until it is completed. They will trust people to get the job done without having to constantly look over their shoulder.

Entrepreneurship and Economic Development

Entrepreneurship plays an important role in the economic development of a country. Entrepreneurship creates the forces of change and ultimately accelerates the pace of economic development. An entrepreneur introduces new ideas, technology and methodology for performing works and jobs in the country. As total production increases so as a whole, economic development is achieved.

The proper utilization of human and non-human resources is important for economic development. Entrepreneurs extend help in this regard by accumulating the scattered resources and make them productive through new ventures. Consequently,

industrialization boosts up both vertically and horizontally which ensures proper utilization of natural and other supplementary resources.

Creation of employment is another important aspect of economic development. Entrepreneurship contributes substantially to employment generation. Entrepreneurs also promote a better skilled workforce through institutional training and introducing them with new technologies.

Entrepreneurs also bring attitudinal changes. Economic advancement greatly depends on the level and degree of use of technology in production. The traditional outlooks, attitudes, values and behavior of the people sometimes hinder economic development. Entrepreneurs in any country help in this regard by introducing new methods and technologies in the society and generating them to remove narrow outlooks and attitudes of people. In fact, developing entrepreneurship can remove the narrow social outlooks and attitudes of people.

Moreover, where entrepreneurship contributes to increase national income, create environment for innovation, change personal consumption, develop infrastructure, increase savings propensity and above all, change the standard of living of the people.

Women Entrepreneurship and Women Development

Women's development all over the world is, now a day, a zenith of the common realization. The attainment of any sustainable development activities cannot be achieved without the full participation and integration of women in all spheres of life. Therefore, the institutions can play a prudential role in promoting women's development through entrepreneurship.

Considering women as an important ingredient of human development, a proliferation of policies, programmes and projects designed to help women has been evolved over the last couple of decades. The conceptual frame work and the institutionalization process of modern times "Women in Development (WID)" approach were familiarized from

“welfare” to “equity” (1950-1970); “equity” to “anti-poverty” (1970-1980); “anti-poverty” to “efficiency” (post 1980s); and to “empowerment” (1990 onwards).

Since independence, Bangladesh has emphasized on women empowerment. Significant increase of women participation can be found in economic activities though it is not up to the optimum level. Government agencies, economists, policy makers, financial executives, political leaders and administrators now think of women empowerment in any development activities. It is also realized that Bangladesh needs to exploit economic potentialities of women as entrepreneurs. Now socio-economic development of Bangladesh and Women Entrepreneurship Development (WED) are co-existed.

At present women are entering into trades and industries. They are contributing to increase their family income and playing important role in the family. In a modern society, women’s roles are not limited to the family alone. Now they are being essentially considered as a potential part of the work force and their roles in the economic development of the country cannot be ignored from the framework of socio-economic development. Their roles in this regard have enhanced their economic independence, ensured their empowerment in any field of development, and established their social status. After realizing this matter, the government is therefore, making policies and implementing various plans and programmes.

The development efforts by GOs and NGOs could not bring any significant change in the quality of women’s life. There are many reasons behind the failure of the various ISs to WED in Bangladesh. This thing frustrates WEs to set up their enterprises. Though the supports to women by different institutions in developing entrepreneurship may be visualized insufficient and less effective, it is positive to find that women are participating in the labour market of Bangladesh, which is contributing to socio-economic development, (and that) provide some qualitative changes in urban and rural areas. From these mentioned views, position of women and entrepreneurship and the relationship with socio-economic development could be evaluated.

Model of Entrepreneurship

There are different models of entrepreneurship. Those are-

- Behavioural Model of Entrepreneurship
- Push’ and ‘Pull’ Theoretical Model of Entrepreneurship
- Model of Strategic Management
- Model of Variables Affecting the Performance of Entrepreneurship
- Entrepreneurial Economic Success Index (EESI)
- Gibb’s Small Enterprise Development Model
- Model developed for the analysis Effectiveness of NGO supported Micro-enterprises

Proposed Model for Assessment of Effectiveness of ISs in WED

This model is developed focusing on the examination of the supports provided by the institutions for the development of WEs. The study was confined on particular businesses where the institutions supported WEs to develop. Again, the study is developed that ISs should have out the performance of WEs in market for specific businesses. That is why WEs, ISs and SMEs kept in the middle of the model surrounding the development wheel where market performance is prime to evaluate. The heart of this model ‘Assessment of effectiveness of ISs in WED’ designated by ‘A’ is placed in a circle in the centre. The size and characteristics of the SMEs, WEs and ISs are shown in the right box (marked- B) of the centre. For the development of WEs, they require ISs. The requirement might be common for all businesses and some requirements might be business specific. It is discussed earlier that the position of women in society suggests ISs for the development of WEs obviously. As the research examines the effectiveness of ISs for WED that is why, on the left hand side box (marked-C) ISs are placed. The concept of institution also has been described in the framework section of this chapter. Institutions provide financial and non-financial, software and hardware supports for WEs. These supports need to be examined. The box (marked- D) below the oval, structured to examine if ISs meet the requirement for the

sustainability of WEs, if institutions' delivery mechanism is designed accordingly. This examination of effectiveness will include the appropriateness, adequateness, proper delivery and finally the external and internal performance of the SMEs. Therefore, for the appropriateness, adequateness and delivery mechanisms concerned with this model aim at examining whether the types of ISs delivered at various stages of development were appropriate and adequate. The SMEs performance will be examined based on their past trends, experience and potentials for various growth and farsightedness. Using qualitative quantitative and measures the effectiveness of SMEs is to be examined.

and WEs. That feedback system was designed to find out the gap between demand and supply. It is also worked out to examine the process and by suggesting appropriate measures, delivery of supports and actions to be taken by WEs. The model incorporates all possible elements in its greater environment those thought to have influence on the delivery of various and the need and operational activities of the SMEs.

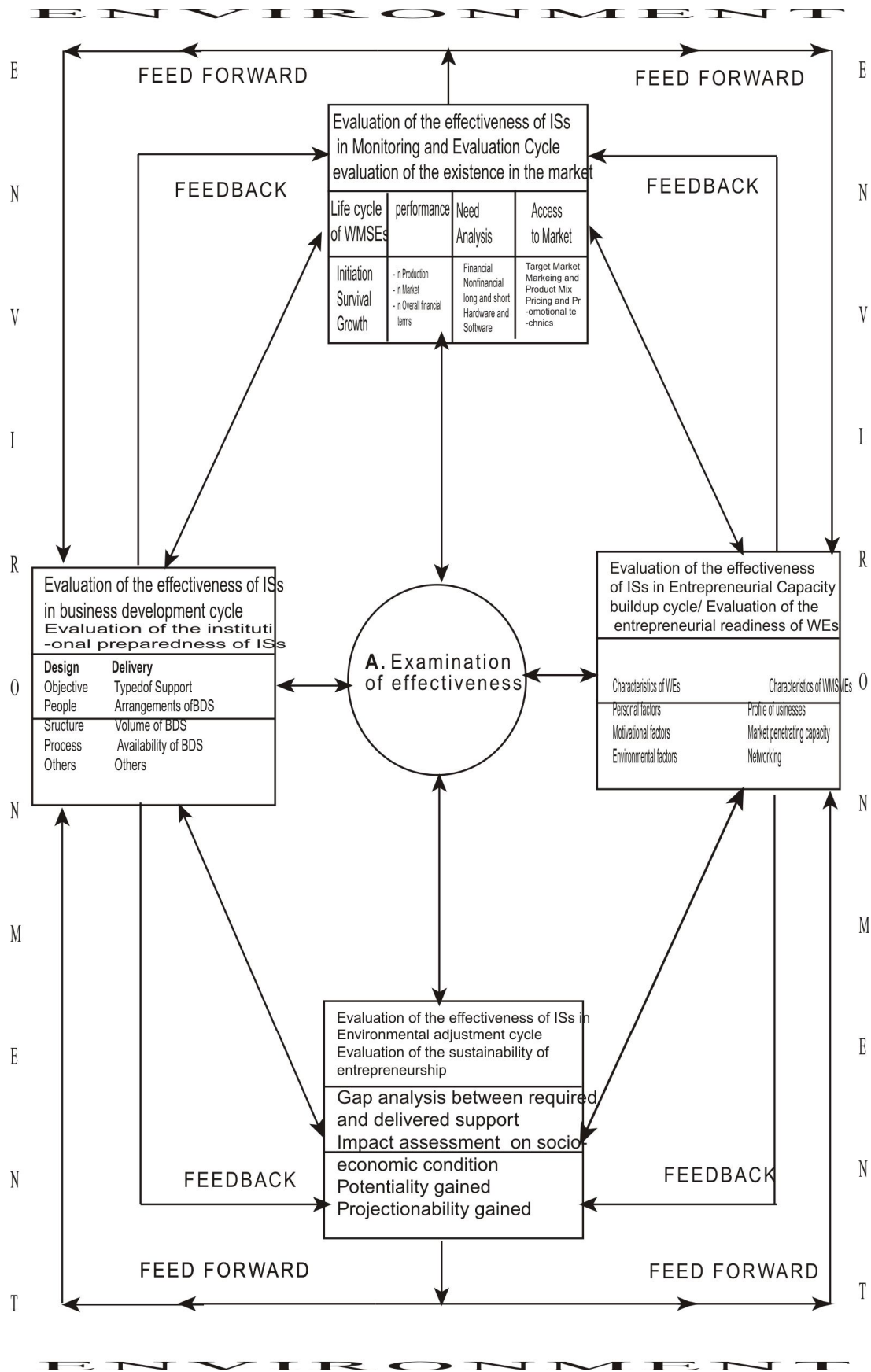
The development of WEs in selected businesses has been thought to the product of effectiveness of the design of ISs at market environment, the performance of supported WEs at market environment with in the greater external environment of the as well as WEs in the internal environment of the institutions and SMEs.

The output of the SMEs is thought to be the combined effect of both ISs and WEs. WEs access in the market environment with

A feedback system also has been developed to have the effect on the supply and demand of ISs as well as on the measures of the effectiveness of ISs. The model also focuses on the measurement of the effectiveness (Marked-E) of ISs. Institution's objectives for choosing such programme, development of the people concerned, the structure of ISs, the process of the delivery of supports and the process of receiving the same by SMEs and other sectors such as strength and weaknesses of the SMEs for particular businesses as shown in the top of the oval, are considered while measuring the effectiveness. The feedback system works here for influencing or adjusting demand and supply of both parties, i.e., institutions product or services of the SMEs supported by institutions develops the entrepreneurship. This happens in each business where feedback from specific market environment for specific business develops WEs.

The quantitative and qualitative measures have been accommodated for examination of the effectiveness of ISs. The overall effectiveness, the focus of the model, thought to have interactive effect on both the design and delivery of ISs and the entrepreneurial capability of WEs for specific SMEs in market environment.

Proposed Model for Assessment of Effectiveness of ISs in WED



Bangladesh is among the most densely populated countries in the world with the seventh large population of the world. Half of the GDP comes from service sector although two-thirds of Bangladeshis are farmers. More than three quarters of Bangladesh's export earnings come from the garment industry. Cheap labor and low conversion cost attracted huge foreign investment in this sector. The huge population and frequent natural calamity are two severe obstacle in economic countries economic growth. Also poor governance and weak public institutions, inefficient use of energy resources, insufficient power supplies, slow implementation of economic reforms, political infighting and corruption are significant obstacles too. Even though According to world bank despite of all these obstacles Bangladesh has shown steady economic growth of 4-5% annually (6.5% in 2006-2007), relatively low inflation and fairly stable domestic debt, interest, and exchange rates.

Bangladesh deserves acclamation for introducing microcredit. It covers a wide area of rural households as a means of poverty reduction. Few example- Grameen Bank, ASA, BRAC, Karitas, Proshika.

Grameen Bank helps to

- ❖ extend banking facilities to poor men and women
- ❖ eliminate the exploitation of the poor by money lenders
- ❖ create opportunities for self-employment for the vast multitude of unemployed people in rural Bangladesh
- ❖ bring the disadvantaged, mostly the women from the poorest households,
- ❖ reverse the age-old vicious circle of "low income, low saving & low investment", into virtuous circle of "low income, injection of credit, investment, more income, more savings, more investment, more income".

The Association for Social Advancement (ASA) helps to

- empowering women for poverty alleviation
- entrepreneurship development
- Capacity building

It introduced a small entrepreneur-lending (SEL) programme

In RMG Sector currently, there are 4490 manufacturing units. The sector contributes significantly to the GDP provides employment to around 4.2 million of whom 90% are women generates about \$5 billion worth of products each year by exporting garment.

Entrepreneurship in India

India is ninth in the Global Entrepreneurship Monitor (GEM) survey of entrepreneurial countries. It is highest among 28 countries in Necessity based entrepreneurship, while 5th from the lowest in opportunity based entrepreneurship. The liberalization, which was started in 1991 and the Information Technology boom of the mid-late 90's, have been significant factors, leading to a wave of entrepreneurship sweeping through the country. Indians have entrepreneurial capacity. Moreover, in India, the post-liberalization and globalization era has brought with it a growing middle class - roughly estimated to be 250 million - and rising disposable incomes. This presents a huge potential, which if tapped can be a veritable gold mine. Entrepreneurs can make the best of this by catering to various demands of this segment. India, with its abundant supply of talent in IT, management, and R&D, has become the hot bed of outsourcing of services from all parts of the globe where companies can reduce their costs, but not their quality [If the foreign company chooses the right Indian partner].

- Indian entrepreneurship is second to none and activity levels are at an all time high
- Entrepreneurs are driving the growth of the Indian economy
- One in every ten Indians is engaged in some entrepreneurial activity or the other.
- Ambani's Reliance Communications made mobile telephony affordable to the common man.
- Tata Motors with their \$2,000 car promise to do the same to the auto sector.

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Entrepreneurship In China

China has emerged as a world economic super power, forcing all players to consider new economic models. The growing significance of small and medium-sized enterprises (SMEs) in China's economy is hard to ignore. Chinese and foreign experts estimate that SMEs are now responsible for about 60% of China's industrial output and employ about 75% of the workforce in China's cities and towns. Private business is the fastest-growing sector of China's economy, expanding at an annual rate of 20 percent, far above the 9.5 percent average growth of the national economy over the past two decades. China has the highest number of the world's richest people under age 40 outside of the United States, according to Fortune magazine. The Chinese government is providing the "enabling environment" for small and medium-sized enterprises (SMEs).

- Industry produced 53.7 percent of China's gross domestic product (GDP) in 2009
- Industry (including mining, manufacturing, construction, and power) contributed 52.9 percent of GDP in 2009 and occupied 2.5 percent of the workforce.
- China is the world's leading manufacturer of chemical fertilizers, cement, and steel.
- SMEs are now responsible for about 60% of China's industrial output and employ about 75% of the workforce in China's cities and towns.

- Chinese entrepreneurs bid on antique Rolls-Royces and pay cash for the latest BMWs.
- Measured on a purchasing power parity (PPP) basis, China in 2006 stood as the second largest economy in the world after the US, although in per capita terms the country is still lower middle-income. 130 million Chinese fall below international poverty lines. While overall income is rising, wealth is not equally distributed.

Entrepreneurship in Thailand

Entrepreneurship has long been the main vehicle of Thai economic growth. The government and other related agencies initiated several projects and activities to help strengthen and promote entrepreneurship in the country. Private enterprises in Thailand can be divided legally into four categories: unlimited partnership, limited partnership, limited company and public company. During the decade of economic boom in Thailand, entrepreneurial activity expanded at a very rapid rate. Entrepreneurship Development Program in Thailand helps the entrepreneurs think systematically and help them make right decisions before investing in and expanding their business. The financial constraints play an important role in shaping the pattern of entrepreneurship in Thailand, especially in the Northeast compared to the Central region.

Thailand is one of the highest rates of women entrepreneurship activity among GEM countries. It stood at 18.5% in 2002. High levels of necessity based rather than opportunity based entrepreneurs. There is a direct correlation between the rates of economic growth with the intensity of entrepreneurial activity in Thailand. Since the 1960s, the private sector has played a critical role in the country's economic growth. A Buddhist belief system has also contributed to tolerance of failures with regards to entrepreneurship.

The Thai Board of Investment (BOI) was set up to facilitate new business ventures. The Thai commercial class is mostly made up of Thais of Chinese origin. This group is characterized as having a greater entrepreneurial drive (a result of their

Confucian belief system). This group has contributed significantly to the economic development of Thailand and is also largely responsible for moving the Thai economy from an agriculture-based economy to a more service-based economy.

CONCLUSION

Entrepreneurial activities are substantially different depending on the type of organization that is being started. Entrepreneurship is a challenging and rewarding profession. It needs to concentrate on market analysis, financial resources, and technology management. Recently Bangladesh has seen a dramatic increase in foreign direct investment. Telecommunications have shown remarkable improvements after the sector was opened for private investment. A number of multinational corporations, including Unocal Corporation and TATA have made major investments, with the natural gas sector being a priority. Goldman Sachs referred Bangladesh as one of the next eleven emerging country and emphasis on the potential of future economical growth. Bureaucracy and red tape is still part of the investment problem but huge local market cheap labor and more export focused government policies encouraging more pro business environment.

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Fabrication of 2D plasmonic super lattice of silver nanocubes for molecular sensing using surface enhanced Raman spectroscopy.

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Abstract: Colloidal solution of silver nanocubes was prepared by polyol method and 2D structure of nanocubes was fabricated by Langmuir-Blodgett technique. The as prepared 2D organization of silver nanocubes exhibited Plasmonic property and was employed to detect Rhodamine 6G molecules at different solution concentrations. Fluorescence and Raman signals were detected at 1pM and 1nM concentrations of Rhodamine 6G respectively. Such plasmonic materials can be used to develop chemical and biosensors platforms.

Keywords: Silver nanocubes, plasmonic material, Langmuir-Blodgett technique, Surface Enhanced Raman Scattering.

Formation of 1,1,1 trifluoroethane (143a) in HCFC-22 Reactor

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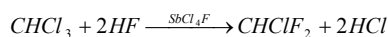
#State Office for Nuclear Safety, Department of Non-Proliferation Division of Chemical Weapons Prohibition, Prague 2 120 00, Czech Republic

HCFC-22 is used as a precursor to produce tetrafluoroethane (TFE) monomer, which is further polymerized to manufacture different fluoropolymers. The presence of 1,1,1 trifluoroethane (143a) in HCFC-22, even at ppm level, is potentially detrimental to the quality of fluoropolymers manufactured from TFE. The objective of the present investigation is to track the source and the reaction mechanism of 143a formation in the HCFC-22 reactor. The investigation started with a careful survey on the possible pollutants in the raw materials of a HCFC-22 plant followed by a critical review of the chemistry of catalyst $HF/SbCl_5$ as well as patented manufacturing processes of fluoro products. The probable source and chemistry towards formation of 143a were examined. It was revealed that both 1,1 dichloroethane and *cis* 1,2 dichloroethene present as contaminants in the raw materials are the potential sources of 143a, with *cis* 1,2 dichloroethene being the most likely source. It was also suggested that facilitating chlorination of the 1,1 dichloroethane and *cis* 1,2 dichloroethene inside the reactor would decrease the amount of 143a formed.

Key words: HCFC-22, 143a, $HF/SbCl_5$, *cis*-1,2-dichloroethene, 1,1-dichloroethane, Chloroform, Hydrogen fluoride

1. INTRODUCTION

HCFC-22, also known as R-22, is a refrigerant used for residential and commercial air conditioning and for medium- and low-temperature commercial refrigeration applications. Although HCFC-22 is subject to Montreal Protocol and phase out as a refrigerant, it is still in use as a precursor for manufacturing the monomer tetrafluoroethane (TFE), which is later polymerized into different fluoropolymer products. HCFC-22 is produced by the continuous, liquid phase reaction of chloroform and hydrogen fluoride in presence of a partially fluorinated antimony pentachloride catalyst. The reaction is carried out in a simple, steam heated, tank type reactor. The overall process for HCFC-22 and by product HCl is as follows;



A very small amount of HCFC-23 is also produced in this process. Table 1 summarizes the reaction temperature and pressure maintained inside the HCFC-22 reactor.

Among the impurities present in HCFC-22, 1,1,1 trifluoroethane (143a) is of particular concern as

it is potentially detrimental to the quality of fluoropolymers, although the chemistry and extent of the effects are not well understood.

Table 1: Temperature and pressure limits of HCFC-22 reactor

HCFC-22 Reactor	Max	Min	Typical	Units
System pressure	240	140	225	psig
Reactor temperature	90	65/70	80	$^{\circ}C$

Laboratory analyses show that 143a is generally present at 1 ppm level in HCFC-22. Two to 3ppm 143a, however, is not uncommon. On some occasion it may go up to as high as 10 ppm. It is postulated that 143a in HCFC-22 has a link with the impurities present at ppm level in the raw materials. The characteristics and chemistry of these impurities are, however, not very clear. It is, nevertheless, imperative to track the source and reaction mechanism of 143a formation in HCFC-22 reactor in order to keep 143a at an acceptable level.

The objective of the present investigation is to identify the source(s) of 143a and to understand

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the chemistry towards its formation in the HCFC-22 reactor. The objective is realized by the following steps;

- i) Survey of related literature
 - a. to obtain a list of possible contaminants in the raw materials, i. e. Chloroform and HF
 - b. to understand fluoro-chloro chemistry of hydrocarbons in presence of $SbCl_5$ catalyst
- ii) Identification of the possible sources and reaction mechanisms of 143a formation
- iii) Suggestion of possible measures to be taken for reduction of 143a formation

2. CONTAMINANTS IN THE RAW MATERIALS

In order to short list the potential contaminants present in the reactor, industrial production processes of the raw materials along with the impurities in commercially available raw materials were reviewed.

Table 4 Potential Contaminants in Raw Materials

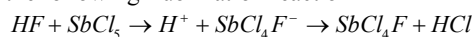
Impurities in Chloroform	Impurities in HF
Bromo-chloromethane	Arsenic
Methyl Chloride	Flourosilicic acid
Methylene Chloride	Nonvolatile acid
1,1 dichloroethane	Sulphur dioxide
Carbon tetrachloride	Water
Acidity as HCl	
Water	
Free Halogens	
Nonvolatile matter	
Amylene content	
Cis 1,2 dichloroethene	
Trans 1,2 dichloroethene	
2-methyl-2-butene	
Benzene	
Toluene	
Chlorobenzene	
Ethylbenzene	
m & p-Xylene	
o-Xylene	
1,3,5 trimethylbenzene	
1,2,4 trimethylbenzene	
1,4 dichlorobenzene	
1,2 dichlorobenzene	
1,2,4,5	
tetramethylbenzene	
Biphenyl	
Hexachlorobenzene	

The list was compared with the list of potential contaminants in raw materials provided by the

raw material suppliers (table 4). It was found that the list provided by the raw material suppliers is comprehensive. One may consider the possibility of presence of two more contaminants in chloroform (b.p.61.2⁰C), namely, 1,1,1 tri-chloroethane (b.p.74⁰C), and 1,1 dichloroethene (b.p.32⁰C). The boiling point differences between Chloroform and these two compounds make their existence very slim in the raw materials. This is also true for *trans* 1,2 dichloroethene (b.p.47.5⁰C), which most of the time does not exist in chloroform.

3. CHEMISTRY OF THE CATALYST $SbCl_5$

In presence of HF the catalyst $SbCl_5$ undergoes the following fluorination reaction ^[2]



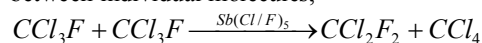
The $SbCl_4F$ takes part in two types of fluorination reaction:

i) Substitution reactions

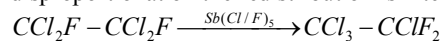
The first type is the substitution reactions, in which fluorination of chlorocarbon takes place through the successive replacement of the chlorine atoms by fluorine. The rate and extent of the overall reaction depend on the fluorine content of antimony halide as well as the relative reactivity of the C-Cl bonds. Some groups i.e. allyl, benzyl and methyl group in CH_3-CCl_3 are very active and the target Cl atom can be replaced easily. By contrast, molecules like in CCl_3-CCl_3 and $CCl_2=CCl_2$ are less reactive and requires pentavalent catalyst with a fluorine content greater than $SbCl_4F$.

ii) Disproportionation reactions

The second type is disproportionation reaction in which the substituents of the organic molecules rearrange themselves into thermodynamically more stable configuration. In an intermolecular disproportionation the groups are exchanged between individual molecules;



One the other hand, in the intramolecular disproportionation the redistribution is internal;



It is to be noted that thermodynamically the most stable configuration is the one possessing the least symmetry.

4. TRACKING THE SOURCES AND RESPECTIVE CHEMISTRY OF 143a FORMATION

The identification of the source of 143a started with the list of hydrocarbons provided by the raw material suppliers. The elimination of the unlikely hydrocarbons forming 143a was done next. Two types of hydrocarbon were excluded from the list based on the following considerations;

- As 143a is an aliphatic compound the aromatic impurities are excluded
- As 143a is a bi carbon compound and the catalyst ($SbCl_5$) does not take part in addition reaction the mono-carbon impurities are excluded

The following three compounds are left in the list for further consideration

1. 1,1- dichloroethane
2. *cis* and *trans* 1,2 –dichloroethylene
3. 2-methyl-2-butene

A literature survey on fluorochemistry shows that almost all contemporary research works deal with the reduction of Freon production or finding alternatives to it rather than the impurities HCFC-22 may contain. Much of the information referred in this investigation is obtained from different patents describing manufacturing conditions and yields of different fluorohydrocarbons. During the investigation, the focus was made on the type of catalyst used and the reaction temperature. The references used in explaining the reaction mechanism are mostly for $HF/SbCl_5$ system. In absence of any reference with $HF/SbCl_5$, references of similar system, such as $HF/SnCl_5$ or $HF/Cr-Mg$ are used to approximate the reaction thermodynamics. In the following sections the chemistry of three probable contaminants as possible sources of 143a are discussed under the conditions prevailing in the HCFC-22 reactor.

i) Chemistry of 1,1 dichloroethane

Investigation on the mechanism of formation of 143a from 1,1 dichloroethane leads to two possible routes (figure 1).

1. The first route 1→2→3 involves fluorination of 1,1 dichloroethane to 1,1 difluoroethane in presence of $HF/SbCl_5$ system and at a favourable temperature i.e. 50-120°C^[1]. Formation of 143a, however, requires further fluorination, which necessitates replacement of one hydrogen atom. This can only be done by free fluorine^[2], not by HF . The list of impurities provided by the suppliers show the presence of free halogen in raw materials. This free halogen, if F_2 , may contribute to the formation of 143a. It is to be noted the free chlorine does chlorinate hydrocarbons at the temperature maintained in the reactor^[3].
2. The second route 1→2'→3' involves chlorination of 1,1 dichloroethane to trichloro-ethane (HCFC-140a). The trichloro-ethane further reacts with HF to form 143a. As mentioned earlier the methyl group in trichloroethane is a highly potent activator for replacement of Cl by $SbCl_5$ catalyst. The reaction temperatures 70 to 100°C., and reaction pressures 50 to 100 psig, are adequate to fluorinate HCFC-140a to form HFC-143a^[4]. The presence of free fluorine, again provides another route to the formation of 143a from tri-chloroethane.

All fluorination reactions, however, have to compete with highly probable chlorination of 1,1 dichloroethane and formation of $CHCl_2-CHCl_2$ and higher chlorinated compounds with high boiling points that build up in the reactor

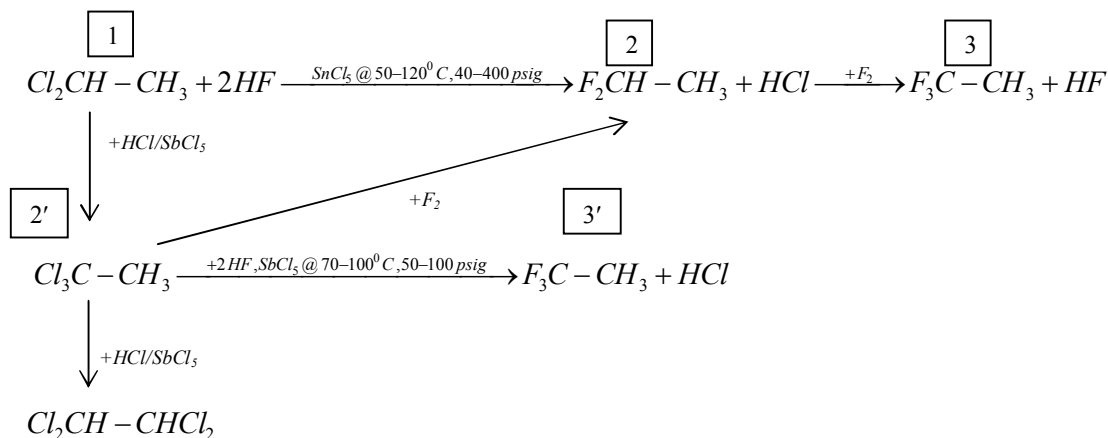


Figure 1 Formation of 143a from 1,1 dichloroethane

ii) Chemistry of 1,2 dichloroethylene or 1,2 dichloroethene

Manufacturing 143a from 1,1 dichloroethene (also known as vinylidene chloride) is a standard practice in the industry. The presence of 1,2 dichloroethene gives rise to the possibility of presence of 1,1 dichloroethene in the reactor as an intermediate product produced from intra-molecular redistribution of 1,2 dichloroethene. The reaction route in figure 2 shows that fluorination of 1,1 dichloroethene to 143a

requires temperature 60-200°C. The same is true for the production of 143a directly from 1,2 dichloroethene^{[5],[6]}. However, in presence of an intermediate product 1, fluoro-1,1 dichloroethane, 1,1 dichloroethene can be converted to 143a at a much lower temperature, i.e. more favourably^[7].

Like 1,1 dichloroethane, 1,2 dichloroethene is subject to further chlorination and formation of high boiling chlorinated ethane which remain in the HCFC-22 reactor

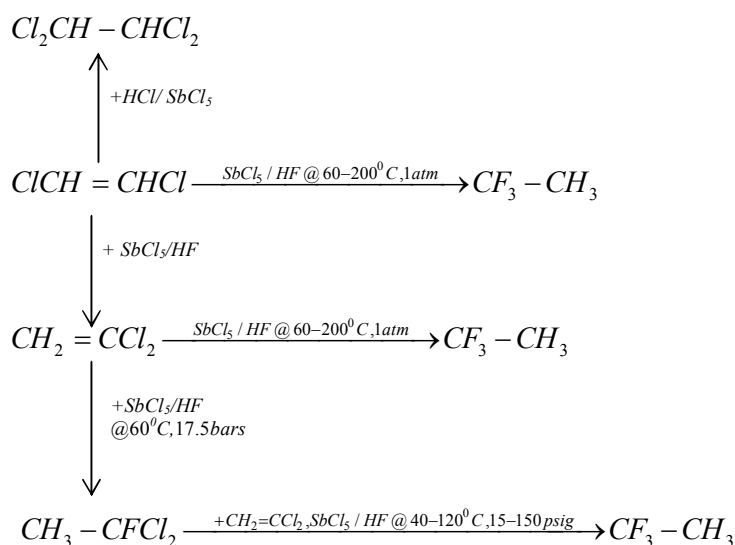


Figure 2 Formation of 143a from 1,2 DCE

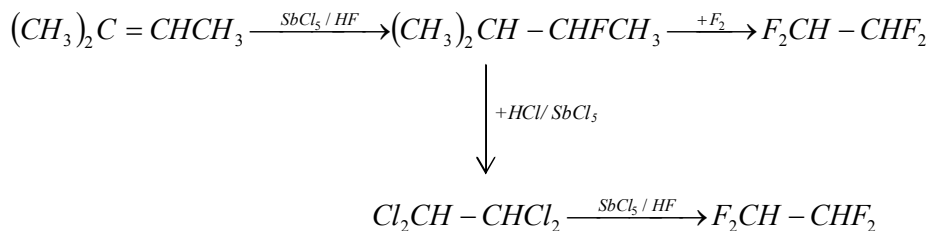


Figure 3 Fluorination of 2-methyl-2-butene

iii) Chemistry of 2-methyl-2-butene

Figure 3 shows that fluorination of 2-methyl-2-butene eventually leads to the formation of difluoroethane, not 143a. Thus, 2-methyl-2-butene may be excluded from the potential source of 143a formed in the HCFC-22 reactor.

From above discussions it is clear that fluorination of 1,1 dichloroethane to 143a requires two step reaction involving two different fluorinating agents i.e. either HF and F_2 or HCl and F_2 . On the other hand, fluorination of 1,2 dichloroethene to 143a is an one step reaction with two more favourable routes. Thus, from reaction mechanism and thermodynamic point of view, 1,2 dichloroethene is a more probable source of 143a than 1,1 dichloroethane.

It is to be noted that both 1,1 dichloroethane and 1,2 dichloroethene are subject to chlorination under the reactor conditions and they only fluorinate partially to form 143a.

5. POSSIBLE MEASURES FOR REDUCTION OF 143a

Following are the two possible options for reduction of 143a formation in HCFC-22 reactor

1. Using raw materials with lower contaminants than those of the currently used raw materials
2. Applying reactor conditions towards lower selectivity of 143a formation

The first option would result in major increase in the cost of raw materials, which is not desirable. The second option, on the other hand, has the potential to affect the purity of HCFC-22 if reactor conditions are to be changed beyond the operation limits. One way of implementing the second option is by promoting chlorination of the 1,1 dichloroethane and 1,2 dichloroethene towards formation of higher chlorinated compounds with high boiling point. As it is mentioned earlier, both of these compounds are prone to further chlorination. Reported data on $HCl/SbCl_5$ show^[2] that up to 300 psia, the system pressure does not have much effect on the Henry's constant, H of HCl , whereas increase in temperature from 60 to 120°C increases H from 88 to 138. Thus running the reactor at a lower temperature within the process limits may facilitate the chlorination reaction and production of high boiling point chlorohydrocarbons. However, as the effect of decreasing temperature on reaction equilibrium of chlorination is not known the above mentioned proposition for

reduction of 143a is subject to the result of trial run of the HCFC-22 reactor.

6. CONCLUSIONS

The investigation on the identification of the source of 143a in HCFC-22 reactor leads to the following conclusions:

- a) 1,1 dichloroethane and 1,2 dichloroethene are the two possible sources of 143a in HCFC-22 with 1,2 dichloroethene to be the most likely source
- b) Only part of 1,1 dichloroethane and 1,2 dichloroethene form 143a and the rest undergoes chlorination reaction
- c) One way of reducing 143a without disturbing the production of HCFC-22 is to favour chlorination reactions in the reactor.

ACKNOWLEDGEMENT

We gratefully acknowledge the support and fund provided by the Organization of the Prohibition of Chemical Weapon (OPCW), the Hague, the Netherlands.

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INFLUENCE OF WEATHER PARAMETERS ON RED SPIDER MITE- A MAJOR PEST OF TEA IN BANGLADESH

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Abstract

An investigation was carried out at the main farm of Bangladesh Tea Research Institute (BTRI), Srimangal, Moulvibazar, Bangladesh during 2005-2009 to find out the influence of weather parameters on the infestation of red spider mite in Bangladesh tea. Monthly data on mite population and infestation were recorded from the experimental plots with systematic sampling method. Five years meteorological data of the experimental area under the Srimangal Meteorology Station were also collected for the study from the Meteorological Department, Dhaka. The weather factors such as temperature, relative humidity, rainfall, sunshine hours etc. are very important for the productivity of tea as well as out break of pests in tea. Pest population have a tendency to fluctuate with the environmental factors. The weather factors exercise a dominating effect on the fecundity, incubation period, reproductive capacity, longevity and development of mite pests. Climatic factors such as temperature, relative humidity and sunshine hours showed positive relationship with the infestation of red spider mite. All the parameters except rainfall were found highly correlated ($r = 0.91, 0.92$ & 0.91 respectively) with the field infestation of mite. On the other hand, heavy rainfall & cloud coverage and water requirement of crop were found to be negatively correlated ($r = -0.89$ & $r = -0.49$) with the infestation of mite. Correlation coefficients are statistically significant at 5% level of significance. This study may be helpful in rescheduling the use of miticides and modifications of some available control options to minimize the infestation of red spider mite of tea in Bangladesh.

Key words: Tea, Red spider mite, Weather, Infestation

INTRODUCTION

Tea is a long established plantation crop of enormous economic importance to Bangladesh meeting the entire domestic demand of this cheapest health beverage. Tea plant is subjected to the attack of several insects, mites, fungal pathogens and weeds. Obviously the intensive monoculture of a perennial crop like tea over an intensive cultivated area during last 160 years had formed a stable tea ecosystem apparently at isolated ecological zone of greater Sylhet and Chittagong districts in Bangladesh for widely divergent endemic or introduced pests (Alam, 1999). Each tea growing country has its own distinctive pests, diseases and weeds. In the world tea, 1034 species of arthropods and 82 species of nematodes are associated with tea plants (Chen and Chen, 1989). Among them, 25 species of insects, 4 species of mites and 12 species of nematodes are recorded

from Bangladesh (Ahmed, 2005). Red spider mite, *Oligonychus coffeae* Nietner is one of the major pests of tea in Bangladesh. It belongs to the order Acarina. Of course, they are not spiders at all although they are related to them. Hundreds of spider mites are found on the upper and undersurface of every tea leaf, together with thousands of eggs and the white skin casts by the mites as they grow. Red spider mites are of major economic importance in tea industry of Bangladesh and are responsible for depredation of yield and debilitation of tea plants. The red spider mite normally attacks the upper surface of mature leaves. But in severe cases young leaves are also attacked. The larvae, nymphs and adult mites cause the damage. When large numbers of mites are present, sucking one leaf cell after another and sucking out the contents, the whole leaf eventually changes to a bronze colour, dries up and drops- especially in hot and dry weather.

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When the conditions are favourable, during spring and summer the eggs produced by the females without fertilization. Crop loss due to the attack of red spider mite in Bangladesh tea is 9.57% (Ali et al. 1994). The eggs are laid singly at intervals on the surface of the leaves, mostly along the mid-rib and veins. During the cropping season (March-October), red spider mite shows the maximum fecundity (60-77 eggs), minimum incubation period (3-5 days), minimum life cycle (7-9 days) and maximum female population (1:1.2) (Ahmed and Sana, 1990). Most of the valley circles reported severe infestation of red spider mites which are more prevalent and alarming round the year for the tea industry. It is noticed for the information of the tea estate that severe damage is apprehended in tea plantations during drought period. Infestation of Red spider mites was high during last decade because of higher temperature and humidity, uneven rainfall and intermittent sunlight. The climatic factors such as temperature, relative humidity, rainfall, sunshine hours etc. are very important for the productivity of tea as well as out break of pests in tea (Ahmed and Uddin, 2001). Pest population have a tendency to fluctuate with the environmental factors. The degree of influencing factors determined the magnitude of increase or decrease in number of mite population. The climatic factors exercise a dominating effect on the fecundity, incubation period, reproductive capacity, longevity and development of mite pests.

No work has been done on the population dynamics and the infestation of red spider mite in Bangladesh tea in relation to weather parameters (temperature, relative humidity, sunshine hours and rainfall). So, an attempt has been made to correlate red spider mite infestation with the weather parameters in general and temperature, relative humidity, sunshine hour and rainfall in particular.

MATERIALS AND METHODS

A detailed investigation was carried out at the main farm of Bangladesh Tea Research Institute (BTRI), Srimangal, Moulvibazar, Bangladesh during 2005-2009 in order to find out the influence of weather parameters on red spider mite, a major pest of tea in Bangladesh. Five years meteorological data of maximum and minimum temperature, sunshine hours, relative humidity and rainfall of the experimental area were collected from the Meteorological Department, Dhaka. Monthly data on the mite infestation were recorded from the clonal tea plants in the experimental plot with systematic sampling method. Ten mature leaves per bush were plucked randomly, mites were brushed by mite brushing machine and calculated under a compound microscope. The percentage of

infestation per plot was calculated by Lubischev's analytical method. The monthly percentage of infestations was compared with the weather parameters, such as temperature, relative humidity, sunshine hours, rainfall and water requirement of the crop and correlation analysis was done between these parameters and red spider mite infestation. Mean monthly values were computed from five years of meteorological data (2005-2009). For the computation of mean temperature, average value of maximum and minimum temperature was taken. The water requirement of the crop was calculated by using Penman (1956) equation:

$$R_n = E_o/L \text{ -----(i)}$$

Where,

R_n = net solar radiation

L = latent heat of evaporation= 590 cal/gm

E_o = potential evaporation in mm (calculated below)

R_n was calculated from total radiation at the top of the atmosphere (R_a), given in the Table-1. (MacDonald & Partners, 1967) using Glover and McCulloch (1958) equation which reads as:

$$R_n = R_a [0.29 \cos \lambda + 0.52 n/N]$$

Net solar radiation is around 55 percent of total solar radiation and varies only little with season (Monteith, 1965).

Hence, E_o may be written as

$$E_o = 0.55 R_a [0.29 \cos \lambda + 0.52 n/N] / L$$

Therefore $E_o = 0.55 R_a$	$\frac{0.29 \cos \lambda + 0.52 n/N}{590}$	cm
or, $E_o = 5.5 R_a$	$\frac{0.29 \cos \lambda + 0.52 n/N}{590}$	mm

Where,

n = actual sunshine hrs recorded

N = maximum possible sunshine hrs (= day length)

λ = latitude

Monthly values of R_a (cal cm⁻² day⁻¹) and N (hr) for Srimangal (latitude 24.3° N) and the equation for the daily estimation of water requirement of the crop $E_{tw} = 0.85 E_o$ are given in Table 1.

Table 1. Monthly values of solar radiation at the top of the atmosphere (R_a) in cal cm⁻² day⁻¹, Maximum possible sunshine hrs (N) for Srimangal (latitude 24.3° N) and the corresponding equation for estimating daily water requirement of the crop ($E_{tw} = 0.85 E_o$).

Month	Solar radiation Cal / cm ² / day	Maximum possible sunshine N (hrs/day)	Equation for water requirement, E _{tw} =0.85 E _o (mm)
January	603	10.9	1.2609 + 0.2279 n
February	705	11.4	1.4741 + 0.2548 n
March	822	12.0	1.7188 + 0.2822 n
April	918	12.8	1.9195 + 0.2955 n
May	969	13.3	2.0260 + 0.3002 n
June	984	13.6	2.0575 + 0.2981 n
July	973	13.5	2.0345 + 0.2969 n
August	934	13.0	1.9529 + 0.2960 n
September	856	12.3	1.7898 + 0.2867 n
October	745	11.6	1.5578 + 0.2646 n
November	631	11.0	1.3294 + 0.2363 n
December	572	10.7	1.1196 + 0.2202 n

E_o = potential evaporation in mm

E_{tw} = water requirement of crop in mm

The significance test of the Coefficient of Correlation (r) was carried out by using Student's t-distribution (Alder and Roessler, 1964):

$$t_{cal} = r / \{(1-r^2)/(n-2)\}^{1/2} \text{ -----(ii)}$$

Where r is the Correlation Coefficient, n is the number of data and (n-2) is the degree of freedom. If the $t_{cal} > t_{0.05}$, the coefficient is significant. Relationship between each of the parameters and the infestation were plotted in 5 different graphs. Correlation co-efficient were calculated in each case to see the significant relationship.

RESULTS AND DISCUSSIONS

The influence of weather factors such as temperature, relative humidity, sunshine hours, rainfall and water requirement of crop are very important and played vital effect on red spider mite infestation. Carr (1972), Kandiah and Thevasadan, (1980) and Devanathan (1975), correlate climatic requirements of tea plant with the yield of tea crop. A prolong drought during early part of the season hinders normal growth of the bushes and the severity of mite attack gradually increases with their quick multiplication. Drought is related to temperature, humidity, light duration, wind effect, shade status, soil type and drainage condition etc. which have the positive effect on red spider mite incidence. The influence of weather parameters on the infestation of red spider mite in Bangladesh tea is shown in the following sub heading:

Temperature

Temperature is an important unique meteorological parameter that influences the growth and development of tea as well as pest infestation. High

temperature influences the infestation of red spider mite in tea. Multiplication rate is greatly increased in higher temperature. In low temperature, population is reduced during winter season but unreasonable low temperature followed by wind during spring leads to high mortality. Potential progeny output increases exponentially i.e. 20 individual at 15.50 C; 12,000 individual at 21.0 C; 13,000,000 individual at 26.50 C (Ahmed and Haq, 2007). Infestation increases with the increase of temperature and vice-versa.

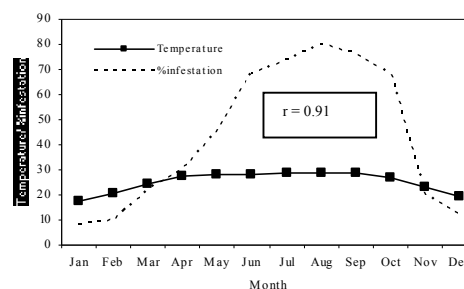


Fig.1 Relationship between temperature and infestation of red spider mite in Bangladesh tea

From April to September monthly average temperature was higher than that of the rest of the months and accordingly the infestation percentage was also observed higher during this period than the other period of the year (Fig. 1). The correlation co-efficient between the percentage of infestation and the temperature is $r = 0.91$. The values are statistically significant at 5% level of significance.

Relative Humidity

Humidity is an important climatic factor that influences the growth and development of tea plant. It interferes with the population build-up of red spider mite. Hot and dry weather with low humidity lead to high infestation of red spider mites. It encourages less feeding, slower egg laying and shorter life span. Like temperature, relative

humidity was also found to be positively related with the infestation of red spider mites in tea. Infestation increases with the increase of relative humidity and vice-versa.

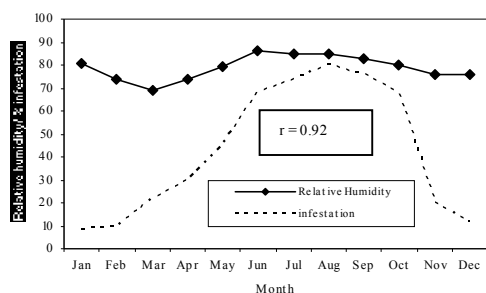


Fig. 2 Relationship between relative humidity and infestation of red spider mite in Bangladesh tea

From April to September monthly average humidity was higher than that of the rest of the months and accordingly the infestation percentage was also observed higher during this period than the other period of the year (Fig. 2). The correlation co-efficient between the percentage of infestation and relative humidity is $r = 0.92$ and the values are statistically significant at 5% level of significance.

Rainfall

Rainfall is one of the major climatic factors that affect the growth, development and yield of tea as well as outbreak of red spider mite. The minimum annual rainfall of 1150–1400 mm is generally considered necessary for successful cultivation of tea (Eden, 1965; Hasan et al., 1965; Harler, 1966). Too much water can be devastating for some pests. Raindrops can physically dislodge them from their host plant and behaviour patterns can be disrupted. Prolonged or heavy rain with big rain drop washes off mites from host. Mites move to underside of the leaf. It leads to high mortality of mites. It also escorts to less breeding of mites. Eggs of red spider mite is least affected. The droplet size of rain has reduced in a small i.e. drizzling. So, light rain with intermittent sunlight increase the populations of red spider mites in tea. Monthly average rainfall and percentage of infestations of mites are shown in Fig. 3.

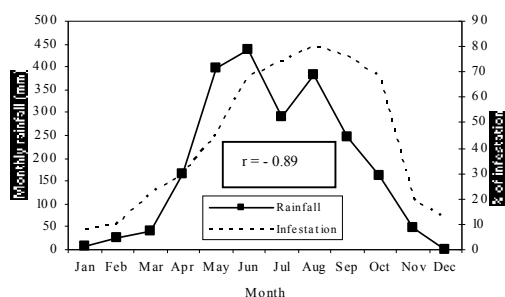


Fig. 3 Relationship between monthly rainfall and infestation of red spider mite in Bangladesh tea

In the figure it is conspicuous that infestation increased with rainfall, but the rate was not same in all the rainy months (May–October). In June rainfall was the maximum but infestation percentage was the maximum having less rainfall in March–May than June. Heavy rainfall might have washed out the mite population from the leaves. At the onset of first rain during February or early March, tea begins to flush and pest continues its life process on tea (Sana, 1989). However, the correlation between rainfall and the percent infestation was found insignificant at 5% level of significance with $r = -0.89$.

Sunshine hours

Sunshine hour is a major weather parameter. Red spider mite is a positively phototropic pest. Light duration (sun light intensity and penetration) in daytime influences the build up of mite population. Light has the positive response in the upper surface of the leaves. It influences egg laying, oviposition rhythm, with the maximum oviposition at dawn and dusk when there is a rapid change in light intensity. Changes in light regime i.e. light to dark leads to peak oviposition. Egg hatching is the maximum at red light. Light penetration within the canopy regulates the distribution of mites. Sunshine hours were found to be positively related with the infestation of red spider mite in tea; the higher sunshine hours, the higher was the percentage of infestation (Fig 4).

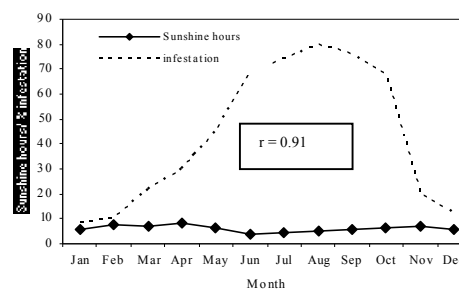


Fig. 4 Relationship between sunshine hours and infestation of red spider mite in Bangladesh tea

From October to April, the length of sunshine hours remained maximum due to minimum cloud coverage and the percentage of infestation was found to be high. It indicates that the length of sunny period has a great influence on the activity of pest attack (Sana, 1989). The correlation co-efficient was found to be $r = 0.91$ which is significant at 5% level of significance.

Water requirement of crop

Water requirement of crop generally plays a negative role on infestation during the production period of tea (April - October).

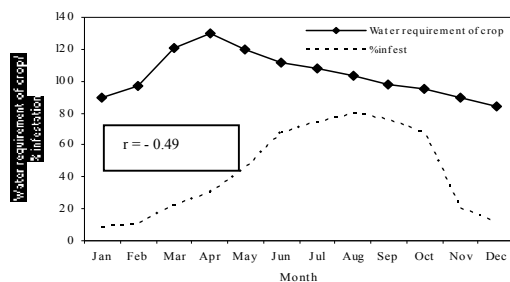


Fig. 5 Relationship between water requirement of crop and infestation of red spider mite in Bangladesh tea

It reveals from Fig. 5, that while water requirement was high, infestation percentage was observed low (March, April & May) and vice-versa during June, July, August & September. The correlation coefficient ($r = -0.49$) shows that the relationship (-ve) between the two factors is not significant.

CONCLUSION

The literature on pest outbreaks of red spider mites gives us some indications of the impacts of extreme climatic conditions. Although the climatic factors are beyond control in nature, some of these situations interfere with the spray fluids and also might have influenced resistance or tolerance of the pest due to exposure to inadequate toxicity from the applied chemical. Thus knowing the behaviour of this particular pest under variable climatic factors, this study may be helpful in rescheduling the miticides use and modifications of some available control options to reduce the infestation of red spider mites in Bangladesh tea. Planters should keep in mind that climate change is likely to be a gradual process that will give them some opportunity to adapt. Planters who closely monitor the occurrence of pests in their fields and keep records of the severity, frequency, and cost of managing pests over time will be in a better position to make decisions about whether it remains economical to continue to grow a particular crop or use a certain pest management technique. Those Planters who make the best use of the basics of integrated pest management (IPM) such as field monitoring, pest forecasting, recordkeeping, and choosing economically and environmentally sound control measures will be most likely to be successful in dealing with the effects of climatic factors.

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Laser Action in Polyfluorene and Fluorene-based Co-Polymers

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Abstract:

We have investigated optical absorption, steady state and time resolved photoluminescence spectroscopy at room temperature and at low temperature of polyfluorene and 9,9-dioctylfluorene-2,7-diyl-dibenzothiophene-s,-s-dioxide-3,7-diyl co-polymers p(F-S)y. Dual phosphorescence is observed for p(F-S)50 that are originated from different monomer units. Drop cast film of polyfluorene and p(F-S)50 show amplified spontaneous emission (ASE) effect peaking at 2.66 eV for later with FWHM at 5 nm .

Keywords: Time resolved emission, spectral narrowing, delayed fluorescence and polyfluorene copolymer.

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PERFORMANCE of THE TWO-CHAMBER MICROBIAL FUEL CELL

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Microbial fuel cell (MFC) is a promising technology for the wastewater treatment with production of sustainable clean energy. Proton exchange membranes (PEM) are often used in the microbial fuel cells to separate the liquid in the two-chamber (one is act as anode and another is cathode) while allowing protons to pass between the chambers. Using Nafion as proton exchange membrane simultaneous power (electricity) generation from readily biodegradable organic substrates was investigated in this study. Biodegradation was the dominant mechanism of the Yellow Cibacron-2G (YC) dye removal in association with glucose substrate. Effect of catholytes in cathode, substrate concentration in anode on power generation was studied. This system demonstrates the performance of the two-chamber MFC, corresponding to the highest power generation of 54 μ A and around removal of chemical oxygen demand (COD) is 50%.

Key words: Microbial Fuel Cell; Wastewater treatment; De-colorization; Electricity generation;

1. INTRODUCTION

As we head into the future, large portion of energy produced and used in the world will be from sustainable sources due to the world's limited supply of fossil fuels and their impact on environmental and economic changes. Microbial Fuel Cell (MFC), a source sustainable energy uses either of low or negative economic value such as wastewater. This technology is recently gaining a great attraction due to their ability to generate electricity directly while accomplishing wastewater treatment. MFCs have been mostly used for converting a variety of carbohydrates such as acetate, butyrate, glucose, or even complex organics in wastewater [Venkata Mohan et al., 2008; Liu et al., 2003].

MFC is a biochemically catalyzed system, which generates electricity by oxidizing biodegradable organic matter in the presence of either fermentative bacteria or enzymes [9-11]. The biocatalyst present in the anode chamber of MFC generates electrons (e^-) and protons (H^+) through anaerobic respiration of organic substrates. Electron transfer occurs through the electrode (anode) integrated with an external circuit to the cathode. Protons diffuse through the proton exchange membrane or salt bridge (which separates the cathode and anode chamber) into the cathode chamber, where they combine with the electron acceptor. The potential difference between the respiratory system and electron acceptor generates the current and voltage needed to generate electricity [Chaudhuri SK, Lovely DR et al 2003; Oh SE and Logan BE et al, 2005].

Azo dyes which constitute the largest chemical class of synthetic dyes are extensively contained in effluent discharged from dye-manufacturing industries and dye-consuming industries. The intense color of

dye-containing wastewater leads to severe aesthetic problems and obstructs light penetration and oxygen transfer into water bodies, thus affecting aquatic life. Treatment of dye-containing wastewater still presents a technical challenge. Most physicochemical methods can remove dye efficiently but are not feasible due to their expensive cost, limited versatility and sensitivity to other wastewater constituents. Alternatively, biological treatment may present a relatively inexpensive way to remove dyes from wastewater [Dos Santos et al., 2007; Pandey et al., 2007]. Decolorization of azo dyes is usually achieved under anaerobic (methanogenic) or anoxic conditions. In the past few years several bacterial strains that can aerobically decolorize azo dyes have been isolated.

In this paper, MFC has been constructed for simultaneous power generation and removal of COD. Glucose (substrate) and YC (mediator) has been used in anode chamber. Potassium permanganate electrolyte solution was used in cathode. Some effective parameters such as effect of catholyte, initial substrate concentration and wastewater treatment have been investigated to evaluate the MFC performance.

2. MATERIALS AND METHODS

YC -2G was used in this experiment, supplied from local textile industry. The IUPAC Name is trisodium 4-[[4-chloro-6-[(4-sulphonatophenyl)amino]-1,3,5-triazin-2-yl] amino]-2-[[1-(2,5-dichloro-4sulphonatophenyl)-4,5-dihydro-3-methyl-5-oxo-1H-pyrazol-4-yl]azo]benzenesulphonate.

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2.2 MFC CONFIGURATION AND OPERATION

The two-chambered MFC was designed and fabricated in the laboratory using PET bottle (Figure 1; Table 2.1). Total volume of both anode and cathode compartment was the same (0.5 L) and each chamber was provided with sample port, wire point inputs (top), inlet and outlet ports.

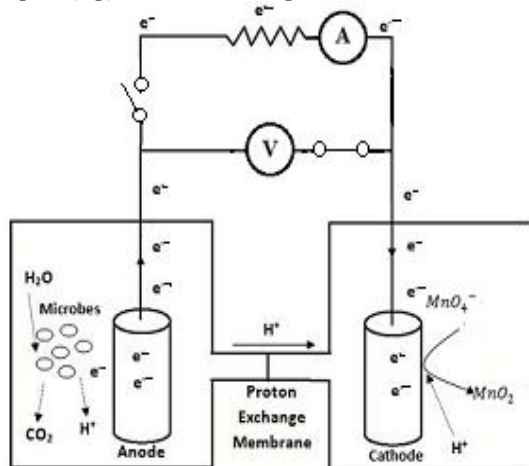


Figure1: Schematic diagram of Two-chamber microbial fuel cell with schematic details

A membrane between two straight conduits was used to connect the two chambers. 9.5 cm long and 0.75cm diameter plastic tube was used. Both anode and cathode electrodes were made of graphite Rod (6 cm; 0.8 cm diameter) obtain from dry cell battery and were positioned at a distance of 2 cm on either side of the membrane. Electrodes had a surface area of 16.08 sq. cm. prior to use, the electrodes were soaked in de-ionized water for a period of 24 h. Contact between electrodes and copper wires was sealed with epoxy material.

Substrate was individually implemented as carbon source for the electricity production and also mediator was used in the anodic chamber of the two-chamber MFC. The anodic inoculums were prepared by using sludge, collected from local waste water drainage system. Before inoculation, the sludge was filtered through a 0.25 mm pore size sieve to remove the impurities.

Constant removal COD and current generation were considered as indicators for satisfactory formation of the bio-film and stable operating conditions. Open circuit voltage (OCV) was measured by connecting multimeter in parallel with the MFC. Note that Sludge containing cell is anode. The current was measured with the help of a ammeter connecting in series with resistance. One end of a resistance connected with Anode terminal (+ve) of the MFC other end will connect with the +ve terminal of the ammeter. Negative terminal of the Ammeter will connect with the Cathode of the MFC.

A series of experiments was conducted to investigate the performance of the two-chamber MFC. Whereas, OCV and current generation vs time, decolorization of YC vs time and removal of COD as a function of time were observed. All experiments were conducted at least in duplicate, in a constant temperature room (30 ± 2 °C), and the average value was reported for all data.

Table 1: MFC component and inoculation condition

Reactor configuration	Dual chamber
Anode chamber	Suspended growth
Anode inoculums	Mixed anaerobic consortia
Mediator-anode	Yellow Cibacron
Oxidant-cathode	KMnO ₄
Volume of anode and cathode chamber	0.5L
Anode and cathode material	Graphite plate
Surface area of electrodes	16.08 (sq. cm)
Membrane	Proton exchange membrane (Nafion)
Feeding nature (l/cycle)	Batch
Operating temperature	30 ± 2 (°C)
pH	6.5 (anode), 7.5 (cathode)

2.3 ANALYTICAL METHODS

2.4.1 COD CALCULATION METHOD:

COD of sample was determined by taking 2.5 ml of sample , 2.5 ml distilled water, 1.5 ml 0.1M K₂Cr₂O₇ and 3.5 ml H₂SO₄ reagent in a 10 ml COD ampule. The ampule was heated at 150°-160° C for 2 hours. Then the ampule was shaken and allowed to cool at room temperature. The solution was then taken in a conical flask and added with 1, 10-Phenophthroline indicator which makes its color blue. Then the solution was titrated with 0.1 M Mohr's salt (FAS) until the color changes to red. The same procedure was conducted with a distilled water sample.

By using the following equation COD of a sample can be calculated

$$\text{COD} = \frac{(V - b) \times N \times 8000}{V_s} \quad (1)$$

where, b is the volume of FAS used in the blank sample, s is the volume of FAS in the original sample, V is the sample volume and n is the normality of FAS. If milliliters are used consistently for volume measurements, the result of the COD calculation is given in mg/L.

2.4.2 DE-COLORIZATION OF YC

Decolorization of YC was determined by monitoring the decrease in absorbance at the maximum wavelength of 425 nm. UV-visible spectrophotometer (Shimadzu, Model -1650) was used for this purpose. For the 48-hr decolorization experiment, test samples (5ml) were withdrawn from the reactor at 0, 2, 4, 6, 8, 10, 12, 24, 30, 36 and 48 hr. samples were centrifuged at 5,000 rpm for 5 min to remove suspended biomass from the liquid media and absorbance was measured. Decolorization activity was calculated as the following:

$$\% \text{ of Decolorization} = \frac{(A-B) \times 100}{A} \quad (2)$$

A is the initial absorbance; B is the observed absorbance.

3. RESULT AND DISCUSSION

3.1 EFFECT OF CATHOLYTE ON MFC PERFORMANCE

The effect catholytes in two-chamber MFC three cells having glucose concentration of 50ppm and 600ppm concentration of YC in anode chamber was operated. Anode wastewater was inoculated with 250mL of wastewater. Cathode chambers were run with the three different electrolyte solutions of 200 ppm KMnO_4 , 200ppm $\text{K}_2\text{Cr}_2\text{O}_7$ and saline water. The experiments were done for both open and close circuit. In closed circuit cells were connected with external resistance of 22.5Ω .

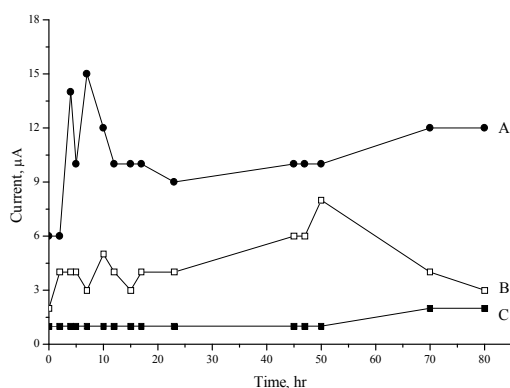
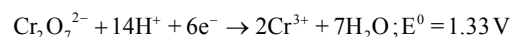
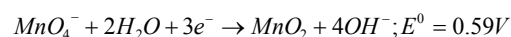
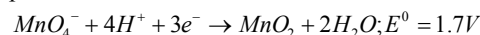


Figure2: Effect of catholyte on the MFC performance (600 ppm of YC in anode; A: 200 ppm KMnO_4 , B: 200 ppm $\text{K}_2\text{Cr}_2\text{O}_7$, C: saline water in cathode; temperature T: $30 \pm 2^\circ\text{C}$ by using 22.5Ω resistance; OCV: $\pm 0.56\text{V}$ for A, $\pm 0.30\text{V}$ for B, $\pm 0.13\text{V}$ for C)

Figure2 shows that the current generated for each case as a function of time. During 3.5 days (80 hr) of this experiment at first 10hr the current increased rapidly for KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ electrolyte solution and reached a maximum value of $16\mu\text{A}$ for the cell operating with KMnO_4 solution. No pH decreasing adjustment was made as it was reported by Li et al, 2009 that low pH values lead to an increase of cathode potential. According to the following Equations, MnO_4^- has a much higher oxidation potential than in alkaline conditions:



In comparison reactive catholytes the saline water as catholyte showed very poor performance because of low consumption of electron in anodic reaction. As a result for further experiments, KMnO_4 solution was used as an electron acceptor in this study.

3.3 EFFECT OF SUBSTRATE CONCENTRATION ON MFC PERFORMANCE

To explore the effect of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) concentration in MFC three cells having glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) concentrations of 50, 300, 600 and 900 ppm in the anode chamber was operated. The anode wastewater was inoculated with 250 mL of wastewater (anode COD = 224ppm). In the cathode chamber was operated with saline water. The experiments were done for both open and close circuit. In closed circuit cells were connected with external resistance of 22Ω .

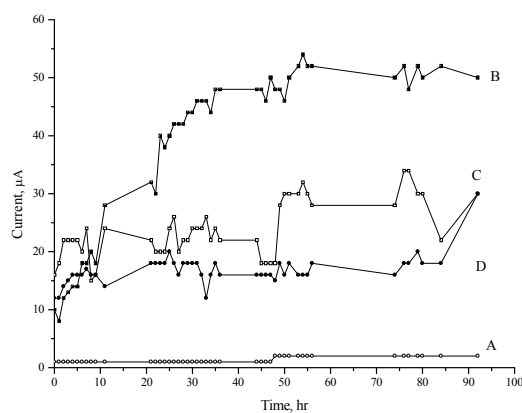
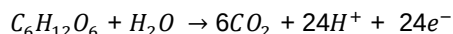


Figure3: Effect of glucose concentration on electricity generation (A: 50, B: 300, C: 600 and D: 900ppm glucose along with 300 ppm YC in each anode; 200 ppm KMnO_4 in cathode; temperature T: $30 \pm 2^\circ\text{C}$; OCV: $\pm 0.14\text{V}$ for A, $\pm 1.1\text{V}$ for B, $\pm 0.66\text{V}$ for C, $\pm 0.61\text{V}$ for D)

Figure3 shows the current generated for each case as a function of time. The duration of this experiment was nearly 4 days (92 h). During the first 3h the voltage and current increased rapidly for all cases and reached a maximum value of 0.35V and 13 μ A respectively after 55 h for the cell operating with 0ppm glucose concentration in anode chamber.

When micro-organisms consume a substrate such as glucose in aerobic conditions they produce carbon dioxide and water. However when oxygen is not present they produce carbon dioxide, protons and electrons as described below (Bennetto et al, 1990; logan BE et al 2007)



According to Hideki Sakai et, all the current increased with the increase in the glucose concentration. For high glucose concentration this may cause the increase of the proton concentration within the immobilized layer by the following glucose oxidation reaction which leads to suppression of the enzymatic activities.



In comparison with various glucose concentrations in anode higher glucose concentration exhibited lower current generation.

3.4 PERFORMANCE OF MFC IN WASTEWATER TREATMENT

Two-Chamber MFC were continuously monitored for the removal COD to enumerate the potential of fuel cell to act as wastewater treatment unit. During operation, three cells having glucose concentrations of 300, 600 and 600ppm along with 300ppm YC concentration was operated. The anode wastewater was inoculated with 250 mL of wastewater (initial anode COD = 224ppm). In the cathode chamber was operated with 200ppm $KMnO_4$ solution.

Figure4 (a) shows the percentage of COD removal increases as a function of time for all cases and reaches a maximum 48% COD removal for the cell operation with 300ppm glucose concentration in anode. The duration of this experiment was nearly 3.5 days (78 h).

In this study de-colorization of azo dye was not so high (figure: 4.b). About 25% of de-colorization was achieved. De-colorization of azo dye by bacteria could be due to adsorption by microbial cells or to

biodegradation was reported by Sani & Banerjee et al.

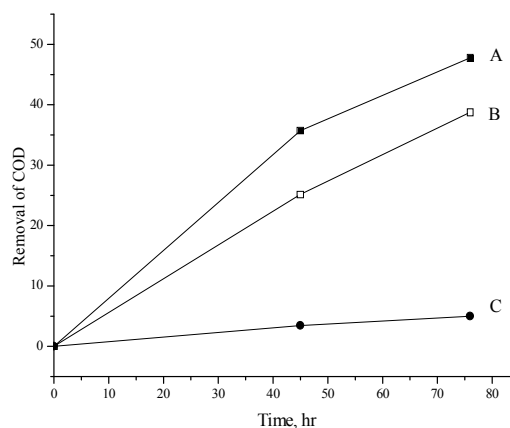


Figure 4(a): % of COD removal in MFC (300,600 and 900 ppm glucose along with 300 ppm of YC in anode; 200 ppm of $KMnO_4$ cathode; temperature T: 30 ± 2 $^{\circ}C$; % of COD removal: 48.9% for A, 37.2% for B, 3% for C)

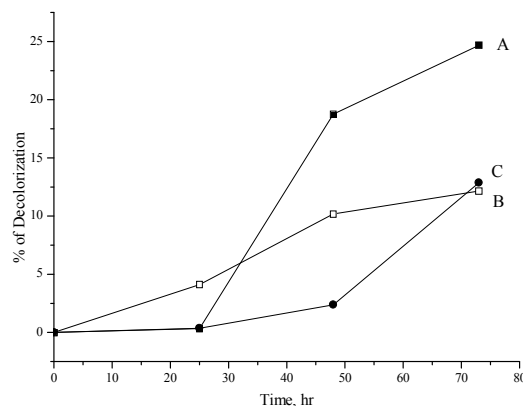


Figure5: % of De-colorization in MFC (300,600 and 900 ppm glucose along with A: 300ppm, B: 600ppm and C: 900ppm glucose in anode; 200 ppm $KMnO_4$ in cathode; temperature T: 30 ± 2 $^{\circ}C$; % of de-colorization: 24.57% for A, 11.87% for B, 12.3% for C)

De-colorization rate may be lowered due to the adsorption of azo dye on the microorganism surface. In adsorption, cells may become deeply colored because of adsorbing dyes, whereas those retaining their original color are accompanied by the occurrence of the biodegradation. The microbial consortium does not remain at its original color after batch de-colorization in this study, indicating that the color removal was actually primarily incurred due to biosorption rather than biodegradation by the living cells.

3.2 STUDY THE PERFORMANCE ON MFC

To investigate the overall Performance of the Two-Chamber MFC having glucose ($C_6H_{12}O_6$) concentrations of 300ppm along with 300ppm of YC in the anode chamber was operated. The anode wastewater was inoculated with 250mL of wastewater (anode COD = 224ppm). In the cathode chamber was operated with 200ppm $KMnO_4$ solution. The experiments were done for both open and close circuit. For closed circuit resistance of 22.5 Ω was used.

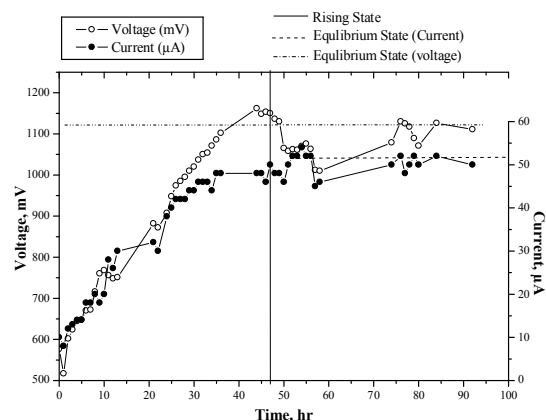


Figure 5(a): Performance of electricity generation in MFC (300 ppm glucose and 300 ppm YC in anode; 200 ppm of $KMnO_4$ in cathode; temperature T: 30 ± 2 °C by using 22.5 Ω resistances; Equilibrium current and voltage: $\pm 54 \mu A$ and 1.16V)

Figure 5(a) shows the voltage and current generated as a function of time. The duration of this experiment was nearly 4 days (92h). During the first 44h the voltage and current increased rapidly and reached a maximum value of 1.2V and 54 μA respectively after 45h of the cell operation.

Generally, voltage and Current increases as the bacteria grows exponentially and decreases when the bacterial growth reaches stationary phase. More precisely voltage and current generation can also be decreases due to limited mass transfer of chemical species by diffusion to the electrode surface or the metabolic losses. To generate metabolic energy, bacteria transport electrons through MFC membrane at a higher potential. The higher the difference between the redox potential of the substrate and the anode potential, the higher the possible metabolic energy gain for the bacteria, but the lower the maximum attainable MFC voltage. To maximize the MFC voltage, therefore, the potential of the anode should be kept as low (negative) as possible (logan et

al, 2006). However, if the anode potential becomes too low, electron transport will be inhibited and fermentation of the substrate (if possible) may provide greater energy for the microorganisms.

Two-Chamber MFC was continuously monitored for the change of pH in anode chamber. Whereas, the cell was operating with glucose concentrations of 300 ppm and 300ppm concentration of YC in the anode chamber and 200ppm $KMnO_4$ in cathode chamber.

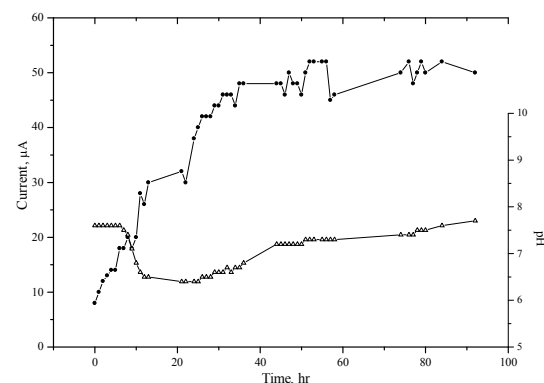


Figure 5(b): pH change in MFC (300,600 and 900 ppm glucose along with 300 ppm YC in anode; 200 ppm $KMnO_4$ in cathode; temperature T: 30 ± 2 °C by using 22.5 Ω resistances, pH range: 6.5-7.8 for Maximum current generation)

Figure 5(b) shows the change in pH during the current generation as a function of Time. Initial pH at anode chamber was decreases due to the proton generation. Mainly pH value in anode chamber is inversely proton generation. Generated protons are then diffuse through the proton exchange membrane (which separates the cathode and anode chamber) into the cathode chamber and increase the pH value again. Optimum pH value of 7.2 is obtained form this experiment.

Usually Nafion as MFC membrane is typically slower than the other cations such as Na^+ , K^+ , Ca^{2+} and Mg^{2+} . Therefore pH of the cathode chamber will increased by leakage of proton, if there is no pH control by using cathode buffer solution.(R A Rozendal et al, Trinh et al 2010). Rozendal et al reported that MFC potential mainly affected by the insufficient supply of the protons at the cathode chamber. Maximum current was obtained when the pH of anode was around 7. Optimum pH for MFC operation using activated sludge in anode chamber is 7-8(Gil et al), with lower current generation is being achieved at pH below 6 and over 9.

4. CONCLUSION

Microbial Fuel cell was fabricated and constructed with the locally available materials. Effect of KMnO_4 , $\text{K}_2\text{Cr}_2\text{O}_7$ and saline water as catholyte concentration on electricity generation has been investigated and KMnO_4 solution exhibited higher voltage and current than $\text{K}_2\text{Cr}_2\text{O}_7$. Effect of glucose concentration was studied. Optimum glucose concentration should be used in order to generating the higher electricity. De-colorization rate may be lowered due to the adsorption of azo dye on the microorganism surface. This system is capable for simultaneous electricity generation of about $54\mu\text{A}$ and also reduced nearly 50% of COD from the wastewater.

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Photocatalytic activities of TiO₂ nanoparticles synthesized using sol-gel method with presence of nanoporous polystyrene.

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Nanotechnology is one of the extensively high advanced technologies of the world & emerging in haste with its entire span & has a diversified use. Following this advancement TiO₂ is playing a vital role in this era & is one of the most important photocatalyst that is used in many purposes like fog proof & self cleaning glass, antibacterial, antiviral, anti soiling, self cleaning, air pollution water treatment, including dye removal from the industrial wasteⁱ. **Nanostructured TiO₂ was synthesized using sol-gel method with presence of nanoporous polymer.** Photocatalytic efficiency of TiO₂ increases with the escalation of surface area of the TiO₂ nanoparticles. Here TiO₂ is synthesized with and without the presence of polymer (polystyrene) and calcinated at 450^oC, 550^oC, 650^oC and compared the photo catalytic performance with that of commercial/standard TiO₂. The samples have been characterized by several techniques (SEM, HRTEM, FTIR, Raman, UV–Spectroscopy and XRD). These 3 types of TiO₂ calcinated at 550 are also applied in industrial dye and the results are compared, which indicate that this photocatalytic process might be effective to remove this color and minimize the cost of an effluent treatment plant. This comparison shows that TiO₂ with polystyrene is much more effective in photodegradation than that of bare TiO₂ sample which is calcinated at temperature of 550 ^oC. The photocatalytic efficiency of the synthesized samples was decreased in case of the samples calcinated at 450 and 650 ^oC.

Keyword: Nanotechnology, **sol-gel method**, photocatalyst, Polymer, Efficiency.

1. Introduction:

Natural water environment in the present day is endangered by a variety of hazardous chemical substances derived from man made products. Various contaminants such as azo dyes and organochlorine and aromatic hydrocarbons have been detected that affect the environment very tremendously. Various methods have been developed to remove organic substance from water, such as biological method^{ii,iii,iv}, chemical oxidation^{v,vi}, electrochemical oxidation^{vii}, and a photo catalytic method^{viii,ix,x}. Among them, the photo catalytic oxidation is one of the most

promising technologies for the eradication of organic micro pollutants because it is highly efficient in mineralization and can utilize sunlight as energy source^{xi}. In particular, the photocatalytic oxidation of organic pollutants by titanium dioxide (TiO₂) has grown much more attention as a promising chemical procedure for environmental cleanup, and organic substance degradation. TiO₂ nanoparticles are effective for the photocatalytic degradation of various organic contaminants in water; however, its practical use in aqueous media is limited because of the difficulty of filtration and recovery of infinitesimally small TiO₂ particles.^{xii} Photocatalytic materials, TiO₂ has been extensively used in sterilization,^{xiii}, ^{xiv} sanitation, and remediation

applications,^{xv} as well as air purification and water treatment. TiO₂ has proven to be an excellent photocatalyst material by which undergoes complete mineralization under UV exposure.^{xvi}

Off late, Titanium dioxide (TiO₂) has been extensively studied as a photocatalyst for applications such as water and air remedy, because of its relatively high photocatalytic activity, robust chemical stability, relatively low production costs, and nontoxicity. Redox reactions of environmental interest are initiated on the TiO₂ surface with trapped electron-hole after band gap excitation. However, TiO₂ is active only under near-ultraviolet irradiation due to its wide band gap energy of 3.0-3.2 eV. Therefore, significant efforts have been made over the last 20 years to develop modified TiO₂ particles that are active under visible light irradiation ($\lambda > 400$ nm).^{xvii}

Titanium dioxide has been extensively used, either as thin films or as submicron powders, in a wide application range in electronic or optical devices as well as pigment or catalyst. In many processes, titanium alkoxide are used as precursors in order to get oxide with controlled purity and morphology. The involved reactions are essentially hydrolysis when we follow sol-gel process.

We have synthesized TiO₂ powders from titanium isopropoxide, Ti (O-iC₃H₇)₄ (referred to hereafter as TTIP), in the presence of a solvent alcohol, at room temperature and Atmospheric presser. In such conditions, narrow-sized particles (20-60 nm) partly crystallized in the anatase structure are obtained. Similar reactions conducted in supercritical.

In powder synthesis, pure dry particles can be recovered, without further washing and drying steps, by removing the solvent and byproducts, simply decompressing the system at a temperature above the alcohol's critical point.

We have recently developed a simplest process for TiO₂ powder production at a laboratory scale. However the aim of the study is to increase the surface area of photocatalyst and for this purpose, polymer is added to prepare TiO₂ powder using sol-gel process that we developed. Expectation is to enlarge the surface area of TiO₂ particle, by using the simplest sol-gel method and to determine efficiency of TiO₂ that we synthesized in laboratory under same conditions.

2. Experiment:

Preparation of Photocatalyst and Apparatus:

2.1. Material:

Titanium isopropoxide, Ti (O-iC₃H₇)₄

Photocatalyst TiO₂ (Degussa P-25, MERCK, GERMANY)

DYE, Methylene Blue (MERCK, GERMANY)

2.2. Synthesis of TiO₂ with the presence of polystyrene in sol-gel process:

For the preparation of TiO₂ powder in a new and simplest sol-gel process that we tried here to produce, 25ml TIP is taken to two round bottle. 51.19 ml isopropanol and 12.24ml distilled water in each bottle is added and stirred in magnetic stirrer (BDH) for 30 min. After adding TIP, isopropanol and water in a given amount in each bottle, 2 gm polystyrene is added to a round bottle and leaves them for 24 hours. After 24 hour we get titanic acid in each bottle; one is only titanic acid and another is titanic acid with the presence of polystyrene.

2.3Calcination:

These 2 samples in the same amount are calcinated at a temperature of 450°C, 550°C, and 650 °C in an Electric Muffle furnace (JSMT-30T, KOREA), Standard TiO₂ is also calcinated at these temperature to compare the efficiency of the synthesized TiO₂ and with the presence of polystyrene.

2.4Preparation of bed:

After completion of calcinations .25 gm synthesized TiO₂ with polystyrene, synthesized TiO₂ and standard TiO₂ is measured. Each of samples is taken to a 100 ml beaker and added a little amount of distilled water to prepare paste bed in each beaker.

2.5. Preparation of 5 ppm Methylene Blue:

At first 100ppm methylene blue is prepared in 1 liter volumetric flux. Then 1ppm, 2ppm, 3ppm, 4ppm, 5ppm, 6ppm, 8ppm, 10ppm of methylene blue solution is prepared from mother solution and made a calibration curve in UV-Spectrophotometer (UV-1650, SHIMADZU).

In UV–Spectrophotometer, the wavelength is taken from 200-800nm. And the highest pick is achieved for MB is 664 nm that we fixed.

2.6. Operation procedure for the photocatalytic Bed:

We mainly do our job in the basis of spectra that gives a graphical representation of absorbance vs. wavelength. Now 50ml of 5ppm methylene blue dye is pour in each bed that is being prepared. Taken 6ml from each beaker and centrifuged (Centrifuger-Effendrop) up to 10 minute. Then centrifuged solution was taken to a plastic cell. After correction of sample baseline, cell is placed in UV-spectrophotometer and measured the sample concentration and the spectrum for each sample at $t=0$. Then the sample solution is backed to their main solution & placed these bed under a UV-light (100 watt) .To protect the eyes carbon paper and gloves are used. In this way, spectrum and the concentration of the samples are determined in equal time interval and when the data is taken the beaker must be placed in a dark condition.

Here we take data in a time interval of 15 minutes for all sample calcinated at 450°C, 550°C, 650°C and try to maintain the same condition for all the experiment.

3. Result and Discussion:

3.1 Adsorption Kinetics of Methylene Blue for the synthesized Tio2 and Synthesized TiO_2 with the presence of polymer Polystyrene:

For our Discussion we named the bed prepared for our experiment by synthesized TiO_2 as only TiO_2 , standard Tio2 as Com. TiO_2 and synthesized TiO_2 with the presence of polystyrene as PS bed only here after.

We know that adsorption is depending upon the surface area of the photo catalyst. There are 2 spectra showed the decrement of curvature area that means the concentration of Methylene Blue is decreasing with time. The area of each spectrum is measured and from here the C/C_0 vs. time is prepared.

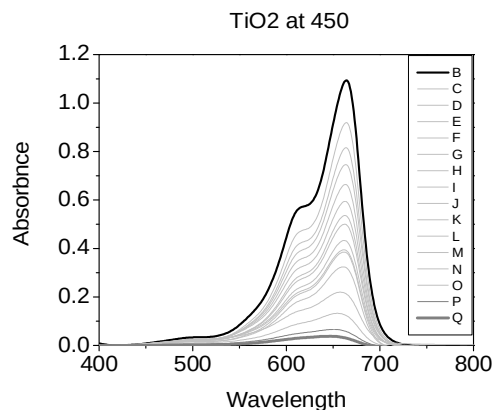


Fig: 01(a)

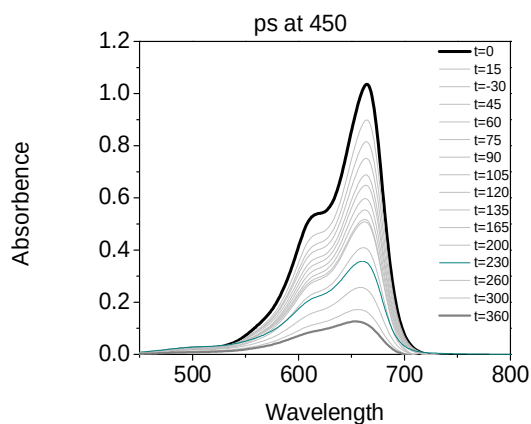


Fig: 01(b)

The comparison of TiO_2 and polystyrene at 450°C shows that the 1st order curve of TiO_2 is below the polystyrene curve in Fig: 01(a) & 1(b). That means the required time for degradation of same amount of Methylene Blue is less for TiO_2 that synthesized the polystyrene in Fig: 02.

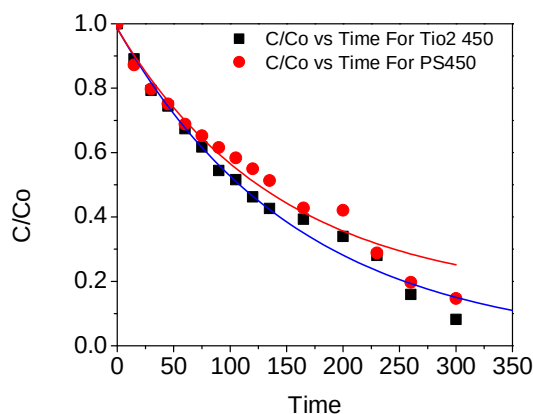


Fig: 02

3.2. Adsorption Kinetics of Methylene Blue for the synthesized Tio2 and Synthesized tio2 with the presence of polymer Polystyrene at temperature of 550°C:

Here 2 spectra also showed the decrease of curvature area that means the concentration of Methylene Blue is decreasing with time. The area of each spectrum is measured and from here the C/Co vs. time is prepared.

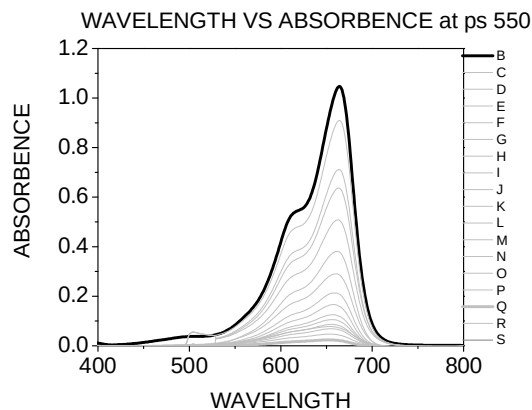


Fig: 03(a)

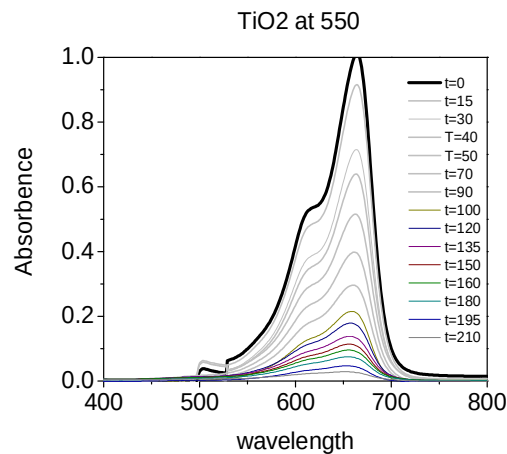


Fig: 03(b)

The comparison of TiO2and polystyrene at 550°C shows totally different behavior than the experiment made for the calcinations temperature of 450°C using same conditions shown in Fig: 03(a) & 1(b) and this is a matter of concern that the 1st order

curve of TiO2 with polystyrene which is indicated by the red curve is below the black curve indicating TiO2 means the required time for degradation of same amount of Methylene Blue is less for TiO2 with polystyrene than synthesized TiO2 shown in Fig: 04.

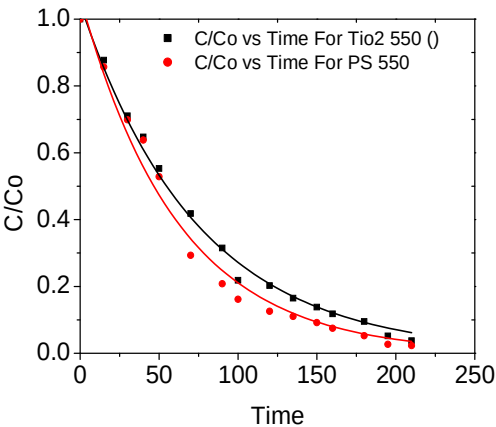


Fig: 04

3.3. Adsorption Kinetics of Methylen Blue for the synthesized Tio2 and Synthesized tio2 with the presence of polymer Polystyrene at temperature of 650°C:

2 spectra also showed the decrement of curvature area that means the concentration of Methylene Blue is decreasing with time. The area of each spectrum is measured and from here the C/Co vs. time is prepared.

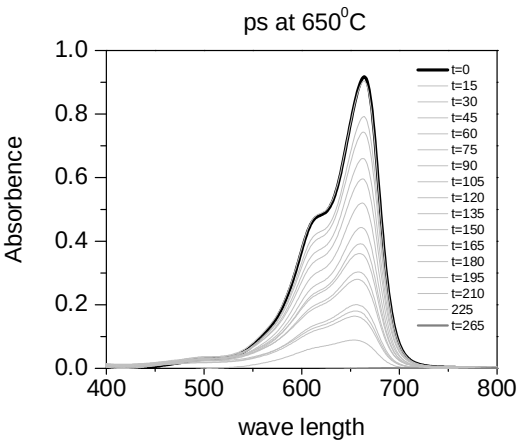


Fig: 05(a)

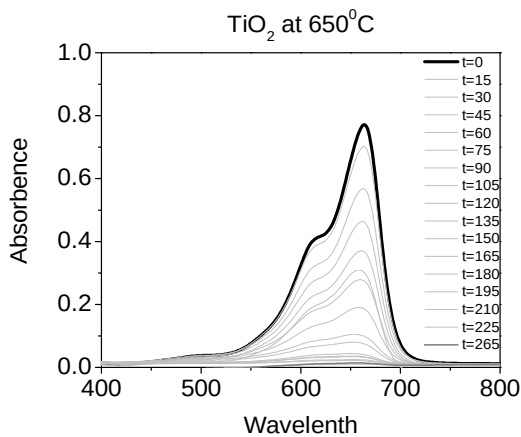


Fig: 05(b)

The graph of C/C_0 vs. time of both of Synthesized TiO_2 and synthesized TiO_2 with polystyrene at temperature $650^\circ C$ shows below is indicating that the black curve is much below than the red curve. That means at $650^\circ C$ the activity of polystyrene is decreased in the TiO_2 bed depicted in Fig: 05 & Fig:

06.

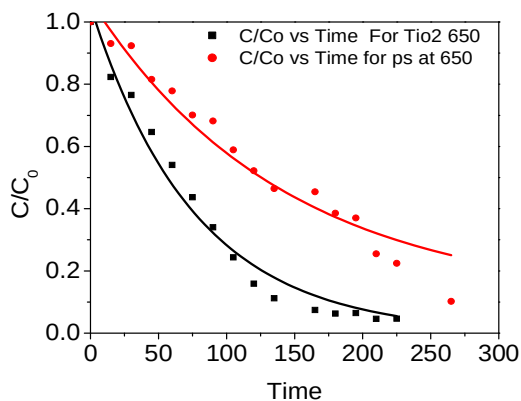


Fig: 06

Now the comparison of TiO_2 at 3 calcinations temperature of $450^\circ C$, $550^\circ C$, $650^\circ C$ is shown in the same graph. In this graph, blue sign indicates the kinetics of TiO_2 at $450^\circ C$, red sign at $550^\circ C$, green sign at $650^\circ C$ and the black color is for the standard TiO_2 calcinated at $550^\circ C$. The graph depicts that the TiO_2 at $550^\circ C$ is less active than standard TiO_2 but it's

more effective than the TiO_2 synthesized at $450^\circ C$ and $650^\circ C$ in Fig: 07.

Again the com TiO_2 is just near about the synthesized TiO_2 at $550^\circ C$.

Similarly the comparison of synthesized TiO_2 with polystyrene at 3 calcinations temperature of $450^\circ C$, $550^\circ C$, $650^\circ C$ is shown below.

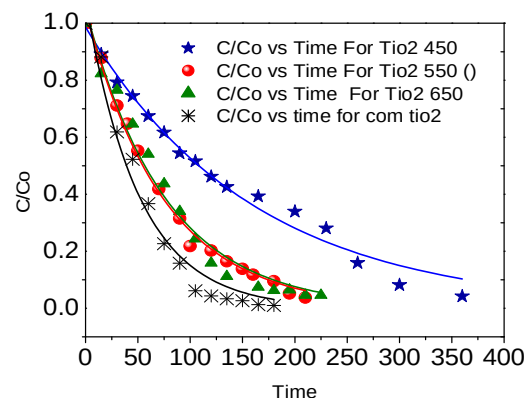


Fig: 07

In this graph, black sign indicates kinetics of synthesized TiO_2 with polystyrene at $450^\circ C$, red sign at $550^\circ C$, green sign at $650^\circ C$ and the blue sign is for the standard TiO_2 calcinated at $550^\circ C$. Again, the graph shows that the synthesized TiO_2 with polystyrene at $550^\circ C$ is less active than standard TiO_2 but it is also more effective than the TiO_2 synthesized at $450^\circ C$, $550^\circ C$ and $650^\circ C$ in Fig: 08.

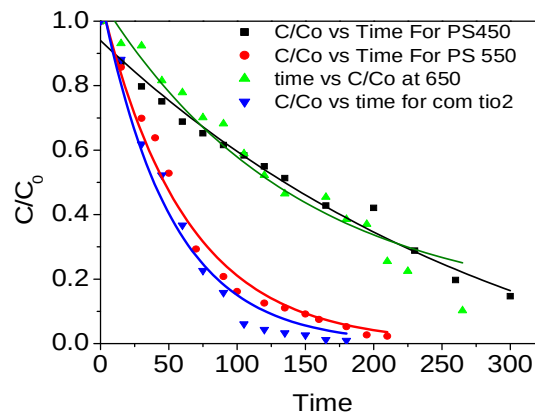


Fig: 08

Conclusion:

The data and graph experimentally demonstrate that the sol-gel process which is developed here is the simplest way that can be used not only for the laboratory work but also for the industrial purpose which behave just like the standard TiO₂.

Apart from this, we also add polymer in this method to enhance the efficiency of TiO₂ that can remove color from the industrial effluent. The experiment says that the surface area of this sample is increased in reasonable extent than the synthesized TiO₂ at same procedure which is calcinated at a temperature of 550°C. So, we can use TiO₂ with the presence of polystyrene at 550°C that can be applied instead of standard TiO₂ and minimize the time that is required in any application of photo catalyst. This research work opens the possibilities of availability of photocatalyst in laboratory work and so for the industrial purpose like water treatment, effluent treatment; which could be useful eminently to save the environment.

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Photocatalytic degradation of reactive dye in batch and continuous modes

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Organic dyes are one of the largest pollutants released in wastewater from textiles and other industrial processes. Because of potential toxicity of the dye and their visibility in surface waters, removal and degradation of organic dyes have been a matter of considerable interest. A wide range of methods have been developed, amongst which the heterogeneous photocatalysis involving titanium dioxide(TiO_2) appears to be the most promising technology. In the present work, titanium dioxide(TiO_2) has been used as photocatalyst for the degradation of methylene blue(MB) and reactive yellow(RY) in batch and continuous modes. Titanium dioxide(TiO_2) was immobilized onto the ceramic plate using cement as binder. The absorption capacities of TiO_2 in bulk and in immobilized form have been investigated. It was found that the maximum absorption capacity of titanium dioxide(TiO_2) decreased only three times due to immobilization. Effect of initial concentration and solution thickness has been studied for photocatalytic degradation of the dye.it was found that the degradation rate decreases sharply due to the increase in the solution depth. Effect of residence time on photocatalytic degradation in continuous mode has been investigated.

Key words: Photocatalysis; Immobilized TiO_2 ; Methylene Blue (MB); Reactive Yellow(RY); UV activation of TiO_2

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PREPARATION OF BIODIESEL FROM WASTE COOK OIL BY USING THREE STEP METHOD

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Waste cook oil was collected from local restaurants for the preparation of biodiesel. The free fatty acid (FFA) of the oil was found as 1.83 wt. %. Biodiesel was prepared by three-step method where in the first step, the oil was saponified by aqueous $\text{Ca}(\text{OH})_2$ solutions, in the second step the soap was converted to FFA by acidification and in the final step the FFA was converted to fatty acid methyl ester by acid catalyzed esterification reaction. The process of preparation of FFA from oil was optimized. Esterification reaction was conducted by reacting FFA with methanol at different methanol/FFA molar ratio in presence of 2-6 wt.% HCl of FFA as catalyst at 60-65° C. The biodiesel properties such as density, viscosity, FFA content, moisture content, pour point, cloud point, Saponification value, iodine value, specific gravity and cetane index were measured and compared with the standard biodiesel properties. The yield of biodiesel from raw oil by this method was found as 67%.

Key words: Waste Cook Oil, Saponification, Acidification, Esterification, Biodiesel.

1. INTRODUCTION

A great quantity of Petroleum based fuel or fossil fuel is used all over the world but its reservation is limited. For reducing the dependence of fossil fuel alternative fuels are introduced. One of the most commonly mentioned alternative fuel is "Biodiesel". Biodiesel is defined as "a substitute or an additive to diesel fuel that is derived from the oils and fats of plants and animals or mono-alkyl esters of long chain fatty acids derived from a renewable lipid feedstock such as vegetable oil or animal fat (Wang Yong et al. 2006) and (Atlin R et. al. 2001). The most common oil sources are waste cook oil (WCO), sunflower oil, corn oil, canola oil, soybean oil, castor oil, rapeseed oil, soybean soapstock, koroch seed oil, Sclerocarya birrea oil (SCO), melon bug oil (MBO), sorghum bug oil (SBO), cardoon (Cynara cardunculus L.), Gum copal (kauri resin), frying oil (a mixture of olive oil and sunflower oil), Karanja (Pongamia pinnata), Jatropha (Jatropha Curcas), Neem (Azadirachta indica), Mahua (Madhuca indica), Simarouba (Simarouba indica), Jojoba (Simmondsia chinensis

Link Schneider) etc. Some of these sources are now used for the commercial production of biodiesel. Such as our neighboring country India is producing biodiesel from Jatropha seeds. Isonox bioenergy has started operations at the Ambad area of MIDC. The unit will manufacture biodiesel from jatropha seeds (Barnwal B.K. et .al. 2004). The main ingredient for biodiesel preparation is WCO and $\text{Ca}(\text{OH})_2$ which are collected from local markets. Nowadays a comparative study on preparation of biodiesel from the WCO by three step method was investigated. The conversion of pure triglyceride (TG) to fatty acid methyl ester (FAME) is high. From the view of chemical reaction refined vegetable oil is the best start material to produce biodiesel. At first free fatty acid (FFA) was prepared from WCO reacting with of $\text{Ca}(\text{OH})_2$. FAME was prepared by esterification of FFA with methanol at different molar ratio. Effect of different parameters such as FFA/methanol molar ratio, catalyst concentration has been studied and optimum parameters are found.

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2. MATERIALS AND METHODS

2.1. Chemicals

Methanol (99-100%), ethanol (99-100%), calcium oxide (CaO) or “dry lime”, sodium hydroxide pellets (96%), potassium hydroxide pellets (>84%), phenolphthalein (P^H 8.2-9.8), acetone (99%), diethyl ether, hydrochloric acid (37%), sulfuric acid (98%), iodine, sodium iodide, bromine, carbon tetrachloride, glacial acetic acid, potassium dichromate etc. All the chemicals were used as analytical reagent grade.

2.2. Waste Cook Oil

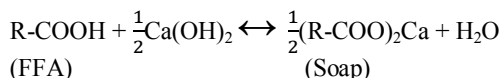
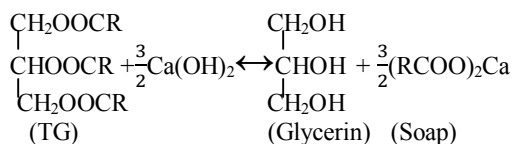
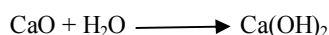
Waste cook oil (palm oil) was collected from local restaurants located in Sylhet city in Bangladesh. The oil was filtered and its properties were measured.

2.3. Biodiesel preparation by Three- step method

2.3.1. Saponification

For saponification process required amount of WCO was taken in a three necked flask and mixed with different stoichiometric amount of aqueous calcium oxide solution. The mixture was heated with vigorous stirring at temperature of $100\text{ }^{\circ}\text{C}$ for 2-3 hours. The reaction was stopped by cooling the reaction mixture. Aqueous calcium hydroxide solution was prepared by dissolving required amount of dry calcium oxide (CaO) in 60-90 ml water. The reaction time and molar ratio of oil to calcium oxide were optimized.

The Saponification reaction:



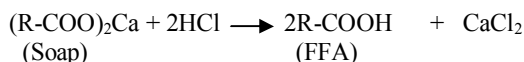
Where R denoted any hydrocarbon chain

2.3.2. Acidification or Free fatty acid (FFA) preparation

After saponification reaction, produced calcium soap solution was treated with different stoichiometric amount of concentrated hydrochloric

acid at a temperature of $65\text{--}70\text{ }^{\circ}\text{C}$ with vigorous stirring. After dissolving the soap, the fatty acid contents were separated in separatory funnel. After separation, hot water wash was given for removing mineral acid from the fatty acid. The fatty acid content was determined by titration method. The different molar ratio of soap to hydrochloric acid was given and optimized.

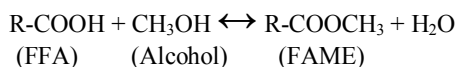
In acidification step following reaction was occur for calcium soap:



2.3.3. Esterification of Free fatty acid (FFA)

When acidification was completed produced FFA was reacted with different stoichiometric amount of methanol with vigorous stirring and heated under reflux at a temperature of $60\text{--}65\text{ }^{\circ}\text{C}$ in presence of hydrochloric acid as a catalyst for 2-2.5 hrs. In the esterification reaction, molar ratio of FFA to Methanol and Catalyst concentration were optimized.

During Esterification the following reaction occurs:



After preparing the biodiesel from WCO various physico-chemical properties was measured and compared with the standard biodiesel.

The yield of biodiesel was calculated by the following equation:

$$\text{Yield} = \frac{W_{\text{biodiesel}}}{W_{\text{Oil}}}$$

Where, $W_{\text{biodiesel}}$ = Weight of biodiesel and W_{Oil} = Weight of Oil

2.4. Analytical methods for Oil and Biodiesel

FFA in the oil and biodiesel samples was analyzed by the method described in AOCS Aa 6-38. To determine FFA of sample and biodiesel, 1ml of oil and biodiesel were weighed in gm then dispersed in 5ml diethyl-ether solution followed by titration against 0.1 M KOH. Saponification value (SV) was determined by method described by Jeffery et al. 2 gm sample is taken in 50 ml alcoholic KOH then heated with vigorous stirring at $65\text{ }^{\circ}\text{C}$ for 30 minutes and titrated with the 0.5 M hydrochloric acid. The iodine value was determined by titrating

the sample with 0.01 N sodium thiosulfate and chemical reagents until the disappearance of blue color. Iodine value is calculated by following equation:

$$\text{Iodine value (IV)} = (V_1 - V_2) * S * 0.1269 * 100 / W$$

V_1 and V_2 are the volume of sodium thiosulfate (ml) required for titration with sample and blank titration, S is the concentration of $\text{Na}_2\text{S}_2\text{O}_3$ in Normality, W is the weight of oil sample in gm. Physical properties color, moisture content and density of the sample were by the following ASTM D 1500, ASTM D 1744 (karl fisher method), ASTM D 1480/81 and ASTM D 240. Viscosity, cloud point, pour point were determined by standards ASTM D445 respectively.

3. RESULT AND DISCUSSION

3.1. Characterization of waste cook oil

The properties of WCO such as viscosity, density, moisture content, saponification value, pour point, cloud point etc were measured and represented in Table 1.

Table1: properties of WCO

Properties	Experimental Value
Color	Yellowish
Density(kg/m^3), at 25 °C	902
Specific gravity, at 25 °C	0.902
Kinematic viscosity (mm^2/s), at 40°C	47.60
Free fatty acid content (%FFA)	1.83
Moisture content (%)	0.40
Saponification value(mg KOH/mg oil)	238
Clod point(°C)	12
Pour point (°C)	6

3.2. Effect of molar ratio of $\text{Ca}(\text{OH})_2$ on FFA preparation

Saponification of WCO was done at different molar ratio (1:2, 1:3) with aqueous calcium oxide solution. After saponification, acidification was conduct to produce FFA. Percent (%FFA)

conversion was observed at different time interval and reaction time was optimized. The results is represent in Fig. 1.

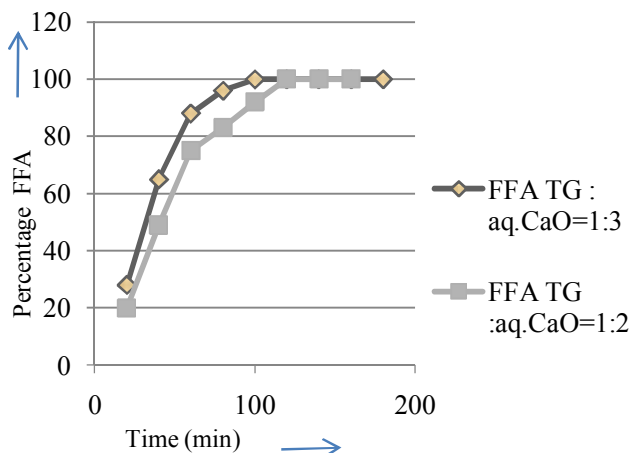


Fig.1: Time vs. % conversion of FFA at different oil/aq. CaO molar ratio [1:3, 1:2 molar ratio of Oil to CaO, reaction time 2-3 hours at 100 °C temperature under reflux with vigorous stirring]

From the Fig.1 it is seen that, at 1:3 oil/CaO (molar ratio) 100% FFA was formed in 100 min, whereas at 1:2 oil/ CaO (molar ratio) 100% FFA was obtained after 130 min. In further experiments FFA was produced using 1:3 oil/CaO molar ratio.

3.3. Fatty acid methyl ester (FAME) preparation by esterification of FFA

3.3.1. Effect of FFA/ methanol molar ratio

The FFA/methanol molar ratio is one of the important factors that affecting the FFA conversion to methyl ester. From the reaction stoichiometry 1 mole alcohol is required per mole of FFA to convert in methyl ester. FFA react with different stoichiometric amount of methanol and the results is represent in Fig. 2.

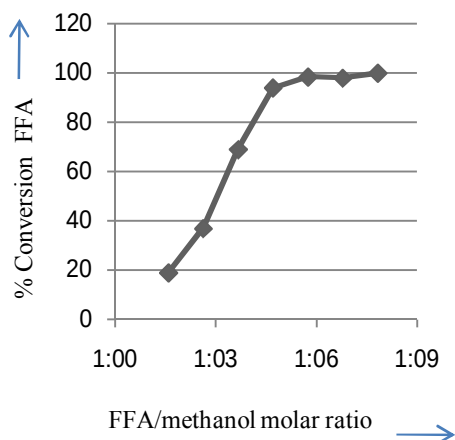


Fig. 2: % conversion of FFA vs. FFA/methanol molar ratio [temperature 65 °C, 5 weight% HCl to FFA as catalyst and molar ratio of FFA to methanol 1:6 under reflux with vigorous stirring].

From the Fig.2, it is observed that the FFA conversion increases as the ratio of Methanol/FFA increases. The conversion is 99.5 % at the molar ratio of FFA to methanol 1:6. Further increase in FFA to methanol molar ratio conversion does not increase. The optimum molar ratio of FFA to methanol is 1:6.

3.3.2. Effect of catalyst concentration on esterification (HCl)

Catalyst concentration has a significant role on conversion of FFA to methyl ester. Increase of catalyst concentration increases the %FFA conversion. The results are shown in Fig. 3. At a certain catalyst concentration the conversion is high.

From the Fig.3, it is shown that, the FFA conversion increases as the catalyst concentration increases and the conversion is 99.5% at the catalyst concentration is 5 wt% of HCl to FFA. Further increase in catalyst wt% conversion does not increase. The optimum catalyst concentration is 5 wt% of HCl to FFA.

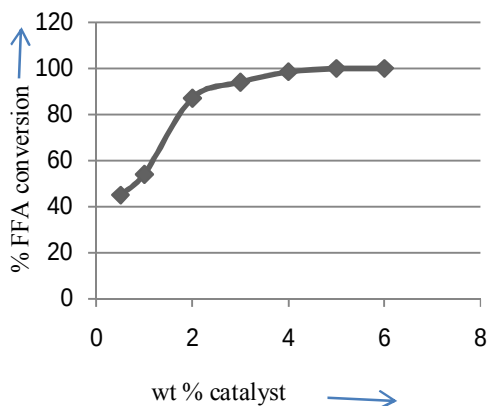


Fig. 3: Catalyst concentration vs. %FFA reduction [Temperature 65°C, Molar ratio of FFA to methanol 1:6 and Reaction time 2.0 hr, under reflux with vigorous stirring].

3.3.3. Effect of time on %FFA conversion

Time has a significant effect on the conversion of esterification reaction. Increase time increases the reaction conversion. After a certain time interval the conversion become maximum.

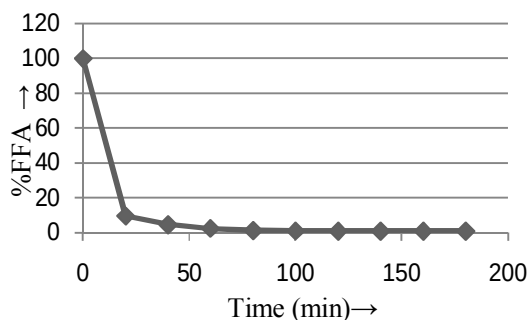


Figure 4: Time vs. %FFA reduction [Reaction temperature 65°C, FFA/Methanol molar ratio 1:6, Catalyst concentration 5 wt% of under reflux with vigorous stirring]

Fig.4 shows the FFA conversion with time respectively. Highest conversion is found after two hours at 65°C temperature. Further increase in time the conversion does not increase. The optimum time is two hours.

3.4. Properties of biodiesel

Properties of produced biodiesel was measured and comparison with biodiesel standard are given in Table 2. The quality of biodiesel is determined by

measuring some properties such as cetane index which indicates ignition characteristic.

Table 2: Properties of biodiesel produced from WCO and comparison with standard value

Properties	Produced biodiesel value	Standard value
Density(kg/m ³), at 25 °C	821	805-895
Specific gravity, at 25 °C	0.821	0.805-0.895
Kinematic viscosity (mm ² /s), at 40°C	4.168	3.85-6.0
Free fatty acid content (%FFA)	0.97	0.65-2.50
Moisture content (%)	0.12	0.09-0.25
Saponification value	199	175-210
Iodine value	89	72-95
Cloud point (°C)	-1	(-1)-(-7)
Pour point (°C)	-3	(-3)-(-26)
Cetane Index	53	38-50

Cetane index of biodiesel is slightly higher than standard value of biodiesel. Other properties such as density, viscosity, FFA content, moisture content, pour point, cloud point, saponification value, iodine value, specific gravity were measured.

4. CONCLUSION

Biodiesel has been synthesized from waste cook oil by three step method with aqueous calcium oxide solution. Three-step method for biodiesel preparation comprises with saponification of oil, acidification of soap to produce FFA and esterification of FFA to biodiesel. Saponification was done by aqueous calcium oxide solution at different molar ratio of oil to CaO and optimized. The optimum molar ratio for saponification by aqueous calcium oxide was 1:3 oil to CaO and reaction time 120 minutes at 100 °C. In acidification the molar ratio of soap to hydrochloric acid was 1:2.5 for calcium soap. In Esterification the optimum molar ratio of FFA to methanol was 1:6, the catalyst concentration was 5 wt% of HCl to FFA, the reaction temperature was 65°C and the reaction time is 2 hour. So the properties of biodiesel such as density, viscosity, specific gravity, cloud point, pour point, cetane number are nearest to the petrodiesel. The present experimental results support that produced biodiesel from waste cook oil can be successfully used as diesel.

5. ACKNOWLEDGEMENT

The financial support from the research grant of University Grants Commission (UGC) of Bangladesh for conducting this research work and ERL for providing their facility for biodiesel properties measurement.

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Recovery of Chromium from Tannery Effluent

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This paper describes the effectiveness of recovering chromium from tannery waste to meet existing environmental regulation. The treatment involves reaction between Magnesium Oxide slurry with chrome bearing tannery effluent. Chromium removal is more effective with dilute tannery effluent.

Keywords: Chromium, ETP, Tannery, Chemical engineering, Waste management.

INTRODUCTION

Environment is a matter of general concern at present times due to the higher degree of pollution. Lather processing is one of those technologies documented by the environmentalists for their pollution prospective [5, 8, 10]. Leather and leather products are the most commonly used commodities in the world. The tannery industries are considered pioneers in the export sector of Bangladesh because of their annual revenue of taka 1500-1600 crore [7]. Therefore it is not possible to terminate the tannery industries because of their contribution to the economy of the country. However appropriate steps can be taken in

order to reduce the pollution from the tannery industries. The 207 tanneries located in Hazaribagh and Kalurghat of Bangladesh involves with US\$ 43 billion of formal trade. There are about 176 tanneries in Hazaribagh on 25 hectares of land where 90% of them do not equipped with any kind of waste treatment facility. The solid and liquid effluents discharging from these tanneries are directly thrown into the Buriganga River resulting severe contamination problem. Effluent discharging from the tanneries containing chromium compound causes an adverse affect on the aquatic life and human health. In addition, chromium is too expensive to be allowed to go freely in the drainage system. Therefore

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an effluent treatment (ETP) plant is necessary for each tannery to sanitize the waste water and to recover and reuse the chromium discharging into the environment.

Due to the constant movement of environmental and human rights organizations, all the 176 tanneries of Hazaribagh are relocating in a 200 acre industrial area of Savar. According to the environmental regulation of Bangladesh, each tannery must be equipped with an ETP to treat the effluents discharging from it. However, construction of ETP for each of the plant requires lot of time and money. This problem can be solved by building a Common Effluent Treatment Plant (CETP) for all the tanneries about to be relocated in Savar. In this case, the effluents from the tanneries will be discharge into the central drainage system that leads to the ETP. Rather than being a part of a tannery the ETP will operate as a single plant. The prime objective of the suggested plant will involve treating the wastewater as well as recovering expensive chromium, which can be reused in the tannery. However, a technical study is required in order to examine the possibility of constructing such type of ETP capable of treating the wastewater from the central drainage system as well as recover chromium from it. Among the two different methods used to recover chromium from tannery waste, Magnesium Oxide treatment method will be used in this project due to its simplicity and extensive usage [2, 18]. A medium scale Effluent Treatment Pilot Plant has been constructed in order to execute the experiments on the tannery effluent. The effluents will be collected from the central drainage system of Hazaribagh where all the wastes from the tanneries mixing and flowing towards

Buriganga. The effluents will be analyzed first at the lab and then feed to pilot plant where they will be treated by Magnesium Oxide. After the treatment, the discharging water from the ETP will be analyzed again to compute the amount of chromium recovered from the effluent. In addition, the experiments will be performed at different operating condition to optimize the recovery and to improve the quality of the effluent discharging from the ETP.

EXPERIMENTAL SETUP

Recovery of chromium from spent tanning after precipitation constitutes an indirect means of recycling and reusing the chrome in processing. By adopting indirect chrome reuse after precipitating the residual tanning floats, the tanner can avoid the problem of increasing float volume. The principal is based on recovering the chrome from floats containing residual chrome by means of precipitation, separation, and subsequent re-dissolution in acid for reuse. There are two methods to precipitate the chrome [1]. The first method involves rapid precipitation with sodium hydroxide and Sodium carbonate, enhancing coagulation with polyelectrolyte, thickening and finally dewatering the voluminous sludge by filtration. There is another process which involves slow precipitation with Magnesium Oxide, settling of the suspension, decantation of the supernatant and subsequent acidification of the relatively dense precipitate.

In the selected process Magnesium Oxide (MgO) is used to separate Chromium from the effluent. Because of its low reactivity

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and solubility Magnesium Oxide (MgO) causes chromium to settle as a compact sludge. This compact sludge of chromium can be separated easily. The settlement of chromium depends on pH. Chromium Hydroxide is insoluble in the pH range of 8 to 12. Optimum pH range is from 8.5 to 9 for better precipitation.

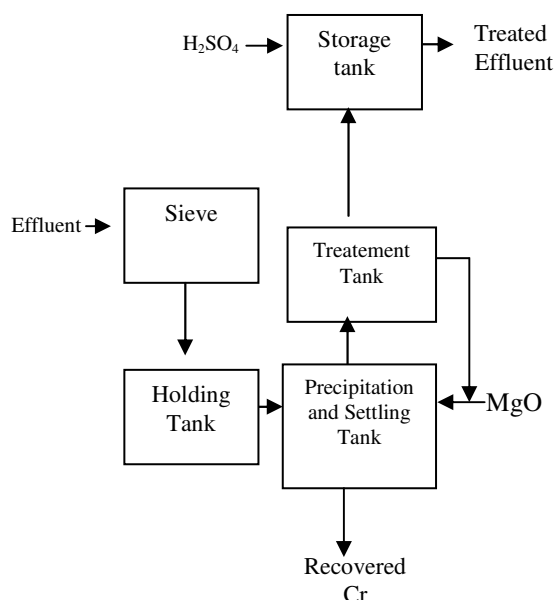
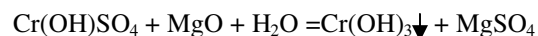


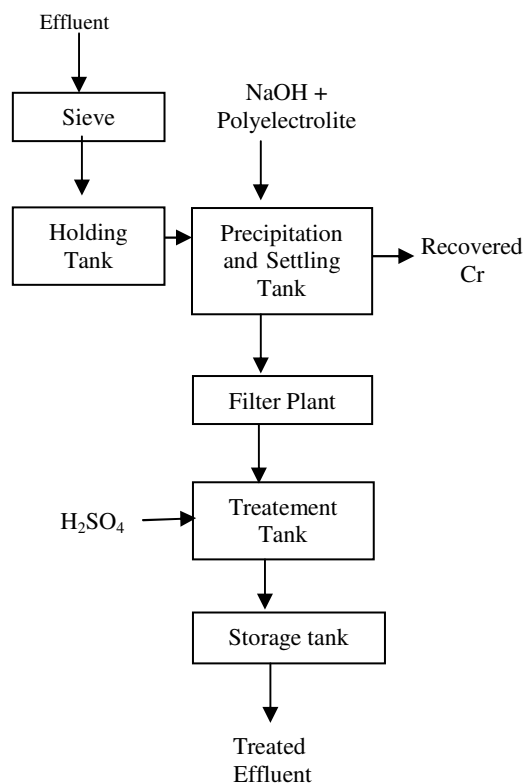
Figure 1 Block diagram of the chrome recovery process by precipitation with Magnesium Oxide (MgO)

Almost 30-50% of basic chrome sulfate comes with waste chrome liquor after tanning. The volume of exhaust chrome liquor is 4-6% of total volume of discharged wastewater. Its pH is about 3.5-4. Chromium (total) content in the wastewater is about 500 mg/l from main chrome tanning drums [4]. At the beginning Magnesium

Oxide reacts with the basic chrome sulfate and as a result of this reaction hydrated Chromium oxide precipitate forming a compact sludge. The following reaction occurs here.



From tanning drums, waste liquor moves to the discharge drain. From here it is collected and placed into the reactor according to the capacity of the reactor. After reaction, it enters into the settling tank where after complete settlement chromium is expected to be recovered.



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Figure 2 Block diagram of the chrome recovery process by precipitation with Sodium Hydroxide / carbonate

The pilot ETP plant used for the experiment consists of three parts; magnesium oxide tank, main reactor and settling tank. The Magnesium Oxide tank is a 10 liters capacity mild steel tank used for MgO solution preparation. A polypropylene valve has been fixed at the bottom outlet. A support structure with top opening for stirring/ manual mixing and cleaning (so that MgO can flow by gravity into the main reactor) is used in this experiment. The main chrome precipitation reactor is of a capacity of 100 liter is made of flat sheet mild steel with fabric reinforced plastic linings using bisphenol resin and one layer FRP as surface mat outside. The bottom slope is in the range of 5-15°. The reactor is equipped with a stirrer. The shaft of the stirrer is in stainless steel for a length of about 78 meters with sets of stainless steel blades. The stirrer is driven by a 0.37 KW motor, which provides constant rotation of 2800-2900 rpm. Here Magnesium Oxide mixes with the basic chrome sulfate and requires stirring due to the low reactivity of Magnesium Oxide. Afterwards, the liquids are transferred to a 100-liter capacity carbon steel tank known as settling tank. Here the liquid is kept for a day to let the hydrated chromium oxide settled. The treated effluents are drained through the bottom valve and chromium oxide is collected. The effluents are treated with sulfuric acid to regenerate magnesium oxide. Thus, Magnesium oxide can be recycled where the remaining effluents are fine enough to be discharged into the river.

In the laboratory, experiments were carried out three times using the same procedure. Samples of three different concentrations were treated. First sample contains 30 liter of waste liquor. It was diluted to 90 liters. Second sample contained 30 liters of waste liquor and it was diluted to 60 liters. Third sample contains 60 liters of waste liquor in absence of any kind of dilution. Before and after the reaction following parameters were measured for the effluents: pH, total dissolved solid (TDS), total suspended solid(TSS) and total chromium content.

Alkaline Hypobromite Oxidation method of HACH was used to determine Chromium (total). Spectrophotometer was set at 540 nm wave length. The range of possible measurement here is 0-0.700 mg/liter. So, dilution was necessary here.

The wastewater was collected from the central drainage system of Hazaribagh by the roadside where effluents from all the tanneries are mixes with each other and discharges into the river. After obtaining the parameters mentioned above for the effluents, amount of Magnesium Oxide required for test run was calculated. Because of the low solubility of MgO, it is better to be used as slurry. When Magnesium Oxide solution mixed with the waste liquor contained in the reactor, they are stirred for 10-15 minutes and then transferred into the setting tank and left to settle for a day.

RESULT & DISCUSSION

The study was related to the existing chrome recovery process in tannery sector. To estimate the amount of chemicals required in the recovery process, pH measurement in

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regular basis and periodical Chromium and basicity estimations are necessary. On an average ratio of the fresh basic chromium sulfate and recovered chromium is almost 7:1.

Run	1 (300% dilution)		2 (100% dilution)		3 (no dilution)	
	Input	Output	Input	Output	Input	Output
pH	9.65	9.86	7.55	7.76	7.79	7.59
TDS, gm/lit	2.45	2.47	3.28	3.20	7.93	7.98
TSS, gm/lit	0.44	0.60	0.98	0.52	0.63	0.323
TS, gm/lit	2.89	3.06	4.26	3.72	8.56	8.303
Cr (total), gm/lit	1.00	0.19	1.80	0.50	3.40	1.20

Figure 3 Data generated before and after the experiments.

Time required for achieving the desired pH is comparatively more. Because Magnesium Oxide is a slow reacting alkali and pH increases slowly after the addition of Magnesium Oxide for chromium precipitation. Considering the initial indication of pH and because of the slow reaction of Magnesium Oxide, excess amount of Magnesium Oxide is added sometimes. This might increase the reactivity between chromium and Magnesium Oxide but it does not have any noticeable effect on the reaction rate.

The reaction carried out at three different dilutions. This will determine the effect of the dilution on the extent of chromium recovery from the effluent. The reactions are also carried out at different stirring and

settling time. Therefore, it was possible to observe and study the rate of reaction in terms of three different parameters.

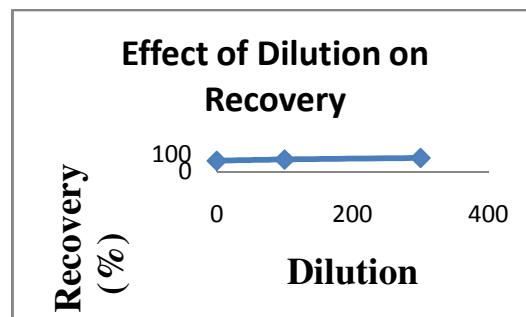


Figure 4 Extant of recovery with wastewater dilution during the experiment. Data shows that the recovery increases with dilution.

The results determined from the lab tests indicates that the amount of chromium detected in the output stream of the ETP is less than the amount enters in it. Therefore, it can be affirmed that, it is possible to recover chromium from the central drainage system wastewater using the Magnesium oxide treatment method. It is also proved from the experimental data that the pilot ETP designed for the purpose is capable of accomplishing the task.

Analyzing the results indicate that the amount of chromium recovery significantly depends on the extent of dilution. The amount of chromium recovery increases with dilution (figure - 4). That means that to increase the recovery the wastewater must be mixed with a stream of water. Increase in recovery with dilution is not surprising because normally reaction rate increases with dilution. However, the collected wastewater is already diluted enough as water from different other sources are

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mixing with the chrome liquor. Therefore, chrome recovery will be high even if diluted water will not be mixed during the operation.

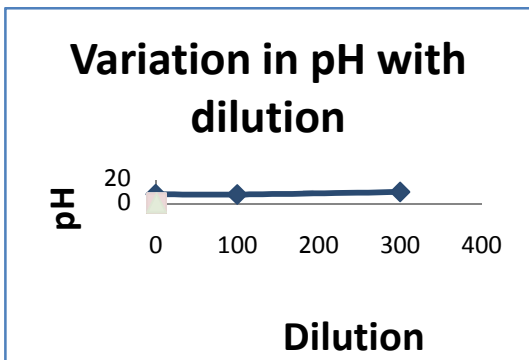


Figure 5 Variation of pH with Dilution. Experimental results indicate that dilution has no significant effect on the pH of the effluent.

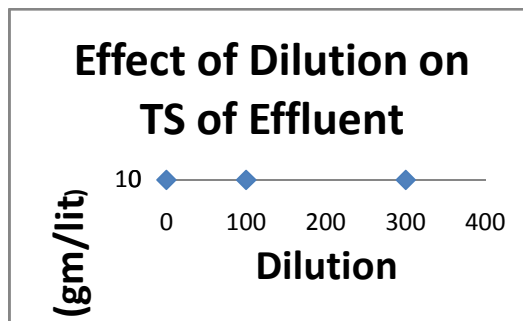
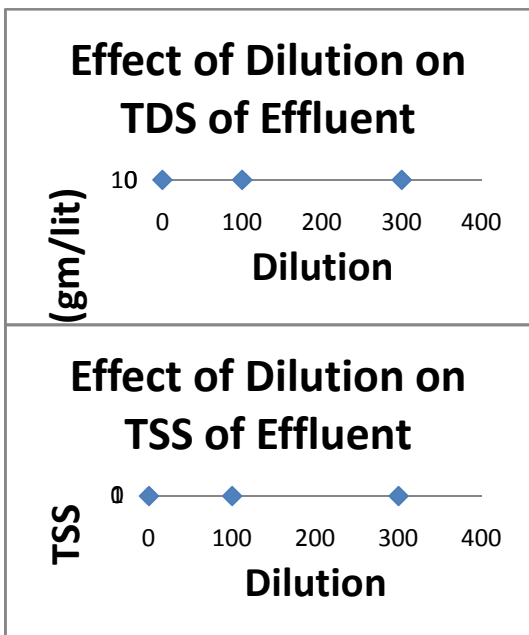


Figure 6 Variations of TDS, TSS and TS with Dilution. Experimental results indicates that dilution

The pH of the tannery wastewater recorded in the laboratory was 8-10 (figure - 4), which matches with the international benchmark standard of wastewater regarding pH. Therefore, dilution is necessary to adjust the pH of the discharged wastewater. It is also evident from the results that the amount of total dissolved solid (TDS) increases and total suspended solid (TSS) decreases after the ETP treatment. The increase in TDS value was observed because the discharged effluents were tested before the sulfuric acid treatment. Therefore, the effluents contain Magnesium sulfate dissolved in it.

CONCLUSION

Characterization of the tanning process revealed that, on a mass basis, a majority of the Chromium, which is lost from the process, is lost in the liquid fraction as soluble Chromium. Chrome recovery is an indirect way if recycling chrome in the lather production as it enables the tanner to avoid problems attributed to the accumulation of the float volume. Adopting this method of chrome recovery and employing it to treat the wastewater of the

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central drainage system of the tannery complex was the prime objective of the project. The laboratory data generated during the experiment suggests that the Magnesium oxide method is suitable for recovering chromium from the wastewater. Experimental data are also suggests that the process do not need any kind of dilution. Therefore, it can be concluded that building a CETP that can treat the wastewater and recover chromium is technically possible and it can be implemented at the industrial area of Savar where the tanneries are going to be relocated.

In this study, the recovery process is optimized only in context of the dilution, stirring time and settling time. However, there are other parameters involve that contains a significant effect on the recovery of chromium. Therefore, these parameters need to be investigated in order to optimize the recovery of chromium as well as tannery waste management.

In addition, the economical feasibility of building a CETP also needs to be investigated. According to DoE, about three thousand tons of tannery waste has been discharged into the river daily [6]. Therefore, it needs to be observed whether a CETP is capable of treating this much amount of wastewater. A study should also be performed on other chrome recovery and waste treatment process to determine the most suitable process to recover chromium from tannery wastewater in terms of both technical and economical point of view.

ACKNOWLEDGEMENT

The authors wish to thank all the operators and officers of Bay Tannery for their technical support in accomplishing the task. The authors also would also like to acknowledge with gratitude the service rendered by the technicians and staffs of Mass Transfer Laboratory and Environmental Laboratory of Chemical Engineering Department of BUET. Furthermore the HACH is thanked for supporting this work.

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Rule of Mixture for Predicting the Elastic Modulus of polymer-fiber and polymer-fiber-particle Composites: A discussion

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Abstract

An analysis has been done on the models proposed in Literature for predicting the elastic modulus of fiber reinforced polymer composites (FRPC). These models have been applied for polymer-fiber as well as for polymer-fiber particle composites system. For polymer-fiber composites Rule of Mixture (RoM) and for polymer-fiber-particle composites Rule of Hybrid Mixture (RoHM) models have been analyzed in this article. RoM can be divided into two forms, depending on the direction of the applied stress on the fiber in the composite material, parallel and series models. RoHM is parallel model for more than two components system. The experimental data reported in different specialized research journals regarding elastic modulus of different FRPC has been fitted to the models. The probable variation in the averaged value of the modulus of elasticity of the polymer and the fiber has been taken into consideration and the validity of the Parallel, Series model has been tested with an acceptable deviation range of the prediction value. It is found the parallel and series models, by no means, predict the modulus within an acceptable deviation factor of 0.1. But RoHM model satisfactorily fits the experimental data.

Keywords: Fibers, Polymer-matrix composites (PMCs), Short-fiber composites, Mechanical properties, Prediction model

Introduction

Fibers are introduced in polymer compositions in order to improve their mechanical properties. Both synthetic and natural fibers are used for the purpose; although in recent years, polymer-matrix composites with natural fibers have received considerable attention both in the literature and in industrial applications due to their improved mechanical properties, significant processing advantages, low cost and low density [1]. Literature data on fiber-reinforced polymer composites (FRPCs) have been accumulating, but reports on theoretical modeling of composition/property relation of these composites are scarce [2-5].

The modulus of elasticity can be considered as one of the most significant mechanical properties of materials for engineering design of structure.

The elastic properties of fiber reinforced composites can be experimentally determined or derived from a variety of mathematical models.

A number of models are available in the Literature [6-11] for the prediction the Young's modulus of the polymer-fiber composites as well as for polymer-fiber-particle (hybrid composite) composites. For polymer-fiber composites the most frequently discussed ones are (i) Rule of Mixture (RoM) (ii) Halpin-Tsai (HT), (iii) Modified Halpin-

Tsai (MHT) (iv) Nairn (v) Mendel (vi) Hirsch (vii) Cox and (viii) Bowyer-Bader (BB) model [2,3] and for polymer-fiber-particle composites (i) laminate analogy approach (LAA), (ii) Rule of hybrid mixtures model [10-11] are frequently used.

Among all the models of polymer-fiber composites the RoM model has the simplest mathematical relation that does not have any adjustable parameter. The modulus of elasticity of the polymer, E_p , and of the fiber, E_f , should be known and then the modulus of elasticity of the composite, E_c , can be calculated for any volume fraction of the fiber in the composition by this model. But those experienced in the field shall admit that this model, in most cases, do not predict the modulus of elasticity of the composites satisfactorily. The experimental observations and analysis of Facca et al [2] and Kalaprasad et al [3] provide evidence for that. The experimentally observed value of the modulus of elasticity of the composites always lies in between those predicted by the parallel and series models.

Recently Mirbagheri et al [10] conducted intensive research on hybrid composites consisting of ternary mixture of wood flour, kenaf fiber and polypropylene, and found that the Rule of Hybrid Mixture (RoHM) could successfully describe the modulus of elasticity of the polymer composites.

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The RoHM in elaborate form practically is reduced to the Parallel model for a three-component system.

Rule of mixture (RoM)

The simplest available model to predict the elastic modulus of polymer-fiber composite is the rule of mixtures (RoM). Depending on the direction of the applied stress on the fiber of the composite materials (Figure 1) RoM can be divided into two forms: parallel model and series model.

Parallel Model [6]

In this case the load (equivalent to stress σ_z), applied parallel to the direction of the fibers, tends to stretch the fiber and the polymer to the same extent. Therefore, by assuming that fiber, polymer and composite experience equal strains, we can write

$$E_c = E_p \varphi_p + E_f \varphi_f \quad (1)$$

$$\text{with } \varphi_f + \varphi_p = 1$$

where the subscripts c , f and p stand for composite, fiber and polymer matrix respectively, E_c , E_f and E_p , are the elastic moduli, and φ_f and φ_p , are the volume fractions.

The Eq. (1) can be theoretically derived for a composite system, in which the fibers are aligned along z -axis and propagate through the whole length of the body as shown in Figure (1). A force (equivalent to stress σ_z) is acting along the z -axis. Then the modulus of elasticity along z -axis is given by Eq. (1) [12]. This equation is very attractive with superficially interesting features: a) This equation is apparently valid for $\varphi_f \in (0, 1)$ and b) for $\varphi_f = 0$,

$$E_c = E_p, \text{ and for } \varphi_f = 1, E_c = E_f.$$

The Eq. (1) is derived for long fibers (The fiber length is equal to the height of the object), but in most cases, attempts are made to apply it for composites with short-fibers distributed randomly. It is also ignored that beyond certain value of φ_f (far below unity), the composite loses its integrity and the eq. (1) can not be applied for high value of φ_f .

There is a popular perception that the Eq. (1) is a theoretical model as it can be derived for the distribution of fibers along the axis of elongation. For short-fiber reinforced composites, the equation is not valid at all. The concept 'Modulus of Elasticity' can not be considered similar to mass or energy that some sort of law of conservation will be validated for it and also whatever short the fibers may be, the composite is not a homogeneous solution to expect the additivity of the some of the

property of the components. Therefore, it is not unusual that the experimental data on modulus of elasticity vs. volume fraction is not described by the model represented by Eq. (1) as reported in the literature [2, 3].

Series Model [6]

In this case, the fiber, polymer and composite experience the equal stress but the produced strains for each are different. The elastic modulus, E_c , of the composite is given as:

$$E_c = \frac{1}{\frac{\varphi_f}{E_f} + \frac{1 - \varphi_f}{E_p}} \quad (2)$$

One could expect that the equation (2) would be derived if the load (equivalent to the stress σ_x or σ_y) is applied to the object in Figure (1) along x or y axis. This is, however, not the case. For the derivation of the Eq. (2), the fiber and polymer material are arranged in a manner as shown in Figure (2), and a load is applied along y - direction and then the Eq. (2) is derived [12]. If the load is applied to the object Figure (2) along x - or z - axis, the parallel model or the Eq. (1) will be obtained. Such an arrangement, however, is not realistic for a composite, as this does not ensure adhesion between the polymer and the fiber. This is not a composite; rather separate elements arranged in series. Thus, the Eq. (2) is not a theoretical model for short-fiber reinforced polymer composites. The series model (Eq. 2) also fails to describe the experimental data on modulus of elasticity of polymer-fiber composites vs. volume fraction of the fibers [2, 3].

RoHM Model [11]

In a hybrid composite more than one type of fibers are used in a single polymer. A hybrid particle/short-fiber/polymer composite consisting of two single composite systems, namely particle/polymer and short-fiber/polymer systems and the two systems then form the hybrid composite. Here it is assumed that there is no interaction between the two single systems and the iso-strain condition is applied to the two single systems.

Then the elastic modulus, E_c , of the hybrid particle/short-fiber/polymer composite system can be evaluated from the RoHM by the following equation:

$$E_c = E_{c1} \varphi_{c1} + E_{c2} \varphi_{c2} \quad (3)$$

Where φ_{c1} and φ_{c2} are, respectively, the relative hybrid volume fraction of the particle/polymer system and the short-fiber/polymer system, and

$$\varphi_{c1} + \varphi_{c2} = 1$$

and

$$\varphi_{c1} = \frac{\varphi_p}{\varphi_p + \varphi_f} \quad \text{and} \quad \varphi_{c2} = \frac{\varphi_f}{\varphi_p + \varphi_f}, \quad \text{where}$$

$(\varphi_p + \varphi_f)$ is the total reinforcement volume fraction and should be used as reinforcement volume fraction for calculation the elastic modulus (E_{c1} and E_{c2}) of both single composites.

Therefore

$$E_{c1} = E_m \varphi_m + E_p (\varphi_p + \varphi_f)$$

and

$$E_{c2} = E_m \varphi_m + E_f (\varphi_p + \varphi_f)$$

Now from Eq. (3) it can be written

$$E_c = [E_m \varphi_m + E_p (\varphi_p + \varphi_f)] \frac{\varphi_p}{\varphi_p + \varphi_f} + [E_m \varphi_m + E_f (\varphi_p + \varphi_f)] \frac{\varphi_f}{\varphi_p + \varphi_f}$$

$$E_c = E_m \varphi_m + E_p \varphi_p + E_f \varphi_f \quad (4)$$

Eq (4) is also a RoM model for hybrid composite system.

Illustration of the model prediction

Before going for validation of the models, one has to be very cautious about the quality of data being used. For the validation of the models, the first two parameters that are essential to be known are the modulus of elasticity of the polymer and the fibers. It is a well-known fact that the polymer properties vary in a wide range depending on the chemical composition, chain-branching, molecular mass distribution and the processing parameters. Therefore, any value of E_p found in literature could, by no means, be considered an acceptable one without reservations. The properties of natural fibers also vary in a wide range. The variation is caused by the fluctuation in environmental conditions (moisture, soil, temperature etc) in the regions, in which the fibers grow and also on the processing methods. Even in the same batch, the properties of fibers have statistical distribution. For this reason, it must be defined first in what range the prediction would satisfy the requirements to the design of structural material.

Tolerable deviation from the values predicted by the models

Let's assume that the coefficient of deviation in the value of the parameters E_p and E_f are respectively γ_p and γ_f i.e. $\gamma_p = \Delta E_p / E_p$ and $\gamma_f = \Delta E_f / E_f$. The deviation in the value of the parameters E_p and E_f will definitely reflect in the deviation of the estimated value of E_c .

Equation for error calculation in parallel model [13]:

Following the Eq. (1), we have

$$dE_c = v_f dE_f + v_p dE_p \quad (5)$$

Then the deviation in the elastic modulus of the composite, ΔE_c is given by

$$\Delta E_c = v_f \Delta E_f + v_p \Delta E_p \quad (6).$$

Substituting ΔE_f and ΔE_p with their equivalents, the Eq. (6) is converted into eq. (7).

$$\Delta E_c = \gamma_f v_f E_f + \gamma_p v_p E_p \quad (7)$$

For every volume fraction v_f the error ΔE_c in the estimation of E_c will be determined from the Eq. (7).

Equation for error calculation in Series model [13]:

Following the Eq. (2), we have

$$\frac{dE_c}{E_c} = E_c \left[\frac{v_f}{E_f} \cdot \frac{dE_f}{E_f} + \frac{v_p}{E_p} \cdot \frac{dE_p}{E_p} \right] \quad (8)$$

Then the deviation in the elastic modulus of the composite, ΔE_c is given by

$$\frac{\Delta E_c}{E_c} = E_c \left[\frac{v_f}{E_f} \cdot \frac{\Delta E_f}{E_f} + \frac{v_p}{E_p} \cdot \frac{\Delta E_p}{E_p} \right] \quad (9)$$

Substituting ΔE_p and ΔE_f with their equivalents, the Eq. (9) is converted into Eq. (10).

$$\frac{\Delta E_c}{E_c} = E_c \left[\gamma_f \frac{v_f}{E_f} + \gamma_p \frac{v_p}{E_p} \right] \quad (10)$$

For every volume fraction v_f , the error in the estimation of E_c will be determined from the Eq. (10).

For simplicity, let's assume that $\gamma_p = \gamma_f = 0.1$. Then for both the Eq. (7) and the Eq. (10) (corresponding to parallel and series model), $\Delta E_c = 0.1 E_c$. This would mean that if the experimentally obtained value of the modulus of elasticity of the composite, E_{exp} , with a given composition lies within the range of $(1.0 \pm 0.1) E_c$, the prediction may be considered satisfactory.

Validation of parallel and Series model

These two models do not have any adjustable parameter. If the experimental value of modulus of elasticity E_{exp} vs. fiber volume fraction data is plotted and the curve lies in the area surrounded by the prediction curves $0.9 E_c$ and $1.1 E_c$, then the

prediction might be considered satisfactory. This procedure of validation is applied to some polymer fiber composites such as High density polyethylene (HDPE)-E-glass, (HDPE) -Hardwood A, HDPE -Hardwood B, HDPE -Hemp, HDPE -Rice hulls, Low density polyethylene (LDPE)-Sisal and Polypropylene (PP)-Flax system. The data were collected from the Literature [2, 3, 4, 14]. The Figures were drawn (For the economy of space, only four of the mentioned figures are presented in this paper) and it was found that in all cases, the experimental curve, E_{exp} , lay far apart from the area surrounded by the curves $0.9E_c$ and $1.1E_c$ as predicted by the parallel and series model. Such was the picture with the prediction by the parallel and series model on all mentioned systems..

Thus, it is hard to rely on the parallel and series model to predict the modulus of elasticity of a polymer-fiber composite. Facca et al [2] have also excellently demonstrated these failures.

Validation of RoHM Model

For the validation of the RoHM, Mirbagheri et al. [10] accepted as the modulus of elasticity of wood flour and kenaf fiber those values, which were obtained by back-calculation from the experimental data of the binary composition of polymer-fiber and polymer-particles. Such approach seems logical as the fibers have anisotropic structure and their modulus can not be considered equal in all directions.

Conclusions

1. To analyze the Young's modulus of polymer-fiber composites, parallel and series models (RoM) were applied to previous experimental result.
2. The analysis was done by assuming a tolerable deviation of 10% from the calculated value.
3. It was found that for all compositions, the experimental curve lay far apart from the area surrounded by the curves $0.9E_c$ and $1.1E_c$.
4. Finally, this suggests that Parallel, Series models totally fail to predict the Young's modulus of polymer-fiber composites.
5. But surprisingly it was found that RoHM model satisfactorily predicted the elastic modulus of particle/short- fiber/polymer composites.

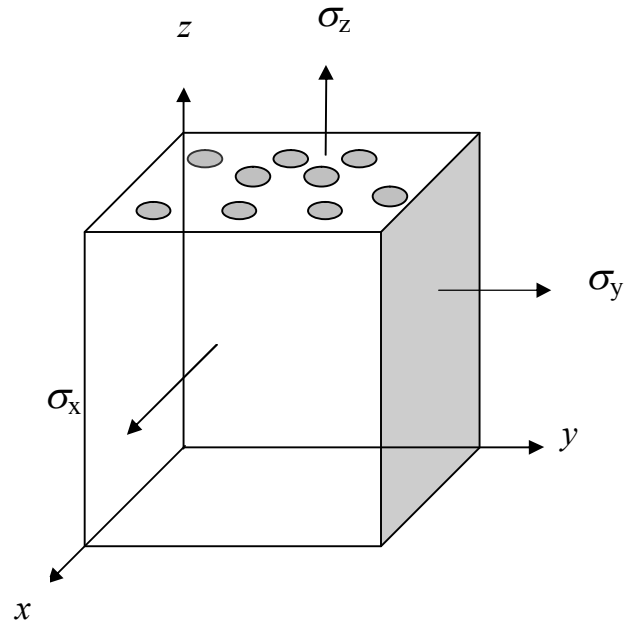


Figure 1 Distribution of the fibers oriented along z-axis and propagating through the whole length of the cube.

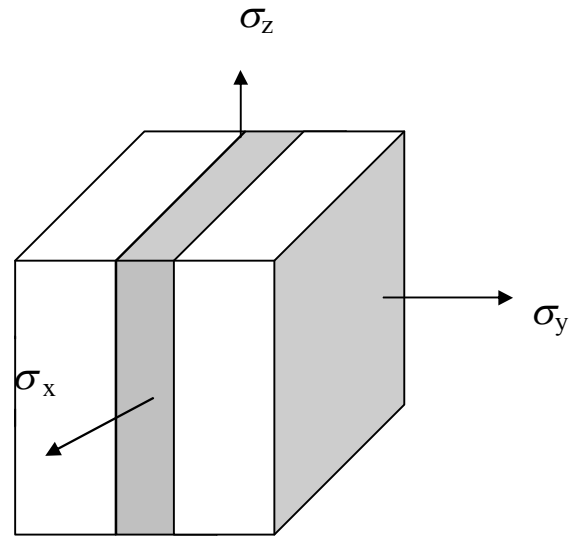


Figure 2 Three-dimensional view of a 'hypothetical'/model arrangement of fibers and polymer matrix: parallel arrangement as viewed along z- and x-axis, and series arrangement as viewed along y-axis.

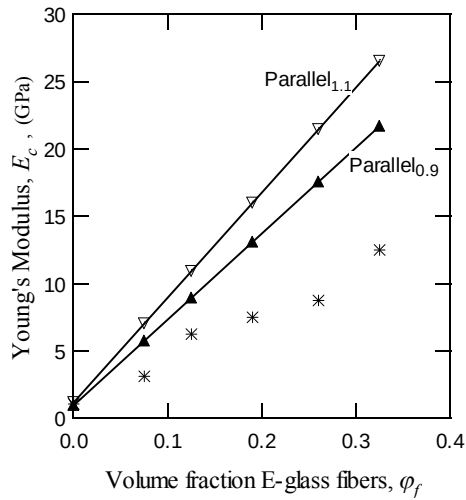


Figure 3 Young's modulus E_c vs. volume fraction of the fiber, ϕ_f , in HDPE-E-glass composite. The symbol * represents the experimental data collected from Facca et al [2]. The interpretation of the symbols is given in the text.

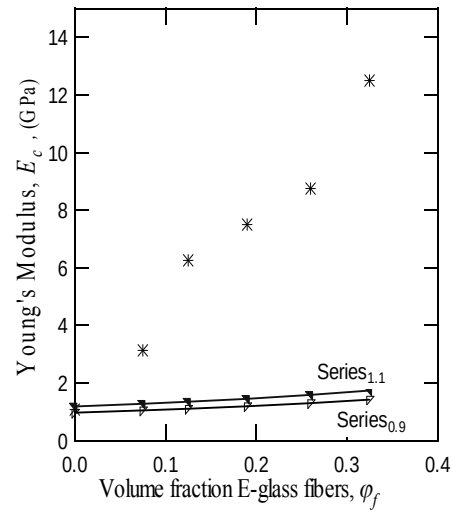


Figure 5 Young's modulus E_c vs. volume fraction of the fiber, ϕ_f , in HDPE-E-glass composite. The symbol * represents the experimental data collected from Facca et al [2]. The interpretation of the symbols is given in the text.

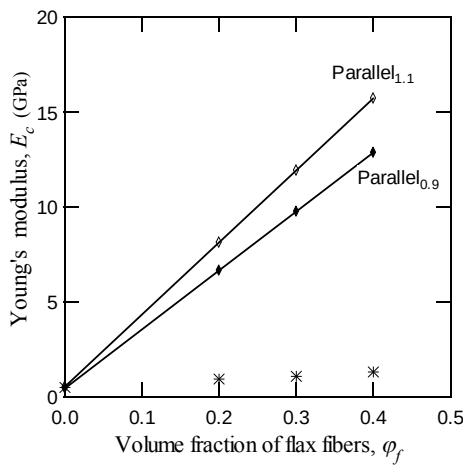


Figure 4 Young's modulus E_c vs. volume fraction of the fiber, ϕ_f , in PP-flax composite. The symbol * represents the experimental data collected from Peponi et al [4]. The interpretation of the symbols is given in the text.

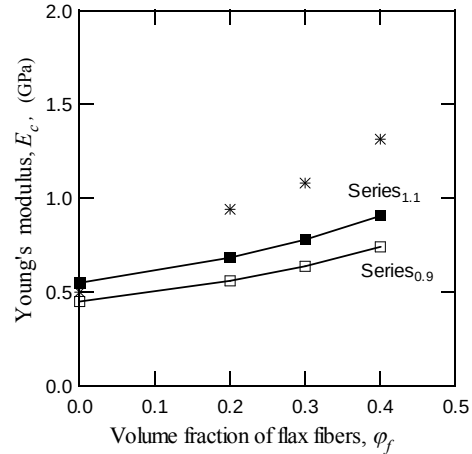


Figure 6 Young's modulus E_c vs. volume fraction of the fiber, ϕ_f , in PP-flax composite. The symbol * represents the experimental data collected from Peponi et al [4]. The interpretation of the symbols is given in the text.

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STUDIES ON THE PROPERTIES OF EPOXY-BASED POLYMER MODIFIED MORTAR

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The main objective of the study is to improve the physical, chemical and mechanical properties of conventional mortar using epoxy based polymer as a binding material. The authors have conducted a series of tests on epoxy resin modified mortar with view to compare their performance with conventional Portland cement mortar. Naturally occurring local fine aggregate obtained from Sylhet has been characterized and used as fine aggregate. Specimens were prepared with varying polymer contents keeping the remaining variables of the composition constant. The properties under control are compressive strength, flexural strength, tensile strength, water uptake, porosity, resistance to chloride ion penetration and chemical resistance to acid and salts. The result of this study shows that the addition of polymer to mortar improves mechanical strength (Compressive strength, Flexural strength and Tensile strength), resistance to chloride ion penetration, chemical resistance to acid and salts and decreases water absorption and porosity. The variation of concentration of the polymer materials is found to be key factor determining the mortar properties. The effects of other variables on the properties of polymer modified mortar have also been discussed. It is concluded that owing to the exceptionally high resistance to water permeability, salt and acid, polymer modified mortar can be used in hydraulic structures in coastal area, drainage systems, canal networks, chemical plants etc, and hence it has high perspective in Bangladesh.

Keywords: Mortar, Polymer, Strength, Porosity, Chemical resistance

1. INTRODUCTION

Masonry mortar can be defined as a mixture of Portland cement, mineral aggregates (sand) with water, which presents hardening capacity and adherence. Masonry mortar functions are: (i) bond units of masonry; (ii) distribute loads; (iii) absorb deformations; (iv) seal joints. Masonry mortars can be employed for joining bricks/blocks, rendering and grouting [ACI 548.3R-95, 2000]. The incorporation of polymers greatly improves strength, adhesion, resilience, impermeability, chemical resistance and durability properties of mortars and concrete [Ohama, 1987, Mirza et al, 2002 and Mehta & Monteiro, 1993]. These properties make Polymer modified mortar (PMM) a suitable material for making various structural and non-structural pre-cast products, repair of structural members, waterproofing, anticorrosive and decorative finishes, overlay of pavements, bridges and industrial floors]. In modern concrete construction and repair works the, role of polymers is increasing day by day. Polymers are

either incorporated in a cement–aggregate mix or used as a single binder. The composites made by using polymer along with cement and aggregates are called polymer-cement mortars (PCM), while composites made with polymer and aggregates are called polymer mortar (PM). A number of thermoplastic or thermosetting polymers are used in modifying mortars and concrete. These are used in various forms like: liquid resins, latexes, redispersible powders and water-soluble homopolymers or copolymers [Ohama, 1987]. Several studies have been carried out to evaluate different properties of polymer mortars with various thermoplastic and thermo setting polymers.

Aggarwal et al. (2007) studied the properties of polymer modified mortars using epoxy and acrylic emulsion, and found that these materials have superior strength properties and better resistance to the penetration of chloride ions and carbon dioxide than those PMCs based on vinyl acetate, copolymers of vinyl acetate–ethylene, styrene–butadiene,

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styrene-acrylic, and acrylic-styrene-butadiene rubber emulsions.

Kim et al. (1999) studied the properties of poly(vinyl alcohol) (PVA) modified mortar and concrete with up to 2 wt% polymer (calculated based on cement) and compared the structure and properties of polymer modified mortar/concrete with those without poly(vinyl alcohol). The authors observed that poly (vinyl alcohol) modified mortar showed merely unchanged compressive strength and slower absorption of water as compared to the unmodified mortar, which was an indication of lower permeability of the polymer-modified mortar.

Mandel and Said (1990) studied the effect of an acrylic polymer on the mechanical properties of mortar and found that the mechanical properties of mortar and the adhesion between mortar and a steel fiber would improve substantially with the addition of an acrylic polymer in the system.

Ohama et al. (1991) investigated the effect of the monomer ratio on the typical properties of the polymer-modified mortars with styrene-butyl acrylate latexes. The author found that the properties (pore-size distribution, flexural and compressive strengths, water absorption, and drying shrinkage) are affected to a great extent by both monomer ratio and polymer-cement ratio. Neelamegam and Ohama (1983) conducted a series of tests on various types of polymer and resin mortar composites and observed superior properties of polymer modified mortar (PMM) than those of ordinary cement mortar. Jain (1992) made a study on the applications of polymer cement mortar and found that the adhesion of mortar and concrete to the old surface could be increased with the addition of suitable polymer. The use of polymer mortars for rehabilitation of distressed reinforced concrete structures, providing seamless flooring in large areas and construction of specialized jobs was also reported in the paper. Limaye and Kamat (1992) studied the effect of six types of polymers in cement mortar and found significant improvement in energy absorption capacity of these polymer modified systems.

But in Bangladesh, however, systematic research in the field of this structural material has merely initiated only few years back (Rahman et al, 2010). Following these studies, an experimental observation on the properties of polymer modified mortar materials based on epoxy resin has been reported in this paper. Mechanical strength (compressive strength, tensile strength and flexural strength) physical properties

including water absorption, chloride ion penetration and porosity and chemical properties (chemical resistance to acid and salts) of polymer modified mortar formed with different compositions are studied and compared with those of unmodified Portland cement mortar in this investigation.

2. EXPERIMENTAL

2.1 Materials

Technical grade epoxy resin based on Epichlorohydrin and bisphenol-A was collected from local market. Epoxy resin used in the experiment had a viscosity of 3600cps at 300C, density of 1.15gm/cm³ and pH value of 7.72. Naturally occurring silica sand collected from Sylhet, Bangladesh was washed, dried and sieved. The particle sizes of Sylhet sand was ranged from 0.15mm to 2.36mm. Ordinary Portland cement was used in the experiment. The properties of the cement are described in The Table 1.

Table-1: Properties of Portland cement used in the experiment

Test performed	Result
1. Fineness test	0.068%
2. Setting time	
Initial	2 hours
Final	3 hours
3. Compressive strength	
7 day	15 MPa
28 day	19 MPa

2.2 Preparation of mortar specimens

Composition of conventional mortar was mixed following ASTM C305 standard method and technique. Compositions of different types of mortar specimens are detailed in Table-2. Addition of polymer in the composition required some modification of the method as pretreatment of polymer and sequence of addition of the components. The epoxy resin, being in liquid state added without pre-treatment.

2.2.1 Polymer cement mortar

Cement, sand and water were first mixed using ASTM C305 procedure, and then polymer emulsion was mixed with the pre-wetted composition. The fresh composition was cast into a steel mould on a vibrating table. For compression test, a cube size steel mould with dimensions 50.8mmX50.8mm X50.8mm was used. These specimens were used for porosity measurement, water absorption and chemical resistance test as well. For the test of tensile

strength, briquettes (dumbbell shaped specimen) were prepared following the procedure as prescribed by ASTM, C190 of mortar specimen. For the determination of the coefficient of thermal expansion and chloride ion penetration, bar type mortar specimen were prepared with dimensions 304.8mmX25.4mm X25.4mm.

2.2.2 Polymer mortar

Polymer mortar was prepared by mixing silica sand with epoxy-based polymer. No Portland cement was added. The mixing procedure and the size of the specimen were the same as those of conventional mortar. The mixing procedure and the size of the specimen were the same as those of conventional mortar.

The mortar specimens were demolded after 24 hour of molding and then stored in water in case of conventional mortar and polymer cement mortar but curing under water is not required for polymer mortar since there is no Portland cement in the specimen. Infact, Polymer mortar specimens were cured in atmosphere until tested (either 7 or 28 days).

Table -2: Ratio of ingredients used in mortar

Mortar/t ype	Ceme nt	Sand	W/C	Polymer
Normal Mortar	1	2.75	0.45	-
Polymer cement mortar	1	2.75	0.45	0.04- 0.26
Polymer mortar	-	10	-	1-1.5

2.3 Methods

2.3.1 Determination of Water absorption kinetics and equilibrium uptake and porosity of mortars

The 50.8mm cube size mortar samples were dried at 110o C in an oven and then taken in desiccators to cool down to room temperature. The process was repeated until a constant weight W_0 of the specimen is attained. Then the dried sample was put under water in a beaker at room temperature. At a predefined time of interval, the samples were taken out, the water adhered to the surfaced were wiped by cloth and weighed. Then the sample is returned in the beaker. In the beginning, the measurement was done at an interval of 1 hour and at the end- at an interval of 6 hours.

Water absorption at a given time t and equilibrium water uptake A_∞ at $t \rightarrow \infty$ are calculated by the following formulae:

$$A_\infty = W_\infty / W_0 - 1 \quad (2)$$

$$A_t = W_t / W_0 - 1 \quad (1)$$

and

Where W_t is the weight of the wet sample at time t and W_∞ is the weight at equilibrium.

$$\rho_a = W_0 / V_0 \quad (3)$$

$$\rho_T = \frac{W_0}{V_0 - (W_\infty - W_0) / \rho_w} \quad (4)$$

and

$$\beta = 1 - \rho_a / \rho_T \quad (5)$$

Where ρ_a , ρ_T and β are respectively apparent density, true density and porosity; V_0 is the bulk volume of the sample, W_∞ is the weight of the wet sample at equilibrium and ρ_w is the density of water.

2.3.2 Chemical Resistance tests

The cured specimens were tested for chemical resistance at room temperature in accordance with standard RILEM PC-12 “Method of test for chemical resistance of polymer concrete and mortar” [RILEM PC-12]. The types of test solutions used were as follows: 10% sulphuric acid (H_2SO_4) and 10% sodium chloride (NaCl). The test specimens after record of their weight were soaked in solutions for periods of time of 7 days. After immersion period, the appearance of test specimens was visually checked, cleaned by running tap water and dried in oven at 110^o C temperatures in an oven until constant weight and weight was measured.

After that, compressive strength was performed on the specimens according to ASTM C109. Test results were compared with those obtained from compressive strength test of specimens untreated in solutions. Mass change and compressive strength change of the specimens was calculated by the following equation:

$$\text{Mass change} = [(M_r - M_i) / M_i] * 100$$

Where M_i is the mass (gm) of the specimens before immersion and M_r is the mass (gm) after test period.

$$\text{Compressive strength change} = [(C_r - C_i) / C_i] * 100$$

Where, C_i is the compressive strength (MPa) of untreated specimens and C_r is the compressive strength (MPa) of test specimens treated solutions for 7 days.

2.3.3 Measurement of compressive and tensile strength

The compressive strength of the specimens was measured by Universal Testing Machine (Model No. TIB/M. C; Capacity-300 Ton).

3. RESULTS and DISCUSSION

3.1 Compression tests of mortar specimens

It is important to measure the mortar compressive strength since this test gives a good overall indication of the quality of the mortar or concrete and its mechanical properties. Also, to increase the abrasion-erosion resistance, the compressive strength must be higher to enable the mortar to successfully handle the repeated impact. The ultimate compressive strength of the polymer cement mortar and polymer mortar are shown in the Figs. 1 and 2 respectively.

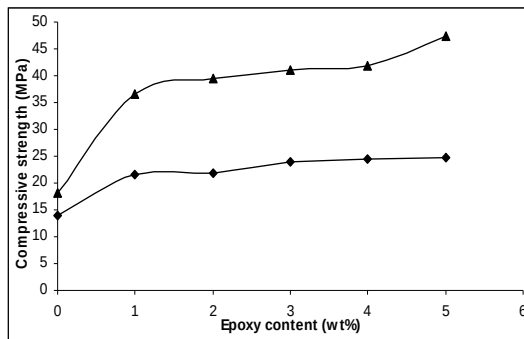


Figure 1. Dependence of the compressive strength on epoxy content for polymer cement mortars water-cured for 7 (♦) and 28 (▲) days

The Fig.1 shows that the compressive strength of unmodified water cured Portland cement mortar specimen is 17 MPa at 28 days. The compressive strength of polymer cement mortar increases with the addition of polymer and maximum 50 MPa strength was indicated by 5 wt.% epoxy content (based on sum of the weight of sand and Portland cement) polymer cement mortar specimen at 28 days curing. The point indicated by 0 (wt %) in the curve actually denotes the result of conventional Portland cement mortar.

The Fig. 2 shows that the strength gain rate of polymer mortar is higher than that of polymer cement mortar and unmodified mortar. Polymer cement mortar gains about 55% of ultimate strength at 7 days curing while, polymer mortar gains 85% of that strength at same curing interval.

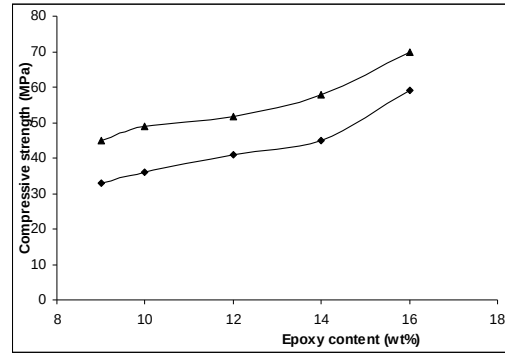


Figure 2. Dependence of the compressive Strength on epoxy content for polymer mortars air cured for 7 (♦) days and 28 (▲) days

Finally, Polymer mortar prepared with the addition of 16 wt.% epoxy (based on weight of sand) provides maximum 70 MPa at 28 days atmospheric curing.

3.2 Properties of different types of mortar specimens

Percentage of porosity, apparent density, true density, tensile strength and flexural strength are determined for unmodified and polymer modified different types of mortar specimens. The obtained result is summarized in table-3.

Table 3. Porosity, tensile strength and flexural strength of different types of mortar specimens

Types of mortar	Porosity (%)	T.S (MPa)	F.S (MPa)
Conventional mortar	7.50	2.44	7.50
5 wt.% Epoxy modified PCM	5.07	5.76	8.60
16 wt.% Epoxy base PM	0.54	8.48	9.50

The result shows that the addition of polymer reduces the porosity and density. It can be explained by; the additions of polymer in mortar fill up the voids inside the mortar which results the decrease in porosity. In case of normal cement-sand mortar, water occupied some space in mortar during casting. After casting extra water dried out, this causes voids. In case of resin modified mortar no cement was added so there was not required to add any water. This is why in case of polymer mortar porosity was not observed. Result shows the porosity of polymer mortar is 0.54% which may be an experimental error. Tensile strength on the other hand increases with the increasing polymer content. Polymer mortar with the addition of 16 wt% epoxy (based on weight of sand) provides maximum 8.48 MPa tensile strength.

Flexural strength increases with the increasing polymer content and maximum 9.50 MPa Flexural strength of polymer mortar with addition of 16 wt% epoxy (based on weight of sand) found after 28 days curing.

3.3 Water absorption and chloride ion penetration of different types of mortar specimens

Figure 3 shows water absorption by different PMM as a function of soaking time t . The Figure shows that initially the absorption rate is very fast and then gradually the water uptake attains an equilibrium value A_{∞} - the value being highest for normal mortar followed by mortars modified by PVA and epoxy resin. The water sorption is a result of combined effect of porosity and mortar composition. The mortar modified with shows higher water sorption than those modified with epoxy. It can be explained by the hydrophilic nature of PVA. The polymer mortar made with epoxy resin shows the lowest water uptake. All the experimental results, however, categorically show that the mortar modified by any of the polymers under investigation possesses water resistance higher than normal mortar.

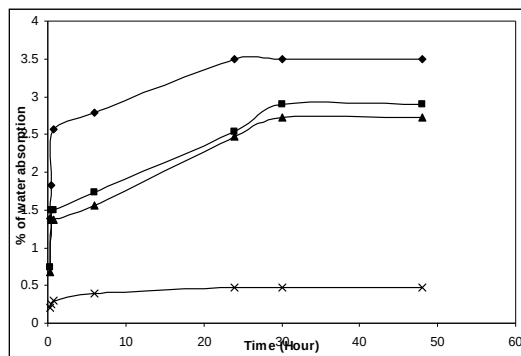


Fig.3 4. Water absorption kinetics of different mortars. (♦) Normal, modified with (■) 2% PVA, ((▲) 5% Epoxy and (×) 14% Epoxy Polymer mortar

Porosity, apparent density and true density are calculated by Eqs. (3-5), and the tensile strength measured by Universal Testing Machine are presented in Table 3. As shown in the Table, the mortar modified by epoxy resin shows lowest porosity and highest tensile strength demonstrating the superiority among the composition studied.

Similar to water absorption, chloride ion penetration also decreases with the addition of polymer (Fig.5). In the present investigation, reduction of chloride ion penetration is up to five

times of polymer mortar using 16 wt.% epoxy (based on weight of sand) comparative to conventional cement mortar. While, reduction in chloride ion penetration is up to 50% of polymer cement mortar using 5 wt.% epoxy (based on weight of sand and cement) comparative to conventional cement mortar. This indicates that epoxy modified mortar should have more resistant towards chloride ion attack. The increased resistance to chloride ion penetration makes PMM very useful in application in corrosion prone (Saline zone) area.

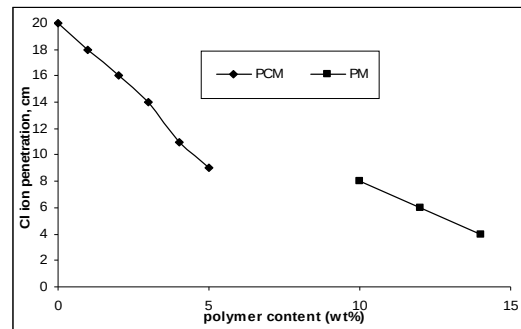


Fig. 5. Effect of polymer addition on chloride ion penetration

3.4 Chemical Resistance of different types of mortar specimens

The test results, mass change and compressive strength change for 10% Sulphuric acid (H_2SO_4) solutions after 7 days immersion period are shown in table-4.

Table 4. Chemical resistance of different types of mortar specimens

Types of mortar	Mass Change (%)	Compressive strength Change (%)
Conventional mortar	7.48	33.00
10 wt.% Epoxy polymer mortar	1.00	3.00
12 wt.% Epoxy polymer mortar	0	1.00
14 wt.% Epoxy polymer mortar	0	0.00
16 wt.% Epoxy polymer mortar	0	0.00

In 10% sulphuric acid (H_2SO_4) solutions, the weight change of epoxy polymer mortar specimens was very small compared to conventional Portland cement mortar. The average mass change of epoxy polymer mortar was 0.0008%, while the average mass change of normal Portland cement specimens was as high as 8%. For 10% sulphuric acid (H_2SO_4) solutions, the compressive strength change was clearly smaller for the

epoxy polymer mortar specimens than conventional 6. Portland cement mortar. It can be explained by the higher chemical resistance of epoxy based polymer mortar specimens.

4. CONCLUSION

The results of this study show that the addition of polymer causes several changes in the microstructure and properties of mortar. For example, the addition of epoxy to cement mortars improves compressive strength, tensile strength and decreases porosity, density and chemical resistance. Among different types of polymer modified mortar, polymer mortar showed higher ultimate compressive strength at higher strength gain rate compared to polymer cement mortar or unmodified mortar at same mortar composition. Thus, epoxy based polymer mortar can be used for repair and retrofitting works.

5. ACKNOWLEDGEMENT

The authors are thankful to Razia Begum, Md. Mirza Shahjahan and Md. Shahidullah khan of housing and building research institute for their helpful suggestions, consultations and continuous inspiration.

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Tailoring MgH₂ with Mg-Nb-O Towards Hydrogen Storage

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Abstract

A breakthrough in H₂ absorption and desorption kinetics of MgH₂ was achieved by ball-milling with 1 mol% MgNb₂O₆, Mg₄Nb₂O₉ and Mg₃Nb₆O₁₁. The presence of Mg-Nb oxides remarkably increases the H₂ absorption and desorption kinetics of nano-structured MgH₂, were examined by a volumetric Sievert apparatus. Prior to this experiment, the ternary Mg-Nb-O compounds were investigated by Mass Spectrometry (MS) in order to understand their interaction with H₂ in mild conditions. Among the various ternary oxides, Mg₃Nb₆O₁₁ compound showed remarkable uptake and release of H₂, may be due to the presence of octahedral niobium clusters in the oxide structure. The results obtained from pressure-composition-isotherms (PCI) measurements, pointed out that the H₂ desorption rate increases with increasing temperature from 593 to 673 K and in the same conditions absorption rate decreases. The most promising results obtained for Mg₃Nb₆O₁₁ doped MgH₂ nano-particle, even compared to MgH₂ promoted with Nb₂O₅, the best additive reported so far. The MgH₂/Mg₃Nb₆O₁₁ system completely dehydrogenated (3.93 wt%) within 5 mins at 673 K under 0.1 MPa H₂ and the activated sample takes only 3 mins for fully rehydrogenation (3.20 wt%) at 613 K under 2.5 MPa H₂. The H₂ content of the nano-structured materials is lower than the stoichiometric capacity may be due to the presence of a non-reactive MgO layer on the surface or at the grain boundaries. Structural analysis of the solid-state materials was carried out by X-ray diffraction (XRD) and solid-state phases were analysed by Rietveld method. Desorption curves were constructed and analysed by the Johnson-Mehl-Avrami formalism in order to derive reaction rate constants at different temperatures. Activation energy was estimated by Arrhenius plot and the values obtained for MgH₂/Mg₃Nb₆O₁₁ mixture and bare MgH₂ to be 106 and 142 kJ/mol, respectively. All desorption data were verified with that obtained from differential scanning calorimeter (DSC), connected to a H₂ detector. The role of ternary Mg-Nb oxides on H₂ absorption and desorption properties of MgH₂ nano-powder will be discussed on the basis of kinetic model, explains by the formation of reactive pathways of ternary oxide species with easier splitting of H₂ that facilitate the H₂ transport into the solid structure, proposed in this context.

Keywords: hydrogen storage, MgH₂, Mg-Nb oxides, absorption and desorption kinetics, activation energy.

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The Effect of percentage of hollow lumen on the mechanical properties of Bangla White Grade B jute fiber

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Abstract:

Composite industries now a days has focused on the natural resources available because of the environmental concern and lowering the weight and cost of the reinforced composite products, and so the emphasis on the natural fiber. Bangla white grade B Fiber diameter was measured using optical method and was cross checked with the weight measuring method and comparative discussions were made. The single Bangla White grade B jute fiber tensile test data showed a large scatter since natural fibers show their strength within a range rather a fixed value. Test data was corrected for machine compliance. Tensile properties of Bangla white grade B were analyzed with normal and Weibull statistics. Afterwards these tensile test data was corrected for the average percentage of hollow lumen present in BWB jute. It was observed that the hollow space inside is not uniform and defects are probable there but Weibull Statistics shape and scale parameter remains unchanged.

Keywords: Jute Fiber, Single fiber tensile test, fiber diameter.

Introduction:

With the demand of high performance materials the entire composite industries has focused its goal not only towards this single value but an integration of the application needs performance, process ability and environment. While the environmental concern comes as a prime target now a days and so the reinforcement choice is natural fiber as reinforcement and bio compatible polymer as matrix materials other than glass, carbon, aramid, kevlar and other artificial fibers and high cost resin system. Although the natural fiber reinforced polymer composite is far more below to that of the properties of the artificial fiber reinforced polymer composite, but with the context of specific strength value natural fiber well compete the artificial fiber. There fore to evaluate the mechanical a property of the natural fiber is necessary.

Mwaikambo L. Y. (2009) measured the tensile properties of both untreated and alkali treated jute fiber. He also studied the surface morphology of the treated and untreated fiber. In this paper he showed that the tensile strength and Young's modulus of jute fiber bundles depends on the physical characteristics of internal structure such as the cellulose content, changes in the crystallinity index. The study demonstrated the brittle failure of jute fiber and dependence of tensile properties on the changes in fiber structure [1].

Chawla N. et. al. (2008) studied monotonic tensile behavior of a sisal fiber and performed micro-force testing system using different gage length. The measured tensile strength was corrected for the machine compliance and

implemented Weibull statistics to quantify the degree of variability in fiber strength and different gage length. He also discussed the failure mode and mechanism in terms of fiber microstructure [2].

Almeida J. R. M. d' et. Al. (2005) while working with piassava fiber showed that the chemical composition, mechanical behavior and morphological characteristics are comparable with the coir fiber [3].

Defoirdt N. et. al. (2010) in her work "Assessment of the tensile properties of coir, bamboo and jute fiber" studied the mean strength and standard deviation of these fibers by normal and Weibull distribution. She also discussed the applicability of Weibull statistics and studied the correction method that assesses the real fiber elongation from the clamp displacement [4].

Andersons J. (2009), studied the mechanical properties of flax fibers and showed that the mechanical property is affected by the natural variability in plant as well as the damage accumulated during processing, and thus have considerable variability that necessitates statistical treatment of fiber characteristics. He tried to correlate the presence of kink bands with the mechanical properties of flax [5].

Cichocki F.R. Jr (2002) in his study employed dynamic mechanical and thermal mechanical techniques to measure the elastic and thermal expansion characteristics of a model composite system containing jute fibers over a broad temperature range. The jute fibers investigated in this study exhibited considerable elastic and thermal expansion anisotropy. The longitudinal Young's modulus of the fibers has been determined. Also the fibers exhibit negative thermal expansion coefficients along their lengths. However, large positive thermal expansion coefficients, similar in magnitude to many polymeric materials, in the transverse directions were also estimated by the researcher [6].

Yu J.Y. (2008) showed that the two-parameter Weibull distribution does not always adequately describe the experimental bast fibre strength at different gauge lengths. For this reason, he modified the test data by incorporating the diameter variation of jute fibres in his paper. The fibre diameter was measured with an optical microscope. It was found that as the fibre diameter variation increased the tensile strength of the jute fibre decreased. In addition, he showed the breaking strength of jute fibre was less sensitive to gauge length than that of cotton fibre because the breaking of jute filament involves ultimate cells breaking repeatedly and matrix cracking [7]

Although all the works of the researchers has comprehended the mechanical properties of these natural fibers well within the previously measured range but more discussion and study is required to characterize these fibers. Regarding this the measurement procedure of fiber diameter should be more precise; this is since the tensile strength is depended on the cross-sectional area of the fiber under test. Also since natural fibers show a wide scatter in their mechanical properties with respect to the testing equipment so more work is required to clearly understand the machine compliance with respect to a particular fiber. These natural fibers are so irregular in shape and also contain a large number of defects at the microscopic level; regarding this the applicability of Weibull statistics could be discussed for the validity of the tensile test data.

Experimental Methods:

Materials:

Bangla white grade B, Jute was kindly supplied by Bangladesh Jute Research Institute. The fiber falls within the genus *Corchorus Olitorious*. The jute fiber was supplied with only retted condition and bottom cut and has an average length of 2.5 meters.

Fiber preparation:

Fibers were chosen randomly from the supplied Bangla white grade B jute, washed in distill water at room temperature and dried at 70°C in oven for 2 days.

Tensile testing of jute fiber:

Jute fiber diameter measurement:

The jute fiber diameter like other natural fiber is irregular in nature along the length of individual fiber, which may be due to the inhomogeneous distribution of pectic and gummy materials along the fiber bundle, fiber entanglement and various kinds of defects that may be of natural or artificial origin. For each test specimen fiber diameter were measured with optical method and also using mass and length measurement considering the density of the fiber for calculating the diameter, and both methods are then cross checked. The density of the jute fiber was taken from the literature value.

Bangla White grade B jute fiber diameter was measured using the following methodology; those are

- Optical root
- Weight measurement root

Before continuing to measure the diameter optically, some jute fibers were first embedded in a mounting mold consist of liquid epoxy polymer mixed with curing agent and fibers were hold vertical with the help of clamps within the mold. The cured epoxy polymer inside vertically mounted jute was then polished to get a mirror like appearance. And then it was observed under the Leica CMD stereo optical microscope equipped with Nikon coolpix digital camera with zooming capability as shown in Figure 1. a)



Figure 1: Optical microscopes, a) Leica CMD stereo microscope, b) Leica MZ8 image processing software based stereo optical microscope

Assuming the jute fiber to have uniform diameter along the length the width of the single fiber filament were measured with computer interfaced and Leica MZ8 image processing software based stereo optical microscope with high precision image processing facility as shown in Figure 1.b). While measuring the width under this microscope the magnification was set constant for all measurement. A large number of width data were taken to opt out the effect of irregularity of jute fiber and get an average value.

Also assuming the jute fiber to be quasi circular a 60mm long fiber were taken and was cut 3mm apart with a very sharp blade and then it was vertically observed under the PHILIPS scanning electron microscope XL30 FEG to get some idea about the variation of the fiber diameter (perimeter) with preceding length. The magnification was set similar for all images and the machine was set to nullify any effect of fiber tilt and get the actual image of the cut surface. The images were then processed with Leica MZ8 image processing software.

To cross check the optical method of diameter measurement of jute fiber weight of similar group of individual fibers were taken and weight measured with Mettler AT261 DeltaRange weighing machine. Then from the literature value of fiber density the diameter was calculated. The optically measured diameter value was compared graphically with the obtained diameter value from the weight measurement procedure.

The defects that are most probable for jute fibers and fiber morphology were studied with PHILIPS scanning electron microscope XL30 FEG; this was discussed in detail in the context of the assumptions of Weibull distribution and its applicability for natural fiber system

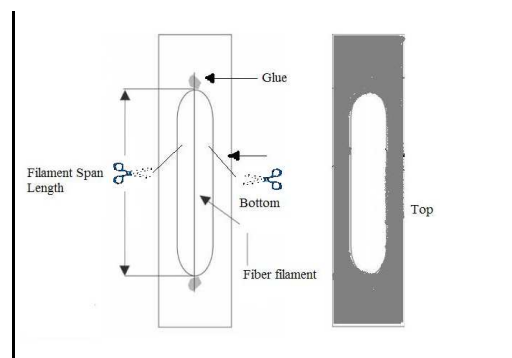


Figure 2: Paper frame for single jute fiber tensile test

To get an average tensile strength property of Bangla white grade B jute more than 50 single fiber filaments were taken of a jute fiber bundle for each span length. The span lengths were 5, 10, 20 and 35mm. The single fibers were glued on a paper frame using cyanoacrylate glue shown in Figure 2.

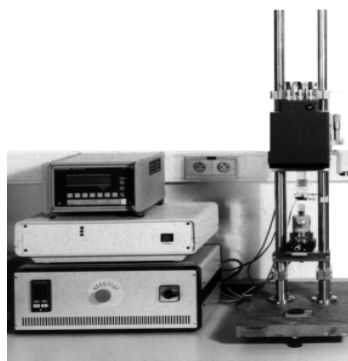


Figure 3: Mini tensile compression machine

Single fiber tension test were carried out in the Metallurgy and Materials Engineering Department of Katholieke Universiteit Leuven in a mini tensile/compression machine. The machine was calibrated and it registers the displacement of the clamps and the force applied on the fiber. The paper frame was cut just before the start of the tensile test as shown in Figure 2. A load cell of 20N and strain rate of 0.1mm/min and screwed clamps were used. Samples that broke near the edge of the clamps were excluded from the analysis.

Weibull statistics:

Natural fibers are very fine filaments in the microscopic scale and their properties can vary considerably according to the local fiber compositional and morphological characteristics. So a statistical knowledge about these fibers strength distribution is necessary since, it's not possible to state a single value for the strength of a fiber since they show considerable scatter in the mean strength decreases with fiber length. Both scatter and length dependence is due to the distribution of defects in the fiber and the longer the fiber the greater the chance of containing sizeable defects.

The assumptions for the Weibull distribution statistics for natural fiber are as follows;

1. The stress field in each link is considered as being uniform
2. The failure stress of one link is independent of that of other link.
3. All links have the same failure probability for a given applied stress.

The first assumption implies that local modification of stress field around and the defect are negligible, so each link can be considered as being subjected to uniform stress field. The second assumption implies that there is no interaction between defects. The third assumption implies that the defect distribution inside materials must be homogeneous and isotropic.

The equation for Weibull Statistics are given as follows

$$F(x, m, \lambda) = 1 - e^{\left(-\frac{x}{\lambda}\right)^m} \quad (1)$$

Where

“m” = Shape factor

“λ” = Scale factor

The Mean and the variance of this distribution is given by equation (2) and (3) respectively

$$\mu = \lambda \Gamma \left(1 + \frac{1}{m} \right) \quad (2)$$

$$\sigma^2 = \lambda^2 \Gamma \left(1 + \frac{2}{m} \right) - \mu^2 \quad (3)$$

To apply the distribution we will need the following equation. According to Weibull distribution a fiber of volume V can have N parts, where V₀ is the volume of individual parts, then the relation between V, N and V₀ is as follows

$$V = V_0 \times N \quad \text{Where} \left(\left[V_0 = \pi \left(\frac{d_{\text{ultimate}}}{2} \right)^2 L_{\text{ultimate}} \right] \right) \quad (4)$$

V₀ can be calculated from the known literature value of length and diameter of ultimate or elementary fiber cell.

The chance that a fiber of N parts will survive or fail at a certain load is given by

$$F(\sigma) = 1 - [1 - F_1(\sigma)]^N \quad (5)$$

Where F₁(σ) is the probability of fiber failure at stress σ and probability of sustaining at that stress [1 - F₁(σ)]

For very big values of N equation (5) becomes

$$F(\sigma) = 1 - e^{-N F_1(\sigma)} \quad (6)$$

According to Weibull

$$F_1(\sigma) = \left(\frac{\sigma}{\sigma_0} \right)^m \quad (7)$$

Where σ₀ is the average value of the property

And the final Weibull distribution is

$$F = 1 - e^{-N\left(\frac{\sigma}{\sigma_0}\right)^m} \quad (8)$$

And the form or shape factor “m” is related with scale factor “λ” as indicated in equation (9)

$$\lambda = \frac{\sigma_0}{N\left(\frac{1}{m}\right)} \quad (9)$$

The mean and the variance of this distribution may be rewritten as

$$\mu = \frac{\sigma_0}{N\left(\frac{1}{m}\right)} \Gamma\left(1 + \frac{1}{m}\right) \quad (10)$$

And

$$\sigma^2 = \left(\frac{\sigma_0}{N\left(\frac{1}{m}\right)}\right)^2 \Gamma\left(1 + \frac{2}{m}\right) - \mu^2 \quad (11)$$

To determine the Weibull parameter the Weibull distribution can be rewritten as

$$\ln\left(\ln\left(\frac{1}{1-F}\right)\right) = m \ln \sigma + m \ln\left(\frac{1}{\sigma_0 N^{\frac{1}{m}}}\right) \quad (12)$$

Equation (12) is of the form $y = mx + b$. By using the median rank approximation for estimating cumulative probability of failure

$$F = \frac{\text{rank}-0.3}{\text{max range}+0.4} \quad (13)$$

And using equation (12) to make plot between $\ln\left(\ln\left(\frac{1}{1-F}\right)\right)$ VS $\ln \sigma$ Weibull parameter and its standard deviation and mean can be determined.

Tensile strength was calculated by using equation (14):

$$\sigma = \frac{F_{\text{Max}}}{A} \quad (14)$$

Where,

σ = tensile strength
 F_{Max} = maximum force
 A = cross-sectional area

Cross-sectional area was measured by using equation (15) and (16)

$$A = \pi \left(\frac{d}{2}\right)^2 \quad (15)$$

and

$$A = \frac{m}{\rho} \times L \quad (16)$$

where,

m = mass
V = volume
L = length
ρ = density
d = diameter

The Young's modulus was measured from the linear portion of the stress/strain curve.

Correction of Tensile Properties

Total machine displacement (“ α ”) can be calculated by using the following equations:

$$\Delta L_{Total} = \Delta L_{Fiber} + \Delta L_{Grip} \quad (17)$$

$$\Delta L_{Fiber} \frac{\sigma \times Span}{E_0 \times \Delta L_{Grip}} = \alpha \times (A \times \sigma) \quad (18)$$

$$\alpha = \frac{\Delta L_{Total} - \Delta L_{Fiber}}{A \times \sigma} \quad (19)$$

Corrected Young’s modulus and strain to failure can be calculated by using the following steps:

$$\alpha_i = \frac{\Delta L_{Total}}{F} - \frac{L_0}{E_0 \times A_i} \quad (20)$$

$$\frac{\Delta L_{Total}}{F} = \frac{\varepsilon \times L_0}{\sigma \times A_i} = \frac{1}{E} \times \frac{L_0}{A_i} \quad (21)$$

$$\frac{\Delta L_{Grip}}{L_0} = \frac{\alpha_i \times A_i \times \sigma}{L_0} \quad (22)$$

$$\frac{\Delta L_{Fiber}}{L_0} \langle Corrected \rangle = \frac{\Delta L_{Total}}{L_0} - \frac{\Delta L_{Grip}}{L_0} \quad (23)$$

Where,

“ α ”	=	machine displacement for each fiber
L_0	=	original span length
E	=	Young’s modulus for each fiber
E_0	=	extrapolated Young’s modulus
A_i	=	cross-sectional area for each fiber
F	=	force
ε	=	strain
“ α ”	=	stress

Results and Discussion:

Probable fiber failure criterion and interaction with defects:

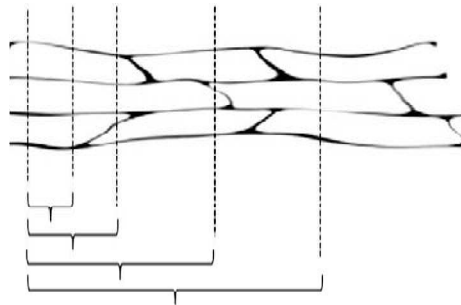


Figure 4: Chain like natural fiber structure [Courtesy Defoirdt N. et. al. (2010) [4]]

Figure 4 shows the illustration of chain like structure of natural fiber like jute. Jute fiber is supposed as a chain of linked smaller parts that consists of the whole of the technical fiber. This kind of fiber is supposed to break at the weakest link and for longer fiber there is greater chance of having large number of flaw and therefore the fiber can fail at a certain applied load [1].

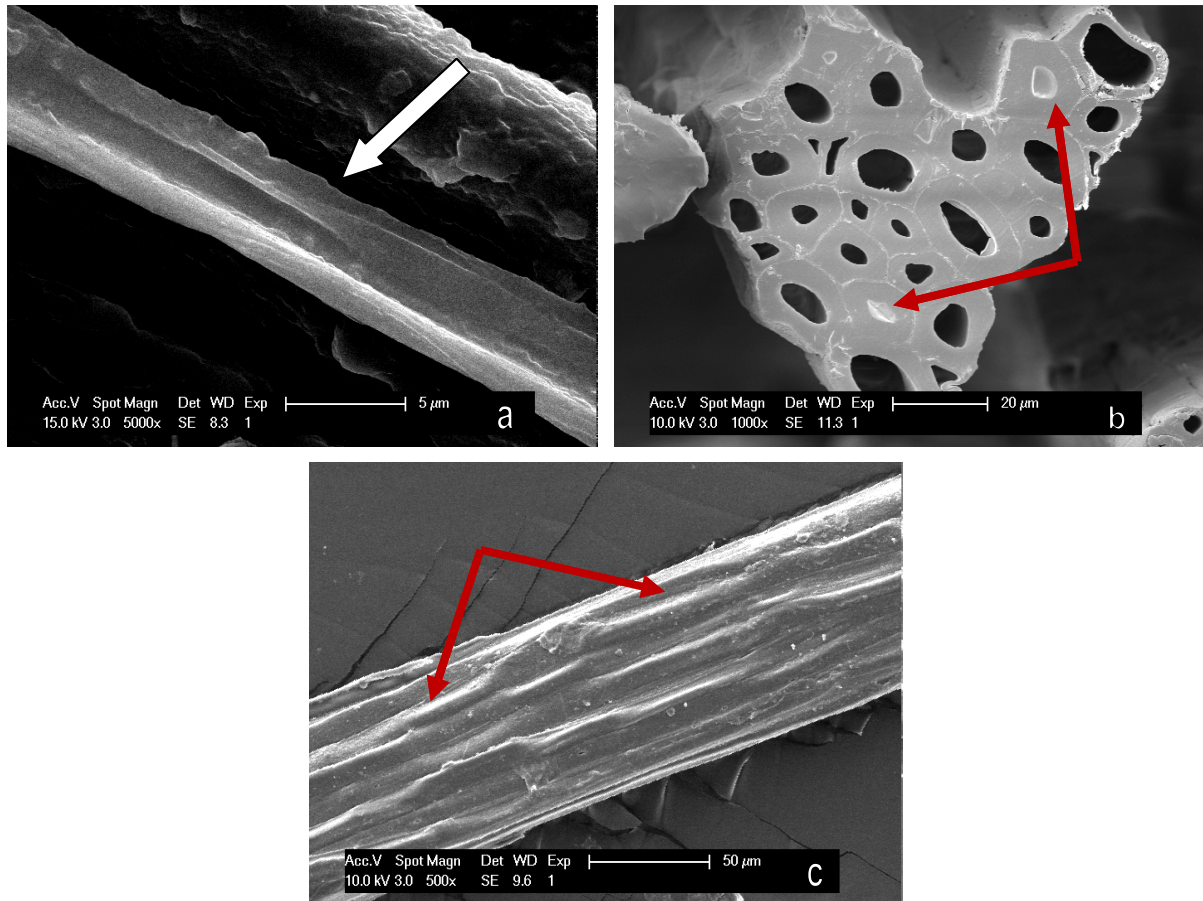


Figure 5: Jute fiber interior and exterior structure a) Lumen interior; b) Membrane like entity inside lumen; c) Node like structure on the exterior of jute fiber.

But jute like fiber is called the extra xylery fiber [8], which means its fiber forming xylem tissue is long enough to facilitate the water and nutrients transportation for the entire plant. Although the lumen of this kind elementary fiber is 2 – 5mm long and is tube like but this tubular structure with a diameter range between 5 and 20μm and it is not uniform as indicated in Figure 5.a throughout the entire length of the elementary fiber [9][10][11]. Also this interior tubular structure is not continuous but separated by a micron level thin membrane like structure called sieve plate as indicated in Figure 5.b. From Figure 5.b the irregularity of lumen size is clearly understood. Figure 5.c shows the exterior of jute fiber. The exterior of this kind of fiber also has irregular shape and the wave like and peak of each of these waves are termed as node [12].

At this point a detailed discussion could be made. It is true that the technical fiber such as jute is like a chain of linked smaller fiber but the linking points may not be the fibrous materials but some could be some kind of pectic materials and a technical jute fiber consists of 8 – 12 lumens of different shape and these lumens are again embedded in irregularly distributed non fibrous pectic, waxy and lignocellulosic materials throughout the entire fiber length; therefore the jute fiber and other natural fibers are natural composites itself [1][8].

Although jute fiber contains cellulose and other pectic, waxy and lignocellulosic materials but only “ α ” – cellulose is considered as the strength contributory part during single fiber tensile test and also when the fiber is put inside a polymeric matrix as reinforcement. But obviously there could be some shear force between the cellulosic and non-cellulosic materials that can occur at the microscopic level that may contribute or nullify some of the fiber strength.

Accordingly since there are amorphous region and crystallite region within “ α ” – cellulose itself [2][8] so regarding the weakest link theory the fiber failure at the narrow portion may not be fully acceptable fact. This is since in all single fiber tensile test there is always some strain value. This strain value could be the contribution of the amorphous zone to elongate other than the narrow crystallite zone and this microscopic elongation is possible everywhere within the fiber under tension. The amorphous zone that elongates and becomes narrower than the narrowest crystallite region can fail immediately as the load is increased farther and this kind of failure is seen as brittle failure. Along with this the applied load could insist the micro fibrils of jute to align with the loading direction at the expense of microscopic elongation of fiber.

Also it is not clear that how defects interact each other while conducting single fiber tensile test but if the larger microscopic defect has more crystallite portion of “ α ” – cellulose rather than its neighboring smaller defect with less strength contributor then the latter portion has a greater chance of failure than the former. Additionally from the morphological study it can be said that the defects are not uniformly distributed. Some defects originated naturally that like leaf growth point (Figure 6; a), some fiber also could have some delaminated lumens (Figure 6; b, c), also the fibers could be very irregular shaped along the length (Figure 6; d), some portion could be very intensely rich in pectic materials (Figure 6; e). Other than these there is always some process assisted defects such as kink bands is always possible (Figure 6; f). There could be more types of defect within the natural fiber but that discussion is beyond the scope this paper.

From the above discussion it may be hypothesized that the fiber failure under certain stress may occur in some sequence. That is a single jute fiber under tensile force will build up stress concentration at some weak defect point or at the narrowest portion of the fiber. But if that weak defect point or narrowest portion is mostly crystallite than its neighboring portion then deformation will start there allowing the fiber to deform under tension and in the successive stage stress concentration point may shift to some new point on the fiber other than the neighboring narrowest portion and fail immediately as the failure stress is reached. This may be one other reason of large standard deviation of fiber strength of natural fiber. So it is not beyond question, which methodology should be appropriate for measuring the cross sectional areas of the thinner natural fiber like jute. So regarding this fact it may be said that the tensile strength, modulus and strain value of jute or other natural fiber always remain within a certain range other than a particular value, and so the translated mechanical properties of natural fiber reinforced polymer composite always show discrepancy with the theoretical value. Although there are lot of other explanation regarding strength of composites but these natural fiber mechanical properties also has influential affect.

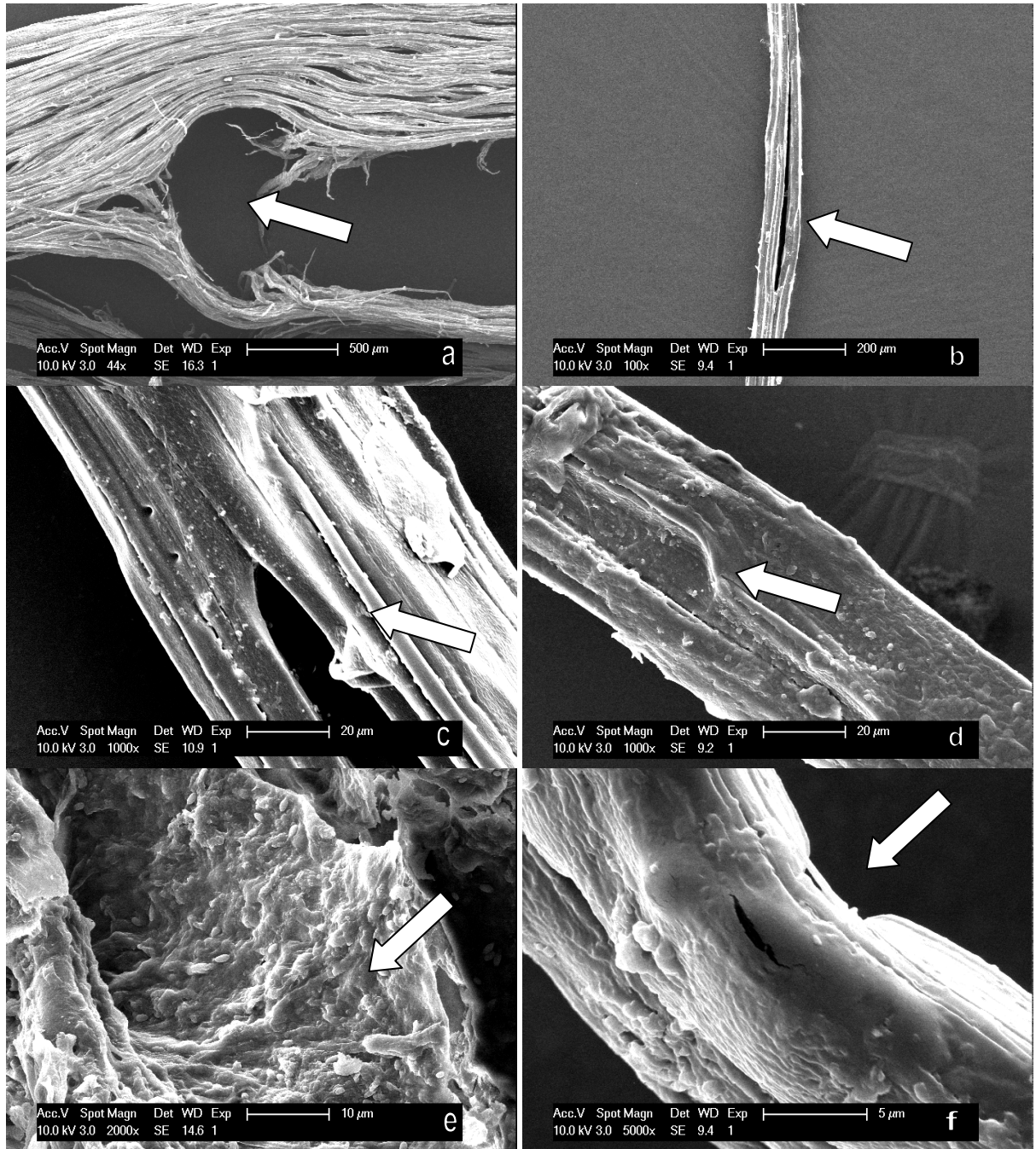


Figure 6: Some natural defects of BWB jute fiber

Determination of fiber diameter:

Regarding diameter determination it was observed that the individual fiber has different perimeter for a same population of fiber as shown in Figure 7. The Figure also shows that the cross sectional view of lumen and has got little resemblance in shape and size to its neighboring lumen, which is also mentioned in Figure 5.b.

The length wise diameter or cross sectional perimeter is not the same when the jute fibers were cut 3mm apart and put under SEM observation and plotted in a graph. From Figure 8 it is clear that although the jute fiber is assumed to quasi circular along its length but this observation clearly show that there is rare resemblance regarding this fact i.e. jute fiber is not circular and the fiber diameter varies widely irrespective of its length. This

could be due to the irregular shape of the lumens and irregular distribution of the non-fibrous binders throughout the entire length of the fiber.

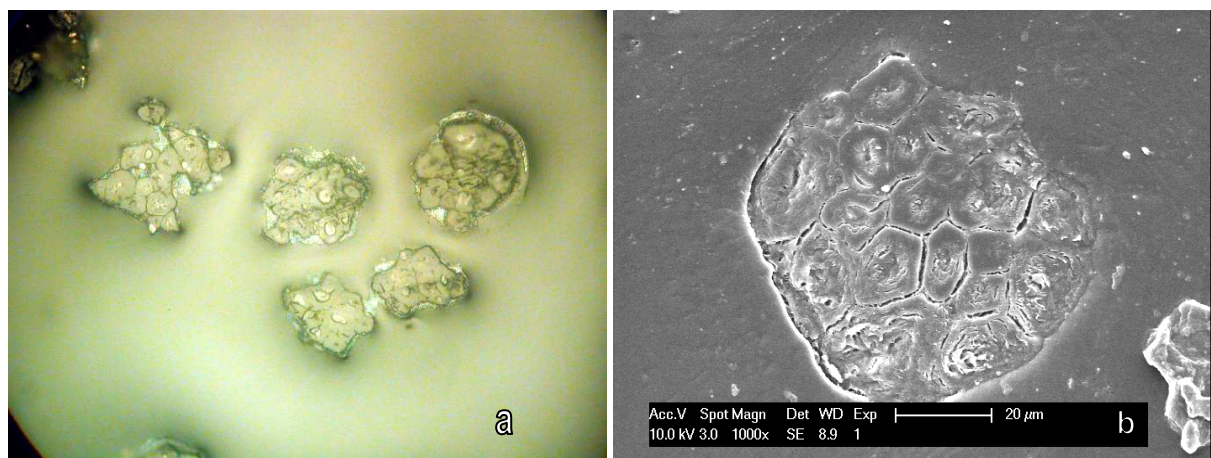


Figure 7: Cross sectional view of BWB jute fiber under a) Leica CMD polarized stereo microscope, b) SEM

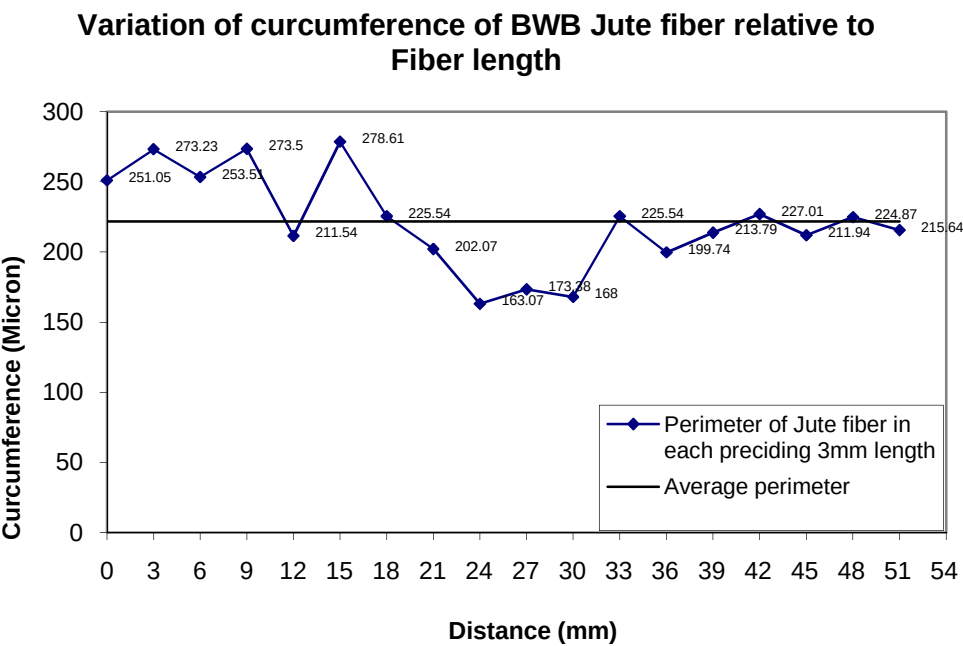


Figure 8: Variation of fiber perimeter of BWB Jute with preceding 3mm length of a 54mm long fiber

Another question may arise regarding the validity of fiber cross sectional area measuring methodology, since jute fiber is very thin and irregular shaped. Some researcher follow optical root to measure fiber diameter, some follow measurement of weight of fiber and then calculate diameter of fiber from known density and fiber length value. Although the latter procedure seem to be convincing but for thinner fiber like jute there is always need of a high accuracy of wt measurement.

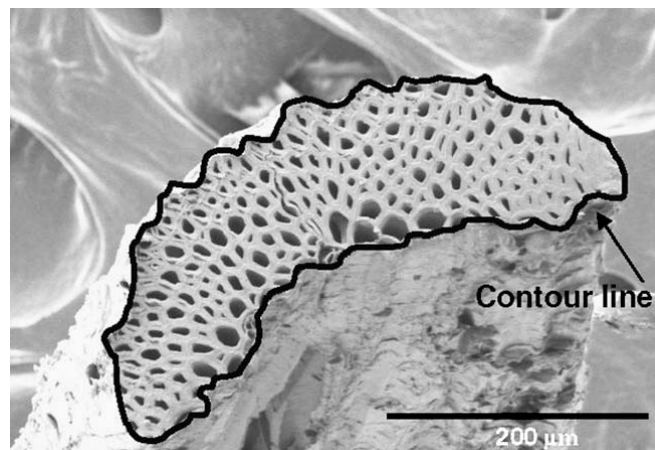


Figure 9: Area calculation using Image [Courtesy Chawla N. et. al. (2008) / Composites Science and Technology 68][2]

The drawback of the optical procedure of fiber diameter measurement is that the cross sectional circumference of the fiber is considered as circle to calculate fiber diameter, but the hollow spaces within the lumens are not excluded. Chawla N. et. al. (2008) tried optical procedure while working with sisal fiber and used java software to calculate the fiber cross section [2] as shown in Figure 9. It is also clear from the Figure 9 that the shape of the sisal fiber is also irregular throughout its length. So regarding the fact this procedure may be used more precisely excluding the average empty hollow spaces of the lumen. This kind of measure may be necessary since the kind of irregularities act at the microscopic level and could have influential affect on the mechanical properties of natural fiber, which is translated into the fiber reinforced polymer composites.

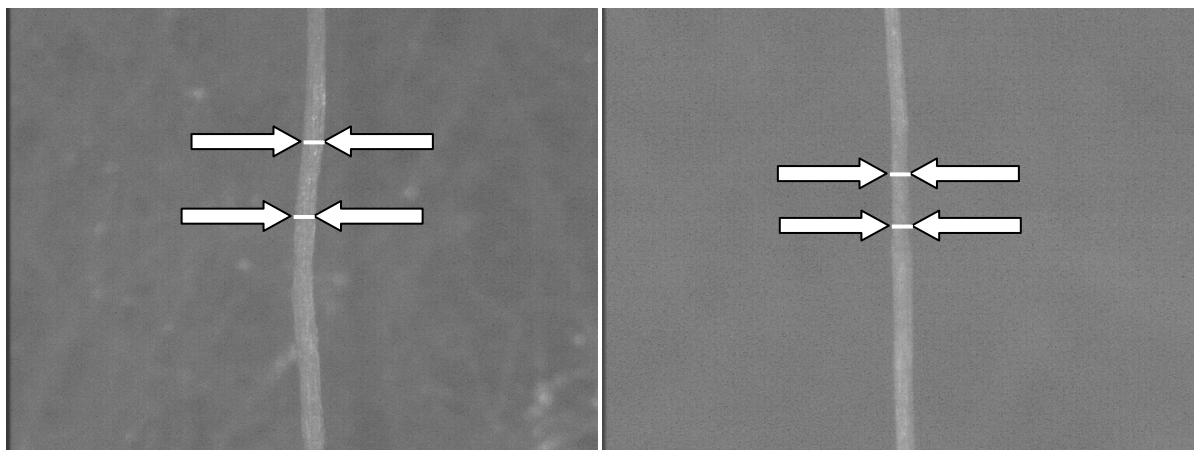


Figure 10: Width measurement of Bangla white grade B jute with Leica MZ8 software based sterio optical microscope

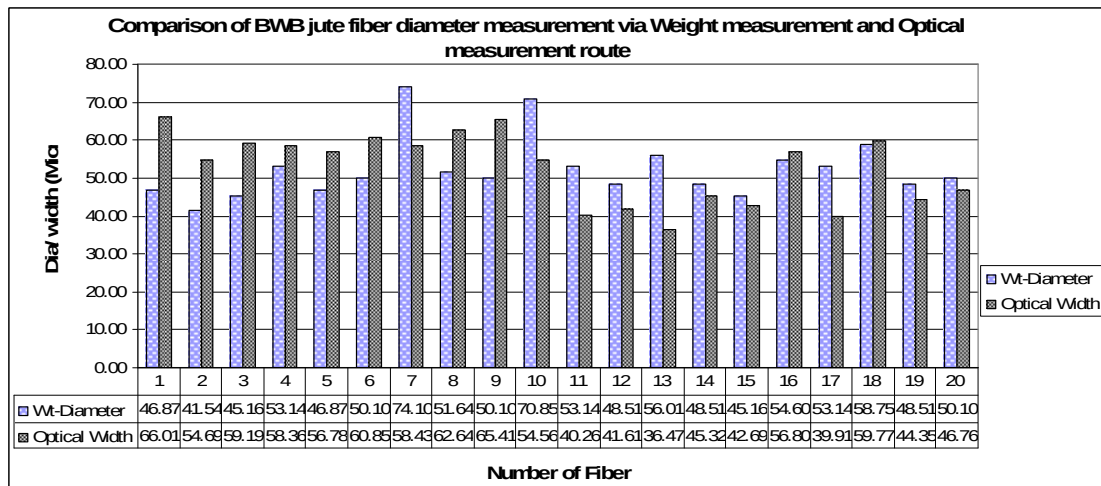


Figure 11: Comparison of diameter value of Bangla white jute fiber diameter value measured by optical and fiber weight measurement method

Figure 10 shows the optical method to measure the width of jute fiber which is taken as diameter assuming that the fibers are completely circular through the entire length. The arrow indicates how it was measured by drawing a line along the width of the fiber and immediately the width value is transformed in to micron value by the software by counting the pixel that has been occupied by the drawn line on the computer screen. Leica MZ8 image processing software based stereo optical microscope keeping the magnification at fixed value of 5 where each pixel value is calibrated as 2.7micron with the software itself. Some 20 fibers of same 50mm length were taken from the same bunch of fiber from which single fiber tensile test specimens were made. At least 60 width data were randomly taken for each fiber through the entire length like it is shown in Figure 11. Accordingly, to crosscheck the optically obtained average width value of these fibers the weight of individual fiber was measured and the average diameter were calculated from the length and density value of jute fiber.

Figure 11 shows that whether the diameter measurement method is either weight measurement based or optical based there could be always some discrepancy. For jute like thin fiber the weight measurement is possible with high precision micro gram range weighing machine and the measured diameter value will be the average of the whole length additionally some moisture may be absorbed by the jute fiber itself, which may increase the weight, volume and the diameter value. The advantage of weight measuring to get the fiber diameter is that the hollow spaces of the fiber are always excluded from the weight value since empty space has no weight although human error is never zero. In accordance with this for any single fiber of any types of shape through the length, if a large number of values of fiber width are taken and the average may closely resemble to the diameter measured via weight measurement method as shown in Figure 11. Larger scatter may be possible or moderately less scatter for another set of fibers if similar procedure is followed.

Table 1: Single fiber tensile testing data summary of 5, 10, 20 and 35 mm span length of BMB jute

Span Length (mm)	Fiber diameter (μm)	Max force (N)	Tensile strength (Mpa)	Strain To failure (%)	Strain To failure (%) Corr	Modulus of elasticity Gpa	Modulus of elasticity Gpa Corr
5 ± 0	64.41 ± 11.36	2.16 ± 0.68	712.87 ± 288.23	3.07% ± 0.65%	1.70% ± 0.59%	25.92 ± 13.03	45.15 ± 6.58
10 ± 0	70.86 ± 14.82	2.17 ± 1.04	524.84 ± 138.86	1.88% ± 0.45%	1.26% ± 0.38%	29.02 ± 7.58	43.14 ± 2.00
20 ± 0	83.47 ± 8.89	2.81 ± 0.77	507.86 ± 93.03	1.46% ± 0.31%	1.19% ± 0.24%	35.62 ± 7.19	42.79 ± 2.64
35 ± 0	69.25 ± 6.57	1.67 ± 0.27	452.27 ± 102.55	1.00% ± 0.14%	0.98% ± 0.13%	45.71 ± 10.15	46.32 ± 9.40

Table 1 indicates the data summary of the tensile test of Bangla white jute fiber. From Figure 12 the tensile strength shows a decreasing trend with increasing span length and the standard deviation is higher for the lower span length. Strain to failure shows decreasing trend with increasing span for the uncorrected and corrected value and again the lower span shows the highest standard deviation for both cases as indicated in Figure 14. From Figure 13 the modulus of elasticity for uncorrected data shows the increasing trend with increasing span length and the corrected data shows the no dependency over span length, but whatever trend may be the standard deviation is always higher for the lowest span length.

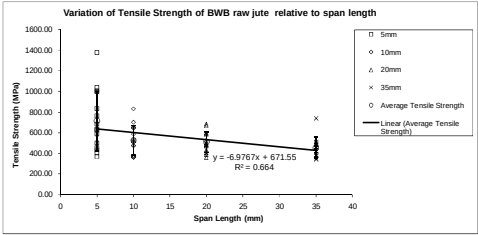


Figure 12: Variation of tensile strength of Bangla white grade B jute fiber relative to span length

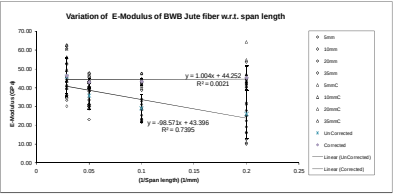


Figure 13: Variation of extrapolated E - modulus of Bangla white grade B jute fiber relative to span length

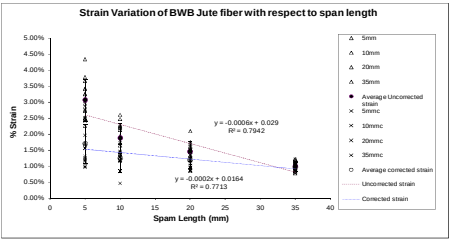


Figure 14: Variation of tensile Strain of Bangla white grade B jute fiber relative to span length

For lumen percentage correction the tensile strength, apparent and corrected e modulus and strain to failure shows similar pattern as Figure 12, Figure 13 and Figure 14, this is shown in Figure 15 – 17.

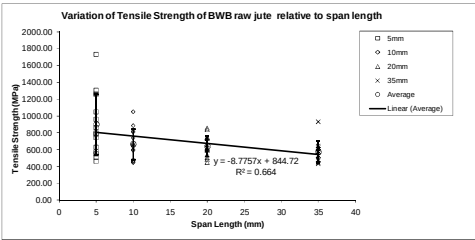


Figure 15: Variation of tensile strength of Bangla white grade B jute fiber relative to span length including % lumen Correction

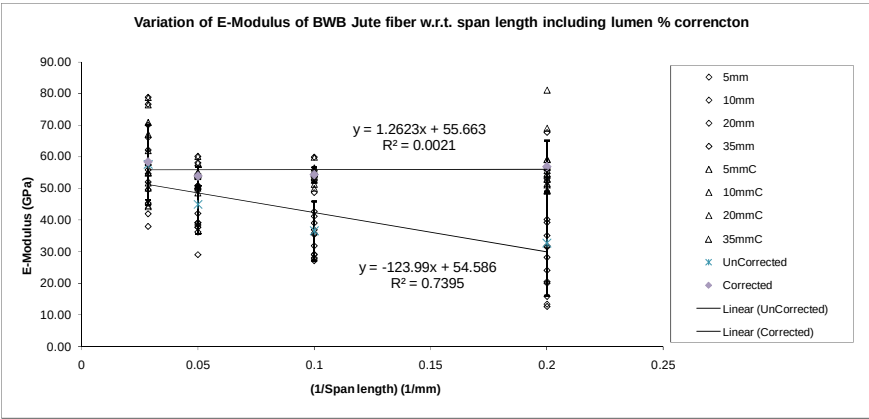


Figure 16: Variation of extrapolated E - modulus of Bangla white grade B jute fiber relative to span length including Lumen % Correction

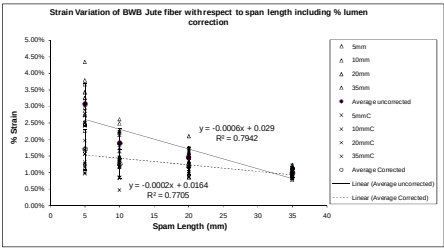


Figure 17: Variation of tensile Strain of Bangla white grade B jute fiber relative to span length including % Lumen correction

If we consider Figure 14 and Figure 17 we can see that the strain to failure remains unaffected by % lumen correction although the strength and stiffness value has increased to a certain percentage. This may be attributed to

the fact that empty space like lumen which is a hollow space never have any contribution to fiber elongation but it is the solid portion which contributes this strain value.

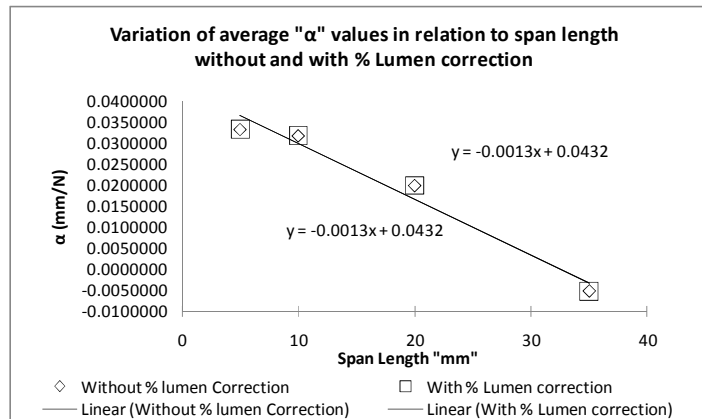


Figure 18: Variation of “α” values with span length without % Lumen and with % Lumen correction.

The “α” value for each test length were calculated for individual specimen since natural fiber has irregular shape through out entire length and along the length the compositional variation is also irregular. The average of each calculated “α” for each span were taken and plot was made as shown in Figure 18. The calculated alpha values for each test length were used for correcting the measured strains and corrections of the E-modulus as indicated in Figure 13&16. From Figure 18 it is clear that the average “α” value is larger at shorter test lengths, which means that for shorter test lengths more slippage in the clamps dominates the strain value. Another remarkable observation from the experiment was that % lumen correction doesn’t have any effect on the failure strain. This is logical since lumen is a hollow empty space and with no fiber forming materials although it is an integrated part of the fiber itself, which is mostly of natural origin.

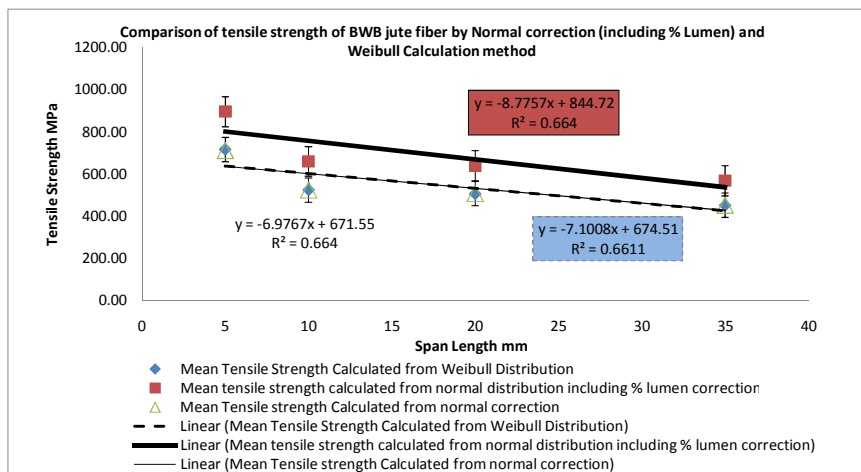


Figure 19: Tensile strength as a function of the test length according to a normal (standard deviation) with and without % lumen correction and Weibull (standard deviation) distribution and for BWB jute Fiber

Figure 19 shows the comparison of the tensile strength of BWB jute calculated from normal correction (standard deviation) and Weibull Distribution method. The data points for both the method are seen to superimpose on each other. Therefore it can be said that whatever may be the diameter (cross sectional area) measuring procedure for

jute like fiber there will always be some scatter in the test result but it will follow some trend which can be predicted by normal and Weibull distribution method to some extent.

Table 2: Weibull parameters calculated for different test length and effect of % lumen correction

Span length (mm)	Ultimate Cell Dimension [8][10][11][12]	Weibull Shape parameter “m” ^a	Weibull Scale Parameter (MPa) ^a $\lambda = \frac{\sigma_0}{N^{(\frac{1}{m})}}$	Calculated Tensile Strength from individual method		
				Normal Distribution without % Lumen correction	Weibull Distribution without % Lumen correction	Normal Distribution with % Lumen correction
5 ± 0	Length	2.5973	807.44	712.87 ± 288.23	717.16 ± 296.57	896.70 ± 362.55
10 ± 0	2 – 5.5mm	3.6989	582.17	524.84 ± 138.86	525.37 ± 158.18	660.17 ± 180.89
20 ± 0	Diameter	5.3279	549.52	507.86 ± 93.03	506.40 ± 109.45	638.81 ± 123.61
35 ± 0	5 - 20µm	4.6110	494.65	452.27 ± 102.55	452.05 ± 111.48	568.90 ± 128.99

^a Without and with % lumen correction.

Table 2 shows the Weibull parameters for different test length. All the shape factor (m) are larger than two, which is an indication of increase in failure rate as the applied load raises. Furthermore the shape factor indicates the variation in the data the bigger the value for the shape factor “m”, the smaller the variation in the data. It was observed that the estimated value of shape factor ‘m’ for the tensile strength data without % lumen correction remains the same as the value of shape factor ‘m’ obtained from the calculated tensile strength obtained from % lumen correction. We used the literature value of the jute ultimate cell length and diameter value to calculate the number of segments “N” present in each average volume of test length and the ultimate cell diameter value includes the hollow space of lumen. This seems logical since the average of % lumen is excluded and solid fiber body is only solid portion of fiber is considered as the strength contributory part. Manmade fibers usually have shape factors between 5 and 20, while natural fibers have shape parameter, which mostly remain between 1 and 6 [4]. In our case the shape parameter is in between 2.5 – 4.7 and different for individual test lengths.

The above discussion implies that if we exclude the % lumen (hollow space) from the optically measured diameter for jute like fiber the strength, stiffness values increases to a certain percentage. But the strain to failure remains the same since “α” value remains the same, which may be an indication of either insensitiveness of the Weibull parameter to wards the % lumen present in the jute fiber or the Weibull parameters includes the irregularly shaped empty spaces of the fiber interior in addition with the exterior and shows an overall shape and scale parameter value. In our case the strength, stiffness and strain to failure values remains well within the literature value of mechanical properties of jute fiber [Ref], but mean strength at infinite fiber length calculated from normal and Weibull distribution is far more below the value obtained from the incorporation of % lumen correction.

Defoirdt N. et. al. (2010) in her work tried to see correlation between the fiber diameter and the “α” value for bamboo, coir (brown and white) and jute fiber and proposed that the “α” value seem to be inversely proportional to the fiber diameter. The study showed that after applying all the correction method the systematic standard deviations are not eliminated. Slippage during the single fiber tensile test is not because of the fiber diameter alone but it is a contribution of the whole fiber volume [4]. This is since some fiber failure seems to be just from the slippage or sliding of elementary fibers within the gage length. It was observed in previous study of Defoirdt N. et. al. (2010) the thicker fiber like bamboo, coir showed less slippage with existing clamping procedure [4]. Along with this since we cannot say the fiber diameter will increase with increasing span length but we can say the fiber volume will increase with increasing span length so it could be better to find a precise relationship

between the “ α ” value and fiber diameter if we incorporate the mean fiber volume instead of the mean fiber diameter for each span length and make a plot.

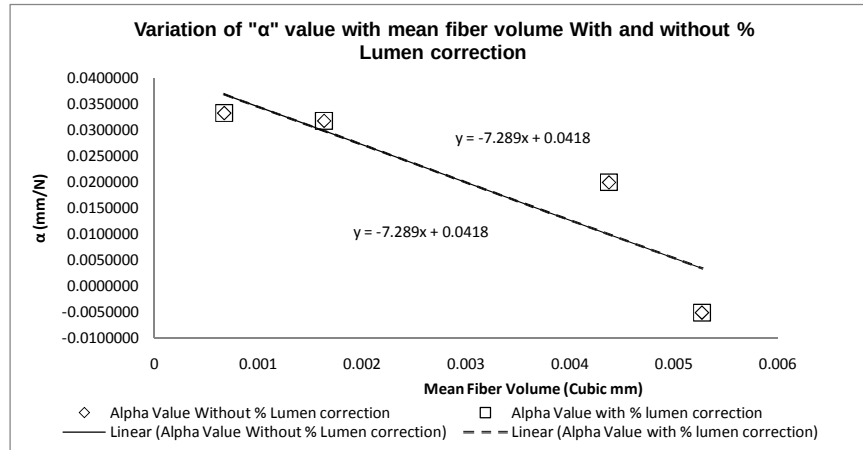


Figure 20: Dependency of "α" value on fiber volume with and without % Lumen correction.

Figure 20 shows the relation between the “ α ” value and fiber volume. From the curve we observed the inversely proportional relationship between these two factors. Along with this we see the average “ α ” value for highest span length is negative which is physically impossible, but the information from this point is that higher the span length the lesser the slippage. From the curve it can be said that the strain to failure for BWB jute fiber is not free from slippage after all these correction. Another observation is that the % lumen within fiber does not have any influence on “ α ” value, since it’s an empty space.

Discussion:

Fiber diameter measurement has been discussed in detail and for jute like fiber a comparison between the wt. measuring method and optical method has been discussed. Many researchers [2] has followed optical route for diameter measurement for single fiber tensile strength. Weight measurement procedure is more appropriate for the thicker fiber. But whatever the method we follow to measure diameter of natural fiber the mechanical test data will always show some degree of scatter, since the fiber forming material composition is non-uniform through entire length. Along with this the crystallite percentage of cellulose within micro fibril is irregular and amount of defect within the fiber during processing has detrimental effect on fiber mechanical properties.

After the completion of tensile test of single jute fiber it was corrected for the with normal correction method for slippage [4][5][7][13]. Weibull statistics is normally employed for brittle fiber. Although jute as a natural fiber has some plastic deformation although not extremely notable but it seem interesting to make a comparison of the normal and Weibull distribution for the tensile properties of jute. It was observed that the standard deviation of the tensile strength obtained from normal and Weibull distribution are mostly equal. But when we incorporate the % lumen correction in the tensile test data Weibull statistics didn’t match the standard deviation value for each span length.

As the chance of defect and weak links increase in larger span length so it is obvious that for larger span length the strength and strain to failure should decrease. The fact is reflected in Figure 12, 14, 15 and 17, and we clearly see from these figures the strength value for each span length has increased after % lumen correction but it did not affect the strain to failure.

The stiffness value as indicated in Figure 13 and 16 showed span length dependency before correction of test data for slippage but after correction the stiffness value shows very small or no dependency on span length for both the case of with and without % lumen correction. As indicated we see the apparent and corrected stiffness value has been increased to certain extent as the percentage of lumen excluded from fiber.

The Weibull shape and scale parameter remained unchanged after % lumen correction. Although lumen is a hollow empty space but its interior is not entirely uniform, so unchanged value of Weibull shape and scale parameter before and after % lumen correction hypothesized with the fact that the failure rate behavior of jute fiber will remain unchanged although the strength and stiffness value has increased and Weibull Statistics prediction is not beyond question at this point. Since jute fiber is one type of fiber so its shape parameter should be one unique value, but we see 4 different values for 4 different test lengths, which is an indication of common natural fiber behavior [4][13].

The decrease in average “ α ” value for higher span seem to correlate strain to failure is less dependent on the slippage behavior at higher span length, which is indicated in Figure 18, and once again we see there is no contribution to the “ α ” value for % lumen correction. For jute fiber this “ α ” value should be only one for all span length, but we see a decreasing trend, which indicates strain to failure is not entirely free from slippage. For 35mm test length we find the average “ α ” value is negative which is not possible but obtained from calculation, although 60% test data showed positive “ α ” value. This is since slippage can never be negative. It is irrelevant to say the increase or decrease in test length will result in increase or decrease in fiber diameter. The previous work of Defoirdt N. et. al. (2010) to correlate fiber diameter with “ α ” value, she stated an inversely proportional relation between fiber diameter and “ α ” value. So it was hypothesized that the “ α ” value for jute is not only related with the span length but the “ α ” value is cumulatively related to the entire average test volume, since slippage may occur along the entire volume of test length of jute like natural fiber and since a single technical jute fiber is not entirely regular as one another jute fibers in the same bunch so there must be different “ α ” value for individual specimen [4][14].

Conclusion:

Bangla white jute can be a great alternative for the fiber reinforced polymer composite industries. From the environmental point of view and natural abundance this can be a valuable alternative to manmade fiber for various uses of fiber reinforced polymer composite. Normal distribution along with % lumen correction showed increased strength and stiffness value but strain to failure remained unchanged. Weibull statistics showed similar standard deviation as normal distribution and showed same shape and scale parameter and remained insensitive to % lumen correction.

Acknowledgement:

The author cordially acknowledges the full support of VLIR authority, Metallurgy and Materials Engineering Department of Katholieke Universiteit Leuven and Materials and Metallurgical Engineering Department of Bangladesh University of Engineering and Technology and Bangladesh Jute Research Institute.

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Use of Waste Plastics with Bitumen for Road Construction

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This paper deals with an investigation on potential use of waste plastics with bitumen for road construction. This provides an understanding of the application of waste plastics for making modified bitumen for use in bituminous pavement construction and repair. The modified bituminous mix with waste plastics was prepared by using bitumen manufactured by ERL. The modified bitumen mix contained shredded LDPE and PP films (LDPE: PP = 3:1) as 8% by weight of the bitumen in the mix. Laboratory data generated after the test on bitumen material indicates that addition of waste plastics substantially improves the stability, fatigue life, indirect tensile strength, and reduced rutting and water damage of bituminous mixes under adverse water logging condition.

Keywords: Bitumen, Waste, Plastic, Transportation, Chemical

INTRODUCTION

Plastics are engineering materials and used extensively for a wide range of applications. Plastics products at the end of useful life are thrown away as municipal garbage. Mixing of different kinds of plastic wastes with other degradable and non-degradable wastes in the garbage has led to limit the use of thin plastic bags for packing and other convenient applications. Collection and reuse of these plastic bags, sheets, films,

bottles, cans etc. are considered a reasonable option to reduce its impact as a nuisance in municipal garbage. Reuse is possible through recycle to plastics industry for lower grade products or use in other applications not yet recognized.

All the polymers used in Bangladesh are imported. Major polymers used include Polyethylene (PE), Polypropylene (PP), Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET), Polystyrene (PS),

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Polyurethane (PU) etc. The estimated import of polymers in FY 2006-07 and 2005-06 were 288,464 and 273,874 tons respectively. Table 3 provides some data about types of polymer imported and category of import where Figure 3 provides the import of PE and PP for FYs 1988-89 thru 1998-99. A recent study reports that per capita plastic consumption per year in Dhaka city is 9 kg while the national average is 3.36 kg which is significantly lower than the global average. It also reports that solid wastes disposed by Dhaka City Corporation (DCC) contained about 4.15% by weight plastic materials in 2005. This represents 10.43% annual increase between 1992 and 2005 for plastic materials in solid waste. During the year 2004-2005, the plastic waste increased by 28.13%. The same study reported that about 91 ton/day of soiled and unsoiled plastics wastes are collected and recycled from DCC dump sites. The quantities of PE and PP dumped in the landfill are estimated to be 31.26 ton and 32.89 ton per day respectively. In order to appreciate the costs of recycled plastics it is worthwhile to examine the recycled chain as shown in Figure 1. The costs data are based on the reports by Waste Concern [12] and are for the year 2005, Figure 4. However, the costs of recycled PE/PP resins today can be excess of Tk. 60/kg depending on the quality ordered.

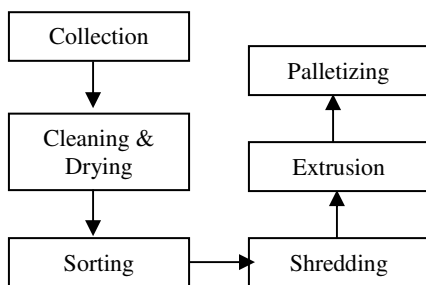


Figure 1 Steps involved in recycling of waste plastics.

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The above statistics indicate that every day a considerable amount of waste plastics are land filled in different dump sites around Dhaka city. The primary goal of this project is to study the application of waste plastics for making modified bitumen for use in bituminous pavement construction and repair.

PREVIOUS STUDY

Some of the studies on bitumen modification suggested that, recycled polyethylene from grocery bags might be useful in bituminous pavements leading to reduced permanent deformation in the form of rutting and reduced low temperature cracking of pavement surface [1]. It was also reported that asphalt concretes that employ polyethylene modified binders are more resistant to rutting during elevated seasonal temperatures [2]. Zorrob [3] and Zorrob et al [4] have shown that recycled plastics consisting predominantly of PP and LDPE can be incorporated into conventional bituminous road surfacing mixtures resulting in greater durability and fatigue life. Some other studies reported that adding LDPE in bitumen would increase the resistance to deformation [5], increase strength [7], and improve temperature susceptibility [6]. Jasto and Veeragavan [11] conducted a study on the use of processed plastic bags as an additive in bituminous mix. The modified bituminous concrete mixes in the surfacing of road pavement has shown improved stability and strength, fatigue life and other desirable properties even under water logging condition. A similar type of study reported that waste plastics being stable in the temperature range 220-230 °C were used as modifier of the mix results in improvement in stability, fatigue life, indirect tensile strength, and reduced rutting

and water damage of bituminous mixes under adverse water-logging conditions [8]. In 1997, a patent was issued in USA with title: Plastics Asphalt Paving Material and Method of Making Same, by incorporating waste plastics which are not sorted [15]. The plastic wastes being unsorted are subject to plasma surface treatment. An experimental study was carried out in the Department of Civil Engineering at BUET dealing with polymer blending with bitumen using virgin polymers that include LDPE, PP, EVA and PVC [19]. All these polymers were compatible for blending with bitumen except that PVC required vigorous stirring during blending. The results indicate that optimum performances were observed with LDPE content around 8% by weight in the bitumen. LDPE modified bitumen mix showed decrease in penetration, ductility, specific gravity and increase in softening temperature when compared with unmodified bitumen. According to Punith and Verraragavan [22], a polyethylene content of 5% by weight of asphalt is recommended for improved performance of asphalt concrete mixtures. In addition, it was reported that higher percentage of polymers in modified bitumen is not favorable [23]. Therefore, it is evident from all the previous studies that the plastic content should be between 5-8% to improve performance of asphalt concrete mixtures.

EXPERIMENT

The first step of the experiment involves investigation of the plastic waste management produce applied in different sector of the country and property evaluation of different types of waste plastic material. Several visits were made to the sites where plastic wastes are dumped. Shops and areas where plastics are sorted, process and sold were visited. Field survey indicates that the waste plastics to be used would be a mixture

of PP and PE (HDPE and LDPE) as the sorting practice does not assure strict separation of PP and PE. Therefore, it was decided to use shredded LDPE and PP for this study. Preparation of plastic modified bitumen mix at bench scale with 50 to 100 gm of bitumen was made while the preparation of modified bitumen mix with plastic wastes for road surfacing required the construction/fabrication of a gas fired furnace, containers and agitator system in another laboratory.

To understand the behavior of plastics in bitumen melt, LDPE, HDPE and PP have been selected for this study considering the melting point, Table 1.

Table 1 Some Properties of Different Polymer and Bitumen. (For polymers, the molecular weight being varying, the values mentioned against properties lie within a range value.)

Properties	Sp. Gr.	Melting Point, °C	Flash Point, °C	Thermal Decomposition, °C
LDPE	0.918-0.93	100-120	>231	>270
HDPE	0.94-0.96	130-140	>360	270-350
PP	0.91-0.97	120-170	400	270-300
PS	1.35-1.39	235-250		>300
PVC	1.35-1.39	130-190	>388	
PET	1.45-1.50	265-310		
Bitumen 80/100 grade	1.01-1.06	54-173	>220	>300

Virgin polymers are used at the initial stage of the experiments to formulate the modified bitumen. These polymers are available in

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granular forms. Later waste plastics, mainly LDPE, HDPE and PP films were purchased from the relevant shops. By noting the melting point of these waste plastics, the plastic types were identified.

The bitumen was tested for determining its grade. The penetration test reveals that the value is 73/74 and the bitumen is not 80/100 grade. It was decided to continue work with it, because this grade is also used for road surfacing in Bangladesh.

Blending of shredded waste LDPE and PE with this bitumen at bench scale using 50 to 100 gm of bitumen sample was carried out for various proportion of LDPE and PP separately in the temperature range 250-300°C. Time required for blending depended on the percentage of plastics added and the range was 60-120 minutes. Blending was carried by stirring the mix manually on and off. Completion of blending was on the basis of visual observation of the mix surface and consistency of the mix melt.

The mix for actual pavement was prepared by using cylindrical containers (38 cm ID and 51 cm height). A separate stand arranged over the container on the gas fired furnace carried the variable speed motorized agitator for mixing the bitumen and plastic mix in molten condition.

The container containing the measured amount of bitumen was placed on the gas fired furnace that has been constructed specifically for this purpose. When the molten bitumen was heated to 240-260°C, the shredded plastics was slowly added by agitating manually. The heating was continued until the mix reached 300-320°C when the gas burner was shut. The agitator was turned on when the plastics appear to be dispersed in the bitumen and not floating as entangled molten mass. The agitation was turned off when the mix reached 240-250°C.

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Six batches of modified bituminous mix with shredded LDPE and PP were prepared and these were used for road surfacing covering an area about 240 sq. ft. The road surfacing was carried out using graded stone aggregates. The bituminous mix constituted 5% by weight of the concrete bituminous mix employed for road surfacing. The quantity of bitumen mix used for making bituminous aggregate mix was based on Marshal Test.

RESULTS AND DISCUSSION

Initial laboratory tests for modifying bitumen with virgin plastics and waste plastics in proportions 2 to 12% by wt showed that they can be mixed with bitumen. Literature review reveals that waste plastics (both PE and PP) when mixed with the bitumen (at 8% wt of bitumen) gives the best performance as bituminous concrete mix.

The mix that was prepared by using bitumen manufactured by ERL has been modified in the laboratory using two different mixtures of PE and PP. The results are shown in table 2,

Table 2 Comparison of different properties between usual and modified bitumen.

	Bitumen (80/100)	Modified Bitumen (LDPE:PE = 3:1) 8% by wt. plastics	Modified Bitumen (LDPE:PE = 1:1) 8% by wt. plastics
Penetration	74	43	37

Softening Point	55°C	78°C	82.5°C
Ductility	118	5 cm	7 cm

Table 2 indicates that, modifying bitumen by waste plastic material significantly changes some parameters of the original bitumen. The penetration rate of the bitumen decreased significantly implying that the modified bitumen is more appropriate for the type of road subjected to excessive water logging. The results also indicate that the softening point of the modified bitumen increased where ductility decrease. Therefore, the modified bitumen is of high strength and less flexible at the same time.

The road surfacing was carried out using graded stone aggregates. The bituminous mix constitutes 5% by weight of the aggregate bituminous mix employed for road surfacing. The quantity of bitumen mix used for making bituminous aggregate mix was based on Marshall Test. The test results on Marshall Specimens shown in Figure 2 indicate that at 4% of air voids, the bitumen content is 4.9%. At this 4.9% bitumen content the Marshall parameters from the experiment are,

Marshall Stability, kg = 1680
Marshall Flow, mm = 3.2
VFA, % = 73
VMA, % = 14.2

Marshall Design Criteria for medium traffic satisfies all the above values. Therefore, the design or optimum bitumen content is found to be 4.9 percent.

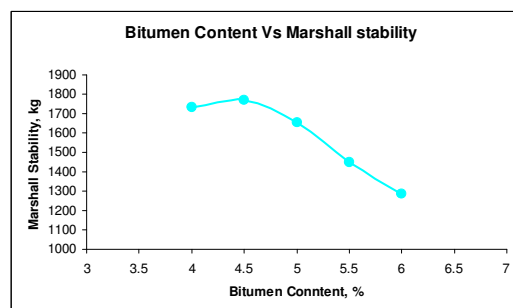


Figure 2 Bitumen Content Vs Marshall Stability Chart

The time for conducting this study was short. Based on the information provided in the literature some decisions were made without repeating works already done. However, this has exposed the difficulties and problems of carrying out the work both on laboratory scale and pilot scale. The chemistry aspects of waste plastic films were not examined.

Right method of road paving with modified bituminous mix (i.e. methodology of road surfacing) could not be employed for lack of equipment. In view of the higher softening temperature of the modified bitumen mix (>78°C), good paving should employ hot rolled technique.

CONCLUSION AND RECOMENDATION

The percentage of waste plastic material required to provide optimum performance by the modified bitumen is determined 8% by wt of bitumen in the laboratory. LDPE and PP were used in the ratio 3:1. At current level of sale price of the shredded waste PE and PP films (about Tk. 60 / kg) against the price of bitumen (Tk. 29/kg), the potential for its use in bituminous mix appears not promising. A life cycle analysis would probably be a better way of judging the

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potential of using waste plastics in bituminous mix.

However, an in-depth study is desirable to assess the potential of using waste plastics films for making modified bituminous mix for road surfacing and other specific applications in Bangladesh. More studies are required to establish the optimum temperature and time for blending plastics in bitumen including type of bending system with agitator in order to avoid decomposition/degradation of both plastics and bitumen. A longer stretch of road, say 5 km, is to be surfaced with modified bituminous aggregate mix to assess its beneficial and improved properties in different regions of Bangladesh encompassing regional characters in respect of weather, flood, and traffic. The road measuring about 240 sq ft paved with modified bituminous mix inside BUET campus even after more than two years (paved on 31.3.2008) is in excellent condition.

ACKNOWLEDGEMENT

The authors express their gratitude to Intermediate Technology Development Group, Practical Action (Bangladesh) for providing the fund required for the study.

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Table 3 Types of Polymer imported and category of import for two financial years.

FY	Total Import (ton)	Polymer Type (% of total)		Category (t)		Export (t)	
		PE	PP	In-Bond	Non In-Bond	In Bond	Non In-Bond
2005-06	273,874	26.31	25.10	80,628	192,246	80,628	192,246
2006-07	288,864	28.73	29.62	103,853	184,611	103,853	184,611

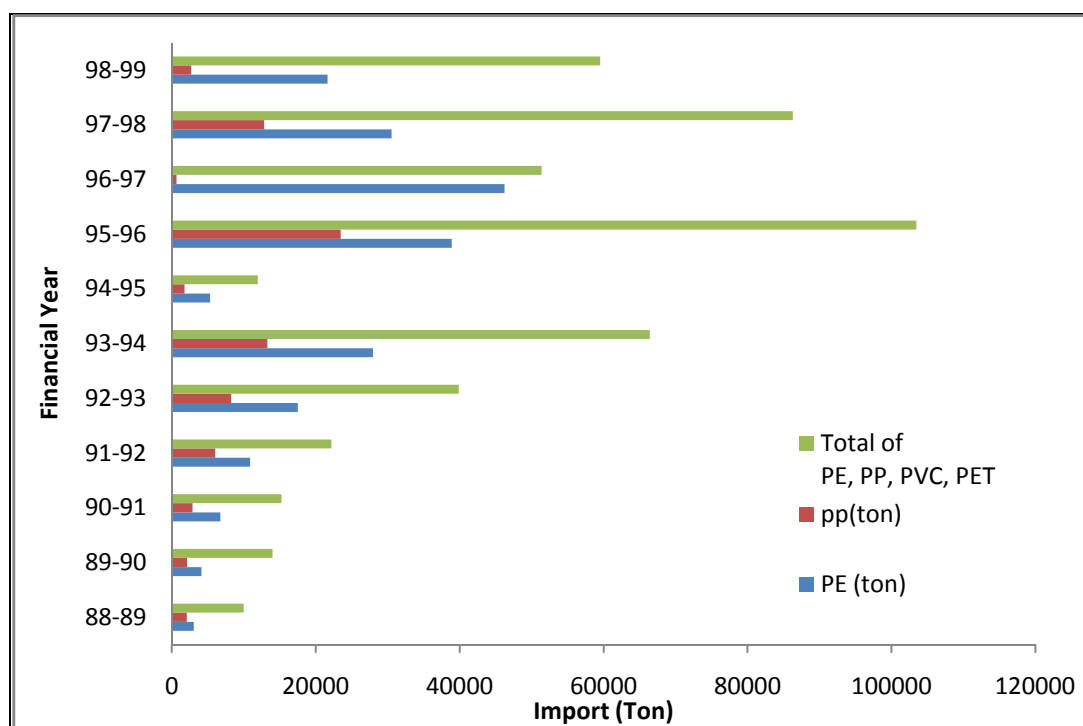


Figure 3 Import of Polyethylene and polypropylene for financial years 1988-89 thru 1998-99.

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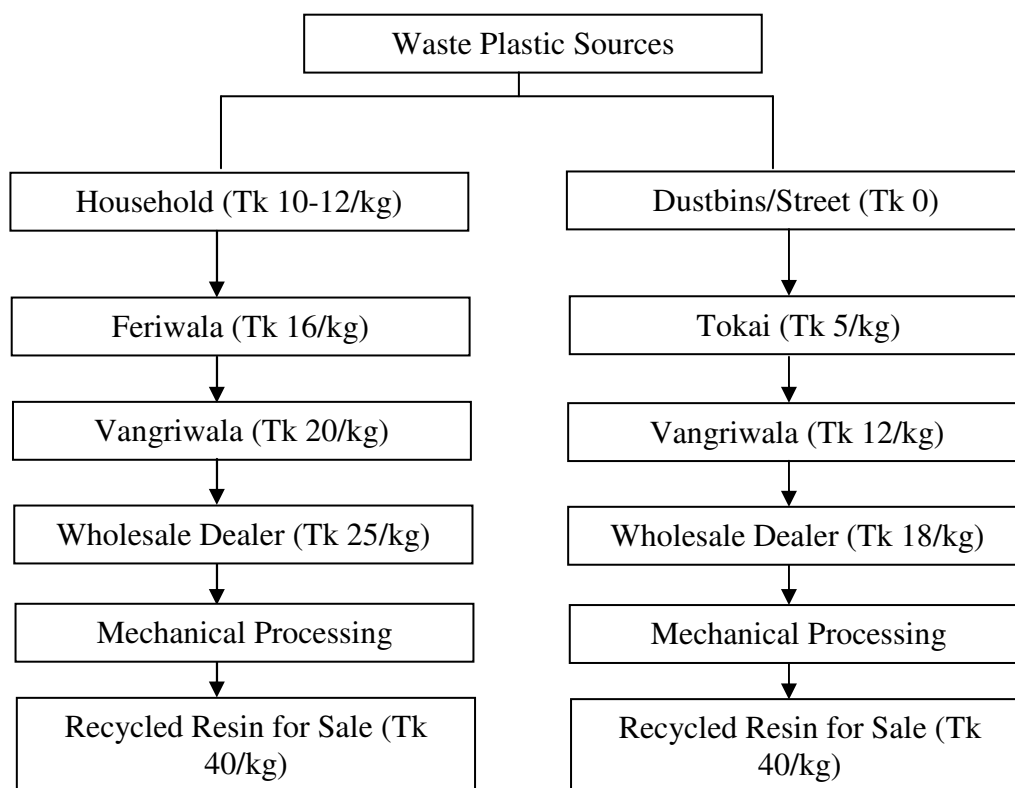


Figure 4 Recycling Chain of different types of waste plastic material via two different routes.

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An Effort to improve software teaching in Engineering Education

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Bangladesh is now going through the growth stage of IT industry. There are over 400 software companies at present. Every year, over 6000 graduates come out from more than 80 universities and 700 colleges. The emerging software companies in Bangladesh, however, feel the necessity of more skilled and competent fresh graduates. An obvious gap between fresh graduates' capability and industry requirement is felt by both the academy and industry. It is found that there are little discrepancies between the BSC curriculum of Bangladesh and universities from abroad. But there is a necessity to improve the teaching method. In order to improve software teaching in engineering education, a case study is performed on a group of mediocre students to evaluate themselves on their own as well as the teaching methodology. Further work is necessary to design an evaluation method of software teaching in our country.

Key words: Skilled software engineer; Education; Curriculum; Teaching methodology; IT industry

1. INTRODUCTION

The demand of producing more skilled software engineers according to market need is growing now-a-days in our country. Recent studies show that, in terms of export, software development can play a major role that really adds to the revenue of the country. A software specialist must go through rigorous course works and practices of software engineering and project management. In general, most of the universities in our country are offering graduation courses on Computer Science and Engineering. The curriculum consists of courses taken from different areas of computer science. These include computer network, database, software engineering mainly. Growth of IT industry requires people having skills in any of these areas.

However, "It is also being observed in Bangladesh that there is a widening gap between the supply and demand sides of software professionals. Both the two sides of this vital industry have been expressing dissatisfaction about this most important ingredient. Although more than 50 universities and numerous colleges under national university have been offering related programs, both the quality of fresh graduates having computer science and ICT related education appear to be discouraging. Some of the common concerns from the demand side are shortage of supply of competent professionals; fresh graduates need too much training time, value creation ability of graduates is low and employee turnovers as well as its impact are high. The supply

side has also some important issues such as fresh graduates are not finding attractive jobs resulting in lower admission in CSE, career path in the software industry is not encouraging, limited on-job learning and growth opportunity, and long term opportunity cost is high. There is no doubt that these burning issues must be addresses to reduce the gap between the industry and the academia for addressing human resource readiness issue for realizing such an important opportunity of nation building" (M.Rokonuzzaman, BASIS Soft expo 2010. Bangladesh) [17].

Understanding the fact that Bangladesh is still growing in IT, the industry requires fresher having basic knowledge on all the areas of computer science. There are other logical reasons why universities facing difficulties in focusing only on software engineering teaching. A software engineer must merge formal knowledge, good decision and taste, understanding, and ability to interact with and understand the needs of clients. It is not easy to teach all of this, undoubtedly not in one or two courses on software engineering in the universities [1].

2. ASSESSMENT METHODOLOGY

Considering the aspects of the problem argued between two groups namely the academy and industry, in this work it is followed the steps given below to perform a comparative study on the inclusion of software engineering courses contained

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in the curriculum of our country and foreign universities. The procedure is

1. Collect courses included in the curriculum of different Bangladeshi and foreign universities
2. Arrangement of the courses topic wise into respective major areas. The major areas considered, are Software engineering, Intelligent System Engineering, Mathematics, Computer Network and System, Telecommunication engineering and Core/general courses.
3. Prepare an average analysis and comment on the practices followed by the universities

The course materials collected from both Private universities such as Ahsanullah University of Science & Technology, BRAC University, East West University, United International University, North South University, American International University-Bangladesh and public Universities such as Bangladesh University of Engineering and Technology, Dhaka University. The foreign universities course materials are from Australian National University, Indian Institute of Technology Bombay, Nan yang Technological University, Stanford University (California), University of Bradford [12-16].

2.1 CSE program offered in our country:

All the course details have been collected from websites. The courses were classified according to major areas [5-12]. Eight universities have considered offering Computer Science and Engineering.

A graphical representation of concentration wise course distribution is shown in Fig.1. This diagram reflects the curriculum structure practiced in our country.

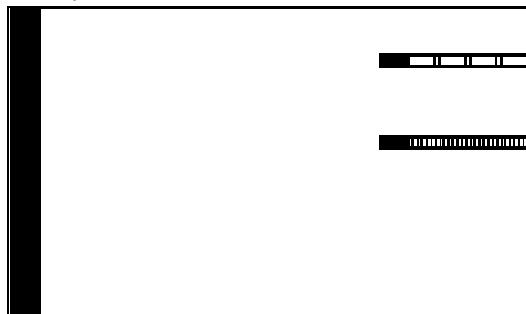


Figure 1: Average courses covered in software engineering trail of CSE program offered in our country

2.2 CSE program offered elsewhere:

Similar classification method as above has been applied on course curriculum followed in several foreign universities. Five engineering universities have been chosen [12-16].

A graphical representation of concentration wise course distribution is shown in Fig.2. This diagram reflects the curriculum structure practiced in 5 different universities.

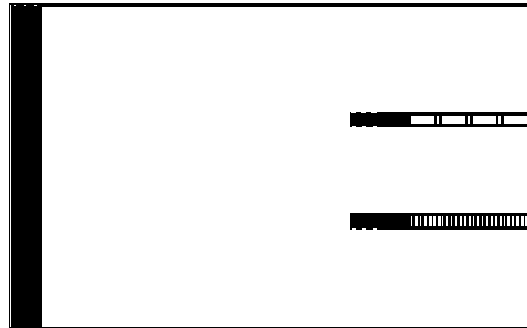


Figure 2: Average courses covered in software engineering trail of CSE program offered elsewhere

3. CLARIFICATION

Our objective is to find out the constraints hindering the development of good software engineers from mediocre students for our local and international job market. Through this study result It can be summarized that our course structure maintains the international standard.

In Fig.1 & Fig.2, it is seen that 12% software engineering courses covered in CSE program offered in our country and 13% covered in CSE program offered elsewhere. And differences between these two categories are bare minimum. There is only 1% deviation between these two categories. The set of curriculum structure of CSE program offered in our country and foreign universities are almost same. So it is assumed that it is a minor problem to produce skilled fresh software engineers. Perhaps more software engineering courses can be added in our course curriculum for betterment of our curriculum structure or introduce improved teaching methodology.

With the assessment result it can be said that, rather than course curriculum more concentration is needed on our teaching method. This is the crucial point for our (Bangladesh) software engineering education.

4. SOME SUGGESTIONS

Teaching software engineering has never been easy and no compromise has emerged from the many debates about how best to do it. At the base of the problem lies the fact that the complexity of software engineering comes from the complexity

of problems and it is impossible to teach this complexity in a traditional classroom setting [2].

In Bangladeshi university course curriculum, there is no active division of Computer Science. Software Engineering, Network, and Database courses are mainly focused here. In some of the universities elsewhere, more specialized degrees are offered as Internet Computing, Mobile Computing, Multimedia Computing, Software Engineering, Business Computing, Computer Systems Administration, Robotics with Artificial Intelligence, Information and Communication Technologies (ICT) [16]. Bangladeshi Universities can have some specialized areas in Computer Science faculty.

Practical courses like java, php, C language cannot be taught as theory courses only, Lab based practices should be emphasized. There should be some pre-defined set of criteria for the teachers about how should a course be offered. More emphasis on lab classes needs to be given by the universities. Theory classes are of course needed but for a programming language course, 80% of the course needs to be practical oriented with problem solving approach.

A practical way of teaching method like "Learning by doing" can be followed by the universities so that the problem of too much dependency on theory can be avoided. "Learning by doing" is a model of teaching which aims to strengthen practical ability and project awareness of engineering students. This model was addressed by Dr. Roger Schank, firstly proposed in Carnegie Mellon University in USA. "Learning by doing", is a way to let students learn through practice, knowledge acquirement, induction and summary. In this teaching model, teachers convey less theoretical knowledge and students needn't take part in classroom activities or have examinations. Here, teachers teach students by particular project or product, students completely take part in development and business activities, finally the knowledge they learned become useful and market- oriented [18].

4.1 Improved Teaching methodology

To improve teaching methodology, many researches and studies has been done internationally. It is known that new ideas are not easily welcomed. The socio-economical structure and language also puts barrier to implement new methods. A literature review and some analysis based on Bangladeshi context it is found that some of these methods can easily be followed to improve teaching SE in our universities. So it is proposed to implement these methods in several phases so it will not be a pressure or impossible to implement.

Phase 1

In phase1 a different method of evaluation namely, student evaluation of module (SEM) questionnaire can be used to obtain students' input and feedback on modules with a view to improving teaching and learning. Usually universities are taking feedback from students to evaluate teachers, but in this method a module is evaluated not a teacher

By any usual SEM several aspects are being overlooked:

- the existing SEM can't reflect problems encountered by students in their learning process
- the existing SEM can't identify modules in which the majority of students are challenged and unable to cope
- the existing SEM can't provide adequate module-related information to lecturers in order to further understand the needs of students

The proposed SEM must be able to identify "difficult" modules and the associated reasons for this perception. In part, the questionnaires should recognize why students are struggling with these modules, as well as whether they have been appropriately equipped with sufficient background knowledge for the current level of studies. Also of interest were ways to aid students in overcoming these difficulties and to increase their interest in learning. As the emphasis of modern engineering education has shifted to what is being *learned* instead of what is being *taught*, the new SEM has to focus on learning outcomes. Lastly, this SEM should provide students with a platform for feedback on supporting facilities such as libraries, computing provision and experimental laboratories [22].

Phase 2

In the second phase, a new method of teaching "bottom up" approach can be followed. This approach utilizes an intensive regimen of laboratory exercises, which require students to add a new feature to an existing corpus of software. To add the new feature, a student must first understand and then redesign (or refactor) the existing code, which is designed for the purpose of illustrating the complexities that arise in large software. Each of these lab exercises gives students a basis in experience for understanding the lecture material, which presents a pattern or solution to address the complexity that was motivated in the lab. Thus, unlike in traditional courses, which begin with a requirements specification followed by design and implementation, SE course begins with directed

implementation and maintenance tasks, which motivate design strategies and techniques.[21]

Bottom up approach actually evolved from a process called *continuous quality improvement* (CQI). In our study it is identified that the curricula of our local universities are of international standard but there is no end of improvement. So, a curriculum must be subjected to a process of *continuous quality improvement* (CQI). CQI is a general framework for systematically improving the products that flow out of a production process. To successfully apply CQI to a curriculum requires:

1. specifying learning outcomes at a granularity that is sufficient for improving specific components of instruction,
2. developing assessment methods to measure these fine-grain learning outcomes and
3. Improving the transparency of instruction, so that variations in outcomes can be traced back to events within the course or its prerequisites [21].

Phase 3

The method is to help students by providing a TA who will help them handson. Here students are as apprentices. This method can be followed by the faculty very easily by just providing an eligible TA to the students.

A significant improvement in students' software engineering skills can be achieved via the following elements:

- challenging students to build four or five applications over a 13-week semester (note that these applications can be sub modules in a single online learning community)
- drawing on the alumni to bring professional software engineers onto the campus to coach students
- a terminal room where students can work together on a scheduled basis
- projects with real clients
- an emphasis on oral and written presentation of results [20].

5. CASE STUDY

Teaching programming language C is initially undertaken in Computer Science studies. To improve the teaching method of C programming, a case study is performed on a batch of students doing C programming course following the guidelines of SEM in phase 1. The sample of students taken for this study has a background which is less than average. First, a questionnaire is made for the students. Students were asked to answer the questionnaire. There were 9 questions

regarding their depth of understanding on 9 different topics of programming. Each question has 4 different answers like Excellent, very well, well, and not well as mentioned in Table 1. Students chose only one answer per question. Later, the filled up forms were collected. The 4 categories of Remarks were marked as 4 (Excellent), 3 (very well), 2 (well), and 1 (not well) also shown in Table 1. As per these weights, each student's total was counted. Table 2 shows the GPA that is followed in result processing. Estimated total number (the expected one) and the grade based on this evaluation are shown in Table 3. Afterward, when the original exam was over, the original grade is given in Table 3 again.

Remark	Mark	Highest Mark
Excellent	4	36
very well	3	27
Well	2	18
Not Well	1	9

Table 1: Mark allocation for questions

80	A
70	B+
60	B
50	C+
40	C
30	D

Table 2: GPA calculation basis

ID	Excel lent	very well	Well	Not Well	Total	GPA (%)	Grade based on Evaluation	Grade Based on Exam
1		2	1		8	67	B	B-
2	3				12	100	A	B+
3		1	1	1	6	50	C+	B-
4		1	2		7	58	C+	B+
5		2	1		8	67	B	C+
6			2	1	5	42	C	B-
7			3		6	50	C+	B
8		1	2		7	58	C+	D
9				3	3	25	D	D+
10			1	2	4	33	D	B
11			2	1	5	42	C	C+
12	2	1			11	92	A	A-
13	2	1			11	92	A	A
14		1	2		7	58	C+	C+
15		2	1		8	67	B	A
16		2	1		8	67	B	B
17	2	1			11	92	A	A

Table 3: Result Chart of student evaluation sheet

Then the questionnaire evaluation grade and the actual exam grade has compared. It is found that 47.06% of the actual result is better than the self evaluation, 29.41% of the actual result is less than the self evaluation and 23.53% of the actual result is similar to the self evaluation. Comparison result is given in Table 4.

Total result	17	%
Accurate	4	23.53
Better than evaluation	8	47.06
less than evaluation	5	29.41

Table 4: Comparison of Grade based on Evaluation and Grade Based on Exam

Though it is found 29.41% of student got less mark than evaluation but the difference is minimal. i.e., Grade based on Evaluation is B and Grade Based on Exam is B- (please see Table 3).

6. CONCLUSIONS

In this paper, our own view of the difficulties of educating a software engineer is presented. Though the analysis of the CSE program offered in our country and CSE program offered elsewhere has shown very little difference, it is understood that the outcome of the teaching is not so similar.

A study based on Student Evaluation Module (SEM) is made and found out that our students are capable enough to self-estimate themselves.

So, in order to prepare themselves to learn and understand more in a fixed time period of a semester, some more measures need to be taken and continuously assess the strengths of those measures toward achieving a better learning outcome.

Options like more practical oriented projects which are related to different companies of local market can enhance the chance of practical experience to the students. The direct relation of universities and business companies can be made so that the students can work in the companies for a limited time for experience. Furthermore, more collaboration is needed between universities and local companies to understand and identify each other's problem to minimize the gap by doing seminars, fairs.

In order to institutionalize the educational experience, It is needed to focus on devising a better and more practical teaching methodology with the objective to help enable students learn more within the stipulated period of a semester.

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DESIGN A SIMPLE DATA STRUCTURE USING MULTILEVEL STACK

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Data structure plays an important role in conventional computer. In this paper a simple but effective process to design a simple data structure of multilevel stack is described. Many kinds of data, including observational data collected in the human and biological sciences, have a hierarchical or clustered structure. Multilevel data structures also arise in longitudinal studies where an individual's responses over time are correlated with each other. To determine if data sets is suitable for multilevel analysis firstly identify the levels in the multilevel structure. This paper aims to give a *Pictionary* of basic structures and classifications that underlie multilevel stack. In this process a unique id for each element is assigned. The parent id of that data is also assigned to indicate the level of that data. The stack has three identifier named id, Pid and data. The id is assigned in ascending order. Binary search is possible to search that data. For searching an element in a data structure, using multilevel stack will be easier and efficient than other data structure.

Key words: Multilevel Stack, Clustered Structure, id, Pid, Binary Search.

1. INTRODUCTION

In computer science, a stack is a last in, first out (LIFO) abstract data type and data structure. A stack can have any abstract data type as an element, but is characterized by only two fundamental operations: push and pop. The push operation adds to the top of the list, hiding any items already on the stack, or initializing the stack if it is empty. The pop operation removes an item from the top of the list, and returns this value to the caller. A pop either reveals previously concealed items, or results in an empty list.

When a model of an object to be designed, or more generally a set of data interrelated in an intricate way, is to be created in the computer, a suitable data structure must be built up in the machine memory. This paper deals with the problem of representing objects composed of other objects, hierarchically organized and linked together by connection relations. A careful analysis of these objects, which are encountered in several applications, has provided the base for designing a flexible, systematic, expandable and relatively compact data structure for their computer representation. It was viewed as The characteristics which are common to several parts of the object are

stored without duplication. An implementation of the structure based on the ring technique, which gives the structure its flexibility, is also described in detail (Browne, 2009).

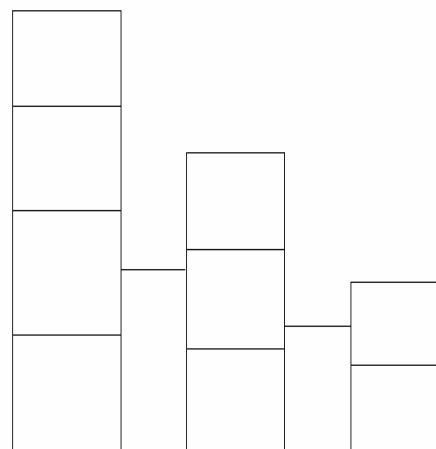


Fig 1: Multilevel Stack

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2. MULTILEVEL MODELING

Multilevel modelling is realistically a complex modelling that generates dependent data. Multivariate responses arise when there are measurements on more than one variable for individuals, leading to a two-level hierarchical structure with responses at level 1 nested within individuals at level 2, this type of modeling is known as hierarchical or multivariate response model. If the responses may be viewed as indicators of one or more unobserved (latent) construct, a factor model is usually more appropriate. In a factor model, the correlation between responses is assumed to be due to their common dependence on one or more latent variable or factor. A structural equation model is a generalization of a factor model in which each factor may depend on explanatory variables and possibly other factors.

The figure is an example of hierarchical structure where all level is represented simultaneously: people nested within households within places in a three level model.

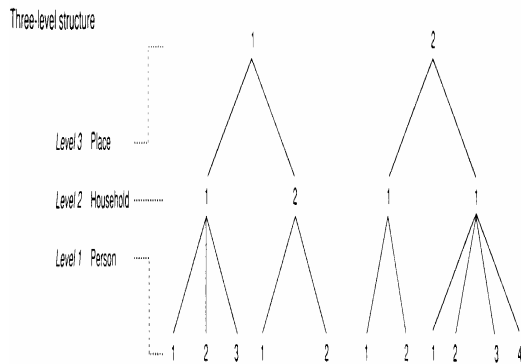


Fig 2: Hierarchical Structure

3. METHODOLOGY

In data structure array is an arrangement of items at equally spaced addresses in computer memory. It is used in a programming language to specify a variable that can be indexed. Although array representation of stack is very easy and convenient But it allows only representing fixed size stack. Single linked list structure is sufficient to represent a stack. In computer science, a linked list is a data structure that consists of a sequence of data records such that in each record there is a field that contains a reference to the next record in the sequence. Linked lists are useful to study for two reasons. Most obviously, linked lists are a data structure which you may want to use in real programs.

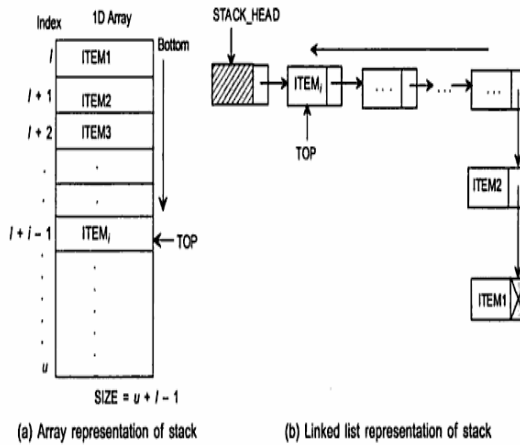


Fig 3: Two ways of representing a stack

The index structures that we have studied involve a sorted index file. A binary search is applied to the index to locate pointers to a block containing a record the file with a specified indexing field value. A multilevel index considers the index file, which was discussed as single-level ordered indexes and will now be referred to as the first (or base) level of the multilevel structure, as a sorted file with a distinct value. We mentioned that an index file is effectively a special type of data file with two fields as pid & value. Thus, we can build a primary index for an index file itself. This new index to the first level is called the second level of the multilevel index. The above process can be repeated and a third-level index can be created on top of the second-level one. The third level, which is a primary index for the second level, has an entry for each second-level block. We can continue the index-building process until all the entries of some index level fit in a single block.

The multilevel structure can be used on any type of index, whether it is a primary, a clustering, or a secondary index, as long as the first-level index has distinct values for and fixed-length entries. The figure below depicts a multilevel index built on top of a primary index.

We can represent multilevel structure as a complex structure, heterogeneity, dependent data and contextually. A large range of structures that ML can handle routinely is termed as complex structure; e.g. houses nested in neighbourhoods. Standard regression models 'averages', i.e. the general relationship ML additionally models variances is known as heterogeneity; e.g. individual house prices vary from neighbourhoods to neighbourhood. A potentially complex dependency in the outcome over time, over space, over context is known as dependent data; e.g. houses within a neighbourhood tend to have similar prices.

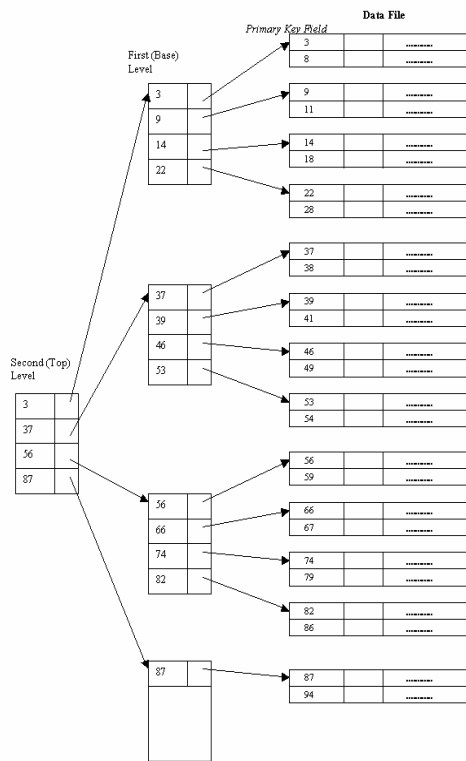


Fig 4: Multilevel Index using Binary Search

Multilevel indexes are used to improve the performance in terms of the number of block accesses needed when searching for a record based on an indexing field value. It should be noted that we could also have a multilevel primary index which could be sparse. In this case, we must access the data block from the file before we can determine whether the record being searched for is in the file. This can be determined by accessing the first-level index without having to access the data block, since there is an index entry for every record in the file.

4. DISCUSSION OF RESULTS

A multilevel index improves the performance of searching for a record based on a specified indexing field value. However, the problems with insertions and deletions are still there, because all index levels are physically ordered files. To retain the benefits of using multilevel indexing while reducing index insertion and deletion problems, database developers often adopt a multilevel structure that leaves some space in each of its blocks for inserting new entries. This is called a dynamic multilevel index and is often implemented by using data structures.

A stepwise method of deriving the high-performance implementation of a set of operations is proposed. This method is based on the ability to organize the data into a multilevel data structure to provide an efficient implementation of all the operations. Typically, for such data organization the performance may deteriorate over a period of time and that can be corrected by reorganizing the data. This data reorganization is done by the introduction of maintenance processes. For a particular example, the multilevel data organization and the different models of maintenance processes possible are considered. The various models of maintenance process provide varying amounts of concurrency by varying the degree of atomicity in different operations. Performance behavior for the different models is derived and a correctness proof for the developed implementation is outlined (Moitra et al., 1988).

CONCLUSION

A complete implementation of the whole process from preprocessing of the multilevel data structures has been implemented. The implementation also is a framework to process and search data, so that further work can be based on the developed structure. Different approaches to extract data in multilevel stack are discussed and implemented. A new method of data structure is presented in this paper.

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DEVELOPMENT OF A SOFTWARE FOR CALCULATING THE THERMODYMIC AND TRANSPORT PROPERTIES OF LiBr AQUEOUS SOLUTION

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With the development in the field of refrigeration, the vapor absorption cycles has gained renewed interest in the last decade due to environmental problems of commonly used refrigerants in vapor compression system. The most common refrigerant-absorbent pairs for absorption systems are water/lithium bromide and ammonia/water. LiBr aqueous solution has been the most popular choice in absorption cooling industry. Properties of the LiBr aqueous solution are very important in order to design and analyze the performance of absorption refrigeration system. Various researchers have given extensive amount of correlations to calculate the thermodynamic and transport properties of LiBr aqueous solution for wide range of temperature and concentration. Currently, there is a lack of suitable software to calculate the thermodynamic and transport properties. To minimize this deficiency software is developed for calculating the thermodynamic properties (such as enthalpy, entropy, specific heat, vapor pressure, density) and the transport properties (such as thermal conductivity, mass diffusivity, surface tension, viscosity) of LiBr aqueous solutions. For the development of the software an object oriented programming VISUAL BASIC is used. Correlations for of thermodynamics and transport properties are taken from literature.

Key words: Absorption refrigeration system; Lithium Bromide aqueous solution; Thermodynamic properties; Transport properties; Computer programming.

1. INTRODUCTION

With the development in the field of refrigeration, cooling and heating systems based on vapor absorption cycles has gained renewed attention in the last decade due to environmental problems of commonly used refrigerant in vapor compression system. The most commonly used absorbents for absorption refrigeration system are water/lithium bromide and ammonia/water. However, LiBr aqueous solution has widely been used in the absorption refrigeration industry for a long time due to its outstanding thermodynamic characteristics. Thermodynamic and transport properties of the LiBr aqueous solution are very import in order to design and analyze the performance of absorption refrigeration system. Various researchers are given extensive amount of correlations to calculate the thermodynamic and transport properties of LiBr aqueous solution for wide range of temperature and concentration.

Refrigerant properties software is a very import tool to analyze, design and simulation of refrigeration system. REFPROP is widely used commercial software for various refrigerants used vapor compression system. However, there is a lack of suitable software for calculating the thermodynamic and transport properties of vapour absorption system. In this perspective, a software is developed for thermodynamic and transport properties of LiBr aqueous solution. Correlations of properties are taken from more recent and updated literature. For the development of the software an object oriented programming VISUAL BASIC is used.

2. CORRELATIONS FOR THERMODYNAMIC AND TRANSPORT PROPERTIES OF LiBr AQUESOUS SOLUTION

To developed a versatile software for properties of LiBr aqueous solution, appropriate properties

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correlations for wide range of temperature and concentration are needed. An ample amount of correlations are available for thermodynamic properties. However, correlations for transport properties are very few. For the thermodynamic properties, Lower (1960) published in 1960 the early prominent correlation. It was the first complete study that provided all thermodynamic properties of the solution. Using a Gibbs energy equation, author successfully described the thermodynamic properties of the solution based on his own experimental data. Later McNeely (1979) developed a Duhring equation from extensive collection of equilibrium vapor pressures and calculated the enthalpies for wide range of temperature and concentration. It has been very popular in the industry because it is easy to use and quite accurate in the working range of conventional absorption machine. Herold and Moran (1987) have reproduced McNeely's (1979) data using Gibbs energy equation with a modified Debye-Huckel model. Feuerecker et. al. (1993) carried out a study based on their own pressure measurements for the solution in the concentration range from 40 to 76 LiBr wt% and temperature range 45 to 190°C and showed good agreement with McNeely (1979). Kaita (2001) suggested a new set of equations for the high temperature and pressure ranges of triple-effect machines by supplementing the vapor pressure data of Feuerecker et. al.(1993).

Transport properties of LiBr aqueous solution is very import for design and simulation of absorption system. However amount of correlations for transport properties are very few. Hattori et. al. (1997) developed a correlation for mass diffusivity and showed that it can predict the experimental data within $\pm 2\%$. Japanese society of thermo-physical properties (JSTP) provided some correlations for mass diffusivity, viscosity, thermal conductivity and surface tension in their handbook.

3. DEVELOPMENT OF THE SOFTWARE

For the development of the software various types of programming languages are available such as Visual Basic, C, C++ , JS Script, and FORTRAN. Among them VISUAL BASIC is chosen as a programming language for this work due to its flexibility and visual interface. Visual Basic is an object-oriented computer programming language from Microsoft. It can be possible to make an EXE file for the application which is made by Visual Basic and this exe FILE can be run freely by DDL (Dynamic link Library).

Thermodynamic and transport properties correlations that are used for the software are given in table 1 and 2. Properties correlations are selected based on their accuracy in wide range of temperature and concentration.

Table 1: Correlations for thermodynamic properties

Properties	Correlations
Entropy	Patek and.Klomfar, 2006 Feuerecker et. al., 1993
Density	Patek and Klomfar, 2006 JSTP Handbook, 2008
Vapor pressure	Patek and.Klomfar, 2006 Uemura and Hasaba, 1964 McNeely, 1979
Specific heat	Patek and.Klomfar, 2006 Iyoki and Uemura, 1989 Jeter et. al., 1992 Rockenfeller, 1987 JSTP Handbook, 2008 McNeely, 1979 Patterson et. al., 1988
Enthalpy	Patek and.Klomfar, 2006 Rockenfeller, 1987 McNeely, 1979 Patterson et. al., 1988 JSTP Handbook, 2008

Table 2: Correlations for transport properties

Properties	Correlations
Mass diffusivity	JSTP Handbook, 2008 Hattori et. al., 1997
Viscosity	JSTP Handbook, 2008
Thermal conductivity	JSTP Handbook, 2008
Surface tension	JSTP Handbook, 2008

Developed software provides the various options for the used to calculate their required properties. Fig. 1 and 2 show the start menu of the software. It provides several options for user. User may choose a specific correlation or a specific property. Software also provides the properties in tabular for either varying the temperature or concentration. Also user may obtain most accurate properties among the correlations. Some screen shots of the software are shown in Fig. 1 to 4. Authors are also trying to develop a DLL file to use this software to other programming language.

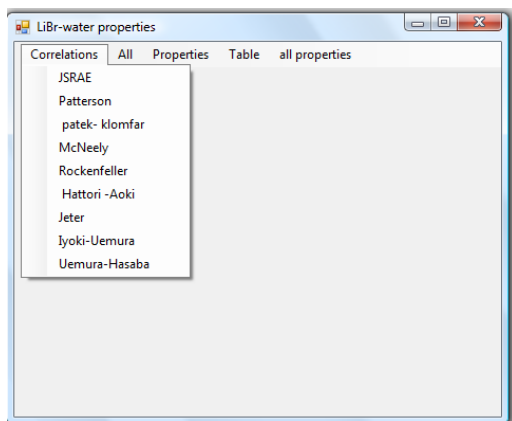


Fig. 1: Program output for selection of correlations

Table for Temperature variation of LiBr-water solution

Lower Temperature (Celsius): 2 Upper Temperature (Celsius): 62 Interval Temperature: 2 Mass fraction of LiBr(kg/kg): 0.55

Calculate Exit

Temperature Celsius	mass fraction of LiBr(kg/kg)	* Enthalpy(KJ/kg)	* Entropy(KJ/kg.k)	* Specific heat(KJ/kg.k)
42	0.55	97.84		2.04
44	0.55	101.98		2.05
46	0.55	106.12		2.05
48	0.55	110.25		2.05
50	0.55	114.39		2.05
52	0.55	118.53		2.05
54	0.55	122.68		2.05
56	0.55	126.82		2.05
58	0.55	130.96		2.05
60	0.55	135.10		2.05
62	0.55	139.24		2.05

* Thermodynamic properties of LiBr-water solutions at high temperature —Y.Katiz
 ** A computationally effective formulation of the thermodynamic properties of LiBr-water solutions from 273 to 500K over full composition range —J.Patek,J.Klomfar
 *** JSTP Handbook

Fig. 4: Program output for properties in tabular form.

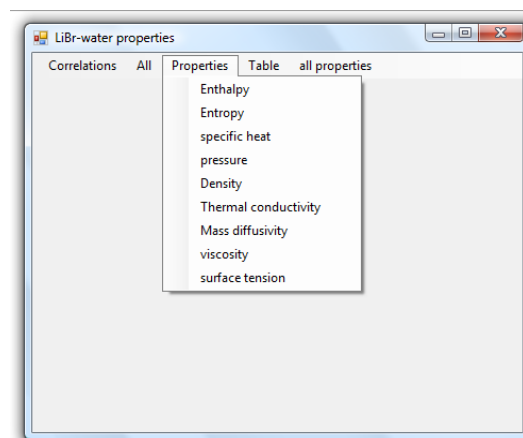


Fig. 2: Program output for selection of properties

Density

Density Calculation

Temperature: Celsius

mass fraction of LiBr: kg/kg

☒ Patek-Klomfar Label1 kg/m³

☐ JSTP Label2 kg/m³

Calculate Exit

Fig. 3: Program output for density calculation

4. CONCLUSIONS

LiBr aqueous solution has been the most popular choice in absorption cooling industry. Properties of the LiBr aqueous solution are very important in order to design and analyze the performance of absorption refrigeration system. In this work a software is developed for thermodynamic and transport properties using various correlations. Developed program can provide various thermodynamic and transport properties in the range from 273 K to 500 K in temperature and for mixture composition 0 to 75 wt% of LiBr aqueous solution. It can also provide properties in tabular form.

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E-COURT IN BANGLADESH : AN EMPIRICAL APPROACH

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Judicial court system is a vital portion of governance which is inescapable for developed country as well as for developing country like Bangladesh. However, from the placement of litigation to the discharge of a case, traditional court system confronts significant amount of time consumption and difficulty in maintenance like file management, rehearing, and date placement etc. This paper demonstrates an efficient electronic automated court system that will replace traditional court system entirely and will provide dramatic savings and improvements in the work of courts and practices of law. E-court system retains a central web-portal that incorporates authenticated public access with the case practitioners, regulators modules: Case Management System (CMS), Judiciary Automated Calendar System (JACS) and E-filing regarding all aspects of traditional system's functionality.

Key words: CMS (Case Management System), JACS (Judiciary Automated Calendar System), E-Filing, E-Governance, E-Docket.

1. INTRODUCTION

Democracy is the ever-most accepted egalitarianism worldwide which is getting its comprehensiveness with the advancement of modern technology. Leading governments, with high intention of democratic transparency and social security; leaning towards captivation of Information and Communication Technology (ICT). In this regard, a methodology is exercising over few last years in which general social people will be incorporated in all the government activities. Largely, this is termed as E-Governance [7]-[5]. E-Governance is a combination of all the automated government activities: E-billing, E-Tax, E-Transportation, E-court e.t.c where each activity attributed the same basic pattern. The design pattern of E-Governance is of three conceptual levels: Information (Data gather and disseminate), Interaction (Direct access of citizen and department) and Transaction (Information exchange and manipulation) [2].

For last few years, E-governance is an important issue of which Bangladesh government is mulling over. Several E-Governance sectors have already planned and financed to implement. In this paper we are concerned with the automated litigation,

court proceedings, court hearing management and all the other court doings by transposing the current system to automated computerized system, i.e. E-Court [4]. However, transforming the current court system to electronic doesn't replace the entire system. Through E-court, place litigation, court hearing date management, court trial can be performed using web-portal and automated court haring. There will be two types of court trials: Electronic; where every event will be maintained and monitored by video conferencing and LCD touch screen, and Conventional; here there the traditional court system will be kept intact except audio/visual recording and documentation. This paper demonstrates and proposes an E-Court system in details that is properly applicable in Bangladesh as well as any other country.

The e-court system will bring bright prospects to the parties involved and to the nation generally, and it will saves time, replace papers by digitalized all the documents This judicial system will be more efficient with improved transparency, and on the other hand, the public's level of access to the judiciary will increase, thus increasing their level of confidence in the judicial system. And by reducing the corruption of the case it will bring the perfect endings of the case.

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2. RELATED WORK OF E-COURT

By digging down the implementation and research of E-Court we can find out several countries as the pioneers to E-court: Australia, USA, Malaysia, Canada and currently in India. Nevertheless, most recently some European countries are showing high interest and determinism to establish E-court. The potential developments are exercising for the last five years over countries.

Jo Sherman and Allison Stanfield explained the mechanism of E-court integration in Australia in a paper titled "*Federal Court of Australia: e-Court Integration Project*". Australia first established its electronic courtroom in early 90's in which automation was limited to court system and database products and display technologies was handled by the programmer in house. Such system was highly customizable and programmers were employed by a governing body Director of Public Prosecution (DPP) [3]. To keep the uniformity, DPP routinely supplied the trial result through CD-ROM to other court to conduct the trial. However, this system was economically unsustainable and unfeasible. In 1998, Australia deployed a unique E-Court system with the help of skilled programmers and setting new technologies. The only difficulty was that there was lack of standards. Finally, standardized protocol was set regardless of technology usage among the courts [3]-[4]. The diversity of different data and presentation formats that was used by the law firms and courts came down the shade of homogenous identity. Besides, these protocols was deposited in a way that will help any e-court system thought the world to share and access of data resided in any provincial court of a country. The success of the top ten law firms focuses the luster of the developed system. It is noteworthy that similar protocols are now using almost all the e-court developed countries including UN. The paper "*Implementation of a leading edge eCourt in Australia*" by Sandra Plotter demonstrated the prominent steps undertaken for gradual shifting of e-court establishment.

"*Prospects and challenges of E-Court in Malaysia*" by Ani Munirah Mohamad explains the developments and challenges of e-court integration in Malaysia. The courts in Sabah and Sarawak have been reported to engage in the e-court system. The New Commercial Courts (NCC), equipped with a computerized system, will allow for electronic filing and tracking of cases, video recording and monitoring of trials and SMS text alerts for interlocutory hearings [8].

Some district courts of India came under the automation system. The Delhi High Court (HC) has introduced the first e-courtroom in India by replacing the paper files with a sleek LCD screen and a touch screen handbook and digitalized all of the documents [1]-[2]. The LCD touch screen was used by the judge to make corrections and certified the copy using his digital signature. It is also considering recording the statement of witnesses through video-conferencing to avoid procedural delays. "*Towards excellence in e-governance*" by Saxena, K.B.C. outlined the strategy of Indian automated e-court integration.

USA already established the e-court system in some parts of the country where the e-hearing, video and audio conferencing facility is available. The court of Arizona, New York and Virginia are the most successful among them.

3. IMPORTANCE OF BUILDING E-COURT

3.1 Traditional court system

To fathom the intensity of the E-court system we first have to understand the court system in hand. In the perspective of Bangladesh, there are several steps from court litigation to the court proceeding:

- a) The plaintiff prosecutes against a defendant through the lawyer.
- b) A complex procedure is to maintain a hearing date for trial by the attorney. The attorney place a date after being confirmed of the availability of the Judge, Magistrate, Police, court reporters and interpreters.
- c) Police will take legal action if the defendant is convicted.
- d) The defendant will seek and pick an attorney and will ask for a rehearing date to the attorney.
- e) The hearing may continue over and over by placing if a trial failed to meet the result.
- f) After each hearing all the results are well documented which are elemental for the next trial.

3.2 Importance of E-court

There is multifarious importance of electronic justice system over traditional system. The fundamental steps composed above, requires a lot of persons and practical bustle which can be mitigated at least up to 60% depending on the structure and construction of the e-court system. Moreover, for a third world country it is largely difficult to have a proper justice if the plaintiff does not possess good economical solvency. In essence, corruption of implicated bodies can be a significant obstruction for apposite judgment. The paper documents that play a vast majority role can be

modified intentionally and thus can invert the flow of jurisdiction. It is fascination of the technology where corruption can be potentially suppressed providing righteousness to the people satisfaction.

E-court system supports an automation system for the court where any kind of electronic hearing by using video conferencing facilities and online dispute resolution proceedings may be carried out by judges, whilst the parties are not physically present at the place.

This automated system is available for 24 hours a day, 7 days a week. E-documents can make out of touch and secure with proper authentication. Electronic justice system provides direct access to all the parties of documents and transcripts processed after the trial. Judges and Magistrates and other authenticated personnel can download and visualize the recorded audio-visual documents that can help in motivation and predetermination for upcoming court proceedings.

Besides, general people have intense inquisitiveness to the court proceedings. Automated E-court system can contribute to the international criminal activities. As long as there is standardized data format for all e-courts throughout the world, important historical data can be exchanged between local courts and international tribunals. This is far convenient when an international judge with sufficient authentication can download all the information of an offender within the blink of an eye.

E-court will be the best resort for any kind of cyber crime. With the increasing demand and usage of technology in our diurnal deeds, cyber criminals are trying to find the glitch of the web and taking the advantage of the fault. Spoofing and spamming e-mail, database and website hacking, stealing secret information are the most wearisome and anxious incidents in the cyber world. After the transplantation of the E-court with current system, all the personnel will be intelligent enough to handle such crime electronically.

4. PROPOSED E-COURT SYSTEM

Our proposed mechanism is to establish a technology incorporated court system where there is a web-portal and central database management system. Parties involved in any case can govern and conduct their regular court activities having the information from the database using the web-portal. Updated information and data can store back to the database. Along with the conventional irrevocable

tasks there are three interrelated basic parts that integrate the E-court system.

1. CMS (Case Management System).
2. JACS (Judiciary Automated Calendar System).
3. E-Filing.

4.1 Basic E-court System

Every person or group that is the participant of the E-court system (Fig.1) is called a party. Party should be identified in our system with unique identification number (ID). ID is provided against an existing unique number which will be NID (National ID) in the case of single person and Reg. No. (Registration Number) for corporate body. All the lawyer, attorneys, court reporters, interpreters, judges and magistrates should be registered as system user with associated privilege. Information about the party and system user will be comprehensive. If there is an existing E-governance where data about each citizen is pre-stored, E-court system can retrieve information otherwise data with all the sufficient information along with the photograph and NID will have to supply to the system. There should be an unbiased governing body (super system administrator) that would be responsible to delegate proper authentication to all the users. As a result, highly privatized web-portal area should be secured and prevented. There is a distinct information history to keep the records metadata i.e. the information about record; the time of record entry in the database, the time of modification, party by whom the record entered / modified. This solidifies the systems integrity and cohesiveness. There will be no way out for a hacker or moulder to be remain intractable.

A plaintiff places a litigation using the web-portal with details information. Being sponsored by an attorney, plaintiff should be included in the attorney's supervision list. He/She will confirm the litigation to progress to the court. It is the job of the attorney to manage a hearing date using the JACS. Being confirmed a trial date a tribunal is ready to proceed to CMS. Necessary documents will come from the E-filing. CMS may face multiple hearing dates. Each hearing date's proceedings are similar. After each CMS process, audio/video recording of trial would be uploaded as a process of E-filing.

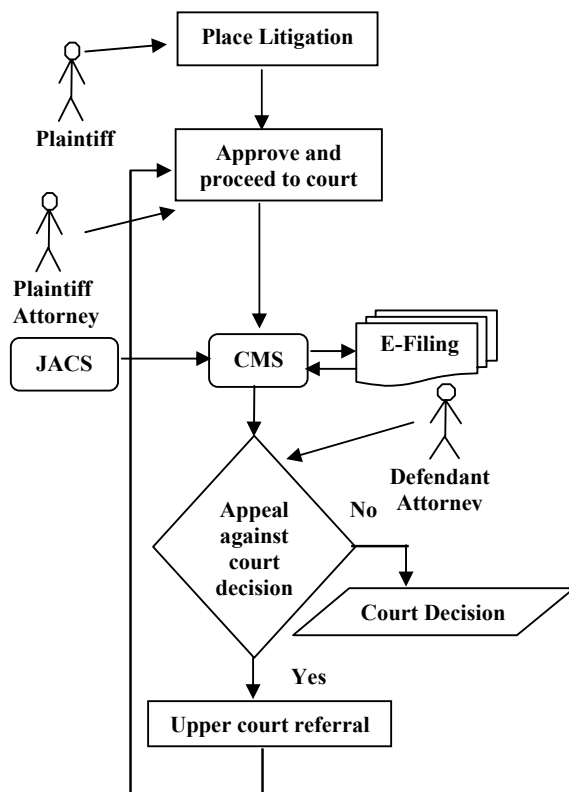


Fig. 1: Activity of E-court System

A defendant may protest against a court decision and consign an appeal by its attorney. In that case, the case may reprocess to the upper court tribunal. Depending on the proceedings a case may be cancelled, postponed or in favor of any involved party. Such a case status can only set by the case judge. E-docket that holds the entire lawsuit's history including its proceedings reports in different courts will be available in E-Filing and is accessible for absolute authorized person.

4.2 CMS (Case Management System)

CMS is the nucleus that links all the other limbs of our proposed E-court system [3]. The role play of any case is the CMS. Nevertheless, a case may be placed and an initial investigation may be done by the police department, it is CMS (Fig. 2) where the parties rely to reach to an end of the case. Sponsor attorney of a plaintiff will manage a trial date by the JACS (Judiciary Automated Calendar System) [3]-[4]. Being set a trial date and confirmed relevant people's availability, a CMS takes place. A trial place will be preoccupied by audio visual equipments. Court proceeding will be recorded and uploaded in the system. Not only this will ease the job of the judges, attorneys but also offer flexibility of access to these files even at home. Judge will

make decision in presence of attorneys, magistrates and polices and plaintiff. A trial consequences an investigation. Successful investigation consequences criminal action.

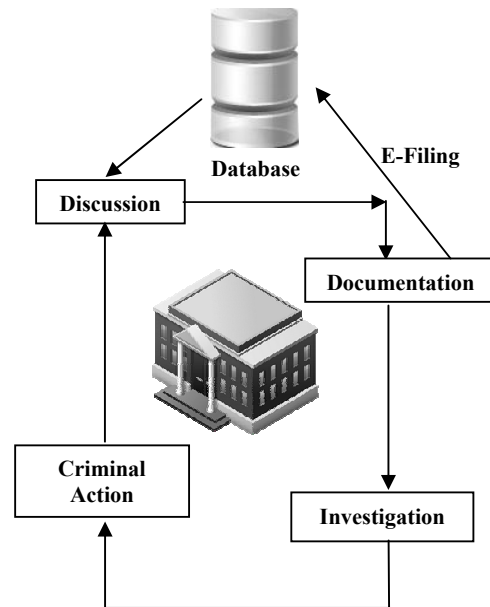


Fig. 2: CMS (Court Management System)

Documentation is the process of E-filing after a discussion. E-docket and audio/visual recording and other necessary documents are among documentation.

4.3 JACS (Judiciary Automated Calendar System)

Scheduling attorney of the plaintiff schedules for an available hearing date. JACS [3] is intelligent enough to deliver an available hearing date for the trial. Attorney only needs to supply the judge, magistrate, interpreters, court reporters and opposing counsellor's identity. JACS will hunt for the near-most available trial date regarding the availability of the supplied people. Scheduling attorney may assign or reject the available date. In case of rejection, He/She may choose an available manually by searching obligatory personnel availability. Several tasks (Fig. 3) need to be completed by scheduling attorney. Following depiction (Fig. 3) figures out JACS and its operation:

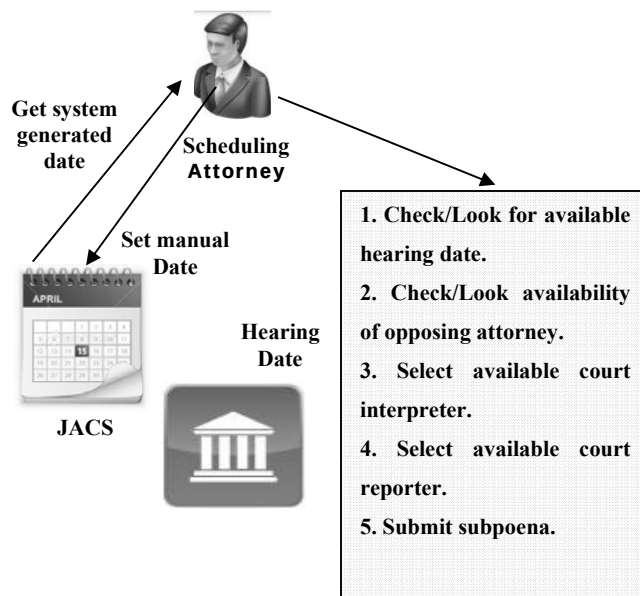


Fig. 3: Operational JACS

4.4 E-Filing

E-Filing [3]-[4] (Fig.4) is a process of updating the database of particular case with every trial's information. Audio and video of each hearing is recorded. Audio transcription and digitalized video is synchronized and archived. Accurate disk cataloguing and indexing information is stored in the database. When a system user want to retrieve files of a specific case via web-portal, list of files along with the audio/visual recording are showed up. To record audio/visual hearing, court system is preoccupied with camera, audio recorder and ADC converter and synchronizer.

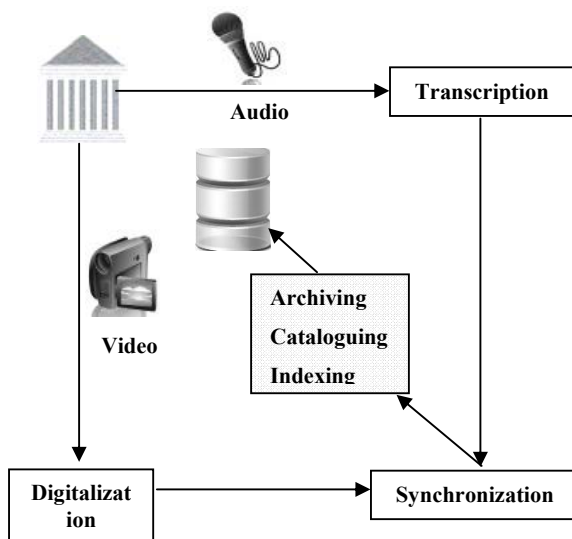


Fig. 4: E-Filing

5. CONCLUSIONS

Our cogent proposed mechanism leads us to a precise conclusion. This system can easily be established with marginal setup expense and lower maintenance cost. In essence, to keep pace with technological transformation of E-governance throughout the world, it is inescapable to automate the conventional court system. Furthermore, this proposed system is comprehensive enough to keep the consideration of local court system and to exchange of data with international E-court systems. Future trend of our proposed mechanism is to make highly data exchangeable and functional web-portal and operate a pilot project under a sponsorship.

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INTERFACE DESIGN OF A CLIENTS-SERVER DISTRIBUTED SYSTEM

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This paper is based on the interface design of a distributed system that involves clients and one server. Two different write-information clients exert separate signatures to their message lines in message queues and write these messages in blocks to a single message file. The server takes note of the signatures, extracts the appropriate blocks from the file and displays them in its interface under two categories of information. Two corresponding read clients extract their appropriate information from the single file and display their particular information separately in their interfaces. The idea behind this project is to present a distributed system and the message transfers that can take place among clients and server through the usage of message queues, signed messages, threads and a message file all incorporated into one system which previous papers have not demonstrated. The designed system stands out to be a useful and knowledgeable experiment not only for academic purposes but also in respect of research as it demonstrates how all the components taken into account together can work in harmony in a step by step manner and on which further future work can be carried out.

Keywords: Distributed system, Threads, Message queues, Signature, Clients-Server interaction

1. INTRODUCTION

A distributed system is defined to be a collection of independent computers that appears to users as a single coherent system. In other words, the distributed system is organized as a middleware. The middleware layer extends over multiple machines, and offers each application the same interface. The goals of distributed systems are to connect users and resources and offer distribution transparency, openness, scalability and security. [5]

The work outlined in this paper is based on the interface design of a distributed system that has been implemented in C Sharp using Microsoft Visual C# 2008 Express Edition editor. The experimental work involves the usage of threads along with message queues, signed messages and a message file all incorporated into a clients-server system, something which previous papers have not approached. There are four clients and one server in the system. The server will receive text messages from a parts write client interface that submits parts information of company products and also receive messages from an address write client interface that submits addresses of customers. Message transfers from these clients to the server take place via

signed messages with the help of message queues separately. The write clients write these messages to a single file and the server extracts the parts and addresses messages from the file via two threads, one for each type of message and displays them in its separate list boxes. Two read clients will extract parts and addresses message information in list boxes respectively on demand.

Section 2 describes the traditional way in which clients connect with the server. The next section explains the importance of threads and how the designed system uses threads to maintain synchrony among the clients and server. Section 4 goes on to demonstrate how message queues exert signatures on messages sent from the write clients, how they assist in transferring these messages to the server side and how the server segregates the two type of messages and displays in its interface under separate categories. The next section shows how two read clients extract the content of the messages on demand. Section 6 demonstrates the snapshots of the message file, clients and server interfaces and how they all work together in harmony in a step by step manner. The paper ends on a concluding note of the work achieved in this experiment and the scope for future work.

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2. CLIENTS-SERVER CONNECTION

The Client Server model is usually based on a simple, connection-oriented request/reply protocol. The client sends a request and gets an answer. The reply message serves as the acknowledgement to the request. [6]

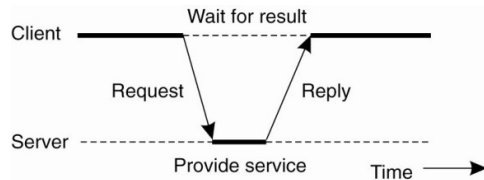


Fig. 1: General interaction between a client and a server

Each client binds to the server through a communication endpoint called socket. The socket listens and binds to a local IP address. The server waits for requests and finally accepts client connection request. Each client gets remote IP address and connects to remote server host via socket. [5]

Writing data from the server to a client's interface is equivalent to sending some data to the client and displaying in the client's interface and vice versa. Reading data from a client means receiving data from the client to the server and displaying in the server's interface and vice versa.

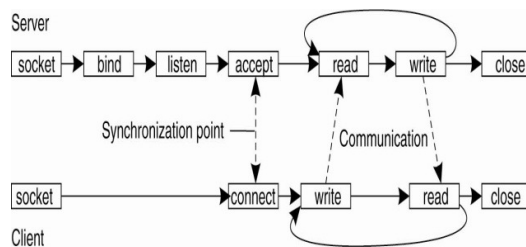


Fig. 2: Connection-oriented communication pattern using sockets

3. USAGE OF THREADS

Threads are like little mini-processes that were invented to allow parallelism to be combined with sequential and blocking system calls. Blocking system calls make programming easier and parallelism improves performance. [6]

In the designed system, two user threads are created. One is used so that the server can read

parts message blocks from a single message file to which the parts write client writes. The other thread is for the server to read address message blocks from the same file to which the address write client submits address messages.

Using threads this way, a synchronous order is maintained in which the two types of write clients write to the message file along with the server reading from the message file and displaying their messages in its interface. Otherwise without the usage of threads this harmony is impossible to achieve.

4. INTERACTION BETWEEN WRITE CLIENTS AND SERVER

Asynchronous persistent communication is achieved through the support of middleware-level message queues. Queues correspond to buffers at communication servers. Basic interface to a queue in a message-queuing system is summarized in the following table. [5]

Table 1. Basic interface to a message queue

Primitive	Meaning
Put	Append a message to a specified queue
Get	Block until the specified queue is nonempty, and remove the first message
Poll	Check a specified queue for messages, and remove the first. Never block
Notify	Install a handler to be called when a message is put into the specified queue

In the system parts write client before sending its message to parts message queue adds a signature "Queue1" to parts message line to differentiate it from address message blocks. Similarly address write client adds the signature "Queue2" to address message line to differentiate it from parts message blocks.

//Signature "Queue1" is added to parts message to differentiate from address message blocks

```

partsItems.Message="Queue1"+String.Format("\r\n")+"Part Desc " + part_desc_txt.Text + String.Format("\r\n") + "Quantity " + qty_txt.Text + String.Format("\r\n") + "Part No " + part_no_txt.Text + String.Format("\r\n")+ "Price per Each " + price_each_txt.Text;

```

```
mq.Send(partsItems);
```

Code 1 [2]: Addition of signature to parts queue

Parts queue writes parts messages to a message file from which the server attempts to read via a thread. Similarly address queue writes address message

blocks to the same file from which the server once more attempts to read via another thread. From this single file, the server checks if a block begins with the signature “Queue1” or Queue2”. If the block begins with Queue1 the server extracts it from the file and displays it in its parts list box. If a block begins with Queue2 the server extracts and displays in its address list box. The write clients can send messages to the server side in any order.

//creates an instance MessageQueue, which points
//to the already existing MyQueueParts

```
if(MessageQueue.Exists(@"\Private$\MyQueueParts"))
    mq1=new System.Messaging.MessageQueue
        (@"\Private$\MyQueueParts");
else
    //creates a new private queue called MyQueueParts
    mq1=MessageQueue.Create(@"\Private$\MyQueueParts");
    mq1.Formatter = new System.Messaging.
        XmlMessageFormatter(new Type[]{typeof
            (WriteItems)});
while (true)
{
    System.Messaging.Message m1;
    // checks if parts queue mq1 has messages
    m1 = mq1.Peek();
    System.Messaging.Message msg1 =
        mq1.Receive();
    WriteItems outputItems =
        (WriteItems)msg1.Body;
    //Writing messages from parts queue to file
    using (StreamWriter sw1 = new
        StreamWriter(outputItems.FileName, true))

        { sw1.WriteLine(outputItems.Message);
          sw1.Flush(); }

    using(StreamReader sr1 = new
        StreamReader(outputItems.FileName, true))
    { int queue = 0;
      string line1;
      //Read from the file and display parts queue
      //message blocks in server's parts list box until the
      //end of the file is reached

      while ((line1 = sr1.ReadLine()) != null)
      { if (line1.StartsWith("Queue1"))
          { queue = 1;}

        else if (line1.StartsWith("Queue2"))
          { queue = 2;}

        else if (queue == 1)
          {
```

```
Client_Parts_Records.Items.Add(line1) ;
        }
    }
}

mq1.Close();
```

Code 2 [4]: Interaction between parts write client and server

5.INTERACTION OF READ CLIENTS IN THE SYSTEM

Parts read client reads four lines at a time from the single file that the parts write client has previously written to. The read client checks if this block starts with the signature “Queue1”. If it does, the client extracts it and displays it in its interface’s list box. The same goes for the address read client which will check if a block starts with the signature “Queue2”. The read clients can read messages in any order.

```
String buffer;

using (StreamReader stream = File.OpenText
    (@"C:\rsk8332\Project2\Server\Msg.txt"))
{ buffer = stream.ReadToEnd(); }

//Stores into each index of lines array the individual
//fields and their values of parts block

string[] lines = buffer.Split(new string[] { "\r\n" },
    StringSplitOptions.RemoveEmptyEntries);

string[] result = new string[4];

if (lines[i].StartsWith("Queue1"))
{
    //Copies into result 4 lines of each parts block
    Array.Copy(lines, i + 1, result, 0, 4);
    Client_Read_Parts_Records.Items.AddRange
        (result);

    i = i + 5;
}
else
{ i = i + 4; }
```

Code 3 [1,3]: Interaction of parts read client in the system

6. INTERFACE DESIGN SNAPSHOTS

Initially the message file to which the write clients write may have information as shown in Fig. 3.

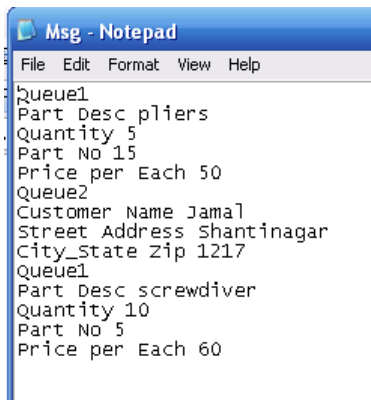


Fig. 3: Single Message File

Extracting information from the message file, the Server Graphical User Interface (GUI) when it is started shows parts and address information in separate list boxes as shown in Fig 4.

A “parts” block message is submitted via Parts Write Client GUI as shown in Fig. 5. An “address” block message is submitted via Address Write Client GUI in the same way. Accordingly, the Server GUI shows in its separate list boxes both newly submitted parts and address message blocks from the corresponding write clients by reading from the single message file as shown in Fig. 6. Parts Read Client GUI reads all the parts information from the single message file as shown in Fig. 7. Address Read Client GUI reads all the address information from the message file in the same way. The write and read clients can interact with the server via the message file in any order. In this way, message transfers take place during clients-server interaction in the designed system. This synchrony has been possible to achieve through the combined usage of a message file, threads, signed messages and message queues as explained in the earlier sections.

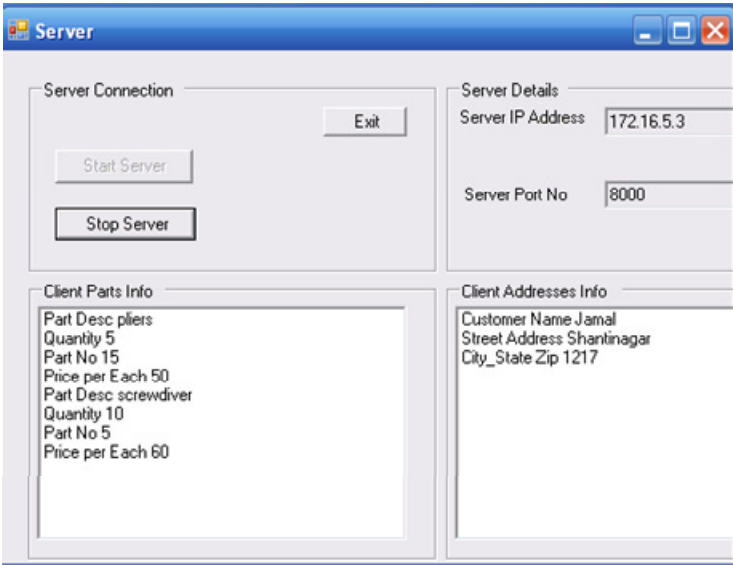


Fig. 4: Server Graphical User Interface (GUI)

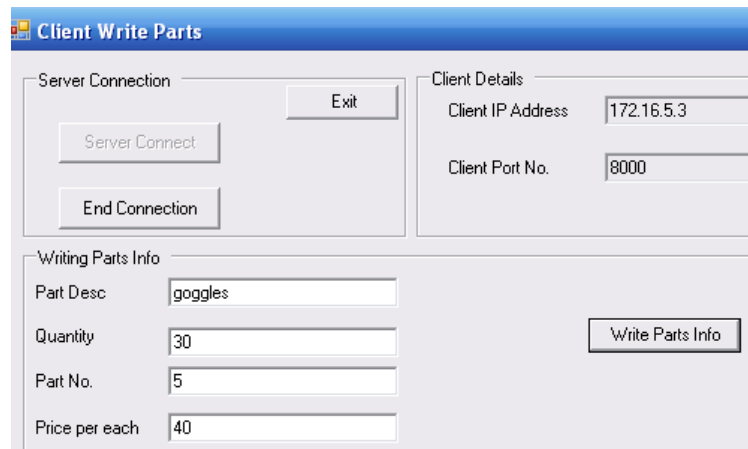


Fig. 5: Parts Write Client GUI

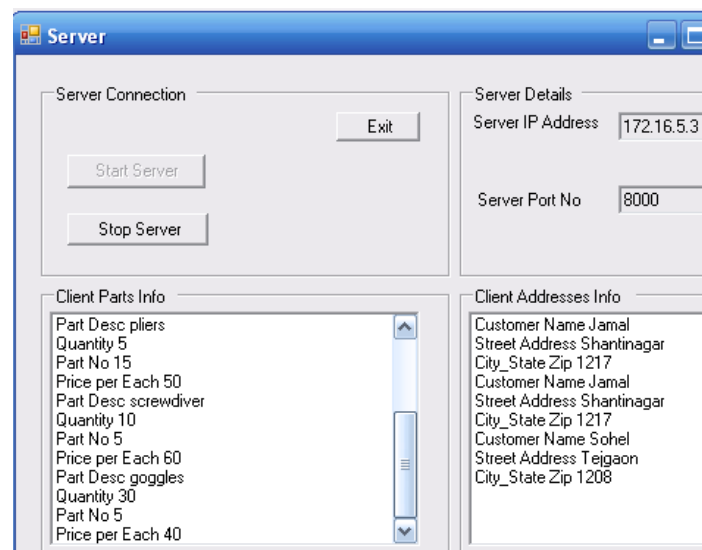


Fig. 6: Server GUI showing updated info

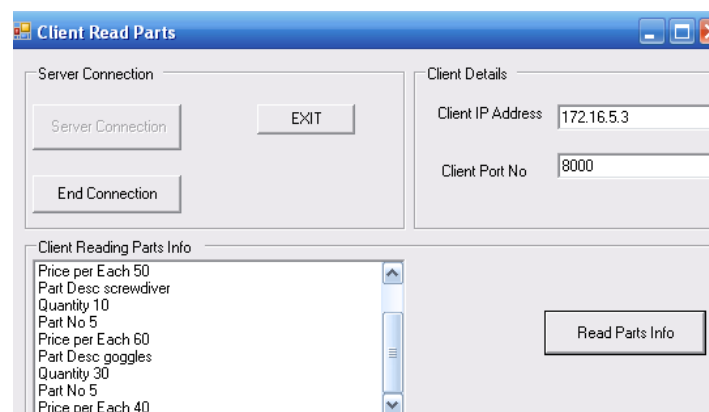


Fig. 7: Parts Read Client GUI

7. CONCLUSION AND FUTURE WORK

In the designed system, write clients use message queues to transfer their messages to the server end, while attaching signatures to the beginning of message lines with the server reading the messages from a file under separate threads and using the signatures to identify the message blocks while extracting them from the file, and while read clients can utilize the same signatures in the same file to extract their corresponding messages. This is the subtleness of the experimental work, the system's homogeneity details being hidden from a high level. Thus the use of signatures in message lines, a message file, message queues, the utilization of threads and overall clients-server interaction are components of the designed system which make the system a good and useful implementation, giving insights on distributed systems by taking into account the collective components working in a series of coordinated steps. The work can be extended for future scope to take into account issues of security such as encryption and authentication during transfer of messages between clients and server.

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Packing Non-Identical Circles in a Smallest Circular Container by Modified Monotonic Basin Hopping Heuristic Approach

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Abstract

Packing problems have mathematical as well as practical application point of interest. Monotonic Basin Hopping (MBH) heuristic approaches are successfully implemented for solving equal circles problems. For the presence of combinatorial part, unequal radii, simple extension of MBH approach is not the appropriate way to co-opt the problem of packing non-identical circles within a smallest circular container. Here, we present a modified Monotonic Basin Hopping heuristic approach to solve the problem. As well as some new perturbation moves are proposed which are suitable for the case of unequal circles packing problems. Extensive computational experiments have been performed for analyzing the problem as well as for choosing an appropriate way the parameter values for the proposed methods. We also performed several experiments to compared the traditional MBH with our proposed modified MBH (Sequential Insertion Based MBH). Several improvements with respect to the best results reported in the literature have been detected.

Keywords: Circle Packing, Monotonic Basin Hopping, Multistart.

I. INTRODUCTION

The problem of optimally placing N non overlapping and possibly of different size objects belonging to $\mathbb{R}^d$ within a smallest container is a classical mathematical problem and have a spectrum of application including production and packing for the textile, apparel, naval, automobile, aerospace and food industries, news paper, web pages design, in particular, to problems related to cutting and packing [1]. They are bottleneck problems in Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) where design's plans are to be generated for industrial plants, electronic modules, nuclear and thermal plants, etc [3]. In particular, we consider in this paper, the Non-Identical Circle Packing in a Circular Container (NICPCC) problems. The NICPCC problems can be described as follows:

Problem: To find the minimum circular container radius D_n which contains N non-identical and non-overlapping circles with given radii. Mathematically,

$$\min r \quad (1)$$

Subject to

$$x_i^2 + y_i^2 - r^2 + 2rr_i \leq r_i^2 ; \quad i \in I \quad (2)$$

$$(x_i - x_j)^2 + (y_i - y_j)^2 \geq (r_i + r_j)^2 ; \quad i, j \in I, i < j \quad (3)$$

$$\max(r_i) < r \quad (4)$$

This formulation has $2N + 1$ variables, one of which is the radius r of the container, to be minimized (1); $2N$ variables for the coordinates of the N circles (note that center of the container assume without loss of generality to be the origin). Equation (2) states that any circle C_i of radius r_i is totally contained within container C . There are N of these constraints, one for each circle C_i . While constraints (3) force circles C_i and C_j not to overlap. There are $N(N - 1)/2$ of these non overlap constraints. Equation (4) provides a positive lower bound for the radius of the containing circle. It substitutes the non-negativity constraint whose elimination from the model makes NICPCC unbounded. Although the objective (equation (1)) is linear and constraints (2) define a convex region, whereas constraints (3) are non convex (and, in particular, they correspond to reverse-convex constraints). It is pretty easy to see that, because of the non convexity, this problem is extremely hard to solve; even local optimization, in presence of reverse-convex constraints, becomes a hard task. Indeed, there exists no any an algorithm that is both rigorous and fast [3].

In comparison with the best known problem of placing identical circles in a smallest container, here the fact that each disk has a different radius generates new difficulties and challenges. In fact, while the problem with identical radii can be considered as a pure continuous optimization problem, here the fact that each circle has a different radius adds some sort of a combinatorial structure over the original one. This is an extremely challenging global optimization test problem. Hence researchers are searching for the efficient heuristic approximation algorithms to solve the problems. Here we proposed a modified Monotonic Basin Hopping (MBH), which is denoted as sequential Insertion Based MBH approach to solve the non-identical circles packing problems.

The proposed modified MBH algorithm is a three-phase Sequential Insertion Based Monotonic Basin Hopping (SIB-MBH) approach.

The *first* phase is to find out the “small” circles and removing them if any (temporarily). The second phase is minimizing the circular container by MBH approach, where the container containing the remaining (large) circles. The last phase is sequentially inserting the small circles which are previously removed (following a non increasing order of the radii) in the “holes” of the current solution (possibly by enlarging the radius of the circular container). Though Donovan and Specht independently present up dated results for identical circles packing problems in their web sites [4] and [5], there are no such benchmark results for packing non-identical circles in a circular container. For comparison of our proposed algorithm we consider the problems given in [6].

This paper is organized as follows. In Sect. II, we present a brief literature survey of circular packing/cutting problems focusing on papers dealing with circular containers. In Sect. III, we describe the three phases of the proposed algorithm and illustrate their mechanisms via examples. In Sect. IV, we evaluate, using a set of problem instances from the literature, the performance of the algorithm and compare the obtained results to those obtained in the literature. Finally, in Sect. V, we summarize the results and explain the possible extensions of the proposed algorithm.

II. RELATED LITERATURE

Though there is a long history of solving packing problems in literature, problems of non-identical circles in a minimized circle have received very little attention. Most published papers focus on packing identical circles [7 – 13]. Very few papers addressing the problem of packing non-identical paper; but most of them considered non-circular container like square container, rectangular container etc [14 – 16]. Below some approaches are pointed out for solving packing problems.

In [17] Fraser and George used a heuristic to pack circles into a rectangular container whereas in [14] George et al. used constructive rules (e.g., quasi-random and genetic algorithm) to mimic the packing operation.

Stoyan and Yaskov [18, 19] developed a mathematical model for packing different radii circles into a minimal length strip. They search for an estimate of the global optimum by an approximate exhaustive search of local minima using the reduced gradient method and the active inequality strategy. Correia et al. [20] proposed two new upper bounds for the problem. Hifi et al. [21] tailored a simulated annealing whose energy function provides, when assuming small values, a good packing of the circles on the left corner of the stock rectangle. Hifi and M'Hallah [22] proposed approximate

algorithms varying from constructive approaches to meta-heuristics such as genetic algorithms. Huang et al. [23] proposed two greedy algorithms which use a maximum hole degree rule and a look ahead search strategy. Hifi and M'Hallah [24] proposed adaptive and restarting techniques based approach for circular packing problems. Addis et. al [25] proposed a heuristic approach to solve unequal circle packing problems. Addis et. al [12] investigated the problem of packing equal circles in the unit square and proposed a quite successful method (MBH) for the problem. Jamali et. al. [26] also used MBH approach to solve identical circles in a circular container rather than square container. It will be worthwhile to mention here that, this approach has been able to improve a large number of solutions which are updated at [5]. Finally, a survey about this problem can be found in [27], and a recent book has been dedicated to the subject [28].

III. PROPOSED MODIFIED MONOTONIC BASIN HOPPING ALGORITHM

In Section (I) we have discussed about the mathematical formulation of NICPCC problems. As the problem is a NP-hard global optimization one, the number of local minimizers tends to increase quite quickly with the number n of circles. When dealing with global optimization problems for NP-hard problem, an obvious and simplest approach is the Multistart (MS) one. In such an approach we simply start different local searches from randomly generated initial points and return the best local minimizer. However, the rapid increase in the number of local minimizers suggests that Multistart can not be an efficient method for this problem [24, 25]. The method MBH is quite close to Multistart (they are both based on multiple local searches and they only differ in the mechanism for the generation of the initial points) but at the same time also dramatically more efficient than Multistart. In the field of global optimization such method has been (to the authors' knowledge) first applied to molecular conformation problems (see [29]) under the name of Monotonic Basin Hopping (MBH).

In order to deal with the case of non-identical circles one may think to extend the approaches employed for the case of equal circles with a slight variant in the perturbation moves: for instance, for the Full Jerk (FJ) perturbation strategy the coordinates of each circle i are displaced by a uniform random perturbation within the interval $[-\Delta_{ri}, \Delta_{ri}]$, where ri denotes the radius of circle i (for Random Perturbation Jerk (RPJ) and Fixed Perturbation Jerk (FPJ) the displacement is restricted to a subset of circles) [24,25]. But, as we will see through some experiments, this simple extension is not the best way to tackle the problem. Indeed, the case of non-identical circles has some peculiarities which have to be taken into account. The combinatorial side of this problem, represented by the different radii of the

circles, can (and actually should) be exploited in some ways. In particular, we will propose a three phase modified MBH approach where the algorithm optimize a fraction of relatively larger circles, and then insert one or a part of the remaining smaller circles sequentially and simultaneously optimize them.

At first we discuss the strategy based on first removing and later re-inserting “small” circles. The basic idea is that, once a configuration with large circles is available, we can easily find some room for the smaller circles within the circular container without having to enlarge the radius of the container, or by only mildly enlarging it. Having removed “small” circles, we have the advantage of dealing with a smaller and simpler problem.

The technique is rather simple. First we select some circles to be removed; then, we apply MBH on the reduced set of circles; finally, the algorithm sequentially inserts the missing circles (following a non increasing order of the radii). In what follows we define this approach as Sequential Insertion Based MBH (SIB-MBH). The new procedure, which exploits the different radii of the circles, performs the following steps:

- (a) apply the Removal Strategy to remove “small” circles;
- (b) apply MBH on the remaining subset of larger circles;
- (c) apply Insertion Rule for sequentially inserting the missing circles.

Besides all components of the MBH approach, there are two further components in this new approach namely (i) Removal Strategy (RemS) and (ii) Insertion Rule (IR). Before giving a formal description of SIB-MBH, we describe these below.

(i) Monotonic Basin Hopping :

At first we would briefly discuss about Monotonic Basin Hopping (MBH) procedure (for more details you are referred to [12, 26]. The main ingredients of the MBH procedure are: (i) Initialization (Init), (ii) local search procedure (LS), (iii) perturbation move (PM), (iv) Acceptance Rule (AR) and (v) stopping rule (SR). Let operator τ and ξ denote LS and PM respectively. Also let $f(X)$ denotes the objective value of the configuration X . Then the pseudo code of MBH approach is as follows:

Monotonic Basin Hopping

Step 1 : Let X_0 be randomly generated initial solution

// Initialization procedure

Step 2: Let $X := \tau(X_0)$ be a local minimum

// local search procedure

While SR not satisfied

Step 3 : Let $Y := \xi(X)$

// perturbation procedure

Step 4: Let $X := \tau(Y)$

// local search procedure

Step 5: If $f(X') < f(X)$, then $X := X'$

// acceptance rule

EndIf

EndWhile

Return X

(ii) Removal Strategy (RemS): It is observed from the experiments that small circles are sometimes relatively easily inserted in holes of optimized configurations for some subset of the larger circles without having to enlarge the container or with just a small enlargement. According to our Removal Strategy, circles are indexed in decreasing order with respect to their radius. Then, a fraction of “small” circles is removed.

Of course, we need to define what a “small” circle is. We define a circle i

as a small circle if its radius is at least four times smaller than the largest one,

i.e., circle i is small if

$$r_i \leq \frac{1}{4} \max_{j=1,2,\dots,n} r_j \quad (5)$$

Let us denote the set of initially removed circles as S_R ; then

$$S_R = \left\{ i, : r_i \leq \frac{1}{4} \max_{j=1,2,\dots,n} r_j \right\} \quad (6)$$

This strategy strongly simplifies some instances of the problem through a considerable reduction of the search space during the first phase where some circles are removed.

(iii) Insertion Rule (IR):

In the insertion process of a given circle c_s in S_R , first the algorithm creates a regular grid of points over a square region containing the circular container. The step of the square grid is half of the inserted circle’s radius. The edge length of the square region is the sum of the diameter of the container and the radius of the circle to be inserted, so that the circular container, which is optimized previously by the reduced circles, is fully enclosed within the square (both have the origin as their common center). Next, the algorithm searches for “free” spaces where to insert circle c_s . Given a point (x_i, y_i) over the grid, we declare the space around it as free, if its distance from the other circles’ centers is at least equal to r_s , the radius of the circle to be inserted. In other words, if we place circle c_s with center in point x_i, y_i over the grid, the other circles’ centers are not in the interior of such circle. Note that at least one free space certainly exists. Indeed,

according to the above definitions, all the corners of the square certainly correspond to free spaces. It is worthwhile to note that the definition of “free” space does not mean that the space is large enough to contain circle c_s with no overlap with the other circles: a partial overlap is permitted and, actually, if the circle to be inserted is small compared to other circles, then even full overlapping may occur during the insertion process.

It may also happen that the new circle is not fully (or even not at all) contained in the circular container. In spite of this partial or full overlap with other circles and of the possibility of crossing the border of the circular container, a local search procedure started at the new configuration with the added circle is able to adjust it in such a way that no overlap occurs without enlarging the radius of the circular container or with an as small as possible enlargement of such radius.

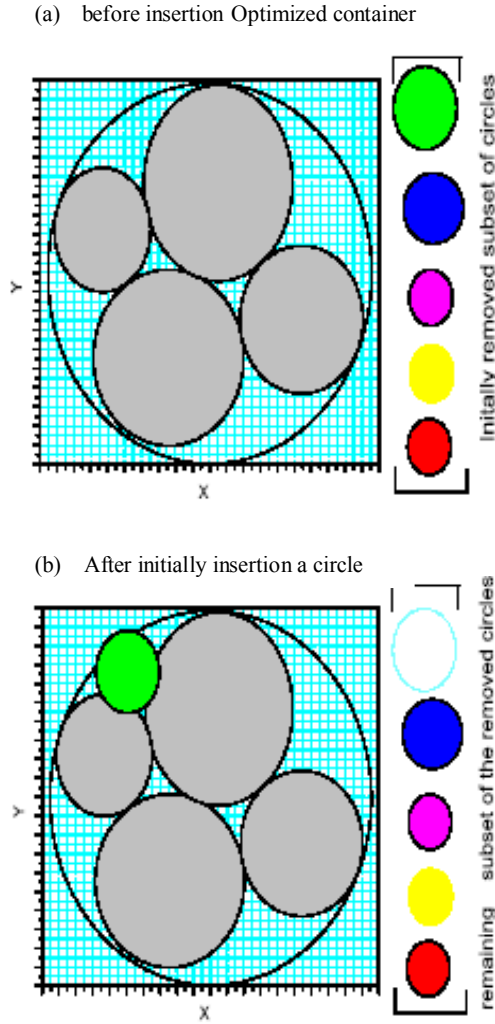


Fig. 1 Illustration of Insertion Rule

We may illustrate the Insertion Rule by Figure 1. Suppose we have 9 unequal circles in which 5 circles are “small”. So after that we have found a configuration with the four larger circles by any algorithm like, e.g. MBH (Figure 1(a)), next the insertion algorithm searches for a space in the given four-circle configuration by exploring the grid of points to insert the remaining largest circle (green color) in S_R . Once the algorithm finds a “free” space, it picks up the green colored (largest) circle from the set S_R and places its

center at the point of the grid where a “free” space has been detected (see Figure 1(b)). Notice in Figure 1(b) that the inserted circle partially overlaps with some of the other circles and also crosses the border of the container circle. After having detected a “free” space, the algorithm starts a local search from the newly created configuration in order to remove possible overlaps and reduce as much as possible the radius of the circular container. The algorithm is stopped when all free spaces have been tested. The new configuration with the added circle will be the one with the smallest radius of the circular container. In case during the search a configuration is detected with the same radius of the circular container as before the addition of the circle, then the algorithm stops returning this configuration. Once the new configuration is returned, the algorithm removes the added circle from S_R , selects the next largest circle in S_R (the blue circle in the example), and repeats the above procedure until S_R becomes empty. The pseudo-code structure of the insertion rule (I_R) starting from an initial configuration X and trying to add circle s is as follows ($\square$ denotes the local search procedure, while function f returns the radius of the circular container for a given configuration):

```

 $I_R(X, s)$ 
Step 1 (Init) Set  $\min_{\text{rad}} = +\infty$ 
Step 2 (Grid): create a regular grid  $T$  on the square region containing the circular container
For each  $(x_i, y_i) \in T$ 
    If the space around  $(x_i, y_i)$  is “free” Then
        Set  $Y = X \cup (x_i, y_i)$ 
        Set  $X' = \square(Y)$ 
        If  $f(X') < \min_{\text{rad}}$  Then
            Set  $X^* = X'$ 
            If  $f(X') = f(X)$  Then
                return  $X'$ 
EndFor
Return  $X^*$ 

```

Once we have defined the insertion procedure, we are ready to give a formal description of the whole algorithm:

Sequential Insertion Based MBH :

```

Step 1(RemS): remove the set  $S_R$  of all the “small” circles
Step 2(MBH): Apply MBH on the reduced problem.
    Let  $X$  be the outcome of MBH
    While  $S_R \neq \emptyset$ 
        Let  $s \in \text{argmax}\{r_i : i \in S_R\}$ 
        Set  $X = I_R(X, s)$ 
        Set  $S_R = S_R \setminus \{s\}$ 
    EndWhile
Return  $X$ 

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In the above algorithm MBH can be easily substituted by any other algorithm returning a configuration in the reduced space.

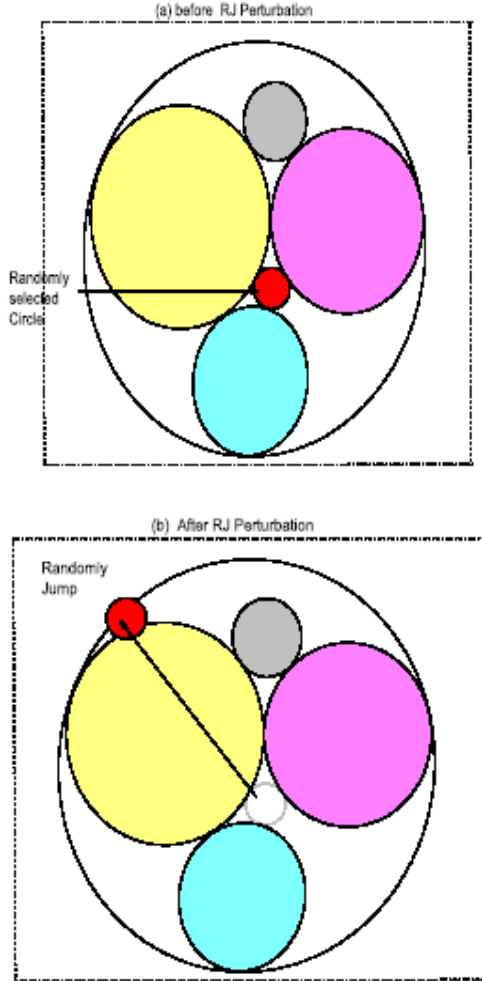


Fig. 2 Illustration of RJ perturbation move

A. Perturbation move

Now we will discuss about the main component of MBH approach i.e Perturbation Moves (PM). The main difference between Multi-start (MS) and MBH is the technique of generation of initial solution of each Local Search (LS). We know that, in MS, the initial solution of each LS is randomly generated. On the other hand in MBH, only the first initial solution X_0 is generated randomly within large enough region, R_{reg}^2 , and all the other subsequence initial solutions of LS are generated by the PM, a simple but efficient procedure. Note that, as our problem can be viewed as a non-convex one with objective and constraint functions continuously differentiable infinitely many times, so any local search method for this kind of problems can be employed. However, our past experience (see [12, 25]) suggests that SNOPT [30] is particularly well suited for these problems.

One of the keys of the success of the existing MBH method is often the perturbation move. A good rule is to choose it in such a way that the structure of the current local minimizer is not completely disrupted. The basic idea is that the method should move between different but “close” local minimizers. In the case of equal circles we proposed three very simple perturbation move, based on a uniform random perturbation of each coordinate of each center of the circle within some interval $[-\Delta, \Delta]$ [25]. In particular, here we propose two further perturbation moves namely (i) the Random Jump (RJ) perturbation move and (ii) the Radius Based

Random Swap (RBRS) perturbation move which are mainly suitable for the unequal radii. The former could actually be employed also with equal circles (in fact, we will see that it is basically equivalent to the Jerk Perturbation move but less “local” [25]). The latter can only be employed with unequal circles.

Random Jump (RJ) perturbation move:

In the Jerk Perturbation (JP) [25] move technique circles’ centers are perturbed within a neighbor space. The proposed Random Jump (RJ) perturbation move is actually quite similar: circles are randomly selected but rather than being slightly perturbed, they can jump within a large region (actually, in some sense the JP move can be regarded as a special case of the RJ perturbation move, in which only small jumps are allowed). Figure 2 illustrates the move. In Figure 2(a) we have a locally optimal configuration. In the example the RJ perturbation move randomly selects a single circle (the red one in the figure). Then, after the RJ perturbation the new configuration is displayed in Figure 2(b). Notice that the red circle jumps within a square region whose edge is $\sum r_i$ and is delimited by the dotted line in the figure, but crosses the border of the container and also overlaps with another circle. As usual, the local search procedure adjusts all the circles so that no overlaps occurs, and the circular container in such a way that its radius is as small as possible. The pseudo-code of the RJ perturbation moves is given below (the value of B_R , the diameter of the square boundary, is fixed to $\sum r_i$):

The pseudo-code of the RJ perturbation

```

Step 1: Let  $Z = \{(z_{11}, z_{12}), \dots, (z_{n1}, z_{n2})\}$  be a local minimum and set  $Z' = Z$ 
Step 2: select  $\Delta n \in (1, n)$  randomly
do  $i = 1$  to  $\Delta n$ 
  Step 3: select  $\square \in \{1, \dots, n\}$  randomly
  Step 4: select  $\Delta z_{\square k} \in (-B_R, B_R)$  randomly
  do  $k = 1$  to 2
    Step 5: set  $z'_{\square k} := z_{\square k} + \Delta z_{\square k}$ 
  end do
  Step 6: set  $Z' = Z' \cup \{z'_{\square}\} / \{z_{\square}\}$ 
end do
return  $Z'$ 

```

Radius Based Random Swap:

In the Radius Based Random Swap (RBRS), first one or few pairs of circles are selected in such a way that in each pair the radii of the two circles are different (it will be soon clear that if two circles in a pair have the same radius, then the RBRS perturbation is meaningless). Then, we keep fixed the centers of the circles but swap their radii. For illustration, let Fig. 3(a) represent a local optimal configuration; let the red and blue circles form the randomly selected pair. Then, after RBRS perturbation the new configuration is given in Fig. 3(b). Notice that after swapping the radii, overlaps between circles occur and the red circle gets (slightly) outside the circular container. As usual, the local search procedure will adjust the situation in order to recover a feasible solution.

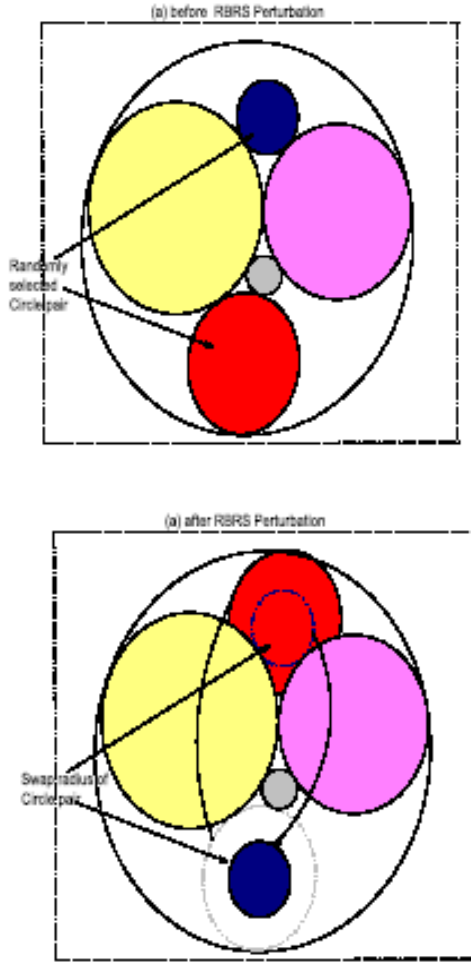


Fig. 3. Illustration of RBRS perturbation move

The pseudo-code of the RBRS perturbation move is given below:

The pseudo-code of RBRS perturbation

```

Step 1: Let  $Z = \{(z_{11}, z_{12}), \dots, (z_{n1}, z_{n2})\}$  be a
        local minimum and set  $Z' = Z$ 
Step 2: define  $\Delta n \square (1, n/2)$ 
        randomly/deterministically
Step 3: randomly select  $\Delta n$  distinct circles'
        pairs  $(i_k, j_k)$ ,  $k = 1, \dots, \Delta n$  so that  $r_{i_k} \neq r_{j_k}$ .
do  $k = 1$  to  $\Delta n$ 
    Step 4: swap the two radii  $(r_{i_k}, r_{j_k})$ 
End do
return  $Z'$ 

```

The choice of this parameter will be computationally investigated in Section IV.

IV. COMPUTATIONAL EXPERIMENTS AND DISCUSSION

In this section we will perform some experiments to investigate different issues. In particular we will study:

- the performance of the proposed perturbations;
- the performance of the Sequential Insertion Based MBH (SIB-MBH) approach;
- the impact of the population.

The test instances which will be considered are those reported in [24]¹. These are 18 test instances for the case of unequal circles. The characteristics of each test are indicated in Table 1. In such table column Test n. denotes the identifier of the instance; column n denotes the number of circles of the instance; column Radii denotes the different radii of the circles in the instance; column BestKnown denotes the best known value in the literature for the instance.

Experiments with different perturbation moves and with the sequential insertion strategy:

The different perturbation moves which will be tested are the Full Jerk (FJ) one [25] (with perturbation range $\Delta i = 0.8r_i$ for the coordinates of the i -th circle), the Random Jump (RJ) perturbation move (with a number of randomly selected circles, on which the perturbation is carried on, equal to $\lceil n/20 + 1 \rceil$, and the Radius Based Random Swap (RBRS) one (with $\lceil n/20 + 1 \rceil$, randomly selected pairs of circles on which the perturbation is carried on). Experiments are performed both with the standard MBH approach and with the moderate MBH i.e. the SIB-MBH approach. In all cases we set MaxNonImp = 200. The number of runs is $R = 50$ for all tests except for the highly computationally demanding Test n. 18 for which we reduced the number of runs to $R = 6$.

For what concerns SIB-MBH, we report in Table 2 for each test instance the total number n of circles for the instance and the reduced number of circles after removal of the “small” circles. We observe from the table that for some test instances like, e.g., n. 6-10

Table 1. Test set with unequal circles

Test n.	n	Radius	BestKnown
1	6	$r_{1-3} = 10, r_{4-6} = 4.826$	21.5480
2	9	$r_{1-4} = 1, r_{5-9} = 0.41415$	2.4142
3	9	$r_{1-3} = 10, r_{4-9} = 3.533$	21.5470
4	12	$r_{1-3} = 10, r_{4-9} = 3.533, r_{10-12} = 2.3$	21.5470
5	13	$r_{1-3} = 10, r_{4-6} = 4.826, r_{7-12} = 2.371, r_{13} = 1.547$	21.5470
6	19	$r_{1-3} = 10, r_{4-6} = 4.826, r_{7-12} = 2.371, r_{13} = 1.547, r_{14-19} = 1.345$	21.5470
7	19	$r_{1-3} = 10, r_{4-9} = 3.533, r_{10-12} = 2.3, r_{13-18} = 1.8, r_{19} = 1.547$	21.5470
8	22	$r_{1-3} = 10, r_{4-6} = 4.826, r_{7-12} = 2.371, r_{13} = 1.547, r_{14-19} = 1.345, r_{20-22} = 1.161,$	21.5470
9	25	$r_{1-3} = 10, r_{4-9} = 3.533, r_{10-12} = 2.3, r_{13-18} = 1.8, r_{19} = 1.547, r_{20-25} = 1.08$	21.5470
10	28	$r_{1-3} = 10, r_{4-6} = 4.826, r_{7-12} = 2.371, r_{13} = 1.547, r_{14-19} = 1.345, r_{20-22} = 1.161, r_{23-28} = 0.9$	21.5470
11	10	$r_1 = 50, r_2 = 40, r_{3-5} = 30, r_6 = 21, r_7 = 20, r_8 = 15, r_9 = 12, r_{10} = 10$	99.8850
12	11	$r_{1-2} = 25, r_{3-4} = 20, r_5 = 15, r_6 = 14, r_7 = 12, r_8 = 11, r_9 = 10.5, r_{10} = 10, r_{11} = 8.4$	60.8900
13	14	$r_1 = 40, r_2 = 38, r_3 = 37, r_4 = 36, r_5 = 35, r_6 = 31, r_7 = 27, r_8 = 23, r_9 = 19, r_{10} = 17, r_{11} = 16, r_{12} = 15, r_{13} = 14, r_{14} = 11$	114.9800
14	17	$r_1 = 25, r_2 = 20, r_{3-4} = 15, r_{5-7} = 10, r_{8-17} = 5$	49.6837
15	12	$r_{1-3} = 100, r_{4-6} = 48.26, r_{7-12} = 23.72$	215.4700
16	15	$r_1 = 1, r_{i+1} = r_i + 1, i = 1, \dots, 14$	39.3700
17	17	$r_{1-4} = 100, r_{5-9} = 41.415, r_{10-17} = 20$	241.4214
18	162	$r_{1-3} = 1.8, r_4 = 1.75, r_{5-16} = 1.3, r_{17-25} = 1.05, r_{26-40} = 0.9, r_{41-71} = 0.8, r_{72} = 0.75, r_{73-83} = 0.7, r_{84-137} = 0.65, r_{138-162} = 0.55$	11.7300

Table 2. The Impact of Removal Strategy in SIR-MBH approach

Test n.	n	Reduced circles
1	6	6
2	9	9
3	9	9
4	12	9
5	13	6
6	19	6
7	19	9
8	22	6
9	25	9
10	28	6
11	10	8
12	11	11
13	14	14
14	17	7
15	12	6
16	15	12
17	17	9
18	162	162

a large number of “small” circles is removed. For some other instances a small number of circles is removed (like, e.g., instances n. 4 and 11). Finally, for

the test instances n. 1, 2, 3, 12, 13 and 18 there is no “small” circle and, consequently, the MBH and SIB-MBH approach are equivalent ones.

The results are reported in Table 3. Column Test n. denotes the identifier of the test instance as indicated in Table 1. Column OBRs (OurBestResult) denotes the best results we could obtain during all our experiments. Note that in all cases a value (in the Column OBRs) at least as good as the BestKnown one in the literature as reported in Table 9.1, is reached and that values in **boldface** indicate better results compared to the BestKnown ones. The next following three columns report the number of successes on each instance for each of the three perturbation moves tested (FJ, RJ, RBRS) with MBH approach. The last three columns report the number of successes on each instance for each of the three perturbation moves tested (FJ, RJ, RBRS) with SIB-MBH, i.e. with the use of the sequential insertion strategy. It is worthwhile to explain here what do we mean by number of successes? When the number of successes is equal to 0, this means that the approach was unable to reach the best known result in the literature. For all the instances for which the best

result obtained by an approach was at least as good as the best known one in the literature, the number of successes is the number of runs where the best result has been obtained. In the latter case, when a result better than the best known one in the literature could be obtained, we also report within parenthesis such result. We also remark here that for Test n.13, we have obtained the best result – **113.5552*** by the 500 runs of SIB-MBH(RBRS) approach 2, while for Test n.18 we have obtained the best result– **11.5119*** by the SIB-PBH(FJ) approach discussed later on.

In the table the row named Failure reports the total number of instances where the approach was unable to reach the best known result in the literature (or, equivalently, the number of instances for which the number of successes is equal to 0). Similarly, row Success reports the total number of instances where the approach was able to obtain a solution at least as good as the best known one. Row Imp. reports the total number of instances for which the approach was able to obtain an improved solution and, finally, row **B. Imp.** indicates the total number of instances for which the approach was able to obtain an improved solution which is also the overall best among all those

obtained in the different experiments. Now we briefly discuss the results reported in Table 3. At first we consider the performance of the different perturbations moves within the standard MBH approach, i.e. MBH without sequential insertion strategy. We observe that the MBH(RBRS) approach was able to obtain success in 13 instances out of 18; in five instances it was able to improve the available BestKnownResult value and in three cases the improvement is a best one. Unfortunately, there are also five failures. Note that enlarging the number of runs only partially helps. Indeed, when we extended the number of runs to $R = 500$, we could get at least one success for all the instances but still two failures, namely for the two tests n. 9 and 10. The situation is even worse for the MBH(FJ) and MBH(RJ) approaches, for which the number of failures is clearly higher compared to that of the MBH (RBRS) approach; moreover, though there are some improvements in both the approaches, none of them has a best improvement.

Things get definitely better when we consider the performance of the different perturbations moves in

Tab 3. The performance of MBH approaches with different perturbation moves. Note that in this table OurBestResults is denoted as OBRs.

Test n.	OBRs	No. of success (Result) of MBH approach			No. of success (Result) of SIB-MBH approach		
		FJ	RJ	RBRS	FJ	RJ	RBRS
1	21.5480	50	15	50	50	15	50
2	2.4142	12	15	37	12	15	37
3	21.5470	14	10	40	14	10	40
4	21.5470	8	1	19	14	10	40
5	21.5480	3	0	5	3	2	9
6	21.5470	0	0	0	19	14	50
7	21.5470	0	0	0	14	10	40
8	21.5480	0	0	0	20	16	50
9	21.5470	0	0	0	14	15	38
10	21.5470	0	0	0	20	15	24
11	99.8850	0	0	12	0	0	50
12	60.7099	0	0	12 (60.7099)	0	0	12 (60.7099)
13	113.5552 (♣)	10 (114.0814)	0	6 (113.5846)	10 (114.0814)	0	6 (113.5846)
14	49.1873	1 (49.31945)	10 (49.6498)	1 (49.2470)	6 (49.1873)	100 (49.1873)	50 (49.1873)
15	215.4700	5	0	7	31	16	50
16	38.8380	1 (38.9189)	10 (39.2962)	1 38.8380	0	3 (39.3534)	5 (38.8380)
17	241.4214	0	0	7	7	8	28
18	11.5119 (♣)	1 (11.5336)	5 (11.6599)	1 (11.5422)	1 (11.5336)	5 (11.6599)	1 (11.5422)
Failure	0	8	11	5	3	3	0
Success	18	10	7	13	15	15	18
Imp.	5	4	3	5	3	3	5
B. Imp.	5	0	0	2	1	1	3

the SIB-MBH approach. The SIB-MBH(RBRS) approach has no failure, five improvements and three best improvements; both SIBMBH (FJ) and SIB-MBH(RJ) approaches, though inferior with respect to SIB-MBH (RBRS), have only three failures but one best improvement. If we focus our attention on the comparison between MBH(RSBS) and SIB-MBH(RSBS), we can remark that the five failures in MBH(RSBS) occur with instances n. 6-10, for which the SIB-MBH(RSBS) approach first removes a relatively large number of ("small ") circles. Once such circles are removed, the problems get quite easy ones and the following sequential insertion can always be carried on relatively easily without having to enlarge the radius of the circular container (i.e., all the missing circles can be inserted in the "holes" of the container). This is not always the case. Instance n. 14 deserves some attention. The different runs of MBH over the reduced space return two distinct solutions with the seven remaining circles, one with radius 48.6111 and the other with radius 48.922, so that the first one is clearly better than the second one. But when moving to the second phase (sequential insertion of the missing circles), the situation is reversed: the first solution leads to a solution with radius 49.2296, while the second one leads to a better solution with radius 49.1873. Basically, the second solution has a worse radius but larger holes where the missing circles can be placed. Therefore, what we can conclude from this is that it is often a good strategy to perform the insertion of missing circles not only from the best solution returned by the first phase, but also from some suboptimal solutions obtained during the first phase, because the latter may lead to better solutions after insertion of the missing circles.

Some attention should be focused on instance n.13 and, even more, on instance n.16. In both cases all radii are different and the difference between two consecutive radii is relatively small. In these cases the MBH(RBRS) approach (or the SIB-MBH(RBRS) approach) works much better than the approaches with other perturbation moves. For instance n.16 we observed a large variability of the final solutions and, in spite of the relatively small dimension, this instance turns out to be particularly challenging. We remark that instance n.16 is one (actually of moderate size) among those proposed in the Circle Packing Contest (see <http://www.recmath.org/contest/CirclePacking/index.php>), and its difficulty seems to confirm that such instances are more challenging than the other test instances with unequal circles reported in the literature. More generally, our impression is that the hardest instances for the case of unequal circles are those with many circles with slightly different radii.

The total elapsed CPU times of the experiments for SIB-MBH(RBRS) approach is shown in the table 4. Note that all the tests have been performed on a Pentium IV 2.4 GHz with 1GB RAM.

Table 4. The total elapsed CPU times of the experiments for SIB-MBH(RBRS) approach

Test n.	Elapsed time (sec)
1	39
2	75
3	104
4	440
5	35806
6	17607
7	3778
8	11768
9	63890
10	52967
11	213
12	264
13	468
14	4975
15	813
16	249
17	3130
18	407137

V. CONCLUDING REMARKS

For the presents of combinatorial nature, in presents of unequal radii, we have proposed two new perturbation moves name Random Jump (RJ)and Radius based Random Swap (RBRS) for solving NICPCC problems. Experimentally it is shown that RBRS is more efficient in non-identical circle packing problem. We also proposed another variant of MBH approach – Sequential Insertion Based MBH (SIB-MBH) approach which is only suitable for unequal circle packing problems. By experimentation we saw that SIB-MBH is more efficient than MBH approach for non-identical circle packing problems. We have also investigated the efficiency of the proposed algorithm for solving packing non-identical circles in minimum circular and have compared with available ones Below we point out the main achievements regarding packing problems:

- Proposed a variant of MBH approach -- SIB-MBH approach for NICPCC. The use of the sequential strategy clearly enhances the performance of all the approaches, independently from the perturbation move employed (for a given perturbation move the performance with the sequential strategy is almost always better than the one without);
- Proposed two perturbation techniques for unequal circle packing problems. The RBRS move is a clear winner with respect to the FJ and RJ moves with a lower number of failures, a higher number of improvements and best improvements, and with a number of successes almost always larger than those

obtained with the other moves. The only exception is represented by instance n.18. The peculiarities of this instance and a possible explanation for the worse behavior of RBRS, with respect to FJ on it, will be discussed later on.

- Radius Based Random Swap (RBRS) perturbation based SIB-MBH/PBH approach seems the most robust one in NICPCC.
- Obtained many improved solutions compared to the available literature.

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Parallel Computing Using Remote Method Invocation

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This paper consists of parallel computing using RMI (Remote Method Invocation). Parallel computing is the simultaneous use of multiple compute resources to solve a computational problem. This paper is on Parallel Computing using RMI system within 4 hosts. It will carry out Prime number calculations that would show how many prime numbers are there in the given number (user input) which could be a small or a large number. In single machine or host this calculation will take much time and instructions are executed one after another. It distributes the task among multiple hosts where the task will execute concurrently. For concurrency multithreading is used. This is done by using Remote Method Invocation system as because RMI itself is a distributed system. This paper describes key features of parallel computing and Remote Method Invocation its architecture and how it works.

Key words: Parallel computing, Remote Method Invocation, RMI architecture, RMI parameters, Function of RMI.

1. INTRODUCTION

In parallel computing a problem is broken into discrete parts that can be solved concurrently. Each part is further broken down to a series of instructions. Instructions from each part execute simultaneously on different CPUs [1]. RMI is a mechanism that comprises two separate programs, a server and a client. The server creates some remote objects, makes references to these objects accessible, and waits for clients to invoke methods on these objects. And in the client program obtains a remote reference to one or more remote objects on a server and then invokes methods on them. In this mechanism the server and the client communicate and pass information back and forth.

It is referred to as distributed object application. It is relatively easy to use and remarkably powerful technology and allows the programmers to develop distributed Java programs with the same syntax and semantics used for non-distributed programs [3].

2. RMI ARCHITECTURE

The RMI architecture defines how objects behave, how and when exceptions can occur, how memory is managed, and how parameters are passed to, and returned from, remote methods. RMI architect creates a system that extends the safety and

robustness of the Java architecture to the distributed computing world.

2.1 Interfaces - The Heart of RMI

The RMI architecture is based on one important principle: the definition of behavior and the implementation of that behavior. RMI allows the code that defines the behavior and the code that implements the behavior to remain separate and to run on separate JVMs. In RMI, the definition of a remote service is coded using a Java interface.

The implementation of the remote service is coded in a class. Therefore, the key to understanding RMI is to remember that interfaces define behavior and classes define implementation [3].

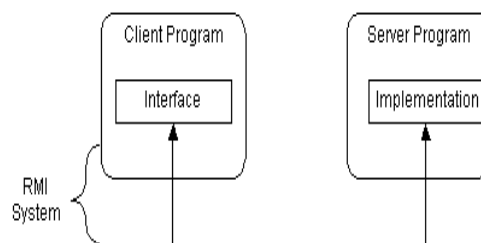


Fig. 1: The diagram illustrates the separation [3]

It supports two classes that implement the same interface. The first class is the implementation of the behavior, and it runs on the server. The second

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class acts as a proxy/stub for the remote service and it runs on the client.

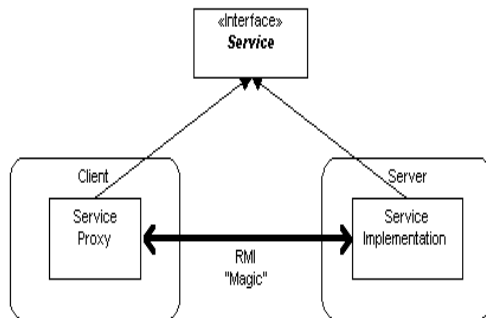


Fig. 2: RMI system implementing same interface [3]

A client program makes method calls on the proxy object, RMI sends the request to the remote JVM, and forwards it to the implementation. Any return values provided by the implementation are sent back to the proxy and then to the client's program.

3. RMI ARCHITECTURE LAYERS

3.1 Stub and Skeleton layers

The stub and skeleton layer of RMI lie just below the Java developer's view. The stub uses the Proxy design pattern, an object in one perspective is represented by another (the proxy) in a separate perspective and it knows how to forward method calls between the participating objects [3].

The skeleton understands how to communicate with the stub across the RMI link. The skeleton carries on a conversation with the stub; it reads the parameters for the method call from the link, makes the call to the remote service implementation object, accepts the return value, and then writes the return value back to the stub.

3.2 Remote Reference layer

The Remote Reference Layers defines and supports the invocation semantics of the RMI connection. An object RemoteRef is offered by this layer which represents the connection to the remote service implementation object. This object understands the invocation semantics for remote services. To forward the method call the stub objects use the invoke() method in RemoteRef.

3.3 Transport layer

The Transport Layer makes the connection between JVMs. All connections are stream-based network connections that use TCP/IP. TCP/IP provides a persistent, stream-based connection between two

machines based on an IP address and port number at each end. Usually a DNS name is used instead of an IP address. On top of TCP/IP, RMI uses a wire level protocol called Java Remote Method Protocol (JRMP). JRMP is a proprietary, stream-based protocol.

The RMI transport layer is designed to make a connection between clients and server, even in the face of networking obstacles.

3.3 Naming Remote Objects

Clients find an RMI remote service by using a naming or directory service that runs on a well-known host and port number. RMI can use many different directory services, including the Java Naming and Directory Interface (JNDI). RMI itself includes a simple service called the RMI Registry, rmiregistry. The RMI Registry runs on each machine that hosts remote service objects and accepts queries for services, by default on port 1099.

3.4 How RMI works?

On a host machine, a server program creates a remote service by first creating a local object that implements that service. Next, it exports that object to RMI. When the object is exported, RMI creates a listening service that waits for clients to connect and request the service. After exporting, the server registers the object in the RMI Registry under a public name [2].

On the client side, the RMI Registry is accessed through the static class Naming. It provides the method lookup() that a client uses to query a registry. The method lookup() accepts a URL that specifies the server host name and the name of the desired service. The method returns a remote reference to the service object

4. RMI PARAMETERS

4.1 Parameters

Parameters can pass by two ways:

- a) Pass-by value.
- b) Pass-by reference.

4.2 Primitives Parameters

When a primitive data type is passed as a parameter to a remote method, the RMI system passes it by value. RMI will make a copy of a primitive data type and send it to the remote method. If a method returns a primitive data type, it is also returned to the calling JVM by value.

4.3 Object Parameters

When an object is passed to a remote method, the semantics change from the case of the single JVM. RMI sends the object itself, not its reference, between JVMs. It is passed by value, not the reference to the object. Similarly, when a remote method returns an object, a copy of the whole object is returned to the calling program object.

Unlike primitive data types, sending an object to a remote JVM is a nontrivial task. A Java object can be simple and self-contained, or it could refer to other Java objects in complex graph-like structure. Because different JVMs do not share heap memory, RMI must send the referenced object and all objects it references. (Passing large object graphs can use a lot of CPU time and network bandwidth.

RMI uses a technology called Object Serialization to transform an object into a linear format that can then be sent over the network wire. Object serialization essentially flattens an object and any objects it references. Serialized objects can be de-serialized in the memory of the remote JVM and made ready for use by a Java program [3].

4.4 Remote Object Parameters

A client program can obtain a reference to a remote object through the RMI Registry program. There is another way in which a client can obtain a remote reference, it can be returned to the client from a method call [3].

5. CREATING DISTRIBUTED APPLICATION BY USING RMI

5.1 Steps to develop distributed a Application

To develop a distributed application the following general steps are required:

- Interface definition for remote service. (example: PrimeNumber.java)
- Implementations of remote service. (example: PrimeNumberImpl.java)
- Stub and Skeleton files.
- A server to host the remote service. (example: PrimeServer.java)
- An RMI Naming Service that allows clients to find the remote services.
- A client program that needs the remote services (example: PrimeClient.java).

5.2 Steps to build RMI system

To develop a RMI system the following general steps are required:

- At first a java code should be written for the interfaces (example: PrimeNumber.java) and compile it. Then implement same interface in the server and client, where the stub class of client and the implementation class (example: PrimeNumberImpl.java) of server uses this interface defines the behavior.

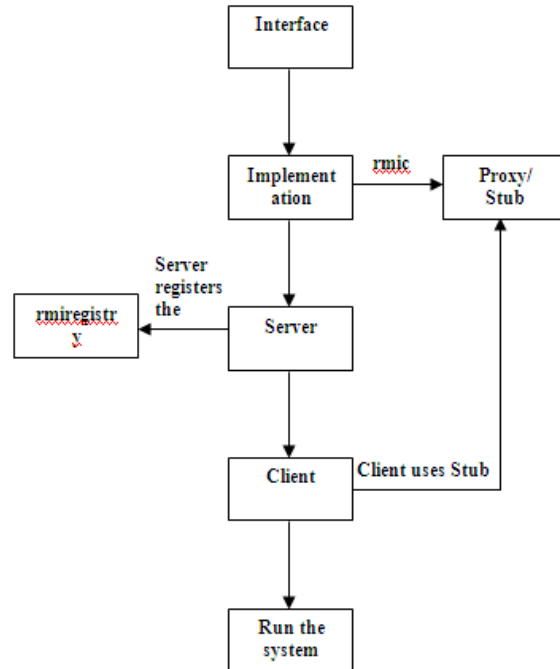


Fig. 3: RMI System.

- Write a java code for the implementation classes which runs in server. The behavior is implemented in the implementation that was defined in the interface.
- Run the RMI compilers, `rmic`, which runs on the implementation class. It generates stub (example: PrimeNumberImpl_Stub) as jdk 1.5 versions is used.
- Write a java code for the remote service host program (example: PrimeServer.java) it contains only the service.
- Write a java code for the client program and compile it. The client sends the request to the hosts to do its task and receives the result.
- Lastly install and run the RMI system. For this, start the registry `rmiregistry` on each server which contains the information of the remote service of each server. The client gets the service information from the `rmiregistry` and hooks up with its desired server. Then run the

servers and send the request from the client host. Fig.3 shows the details of the process.

5.3 Analysis

The following figure shows the time difference between single and four hosts. It will carry out Prime number calculations that would show how many prime numbers are there in the given number (user input) which could be a small or a large number. In single machine or host this calculation will take much time and instructions are executed one after another. Our aim was to distribute the task among multiple hosts where the task will execute concurrently. For concurrency we have used multithreading. This is done by using Remote Method Invocation system as because RMI itself is a distributed system. And here it is taken some inputs and show the time that it takes for calculation. The white bar shows the calculation time for single host and black bar shows the calculation time for multiple host. From the graph and table it can be easily understand the advantages of this system.

Table 1: Efficiency comparison of Single host with four hosts.

Number	Single Host (sec)	Four Hosts (sec)
50,000	1.839	1.452
1,00,000	5.094	3.539
1,50,000	11.866	7.43
2,00,000	17.097	9.173

With the above data the following graph could be drawing which shows the time differences between single and four hosts.

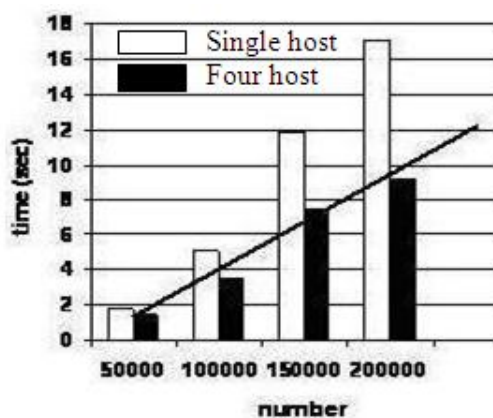


Fig. 4: Time differences between single and four host

6. CONCLUSION

RMI or Remote Method Invocation is used for parallel processing. It is a Distributed object application. The RMI System can process a large volume of workloads in parallel by distributing the workloads to multiple machines. It is the system that support only java program. From this paper, it is clear that distributed program using RMI is much faster then non-distributed program.

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PERFORMANCE EVALUATION OF KALMAN FILTER IN ACCOUSTIC ECHO CANCELLATION

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In wireless communication each signal propagates different paths and is debilitated by fading, attenuation, non-linear distortion and noise. Similar circumstance is found in the sound system of a conference room. Output signal turns out from the speaker reflected back to the microphone from numerous directions of the room. Analogically, these reflected feedback signals resemble the multi-path propagation of wireless communication; exception is that the noise level is very low. The signal path of the feedback signal is a non-linear system can be replaced by a finite impulse response filter. The aim of the project work is to resolve the situation eliminating both noise and feedback signals from the microphone to combat the occurrence of echo. In this regard, Kalman filter is used to recover the original signal from the noisy and severely interfered microphone signal before sending to the speaker. Performances of Kalman filter is also analyzed in acoustic echo cancellation technique.

Key words: Predictor-corrector algorithm, near and far-end signal, Accoustic echo cancellation (AEC) and Kalman equation, Kalman gain.

1. INTRODUCTION

In wireless communication, the transmitted signal from any source may traverse through multiple paths towards the receiver. Such propagation happens by the obstruction or reflection of natural barriers such as ground, buildings, vehicles, hills at different atmospheric levels [1]-[2]. As a result of such propagation, the receiver receives multiple copies of same signal each of different physical length. Each signal experiences different noise, attenuation, phase shift and delay [3]-[4]. Sound system in a conference room resembles the consequences of wireless transmission [5]. A voice signal been sent by one participant come out from the speaker propagates through multiple paths and echoed back from the conference room walls

crossing multiple directions yield the distortion of root voice signal of the microphone. The distinguishing feature between the two analogous systems is that the feedback signal in acoustic echo cancellation retains less signal length and also low strength. The goal of the paper is to learn the performances of Kalman filter through evaluation. Frequency domain adaptive filter (FDAF) has an adaptable feature riding which the coefficients of the signal continually adjust. At every time state the input signal is estimated and after processing error signal is generated and refine the coefficients of the estimated signal. Least mean square (LMS) filter uses the instantaneous estimates of its weights where FDAF uses weight vector gained from all the previous estimates. Kalman Filter is widely used due to its recursive strategy to estimate the current

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As a detection of the *innovation* i.e. the new information of observation $y(n)$ can be calculated as in (4):

$$\alpha(n) = y(n) - C(n) \hat{x}(n | y_{n-1}) \quad (4)$$

Time state update of one unit for current use is the result of multiplication of a transition matrix

$F(n+1, n)$ and previous time state $\hat{x}(n | y_{n-1})$ incorporating Kalman gain $G(n)$ and innovation $\alpha(n)$ as shown in (5). This is the basic prediction equation.

$$\hat{x}(n+1 | y_n) = F(n+1, n) \hat{x}(n | y_{n-1}) + G(n) \alpha(n) \quad (5)$$

Correction of error correlation matrix of the current time can be obtained by (6):

$$K(n) = K(n, n-1) - F(n, n+1)G(n)C(n)K(n, n-1) \quad (6)$$

In the final part of the calculation, we need to *update the measurement* of the future error correlation matrix $k(n+1, n)$. As an integral part of this, white Gaussian process noise $Q_i(n)$ will be added to it. Mathematical equation has composed in (7)

$$k(n+1, n) = F(n+1, n)K(n)F^H(n+1, n) + Q_1(n) \quad (7)$$

4. ACCOUSTIC ECHO CANCELLATION

An acoustic echo cancellation is noise cancellation of a recorded speech signal. A recorded speech signal from the loud speaker returns to the microphone as an echo reflecting from the room and mingled with original speech signal. This signal is also called far-end speech signal. The speaker signal, i.e. the near-end speech signal at the microphone input thus is not uniform and distorted [8]. During the processing of the distorted signal adaptive filter produces the best estimation of the noisy signal. Subtraction of this noisy signal from original signal will solve the problem. Concurrently an error signal will be generated mirroring the difference between the actual signal and our approximation and hence coefficients will be updated.

4.1 Experimental Setup

Signal inserted in microphone of a hall room is the direct speech signal $d(n)$ of the speaker and echoed signal $\hat{d}(n)$ that arises from the reflection of walls in Fig.1. Direct speech signal is called near-end signal (NES) and the echoed signal is called far-end signal (FES). The combined input signal of the microphone, $\mu(n) = d(n) + \hat{d}(n)$. Objective of an echo canceller is to remove the far-end signal so that only near-end signal is sent to the

loud speaker. The path or channel between loud speaker and the microphone is represented by a long finite impulse response filter. For an instance, Room environment of an acoustic echo canceller depicted in Fig. 1.

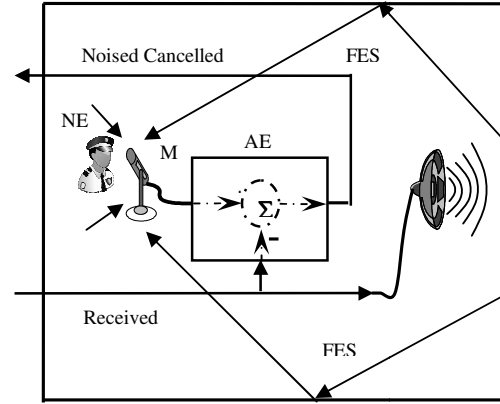


Fig.1: Room environment of Acoustic Echo Canceller

5. RESULTS

We used *chebyshev2* filter to have the basic channel impulse response of the room. The filter is assumed to be fourth order ($N=4$) and sampling frequency f_s as 8000. Stop-band ripple presumed as 20 and edge frequency W_n will be in the range $(0.1 < W_n < 0.7)$. Let us consider number of time sequences $M = 4001$. The time domain and frequency domain views of the system are show in Fig. 2 and 3 respectively.

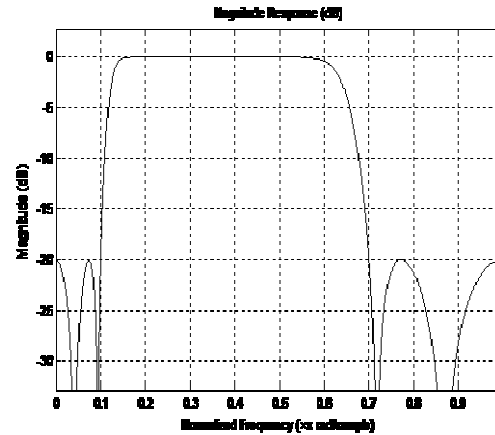


Fig.2: Impulse response of the room (Frequency domain)

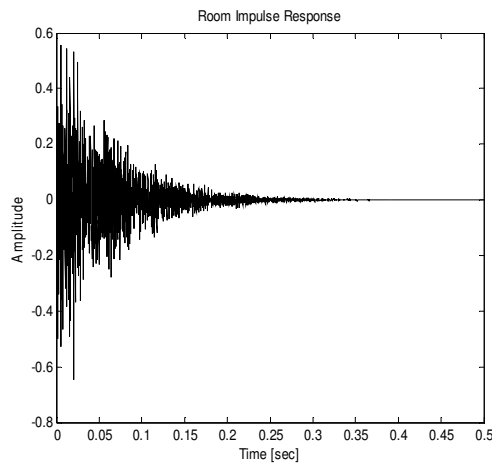


Fig.3: Impulse Response of the room
(Time Domain)

5.1 Kalman Filter Observations

Let us observe the performance of Kalman filter considering the signal to noise ratio ($SNR = 45$ to $SNR=30$) and number of samples 15000.

KalmanSignalDenoyer(Noisy, Clean, f_s) is the method of working with Kalman filter in Matlab. It consists with three parameters: noisy signal, desired signal and sampling frequency. The output is our target signal and the mean error, max error and standard deviation of all the points around the mean error have been identified is in Fig.4.

The amplitude of the filtered wave and mean square error in error estimation had shown in Fig. 4,5,6,7,8,9,10,11 respectively for Kalman filter at $SNR= 45$ to 30.

At $SNR = 45$, Number of Samples = 15000

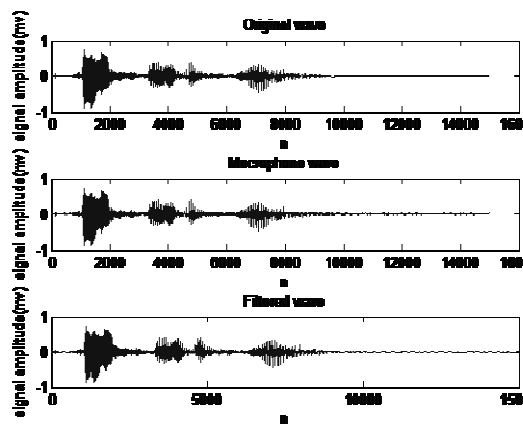


Fig.4: Amplitude comparison of Filtered wave relating to original wave (in milivolts)

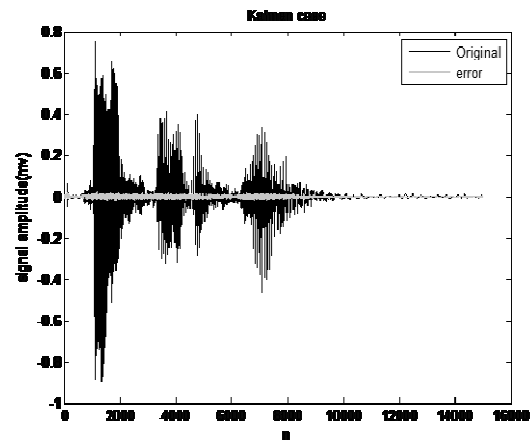


Fig.5: Error in estimation of clean wave relating to original wave (mean error = 1.383×10^{-5}).

At $SNR = 40$, Number of Samples = 15000

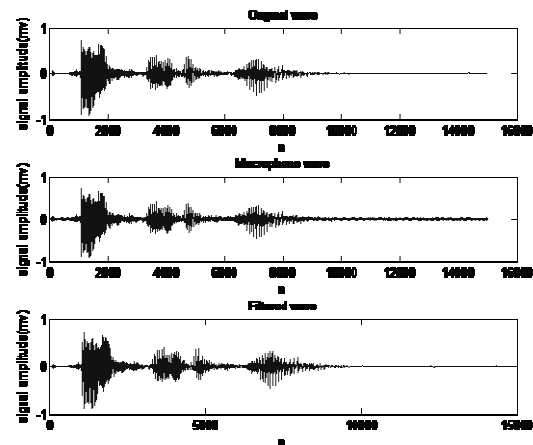


Fig.6: Amplitude comparison of Filtered wave relating to original wave (in milivolts)

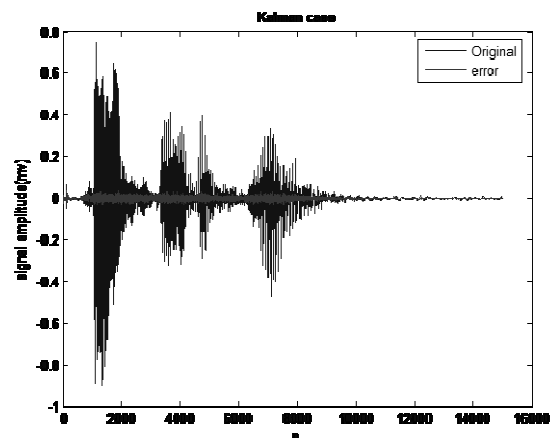


Fig.7: Error in estimation of clean wave relating to original wave (mean error = 3.714×10^{-5}).

At SNR = 35, Number of Samples = 15000

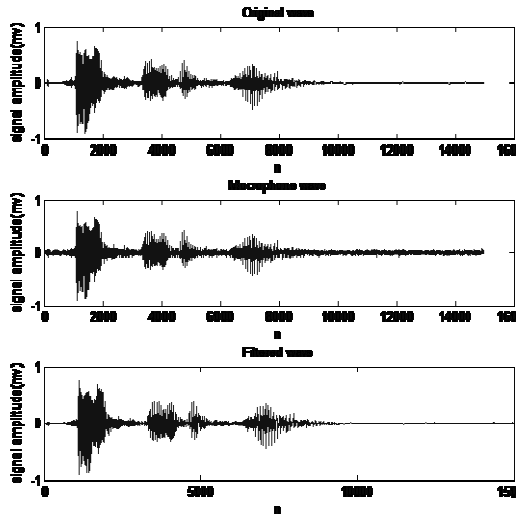


Fig.8: Amplitude comparison of Filtered wave relating to original wave (in milivolts)

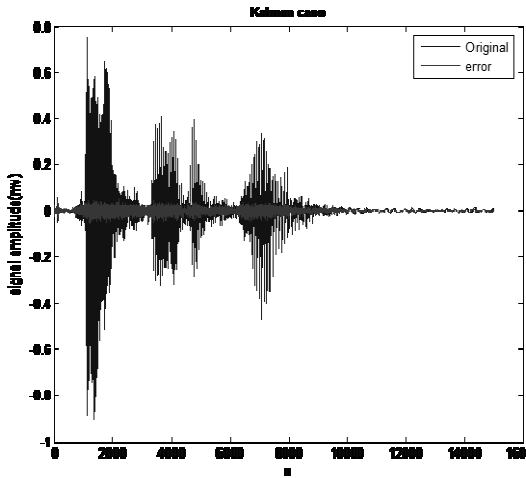


Fig.9: Error in estimation of clean wave relating to original wave (mean error = 8.6318×10^{-5}).

At SNR = 30, Number of Samples = 15000

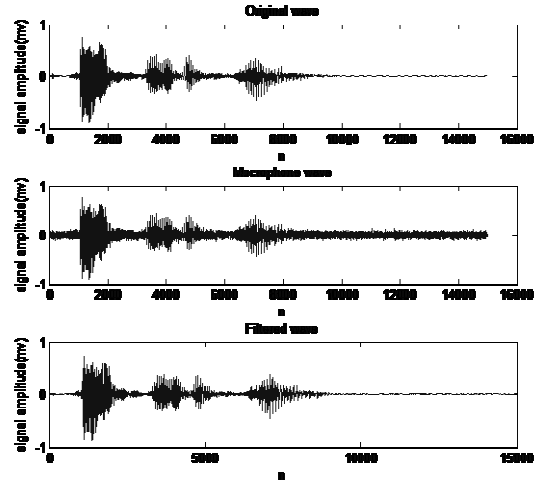


Fig.10: Amplitude comparison of Filtered wave relating to original wave (in milivolts)

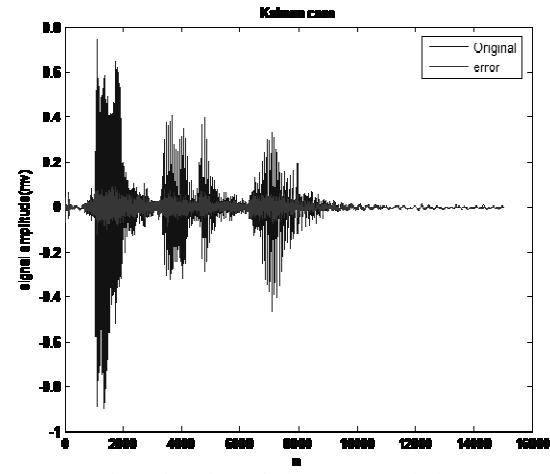


Fig.11: Error in estimation of clean wave relating to original wave (mean error = 2.0361×10^{-4}).

Table-I demonstrates the results of observations of Kalman filters. We portrayed the observation of several SNR from 45 to 30.

Table-I Performances of kalman filter with varying signal to noise (SNR) ratio

SNR(db)	Errors in Kalman Filter			
	Max	Min	SD	ET
45	0.0230	1.38e-5	0.0037	3.96
40	0.0344	3.71e-5	0.0061	3.26
35	0.0578	8.63e-5	0.0093	3.15
30	0.0918	2.03e-4	0.0143	3.18

According to the analysis, change in Max error, Mean error and standard deviation (SD) of the mean error of Kalman filter with the increase of SNR are mutually related. At the time of $SNR = 45$ db Max error of Kalman filter is 0.0230 which prescribes its good performance. One important thing to notice is that Kalman filter require much execution time (ET). As the noise increases the max error also increases and ET decreases due to the adaptability. For Kalman filter max error is inversely proportional to the SNR and retain strong convergence.

6. CONCLUSIONS

We can conclude this paper with subtle differences on the performances of Kalman filter regarding acoustic echo cancellation technique. Besides its aptitude in almost all system Kalman filter performs best in a heavily noisy system. The only shortcoming of the Kalman filter is its lengthy process time. Kalman filter, which contains an easy operational algorithm, is easy to implement than other filters. Kalman filter continuously update the best estimate with the system current state and provides good convergence. For heavily noisy system Kalman filter performs extremely well. We can easily apply it in areas like Aerospace, Marine Navigation, nuclear power plant implementation. Though Kalman filter can smoothly handle the noise from the original signal, it takes comparatively much time for processing.

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Importance of Physics Education for the Undergraduate Medical Students of Bangladesh

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Abstract

The study is done to identify one of the remarkable lacking in conducting undergraduate medical course curriculum (MBBS) in Bangladesh and that is the absence of the study of physics. Physics deals with the most general laws of nature. The human body and its components are physical objects that can be viewed, measured and altered in ways that resemble what a physicist might do with any physical object. There is a long tradition of physicists and physics-based techniques making important contribution to biology and medicine. The relationship between physics and medical science proves that collaboration between different disciplines can be hugely productive. Physics is at the heart of many medical techniques, and life scientists are finding new ways to study biological matter. Bio-systems are based on the same laws as physical systems. Medical physics is an applied branch of physics concerned with the application of the concepts and methods of physics to the diagnosis, management and treatment of human disease. Some vital areas of application are ionizing radiation, imaging with X-rays, ultrasound and MRI, nuclear medicine, electroencephalography, electrocardiography, thermography, hyperthermia, optical imaging, and RF and laser surgery. For this purpose an internet survey has been conducted and it is found that medical students in different highly developed countries like USA, Russia, Germany, England, France etc. are studying physics long before. Unfortunately the study of physics is not included in the undergraduate medical education curriculum in Bangladesh. Some may raise question, whether it is really meaningful to teach physics in undergraduate since it is taught in the higher secondary schools. However, the course taught in the secondary school level it is very much general. For the better understanding of the subject and its correlation with future professional activities is necessary to study physics at advanced level. For instance physics is taught in BUET and other universities teaching engineering. Pharmacy students are also studying physics. Now it is suggested that physics courses should be included in the undergraduate medical curriculum in Bangladesh. This course will facilitate to understand the advanced medical courses.

Key words: medical education, physics, medical techniques, life science, medical physics, interdisciplinary correlation.

1. INTRODUCTION

The physics has wide application to medicine. Physics is changing the way medicine is practiced. While a doctor will still use a stethoscope, a diagnosis now often requires devices that make use

of sophisticated physics. As a consequence of technological evolution of medical science, doctors are more and more recognizing the influence of physics to medicine. The history of the application of physics to medicine started in the Islamic Golden Age. De Gradibus an Arabic book published by

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Muslim physician Al-Kindi (801-873 CE) was the first attempt at serious quantification in medicine. Al-Kindi also developed a system based on the phases of the moon, that would allow a doctor to determine in advance the most critical days of a patient's illness [1]. Ibn Sina the father of modern medicine in his famous book *The Canon of Medicine* (1025 C.E.) [2], (the first book dealing with evidence based medicine) established a set of rules, one of them is "The quality of drug must correspond the strength of the disease. For example there are some drugs whose heat is less than the coldness of certain diseases, so that they would have no effect on them." The law is directly related to the heat and thermodynamics chapter of physics. The contribution of famous Muslim physicist Ibn Al-Haytham (Al-Hazen) to anatomy and physiology include many improvements in our understanding of the process of visual perception in his *Book of Optics* [3], published in 1021. Much later in Europe Leonardo da Vinci, showed profound interest in the mechanics of human locomotion. The subsequent gradual development in physical tools contributed to advances in the medical sciences. One outstanding example is the microscope by Leeuwenhoek during the 17th century. The development of electromagnetism in the 19th century enabled physicists to make contributions to medical treatment and diagnosis. D'Arsonval, a French physicist, pioneered the therapeutic use of high-frequency electric currents and pointed the way towards development of critical measuring instruments. Thus electrocardiography and electroencephalography was developed. The discoveries of X-rays and radioactivity by the physicist Roentgen in 1895 and Becquerel in 1896 were rapidly followed by the application of ionizing radiations to the diagnosis and treatment of disease. This actively has been primarily responsible for bringing physicists directly into the sphere of hospital. Bio-systems are based on the same laws as physical systems. Medical physics is an applied branch of physics concerned with the application of the concepts and methods of physics to the diagnosis, management and treatment of human disease. Some vital areas of application are ionizing radiation, imaging with X-rays, ultrasound and MRI, nuclear medicine, electroencephalography, electrocardiography, thermography, hyperthermia, optical imaging, and RF and laser surgery. Considering the profound relation of physics with medical science highly developed countries like USA, Russia, Germany, England, France, Italy, Ukraine, etc. included the physics education in their medical schools.

2. METHOD

An internet survey was done to different countries' undergraduate and post-graduate program to find out if physics is taught at that level. Discussions were also performed with doctors who studied abroad and also in Bangladesh.

3. RESULTS

- i) In many medical institutions of USA, medical physics is taught. Johns Hopkins School of Medicine is one of them [4].
- ii) In all medical institutions of Russia, medical students are studying physics. [5]
- ii) Three Canadian universities currently offer undergraduate medical physics degrees.
- iii) Lund University of Sweden teaches physics to medical students.
- iv) In Bosnia and Herzegovina, medical students study biophysics. [6]
- v) In Belgium, medical students are taking general scientific courses, biophysics is one of them.
- vi) Medical studies in France include biophysics as a first year course. [7]
- vii) In Germany the first two years medical school consists of classes of basic sciences, physics is one of them [7].
- viii) In Italy first three years are devoted to basic subjects including physics [7].
- ix) Charles university (Univerzita Karlova) in Prague (Czech Republic) teaches physics to the first year medical students. [8]
- x) In Japan also medical students are studying physics.
- xi) In the MBBS course in India, in phase-I some pre-clinical subjects are taught Biophysics is one of them [9]. Also there are books on Medical Physics written by Indian authors [10].
- xii) According to the course curriculum of Bangladesh medical colleges, physics is not at all included. Thus the Bangladeshi doctors are deprived of gaining valuable knowledge in physics that could contribute some ground-breaking research outcome in near future.

4. DISCUSSION

The inclusion of physics education in the medical schools of different highly developed countries shows its importance. Some may raise question, since physics is taught in the secondary schools, is it really meaningful to teach it in undergraduate courses? However, the course taught in the secondary school level it is very much general. For the better understanding of the subject and its correlation with future professional activities is necessary to study physics at advanced level. For instance physics is taught in BUET and other

universities teaching engineering (American International University-Bangladesh teaches physics in engineering faculty which includes nuclear physics and modern physics). Pharmacy students are also studying physics. The course should cover all necessary branches of physics (mechanics, electricity and magnetism, fluids, heat, sound, atomic and molecular physics, optics etc.). The physical concepts should be medically oriented with the intention of relating physics to the students' future professional lives. Each topic should start with a medical case related with medical diagnosis and treatment. It is well known that vital areas of application of physics in medicine are ionizing radiation, imaging with X-rays, ultrasound and MRI, nuclear medicine, electroencephalography, electrocardiography, thermography, cardiac pacemakers, hyperthermia, optical imaging, and RF, laser surgery. Once the equipment is accepted, the doctors should have sound knowledge on all those machines, so that the equipment can be used clinically. The doctors also should have knowledge on equipments' physical concept and their effect on human body.

5. CONCLUSIONS

Considering the importance of physics education in medical science, it is suggested that physics courses should be included in the undergraduate medical curriculum in Bangladesh. This course will facilitate to understand the advanced medical courses. Now-a-days medical science has advanced beyond imagination but we are still following the eighties curriculum. If we don't add physics in MBBS degree curriculum our students will fall behind in completion further in international arena and we have no right to deprive them in pursuing international standard education in Bangladesh.

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Visual-*miR*: Visualization system of precursor microRNA

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Abstract

MicroRNAs (miRNAs) are single-stranded small non-coding RNA molecules of about ~22 nucleotides which regulates near about 30% of human genes involving cancer, tumor, neurodegenerative disorders, developmental timing, differentiation, proliferation, cell death etc. In the biogenesis, mature miRNAs are originated from their precursors (pre-miRNA) containing more informative properties with the attributes of stable secondary structure. Proper exploration and visualization of the diversified sequences of pre-miRNA is noteworthy for the biologists in effective analysis and experimentation of pre-miRNAs including the quest of finding a set of characteristics for unique identification. This article proposes a concept of pre-miRNA visualization and implemented a new tool Visual-*miR* for better perception of the

sequences. This tool uses standard information visualization techniques as well as other innovative techniques. The Visual-*miR* provides different visualization of linear pre-miRNAs sequences based on different properties with comparative viewpoint. By presenting techniques for visualizing pre-miRNA in this unique tool, we believe to bring new prospects for scientists as they seek to make sense of the rapidly expanding body of miRNA discovery.

Keywords: Visual-*miR*, Precursor microRNA, Sequence property, Information visualization techniques, miRNA discovery.

Introduction

Recent years have witnessed an explosive growth in RNA research, as numerous new non-coding RNAs (ncRNAs) have been discovered [1, 2]. It is increasingly evident that RNAs play important roles, far beyond transferring genetic information from DNA to protein. The microRNAs (miRNAs) are a special class of non-coding RNAs of ~22-nt length that regulate the protein coding gene expression through incomplete complementary bindings at the post-transcriptional level [3]. It is believed that near about 30% of human genes are regulated by miRNAs [4, 5] and as a consequence miRNAs have pulled the interest of biologists for its association in cancer and tumor with its therapeutic values [6]. Each miRNA molecule is derived from its precursor molecule precursor miRNA (pre-miRNA) which is the most thermodynamically stable state and in our system we used pre-miRNA sequences. Pre-miRNA has only a single

polynucleotide chain which is composed of four different nucleotides e. g., A, U, G and C. To aid the continuous scientific effort for the expansion of the number of known miRNA families that is so far rather limited, we used the concept of graphical representation that will facilitate new insight in the realization of miRNA sequences and compare them for their different chemical features along with its sequence composition. In this study we applied a system named *Visual-Mir* to visualize different sequence properties of miRNA sequences for better understanding of them and visually compare miRNAs.

Data visualization now benefits from developments in technologies that offer innovative ways of presenting complex data. Biological Data Visualization is a branch of bioinformatics concerned with the application of computer graphics, scientific visualization, and information visualization to different areas of the life sciences. This includes visualization of sequences, genomes, alignments, phylogenies, macromolecular structures, systems biology, microscopy, and magnetic resonance imaging data. In many areas of bioinformatics it is important to be able to view information at several levels of detail and shift between them readily, which can be challenging for software. Graphical representations of data can communicate complex information, help to understand complicated relationships between multiple variables, uncover information hidden in the data, and solve problems through visual representations in the form of data structures for expressing knowledge. Software tools used for visualizing these data range from simple, stand-alone programs to complex, integrated systems [7]. A large number of tools are available for visualization biological

data that can range through one-dimensional, two-dimensional, multi-dimensional, text/web, hierarchies/graphs, and algorithm/software. The genome browser applications represent a one-dimensional world in that they display location-based features across a single axis defined by the genomic sequence data itself [8]. Two-dimensional visualization is frequently used in RNA secondary structure analysis [9, 10]. For example, visualization method is successfully used in the study and comparison of nucleotide skews at different scales in various genomes in understanding this phenomenon GC-AT skew along with its evolution in the phylogenetic tree [11] and also in graphical representations to enumerate, construct, and analyze two-dimensional (2D) RNA secondary topologies [12]. RNA secondary structure, the pattern of base-pairing, contains the critical information for determining the three dimensional structure and function of the molecule which can be understood by three dimensional representations [13].

A variety of computational methods have used the secondary structure of RNA molecules to search and categorize ncRNAs including miRNAs [9, 14, 15, 16], but many of these methods are limited in their use of secondary structure. The visualization of biological data is hampered by the wide range of data types and exponentially increasing volume of data available, and by the lack of interoperability of existing tools. In this study, we present a complete and fine scheme to represent sequence features of miRNA molecules graphically. These representations will facilitate the exploration of the numerous detailed facets of each miRNA constituents and their combined patterns in creating new insights regarding to miRNAs. Herein we introduce five categories of 14 different techniques of information visualization that are discovered in this article as novel two

dimensional representations of miRNA sequences.

Materials and methods

Materials

Human pre-miRNA sequences are retrieved from MirBase [17] release 15.0. We analyzed randomly selected 100 pre-miRNA sequences from 940 reported pre-miRNA entries for their nucleotides with different nitrogenous bases (A, U, G and C) and two parent compounds of the nitrogenous bases, pyrimidine and purine. Visualized information of nitrogenous bases and the parent compounds are named as AUGC and PuPy data type respectively. AUGC data type divides the sequence into four groups for four different nucleotides e.g., A, U, G and C whereas PuPy data type separates each sequence into purine and pyrimidine bases. These two data types are effectively used in our system for proper understanding of the chemical properties of pre-miRNAs and to realize the sequences form different viewpoints of visualization.

Methods

This software provides five looks of pre-miRNA sequences using different visualization techniques from exceptional standpoint that are named as 1) *Ratio Look*, 2) *Bar Look*, 3) *Vector Look*, 4) *Skew Look* and 5) *CMP Look*. The *Ratio Look* stands for percentage of AUGC and PuPy data types in total sequence length as rectangle ratio look with ratio percentage in x-axis and a constant width in the y-axis is used. Another *Ratio Look* is pie ratio look for the same data within a pie chart

to visualize the relative proportion of these two different data types with distinctive colors. The *Bar Look* represents cumulative positional number of occurrences of AUGC and PuPy data types for visualization of pre-miRNA sequences in two types of visualization for cumulative groupBar and stackBar view. When considering each nucleotide as a vector the *Vector Look* presents total sequence as a graph. We classified the *Vector Look* into DV-Curve and inverse DV-Curve to observe a particular sequence from two inversely related views for AUGC data type. DV-Curve means Dual-Vector Curve that uses two vectors to represent one alphabet of nucleotide sequences for a good visualization of sequences of any length [18]. Inverse DV-Curve uses inverse interchange of graphical vector representation of G and U for the same sequence. In the *Skew Look*, pre-miRNA sequences are visualized for GC-AU skew in a 2-D image to see the occurrence of C and U over G and A respectively for these short miRNA sequences. The GC skew is usually calculated as $(C-G)/(C+G)$, which gives the percentage of excess of C over G. Previously cumulative GC skew have been used only in case of DNA but here we introduce this in RNAs as a feature of visualization [19]. *CMP Look* means the comparative look of multiple sequences of pre-miRNA that uses the originally stacked horizontal bar look altogether 100 sequences for AUGC and PuPy data types. In the coding section all the visualization techniques in this research were implemented in *matlab*.

Result and Discussion

It is well known that human brain is much more powerful than computer to recognize figures and complex patterns. This advantage of our brain is very helpful for similarity analysis in multiple sequences. So it is desirable to develop a simple, clear, unique, 2-D and non-degenerate graphical representation of miRNA sequences. Molecular biologists can use this graphical representation as an intuitive tool to find out which sequence is most similar to the target sequence from many different coding RNA sequences. Existing tools cannot provide the chemical features and composition of miRNA sequences. As a consequence, in this program, we meet the biologists' need of sequence features, even if two miRNAs have similar secondary structure to each other, the sequence composition can be very different [20]. Efficient comparison of pre-miRNA sequences must allow the user to visually compare two miRNA sequences. Therefore, we have developed a miRNA visualization tool

that fulfills all defined requirements.

1. Ratio Look

The *ratio look* shows the relative proportion of AUGC and PuPy data types for a single sequence. We classified *ratio look* as rectangle ratio look and pie ratio look. In case of rectangle ratio look, ratio percentage of A, U, G and C and purine-pyrimidine is represented in x-axis from left to right and a constant width in the y-axis for AUGC and PuPy data types respectively (see figure 1.a, b). The pie ratio look represents the relative proportion of two different data types with distinctive colors for the same data within a pie chart (see figure 1. c, d). The components of rectangle ratio look and pie ratio look represent the same information of data but using different representation concepts to make the visualization more interactive.

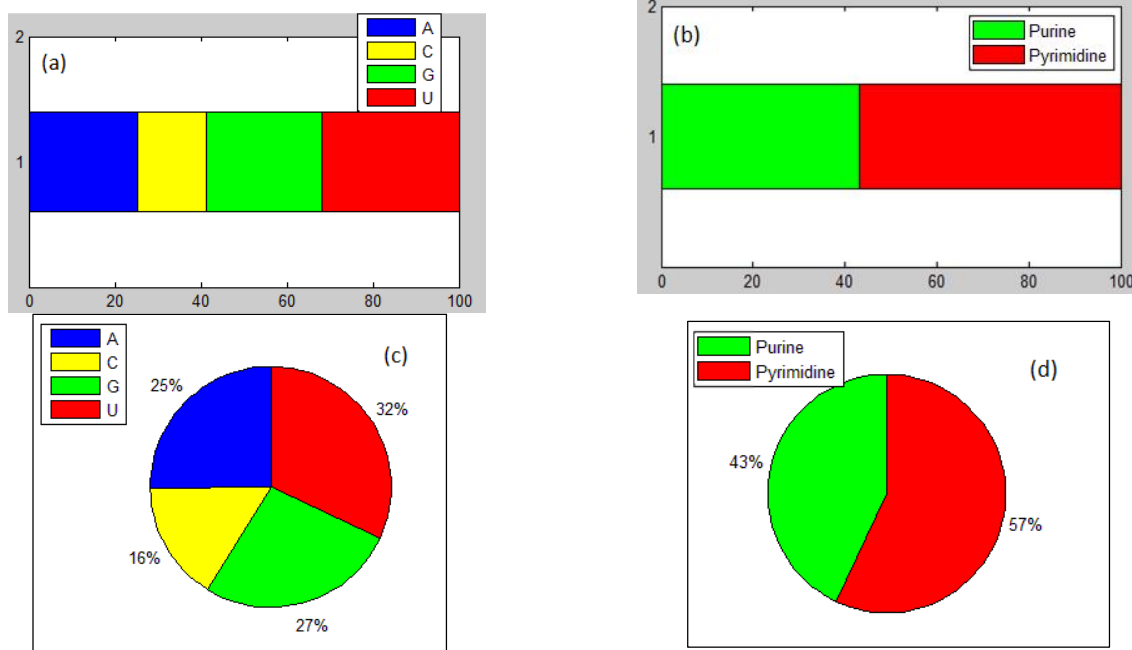


Figure 1 The relative proportion of components for AUGC and PuPy data types in as rectangle ratio look (a, b) and pie ratio look (c, d).

2. Bar Look

A bar look shows information of same data for cumulative groupBar and stackBar look. In the cumulative groupBar look the sequence is positioned on a horizontal axis; the vertical axis is used for cumulative bars of information of AUGC and PuPy data types (see figure 2. a, b) in different colors. For stackBar look the sequence is plotted in the x-axis according to the sequence length and in the y-axis cumulative stacking of AUGC and PuPy data types is placed (see figure 2. c, d). The stackBar look

for AUGC data type represents A, C, G and U from bottom to top respectively and purine and pyrimidine in the same orientation for PuPy data types. This visual representation helps to realize these sequence properties easily which is not possible to observe from a raw sequence. The *Bar look* representation gives a new insight about the cumulative sequence properties of pre-miRNAs which is beyond the reach to observe from linear sequences.

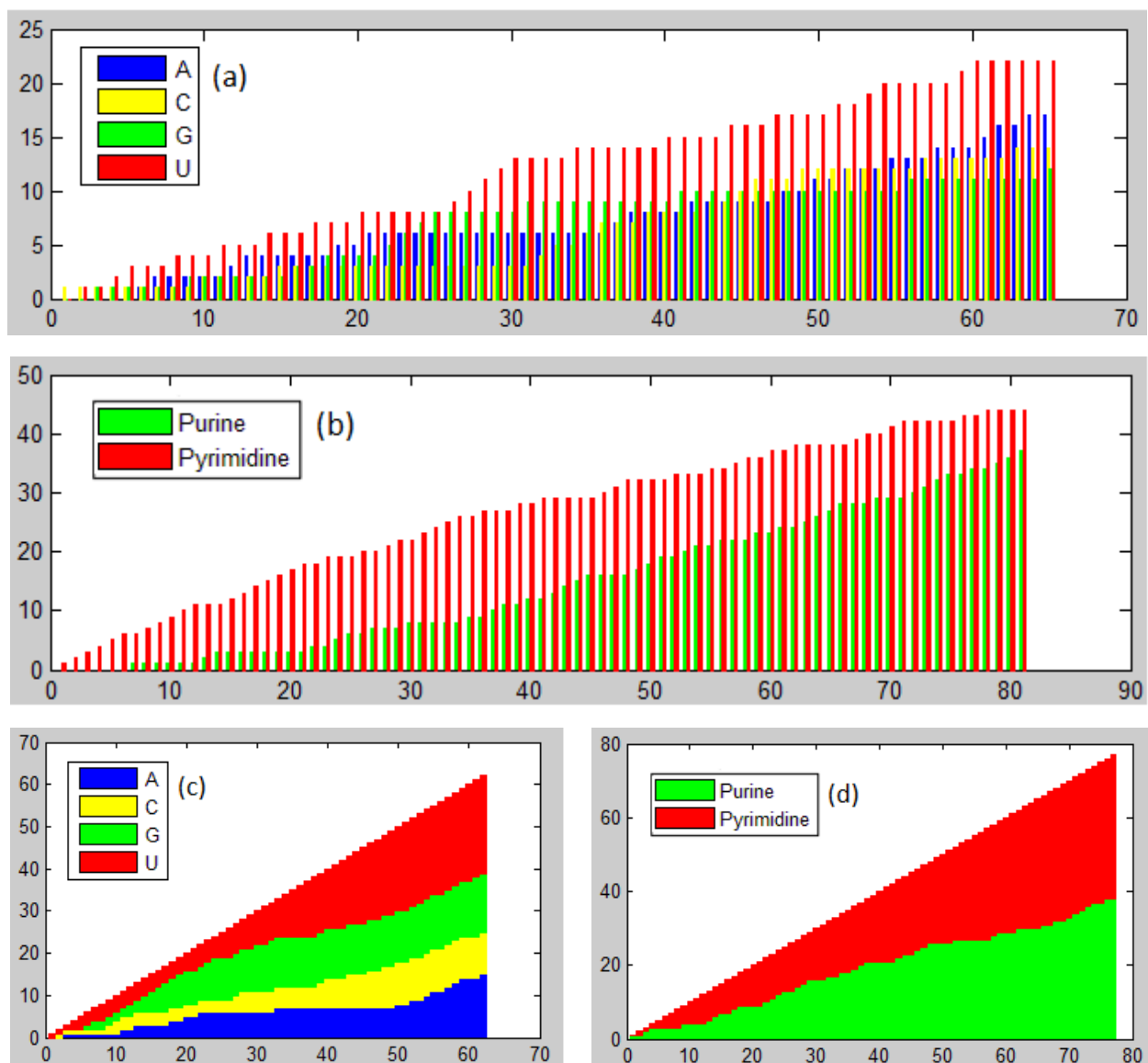


Figure 2 Cumulative groupBar and stackBar of AUGC and PuPy data types show the cumulative relationship of number of nucleotides (a, c) and purine-pyrimidine in the sequence (b, d) in bars and stacks.

3. Vector Look

We consider each nucleotide as a vector in *vector look*. The vectors with its corresponding nucleotide are illustrated in **Table 1**. The graph of Vector Look is constructed by placing the nucleotide position in the horizontal axis and the vector

of each nucleotide in vertical axis for only AUGC data type in both DV-Curve (see figure 3. a, b) and inverse DV-Curve (see figure 3. c, d). This zigzag view of sequence provides the information to biologists for understanding how the nucleotides are arranged in the precursor microRNA sequences.

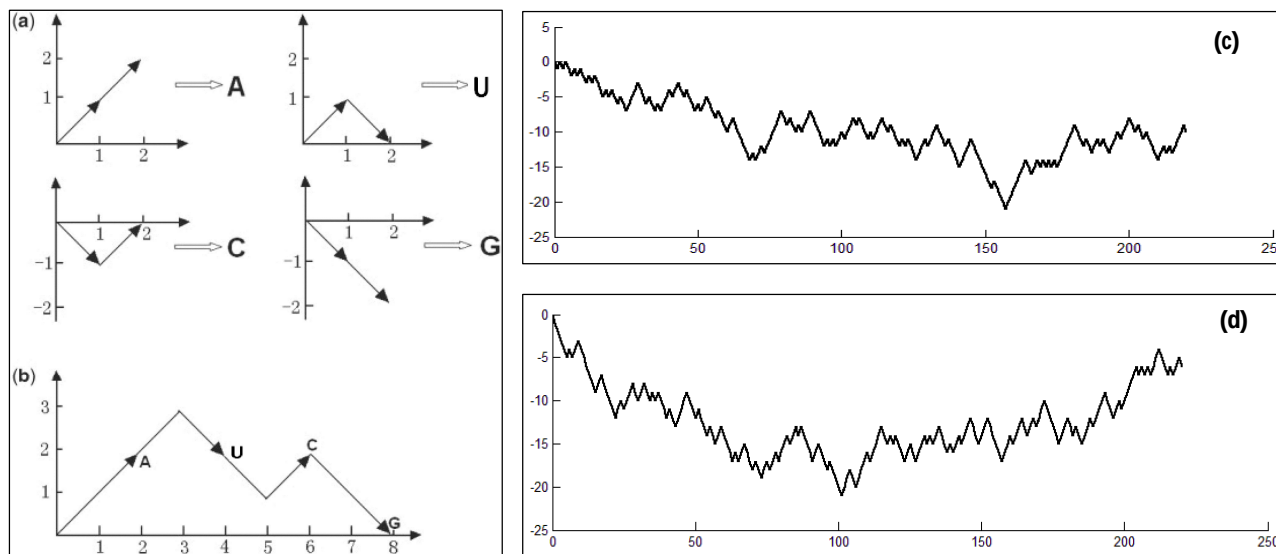


Figure 3 (a) Representations of four nucleotides A, U, C and G of DV-Curve, (b) The DV-Curve of sequence 'AUGC', (c) and (d) are the examples of DV-curve and Inverse DV-curve of randomly chosen microRNA sequences respectively.

4. Skew Look

This view is significantly used in DNA visualization which gives the percentage of excess of C/A over G/T. Our tool uses this sequence property GC (see figure 4. a, b) and AU (see figure 4. c, d) skew of miRNA for the same purpose only using AUGC data type. *Skew look* is described in method section in details.

5. CMP Look

For comparing pre-miRNA sequences CMP Look; randomly selected 100 sequences were aligned for their comparative percentage of AUGC and PuPy data types. This is mainly the comparison of rectangle ratio look for AUGC and PuPy data types (see figure 5. a, b). This view gives the information about how the sequence data are distributed in different

sequences.

Application of Visual-Mir

Based on the fact that human brain is much more powerful than computer to some extent in pattern recognition, our system will be helpful to scientists for sequence analysis, comparison and similarity searching. We can locate the mutation to find out what happened in miRNA through evolution by inspecting DV-Curves and Ratio Look. Functional properties of pre-miRNA can be retrieved from our graphical representation of sequence features since those properties completely depend on sequence arrangement. From the figures of

Visual-Mir we can easily observe relative nucleotide compositional information of pre-miRNA, which is far easier to observe than from a letter/text based raw sequences. These sequence properties can also be used effectively used as features in prediction of

pre-miRNAs using machine learning algorithms. The input format in our system is FASTA and embl format of miRNA sequences. The user can get images in bmp format as output for the different looks by Visual-Mir.

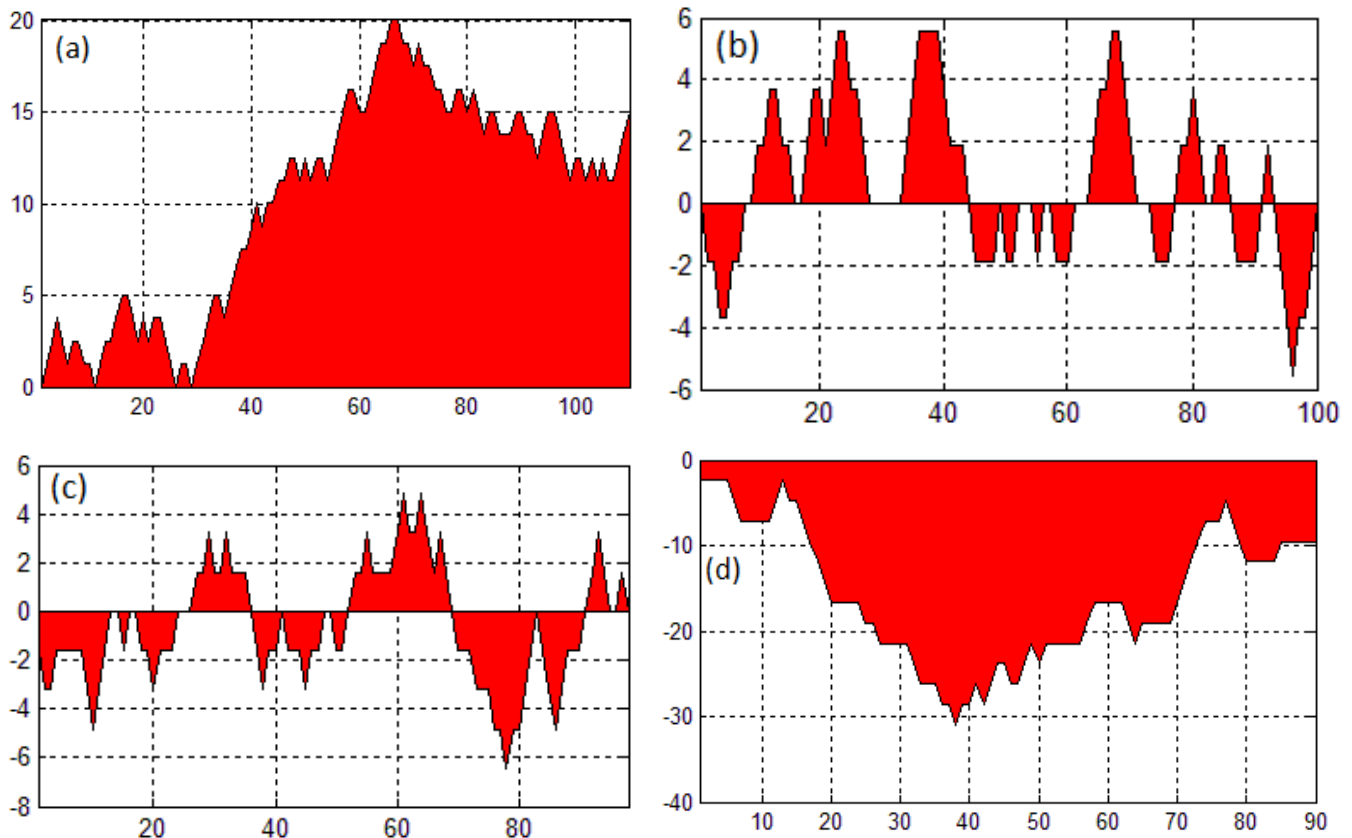


Figure 4 (a) and (b) are GC-skew of two randomly selected pre-miRNA sequences; AU-skew of another randomly selected two sequences is (c) and (d).

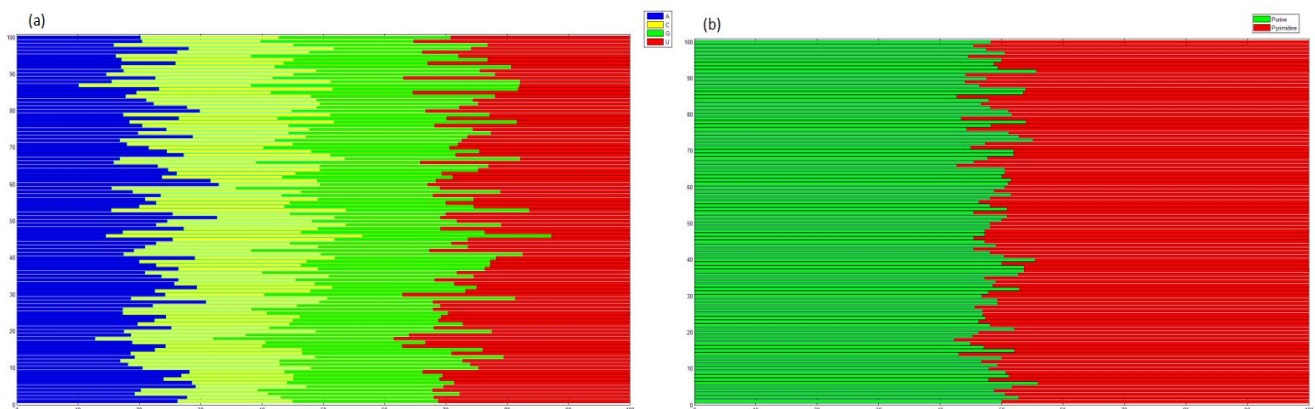


Figure 5 CMP look of AUGC (a) and PuPy (b) data types using randomly selected 100 sequences of pre-miRNA in both cases.

Conclusion

In biological science, visualization can play an important role in exploratory data analysis, where visual representations can help the scientist to build up an understanding of the content of their datasets. Visualization seeks to harness the remarkable capabilities of the human visual system to aid cognition, through the use of computer-generated representations. Biologists can make sense of

the information more effectively when it is presented in an interactive, graphical format. This study presents a complete and fine scheme to represent miRNA molecules graphically. These representations will facilitate the exploration of the numerous detailed facets of each miRNA element and their combined patterns in creating new perceptiveness of miRNA.

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20 kWp GRID CONNECTED SOLAR POWER STATION: MONITORING AND ASSESMENT

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This paper describes the components, operations and performance of a 20kWp grid-connected photovoltaic system installed in Khulna city in Bangladesh. The photovoltaic system has been running for two years successfully. The paper offers the concept of grid connected PV system in Bangladesh as well as analyses the performance of PV modules in Bangladeshi climate. Energy production in 2009 was about 10,000 kWh, in 2010 (up to 3rd June, 2010) is about 5,000 kWh. The average daily generation is about 60 kWh. In good irradiance conditions, PV modules efficiency is about 5% and efficiency of entire PV system exceeds 4%. Although, weather is a strong influencing factor but other parameter settings can make the system performance better. There is no problem in compatibility of the 20 kWp photovoltaic systems with Bangladesh grid system.

Keywords: renewable energy; PV system; grid system; solar energy; photovoltaic

1. INTRODUCTION

The increasing demand of electric power and the shortage of present energy resources lead today engineers and scientists to think about the alternative sources of energy. As a renewable energy, the sunlight is a potential resource for generating electric power. In recent years, it is increasingly used to generate power. As photovoltaic system is a rapidly developing technology, there is high potential of more and more solar power station to be installed in the coming decades.

Khulna Solar Plant is installed to introduce Renewable Energy (RE) as an alternative solution for power generation to overcome regular shortages in power supply for urban areas in Khulna division. The plant capacity is 20KWp. up to this the maximum generation has been recorded as 16KW. The plant consists of three independent plants with capacity 15KW, 4KW and 1KW. These plants are used independently for training purpose. During daytime, the solar module generates power by utilizing solar energy, charges battery and supplies to the loads and grid. At night, no power is generated and the load consumes the battery stored energy.



Fig. 1: PV panels installed on the roof

2. PV SYSTEM DESCRIPTION

Each module consists of a series and parallel combination of many photovoltaic cells. Thin film technology is used here. Each module rating is: 90W, 50 Volt & 1.8A.

Charge Controller controls the charging of the battery and prevents the battery from undesirable discharging. Each battery rating is: 12V/280Ah.

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Inverter rating: 400V/12.6A DC, 230V/21.7A AC. Automatic Switch Box is a microprocessor based automatic controlling mechanism which synchronizes voltage and Frequency, controls power flow direction and disconnects the solar panel from grid during abnormal conditions. AC load consists of some fans, fluorescent lights, security lamps etc. Total load is approximately 700W. In this system, an 11KV/415V distribution transformer's LT side is used for grid connection. Though in strict sense, it's not a grid connection.



Fig. 2: Control room and batteries.

As the capacity of Khulna solar plant is 20KWp, so its maximum generation is 20KW. During daytime, the solar modules absorb solar energy from sun light and convert this energy into electrical energy. The generation of electrical power is subject to irradiance, temperature, maximum power tracking, grid demand etc.

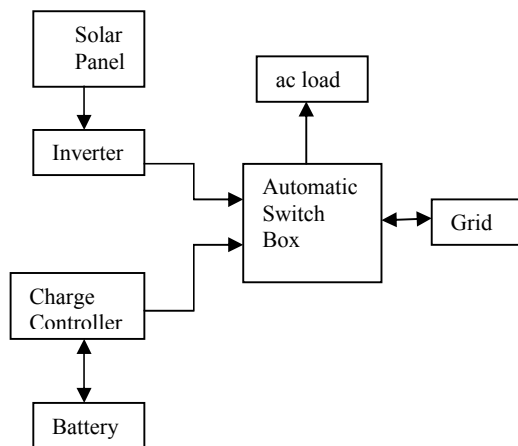


Fig. 3: Block diagram of solar system

Sufficient irradiance is available from 9am to 3pm. So, significant amount of electrical power is generated during this time. The generated electrical energy is supplied to the official load of approximately 700W and charges the batteries. When the battery is fully charged, the surplus power is fed to the grid. Here the grid is the LT side of a distribution transformer at 415V.

As the solar modules generate dc power, so inverter is used to convert the dc power into ac power and then supplied to load and grid. Charge controller is used to avoid unexpected battery discharging. If the solar module can't generate power for any inconvenience, then power is drawn from the grid to run the official loads and charge the battery.

The amount of power supplied to grid from solar module is dependent on grid demand. If grid demand increases, solar supply also increases. If grid demand decreases, solar supply also decreases. So solar supply falls during load shedding i.e. solar power can't be supplied to grid during load shedding.

During night, no irradiance is available so no power is generated. So at night power is drawn from the battery and supplied to security lamps.

The total system is controlled by automatic switch box which is a microprocessor programmed device. It also disconnects the solar system from the grid during over/under voltage conditions. The generation is being recorded and plotted graph by computer.

3. OPERATION AND MAINTENANCE

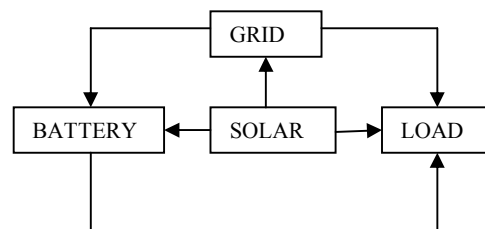


Fig. 4: Power flow diagram

In Khulna Solar Plant, the power may be supplied from solar panel, grid or battery and the power may be consumed by official load and grid. The power flow direction will be different for different conditions. The Automatic Switch Box controls the power flow and synchronizes voltage and frequency. The power flow conditions are as follows:-

When the solar plant generates power sufficiently, the total generated power will be extracted from solar panel. The generated power will charge the battery first. If the battery is fully charged then the power will be supplied to the official load. If the difference between solar power generation and grid

demand is at least 3kw, then the surplus power will also be supplied to grid.

If the power generated from solar panel is insufficient for office load, then power from grid will compensate to load.

If the solar panel doesn't generate any power then the official load will be supplied by the battery (at night). If the battery power is also unavailable, then the power will be drawn from the grid. This time the grid power will supply the office load as well as charge the battery.

If the grid voltage becomes over/under the nominal value, then the solar panel will be disconnected from the grid. Thus the solar panel can't supply power to grid during load shedding.

4. YIELD STATISTICS AND ANALYSIS

This project has been running from February, 2009. The generation of electrical energy is recorded everyday. The available data is from the end of February, 2009 to the beginning of June, 2010. The daily generation is recorded in kilowatt-hours. The following two tables show the daily generation of two years:-

From the Fig. 5, it is seen that the maximum daily generation was recorded on May 8, 2009 and it is 102 kW-hr.

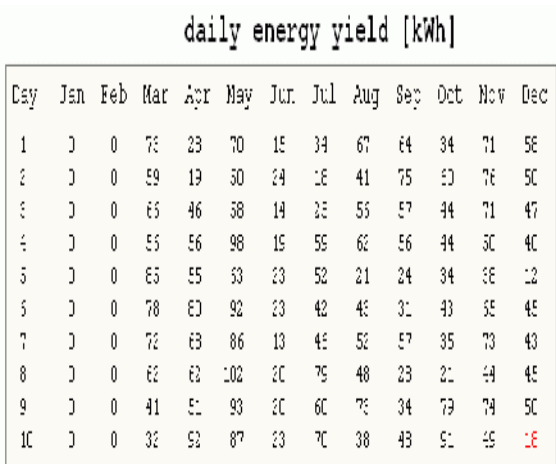


Fig. 5: Energy yield day by day for 2009 in kWh.

Here, the generation from day 1 to day 10 of each month in 2009 is shown. Sometimes the generation falls as the generation is subject to load shedding, present grid demand, cloud, rainfall etc.

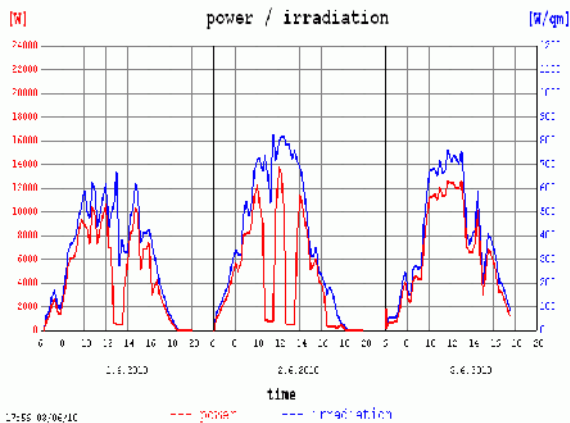


Fig. 6: Comparison between irradiation and generation.

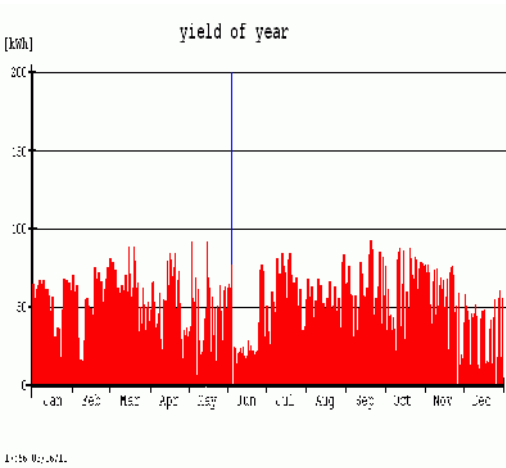


Fig. 7: Energy yield day by day for 2009

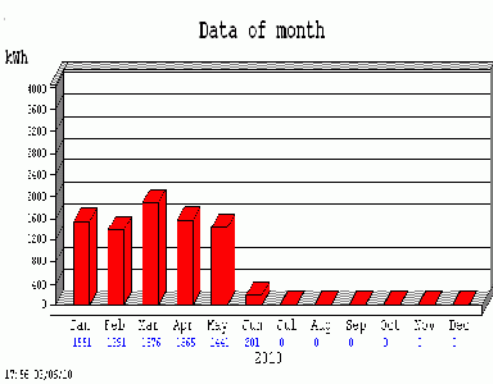


Fig. 8: Energy yield distribution in 2010

From the fig. 7, it is seen that the power generation falls nearly to zero though the presence of good

irradiation conditions. This is occurred due to the load shedding. As the PV output is connected to the LT side of a distribution transformer at 415V, so when load shedding occurs, PV can not supply to grid.

In the fig. 8, daily generation of each month of 2009 is shown. It is seen that the generation varies with irradiance from month to month.

5. IMPACT ON GRID

The large scale penetration of photovoltaic generation will affect the power system in different ways. Normally the photovoltaic system is connected to the grid in such a way that if any disturbance occurs, the photovoltaic generation will automatically be disconnected from the grid system. Thus during disturbances, large power generating unit will be disconnected and will thus intensify the disturbance. Again if cloud travels over the photovoltaic panel area, the irradiance will suddenly fall which in turn reduce the photovoltaic generation as well as the voltage. However, the power factor control may mitigate such voltage fluctuations [5].

6. ENVIRONMENTAL EFFECT

Using the common evaluation method, 10,000 kWh is equivalent to 2.43t oil or 3.89t coal consumption reduction, and 9.95t CO₂ emission reduction [4].

7. CONCLUSIONS

This photovoltaic power system has been successfully running for near two years. The daily generation of the photovoltaic system is good. However, if the load shedding effect can be avoided, then the yield will further increase.

The solar panels are faced at south direction at an angle near the latitude. However, the tilt angle should be such that the sun light is approximately vertical to the panels around the peak irradiation hours. If possible, the grid connected PV system should have sun tracking devices, they effectively increase the yield. Again the power required for tracking arrangement and yield increase both should be considered.

As the presented above results show, in Bangladesh condition PV system works satisfactorily. There were no problems with compatibility with Bangladesh grid system. Thus it is encouraged to

install more photovoltaic power plants to meet the crisis and increasing demand of power the country.

ACKNOWLEDGEMENTS

The monitoring and assessment of the project was possible through the cooperation of the authority, technicians and trainees of Khulna Renewable Energy and Training Centre. The authors give sincerely thanks to Khulna Renewable Energy and Training Centre, for their cooperation and assistance to us.

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A CMOS IC USING NANO-POWER ELECTRONIC CIRCUITS FOR LIFE-SAVING APPLICATIONS IN BANGLADESH

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Nano-power electronics is an area of emerging semiconductor VLSI technology where scaled down CMOS circuits are primarily used in this work. A fabricable CMOS integrated chip (IC) is designed using Magic CAD tools and it was also incorporated with scalable design techniques of MOSIS. A circuit components reduction technique is applied to redesign a sense amplifier circuit to lower the power to nano-watts level. This scalable design technique improved power by lowering from $7.15\text{E-}03$ watts to $1.31\text{-}09$ watts for the sense amplifier. Applications of this IC have been explored and it is found to be a life-saving design for launches in Bangladesh waterways. Application of two types of sensor is identified to use with this IC that can sense the catastrophic situations ahead of time by the proper placement in the launch. Floor plan of all components and their pin-assignments of the IC layout are described. PSPICE simulation to verify the operation and power consumption of components in the chip is presented in the paper.

Key words: Nano-Power; CMOS; Scalable Design; MOSIS, CAD; PSPICE

1. INTRODUCTION

Nano-power electronics is a fast developing field of engineering. The circuitry is composed of micro and nano-meter device scale, having ultra-low power electronic components. There are different types of semiconductor switches and devices that operate in nano-power range. Nano-power electronics have recently been used in various fields of engineering, biotechnology, physics, chemistry, space systems etc [1]. Upcoming technology includes nano scale electronics and semiconductor nanotechnology would also primarily consider consumption at nano-power levels. Micro and nano scale electromechanical systems including MEMS (Microelectromechanical System) which function with other nano power elements built within systems. They are very useful for engineering, medical science and many other areas of life saving applications [2].

1.1 Goals and Objectives

The goals of this project are to provide an overview of nano-power electronics design of an integrated chip and an assessment of how that technology can

be utilized in Bangladesh. The objectives are following:

- To design, simulate and verify nano-power electronic circuits by using scalable CMOS technology.
- Layout of a test chip that can be fabricated by MOSIS standard processes using the scalable design CIF file.
- To discuss about sensing signals and process by the chip using nano-power circuits that can save lives from catastrophic events.

2. CIRCUIT DESIGN, SIMULATION AND VERIFICATION OF SENSE AMPLIFIERS

The main concern of this work involved with two amplifiers to compare and determine their performance. These are sense amplifier based flip-flop and advanced modified sense amplifier. The sense amplifier based flip-flops are run with digital signals [3]. Borivoje and Oklobdzija designed this high-performance and low-power digital system and it works at low milliwatts power. It contains

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total twelve transistors. Four of them are large and the others are normal in size. It is a CMOS design having six PMOS and six NMOS transistors. The circuit has four inputs: R, R-bar, S, S-bar and two outputs: Q, Q-bar.

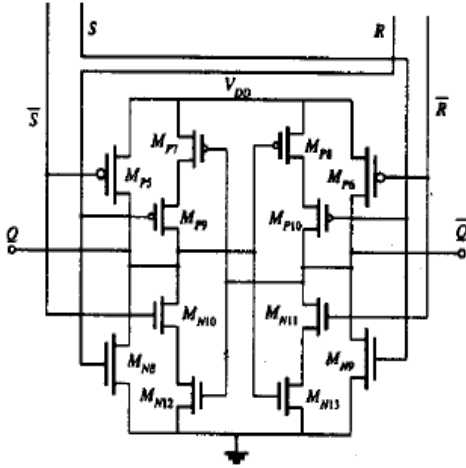


Fig 1: Schematic of sense amplifier based flip-flop

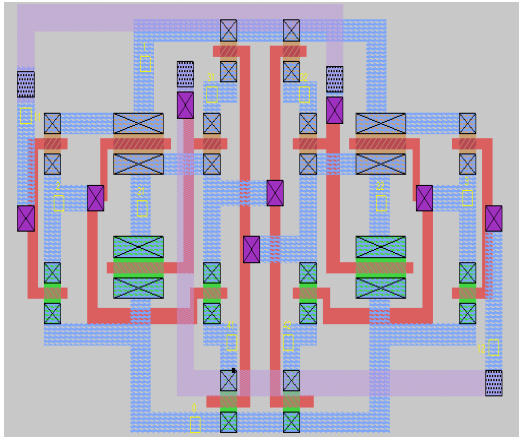


Fig 2: MAGIC layout of sense amplifier based flip-flop

PSPICE simulations and verification are necessary by converting circuit layouts into mathematical models; thus determine their behaviors. Figure 3 shows the input signals R, R-bar and S-bar of the sense amplifier based flip-flop. Figure 4 shows the output signal Q. The mathematical representation of these simulations show that the total power dissipation of the sense amplifier based flip-flop is 7.15E-03 watts. It is a very good sense amplifier where no power sensitive issues present. This milliwatts-power flip-flop based amplifier has some other advantages, as it is a logical toggle switch.

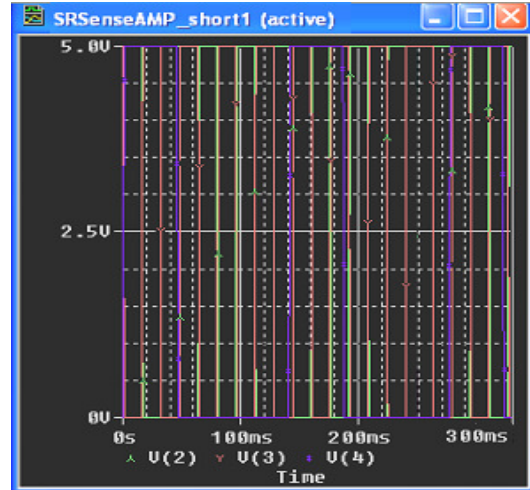


Fig 3: Input signals of sense amplifier based flip-flop

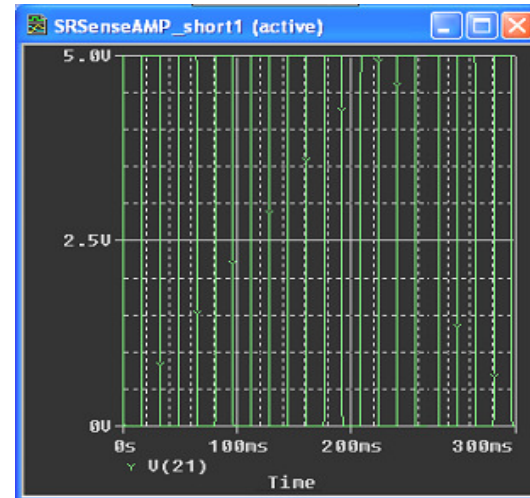


Fig 4: Output signal of sense amplifier based flip-flop

On the other hand, advanced modified sense amplifier is a mixed signal circuit, designed by Dr. Shuza Binzaid [4]. The circuitry of advanced modified sense amplifier is very simple. It contains two PMOS and three NMOS transistors. It has two input terminals V_1 , V_2 , enable and the output terminal V_{out} .

Figure 7 shows the two input signals and the enable signal. Figure 8 shows the output signal. The simulation and verification of the advanced modified sense amplifier shows that the total power dissipation is 1.31E-09 watts. This sense amplifier is fast and it operates at nanowatts, which can be suitable even for the remote power scavenging

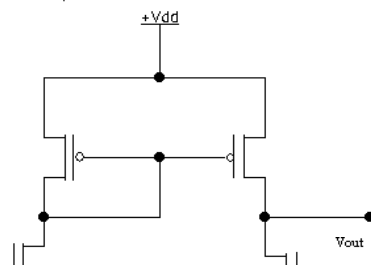


Fig 5: Schematic of the advanced modified sense amplifier

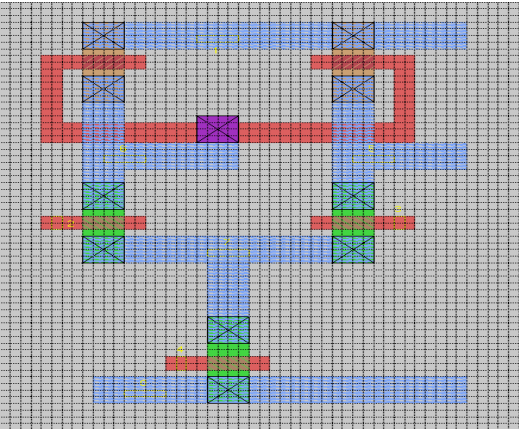


Fig 6: MAGIC layout of the advanced modified sense amplifier

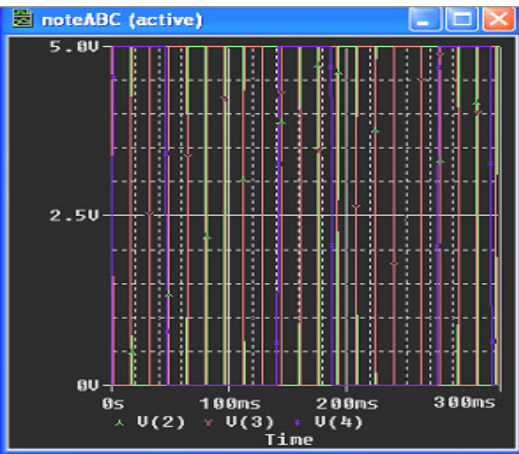


Fig 7: Input signals of the advanced modified sense amplifier with buffer inverter

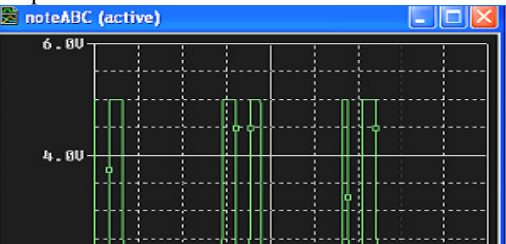


Fig 8: Output signals of the advanced modified sense amplifier with buffer inverter

By comparing the simulation and verification results, it is confirmed that the advanced modified sense amplifier dissipate less power than the sense amplifier based flip flop

3. DESIGN OF THE NANO-POWER CHIP

In this work, a nano-power chip has been designed following rules of MOSIS silicon process technology. The MOSIS scalable CMOS design techniques were used with MAGIC 2-D CAD tools for designing VLSI layout. SPICE circuit simulation tools were used to simulate each circuit component in the chip in order to verify the integrity and performance [5-8].

In figure 9, showing the designed chip floor plan having 20 pins. It contains a PMOS transistor, a NMOS transistor, a NAND gate, a buffer inverter, an inverter, an advanced modified sense amplifier, a sense amplifier based flip-flop. Pin assignments are presented in table 1.

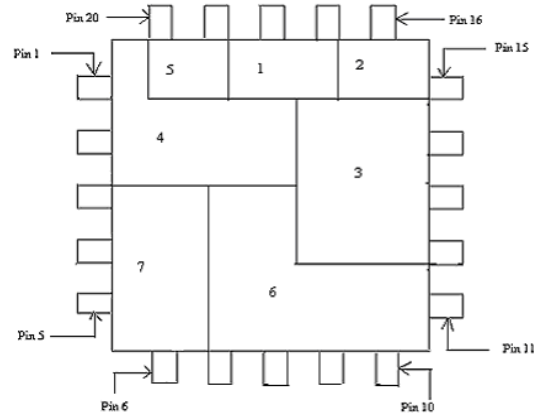


Fig 9: Floor plan of the chip
Table 1: List of devices in the chip and their pin assignments

SL No	Name of devices	Pad Assigned	Pin Name
1	PMOS Transistor	17,18	OP6, IN9
2	NMOS Transistor	15,16	OP5, IN8
3	NAND Gate	12,13,14	IN6, IN7, OP4
4	Inverter	1,2	OP1, IN1
5	Inverter Buffer	19,20	OP7,IN10
6	Sense Amplifier Based Flip-Flop	7,8,9,10,11	IN4, OP3, IN5,Vdd, GND
7	Advanced Modified Sense Amplifier	3,4,5,6	OP2, IN2, IN3, Enable

Every integrated chip has an interface to the external world through the metal pins of its package. These pins are connected inside package to metal on the silicon chip by welded micro-thin gold wires. The connecting metals in the chip silicon are called pads. The pad frame is also known as the I/O region. A quad package pad frame is used for the projected chip. Figure 10 shows the layout of a pad. Figure 11 shows the completed chip with pad frame. It contains testable devices and circuits. Each side of the chip is having 5 pins around the quad pad frame. MOSIS service can also facilitate with packaging vendors of such quad pad frame designs.

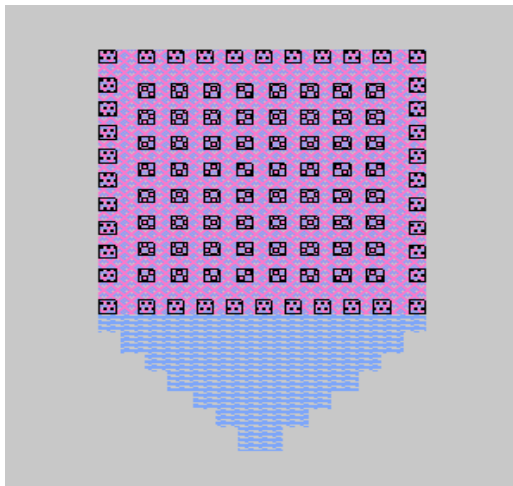


Fig 10: Layout of a bonding pad on silicon

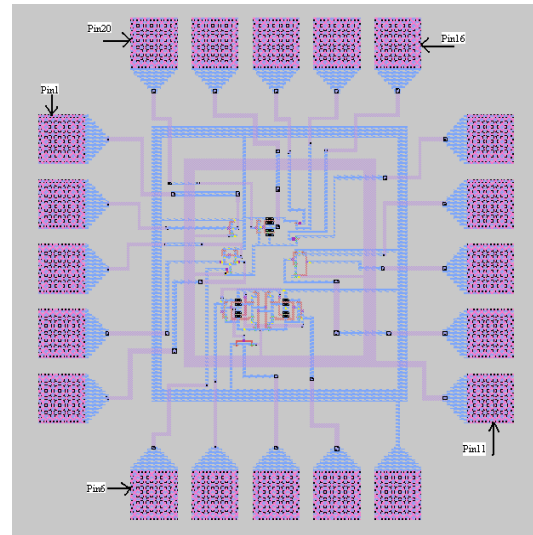


Fig 11: Complete chip with pad frames

MAGIC layout rule checker command 'drc' is applied to the design for the final checkup [9]. Then a CIF file is made. Then MOSIS header is added to the file when no errors were found in CIF file. This CIF file with header can be sent for fabrication using MOSIS service. The MOSIS service is a prototyping service that offers fast turnaround standard cell and full custom VLSI circuit development at very low cost. MOSIS has developed methods for merging many different designs from various organizations and place onto a single wafer. Wafer fabrication runs are scheduled on a regular basis for available fab processes of present semiconductor technologies with multi-layer metal CMOS/bulk technologies. MOSIS also provides different technologies for custom fabrication and also various chip packages [10].

4. LIFE-SAVING REAL APPLICATIONS OF THE CHIP

Bangladesh is a riverine country. Rivers play an important rule on transport media. Every year there occur many accidents in rivers. As unfortunate results, many lives and properties are at loss. Overloading and clashing of transports like boats, launches, ferries are the main reasons of these accidents.

The designed chip in this project can prevent accidents caused due to overloading or clashing especially with dockyards. Figure 12 shows a ship, which has two types of sensors. They are the sensor belt for the docking sides and the pressure sensor of the buoyancy [11].

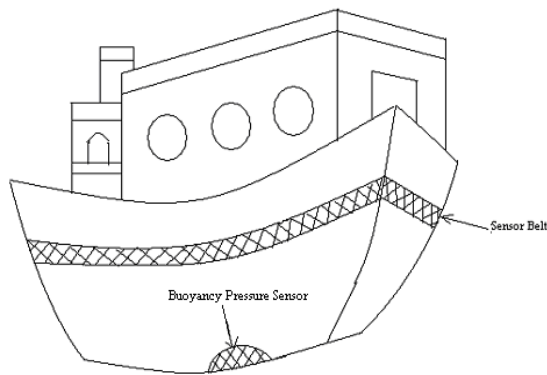


Fig 12: Applications on a ship showing sensors positions for sense amplifier circuits

A pressure sensor is used for monitoring the buoyancy conditions of the floating factors of the ship. It can be placed under the center of the keel. When the ship becomes overloaded, it can sense the threshold to electronic system with the designed chip for producing an alarm signal to captain of the ship, before leaving the dock. An electronic circuit can also send the signal to the dockyard regulatory service teams about the ship's risky situation.

The Sensor belt is for sensing the force on the frame of the ship if a clash is caused by the ship with the dockyard or any obstacle. It is placed on the surroundings of the ship's hull. The system can measure the electrical signal of the pressure V_1 , caused by clashing force and then compare it to the reference critical voltage V_2 input to the chip. If the strength of the clash crosses the safe level, then the chip can produce signal V_{out} for the alarm and thus it can prevent a catastrophic event.

5. CONCLUSION

A mixed signal chip is designed for low power practical applications. All the circuit layouts were completed by using MAGIC and their simulations for electrical characteristics were completed by using SPICE tools. Also following MOSIS SC MOS design rules, layout of pads was complete and DRC was verified. A 20-pin pad frame was designed for the chip. These chip components include two types of sense amplifiers: sense amplifier based flip-flop and advanced modified sense amplifier. Spice simulation showed they dissipated $7.15E-03$ watts and $1.31E-09$ watts, respectively. So the new advanced modified sense amplifier is improved significantly. It was in the range of nano-power. Also from these results, it is found that the power dissipation was reduced by $5.46E-06$ times.

For future work of this project, it is planned to implement the designed chip to a water transport.

This chip with sense amplifiers can be used to detect collision forces and also the overloading conditions of the ship. This chip easily monitors and determines certain dangers; thus help avoiding catastrophic situations. So the system can save lives.

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A COMPARATIVE STUDY OF ELECTRICAL, HALL EFFECT AND MAGNETIC PROPERTIES OF Co THIN FILMS DEPOSITED ON GaAs(001), Si(001) AND GLASS SUBSTRATES

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Cobalt (Co) thin films have been prepared by e-beam evaporation technique on glass, Si(001) and GaAs(001) substrates at a pressure of about 2×10^{-4} Pa. The thickness of the films is 100nm. The deposition rate of the films was about 0.93 nms^{-1} . The as-deposited films have been annealed in open air for 4 hours at constant temperature of 523 K. Magnetic, electrical and Hall Effect properties of the films have been studied. Magnetic and electrical study showed that the interfacial resistance (IR) is present at Co/Si interface. Coercivity of 100nm Co films on glass substrate is found to be 44 Oe. It is increased to 77 Oe for the same thickness Co film on GaAs substrate. Electrical resistivity for the as-deposited and annealed films has been measured as a function of temperature ranging from 303 to 451 K. The resistivity of the films on glass substrate is increased after annealing. It is only $11 \mu\Omega\text{-m}$ for 100nm films. At room temperature, the values of resistivity for both the as-deposited and annealed films on silicon substrate were $6.04 \mu\Omega\text{-m}$ and $15.66 \mu\Omega\text{-m}$, respectively. The positive value of T.C.R indicates that the metallic behavior of the films. The Hall effect measurement showed that the Hall coefficient of Co films on glass substrate is decreased with increasing film thickness. It is found to increase after annealing for both Co films on glass and silicon substrates. The carrier concentration was $13.3 \times 10^{19} \text{ cm}^{-3}$ for 100nm Co film on glass but it is decreased $3.8 \times 10^{19} \text{ cm}^{-3}$ for the same thickness Co film on silicon substrate. Co thin films have been produced by electron beam bombardment heating technique and thickness measures in Fizeau fringes method. Electrical resistivity and Hall Effect studies are measured Van-der-Pauw technique.

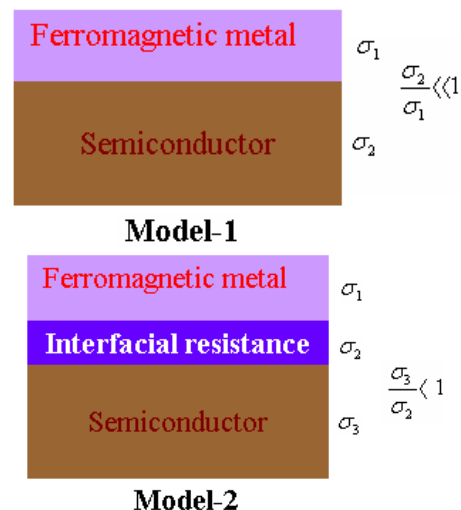
Key words: Spin injection efficiency; interfacial resistance; coercivity; anisotropy; hysteresis loop

1. INTRODUCTION

Electrical spin injection of electrons across a ferromagnetic metal and semiconductor interfaces yields an injection efficiency η of 1% or even less [1-2]. Spin injection efficiency is largely affected by interfacial resistance (IR) at the interface of ferromagnetic metal and semiconductor due to conductivity mismatch [3-4]. It is known that it depends on

$$\eta \propto \frac{\sigma_{\text{Semiconductor}}}{\sigma_{\text{Metal}}} \ll 1$$

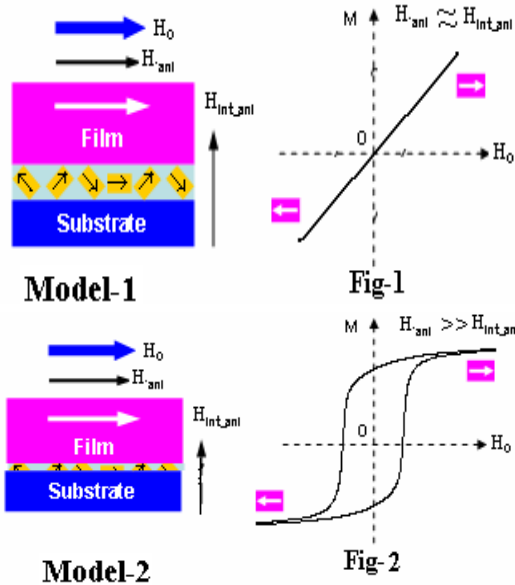
It is possible to increase the above value by introducing interfacial resistance (IR) at the interface between semiconductor and ferromagnetic metal.



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2. THEORY

If the in plane anisotropy field (H_{ani}) is comparable to the anisotropy field (H_{int}) due to interface, then the $M \sim H$ curve will be a straight line (Fig-1). In the absence of anisotropy field due to interface (in the case of glass substrate) or very small interfacial anisotropy field (in the case of GaAs substrate). The $M \sim H$ curve shows typical hysteresis loop as shown in Fig-2.



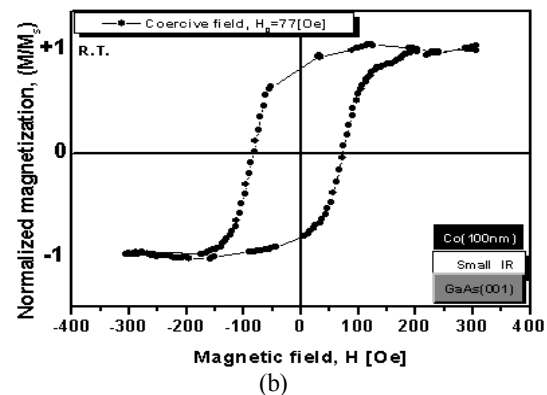
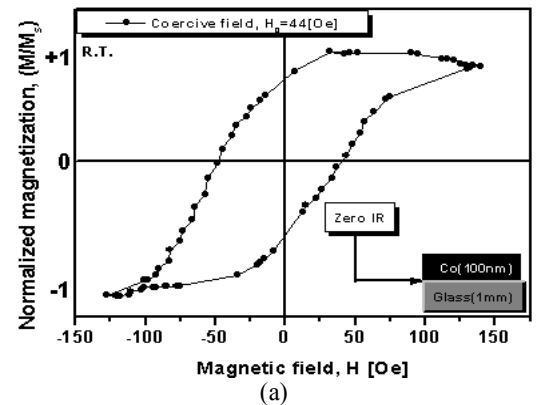
Our objective is to verify that there is an interface in Co/Si system. To verify this, we have measured the hysteresis loop of Co/Si, Co/glass and Co/GaAs. The interfacial resistance mainly due to the formation of CoSi and its resistivity is much larger than the resistivity of pure Co film. Therefore, the same thickness Co film on Si should show larger resistivity than Co on GaAs (small interface) as well as glass substrate

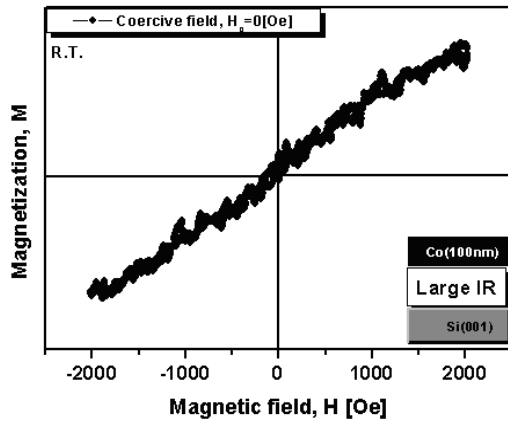
3. RESULTS AND DISCUSSION

Fig-3(a) and Fig-3(b) represents a comparison of such hysteresis loops for both the cases. For these measurements, magnetic field was applied parallel to the sample surface and the hysteresis loops were recorded up to the saturation magnetization. One can see from observed results that the hysteresis loop of Fig-3(a) and Fig-3(b) are not square in shape indicating that the magnetization processes of sample having some interfacial anisotropy. If the dominant part of interfacial anisotropy lie perpendicular to the sample plane then the magnetization process are different. The effective magnetic field also reduced in this case and equal to

the vector sum of these fields. Therefore, the saturation field is higher than the coercive field. Observed coercivity and saturation magnetization values are found to be 44Oe and 1.541×10^{-4} emu respectively on glass substrate. 77Oe and 2.373×10^{-4} emu values are found of coercivity and saturation magnetization on GaAs substrate. Then on the silicon substrate are zero. The crystalline hcp Co phase is obtained for Co/glass system. It is well known that when the crystal grains are large, crystalline magnetic anisotropy is large and magnetization in each crystal grain orients in different directions, because easy axes are not parallel to each other [5]. Therefore, larger grain size should lead to a large coercivity in Co/GaAs than Co/glass thin films [6].

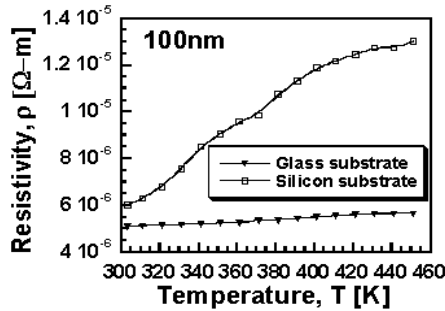
The interfacial resistance (IR) at the Co/glass interface is zero. The $M \sim H$ curve shows typical hysteresis loop of polycrystalline Co films. But in the case of Co/GaAs, the interfacial reaction is low and IR value is believed to be small. Co films on the silicon substrate, the interfacial reaction is high. Co forms CoSi at the interface and it is not magnetic material. It is believed to be diamagnetic or paramagnetic and its moments lie perpendicular to the substrate surface. Therefore, the $M \sim H$ curve does not show in the hysteresis loop.



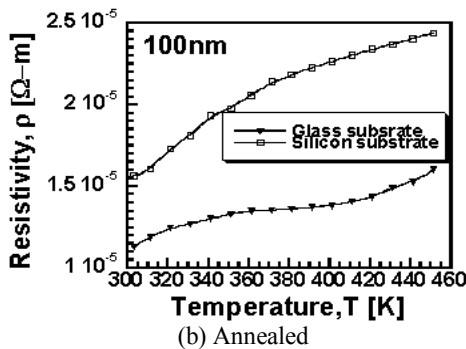


(c)
Fig-3: Variation of normalized magnetization or magnetization with magnetic field for as-deposited 100nm Co thin films on (a) glass substrate (b) GaAs substrate and (c) silicon substrate

The variation of resistivity with temperature for both the as-deposited and annealed 100nm Co thin film deposited on glass and silicon substrates is shown in Fig-4(a) & (b). It is seen from the Figures that for both the cases resistivity higher for film on silicon substrate. It is also evident that the annealed films have higher order of resistivity than as-deposited films for both the cases.



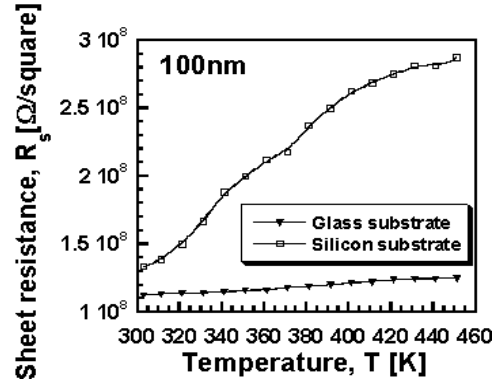
(a) As-deposited



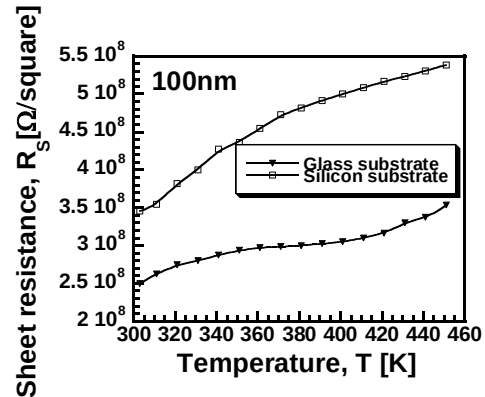
(b) Annealed

Fig-4: Variation of resistivity with temperature for 100nm Co thin films on glass and silicon substrates

The variation of sheet resistance with temperature for both the as-deposited and annealed 100nm Co thin film deposited on glass and silicon substrates is shown in Fig-5(a) & (b). It is seen from the Figures that for both the cases sheet resistance high for film on silicon substrate. It is also evident that the annealed films have higher sheet resistance than as-deposited films for both the cases.



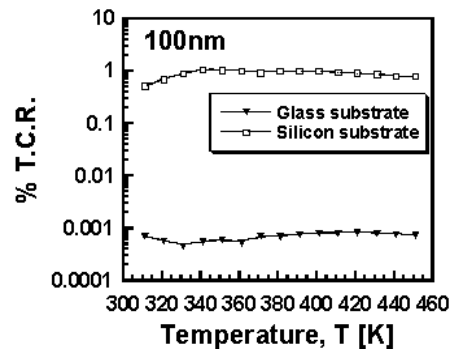
(a) As-deposited



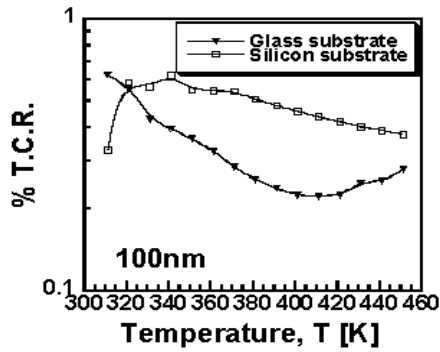
(b) Annealed

Fig-5: Variation of sheet-resistance with temperature for 100nm Co thin films on glass and silicon substrates

The TCR for 100nm Co thin films on silicon and glass substrates is shown in Fig-6(a) and 6(b).



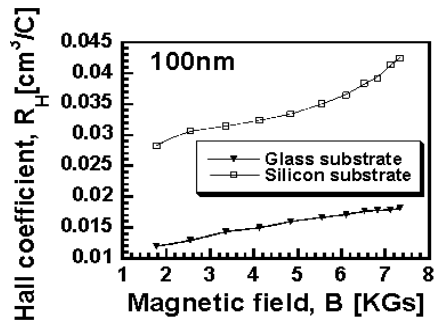
(a) As-deposited



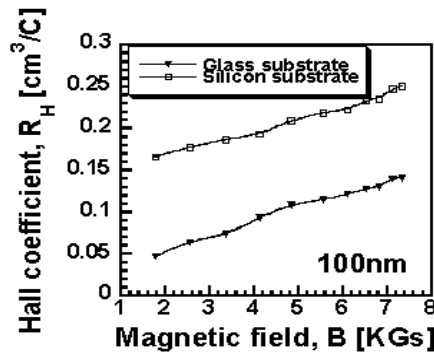
(b) Annealed

Fig-6: Variation of T. C. R (%) with temperature for 100nm Co thin films on glass and silicon substrates

Fig-7(a) and 7(b) show the variation of Hall coefficient with magnetic field for both the as-deposited and annealed 100nm thick Co film deposited on glass and silicon substrates. It is revealed from the Figures that for both the glass and silicon substrates carrier is p-type. It is also observed that film deposited on silicon substrate has higher Hall coefficient. It is also evident that after annealing Hall coefficient increases for film deposited on both substrate.



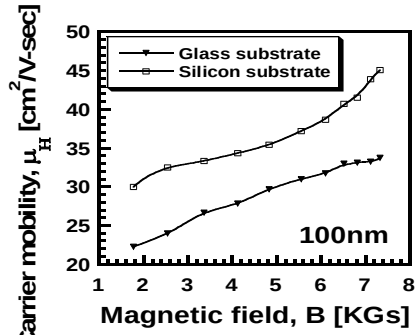
(a) As-deposited



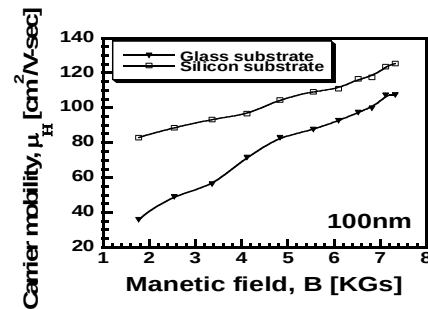
(b) Annealed

Fig-7: Variation of Hall co-efficient with applied magnetic field for 100nm Co thin films on glass and silicon substrates

The variation of carrier mobility with magnetic field for both the as-deposited and annealed 100nm thick Co film deposited on glass and silicon substrates at room temperature is shown in Fig-8(a) and 8(b). It is seen that deposited film on silicon substrate has higher carrier mobility than that of glass substrate.



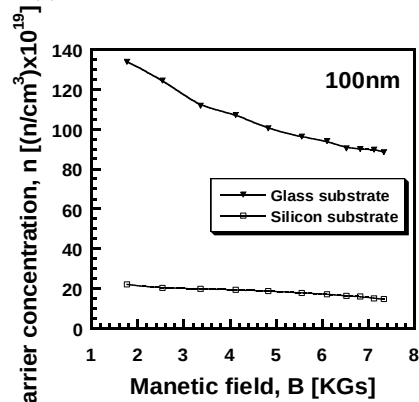
(a) As-deposited



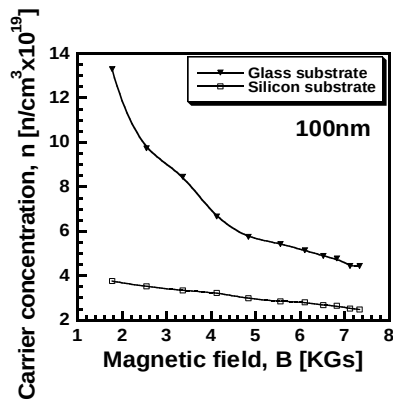
(b) Annealed

Fig-8: Variation of carrier mobility with applied magnetic field for 100nm Co thin films on glass and silicon substrates

The variation of carrier mobility with magnetic field for both the as-deposited and annealed 100nm thick Co film deposited on glass and silicon substrates at room temperature is shown in Fig-9(a) and 9(b).



(a) As-deposited



(b) Annealed

Fig-9: Variation of carrier concentration with applied magnetic field for 100nm Co thin films on glass and silicon substrates

It is seen that film deposited on silicon substrate has lower carrier concentration than that of glass substrate for both the cases.

4. CONCLUSION

Magnetic and electrical studies showed that the interfacial resistance (IR) is present at Co/Si interface. Coercivity of 100nm Co film on glass substrate is found to be 44 Oe. It is increased to 77 Oe for the same thickness Co film on GaAs substrate. At room temperature, the values of resistivity for both the as-deposited and annealed 100nm Co films on silicon substrate were $6.04 \mu\Omega\text{-m}$ and $15.66 \mu\Omega\text{-m}$, respectively. The resistivity of same thickness Co film on glass substrate was found to be $5.09 \mu\Omega\text{-m}$ for as-deposited and $11.33 \mu\Omega\text{-m}$ after annealed. The carrier concentration was $5.2 \times 10^{20} \text{ cm}^{-3}$ for 100nm Co film on glass but it is decreased $2.2 \times 10^{20} \text{ cm}^{-3}$ for the same thickness Co film on silicon substrate. Therefore, we have accomplished our purpose by comparing the properties of pure Co film (Co/glass) with Co film having CoSi interface (Co/Si).

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A RECURRENT NEURAL NETWORK BASED BACK EMF ESTIMATOR FOR POSITION SENSORLESS CONTROL OF IPM SYNCHRONOUS MOTOR DRIVE

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This paper investigates the performance of a position sensorless Interior Permanent Magnet (IPM) synchronous motor drive based on Recurrent Neural Network (RNN). The drive system is powered through a Space Vector Modulated (SVM) voltage source inverter. The input stationary two-axis phase voltages, corresponding phase currents, and motor speed error are fed to a RNN to estimate the back Electromotive Force (EMF) along stationary α - β axes. The RNN back EMF model is trained off-line and it estimates the back EMF components accurately. The rotor position information is used for vector control of the IPM motor drive. A Proportional-plus-Integral-plus-Derivative (PID) controller is used to control the motor variables in closed loop. To validate the effectiveness of the drive system, simulation study is carried out under different operating conditions. The proposed drive is found to work effectively under these conditions with excellent dynamic performance.

Key words: Back EMF; IPM synchronous motor; recurrent neural network; sensorless control; space vector modulation

1. INTRODUCTION

Nowadays, permanent magnet synchronous motors are widely used in industries because of their inherent advantages such as lower mass, lower moment of inertia, highly efficient, and being easy to control and maintain. IPM motors are recently built with NdFeB permanent magnet material and have applications in high performance drives. A high performance IPM drive system for four quadrant operation is proposed in (Bose, 1988). The paper describes drive performance under constant load torque and field weakening regions. The control law is implemented in a microprocessor based environment. Fuzzy logic controller based four switch converter with reduced cost is proposed in (Uddin et al., 2006). Hysteresis current control processed through fuzzy logic controllers activated by speed error and change of error is used in the paper. Application of fuzzy logic controllers for avoiding exact modeling uncertainties attracted the authors in (Roy et al., 2008) to apply it in the IPM motor control. They used hysteresis current controller to force the current vector in the three phase load according to a reference trajectory. Microprocessor based implementation of an IPM

synchronous motor drive system is provided in (Bose and Szczesny, 1988). The proposed system is claimed to be suitable for vehicle applications. Simple current control method and simulation are found to be complying with the proposal. In (Chen et al., 2002) the authors proposed maximum torque per ampere method to control an IPM motor drive. The drive system has been applied for flux weakening region also.

IPM motors require proper modeling for controller design because of their inverse type saliency effect. Analysis and description of the motor models under different operating conditions are considered in (Ohm et al., 1995). A detailed analysis of IPM lumped parameter model starting from variable inductance and mutual coupling is presented and a simplified model in synchronous d-q reference frame is deduced by the authors. The paper also shows the d-q equivalent circuit and describes methodology to measure the lumped parameters of the machine. Machine inductances based on angle dependent reluctances are considered in (Nakamura et al., 2003) for dynamic analysis. The authors also presented simulated results those comply with their proposal.

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A good number of researchers have been working with IPM motors to design controllers with minimum sensors. IPM motors possess magnetic saliency that introduces harmonics in the motor current. This phenomenon is introduced in (Ogasawara and Akagi, 1998) to find out position and speed of the IPM motor. The authors proposed harmonic current extraction method with practical circuit. An extended induced voltage model based sensing of back EMF and rotor position is presented in (Tanaka and Miki, 2007). It uses a position error estimation to calculate speed and rotor position. A sliding mode observer based estimation of back EMF along stationary mutually perpendicular reference frames is shown in (Xu and Rahman, 2004). The estimated back EMF components are then used to find out rotor position. A Novel back EMF detection technique in brushless dc motor is shown in (Lai and Lin, 2008). The paper proposes unexcited phase detection to find out the back EMF. A RNN based stator flux estimator is proposed in [Halder and Ghosh, 2010]. The authors showed that the rotor position can be estimated accurately by using RNN. This rotor position information is then used for vector control of IPM synchronous motor drive.

This paper proposes a rotor position estimator using back EMF based on RNN. The voltage source inverter based systems exhibit poor performances if flux estimation is considered. The back EMF components along stationary perpendicular axes are used to calculate instantaneous position of the rotor. Space vector modulation technique is used to reduce the ripple in torque. The proposed control system is tested for sudden change of load and speed reversal condition.

2. MATHEMATICAL MODEL

A mathematical model of the IPM synchronous motor is required for proper simulation of the system. Fig. 1 shows different axis of the IPM motor. The dynamic model of the IPM motor in the synchronously rotating d-q reference frame can be expressed as follows (Ohm et al., 1995):

$$v_q = Ri_q + pL_q i_q + \omega_r \psi_f + \omega_r L_d i_d \quad (1)$$

$$v_d = Ri_d + pL_d i_d - \omega_r L_q i_q \quad (2)$$

Flux Linkages along the fictitious d-q axes are:

$$\lambda_q = L_q i_q \quad (3)$$

$$\lambda_d = L_d i_d + \psi_f \quad (4)$$

Where, v_d and v_q are the d-q axes voltages, i_d and i_q are the d-q axes stator currents, L_d and L_q are inductances acting along the d-q axes, λ_d and λ_q are the d-q axes stator flux linkages respectively, R is the stator resistance per phase, ω_r is the rotor speed,

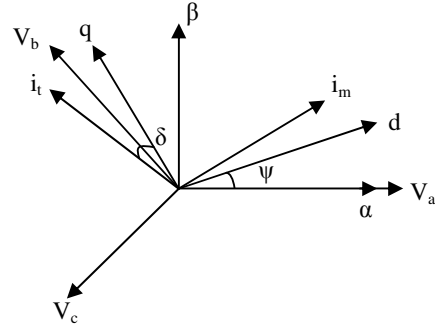


Fig. 1: Stationary and rotating axes of the IPM synchronous motor

ψ_f is the permanent magnet flux, and p is the derivative operator (d/dt).

The developed electromagnetic torque is given as:

$$T_e = \frac{3P}{2} (\psi_f i_q + (L_d - L_q) i_d i_q) \quad (5)$$

The torque balance equation for the motor speed dynamics is given by

$$T_e = T_L + J_m p \omega_m + B_m \omega_m \quad (6)$$

The machine model can be expressed in state-space form as:

$$L_q \frac{di_q}{dt} = v_q - Ri_q - P_p \omega_m L_d i_d - P_p \omega_m \psi_f \quad (7)$$

$$L_d \frac{di_d}{dt} = v_d - Ri_d + P_p \omega_m L_q i_q \quad (8)$$

$$J_m \frac{d\omega_m}{dt} = T_e - T_L - B_m \omega_m \quad (9)$$

$$\text{and } \omega_r = p_p \cdot \omega_m \quad (10)$$

Where, ω_m is the rotor mechanical speed and P_p is the number of pole pairs.

3. PROPOSED CONTROL SCHEME

The high performance control strategy is implemented in closed loop using PID controller as shown in Fig. 2. The speed error is processed to generate the torque producing component of the stator current (i_t^*). The torque angle δ is a function of (i_t^*/i_m^*) and is assumed in this study as

$$\delta = \tan^{-1} \left(\frac{i_t^*}{i_m^*} \right) \quad (11)$$

The d-q axes reference current components are formulated as follows:

$$i_d^* = i_m^* \cos \delta - i_t^* \sin \delta \quad (12)$$

$$i_q^* = i_t^* \cos \delta + i_m^* \sin \delta \quad (13)$$

The reference voltage components V_d^* and V_q^* are calculated using (1) and (2).

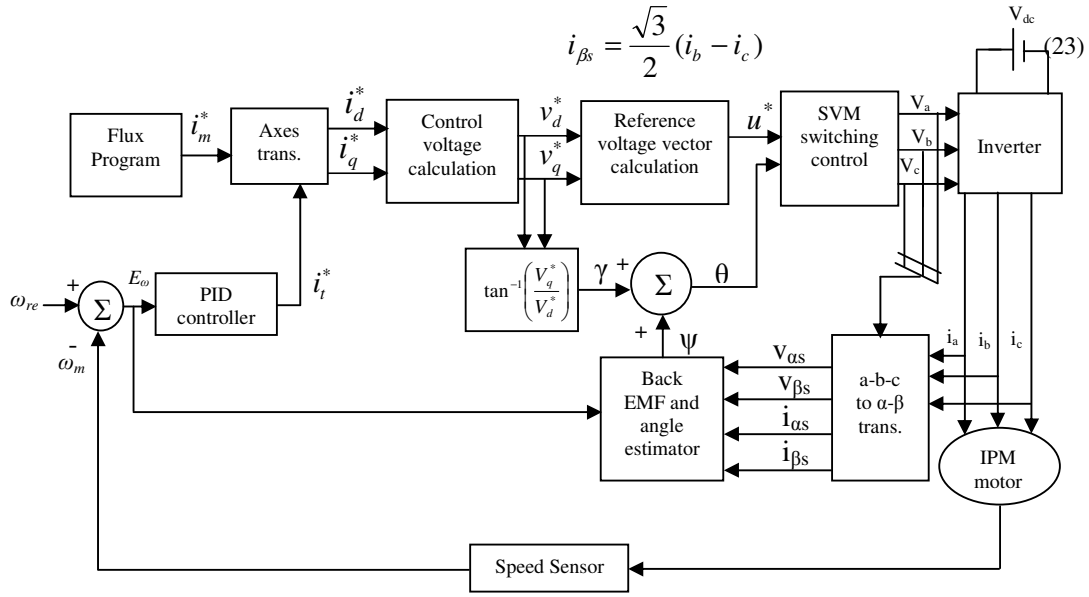


Fig. 2: Proposed control scheme of the IPM synchronous motor drive

The reference voltage vector u^* and the inverter switching time are calculated using the formula presented in (Bose, 1997).

If γ is the angle between resultant voltage vector and V_q^* then

$$\gamma = \tan^{-1} \left(\frac{V_q^*}{V_d^*} \right) \quad (14)$$

The d-q axes back EMF components are given by

$$e_q = \omega_r L_d i_d + \omega_r \psi_f \quad (15)$$

$$e_d = -\omega_r L_q i_q \quad (16)$$

If ψ is the angle of resultant back EMF with α -axis then

$$\psi = \tan^{-1} \left(\frac{e_{\beta s}}{e_{\alpha s}} \right) \quad (17)$$

Estimated angle of voltage vector,

$$\theta = \gamma + \psi \quad (18)$$

The reference phase currents are formulated as follows:

$$i_a^* = i_m^* \cos \theta - i_t^* \sin \theta \quad (19)$$

$$i_b^* = i_m^* \cos(\theta - 120^\circ) - i_t^* \sin(\theta - 120^\circ) \quad (20)$$

$$i_c^* = i_m^* \cos(\theta + 120^\circ) - i_t^* \sin(\theta + 120^\circ) \quad (21)$$

The stationary 3-phase (a-, b-, c-) to stationary 2-phase (α -, β -) transformation is given by

$$i_{\alpha s} = i_a - 0.5 i_b - 0.5 i_c \quad (22)$$

4. RECURRENT NEURAL NETWORK BASED BACK EMF ESTIMATION

The Recurrent Neural Network is a single layer neural network with input and output nodes. The output nodes act as summing nodes and in this study the two output variables, i.e., α - and β -components of stator back EMF are fed to the input with unit delay operator. The value of activation function at the output node is taken unity. The common inputs for both the outputs are α -, β -components of stator current and the speed error. The α -component of stator voltage is given as input for α -axis stator back EMF estimation. Similarly, the β -component of stator voltage is given as input for β -axis stator back EMF estimation. The resultant matrix equation can be written as (Rafiq et al., 2006):

$$\begin{bmatrix} e_{\alpha s}(k+1) \\ e_{\beta s}(k+1) \end{bmatrix} = \begin{bmatrix} W_{11p} & 0 \\ 0 & W_{22p} \end{bmatrix} \begin{bmatrix} e_{\alpha s}(k) \\ e_{\beta s}(k) \end{bmatrix} + \begin{bmatrix} W_{11} \\ W_{21} \end{bmatrix} i_{\alpha s} + \begin{bmatrix} W_{12} \\ W_{22} \end{bmatrix} i_{\beta s} + \begin{bmatrix} W_{13} & 0 \\ 0 & W_{23} \end{bmatrix} \begin{bmatrix} v_{\alpha} \\ v_{\beta} \end{bmatrix} + \begin{bmatrix} W_{14} \\ W_{24} \end{bmatrix} E_{\omega} \quad (24)$$

Where, $W_{11p}, W_{22p}, W_{11}, W_{22}, W_{13}, W_{14}$ etc. are the weights of the RNN, which is shown in Fig. 3.

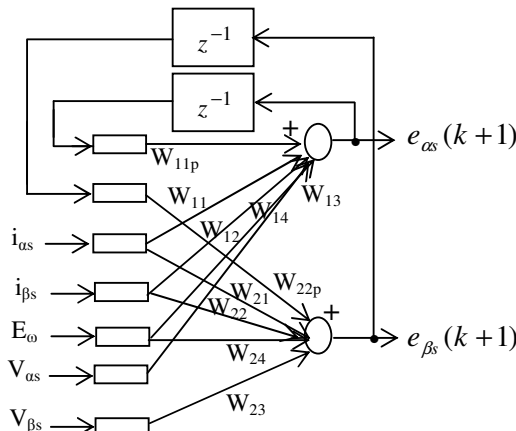


Fig. 3: Stationary α - and β -axis stator back EMF estimation by RNN

5. SIMULATION RESULTS

Computer simulations are conducted in order to test the performance of the drive system under different operating conditions. The system under consideration is simulated in a Pentium-based PC with C++ environment. The incremental time Δt for simulating the system is $0.5\mu s$ and the sampling time for SVM is $0.5ms$.

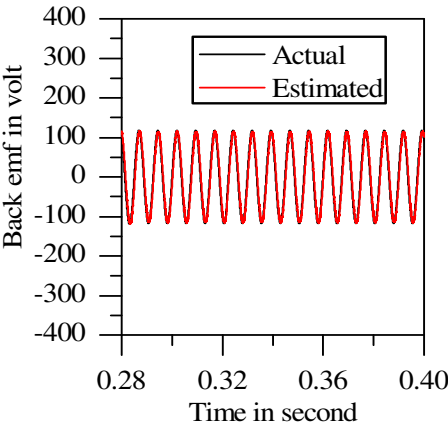
5.1 Performance of RNN for Back EMF and Angle Estimation

The effectiveness of the proposed RNN back EMF estimator along α - β axes is verified before implementing it in the drive system. Actual back EMF components calculated from exact values of motor variables are computed and compared with the estimated back EMF components. Fig. 4(a) & (b) show the estimated α - and β -axis back EMF components respectively. It can be visualized that the proposed RNN estimates the back EMF components accurately. A complete matching of the variables is indicated in the following figures. Fig. 4(c) shows the estimated angle which follows very closely the actual angle deduced from the machine model.

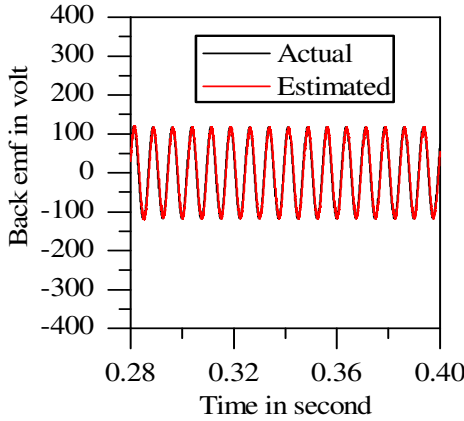
5.2 Starting Performance of the IPM Synchronous Motor Drive

The motor was started with a command speed of 955 rpm and load torque of 2.5 N-m from standstill condition. Fig. 5(a) shows the simulated speed response of the drive. It is observed that this drive follows the command speed closely and reaches the set value at 0.27 sec. The drive shows very fast speed response with no overshoot. Fig. 5(b) shows

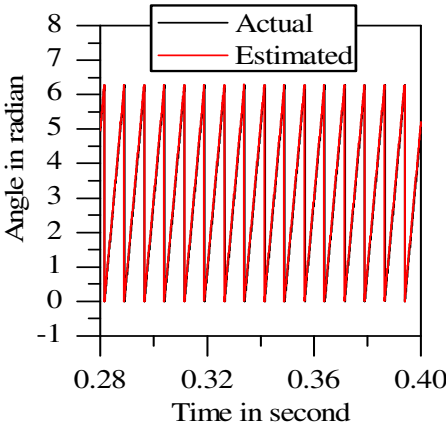
the developed torque that oscillates around the load torque when the motor reaches the set speed. It is noticed that higher electromagnetic torque is generated during the motor acceleration. Some pulsations in electromagnetic torque is noticed which is due to switching voltage disturbances of the devices with SVM.



(a)



(b)



(c)

Fig. 4: (a) α -axis components of estimated and actual back EMF, (b) β -axis components of estimated and actual back EMF, and (c) Estimated and actual rotor angle

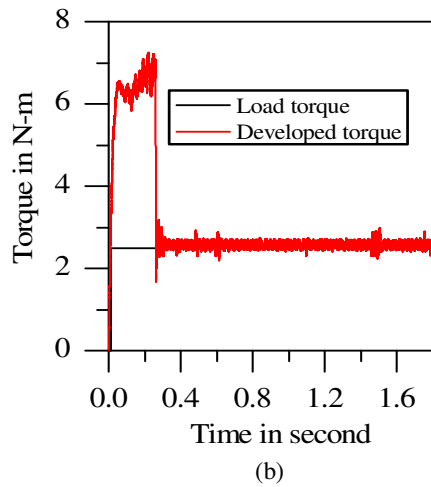
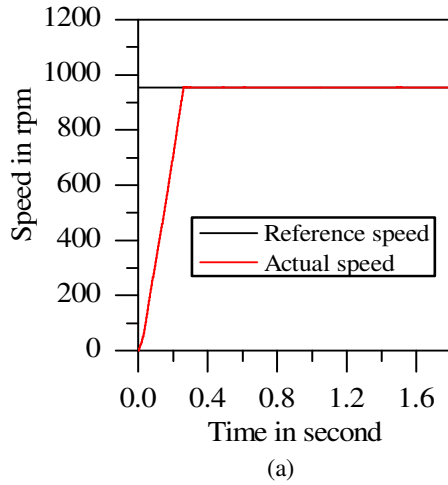


Fig. 5: (a) Simulated speed response, (b) Developed electromagnetic torque under transient and steady-state condition

5.3 Performance under Load Change and Speed Reversal Condition

To demonstrate the effect of load change on the performance of the drive, the load torque was doubled to 5.0 N-m at 1.0 sec. The developed electromagnetic torque and speed response are given in Fig. 6(a) & (b). Sudden application of load torque causes no appreciable variation in speed. The steady-state error is almost negligible. To verify the effect of speed reversal, the command speed was suddenly reversed from 955 rpm to -955 rpm at 0.6 sec. Again the command speed was set to 955 rpm at 1.2 sec. Fig. 7(a) shows the speed response for reversal of speed. It is observed that the drive system follows the command speeds accurately without any oscillation. Fig. 7(b) shows

the corresponding developed electromagnetic torque.

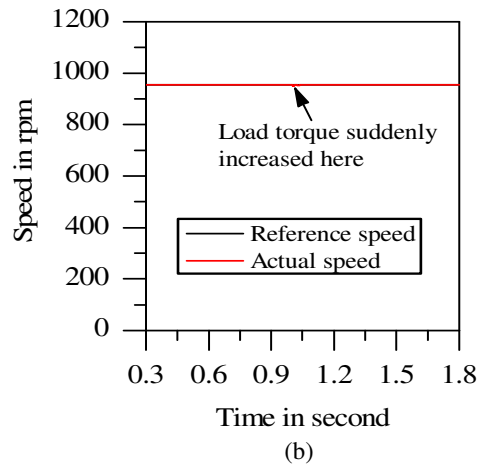
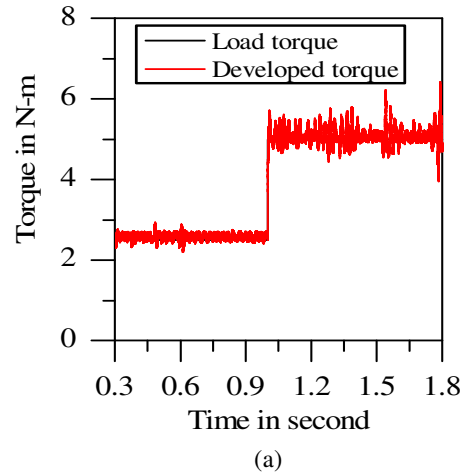
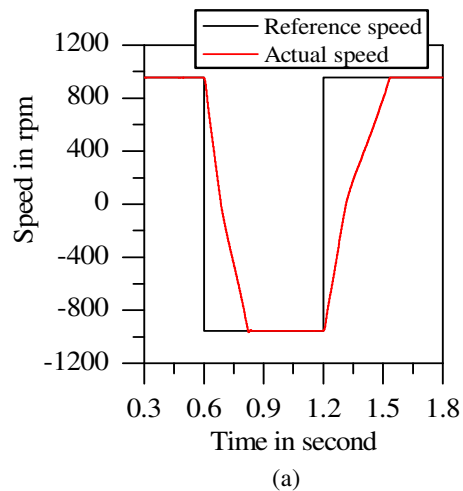


Fig. 6: (a) Developed electromagnetic torque, (b) Simulated speed response for change in load torque



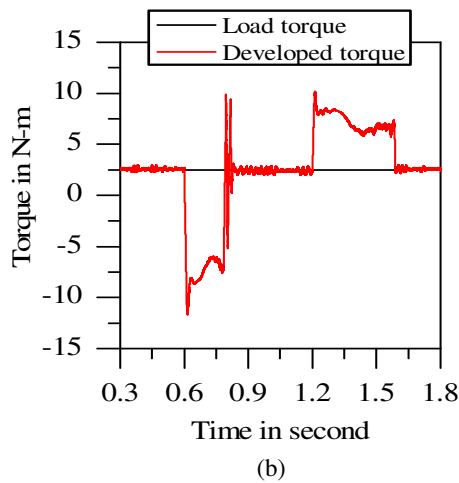


Fig. 7: (a) Simulated speed response, (b) Developed electromagnetic torque for speed reversal condition

6. CONCLUSIONS

A position sensorless vector control methodology with recurrent neural network for IPM synchronous motor SVM drive has been presented in this paper. The results obtained in this work indicate that the proposed position sensorless control scheme produces very fast response of the IPM synchronous motor drive. This methodology needs only speed transducer and very simple three phase voltage regulated SVM inverter. It is observed that the proposed drive with RNN based back EMF estimator is capable to estimate accurately back EMF and rotor position both in steady-state and transient conditions. The proposed control scheme is sufficiently stable and robust under load disturbances and speed reversal condition.

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AN AES PROCESSOR ON A RECONFIGURABLE HARDWARE

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Advanced Encryption Standard (AES) plays a crucial role to secure information. So implementing the AES in a faster and secured way is expected. AES can be implemented in software/hardware. In hardware implementation ASIC solution requires high cost and much design time while FPGA based implementation offers lower cost, quicker and more customizable solution. This paper represents implementing AES in FPGA with minimum latency and speedy throughput where Verilog HDL is used to simulate the operations. Both Encryption and Decryption are carried out and simulated in an iterative design approach to minimize the hardware consumption. Here the operation of AES like substitution bytes, mix column are simplified to reduce complexity and to produce a simple design which would deliver a high throughput and minimum latency with EP2C35F672C6 device from Altera provided Cyclone II family. The design would be used for both end system and also for transmission device with full of confidence and accuracy.

Index Terms—AES, FPGA, Verilog HDL, cryptography, encryption.

1. INTRODUCTION

With the growth of information and communication technology, the processing of data and transferring the same through different media involves security [1]. A number of crypto algorithms have been developed [2-4]. Keeping pace with maturity of the security technology the hackers, the electronic eavesdroppers, virus and the electronic frauds have been coming into the field with new sophisticated techniques to attack the security mechanism [14,15]. So to protect any unusual attack to the valuable information source and their transmission, the algorithm Advanced Encryption Standard(AES), a Federal Information Processing Standard (FIPS) is approved by National Institute of Standards and Technology(NIST)[4,7,8,11]. But AES has 10(Ten) round of complex algebraic and matrix operation which involve high processing power and introduce delay in encryption and decryption process. For this reason at the start of this work the speed is treated as a major issue and concentration is given on hardware based implementation. There are also two types of hardware based implementation. FPGA (Field Programmable Gate Array) based implementation is chosen in this work as FPGA offers lower cost, flexibility and reasonable performance than ASIC (Application Specific Integrated Circuit) implementation. Previously researcher proposed implementation of AES processor on FPGA hardware dropping many security features since earlier version of the FPGA available in the market was low capacity. Now high capacity FPGA from

different vendor is coming in the market. Recently design of an AES processor using VHDL and its implementation on Xilinx FPGA without sacrificing any security feature of the algorithm is reported [6]. Altera's FPGA is another famous FPGA to the customers. It offers a lot of high capacity FPGAs under different families. Literatures [10],[12],[13],[18],[21-23] describe design and implementation of AES processor in the FPGA platform where maximum throughput achieved is 21.54 Gbps with latency 71 clock cycle. However reduced latency is essential for developing real time applications. So a research work conducted to implement the AES processor on this FPGA to achieve minimum latency with suitable speed performance.

2. AES STRUCTURE

AES, also known as Rijndael, is a block cipher adopted as an encryption standard by the US government, which specifies an encryption algorithm [8-11]. The AES algorithm is capable of using cryptographic keys of 128, 192, and 256 bits to encrypt and decrypt data in blocks of 128 bits sequence. In this paper 128 bits key is used for 128 bit data block. The input, output and cipher key bit sequences are processed as arrays of bytes that are formed by dividing these sequences into groups of eight contiguous bits to form arrays of bytes. The different transformations operate on the intermediate result, called the state, which is the intermediate cipher result. The state can be pictured as a rectangular array of bytes. This array

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has four rows; the number of columns is denoted by N_b and is equal to the block length divided by 32. The cipher key is similarly pictured as a rectangular array with four rows. The number of columns of the cipher key is denoted by N_k and is equal to the key length divided by 32. The number of rounds is denoted by N_r and depends on the values N_b and N_k . It is given in Table 1.

Table 1. AES Key length and Rounds.

	Key Length N_k	Block Size N_b	Number of Rounds N_r
AES 128	4	4	10
AES 192	6	4	12
AES 256	8	4	14

For the AES algorithm, the number of rounds to be performed during the execution of the algorithm is dependent on the key size. The number of rounds is represented by N_r , where $N_r = 10$ when $N_k = 4$, $N_r = 12$ when $N_k = 6$, and $N_r = 14$ when $N_k = 8$. For both its cipher and inverse cipher, the AES algorithm uses a round function that is composed of four different byte-oriented transformations:

- 1) Byte substitution using a substitution table (S-box), 2) Shifting rows of the state array by different offsets, 3) Mixing the data within each column of the state array, and 4) Adding a round key to the state.

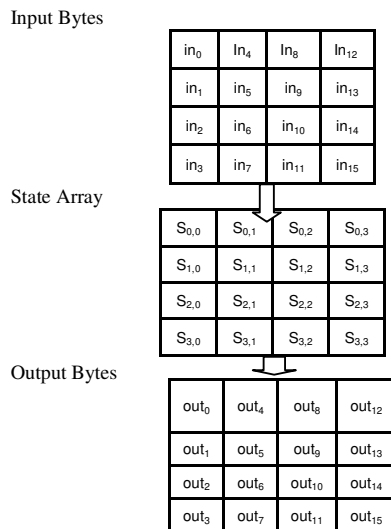


Fig 1: States of the AES

The input and output used by Rijndael at its external interface are considered to be one dimensional arrays of 8-bit bytes numbered upwards from 0 to the $4*N_b-1$. These blocks hence

have lengths of 16 bytes array indices in the ranges 0..15. The cipher key is considered to be a one-dimensional arrays of 8-bit bytes numbered upwards from 0 to the $4*N_k-1$. These blocks hence have lengths of 16, 24 or 32 bytes and array indices in the ranges 0..15, 0..23 or 0..31 for 128 bit, 192 bit and 256 bit key respectively. The cipher input bytes are mapped onto the state bytes in the order $a_{0,0}$, $a_{1,0}$, $a_{2,0}$, $a_{3,0}$, $a_{0,1}$, $a_{1,1}$, $a_{2,1}$, $a_{3,1}$, $a_{4,1}$... and the bytes of the cipher key are mapped onto the array in the order $k_{0,0}$, $k_{1,0}$, $k_{2,0}$, $k_{3,0}$, $k_{0,1}$, $k_{1,1}$, $k_{2,1}$, $k_{3,1}$, $k_{4,1}$... At the end of the cipher operation, the cipher output is extracted from the state by taking the state bytes in the same order as shown in Fig1.

Encryption Process of AES: Four different stages are used, one for permutation and three for substitution. The stages together provide confusion, diffusion and nonlinearity[4]. The stages are as follows:

Substitute bytes: Uses an S-box to perform a byte-by-byte substitution of the block. For encryption and decryption, this function is indicated by `SubBytes ()` and `InvSubBytes ()` respectively.

Shift rows: A simple permutation. For encryption and decryption, this function is indicated by `ShiftRows ()` and `InvShiftRows ()` respectively.

Mix Columns: A substitution that makes use of arithmetic over $GF(2^8)$, with the irreducible polynomial $m(x) = x^8 + x^4 + x^3 + x + 1$. For encryption and decryption, this function is indicated by `MixColumns ()` and `InvMixColumns ()` respectively[1].

Add round key: A simple bitwise XOR operation of the current block with a portion of the expanded key. For both encryption and decryption this function is indicated by `AddRoundKey ()`.

3. FPGA IMPLIMENTATION

Hardware implementation can be both by ASIC Solution or by FPGA. ASIC (Application Specific Integrated Circuit) solution can be better for mass production but which incurs more design time and also a costly solution[6,11,12].

But Field programmable gate array (FPGA) is an integrated circuit that can be reconfigured by the designer to produce different design and test a lot of circuits with a minimal time which is also be a customizable solution. It means that the circuit may be usable for different application. With each configuration, which takes only fraction of a second, an integrated circuit can perform a completely different function which is said to be a customizable solution[19].

For this reason this project is intended to develop FPGA based customized high speed AES processor to get low latency and high throughput for encryption and decryption. In this project a FPGA solution is developed and tested using Altera provided FPGA and Verilog HDL with the help of Quartus II software.

4. DESIGN PARTITIONING AND MODULES

The project is partitioned in to main four basic modules and key expansion operation in the main module for encryption and same for decryption cycle.

AES_SUB_BYTE Module: This module perform the Substitution byte operation of AES algorithm. The substitution byte transformation of input state to the output state involves basically two algebraic calculation for each byte which is responsible for high processing time. So for this reason a 16 x 16 byte lookup table is used for substitution to eliminate complex algebraic operation which will increase throughput.

AES_SHIFT_ROW Module: This module is used for performing shift row operation of the AES. The operation is very simple just to alter the position of the bytes on the state matrix.

AES_MIX_COLUMN Module: This is a operation in AES to multiply the present state of AES to a constant matrix by the multiplication rules used in $GF(2^8)$ Field[1,8].

AES_KEY_EXPANSION: This is very simple. It takes the key which is supplied for the algorithm which is called symmetric key and generate 10 additional key for next 10 rounds by a complex algebraic operation. Key expansion is performed at the starting of encryption process in the encryption main module.

There is another AES operation which is AddRoundKey where key of each round is XORED with the state during round operation. There is no separate module for AddRoundKey but this is done in main module of encryption and standard modules named as onetionine module where other AES operation are done simultaneously.

Onetionine module: This module is treated as standard module in AES which perform the operation of a standard round in AES. Nine standard rounds includes all four operation of AES such as substitution byte, shift row, AddRoundKey and Mix column operation. In the encryption part at first key expansion is performed to generate ten additional key from the supplied symmetric key and

then AddRoundKey which is done by the supplied symmetric key in the main encryption module called AES_Encryption module. After then other nine standard rounds are performed in AES_Encryption module each containing 4 basic operation of AES. The standard module onetionine is called from the main module AES_ENCRYPTION for each round from one to nine. 10th Round is different from standard round where mix column operation is skipped. For this reason it is done from AES main module AES_ENCRYPTION. Operational diagram of AES is shown in Fig 2.

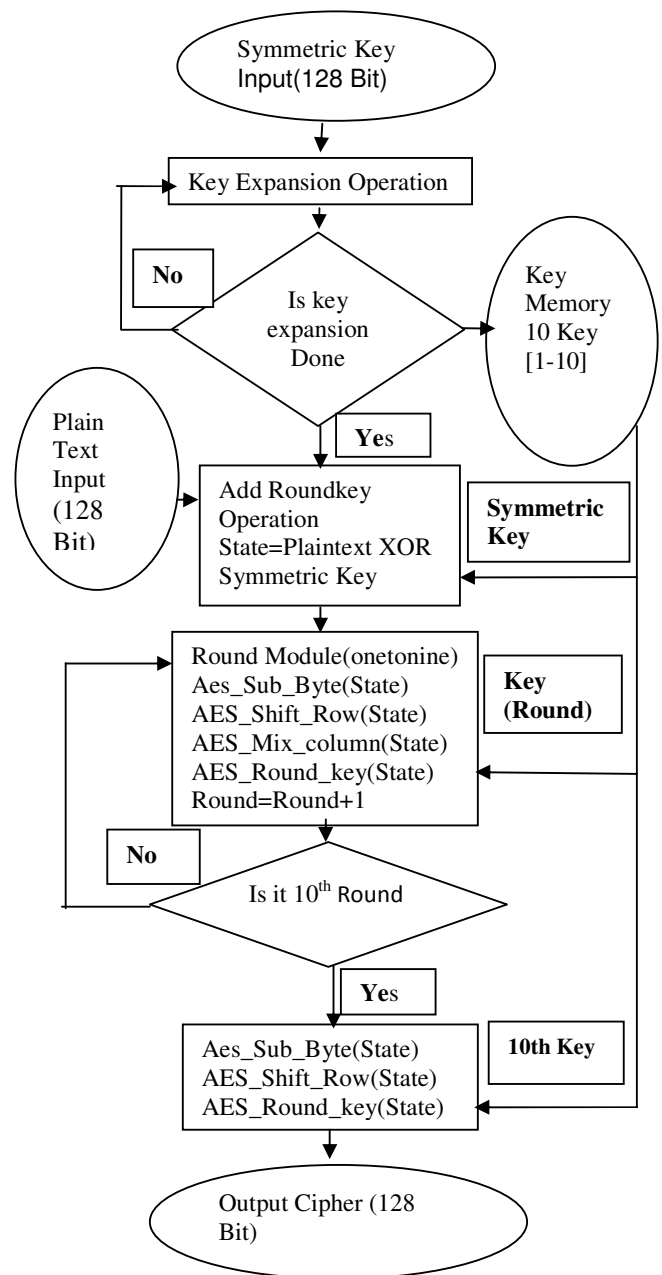


Fig 2: Operational Diagram of modules of AES

In Fig 3 the processing and memory unit used in AES processor is shown where memory S-Box used by Sub Byte module, Round key is generated by key expansion processor using Round constants and supplied key in memory and the key produced are used by add_round_key processor in each round. Inv S-Box memory is used by Inv_sub_byte processor in each round of decryption module.

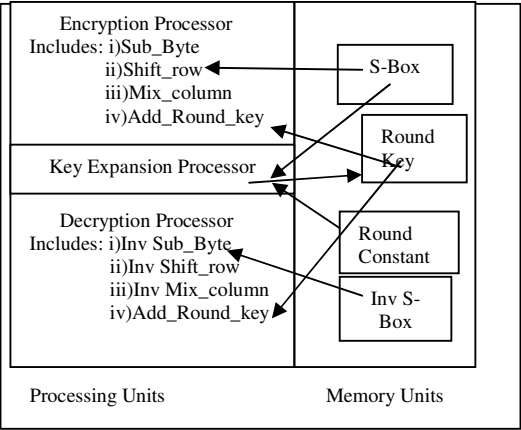


Fig 3: Design Components of the total implementation

5. RESULTS & SIMULATIONS

The design of the AES processor described in the previous section has been coded by Verilog HDL. The Quartus II development software is used for coding and simulation. The design is implemented on Altera provided Cyclone II FPGA which is based on a high performance architecture with sufficient memory. Here in this project the device used is EP2C35F672C6.

Compilation results of Encryption are as follows:

Total Logic Elements :3405/33216
Total Combinational functions :3405/33216
Dedicated logic registers: :1
Total registers :1
Total Pins :388/475
Total memory bits :327680/483,840

Simulation Results: At first each operation like substitution byte, shift row, mix column and key expansion operation are simulated using verilog code and design files. Output is realized using input vectors and key from NIST publication [4].

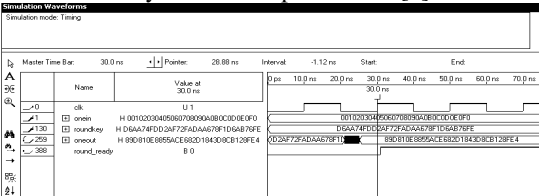
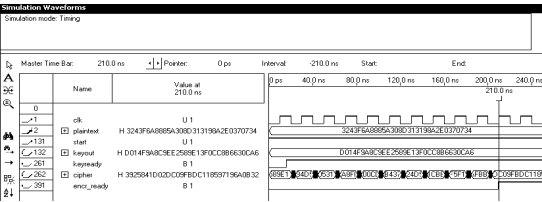


Fig 4: Simulation of one Standard round (one to nine round)

In encryption module each standard round is simulated and output is verified. Figure 4 shows the simulation of one standard round where all basic operations (Substitution bytes shift rows mix columns and add round key) are performed and latency is observed.

The simulation results of full encryption module is shown in Fig 5 where input vectors and key is given from NIST standard publication [4] and output was verified.
Plain text: 3243f6a8885a308d313198a2e0370734



Cipher Key :2b7e151628aed2a6 ab f71588 09 cf 4f 3c

Fig 5: Simulation of full Encryption Module

The output result of the encryption was found accurately after 11 clock cycle from the starting of encryption process. So the latency of encryption is only 11 clock cycle. In the Fig 5 the generated last key(10th) is shown as keyout and latency is observed by keyready function. As the device used is Altera EP2C35F672C6 from Cyclone II family has maximum clock frequency of 50MHz, so the encryption through put will be 6.4Gbps as per clock cycle encrypt 128 bits data samples. If other device having more clock frequency is used then throughput can be increased linearly.

The output of the algorithm are visualized by the 8 seven segment display of the FPGA board where first, second ,third and forth 32 bit of the cipher produced from 128bits plaintext shown in the simulation of Fig 5. Fig 6, 7, 8 & 9 respectively shows the output of FPGA where input is given by toggle switch or by input data to the program. 128 bit encryption key are also given to the code directly.



Fig 6: Seven segment output of FPGA (1st 32 bit cipher)



Fig 7: Seven segment output of FPGA (2nd 32 bit cipher)



Fig 8: Seven segment output of FPGA (3rd 32 bit cipher)



Fig 9: Seven segment output of FPGA (4th 32 bit cipher)

Overall the simulation of quartus II software and implementation results on the FPGA board found accurate with reduced latency of 11 clock cycle.

7. CONCLUSION AND FUTURE WORKS

This is the work to implementing a faster cryptosystem in hardware to ensure speedy IT security. A synthesizable Verilog design is developed for each of the encryption and decryption module and has been tested with FPGA cyclone II device EP2C35F672C6. Where the performance of the each of the sub module with entire Encryption and decryption module is found satisfactory with proper accuracy having minimum latency and speedy throughput which can be described as a simple, portable and efficient AES implementation for secure communication in a reconfigurable hardware with reduced latency. In this implementation total throughput gained is 6.4Gbps and latency of 11 clock cycle/210ns with max clock frequency of 50Mhz.

AES is a strong algorithm due to its large rounds and algebraic complexity inside the rounds[9]. For this reason this project is conducted to implement the AES in hardware to speed up the AES enabled

processing system where minimum latency with required throughput is gained which would required for real time application. Portable electronic system is the vision of this day where power is an important issue. So power analysis of the processor can be carried out. The proposed processor can be implemented on ASIC to improve its performance.

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ANALYSIS OF THE RADIATION PROPERTIES OF HALF-WAVELENGTH J-POLE ANTENNA ARRAYS

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In this paper, the analytical expression of the radiation pattern of a half-wavelength J-pole antenna array has been derived assuming sinusoidal current distribution in the limit $\lambda/4$ to $3\lambda/4$. The proposed expression is valid for any number of elements in the array. The results have been compared with the center fed half-wavelength dipole array with similar current distribution in the limit $-\lambda/4$ to $\lambda/4$. It has been observed that for a J-pole array, the field pattern is more pronounced than that of a center fed dipole array.

Key words: Azimuth plane, broadside array, end-fire array, field pattern, j-pole array

1. INTRODUCTION

When the feed points of the antenna elements are arranged in a straight line then it is called a linear array [1]. There are five controls that can be used to shape the overall pattern of the antenna array [2]. These are: (a) the geometrical configuration of the overall array (linear, circular, rectangular, spherical etc.), (b) the relative displacement between the elements, (c) the excitation amplitude of the individual elements, (d) the excitation phase of the individual elements, and (e) the relative field pattern of the individual elements.

The J-pole antenna is a half-wave, end-fed, dipole antenna having omni-directional radiation pattern [3] [4]. In this configuration, the conventional end fed antenna is elevated at least $1/4$ wavelength above ground, thus eliminating the ground losses and "normalizing" the radiation pattern [5].

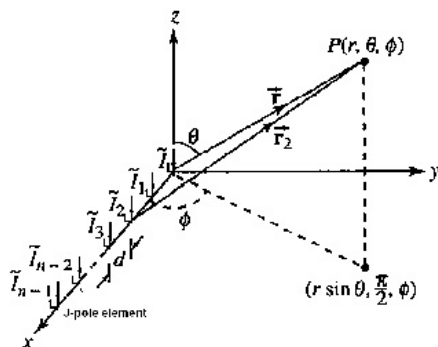


Fig. 1A J-pole antenna array

As shown in Fig. 1 a linear array of n-element half wave Jpoles are assumed to have sinusoidal current distribution. For each element we have considered stub current feed. Beyond the feed position, the antenna position of the J-pole element extends from $\lambda/4$ to $3\lambda/4$ along element axis.

2. DEDUCTION OF THE FIELD PATTERN OF AN N-ELEMENT HALF-WAVELENGTH J-POLE ANTENNA ARRAY

Let us consider an n-element uniform, linear J-pole antenna array. The term linear implies that all elements of the array are spaced equally along a straight line, and the term uniform indicates that the magnitude of the current in each element is the same and the phase shift is progressive [6].

The current distribution of a single half-wavelength J-pole antenna is assumed to be,

$$\tilde{I} = -I_0 \cos(\beta z)$$

In phasor form the current distribution can be written as,

$$\tilde{I} = I_0 \angle 180^\circ$$

Therefore, the current distribution in the k-th element of an N-element J-pole antenna array can be expressed as,

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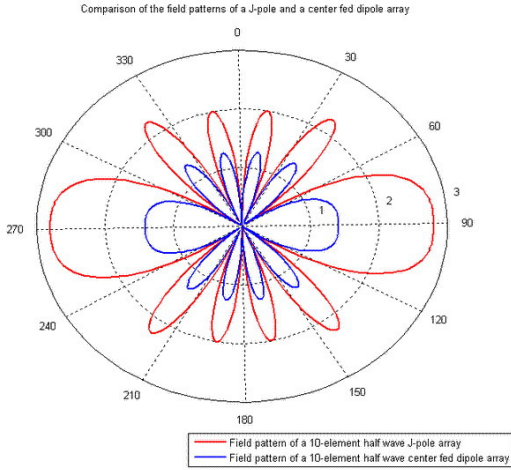


Fig. 2. Comparison of field pattern of J-pole array with that of half wavelength dipole array with $d = \lambda/2$

$$\tilde{I}_k = \tilde{I} \angle \alpha = I_0 \angle (k\alpha + 180^\circ)$$

The current distribution in the (k+1)-th element is,

$$\tilde{I}_{(k+1)} = I_0 \angle \{(k+1)\alpha + 180^\circ\}$$

The electric field of a single element J-pole antenna is found to be [4],

$$\tilde{E} = \frac{j\eta I_0 e^{-j\beta r}}{4\pi r \sin \theta} \left[\left\{ \cos\left(\frac{3\pi}{2} \cos \theta\right) + \cos\left(\frac{\pi}{2} \cos \theta\right) \right\} + j \left\{ \sin\left(\frac{3\pi}{2} \cos \theta\right) + \sin\left(\frac{\pi}{2} \cos \theta\right) \right\} \right] \tilde{a}_\theta$$

The electric field can be expressed as,

$$E_\theta = E_m F(\theta, \phi) \frac{1}{r} e^{-j(\beta r - \frac{\pi}{2})}$$

where, $E_m = \frac{\eta I_0}{4\pi}$ = maximum electric field

$$F(\theta, \phi) = \frac{1}{\sin \theta} \left[\left\{ \cos\left(\frac{3\pi}{2} \cos \theta\right) + \cos\left(\frac{\pi}{2} \cos \theta\right) \right\} + j \left\{ \sin\left(\frac{3\pi}{2} \cos \theta\right) + \sin\left(\frac{\pi}{2} \cos \theta\right) \right\} \right]$$

where,

$$r_1 = r - d \sin \theta \cos \phi$$

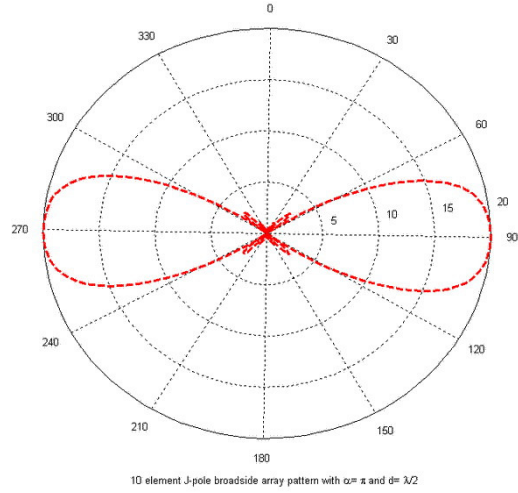


Fig. 3. Radiation pattern of J pole array in the xy plane with $\alpha = \pi$ and $d = \lambda/2$

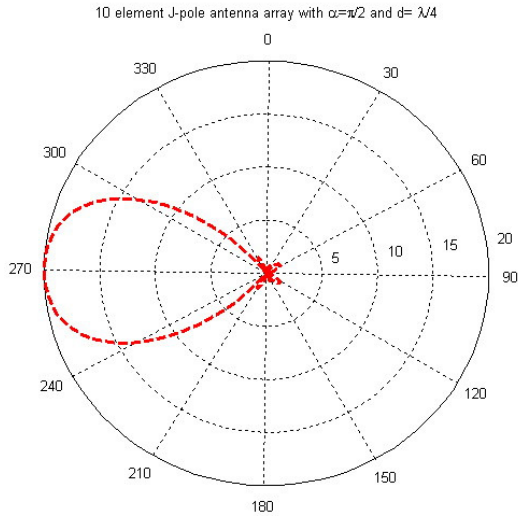


Fig. 4. Radiation pattern of J pole array in the xy plane with $\alpha = \pi/2$ and $d = \lambda/4$

For an n-element antenna array, the overall electric field can be expressed as,

$$E_\theta = E_m F(\theta, \phi) \frac{1}{r} e^{-j(\beta r - \frac{\pi}{2})} [1 + e^{j\psi} + e^{j2\psi} + \dots + e^{j(n-1)\psi}]$$

where,

$$\psi = \beta d \sin \theta \cos \phi + \alpha$$

d=separation between two successive elements.

Multiplying the above equation by $e^{j\psi}$ and then subtract the product from the above equation, we get,

$$\begin{aligned}
E_\theta &= E_m F(\theta, \phi) \frac{1}{r} e^{-j(\beta r - \frac{\pi}{2})} \left[\frac{1 - e^{jn\psi}}{1 - e^{j\psi}} \right] \\
&= E_m F(\theta, \phi) \frac{1}{r} e^{-j(\beta r - \frac{\pi}{2})} \frac{e^{\frac{jn\psi}{2}}}{e^{\frac{j\psi}{2}}} \left[\frac{e^{\frac{jn\psi}{2}} - e^{-\frac{jn\psi}{2}}}{e^{\frac{j\psi}{2}} - e^{-\frac{j\psi}{2}}} \right] \\
&= E_m F(\theta, \phi) \frac{1}{r} e^{-j(\beta r - \frac{\pi}{2})} e^{\frac{j(n-1)\psi}{2}} \left[\frac{\sin(\frac{n\psi}{2})}{\sin(\frac{\psi}{2})} \right]
\end{aligned}$$

Therefore, the normalized array pattern is,

$$F(\psi) = \frac{\sin(\frac{n\psi}{2})}{\sin(\frac{\psi}{2})}$$

According to the principle of pattern multiplication, the total field pattern of an array of similar elements is the product of the element pattern, $F(\theta, \phi)$ and the array pattern, $F(\psi)$ [6].

$$\begin{aligned}
F(\theta, \phi, \psi) &= F(\psi) \times F(\theta, \phi) \\
&= \frac{\sin(\frac{n\psi}{2})}{\sin(\frac{\psi}{2})} \left[\cos \frac{(n-1)\psi}{2} + j \sin \frac{(n-1)\psi}{2} \right] F(\theta, \phi) \\
&= \frac{\sin(\frac{n\psi}{2})}{\sin(\frac{\psi}{2}) \sin \theta} \left[\left\{ \cos \frac{(n-1)\psi}{2} \cos \left(\frac{3\pi}{2} \cos \theta \right) \right. \right. \\
&\quad \left. \left. + \cos \frac{(n-1)\psi}{2} \cos \left(\frac{\pi}{2} \cos \theta \right) - \sin \frac{(n-1)\psi}{2} \sin \left(\frac{3\pi}{2} \cos \theta \right) \right. \right. \\
&\quad \left. \left. - \sin \frac{(n-1)\psi}{2} \sin \left(\frac{\pi}{2} \cos \theta \right) \right\} + j \left\{ \cos \frac{(n-1)\psi}{2} \sin \left(\frac{3\pi}{2} \cos \theta \right) \right. \right.
\end{aligned}$$

3. RESULT AND DISCUSSION

The radiation pattern has been plotted in Fig. 2. Distinct improvement is observed in the radiation pattern of J-pole array over that of half-wave dipole array. The radiation pattern of half wavelength dipole array was obtained from [2]. In Fig. 3 the radiation pattern of a broad side array has been plotted. Here, the value of α has been assumed to be equal to π and number of element in the array was 10. In Fig. 4 the radiation pattern was plotted assuming $\alpha = \pi/2$ and $d = \lambda/4$. The J-pole array also works equally well as end-fire array whose

radiation pattern is plotted in Fig. 5. Here, $\alpha = \pi$ and $d = \lambda/8$ have been assumed.

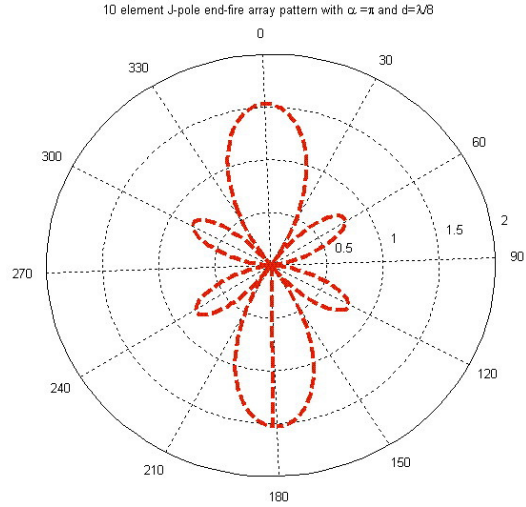


Fig. 5. Radiation pattern of J pole array in the xy plane with $\alpha = \pi$ and $d = \lambda/8$

4. CONCLUSIONS

The general analytical expression of the radiation pattern of a J-pole antenna array has been presented assuming sinusoidal current distribution. It is found from the analysis that the J-pole antenna array exhibits improved field pattern compared to that of a half-wavelength array.

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BI-EDF-BASED OPTICAL AMPLIFICATION AND MULTIWAVELENGTH LASER

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This research focuses on the exploitation of nonlinear effects in photonic crystal fiber (PCF), mainly the Stimulated Brillouin Scattering (SBS) to generate multi-wavelength signal in a Bismuth-based Brillouin Erbium Fiber Laser (BEFL). A 2.15m Bismuth-based Erbium-doped Fiber (Bi-EDF) with erbium ion concentration of 3250 wt. ppm is used in this study as a linear gain medium. The gain and noise figure characteristics of the Bismuth-based Erbium-doped Fiber Amplifier (Bi-EDFA) are also demonstrated. The Bi-EDFA exhibits gain in L-band region with a forward pumping scheme. The maximum gain of 12.1 dB has been obtained at input signal power of -40dBm and wavelength of 1610nm. By using a bi-directional pumping scheme with a higher pump power, gains of more than 20dB are obtained within a wavelength band from 1570 to 1620nm. The bi-directional Bi-EDFA is then used to assist a multi-wavelength generation in PCF-based Brillouin fiber laser (BFL). The PCF-based BFL or BEFL uses a ring configuration with 20m long PCF as a nonlinear gain medium. The injected BP wavelength and power as well as the power of 1480 nm pumps and effective cavity loss in the cavity exhibited a great effect on the number of wavelengths and output power of the generated wavelength comb. The ring cavity BEFL with lower cavity loss could generate up to 13 lines Stokes and anti stokes lines. The stable output laser comb of 13 lines with a line spacing of 0.08nm is obtained at a BP wavelength of 1574 nm by using a total power of 1480 nm pump of 240mW. The number of lines increases as the pump power increases. The anti-Stokes is also observed due to the four-wave mixing effect. The multi-wavelength BEFL signal has potential applications in wavelength division multiplexing (WDM), optical fiber sensor system, optical component testing and spectroscopy applications.

Key words: Photonic crystal fiber, Stimulated Brillouin Scattering, Bismuth-based Erbium-doped Fiber Amplifier, Four-wave mixing, wavelength division multiplexing.

1. INTRODUCTION

The area of photonic crystal fibre (PCF) technology has progressed rapidly in recent years and has been successfully applied to the development of a variety of photonics devices and applications [6-1]. Stimulated Brillouin scattering (SBS) is a nonlinear effect resulting from the interaction between intense pump light and acoustic waves in a medium and giving rise to backward propagating frequency-shifted light [2]. Although Brillouin generation can be detrimental in coherent optical-communication systems [4], it has been advantageously utilized in the past few years for the many applications such as optical-fiber characterization [9], distributed strain and temperature measurements [12-7] and narrow-bandwidth amplification [5]. Perhaps the largest interest has arisen from the use of SBS to produce Brillouin fiber laser [10-11] with applications such

as gyroscopes [14]. Photonics crystal fibers (PCFs) are a class of micro-structured fiber which possesses a solid core surrounded by a cladding region that is defined by a fine array of air holes that extend along the full fiber length. Due to the high index difference between silica core and air hole cladding, these PCFs allow much stronger mode confinement, and thereby much higher nonlinearities than that of a conventional single mode fiber (SMF) [3]. This fiber can be used as a nonlinear gain medium to develop a compact BFL. In the previous reports, BFLs have been achieved using more than 70m long PCF as a gain medium [8-13].

BFL has various applications in optical communication and sensing technology and can be constructed using stimulated Brillouin scattering (SBS) effect in single mode fibers. SBS is a

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nonlinear effect resulting from interaction between intense pump light and acoustic waves in a medium and giving rise to backward propagation frequency - shifting light. The required gain medium length can be substantially reduced using PCF to replace a conventional SMF. However most of earlier works on PCF-based BFLs are mainly on single wavelength operation. In next sections, we present the first experimental demonstration of a multi-wavelength BFL operating in long wave length band (L-band) region. The proposed BFL also uses a very short length of PCF in conjunction with 45 highly nonlinear bismuth-oxide based erbium-doped fiber (Bi-EDF) as a linear gain medium to assist in multi- wavelength operation.

2. EXPERIMENTAL SETUP OF THE PCF- BASED BFL

The experimental setup for the PCF-based BFL is shown in Fig 1. The ring resonator consists of a circulator, a 20m long PCF, a 215 cm long Bi-EDF, two 1480 nm pump diodes, two wavelength selective couplers (WSCs), three isolators, a (80-20, 90-10, 95-5) output coupler and a polarization controller (PC). The PCF used as a nonlinear gain medium is a polarization maintaining fiber which has a cut-off wavelength of 1000 nm, zero dispersion wavelength of 1040 nm, nonlinear coefficient of 11 (W.km)^{-1} and a mode field diameter of $4.0 \mu\text{m}$. The Bi-EDF used has an erbium concentration of 3,200 ppm with a cut-off wavelength of 1440 nm and a pump absorption rate of 83 dBm at 1480 nm. The Bi-EDF is pumped bi-directionally using two 1480 nm lasers. Optical isolators are used to block the Brillouin pump (BP) from oscillating in the cavity and also to ensure a unidirectional operation of the BFL. An external cavity tunable-laser source (TLS) with a linewidth of approximately 20 MHz and a maximum power of 8 dBm is used as the Brillouin pump (BP). PC is used to control the birefringence (breakage of a light ray into two different directions therefore creating two separate light rays) of the ring cavity so that the power of the laser generated can be controlled. The experiment executed using 3 different type of couplers that are 80-20, 90-10 and 95-5. The output for the BFL is tapped from the leg with smaller ratio of the output and is then characterized using an optical spectrum analyzer (OSA) with the resolution of 0.015.

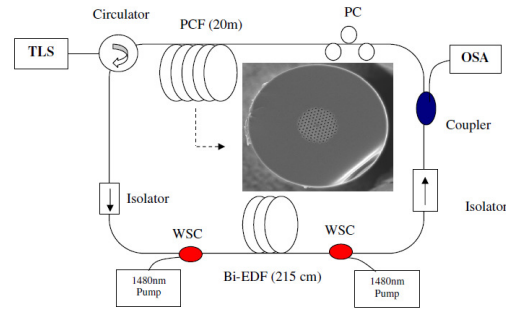


Fig 1: Configuration of multi-wavelength BFL

The BP is injected into the ring cavity and then PCF via the circulator to generate the backward propagating Stokes light at opposite direction. However, since the PCF length is not sufficient enough, the back-scattered light due to Rayleigh scattering is relatively higher than the Stokes light. Both back-scattered pump and the Stokes lights are amplified by the Bi-directionally pumped Bi-EDF and oscillate in the ring cavity to generate first Stokes in the anti clockwise direction. This oscillation continues and when the intensity of the first Brillouin stock is higher than the threshold value for Brillouin gain, the second order SBS is generated in clockwise direction and this signal blocked by the isolator in the cavity however, the back-scattered light from second SBS will be amplified by the Bi-EDF.

However, the nonlinear gain by both PCF and Bi-EDF only amplifies the Stokes light and thus the Stokes light is more dominant and laser is generated at the Stokes wavelength. The spacing between the BP and the BFL is obtained at approximately 10 GHz, which is equivalent to the Stokes shift in the SMF.

3. RESULT AND DISCUSSION

The operating wavelength of the BFL is determined by the bi-directionally pumped Bi-EDF gain spectrum which covers the L-band region from 1560 to 1600 nm as well as the cavity loss. As shown in figures 2 (a), (b) and (c) the free running spectrum of the BFL or without BP (TLS) off for 3 different type of couplers. As shown in three figures the peak wave generated at around 1574nm with bandwidth is approximately 3nm due to the difference between Bi-EDF's gain and cavity loss is largest in this wavelength region. The chosen BFL is operating wavelength must be within or close to the bandwidth of free running BFL. Therefore the BP is set within 1574 nm region. The free-running BFL also exhibits a peak power of approximately -

6 dBm with 20 dB bandwidth of approximately 1 nm for 80-20 coupler. And the peak power for 90-10 is approximately -10 dBm and for the 95-5 coupler is about -15 dBm. The cavity loss is lowest with 80-20 coupler and therefore the peak power is highest.

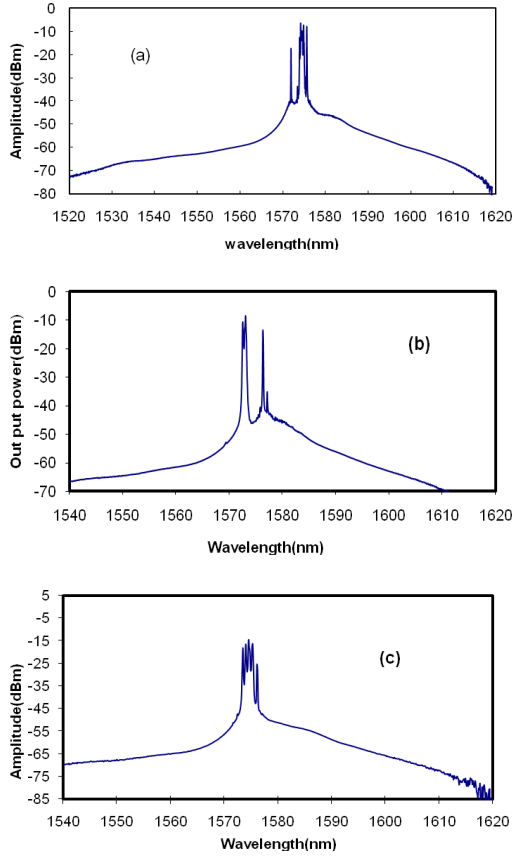
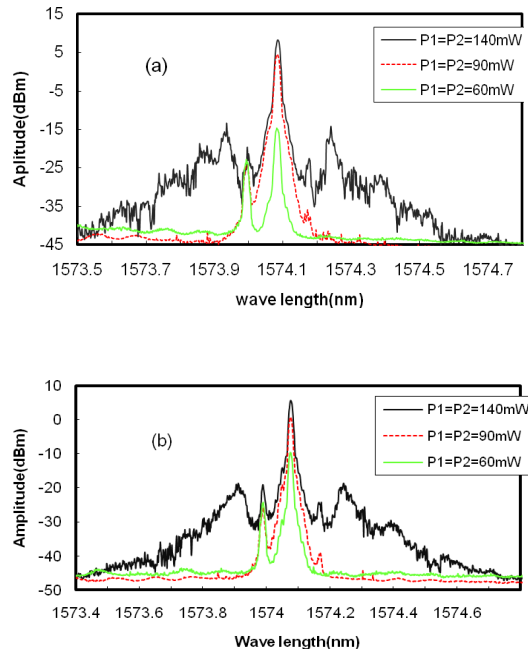


Fig 2: Free-running spectrum of the VFL using (a) 80-20 coupler, (b) 90-10 coupler, (c) 95-5 coupler

Figures, 3 (a), (b) and (c) show the output spectrum of the BFL at output couplers of 80-20, 90-10 and 95-5, respectively. The experiment was carried out for three different pump powers. Both 1480 pump is set at the same power and power of each pump is varied from 60 mW to 140 mW. The threshold of the BFL is observed to be around 60mW for all set-ups. The BP wavelength is optimized at 1574.0 nm which is within the lasing bandwidth of the free running BFL. For all figures at pump power below of 60 mW (threshold) the erbium gain is very low and cannot be sufficient to compensate for the loss inside the laser cavity and thus no Stokes are observed. When increasing the 1480nm pump power the number of wavelength generated is increased and the anti-Stokes wave is also appeared, which is attributed to the increment of the erbium gain with pump power. This situation provide sufficient signal for SBS as well as the four-wave mixing to generate stokes and anti

stokes. In this experiment, more than 13 lines are obtained at the maximum 1480 nm pump power of 140 mW with wave length spacing of approximately 0.08nm.

At pump power of 140 mW, the BFL is achieved at 1574.08 nm for 80-20 coupler with the peak power of 8 dBm and the 3 dB bandwidth of approximately 0.02 nm (which is limited by the OSA resolution) as shown in figure 3 (a) for 80-20 coupler. For 90-10 coupler of figure 3 (b), the first Stokes peaks at 5 dBm is with the maximum 1480 nm pump power. For (95-5) coupler of figure 3(c), more than 13 lines are obtained with peak power of about 0.3dBm and the 3 dB bandwidth of about 0.2 nm at the maximum 1480nm pump power. The number of line is largest at this coupling ratio as a result of the lowest cavity loss. The side mode suppression ratio (SMSR), which is defined as the power difference between the BFL's peak with the second highest peak obtained are obtained at approximately 26.31dB, 24.42dB, 16.33dB for 80-20 ,90-10 and 95-5 couplers, respectively as shown in Figure 3. The best spectrum is obtained with (95-5) coupler. The multi-wave length output of the BFL is observed to 50 be stable at room temperature with only minor fluctuation observed coinciding with large temperature variances. The side modes are mainly due to anti Stokes and additional Stokes of the BFL, which arises due to four-wave mixing effect in the ring cavity.



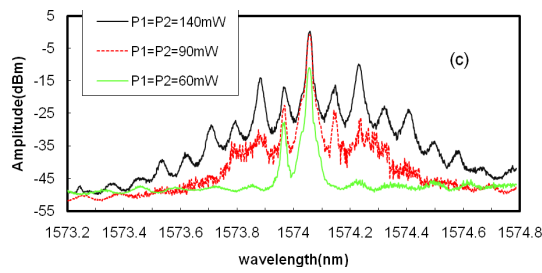


Fig 3: The BFL output spectrum for (a) 80-20 coupler, (b) 90-10 coupler and (c) 95-5 coupler

The laser reached threshold of a pump power of 60 mW, and at the higher pump powers yield two sets of spectral lines corresponding to odd-and even order stokes and anti-stokes waves that counter-propagated in the ring. Figure 4 shows the output spectrum of the BFL for (95-5) coupler with and without polarization controller (PC). PC is used to adjust the polarization state of the light inside the cavity. Proper adjustment of the birefringence or polarization of the light is important to achieve a multi-wavelength oscillation. As shown in the figure, a better spectrum is obtained by adjusting of PC. The anti-stokes waves can also be observed in PCF-based BFL because of four-waves-mixing between pump and stokes waves or between different stokes order. At a pump power of 140 mW, four-wave mixing between the two first odd-orders stokes waves lead to the generation of more than 15 spectral lines.

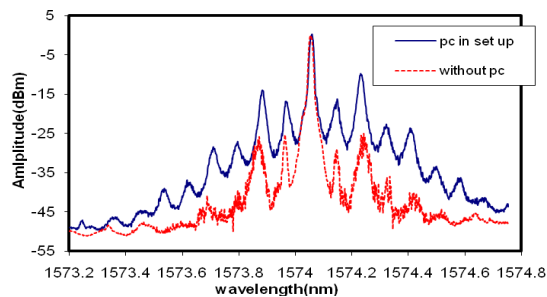


Fig 4: BFL output spectra with and without PC

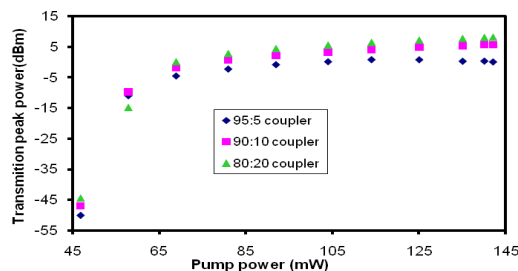


Fig 5: Out put peak power as a function of 1480 total pump powers (nm)

Figure 5 shows the peak power of the BFL for different coupler against the total input 1480nm pump power and BP pump power, respectively. The BP is fixed at 8 dBm and 1547nm. The BFL starts to lase at 1480nm pump power of 60mW which is the threshold power. Below this power, the erbium gain is very low and cannot sufficiently compensate for the loss inside the laser cavity and thus no Stokes is observed. The peak power increases as the 1480nm pump power increases which is attributed to the increment of the erbium gain with pump power. As we see also the peak power for 80-20 coupler is higher than 90-10 and 95-5 coupler. Saturation power pump for both pumps is around 145 mw. The output of the BFL is observed to be stable at room temperature with only minor fluctuations observed coinciding with large temperature variances.

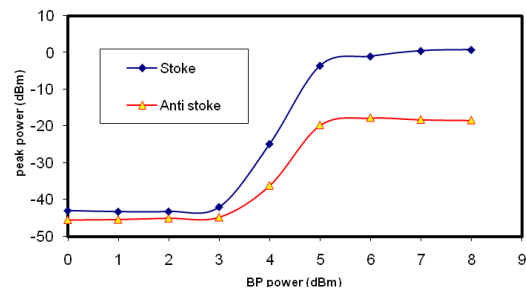


Fig 6: The Brillouin stoke and anti-stoke peak power against BP power

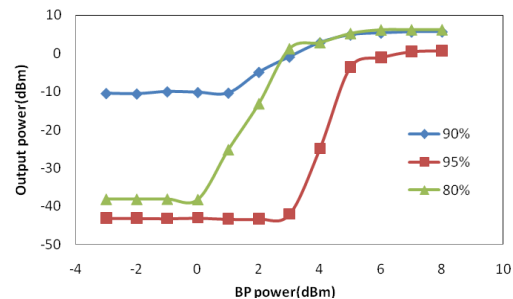


Fig 7: Comparing the threshold power for the 3 couplers

Figure 6, shows the peak power of stokes and anti stokes against the input pump power. The coupling ratio is set at 95-5, which is the optimum. As shown in this figure, the threshold for pump power BP to generate the Stoke and anti-Stokes wave is around 5 dBm. Figure 7 shows peak power of the first Stokes against input BP power at different coupling ratio. As shown in the figure, the Brillouin threshold for (95-5) coupler is approximately 4 dB higher than the (80-20) coupler. The Brillouin threshold is obtained at 2 dBm and 1.5dBm with 80-20 and 90-10 coupler respectively.

4. CONCLUSION

In summary, a new configuration of multi-wavelength BFL is proposed and demonstrated using a PCF in conjunction with bi-directionally pumped Bi-EDF. The BFL uses a ring cavity structure to generate Stokes and anti-Stokes via SBS and FWM processes. The proposed BFL is able to generate up to 13 lines including anti-Stokes with a channel spacing of 0.08 nm at the 1574 nm region at a BP power of 5 dBm and the total 1480 nm pump power of 240 mW. The multi-wavelength BFL is stable at room temperature and also compact due to the use of only 20 m long of PCF and 215 cm long of Bi-EDF.

5. FUTURE WORK

This research work can be extended for future research to reduce further the length of Bi-EDF or to replace the Bi-EDF with other enhanced rare earth dopant fibers like Zirconia-Yttria doped fiber that can maintain high flat gain per length coefficient of compact amplifiers. In the future, a development study can be done by employing a state of the pump-signal technique which is useful for determine the Brillouin linewidth with high frequency resolution near to 1 MHz.

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CHARGE CONTROL STUDIES IN $\text{In}_x\text{Ga}_{1-x}\text{N}/\text{InN}/\text{In}_x\text{Ga}_{1-x}\text{N}$ -BASED DOUBLE CHANNEL HIGH ELECTRON MOBILITY TRANSISTORS (DHEMTs)

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This paper describes the charge control studies of $\text{In}_x\text{Ga}_{1-x}\text{N}/\text{InN}/\text{In}_x\text{Ga}_{1-x}\text{N}$ double channel high electron mobility transistor (DHEMT). This includes the solution of the Schrödinger and Poisson equations self consistently to find the electronic states in $\text{In}_x\text{Ga}_{1-x}\text{N}/\text{InN}/\text{In}_x\text{Ga}_{1-x}\text{N}$ selectively doped double heterostructure system. The model takes into account the highly dominant spontaneous and piezoelectric polarization effects to predict the two dimensional electron gas (2DEG) sheet density more accurately at the heterointerfaces. The band profile is calculated for the first three sub band energy with In composition $x = 0.05$. A large conduction band offset of about 1.58eV is obtained for the proposed device, which ensure the better carrier confinement and higher sheet charge density. The two dimensional electron sheet concentration of high up to $4.97 \times 10^{18} \text{ cm}^{-3}$ for lower InN/InGaN hetero interface and $4.78 \times 10^{17} \text{ cm}^{-3}$ for upper InGaN/InN hetero interface are found for In content of 0.05. This analysis provides indepth investigation of the performance of the DHEMT and to optimize their design.

Keywords: 2DEG, Heterostructure, Schrödinger's equation, Self consistent calculation, DHEMT.

1. INTRODUCTION

Indium nitride (InN) semiconductor has been regarded as a very interesting and highly promising material system for both optical and microwave applications. In recent years, there has been interest in the development of HEMTs based on InN because of their high critical electric field for high saturation velocity and breakdown (Mimura et al., 2005). Advances have also been made in InGaN/InN HEMTs since the early report of two dimensional electron gas (2DEG) and high electron mobility (Hasan et al., 2008). However, they often suffer from low current densities due to the relatively small carriers in the channel. The sheet carrier density can be improved to some extent by increasing the doping in the donor layer at the expense of lower breakdown voltages. A better approach to achieve high current driving capability is by distributing doping into multiple donor regions by employing multiple heterojunctions. In this way multiple Two-Dimensional Electron Gases (2DEGs) are formed and high current density can be expected (Kwon et al., 1995). Dual channel HEMT device uses a heterojunction on both sides of the undoped conductive channel.

The electron confinement in the channel is expected to be stronger in the double heterostructure than in the conventional single heterostructure due to the enhanced polarization induced electric field. Chen et al. have proposed and demonstrated an $\text{AlGaIn}/\text{InGaIn}/\text{GaIn}$ double-heterostructure transistor (DHFET) where the electron confinement is significantly improved due to enhanced potential barriers at the $\text{AlGaIn}/\text{InGaIn}$ and $\text{InGaIn}/\text{GaIn}$ heterointerfaces (Hasan et al., 2008). Current collapse free performance of the DHFET was demonstrated. However, there is very little theoretical works on the InN-based HEMTs, which are mainly concentrated in the conventional single channel HEMT. Recently, we have calculated the 2DEG properties in InN based double channel HEMTs. The 2DEG sheet carrier concentration and mobility for dual channel is higher than conventional single channel HEMTs (Hasan et al., 2008). Therefore, attention should be given in the InN-based dual channel HEMT. For improving the device performance an indepth investigation of charge control studies in $\text{InGaIn}/\text{InN}/\text{InGaIn}$ double heterostructures is urgently required.

In this work, a self-consistent charge control model based on one dimensional Schrodinger-Poisson equations is developed to study the performance. To

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get an insight into the physical operation and carrier control mechanism of InN based DHEMT this model is applied to investigate the quantum confinement and the effect of applied gate voltage on the carriers. The highly dominant effect of spontaneous and piezoelectric polarization is incorporated in the present model to accurately predict the 2DEG sheet charge density at the InGaN/InN and InN/InGaN interfaces.

2. DEVICE STRUCTURE

The schematic of the proposed InGaN/InN/ InGaN device model is shown in Fig. 1. An undoped 30nm InN channel layer is sandwiched between two n-InGaN layers with a thickness 20nm. Intentional stress will be produced at the interfaces due to the lattice mismatch between InGaN/InN and InN/InGaN heterostructures. Electrons will be defused to the lower energy InN layer where they are confined due to the energy barrier at the heterointerface. The region of the $\text{In}_x\text{Ga}_{1-x}\text{N}$ depleted of electrons forms a positive space charge region, which is balanced by the accumulated electrons at the InN heterointerface. The technique of modulation doping is a perfect means of introducing electrons into the InN layer without the adverse effects of donors. With increasing the spacer layer thickness enhances the electron mobility by reducing columbic scattering. However it reduces the 2DEG carrier density as well, which is not desired because of the reduction in electron transfer. Therefore a compromise should be made between the donor density in n-InGaN, conduction band edge discontinuity, which is controlled by the In content in the n- $\text{In}_x\text{Ga}_{1-x}\text{N}$, and the thickness of the undoped InGaN spacer layer to maximize both saturation velocity and the electron density of 2DEG in the HEMT undoped InN channel.

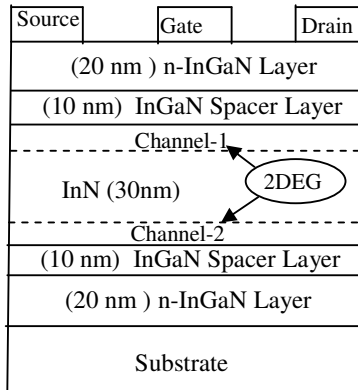


Fig.1: Schematic view of proposed InGaN/InN/InGaN based DHEMT.

3. MODEL FORMULATION

The model considered first obtains the potential profile in the DHEMT structure by solving the Schrödinger equation and Poisson equation self-consistently. The Schrödinger equation yields the confined charge terms in the Poisson equation which, in turn, determines the potential profile. This potential profile is fed back into the Schrödinger equation until the solution of Poisson equation goes to convergence. According to the effective mass approximation, the one dimensional Schrödinger equation is given by

$$\frac{\hbar^2}{2} \frac{d}{dz} \left[\frac{1}{m^*} \frac{d\psi_i(z)}{dz} \right] + V(z)\psi_i(z) = E_i\psi_i(z) \quad (1)$$

Where, m is the effective mass, ψ_i is the wavefunction of the i th sub band and is found from the solution of Schrodinger equation couple with Poisson's equation, E_i is the energy of i th subband. The unknown potential energy $V(z)$ is given by

$$V(z) = -q\phi(z) + \Delta E_c(z) \quad (2)$$

q is the electronic charge, $\Delta E_c(z)$ is the conduction band offset and $\phi(z)$ is the electrostatic potential and is found from the solution of Poisson's equation, expressed as

$$\frac{d}{dz} \left[\epsilon \frac{d\phi(z)}{dz} \right] = -q[N_D^+ + p(z) - n(z) - N_A^-] \quad (3)$$

Where, ϵ is the dielectric constant, N_D^+ , $p(z)$, $n(z)$, N_A^- , are the density of ionized doping donors, free holes, free electrons, and ionized doping acceptors. In the simulation region we assume $N_A^- = p(z) = 0$ and the inherent electron accumulation at InN surface due to the effects of surface charge and dislocation densities is not considered. For InGaN/InN and InN/InGaN material, we must take account of the polarization sheet charge at the interfaces in Poisson's equation, and the boundary condition is

$$E_{\text{In}_x\text{Ga}_{1-x}\text{N}} \epsilon_{\text{In}_x\text{Ga}_{1-x}\text{N}} - E_{\text{InN}} \epsilon_{\text{InN}} = -\sigma \quad (4)$$

Where, E is the electric field, ϵ is the dielectric constant and σ is the bound polarization induced charges at the surface of InGaN. For the top hetero interface of InGaN/ InN $\sigma(x)$ is given by

$$|\sigma(x)| = |P1_{pz}(In_xGa_{1-x}N) + P1_{sp}(In_xGa_{1-x}N) - P_{sp}(InN)| \quad (5)$$

$$C/m^2$$

For the bottom InN/InGaN hetero interface

$$|\sigma(x)| = |P2_{pz}(In_xGa_{1-x}N) + P1_{sp}(In_xGa_{1-x}N) - P_{sp}(InN)| \quad (6)$$

$$C/m^2$$

Where, $P_{pz}(In_xGa_{1-x}N)$ and $P_{sp}(In_xGa_{1-x}N)$ are given by Ambacher et al. (Ambacher et al., 2002)

$$P1_{pz}(In_xGa_{1-x}N) = [-0.113(1-x) + 0.0276x(1-x)] \quad C/m^2$$

$$P2_{pz}(In_xGa_{1-x}N) = [-0.17x + 0.17] \quad C/m^2$$

$$P1_{sp}(In_xGa_{1-x}N) = -0.042x - 0.034(1-x) + 0.037x(1-x) \quad C/m^2$$

$$P_{sp}(InN) = -0.032 \quad C/m^2 \text{ is given by (Sacconi et al., 1997).}$$

4. RESULTS AND DISCUSSION

To study charge control characteristics of a device it is needed to examine in detail the band profile of the device. The conduction band profile for the InGaN/InN/InGaN DHEMT using self consistent solution of the Schrödinger and Poisson equation over the entire device structure is shown in Fig. 2. The band profile is calculated for the first three sub band energy (i.e, for E₁, E₂ and E₃ quantum states) for In mole fraction of 0.05. The parameters used for the calculation is shown in Table 1. A large conduction band offset of about 1.58eV for In mole fraction of 0.05 is obtained for the proposed device, which ensure the better confinement and higher sheet charge density.

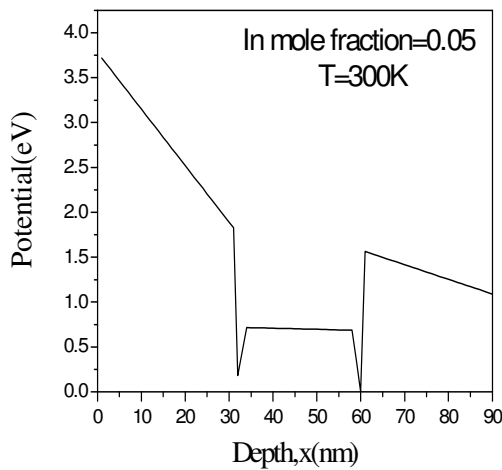


Fig. 2: Conduction Band profile as a function of distance of InGaN/InN/InGaN DHEMT.

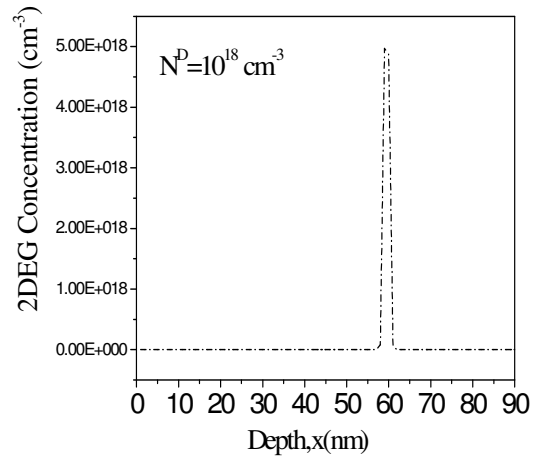


Fig. 3: Charge distribution of lower hetero interface as a function of distance of InGaN/InN/InGaN DHEMT.

The calculations here shown have been obtained considering the polarization charge at the InGaN/InN and InN/InGaN interfaces. The 2DEG forms at the hetero interface with a peak concentration of high up to $4.97 \times 10^{18} \text{ cm}^{-3}$ is found for lower InN/InGaN interface of InGaN/InN/InGaN DHEMT for doping density $N^D = 10^{18} \text{ cm}^{-3}$ as shown in figure 3. The high concentration mainly caused by two factor, one is the large piezoelectric polarization caused by the significant lattice mismatch between InGaN and InN. The other is strong quantum confinement effect caused by the large conduction band offset of about 1.58eV. Also, The 2DEG forms at the hetero interface with a peak concentration of high up to $4.78 \times 10^{17} \text{ cm}^{-3}$ is found for upper InGaN/InN interface of InGaN/InN/InGaN DHEMT for doping density of 10^{18} cm^{-3} in InGaN layer as shown in figure 4.

Table 1. Parameters used for the calculation.

Parameters	Description	Value
x	Mole fraction	0.05
T	Temperature	300K
ΔE_c	Conduction band offset	1.58eV
$\Phi_b(x)$	Barrier height	0.822eV
ϵ_0	Absolute permittivity	$8.854 \times 10^{-12} \text{ F/m}$
ϵ_s	Permittivity of InGaN	$9.22\epsilon_0$
$P_{sp}(x)$	Spontaneous polarization of mole fraction x	-0.0326 C/m^2

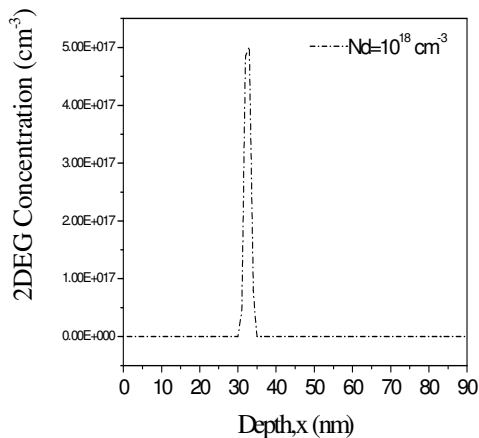


Fig. 4: Charge distribution of upper hetero interface as a function of distance of InGa_N/InN/InGa_N DHEMT.

The lower hetero interface has higher sheet carrier concentration due to the large polarization induced charge. So, the total carrier concentration in the device is much higher than the Single Channel High Electron Mobility Transistor (SHEMT).

5. CONCLUSIONS

We have studied InGa_N/InN/InGa_N double channel high electron mobility transistor (DHEMT) with high 2DEGs. A self consistent charge control model is developed to calculate the electronic states of the device. The model takes into account the highly dominant spontaneous and piezoelectric polarization effects to predict the 2DEG sheet charge density more accurately at the heterointerfaces. The band profile is calculated for the first two sub band energy for In mole fraction of $x = 0.05$. A large conduction band offset of about 1.58 eV is found, which ensure the better confinement and higher sheet charge density. The two dimensional electron sheet concentration of high up to $4.97 \times 10^{18} \text{ cm}^{-3}$ for lower InN/InGa_N hetero interface and $4.78 \times 10^{17} \text{ cm}^{-3}$ for upper InGa_N/InN hetero interface are found for In content of 0.05. This high density 2DEG leads to unprecedented high power densities and high current drive capability that are one order of magnitude higher than SHEMT.

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DESIGN & IMPLEMENTATION OF UP-CONVERTER ON FPGA HARDWARE WITH OFDM (TRANSMITTER & RECEIVER) SIGNAL

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With the rapid growth of digital communication in recent years, the need for high-speed data transmission has been increased. The mobile telecommunication industry faces the problem of providing the technology that be able to support a variety of services ranging from voice communication with a bit rate of a few kbps to wireless multimedia in which bit rate is up to 2 Mbps. Many systems have been proposed and OFDM system has gained much attention for its outstanding method. Among various implementation process of OFDM system into hardware Field-Programmable Gate Array (FPGA) has gained the best choice due to its fastest functionality and flexibility to the program design. An FPGA could be reprogrammed for new functions by a base station to meet future needs particularly when new design is going to fabricate into chip. This research is the continuation and improvement over the previous research entitled “Design of an OFDM Transmitter and Receiver using FPGA”. In this research I have used the previous method and added an additional up converter for mixing the OFDM output signals and pre-amplifier before the final amplify of the output signal and reverse process to get the original base band signal at the receiving terminal. This new scheme reveals that at a room temperature (40⁰c) the transmission rate (speed) raised to a high value and the system requires fewer repeaters in the transmission procedure. At the same time I have used MAX2023 in this scheme which has reduced the overall size of the transmitter/receiver that also made the system easier and cost effective.

Keyword: OFDM; FPGA; Up-converter; Transmission speed and Pre-amplification.

1. INTRODUCTION

Although OFDM was first developed in the 1960s, only in recent years, it has been recognized as an outstanding method for high-speed cellular data communication where its implementation relies on very high-speed digital signal processing. This method has only recently become available with reasonable prices versus performance of hardware implementation^{[2][3]}. Since OFDM is carried out in the digital domain, there are several methods to implement the system. One of the methods to implement the system is using ASICs (Application Specific Integrated Circuit) which are the fastest, smallest and lowest power way to implement OFDM into hardware. The main problem using this method is inflexibility of design process involved and the longer time to market period for the designed chip. Another method that can be used to implement OFDM is general purpose Microprocessor or Micro Controller which is highly programmable and flexible in term of changing the OFDM design into the system. The disadvantages

of using this hardware are, it needs memory and other peripheral chips to support the operation^{[3][4]}. Beside that, it uses the most power usage and memory space, and would be the slowest in term of time to produce the output compared to other hardware. Field-Programmable Gate Array (FPGA) is an example of VLSI circuit which consists of a “sea of NAND gates” whereby the function are customer provided in a “wire list”. This hardware is programmable and the designer has full control over the actual design implementation without the need (and delay) for any physical IC fabrication facility. An FPGA combines the speed, power, and density attributes of an ASIC with the programmability of a general purpose processor will give advantages to the OFDM system. An FPGA could be reprogrammed for new functions by a base station to meet future needs particularly when new design is going to fabricate into chip^[9]. This will be the best choice for OFDM implementation since it gives flexibility to the program design besides the low cost hardware component compared to others.

2. BASIC PRINCIPLES AND GENERATION OF OFDM SIGNALS

In the multipath environment, broadband communication systems suffer from frequency selective fading. OFDM is an attractive modulation scheme used in broadband wireless systems that encounter large delay spreads. OFDM avoids temporal equalization altogether, using a cyclic prefix technique with a small penalty in channel capacity. Where Line-of-Sight (LOS) cannot be achieved, there is likely to be significant multipath dispersion, which could limit the maximum data rate. Technologies like OFDM are probably best placed to overcome these, allowing nearly arbitrary data rates on dispersive channels. An OFDM signal consists of N subcarriers spaced by the frequency distance f thus, the total system bandwidth B is divided into N equidistant subchannels. On each subcarrier, the symbol duration $T_s = 1/f$ is N times as large as in the case of a single carrier transmission system covering the same bandwidth.

To implement the OFDM transmission scheme, the message signal must first be digitally modulated. The carrier is then split into lower-frequency subcarriers that are orthogonal to one another using a scheme such as BPSK, QPSK, or some form of QAM (16QAM or 64QAM for example). To convert the sub-carriers to a set of orthogonal signals, the data is first combined into frames of a suitable size for an FFT or IFFT where The Fast Fourier Transforms (FFT) is used to calculate the spectral content of the signal and the Inverse Fast Fourier Transforms (IFFT) performs the reciprocal operation^[1].

3. FIELD PROGRAMMABLE GATE ARRAYS (FPGA)

In order to implement large circuits, it is convenient to use a type of chip that has a large logic capacity. A field-programmable gate arrays (FPGA) is a programmable logic device that supports implementations of relatively large logic circuits contains three main types of resources: logic blocks, I/O blocks for connecting to the pins of the package, and interconnection wires and switches. The logic blocks are arranged in a two-dimensional array, and the interconnection wires are organized as horizontal and vertical routing channels between rows and columns of logic blocks. The routing channels contain wires and programmable switches that allow the logic blocks to be interconnected in many ways. FPGA can be used to implement logic circuits of more than a few hundred thousand equivalent gates in size^{[7][9]}. Equivalent gates is a

way to quantify a circuit's size by assuming that the circuit is to be built using only simple logic gates and then estimate how many of these gates are needed.

When a circuit is implemented in an FPGA, the logic blocks are programmed to realize the necessary functions and the routing channels are programmed to make the required interconnections between logic blocks. The FPGA device is configured by using the in-system programming (ISP) method, which means that the FPGA can be programmed while the chip is still attached to its circuit board. The storage cells in the LUTs in an FPGA are volatile, which means that they lose their stored contents whenever the power supply for the chip is turned off. Hence the FPGA has to be programmed every time power is applied. Of this, a small memory chip that holds its data permanently, called a programmable read-only memory (PROM) is included on the circuit board that houses the FPGA. The storage cells in the FPGA are loaded automatically from the PROM when power is applied to the chips.

4. FPGA IMPLEMENTATION

The base band signals from FPGA are sent to a D/A converter. After the reconstruction filtering, the D/A output signals are provided at the input of the I/Q modulator (Maxim MAX2023). This mixing stage is used to shift the baseband signal to an IF at 1.95 GHz. The selected I/Q-modulator supports IF- frequencies between 1.5 to 2.3GHz. The core devices of the second up conversion stage are the mixers (Mini- Circuits ZX05-42MH) and the preamplifiers (Hittite HMC409LP4). The frequency shifted 2nd stage input signal is filtered to suppress all out-of-band signal components and scaled by a step-attenuator and then transmit.

To generate low distortion local oscillator signals for the mixers, the outputs of the two LO generators were boosted by amplifiers and low pass filtered to minimize the second and third order harmonic distortion. After the amplifiers' output signal is reduced to the desired magnitude it is applied to the input of the receiver branch. Here, the down conversion to the IF frequency is performed. The mixer output signal is then filtered to suppress all undesired signal components and amplified to the required input power level of the I/Q demodulator (also Maxim MAX2023). The signals provided by the demodulator are filtered before they are fed into the A/D converters. These devices show the same characteristics as the corresponding D/A converter. To assure a fixed phase relationship between the different

frequencies used in the test-bench the local oscillators were locked to the same 10 MHz reference clock.

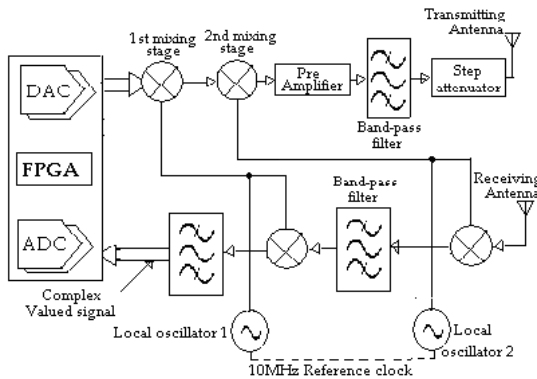


Fig. 1: Proposed block diagram of up conversion on FPGA.

One last thing to say about the assembly already shown, is that the use of two signal generators, one at 1.95 GHz and the other one at 1.55 GHz, is not due to a limitation of the signal generators but it is because a limitation of the electronics used in the signal amplifiers, that is why two signal generators has been used and not only one at the single frequency of 3.5 GHz. The use of the signal generator must begin just when the output signal from the FPGA is stabilized; the reason of this is because before the stabilization of the signal some peaks are generated, and those peaks can damage the devices.

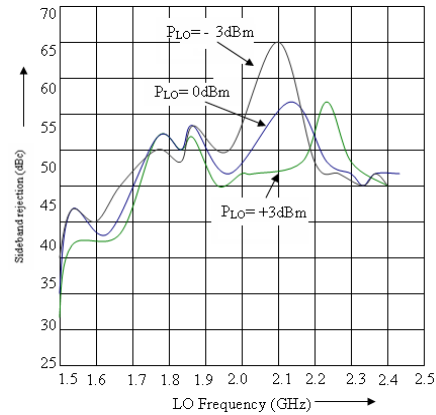


Fig. 2: Modulator single-sideband suppression vs LO frequency

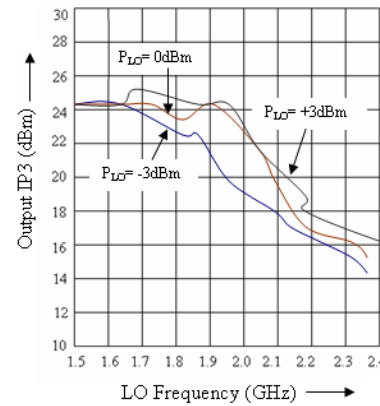


Fig. 3: Modulator output IP3 vs LO frequency

Table 1: Electrical properties of MAX2023 (Modulator/Demodulator)

PARAMETER	CONDITION		
MODULATOR	$V_{CC} = +4.75V$ to $+5.25V$, $f_{IQ} = 1$ MHz, $P_{LO} = 0dBm$, $T_C = +25^{\circ}C$		
Base band input differential impedance	$f_{IQ} = 1$ MHz		55 Ω
RF output IP3	$P_{out} = 0$ dBm	$f_{LO} = 1750$ MHz	+ 24.2 dBm
	$f_{BB1} = 1.8$ MHz	$f_{LO} = 1850$ MHz	+ 23.5 dBm
	$f_{BB2} = 1.9$ MHz	$f_{LO} = 1950$ MHz	+ 22.0 dBm
RF output IP2	$P_{out} = 0$ dBm		+ 61 dBm
	$f_{BB1} = 1.8$ MHz, $f_{BB2} = 1.9$ MHz, $f_{LO} = 1850$ MHz		
Output power variation over temperature	$P_{out} = +5.6$ dBm, $f_{IQ} = 100$ kHz, $T_C = -40^{\circ}C$ to $+85^{\circ}C$		0.25 dB
RF return loss	$f_{LO} = 1850$ MHz		17 dB
Output noise density	- 174 dBm/Hz		
Output noise floor	$P_{out} = 0$ dBm		- 165 dBm/Hz
DEMODULATOR	$V_{CC} = +4.75V$ to $+5.25V$, $f_{IO} = 1850$ MHz, $P_{RF} = P_{LO} = 0dBm$, $f_{BB} = 1$ MHz, $T_C = +25^{\circ}C$		
RF input frequency	1500 – 2300 MHz		
Conversion loss	$f_{BB} = 25$ MHz		9.5 dB
Noise figure	9.6 dB		
I/Q gain mismatch	$f_{BB} = 1$ MHz		0.025 dB
I/Q phase mismatch	$f_{BB} = 1$ MHz		0.56 degrees

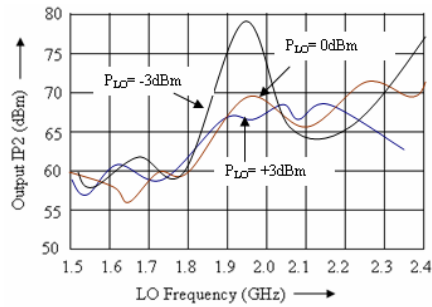


Fig. 4: Modulator output IP2 vs LO frequency

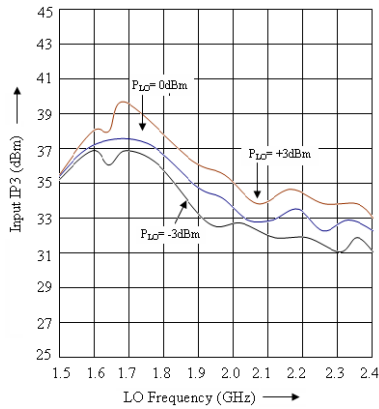


Fig. 5: Demodulator input IP3 vs LO frequency

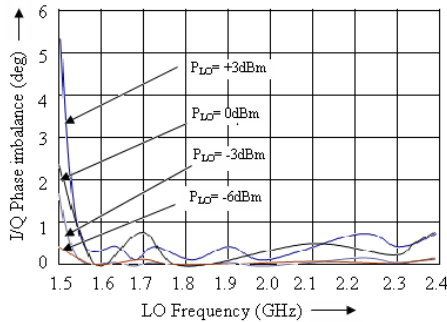


Fig. 6: Demodulator I/Q imbalance vs LO frequency

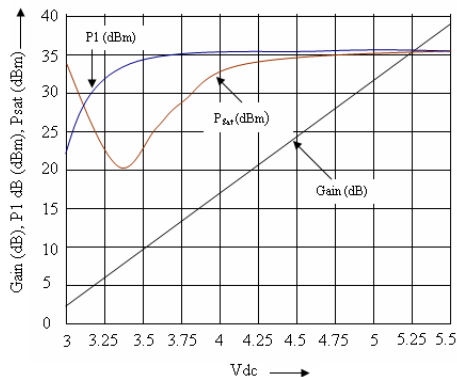


Fig. 7: Gain, Power & Quiescent supply current vs V_{dp} @ 3.5 GHz

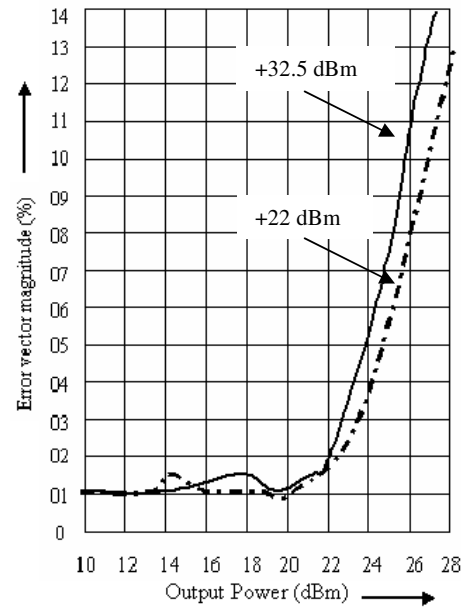


Fig. 8: EVM vs gain @ 3.5 GHz OFDM 54 Mbps signal

Figure 7 and 8 shows the improvement of 54 Mbps output OFDM signal at 3.5 GHz range providing 31dB gain and +32.5 dBm of saturated power with an error vector magnitude of 2%. Basically this 54 Mbps signal provides +22dBm of output power.

5. CONCLUSION

The proposed scheme of up converting the 3.5 GHz baseband OFDM signal from FPGA where the MAX2023 modulator/demodulator is composed of a pair of matched double-balanced passive mixers and a balun has increased the transmission speed of about 31 dB and at the same time the overall size of the Tx/Rx system. Though the transmission speed has raised, the complexity remain unchanged which has made the system easier and cost effective. As the transmission speed has raised to a high value, it requires fewer repeater in the transmission procedure. This research is modeled on the basis of mathematical analysis and the output is calculated through simulation of hardware and for this reason the output simulation graph showed some fading effect and some mismatch.

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DESIGN AND FABRICATION OF A DIGITAL POWER FACTOR METER

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Abstract- This paper is being to design a reliable digital power factor meter and fabricate the designed digital power factor meter. The circuit is used only integrated circuit (IC's) and liquid crystal display (LCD) to display the output of the meter. The second part of the paper describes its performance and compare with the electromechanical type meter and conventional type meter. And finally analysis the data results of the meter and discuss the error and limitation of the proposed meter. It has been seen that the reading of conventional power factor meter and designed power factor meter are close to each other at high power factor but at low power factor, the difference in reading between two meters is being increase.

Keywords- Microcontroller, Analog and Digital power factor, Error and limitation.

1. INTRODUCTION

In the modern world, the electrical energy is almost exclusively generated, transmitted and distributed in the form of alternating current. Practically, there is generally a phase difference between voltage and current. Hence, the question of power factor (phase difference between voltage and current) is immediately comes into picture. A low power factor is highly undesirable as it causes an increase in the current, resulting in additional losses of reactive power in all the elements of the power system. In order to ensure most favorable conditions for a supply system from engineering and economical point of view, it is important to have power factor as close as possible. Therefore, a continuous monitoring is always needed to set the power factor to a desired value. [1]

In this paper, a digital power factor meter was designed by a very simple logic, that that provides the operating power factor which is displayed by a liquid crystal display (LCD). It must be easier than an analog meter to understand, which is the most important of the fabricated power factor meter. This

power factor meter can be used for both single phase and three phase supply. The logic is very

simple and the cost of the power factor meter is desirable.

Digital power factor meter displays measurements of power factor as discrete numerals rather than pointer deflection on continuous scale that used in electromechanical meter. A digital meter reduces operator training, measurement error and possible instrument damage through overload. [2]

There are some significant advantages than analog meter

- Reduces human reading and interpolation error.
- Eliminate parallax error.
- Increase reading speed.
- Higher order of accuracy than analog system.
- Digital lag or lead information.

2. BLOCK DIAGRAM

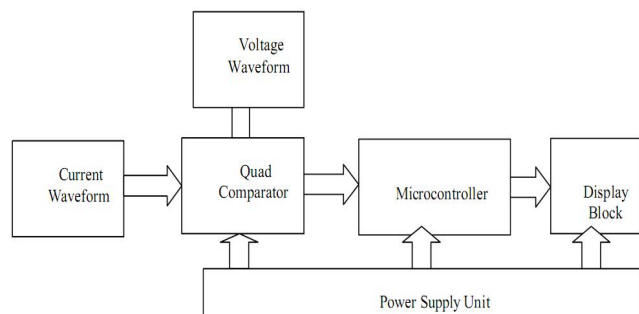


Fig.. 1 Block Diagram representation of proposed configuration

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operation of two rectangular waveforms, to convert power factor angle into power factor and to display the power factor by LCD display in the numeric form.[3].

A liquid crystal display (LCD) device “YM1602C” is used by which the output of the microcontroller (resultant power factor and lagging leading information) is displayed.

This device consists of four independent precision voltage comparators with an offset voltage specifications as low as 2mV max for LM33. This comparator was designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible. This comparator also has a unique characteristic in that the input common-mode voltage range includes ground even though operated from a single power supply voltage.

A microcontroller “ATmega32” is used, in which a computer program to be written to execute XOR

Fig. 2 Complete circuit diagram of the designed power factor meter

4. OPERATING PRINCIPLE

In alternating current system, there is a phase difference between voltage and current, which always exists. The cosine of the angle between the voltage and current in an a.c circuit is known as power factor (p.f). [3][4]. The quad comparator used in the project takes the voltage and current wave shape of a load under the operating condition to provide two rectangular wave forms by comparing the wave shape separately. Then the XOR operation of the two outputs of the quad comparator is done by, which gives the power factor angle. The execution of XOR operation and the conversion of power factor angle into the power factor are done by a computer program in the used microcontroller. Finally, the measured power factor is displayed in digital form by the LCD display. Fig: (art-4.3) denotes the graphical representation of operation. Fig- 4.9 shows the operation of the digital power factor meter. [5]

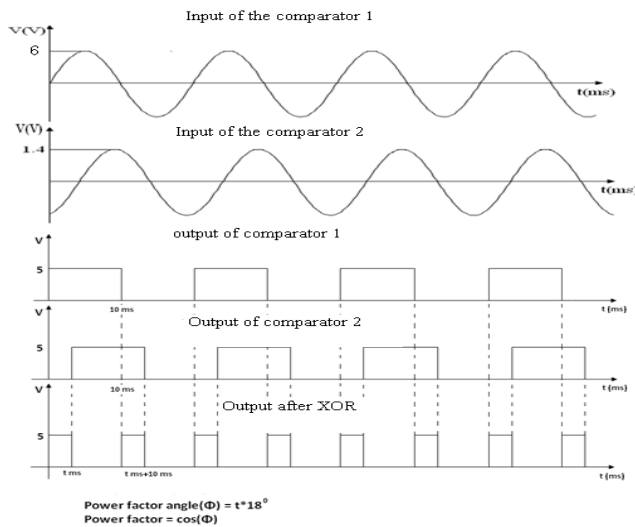


Fig.. 3 Operation of the designed digital power factor meter

5. RESULT AND DISCUSSION

The designed power factor meter was tested several times. It was done a simple R-L series circuit to test the performance of the designed meter [6][7]. A Conventional electromechanical power factor meter was also connected with the testing circuit so that it can compare the reading to two power factor meters.

The reading was taken by varying the value of inductance and resistance. Table 5.1 shows different reading of two power factor meter and reading of p.f using watt meter, voltmeter& ammeter method.

S.L No.	Reading of the fabricated power factor meter	Reading of the conventional power factor meter	Reading of p.f using wattmeter, voltmeter& ammeter method.
1	0.998	0.985	0.970
2	0.975	0.952	0.936
3	0.927	0.903	0.921
4	0.890	0.871	0.884
5	0.851	0.847	0.847
6	0.813	0.792	0.802
7	0.795	0.670	0.783
8	0.742	0.528	0.712
9	0.648	0.483	0.625

6. ERROR ANALYSIS

In this paper, it has used a current transformer and voltage transformer. The first one deals with phase error and ratio error [8]. The current transformer used during the experiment has a negligible ratio error and that was considerable. But the phase error has a great effect on our project result. Phase error means, shift in phase between primary and secondary currents. The figure 4 shows the Phase shift between primary and secondary of used CT is actual P_f is 0.952 where the designed power factor meter reading was 0.975.

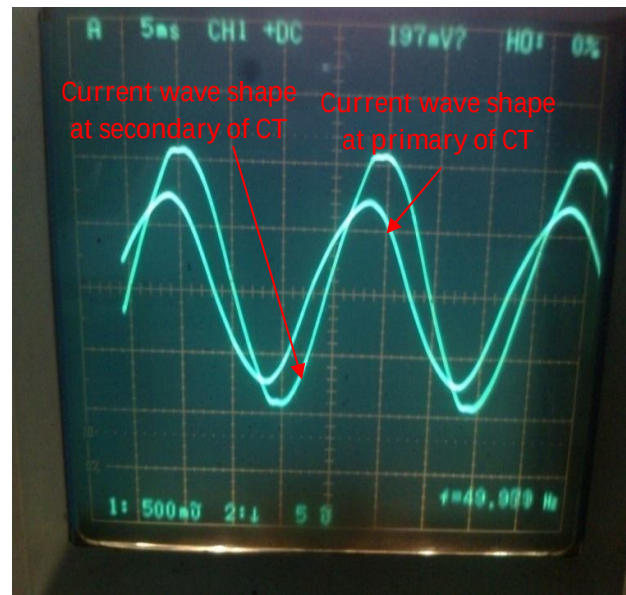


Fig. 4 Phase shift between primary and secondary of CT

7. CONCLUSION

The objective of our project was to design a reliable digital power factor meter. From the data table it is seen that the reading of conventional power factor meter and designed power factor meter are close to each other at high power factor, nearly from 0.851 to 1.00. As the actual power factor decrease, the difference in reading between two meters is increases. The reason is that, the phase error of used CT plays a bad role there. It is seen that, the phase shift between primary and secondary of CT varies non-linearly with the variation of actual power factor. That's why the designed power factor meter does not give actual output. During the experiment it could not remove this error but the error was detected. So the result is that, it is partially successful in completing the project. By minimizing the error properly we can get a reliable digital power factor meter. The logic used to design the power factor meter is very simple. It will give the power factor by digital display. So it must be very easy to read. The designed digital power factor meter can be used for both single phase and three phase system. The components used in the project are available in the market and has considerable cost.

8. LIMITATION

- o Maximum current at the secondary of CT must be less than 3.3Amp.
- o This fabricated power factor is capable of measuring the power factor within a range of .684 to .998 with more precisely.

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DESIGN AND IMPLEMENTATION OF A MICROCONTROLLER BASED ELEVATOR CONTROL SYSTEMS

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Abstract

In this paper, we have designed and implemented a prototype elevator and its control systems using a very low cost microcontroller (PIC16F84) based circuit. Thus the conventional analog control circuit has been replaced. The elevator is operated by using DC motors and gears along with timing belt. Forward and reverse direction of motion of the DC motor is obtained by using a MOSFET bridge. An assembly language program has to be developed for the microcontroller for implementing different logic operations, such as, floor selection, sensor signal detection, alarm signal transmission and reception etc. Different mechanical parts, such as, cabin, doors, gears, guide, timing belt etc. have also been designed for the prototype system. Before implementation of the system, we have simulated the microcontroller based control circuit using 'Proteus' software. It was found that the simulation results are satisfactory and practical systems work very well. We also expect that this will save our valuable foreign currency if we go for practical implementation.

Key words: Microcontroller, DC motor, elevator, gear, control circuit.

1. INTRODUCTION

An elevator (or lift in British English) is vertical transport equipment that efficiently moves people or goods between floors or levels of a building [1]. At present, many high rise buildings are being built in Bangladesh to be used as apartments, offices, shopping malls, hospitals etc. So, all these high rise buildings require elevator. But these are very costly because they are being imported from different foreign countries.

Elevators are generally powered by electric motors that either drive traction cables and counterweight systems like a hoist, or pump hydraulic fluid to raise a cylindrical piston like a jack. So, these motors need to be controlled by sophisticated control circuits. If the costs of these control circuits and other parts can be reduced then the overall costs of the elevator will be reduced. In this work, we have developed a low cost elevator system using microcontroller based control circuit. Because microcontroller has emerged as one of the low cost controller IC and many works have been found in the literatures using microcontroller for minimizing the cost [2-5]. The whole system and

the controller circuit have been tested for various conditions of the elevator operation and it has been observed that the system works very well.

2. HARDWARE DESCRIPTION

The overall system architecture is shown in Fig. 1 as a block diagram. The circuit configuration is each component is briefly described in this section. The 8-bit PIC microcontroller IC 16F877 was chosen to obtain the analog data from the sensor circuit in transmitting to control the DC motors. This microcontroller has a 25 MHz processor (the current compiler runs the processor at 20 MHz), 33 input/output (I/O) pins, (8k*14 words) of Enhanced FLASH program memory, (386*8bytes) of RAM, (256*8bytes) of data EEPROM. The PIC does not have an operating system and simply runs the program in its memory when it is turned on. This PIC microcontroller has several hardware features that are very useful for use in a UAV and simplify the interfacing of sensors and motors with the microcontroller, such as an analog to digital converter (ADC), interrupts, timers, and

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capture/compare/pulse width modulation (CCP) channels. One microcontroller circuit produces the required signals for controlling the levels and another microcontroller produces the control signals for the car. For each floor, one board is needed and for car control each level requires one such board.

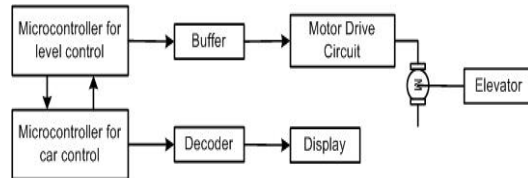


Fig. 1 Block diagram of microcontroller based elevator control system

Our designed system has the various electrical and mechanical parts. The main components are the two DC motors with gear, one motor for the car operation and the other motor for the door open/close. Besides, motors' driver circuits have to be designed. There are various sensors for the transmitter (Tx) and the receiver (Rx) circuit, one microcontroller (PIC16F84) circuit. Power supplies for various controller circuit and motors have also been designed. Since this system is a prototype system, therefore, only a +12V DC power supply was required.

3. SOFTWARE DEVELOPMENT

The program is developed for the microcontroller using the MPLAB software in assembly language and then debugged and edited as required. Finally the hex codes are generated to be loaded into the microcontroller by the TOP2049 Universal Programmer using the TOPWIN software [8]. MPLAB is an Integrated Development Environment (IDE) tool for this task. The architecture and flow chart of the developed program are shown in Figs. 2-4. The clock frequency used for this program is set at 4 MHz. The program is written in assembly language. A typical assembly language program consists of assembler directives, sub-routines (if needed) and the main program code.

Assembler directives are a collection of commands that tell the assembler such things as the type of microcontroller being used, its clock speed, etc. They also allow names to be used for memory locations, ports and registers for making the program more readable [8]. In Figs. 3-4, we have shown two flow charts [9], one for the level board microcontroller's and the other for the car board microcontroller's. The flow charts are self explanatory.

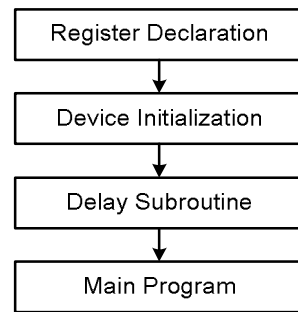


Fig. 2 Program architecture

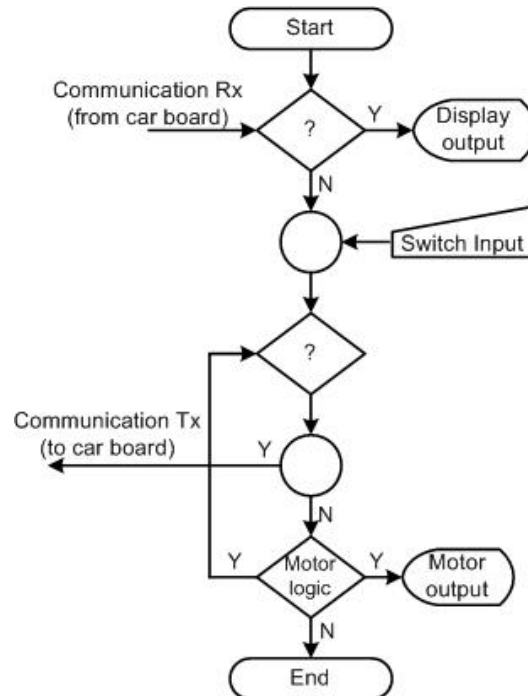


Fig. 3 Flow chart of the program for level board

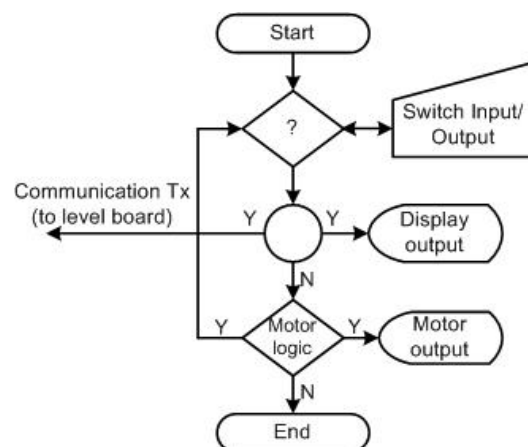


Fig. 4 Flow chart of the program for car board

4. SYSTEM DESCRIPTION

At first, we develop the motor control circuit as shown in Fig. 5. This circuit uses opto-couplers and relays to control the DC motor's operation. The circuit is designed in such a way so that the motor can be driven in forward or reverse direction.

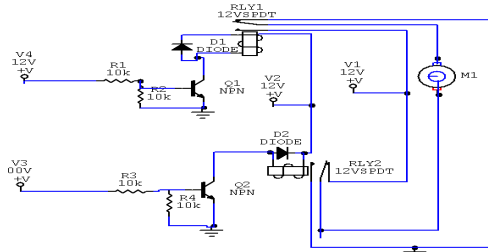


Fig. 5 Motor control circuit diagram

Then we design the sensor circuit for the car board and level board as shown in Fig. 6. In this circuit, the photo diode transmits the signal and the phototransistor receives it. Then we develop the microcontroller circuit to integrate these circuits. The complete hardware circuit is shown in Fig. 7.

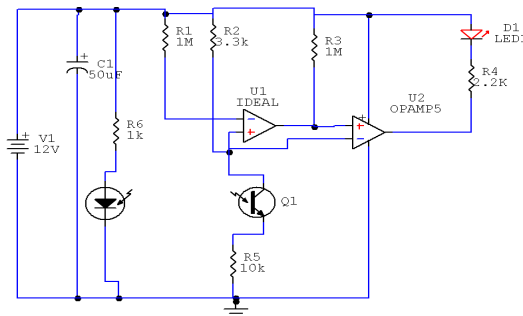


Fig. 6 Sensor circuit diagram

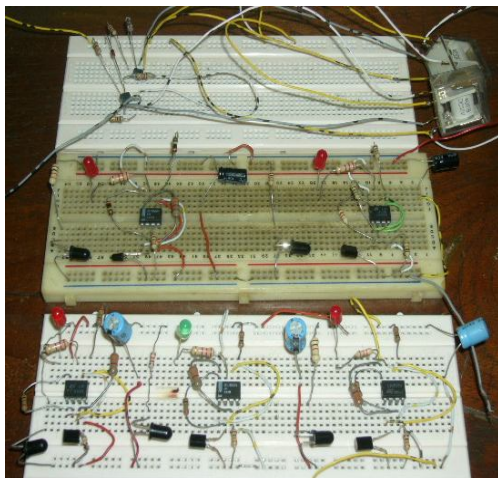


Fig. 6 Complete hardware circuit without microcontroller circuit

Then we have to design the mechanical parts of the system. Of them, the door control panel is shown in Fig. 8. This is a wooden frame where different switch boards and LEDs are connected. The photograph of the complete system is shown in Fig. 9. It is a 3-storied prototype elevator model.

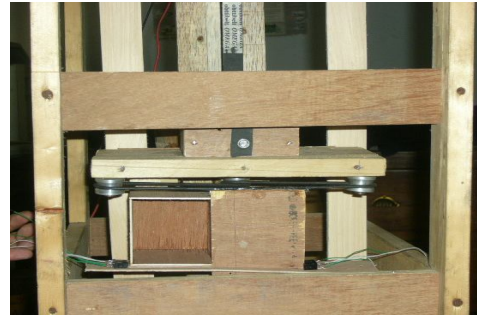


Fig. 8 Door control panel

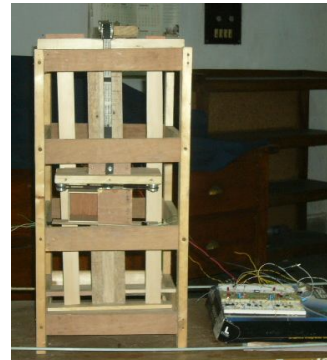


Fig. 9 The complete system

5. CONCLUSIONS

In this work, we have designed and implemented a prototype elevator and its control systems using a very low cost microcontroller based circuit. Thus the conventional analog control circuit has been replaced. The elevator is operated by using DC motors and gears along with timing belt. Forward and reverse direction of motion of the DC motor is obtained by using a MOSFET bridge. An assembly language program has been developed for the microcontroller for implementing different logic operations. Different mechanical parts have also been designed for the prototype system. Before implementation of the system, we have simulated the control circuit. It was found that the simulation results are satisfactory and practical systems work very well. We also expect that this will save our valuable foreign currency if we go for practical implementation. As future scopes, the main controller can be re-designed in such a way so that a three phase induction motor can be operated through a speed control circuit.

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DESIGN AND IMPLEMENTATION OF A MICROCONTROLLER BASED LIQUID LEVEL CONTROL SYSTEM

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This paper presents design and implementation of a microcontroller based automatic liquid level control system. The design part contains one hardware portion (motor, transistor, resistors, relay, liquid tank, dc voltage source, ac voltage source and coupling circuit) and another software portion (microcontroller operating program). The liquid level control system is very essential for factory, laboratory, house and other places where liquid level controlling is essential. The conventional liquid level control systems which are not programming based that can't sense, operate and display for the little amount fluctuation of liquid level. But the performance of our programming based propose liquid level control system can handle and operate very smoothly and display very little amount of variation and fluctuation of liquid level compare with the conventional system. Again our research device is very cheap to implement compare to others. A detail design procedure including block diagram, circuit design, algorithm, flow chart, description of the microcontroller and the practical outputs are presented in this paper.

Key words: Liquid Level Detector; Microcontroller; Programming, Automatic Controlling Circuit.

1. INTRODUCTION

Liquid level control systems play important role in industrial application such as in food processing, beverage, dairy, filtration, effluent treatment, Pharmaceutical industry, water purification system, Industrial chemical processing and spray coating. So that the requirement of industrial manufacturing processes, the liquid level control system is applied to many processing fields. Many efforts [1-10] have been given in this field by a number of researchers. Our topic is different from the other researchers who have done their research on the same area. To show in difference between our findings and others, we would like to explain their researches. The principle of Proportional Integral Differentiator (PID) is that the action of the controller is calculated by multiplying a constant factor with the error, the integral of the error and the derivative of the error [1]. Ziegler- Nichols has developed a well known design methods to provide a closed-loop response with a quarter-decay ratio [2]. A simple PI controller design method has been proposed by Wang and Shao that achieves high performance for a wide range of linear self-regulating processes [3]. Ari Ingimundarson and Tore Hagglund have compared the performance of PI, PID and dead-time compensating controllers for level controlling

[4]. A design method for robust PID controller for liquid level to address the model uncertainty has been proposed by Ming Ge et al [5]. Presently, it is becoming increasingly advantages in carry out information processing and control functions using digitally methods for controlling level [6]. It is well known fact that the digital control system can offer high accuracy and high-speed response [7]. These are the reasons that cause strong motivation to design and implementation of the automatic control system based on the digital controller. Recently, a variable structure control for liquid level in the discrete-time domain has received much the attention [8-10]. These are the reasons that cause strong motivation to design and implement the automatic control system based on the digital microcontroller. So from the above discussions so far as we know that our designed liquid controlled system can handle and operate very smoothly, accurately and display very little amount of variation and fluctuation of liquid which has not explained to the other papers.

2. BLOCK DIAGRAM OF LIQUID LEVEL CONTROL SYSTEM

The general block diagram contains liquid level detector circuit, liquid tank, coupling circuit,

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automatic control unit, microcontroller and motor. The design part contains one hardware portion (motor, transistor, resistors, relay, liquid tank, dc voltage source, ac voltage source, coupling circuit and automatic control unit) and another software portion (microcontroller and microcontroller operating program).

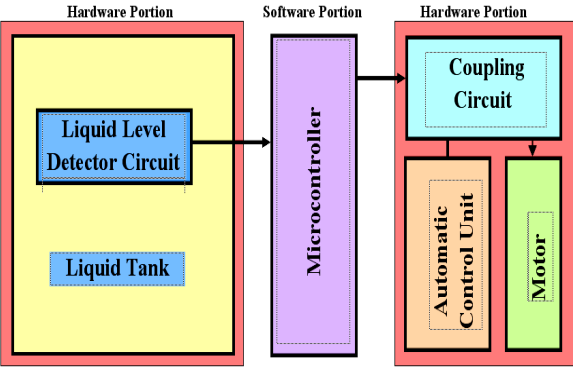


Fig. 1: Block diagram of a microcontroller based automatic liquid level control system

3. HARDWARE PORTION

It is a device which automatically controls the supply of liquid to avoid the dissipation of liquid. DC motor is used mainly to control the liquid level in the device. Motor will active when liquid is under the desired level and out of order when liquid is over the desired level. Application of the transducer is used here for sensing the height of liquid in tank. Using the liquid level, the motor pump is either ON or OFF condition. The complete circuit diagram of the project is given below.

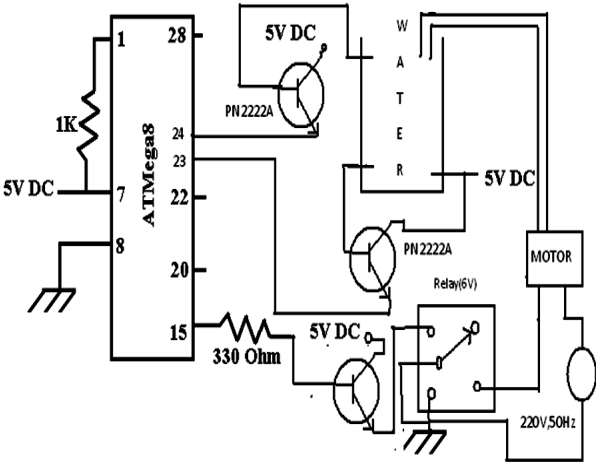


Fig. 2: Schematic circuit diagram of automatic liquid level control system

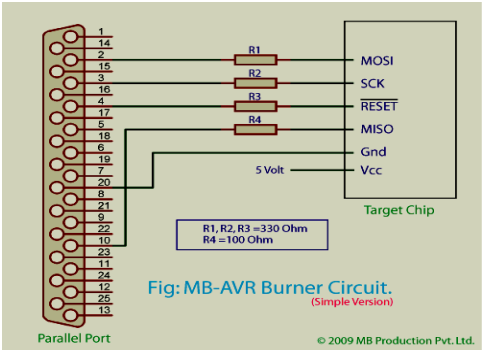


Fig. 3: Interface between microcontroller and personal computer for burning

4. SOFTWARE PORTION

Microcontroller is a programmable device which contains a microprocessor, memory as same as a single chip computer. As microcontroller is a low cost programmable device, it is used in the automatic control application like robot, microwave oven, digital watch, mobile phone, electronic display and some conditions where circuit is difficult.

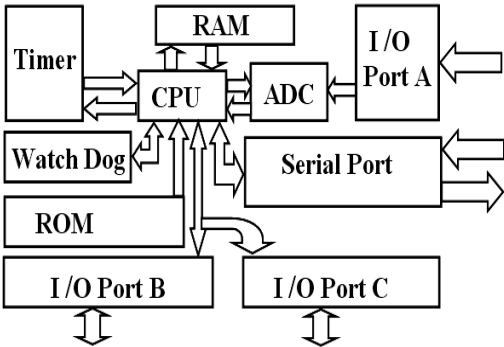


Fig. 4: Internal block of a microcontroller

PIN	Symbol	Function
1	Vss	Ground
2	Vdd	Supply Voltage
3	Vo	Contrast Setting
4	RS	Register Select
5	RAW	Read/Write
6	En	Enable
7-14	DB0-DB7	Data Lines
15	A	Gnd for backlight
16	K	Vcc for backlight

Fig. 5: Pin configuration of LCD

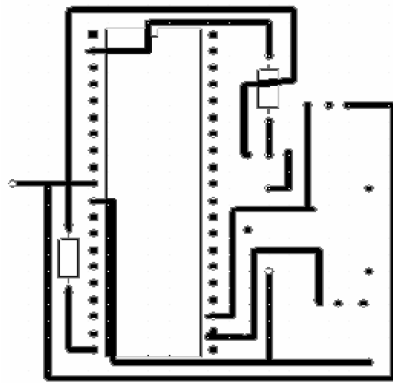


Fig. 6: PCB layout of the total system

4.1 Flow chart of the microcontroller program

Here the sensor senses the height of the liquid level. If the level is below the desired level then the motor is started, otherwise off. The same work is done continuously until the power supply is on. When the power supply is off then the program is ended.

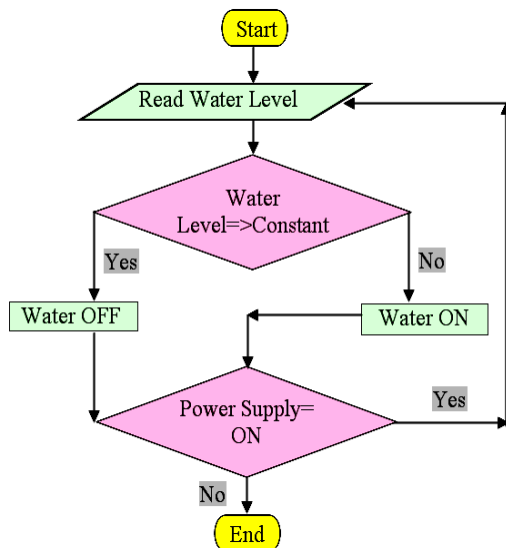


Fig. 7: Flow chart of for the program of the microcontroller based automatic liquid supply level control system

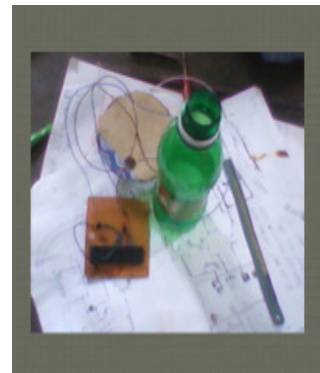
5. IMPLEMENTATION OF THE AUTOMATIC LIQUID LEVEL CONTROL CIRCUIT

Required components are collected from the local market and connected on the project board according to the circuit diagram and performance of

the total system is tested and our desired result is obtained.



(a)



(b)

Fig. 8: Implemented circuit of the microcontroller based automatic liquid level control system

6. RESULTS

The overall performance of the task is very good & the response is very fast. This system also stores the information of motor state (that is the ON or OFF state). This information may be used during electricity disturbance period. This system is not affected by temperature or other factor. The Upper level of the water tank = 10ml and the Lower level of the water tank = 0ml are fixed for our desired level.

Table1

Measuring test result on the basis of the liquid level in the tank

Reading	Water level	Motor condition
1	0ml	On
2	5ml	On
3	7ml	On
4	9ml	On
5	10ml	Off
6	10ml and above	Off

7. CONCLUSIONS

The control circuit was constructed on a project board and performance was tested in the laboratory. The proposed automatic liquid level control system was worked properly. It always keeps the liquid tank filled by liquid. A single drop of liquid is not wasted. DC motor is turned on when the liquid level is gone below the desired mark of the liquid tank. If the power supply is off for some hours or for some days then the system is off, otherwise it is always on. It is very reliable for non-stopping liquid supply. Also the components are available in the local market and very cheap. So this microcontroller based liquid level control system is very essential, reliable and efficient.

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DESIGN AND IMPLEMENTATION OF A PLC BASED SCREW AIR COMPRESSOR FOR INDUSTRIAL APPLICATIONS

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Abstract

Programmable Logic Controllers (PLCs) have been used in various control systems in order to increase efficiency, to reduce the initial investment and to minimize the long term maintenance costs. Every industrial plant requires compressed air to perform various operations. This can be obtained by air compressor. Screw air compressor has high capacity and stable flow in varying conditions. But this requires sophisticated control algorithm. In this work, we have designed and implemented a PLC based screw air compressor for industrial applications. LEDs are used to indicate different conditions of the air compressor, such as, over load, no load, full load, cooling fan's on/off, vent valve's open/close or oil level low/high conditions etc. Besides, to show different error messages, such as, oil level error signal, over temperature error, over air pressure error, over motor current error signals etc. few more LEDs are used. Manual and automatic modes of operations have been incorporated in the system. Besides, reset system has been included in case of emergency. In practice, it is found that the developed control system works very well for different types of input signals from the sensors and provides appropriate output.

Key words: PLC, screw air compressor, relay.

1. INTRODUCTION

Different industry needs different control algorithm and this must be compatible with its goals, its competitive environment and any salable benefits. Industrial practice differs from the theoretical technique, such as, nonlinearity, high-order dynamics and process uncertainty. But more subtle are the differences in the scale of industrial designs over what can be taught or the requirements for compatibility with human operation and maintenance with the multidisciplinary system design [1].

Automation plays great role in contemporary industries. Through the twentieth century it has been evolved from simple sequential control to the complicated electronics systems. Programmable Logic Controller (PLC) has become the most powerful change to occur in the electronics world for factory automation [2]. This is well suited to the cyclical and repetitive operations [3]. Unless a system reconfiguration is required, the functions executed by a PLC are fixed, the programs need not be changed and therefore, they

may be stored in a Programmable Read Only Memory (PROM) [4-5]. Today it is hard to imagine a factory without robots, numerically controlled machines and programmable logic controllers (PLC) [6]. PLCs are being used in automatic controlling of doors in public transport systems [7-8]. Few works on traffic controllers are found using microcontroller [9]. But PLC has many advantages over microcontroller, such as, graphic mode programming, noise immune, less hardware connections, easy downloading of program, faster acting etc. Thus, an automatic traffic control system has been developed using PLC. The system is developed for a junction of four roads only [10]. Besides, PLC based automatic railway gate control system has also been designed [11].

The work is aimed at designing and implementation of a PLC based industrial controller for the screw air compressor. The system has been tested for various faulty and fault free condition and it has been observed that the system works very well. Few suggestions for the future extensions of this work have also been provided.

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2. SOFTWARE DEVELOPMENT

IBM PC is used to develop the ladder program for the PLC and also to edit, compile, debug and then finally to download the program in to the PLC. The PC's serial port (COM1) is connected to the PLC's DIN socket by a 9 pin serial connector [12]. At that time, the PLC must be in PROG mode [4]. After downloading the program PC is no longer required. Then the PLC is set in RUN mode to send the output signals to its output ports. The developed ladder program for the PLC is given in Fig. 1.

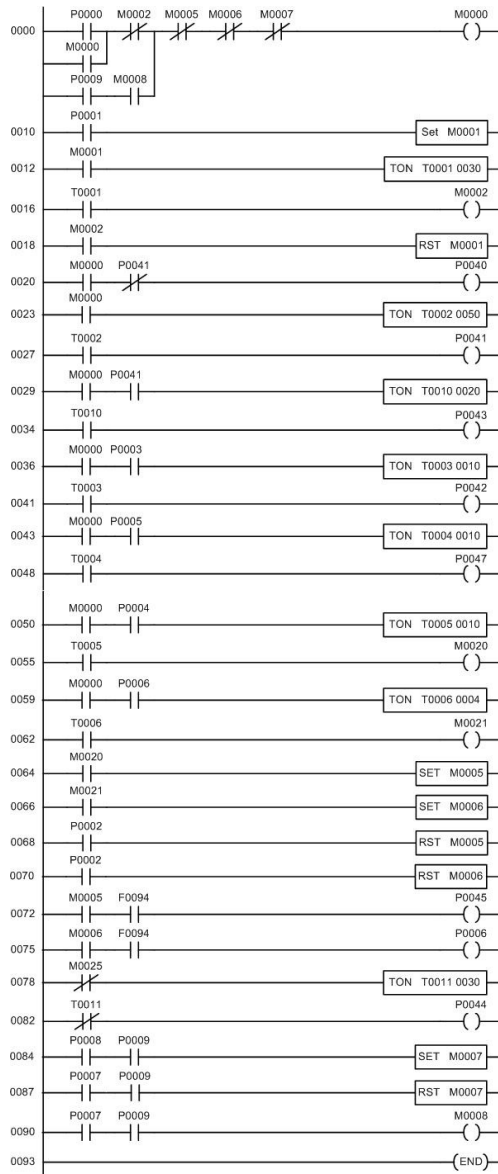


Fig. 1 Complete PLC program of the screw air compressor for industrial automation

Different examine ON and OFF instructions are used to get the signals from the sensors and

different output energize instructions are used to send appropriate signals at the various output devices. Besides, various timer ON instructions are used to make the delays in sending and receiving the signals and also reset instructions are used to reset the timer instructions.

3. HARDWARE IMPLEMENTATION

Every manufacturing plant requires compressed air to perform various operations. This compressed air can be obtained by air compressor. Air compressors are classified by various types. The most useful and important air compressor gives trouble free operation during working conditions.

Screw air compressors are modified stage of rotary air compressor. It is a single stage, oil flooded and driven by electric motor through a coupling. Its casing accommodates a pair of male and female helical rotors, machined with highest precision and mounted on rolling bearings as shown in Fig. 2.

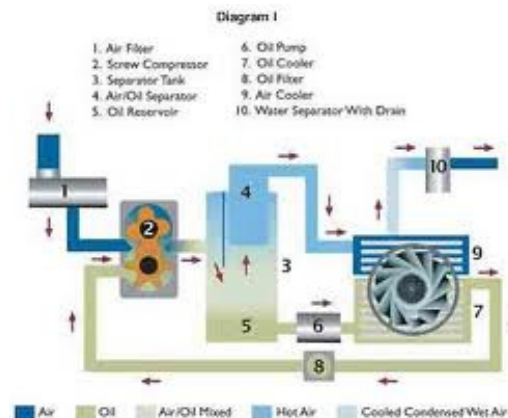


Fig. 2 (a) A schematic of the screw air compressor



Fig. 2 (b) Screw of the screw air compressor

The male rotor has four helical lobes which mesh with six flutes of the female rotor. The speed of male rotor is 1.5 times higher than female rotor. The male rotor is driven by coupling through step-up gears. The male rotor lobes rotate into the

female rotor flutes, the air is trapped in the inter lobe spaces and smoothly compressed until the lobe-flutes reach the outlet port. Pulsation free air is delivered by screw air compressor, due to the continuous compression takes place in all the lobe-flute spaces.

The oil injected through the lower gusset of the air compressor casing mixes with the indrawn air and ensures an efficient sealing between the rotors and the casing and at the same time, giving an intensive cooling during the compression process. Huge quantity of lubrication oil cools the compressed air; therefore inter coolers are not necessary in screw air compressor. The oil, which lubricates the compressor, seals the clearance spaces [13].

In air cooled models, the oil is cooled in oil cooler by separate fan motor whereas it is cooled by water, in water cooled models.

The screw compressor is not equipped with valves and has no mechanical forces that cause unbalance. This means it can work at a high shaft speed and combine a large flow rate with small exterior dimensions. An axial acting force, dependent on the pressure difference between the inlet and outlet, must be taken up by the bearings [14-15].

For hardware implementation of this work, Programmable Logic Controller (PLC) of model K7M - DR20U, brand LS, Korea, is used. To run the PLC as well as the whole system an external DC Power Supply Unit (220 V AC- 24V DC, 6 Amp) needs to be designed. Twelve external relays of 24 V DC, six piano switches, six push switches, one selector switch, two dozen LEDs are used. The schematic of the connections of the circuit diagram is shown in Fig. 3. LEDs indicate the various input and output status of the control systems. Relays actuate the output LEDs when energized by the output signals of the PLC. Switches give the appropriate input signals to the PLC. Internal hardware connection is shown in Fig. 4 and the systems control panel is shown in Fig. 5.

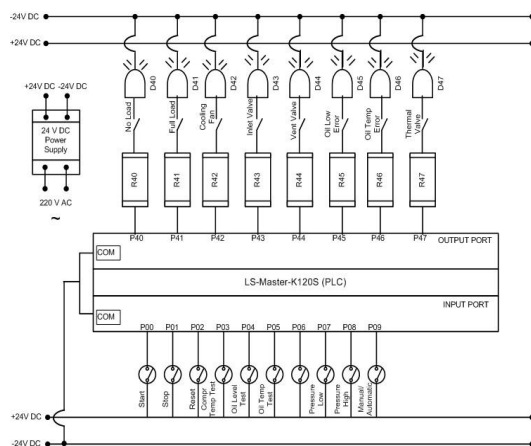


Fig. 3 Schematic of the circuit diagram



Fig. 4 Hardware set-up, internal wiring connections



Fig. 5 Front view of the control panel of the screw air compressor

4. SYSTEM OPERATION

When power switch is on, vent valve is automatically ON for few moments, then air will be released from air tank/air reservoir to reduce load from the main motor. When compressor is ready for start then push switch is pressed to start ON button. After that, at first the motor moves without clutch at no load power. After some times, the motor moves with full load including clutch. After for a few moments, suction valve will open and air to be entered into the air inlet to make air pressure. The screw is attached with the main motor through belt and pulley which will be moved slowly and make air train. In the mean time, oil spray continues into the compressor chamber to reduce the temperature inside the chamber and it also smoothes the mechanical friction.

Air train becomes pressurized slowly during moving the screw. That means, air pressure increases into the compressor chamber. When a certain pressure creates into the compressor then the inlet valve closes and the outlet valve starts and the screw rotates in the opposite direction and this completes one cycle of the compressor. After that pressurized air is deposited into the air oil barrel. Air and oil will be separated into the air oil barrel through the oil separator. Oil continues to spray again through oil line from the oil tank into the compressor chamber and oil circulations to be

continued in such a way. It is to be mentioned that a thermostatic gate valve and oil cooler already connected with the oil line.

Normally when oil temperature is lowered than 60⁰ C then oil passes to the oil spray line through oil filter directly by passing thermostatic valve. But when temperature rises above 60⁰ C the thermostatic gate valve is opened automatically. So, oil flow path is connected to the oil spray line through thermostatic valve, oil cooler and oil filter.

When a certain air pressure is developed into the air barrel then minimum pressure valve becomes open through air cooler and connected with the air service line.

If over air pressure is developed for any reason then the safety valve connected with air barrel becomes open and releases the air pressure. If after sometimes compressor body is heated (say, 70⁰ C) from normal temperature then the connected cooling fan becomes on automatically and it becomes off at a certain temperature.

It is to be mentioned that compressor can run in two modes, e.g., normal mode and auto mode. Generally, start and stop buttons are used to run the compressor at normal mode. In auto mode, high and low pressure switch of air barrel are used to run the compressor as desired. That means, compressor stops for high level pressure and starts again for a certain low level pressure.

When in any case machine becomes faulty then machine stops automatically and error signal is generated and is displayed in the control panel. This fault may be checked in certain suction after the formation of an error signal and removed this fault easily. Some of the error signals that are displayed in the control panel of this work are oil level, over temperature, over air pressure, over motor current error signals etc.

To run the compressor again, reset button is to be pressed after the remedy of an error signal or fault, otherwise the system will not run. The complete operation of the system is shown in Figs. 6-7 using pulse diagrams.

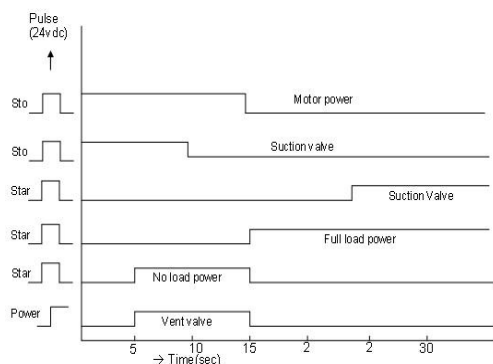


Fig. 6 Pulse diagram of input and output devices of control panel

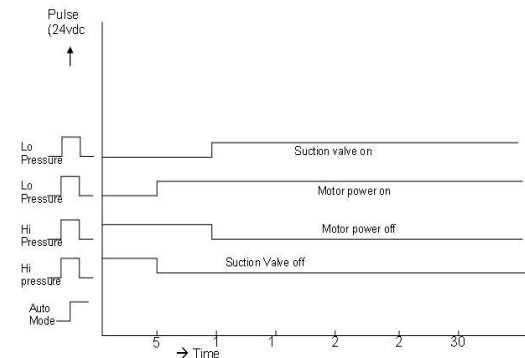


Fig. 7 Pulse diagram of input and output devices of control panel

To compare our work, with the existing systems we have studied two existing methods used in industrial motor controller for the screw air compressor- one is inverter and the other one is star-delta starter. When these types of starters are used then PLCs are not used. Star-delta starter is used due to its low cost, but its connection is cumbersome and the contactors may burn when short circuit occurs. Inverters are very expensive and its design and implementation is time consuming. But PLC programming is very easy to use and it saves time, money and man power.

5. CONCLUSIONS

In this work, we have developed a control system for screw air compressor based on PLC for industrial automation. We have used different sensors to sense the signals. A prototype process control model has been developed and implemented using different switches and lights. Ladder program is developed for the PLC in an IBM PC and then the whole program is downloaded to the PLC from the PC through its serial port. The signals for lamps are obtained from different external output ports of the PLC and input ports of PLC are used to get the sensed signals into the PLC. In practice, it is found that the developed system works very well.

The advantage of using the PLC is that since the same PLC is used for several controlling functions of an industrial process using screw compressor, the system will automatically be synchronized for different functions. There is no need to install additional synchronizing equipment or circuitry or need to develop separate program. The main limitation of the system is that the real time sensors could not be incorporated in this model, but the provision for accommodating real time control is there. As future extension of this work, more sensors at the input and output ports can be added according to the needs. In this regard, few modifications in the PLC program may be required.

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DESIGN AND IMPLEMENTATION OF A REMOTE SENSING ELECTRICITY SUPPLY CONTROL FOR INDUSTRIAL APPLICATIONS

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Abstract

In this work, we have developed a remote sensing electricity supply control systems for industrial applications. For this purpose, we have used a magnetic contactor, two cell phones, two voltage amplifiers and one relay. The output voltage of cell phone's ringer is used for sensing and providing the control signals from the remote position. Magnetic contacts and relays are used to turn on or to turn off the electricity supply from the main distribution board. The circuit has been designed, implemented and tested in various industrial areas in Bangladesh and it has been found that this controller circuit works very well.

Key words: Electricity supply control, cell phone, remote sensing.

1. INTRODUCTION

Now a day, several industrial fire accidents have occurred in Bangladesh mainly because of electrical short circuits problem. When these accidents occur, switching off the main distribution board is must. But it can not be done at that time due to various practical reasons, such as non-availability of key of the main board, or the person in-charge, or the place of the accidents is near the main board, or on its way etc. So, if this can be done by remote sensing then damages and losses can be reduced or even can be avoided.

This work is aimed at designing and implementation of an electric supply controller circuit using magnetic contactors for the industrial application. The controller circuit has been implemented using two cell phones. It has been observed after practical testing that the designed circuit works very well.

2. HARDWARE DESCRIPTION

Fig. 1 shows the block diagram of the electric supply control circuit. The ac source is connected to the load through a magnetic contact [1-2]. The magnetic contractors are connected to the ac source via two relay contacts (1 and 4 in Fig. 1), one

normally open (NO) control terminal of the magnetic contact (2) and one push button switch (3). Relay contact 1 is normally open and relay contact 4 is normally close. Push button switch 3 is also normally open. Two relay coils are connected to the output terminals of the two voltage amplifiers (as shown in Fig. 1) whose inputs are connected to the output signals of the two mobile phones. The output signals of the mobile phones used here are the vibration signals produced by the mobile sets. These signals are too weak to energize the relay coils and these are DC signals. Therefore, DC voltage amplifiers are used. To get the DC bias for the two voltage amplifiers, two step down transformers (220V/12V, ac, 50 Hz, 500 mA) and two bridge rectifiers are also used. Push button switch 3 is used here so that the electric supply to the load without the help of the mobile phone can be connected. Switch, SW is used so that the electric supply to the load without the help of the mobile phone can be disconnected.

Fig. 2 shows the photograph of the voltage amplifiers. Here two bipolar junction transistors (BJT) are used in common emitter mode for the DC voltage amplification [3]. The gain of the amplifier is 5. The output of the mobile phone set is the input voltage of this amplifier and it is 1.2 V, DC. So, the output voltage of the amplifier is 6 V, DC. Since this voltage drives the relay coil (black box in Fig.

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2), so relay used here is a 6 V DC relay [1]. Both relays have two contacts, normally open (NO) and normally close (NC) contacts.

Bulbs are used as the load in our controller circuit as shown in Fig. 3. If the load is larger then another large sized magnetic contact is used and this magnetic contact is energized by the output of this small magnetic contact.

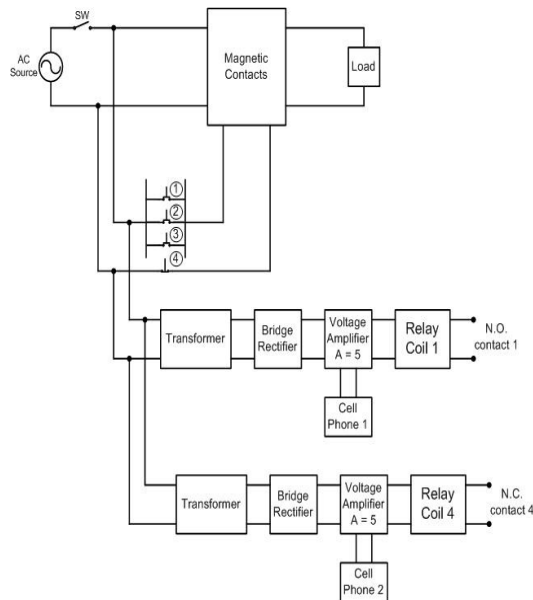


Fig. 1 Block diagram of the electric supply controller for industrial application

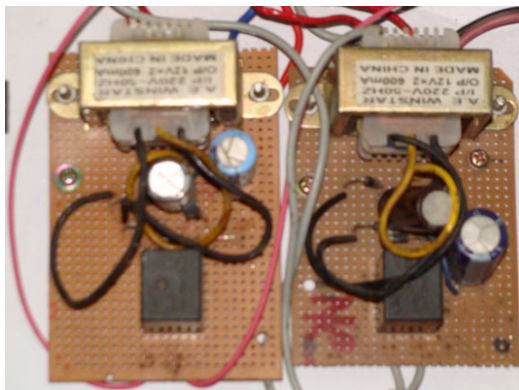


Fig. 2 Photograph of the voltage amplifier

Fig. 4 shows the back view of the cell phones from which terminals of the ringer has been taken out of the cell phone and connected to the voltage amplifier's input terminals. Cell phone settings have to be customized, such as, ringer tone should be made off, all message alerts should be turned off, authorized cell numbers should be saved in the cell phone's SIM by using different names and the calls from the other numbers should be blocked so

that any unauthorized person can not operate or control this system.



Fig. 3 Top view of the control circuit

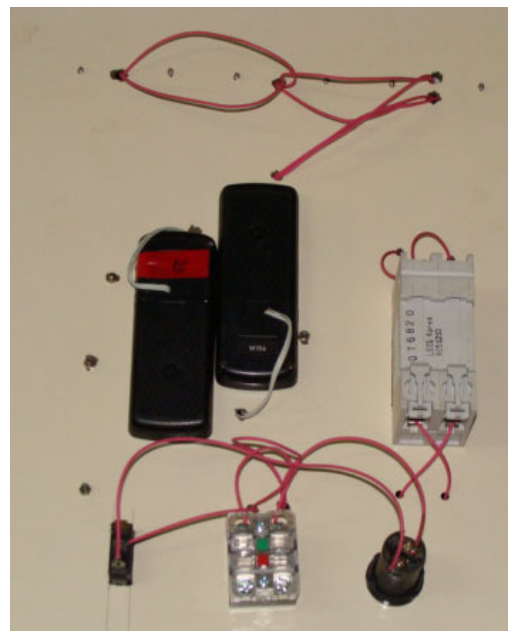


Fig. 4 Back view of the control circuit

4. SYSTEM OPERATION

When power switch (SW) is ON and cell phone call is made then the coil relay 1 is energized by the output of the voltage amplifier connected to the mobile phone's ringer signal and thus normally open contact of relay 1 is closed. Immediately after that coil of the magnetic contacts are also energized

and hence the magnetic contacts 2 gets closed. Now if the cell phone is OFF then the relay coil 1 is de-energized and hence relay contact 1 becomes OFF, but magnetic contact remains energized as long as the magnetic contract 2 remains closed. Therefore, the load connected to the ac source via the magnetic contact gets the electric power supply. But if there any accident, such as, short circuit, occurs in the load side then we may switch it OFF by making another call from the cell phone. This time the output signal of another mobile phone is amplified by the voltage amplifier and it actuates the relay coil 4 and hence the normally closed contact of relay 4 becomes OFF. Hence the power supply is cut from the load. If we want the electric power supply to be established manually then we can press the push button switch 3 and hence magnetic contacts 2 will be closed and the load continues to get the ac supply as before.

5. CONCLUSIONS

In this work, we have developed a remote sensing electricity supply control systems for industrial applications. Magnetic contacts and relays are used to turn on or to turn off the electricity supply from the main distribution board. Cell phone sets have

been customized very carefully so that any unwanted signals can not activate the cell phone and thus to control the electricity supply connected with the load side. The circuit has been designed, implemented and tested in various industrial areas in Bangladesh and it has been found that this controller circuit works very well. The design and implementation cost is very small with regards to its applications.

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DESIGN AND IMPLEMENTATION OF AN INTELLECTUAL SECURITY SYSTEM FOR THE WORLD WIDE APPEARANCE OF OWNER

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This paper presents design and implementation of an intellectual optical security system for any unsecured place which gives acknowledgement to owner of the security signal on owner appearance at any place in the world where the mobile communication is available. Security system is essential for house, educational organization, public places and other important architecture. The security system CCTV and others are very expensive and need man power. But the proposed design security system is cheaper for installing and maintaining and providing better performance than the conventional security system. This security system can protect both vertical and horizontal area of almost 16 thousand square feet. A detail design procedure including block diagram, theoretical description, circuit design and practical outputs are presented in this paper. Design steps are presented in a sequential manner that would be advantageous for the beginners as well as for the advanced readers.

Key words: LASER; LDR; Siren generator; Counter; Coupling circuit with mobile.

Section 1.01 1. INTRODUCTION

A security system is a device that detects intruder and any unwanted objects. Security is a vital need for man kind from long years ago. At first door security was need. After that huge area, money and other valuable things are need to be secured. The security system has been invented from long years by a number of researches. Most of the previous researches are based on electronic circuits and now computerized security systems are very popular like CCTV. Our proposed security system is different from the other researchers who have done their research on the same area. To show in difference between our findings and others, we would like to explain their researches. An electric fence security system was developed in 1936–1937 by William Bill Gallagher [7]. In 1962, another inventor Doug Phillips invented the non-short able electric fence based on security system using capacitor discharge [6]. Electronic security system has been invented in 1984 for the first time [7]. In 1971, a detection security System was designed by another researcher Hedin et al in United States of America. The invention had a logic system which included differential amplifier systems with individual photo resistors [1]. In 1972, an alarm system for sensing

smoke and intruders was designed by W. Henry and Gans Frederick [2]. In 1973, intrusion detector was made by Missio, V. Danilo et al which could detect only the intruder [3]. Also in 1973, another project called segment locating alarm system for security was designed by Schlisser [4]. In 1976, an original optical security alarm circuit system was invented by Todeschini and John David [5]. So far as we know that all the mentioned project inventions are explained about the alarm based security system and intruder detection system but there is no technique to give acknowledgement to the owner through mobile communication with low alarm circuit which creates no disturbance to the neighbor. But our proposed circuit can do so. That is why our proposed security system is unique, efficient and cheap as for manufacturing and maintenance.

2. BLOCK AND LAYOUT DIAGRAM OF THE SECURITY SYSTEM

It includes a light source (infrared), some lens to collimate the light into a beam and a photodiode or other photoelectric sensor as a light detector. The

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light passes in front of the detector to a straight line. When intruder or any unwanted objects are come in between the beam and mirror then the light does not incident on the sensor for any time then the circuit triggers the mobile to make call to the owner. The block diagram of the total system is given in figure 1.

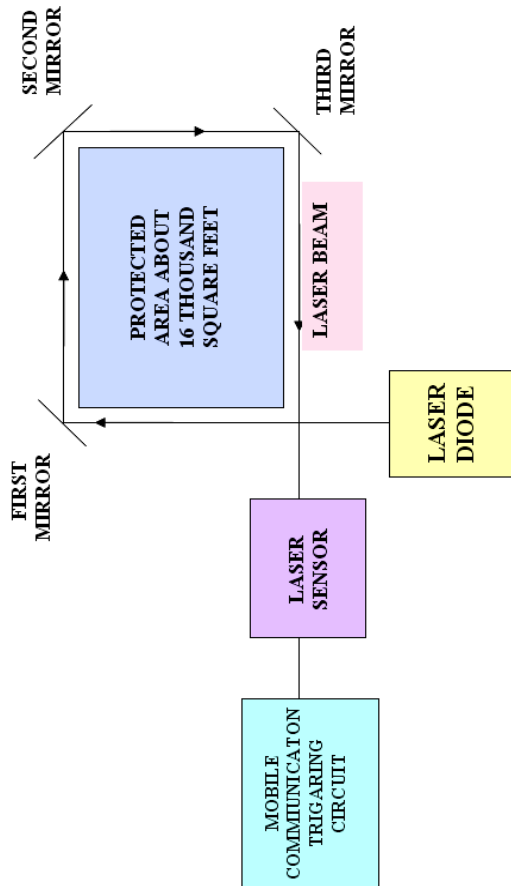


Fig. 1: Block layout diagram of the proposed whole security system

First all the mirrors are adjusted in a balanced way that the light is covered and surrounded the whole area. The beam is first incident upon on the first mirror, then after reflecting it is incident on the second mirror and so on. In the similar process the beam is reflected and incident on the sensor. The LASER beam is constructed around the protected area of about 3 inches away from the wall. About 16 thousands square feet can be protected by our proposed protected system. When the intruder or any unwanted objects are tried to enter that area then it creates barrier to the LASER beam. This event turns on the mobile communication circuit and within six seconds a call is send to the owner mobile cell phone as any appearance of the owner in any place of the world where the mobile network

is available. Blocks based on operation of the whole system is represented in figure no 2. A high power LASER diode is used in this research circuit. Light dependent resister (LDR) is used for sensing the LASER light. The time counter are used for splitting the pulse which is generated by the pulse generators. Alarm tone is generated by the tone generator. Photo coupler is used here for triggering the mobile for sending a call to the owner. The splitter fixes the time interval of the pulse in three second. After sensing once the reset button is need tobe reset all the systems. When the reset button is pushed then the whole process starts instantly, otherwise it will continue the whole process.

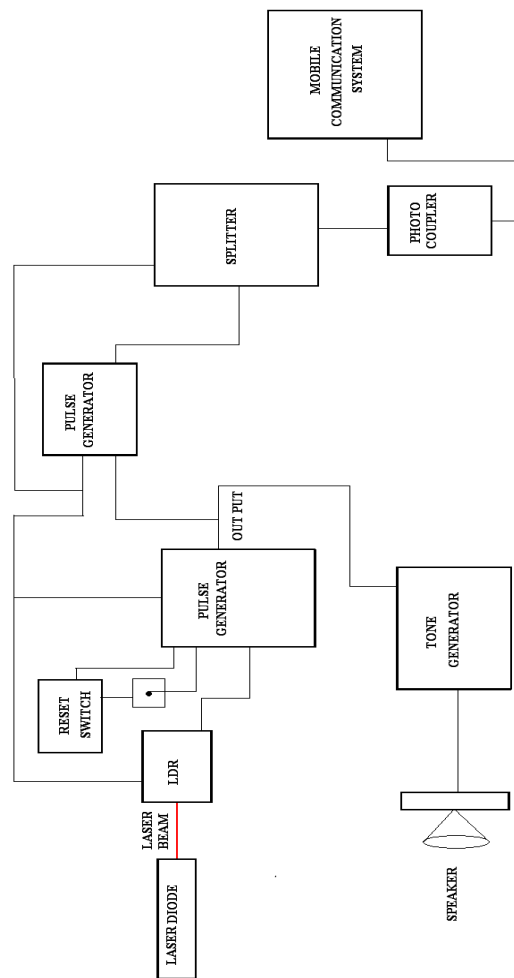


Fig. 2: Block diagram of operation of the whole security system

3. DETAIL CIRCUIT DESIGN OF THE TOTAL SECURITY SYSTEM

Detail circuit design of our proposed security system is given in the figure no 3. In this circuit

design +6v DC is applied as voltage source. In4007 rectifier diode rectifies the current to 100mA. When light incidents upon the 1 no LDR, the LDR is acted like an 18 k ohm resistor. According to the KVL, the voltage is divided between both the no 1 LDR and R1 resistor. R1 is 220k ohm and the voltage across R1 is supplied to the input pin 2 of no 1 555IC. When the laser beam or light is interrupted by intruder or any other unwanted objects then the no 1 LDR is acted like open circuit cause increasing its resistivity to the level of infinite then the voltage across the R1 becomes 0 volt. In this condition, no 1 555 IC generates a pulse which is delivered from the output pin no 3. The pulse is rectified by diode D2 and further rectified by D3. A voltage is developed across the resistor R6 which is acted like base voltage of the transistor T2. Then the collector voltage is developed across the resistor R10 again which is the base voltage of T3. Then T3 supply its collector voltage which is developed across the R11, D4 and R14, R15, C5, R16 respectively. Again the voltage is divided according to KVL between R14, R15. IC3 555 which is used as an astable multivibrator

generates a pulse which is delivered from the output pin 3 to the 14 no pin of IC4. IC4 keeps the amplitude of the pulse same and fixes the time interval of the pulses in three seconds. The split pulses are delivered by the output pins 3 and 4 sequentially. Each pulse develops voltages across R17 and R18 sequentially. So that a base voltage is developed across the base of T6 and then second pin of the photocoupler gets the collector voltage from T6 sequentially and 1 no pin gets the voltage direct from the collector of T3 which is developed across the R16. The 3 and 4 no pins of photocoupler are connected directly to the send key of the mobile cell phone and they are shorted sequentially after every 3 second. The collector voltage of T3 is divided between R11 and D4 according to KVL. The voltage developed across the D4 works as the input of IC2. When 3.3 volt is developed across the 5 no pin of IC2 then it generates an alarm tone and activates the mobile cell phone to create a call to the owner under the network with the owner station of any place in the world.

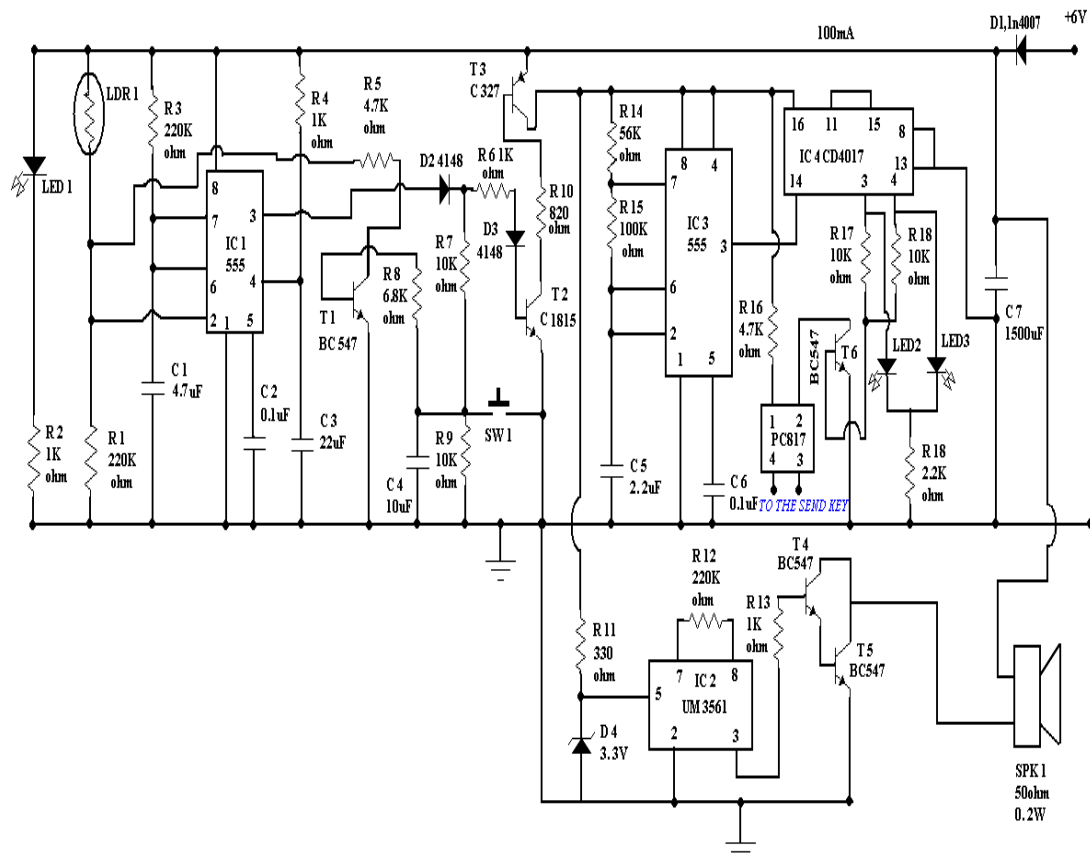


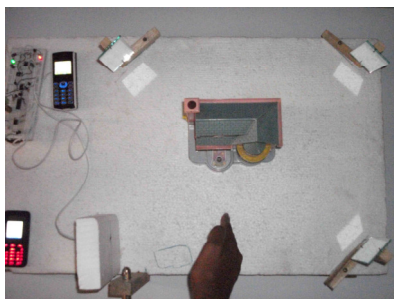
Fig. 3: Detail circuit design of the total security system

4. RESULTS, OUTPUTS AND COMPLETE SNAPSHOTS OF THE SECURITY SYSTEM

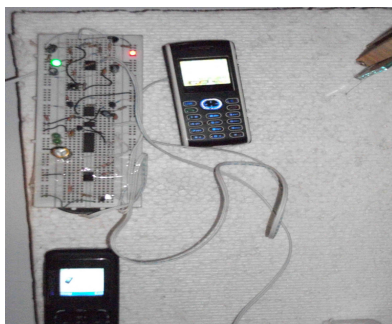
From the given below figure no 4 (a) shows the whole security system which is deactivating mode before the intruder enters into the laser barrier. (b) Shows when the intruder enters in between the LDR sensor and the laser beam which creates an interrupt by the intruder. This turns on the whole circuit of the security system and the mobile call establishing circuit system triggers to create a call. (c) Shows full view of the security system and both mobiles of the security system and owner, which are activated automatically. (d) Shows the call sending process from the security system mobile (which is triggered by the circuit) to the number of the owner. (e) Shows the incoming call process of the owner's mobile from the security system mobile.



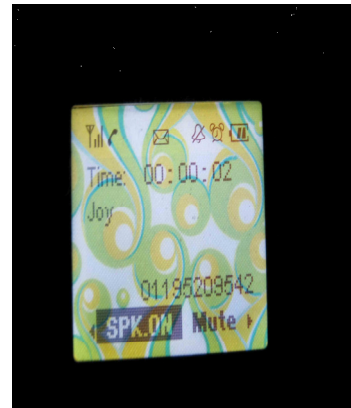
(a)



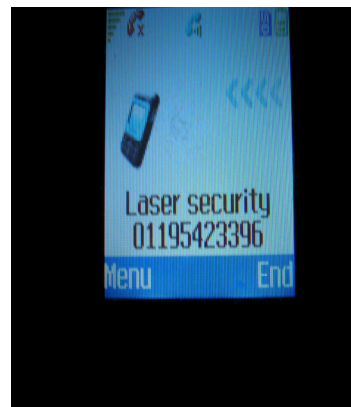
(b)



(c)



(d)



(e)

Fig. 4: Results of the whole security system

- (a) Total system without entering the intruder or any unwanted object
- (b) Total system with entering the intruder or any unwanted object
- (c) Establishing a call between the security system mobile and owner mobile
- (d) Sending call from the security system mobile to the owner mobile
- (e) Incoming call from the security system mobile to the owner mobile

5. CONCLUSIONS

Our proposed intellectual optical security system is better than the conventional security system. It is not expensive. No need of man power to provide security. It is a fully electronic sensor based circuit with DC supply, which provides a continuous alarm and a number calling system through a cell phone. This project can protect an area of around 16 thousand square feet. This proposed circuit can also use to capture the image of the intruder by connecting a camera with this circuit and it has a wide military application. The proposed Intellectual optical security system is deferent from the other security system because of the owner calling

system through a cell phone with a burglar alarm and its multipurpose use. It also deferent for its nice control switching circuit which can switch anything in a time controlled manner.

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DESIGN AND MANUFACTURING OF A LOW COST SYNCHRONOUS MOTOR-GENERATOR FOR ELECTRICAL MACHINE LABORATORY

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Abstract

In this work, we have developed a very low cost synchronous machine which can be run as both synchronous motor as well as alternator. When the machine runs as an alternator, an induction motor or a DC shunt motor is required as the prime mover. This has also been developed. The machine has four poles. Its stator voltage is 415 V (AC), stator current is 0.75 A, rotor voltage is 0 to 240 V (DC) and rotor current is 0.4 A. With this machine, at least eight experiments can be performed for the undergraduate level students. There are future expansion provisions in this machine. All the experimental results support theory. It has also been found that the machine reduces the cost by around 67 % than that of an equivalent machine imported from foreign country.

Key words: Synchronous motor, alternator, electrical machine laboratory.

1. INTRODUCTION

At present, many public and private universities in Bangladesh have established Electrical and Electronic Engineering (EEE) department due to the high demand of this subject at home and abroad. But the establishment of electrical machine laboratory for the EEE department is a big challenge due to the huge expenditures. To establish an electrical machine laboratory, we need to purchase various machines, such as, DC motor, DC generator, induction motor (1- ϕ /3- ϕ), alternator (1- ϕ /3- ϕ), synchronous motor, transformer (1- ϕ /3- ϕ), electro-dynamometer, power supply, various measuring instruments etc. Synchronous motor and alternator are the two important machines because many important experiments and research works can be carried out using these two machines. These machines are very expensive since these are being imported from foreign companies.

The work is aimed at designing and manufacturing of a low cost synchronous motor-generator for electrical machine laboratory. All the designed steps are described step by step and are shown in the photographs of various stages. The machine has

been tested for various experiments and it has been observed that the experimental results match the theoretically obtained results very well.

2. BASIC THEORY

The motor that has zero slip, i.e. no load and full load speeds are same, are called synchronous motor. In this motor, stator winding takes the 3-phase AC supply and the rotor winding takes the DC supply to produce magnetic flux. Stator winding also makes a rotating magnetic field which rotates at a speed of $120/P$. But stator's magnetic poles and rotor's magnetic poles are in opposite direction. So these two fields become locked at a particular speed and both the fields rotate at the same speed of $120/P$. This speed is called synchronous speed and that's why this motor is called synchronous motor. Loading capacity depends on the magnetic strength produced by the motor. The magnetic strength can be varied by varying the excitation of rotor winding [1-3].

In case of alternator, rotor is driven by a prime mover and rotor field is excited by DC field. Like synchronous motor, its stator field produces a rotating magnetic field by taking 3-phase AC

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supply. The stator thus induces the electromotive force in the stator terminals. Its amplitude depends on the rate of change of flux that depends on the speed of the prime mover, flux density and number of poles [1-4].

2. DESIGN PROCEDURE

There are two parts in this design. One is the synchronous motor and the other one is the alternator. There are many parts that have to be designed, such as, the rotor, the stator, the yoke or the frame etc. In the following subsections, design procedures of these parts are described.

2.1 Rotor Design

At first, two identical rotors of two squirrel cage induction motors are taken. Then materials inside the rotor of one motor is removed to make a hole inside it, but on the outside surface squirrel winding remains as shown in Fig. 1.

Now the second induction motor is turned in lathe machine to strip off the squirrel winding as shown in Fig. 2.

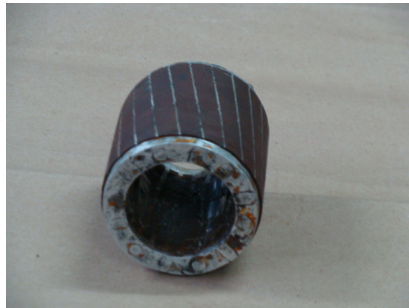


Fig. 1 Rotor with hole having squirrel cage winding



Fig. 2 Rotor turned in Lathe machine to remove squirrel cage winding

Turning process should be completed in such a way that rotor of Fig. 2 can be entered into the hole of the rotor of Fig. 1. After that slots should be made on the rotor of Fig. 2 to wind DC coils on it. DC coils should be placed from the two opposite limbs.

After that rotor of Fig. 2 should be glued into the rotor of Fig. 1 as shown in Figs. 3-4. Finally, vanishing oil should be given on the winding. The rotor will be placed inside the stator.



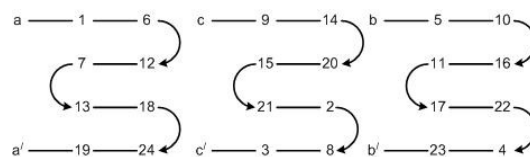
Fig. 3 One rotor is being entered into the another rotor



Fig. 4 Final rotor of the synchronous motor

2.2 Stator Design

There are two types of stator winding connections, such as, lap winding and wave winding [5]. In this machine, we have used lap winding connection, because this type of winding reduces starting current of the machine [6]. It has full pitch and single layer. Total number of slots used here are 24 and the total number of poles used are 4. The coil span for full pitch winding are $24/4=6$. Therefore, the electrical degree completed for per rotation of the stator is $180^\circ \times 4 = 720^\circ$. That is, two full cycles will be completed. The electrical degree for one slot is $720^\circ/24=30^\circ$. The winding connection is shown in the diagram given in Fig. 5.



shape so that the slots in the sheets are obtained at the inner periphery of the stator. All the slots are identical. In these slots, conductors for the stator coils are placed. Around 220 to 240 identical sheets are required to cut for preparing the stator. All the sheets are pressed together and then clipped by 4 metal strips across the periphery.

Fig. 7 shows the stator with the coil inside the 24 slots. The coils are connected as per stator winding diagram shown in Fig. 5. The wires of the coil are taken from copper wires. The designed rotor of Fig. 4 is then inserted into the stator of Fig. 7.

Fig. 8 (a) shows the yoke with front and back flanges. These are made by aluminium in foundry shop. After inserting the stator and rotor inside the yoke, front and back flanges will be connected at the two ends of the yoke by nuts. The yoke with connected flanges at the end is shown in Fig. 8 (b).

Fig. 9 shows the side view of the completed machine. At the back side of the machine, two terminals of the rotor winding are connected with the two slip rings on which the carbon brushes touch the slips rings. Through this carbon brushes, DC supply is given to the rotor winding.

Fig. 10 shows the front view of the completed machine and its input/output terminal panel. Ratings are also written at the front panels.

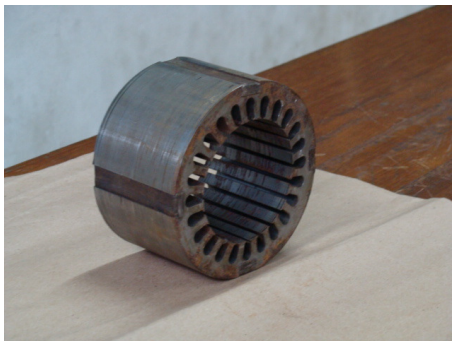


Fig. 6 Stator made by laminated core with 24 slots



Fig. 7 Stator with coils inside the slots



Fig. 8 (a) Yoke with front and back flanges



Fig. 8 (b) Yoke with front and back flanges fitted



Fig. 9 Side view of the completed machine

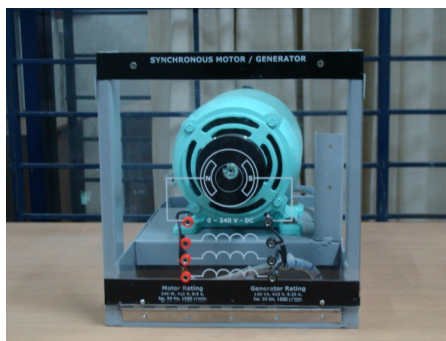


Fig. 10 Front view of the completed machine

The specifications of the designed machine, both the alternator and synchronous motor are shown in Table 1.

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Table 1 Machine specifications

Specifications	Rated Values	
	Motor	Alternator
Rated voltage, V	415	415
Rated current, A	0.75	0.40
Rated power, W	310	-
Rated Volt-Ampere, VA	310	165
Rated speed, rpm	1500	1500
Rated field voltage, V	0~240, DC	0~240, DC
Frequency, Hz	50	50
No of poles, P	4	4
No of conductors per slot, Z	92	92

3. EXPERIMENTAL RESULTS

Numerous experiments have been performed using the designed machine. Two important results are shown here for the brevity of the paper, one is V-curve plot for the synchronous motor and another is open circuit voltage plot for the alternator. All experimental results are taken by using conventional meters. So, there may be some measurement errors, but the results are very much similar to that of theoretically obtained results.

3.1 Synchronous motor's experiment

When the machine run as a synchronous motor, various experiments can be performed, such as, V-curve plot, synchronous condenser, loading curve etc. Here we have shown the V-curve of our designed machine in Fig. 11. In the figure, we see that as the field current is increased from 0 mA, armature current of the motor is decreased becomes minimum after a certain point and again as the field current is increased the armature current is increased and thus the curves look like a V-shape of the English alphabet [1]. This result is very much similar to that of the observed results in the book [1-4]. The magnitude of the armature current reflects the transfer of reactive energy into or out of the machine. If the field is providing just the right amount of flux to produce the torque, the armature current will transmit only real power. At this condition, the armature current is minimized for this particular load and the terminal power factor is unity. For a given level of real power transmission, the position on the V-curve is controlled by the magnitude of the field current. In fact, at very low power levels the synchronous motor can be made to "look" capacitive and can be used as a continually adjustable power factor corrector.

The impedance parameters for the equivalent circuits can be found by testing the machine. The armature resistance is found by placing a DC source across the appropriate armature terminals

and measuring the voltage and current. The resistance is the ratio of voltage to current multiplied by an appropriate correction to account for skin effect (approximately 1.2 at 60 Hz).

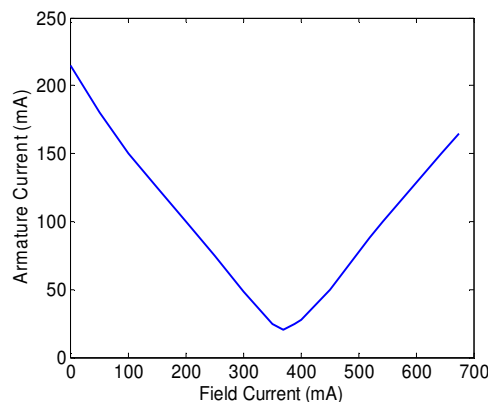


Fig. 11 V-curve of the synchronous motor

3.2 Alternator's experiment

When the machine run as an alternator, various experiments can be performed, such as, finding open circuit characteristics, short circuit characteristics, loading characteristics, determination of voltage regulation etc. Here we have shown the open circuit characteristics of our designed machine in Fig. 12. For plotting the open circuit characteristics, the alternator is run by a prime mover at synchronous speed. The field excitation is varied in steps and the corresponding open circuit voltage is recorded. The data are taken till the open circuit voltage approximately 25 to 30 % higher than the rated value. An open circuit characteristics is finally plotted. In the figure, we see that as the field current is increased from 0 mA, open circuit voltage is increased and after a certain point the open circuit voltage will be fixed due to the saturation of the magnetic flux in the field circuit. This result also supports the theory [2-6].

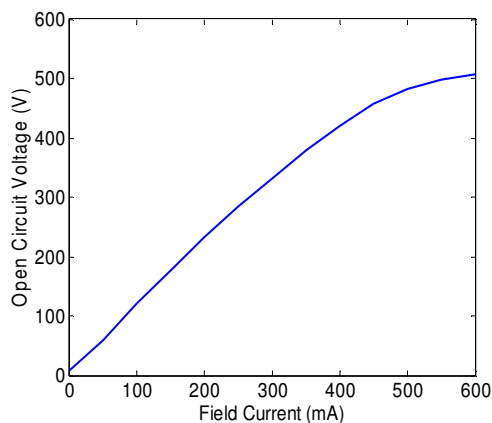


Fig. 12 Open circuit characteristics of the alternator

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5. CONCLUSIONS

In this work, we have developed a very low cost synchronous machine which can be run as both synchronous motor as well as alternator. Using this machine few experiments have been performed and it has been observed that these results support the theoretically observed results. It has also been found that the machine reduces the cost by around 67 % than that of an equivalent machine imported from foreign country. There are future expansion provisions in this machine. Computer interfacing can be incorporated with this machine so that the experimental data can be acquired in the PC through the RS232 interfacing cable and parallel ports of the PC. Besides, we will design the other machines that are required for the electrical machine laboratory by cost reduction.

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DESIGN AND SIMULATION OF A MULTI-LANGUAGE DIGITAL CLOCK BY SWITCHING SYSTEM

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This paper presents design and simulation of a microcontroller based multi-language digital clock. The design part contains one hardware portion (DC power supply, LCD display and a microcontroller) and another software portion (program for operating microcontroller). The conventional digital clocks which are available in market can display only one language. But our designed digital clock is flexible enough to use in different countries as it can display multi-language at a time using switching system. Again our research device is very cheap to implement compare with others. The programming algorithm of multi-language digital clock can be used to display same meaningful sentence in different language by a single microcontroller through graphical display. This type of digital clock can be used where different cultural people gather together. Detail design procedures i.e., block diagram, circuit design, algorithm, flow chart, description of the microcontroller and the simulation outputs are presented in this paper. Design steps are presented in a sequential manner that would be advantageous for the beginners as well as for the advanced readers who are interested to research with microcontroller.

Key words: Graphical display; Microcontroller; DC power supply unit; LCD display.

1. INTRODUCTION

An efficient use of multi-language digital clock and multi-language digital display of any text are many folds; it has a greater advantage than a single display clock, it can be used where different cultural people gather together, cheaper than single language digital clock, nice to display and easy to implements. The display part can be a LCD or graphical display. The operating program for microcontroller is designed by programming language C in AVR platform because of AVR studio is very suitable for ATMEGA type microcontroller. Except one or two, there are not many efforts have been done in this field by researchers. But our topic is different from the other researchers who have done their research on the same area. To show in difference between our findings and others, we would like to explain their researches. One of the researchers K. Benkrid [1] who have designed multi-language framework to FPGA hardware development which aims to satisfy the dual requirement of high level hardware design and efficient hardware implementation. Another researchers Wichit Sirichote designed a normal electronic digital clock by using seven segment

display which is not multi-language [2]. Only Thai language is discussed by wikipedia [3]. Again Hindi language can be learned from the reference no 4. All the mentioned papers explained about electronic seven segment digital clock based on single language, detail description about different language. But so far as we know that there is no paper explains about the microcontroller based multi-language digital clock. So our paper is unique that all the design, simulation and results of our proposed research are presented in this paper.

2. BLOCK DIAGRAM OF THE MULTI LANGUAGE DIGITAL CLOCK SYSTEM

Power supply unit is used to produce constant 5 volts. Microcontroller which is the main part of this proposed research work that process the program and control all hardware operation. Switch is a push pull device which is used to produce a high pulse through the microcontroller input pin. Liquid crystal display (LCD) is used to display the clock. The total system is given below based on block diagram in figure 1.

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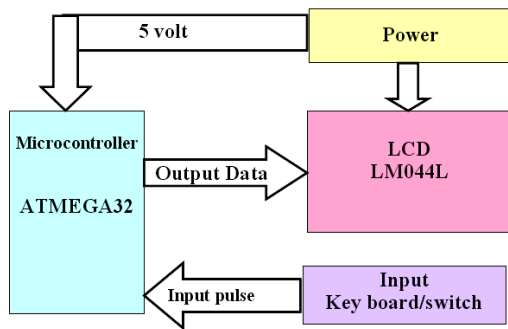


Fig. 1: General block diagram of the multi-language digital clock system

3. CIRCUIT DESIGN OF THE MULTI-LANGUAGE DIGITAL CLOCK

The microcontroller needs a DC supply of +5 volts to the pin no 1 of the microcontroller and it grounded through a resistor for sensing 0 when supply is off. The pin no 14, 15, 16, 18, 19, 20, 21 of the microcontroller are declared as outputs and are connected with the pin no 4, 5, 6, 11, 12, 13, 14 respectively of the LCD. After pressing the switch, a high pulse is gone to the pin no 1 to the microcontroller and after that the microcontroller becomes active. This high pulse is checked by the program and then the program is running in the loop of second, minute, hour step by step. LCD is used here for displaying the time in digital multi-language pattern.

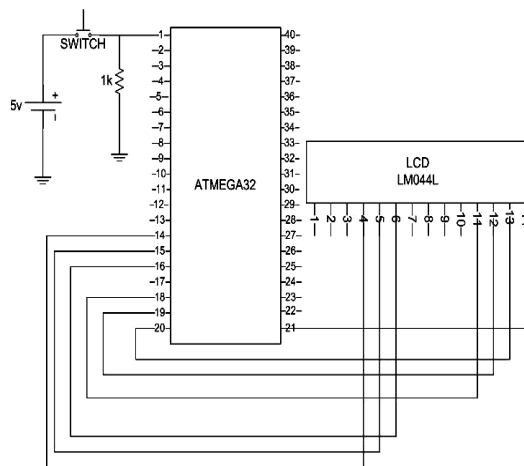


Fig. 2: Detail circuit design of the multi-language digital clock system

The main part microcontroller is a programmable device which contains a microprocessor, memory as same as a single chip computer. As microcontroller is a low cost programmable device, it is used in the automatic control application like

robot, microwave oven, digital watch, mobile phone, electronic display and some conditions where circuit is difficult. The block diagram of the microcontroller is given below in the figure no 3. A liquid crystal display (LCD) is a thin, flat electronic electronic visual display that uses the light modulating properties of liquid crystals (LCs). This is used in a wide range of applications including computer monitor, television, instrument panels, aircraft display and also in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephone. This model has 20 character and four lines. This LCD operate in +5v. and pin configuration of the LCD is given in the figure no 4.

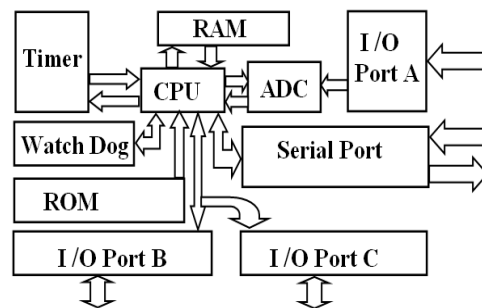


Fig. 3: Block diagram of microcontroller

PIN	Symbol	Function
1	Vss	Ground
2	Vdd	Supply Voltage
3	Vo	Contrast Setting
4	RS	Register Select
5	R/W	Read/Write
6	En	Enable
7-14	DB0-DB7	Data Lines
15	A	Gnd for backlight
16	K	Vcc for backlight

Fig. 4: Pin configuration of LCD

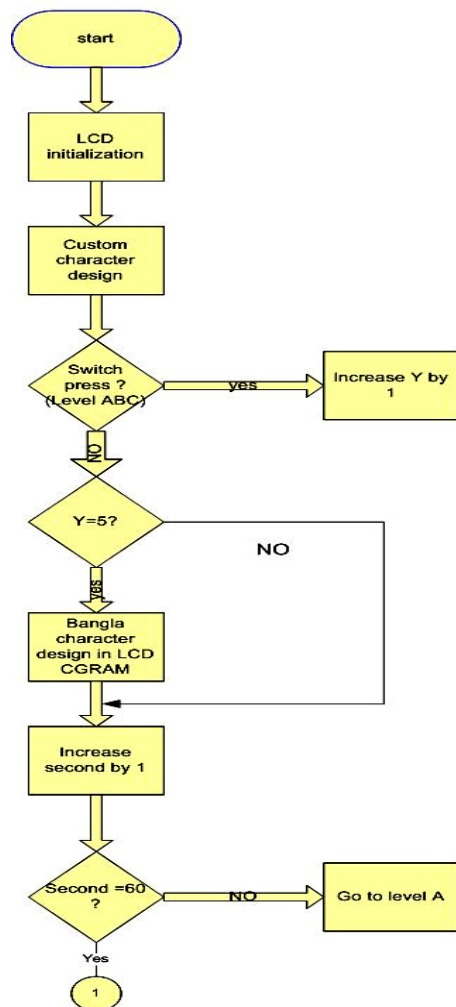
4. SOFTWARE PORTION

4.1 SIMULATION SOFTWARE

Proteus 7.6 is a software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design [5]. It is developed by lab center electronics. The XGamestation micro edition was designed using lab center's proteus schematic entry and PCB layout tools. Also AVR Studio 4 provides a complete set of features including debugger supporting run control including source and instruction-level stepping and breakpoints, registers, memory and I/O views and target configuration and management as well as full programming support for stand alone programmers.

4.2 Flow chart of the microcontroller program

Here 8 pin of microcontroller as output is used which connected with LCD. 1 no pin is used as an input where switch is connected. Here the program is written in programming C language. The program can be divided in some parts. One part of the program is for clock and shows the clock in LCD. And other part is for controlling the language before show the clock in LCD. Under this part the clock data is send to LCD and then declare the function for different language and apply a simple condition of changing language by switching. For every high pulse from switch the language is changed. When we connect the power in project then a high pulse goes to the micro controller program under the microcontroller for matching this pulse with the statement of program. The LCD displays Bangla language first, then English, Hindi and Thai.



4.3 Algorithm of the microcontroller operating program

- Step 1: Initialize the LCD
- Step 2: Custom character design
- Step 3: Switch press check
- Step 4: increase second from 0 to 59
- Step 5: Increase minute 0 to 59
- Step 6: Increase hour from 1 to 12
- Step 7: Convert each number in ASCII code
- Step 8: Show clock in bangla for switch =1
- Step 9: Show clock in English for switch =2
- Step 10: Show clock in Hindi for switch =3
- Step 11: Show clock in Thai for switch = 4
- Step 12: Go to step 3

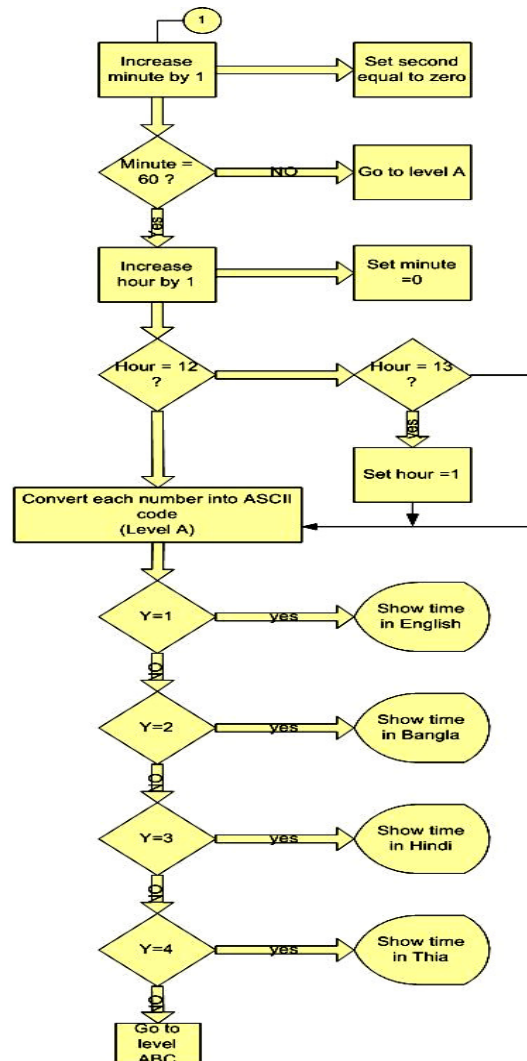


Fig. 5: Flow chart of the microcontroller operating program

4.4 Design of the numeric value for different language

Microcontroller first initializes the LCD. Then declare the custom character. For design custom character we use custom code under the function. For generating the custom code, bascom-AVR software is used. In bascom-AVR software has a tool which can be applied for LCD design. First the custom character is designed by LCD designer. An example of one in Bangla is designed and given in figure no 6. Also figure no 7 shows the coding technique of design one in Bangla.

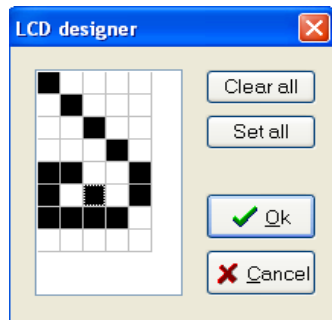


Fig 6: Design procedure of one in Bangla language by the bascom-AVR software

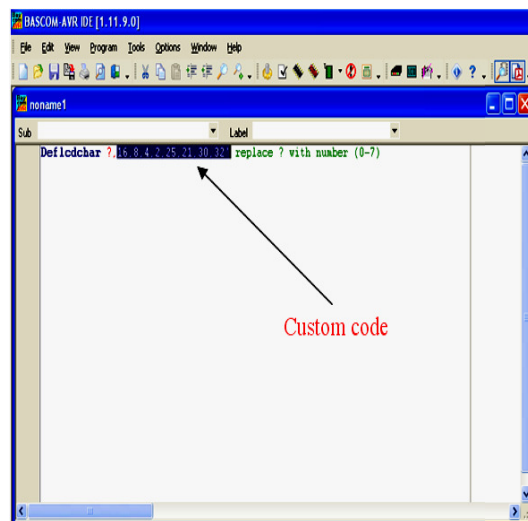


Fig 7: Design procedure of one in Bangla language by the bascom-AVR software

This custom code displaying one in bangla is given below.

```
const uint8_t bn_one[8] PROGMEM=
{
  28, 2, 1, 1, 13, 18, 12, 32
};
```

Microcontroller sends this code in LCD RAM to show one in bangla in LCD. In this way different language such as Bangla, English, Hindi and Thai can be designed. After design the custom character, the program is applied to a loop and wait for the pulse from switch. After completing language designing program converts the all above number in ASCII code.

5. SIMULATION CIRCUIT, WAVE SHAPES AND RESULTS

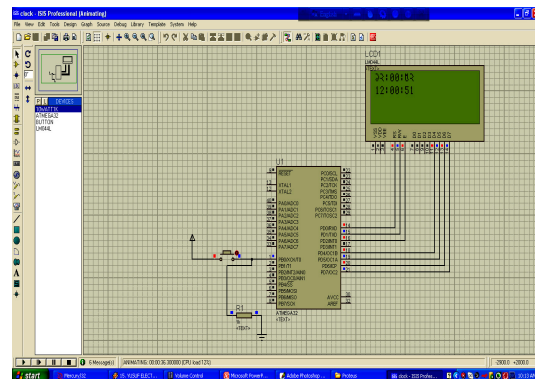
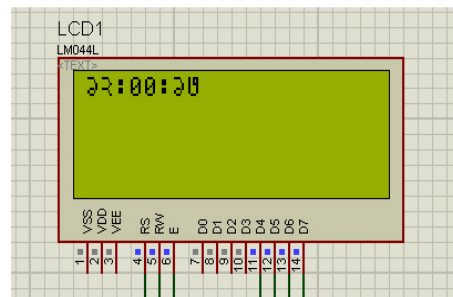
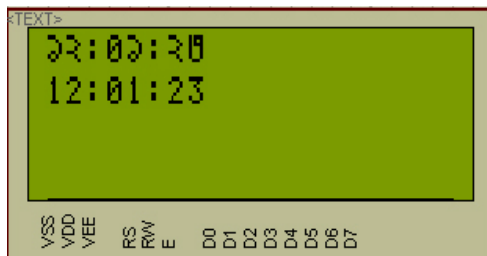


Fig. 8: Simulation circuit of multi-language digital clock

In simulation circuit a microcontroller Atmega 32 and a LCD is used. Also outputs of different languages are shown in figure 9. (a) no is the output result of the clock in Bangla language. The language is displayed at the left-top corner of LCD. (b) no represents the bangle and English both language in LCD display. When input pulse of switch y=2 then the LCD show the bangle and English language. (c) shows the Hindi language clock time in LCD display. When switch y=3 then LCD display is activated for this language. (d) is next snap shoot figure of the LCD where it display the Thai language. When switch pressed in 4th time then the LCD displays the Thai language.



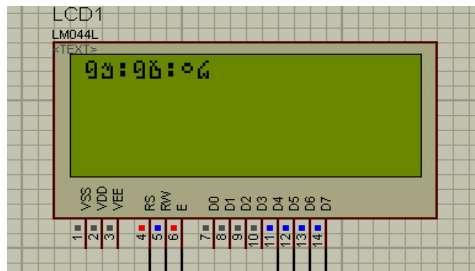
(a) Bangla language



(b) Bangla and English language



(c) Hindi language



(d) Thai language

Fig 9: Simulation results of multi-language digital clock

6. CONCLUSIONS

Our proposed designed microcontroller based multi-language digital clock is unique, cheaper and effective compare with others'. ATmega32 type microcontroller is used which is available and easy to burn. The circuit is also very simple. The most advantage of our designed circuit can display multi-language time in LCD display by switching system step by step. That is why it can be used in that place where different cultural people gather together.

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DESIGN AND SIMULATION OF AUTOMATIC LOAD CONTROL WITH HUMAN COUNTING SYSTEM OF A SPACE

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This paper presents design, simulation and implementation of a microcontroller based automatic load control (for summer-fan and light, for winter only light) with human counting system of a space. The design part contains one hardware portion (AC to DC converter, IR transmitter and receiver sensor, LCD display and a microcontroller) and another software portion (program for operating microcontroller). Normally loads are switched on and switched off manually by human of a room. The proposed design circuit can control loads automatically according to the human entry and exit from a room and count the number of people who are present in that place. This is a new research circuit to build digital Bangladesh and to save the power as a person has a nature that he forgets to OFF the load when he exits from a room. Again our research device is very cheap to implement and has many advantages for human life. Detail design procedures i.e., block diagram, circuit design, algorithm, flow chart, description of the microcontroller program and outputs of the simulation and practical circuits are presented in this paper. Design steps are presented in a sequential manner that would be advantageous for the beginners as well as for the advanced readers who are interested to work with microcontroller.

Key words: Microcontroller; AC to DC converter; IR transmitter; IR receiver sensor and LCD display.

1. INTRODUCTION

An efficient use of room load control with counting system is very useful and demandable. Most of the time human are forgotten to off the load when he goes outside. It can also count the total people. Many efforts have been done in the field of power system, control of load and its parameters by a number of researchers. Our topic is different from the other researchers who have done their research on the same type controlling area. To show in difference between our findings and others, we would like to explain their researches. In 2009, D. Craciun et al proposed a new concept of residential consumers' soft load shedding (SLS) [1]. It has taken only a fraction of the consumers' power, even if the effort was spread over a larger number. Another author P. A. Gnadt explained the electric power distribution system [2]. In 2008 Essam E. Khalil designed residential variable load like residential air conditioning equipment control system with varying of line voltage and frequency. In 2008, F. Wernstedt and C. Johansson proposed a system about a field test where a distributed load control system uses load shedding to even out the

daily fluctuations found in the energy demand within a district heating system. All the mentioned papers explained about the power system, room load control on the base on frequency and voltage. But so far as we know that there is no paper explains about room load control system with human entry and exit. So our paper is unique that is microcontroller based automatic load control with human counting system of a space. Again our proposed design implemented circuit of automatic load control system is cheaper, efficient and easy to implement.

2. BLOCK DIAGRAM OF THE SYSTEM

The microcontroller based automatic load control circuit works on the principle of when a person enters into a room, it automatically senses and counts the number of entries of the room or space and switch on the loads (for summer-fan and light, for winter only light) and also calculate when the people exit from that room or space and switch off the loads if there is no people in that place. Winter and summer season is considered on the basis of

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graph TD
    IR[IR SENSOR] --> MC[MICRO CONTROLLER]
    MC <--> LCD[LCD DISPLAY]
    MC --> Summer[RELAY FOR SUMMER LOAD<br/>(FAN AND LIGHT)]
    MC --> Winter[RELAY FOR WINTER LOAD<br/>(LIGHT ONLY)]
  
```

3. CIRCUIT DIAGRAM OF THE TOTAL SYSTEM

receiver arrangement are used. IR LEDs emit or demodulate energy in the infrared radio spectrum. This arrangement is done for determining either entries or exits of people from the room. If first sensor detects the object first and then second sensor detects, in this case it operates on entry mode. On the other side if the second sensor detects the object first and then first sensor detects the object, in this case it operates on exit mode. A microcontroller (ATmega8) is burned with a program to operate the whole system. A burner circuit is given in the figure no 3. It has 40 pins. Pin 14 and 15 are used for connecting IR sensors as input operation. Pin 7 and pin 1 is connected with a 1K resistance through the Vcc. Pin 8 is grounded and a resistance 1K is connected between pin 8 & pin 11. A Vcc voltage is supplied to the pin 7 and 11 through a switch. Pin 23 to 26 are used as data outputs of the display device where pin 17 is used to enable the display and 28 set or reset the data. Here LED- and LED+ of the display device show the output flashing green light. Here Vss, Vo, R/W, LED- are grounded and Vdd and LED+ are supplied by Vcc voltage.

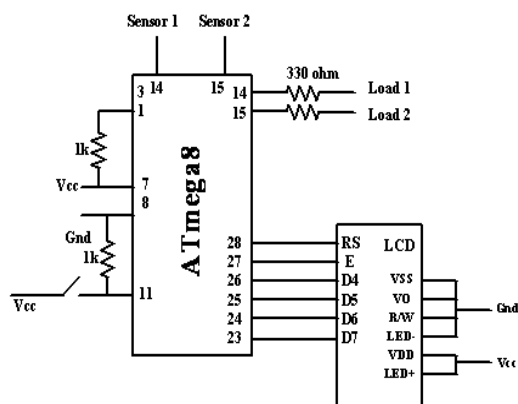
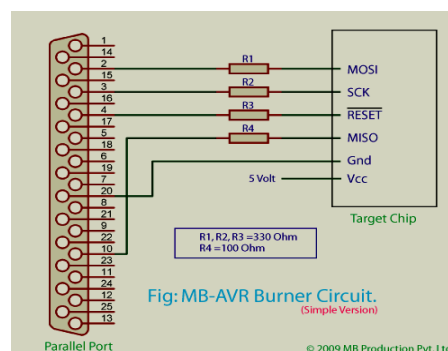


Fig. 2: Schematic circuit design of the automatic load control with human counting system of a space



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4. SOFTWARE PORTION

It contains microcontroller, simulation software, programming flow chart, algorithm of the program.

4.1 Microcontroller

The main part microcontroller is a programmable device which contains a microprocessor, memory as same as a single chip computer. As microcontroller is a low cost programmable device, it is used in the automatic control application like robot, microwave oven, digital watch, mobile phone, electronic display and some conditions where circuit is difficult. The block diagram of the microcontroller is given below in the figure no 4. A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). This is used in a wide range of applications including computer monitor, television, instrument panels, aircraft display and also in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephone. This model has 20 character and four lines. This LCD operate in +5v. and pin configuration of the LCD is given in the figure no 5.

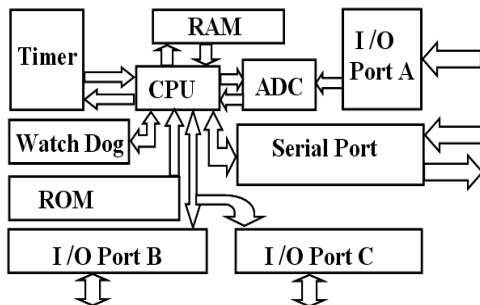


Fig. 4: Block diagram of microcontroller

PIN	Symbol	Function
1	Vss	Ground
2	Vdd	Supply Voltage
3	Vo	Contrast Setting
4	RS	Register Select
5	R/W	Read/Write
6	En	Enable
7-14	DB0-DB7	Data Lines
15	A	Grid for backlight
16	K	Vcc for backlight

Fig. 5: Pin configuration of LCD

4.2 Simulation software

Proteus 7.6 is a software for microprocessor simulation, schematic capture and printed circuit board (PCB) design [5]. It is developed by lab

center electronics. The XGamestation micro edition was designed using lab center's proteus schematic entry and PCB layout tools. Also AVR Studio 4 provides a complete set of features including debugger supporting run control including source and instruction-level stepping and breakpoints, registers, memory and I/O views and target configuration and management as well as full programming support for stand alone programmers.

4.3 Algorithm of the program

Step 1: Start.
 Step 2: Read sensor data.
 Step 3: Display data to LCD.
 Step 4: Check entry or exit.
 Step 5: If Entry occurs increment the count.
 Step 6: If Exit occurs decrement the count.
 Step 7: If Count greater than 0 turn ON the loads and go to step 2.
 Step 8: If Count equal to zero then turn OFF the loads and go to step 2.
 Step 9: Stop.

4.4 Programming flow chart

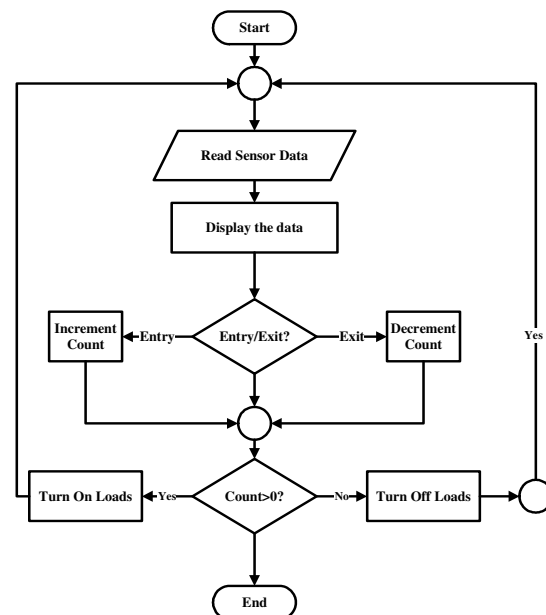
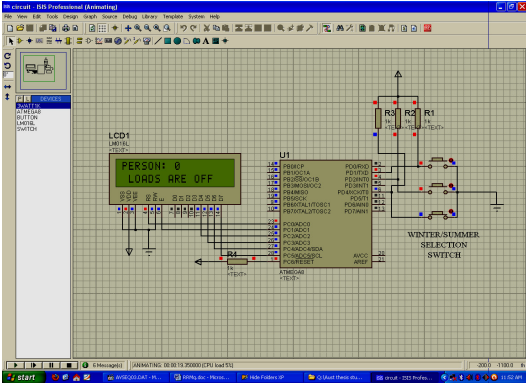


Fig. 6: Flow chart of the microcontroller operating program

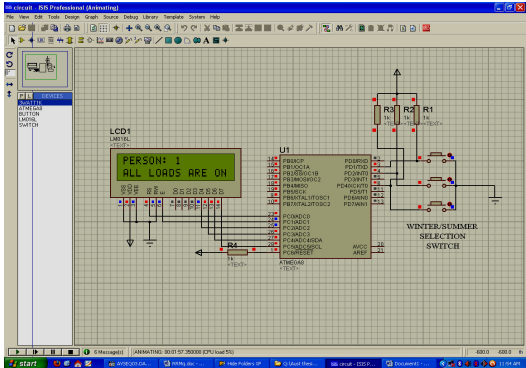
5. SIMULATION RESULTS AND CIRCUIT

In the simulation circuits of figure 7 one microcontroller, one LCD and some sensors are used. In this section we have showed some simulated results of this system using computer simulation software. In the (a) simulation snap shot

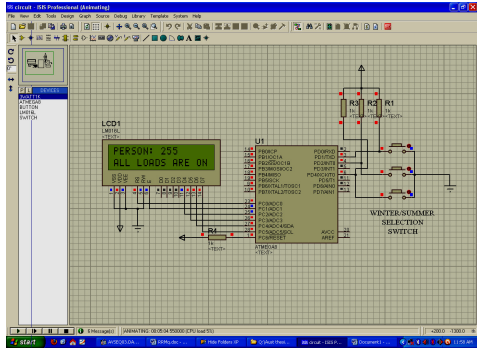
where switch is either summer or winter mode and the counting result is zero. The LCD display shows that all loads are off indicating winter or summer and that is why the counting result is zero. In the (b) simulation where one entry occurs then the previous result is incremented by one and the LCD display shows all loads (fan and light) are on means summer season. In the incrementing technique, the snap shot (c) shows that the counting result is 255 means the total number of people in that space or room is 255 which can be calculated by the sensor signal and microcontroller and all loads are on in that situation. In the (d) simulation result shows 254 no of people are present in that place when one exits then the number of person is decremented by one from the previous result and shows the number of person is 254 at the mode of summer season. In this way for each number of exiting person, it automatically decrement the result from the previous one and shows result on the LCD display. In the (e) simulation where one entry occurs then the previous result is incremented by one and the LCD display shows winter load only light is on means winter season. In the incrementing technique, the snap shot (f) shows that the counting result is 255 means the total number of people in that space or room is 255 which can be calculated by the sensor signal and microcontroller and only winter load (light) is on in that situation.



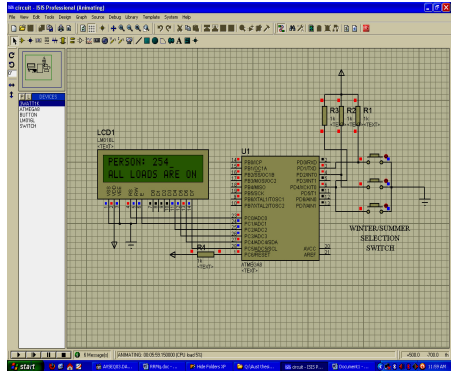
(a)



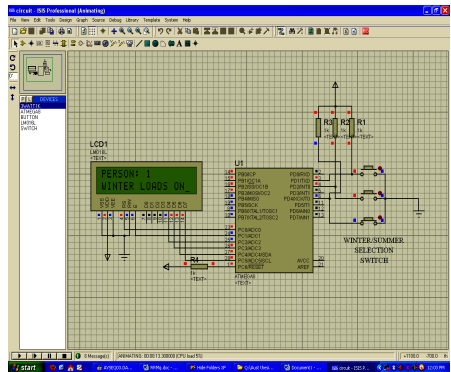
(b)



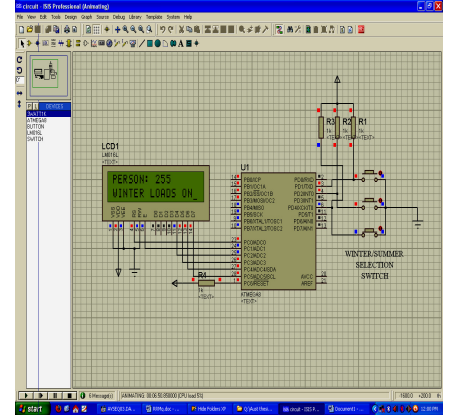
(c)



(d)



(e)



(f)

Fig. 7: Snap shot of the results of simulated circuit

6. CONCLUSIONS

Our proposed designed circuit is a new research circuit to build digital Bangladesh and to save the power as a person has a nature that he forgets to OFF the load when he exits from a room. Again our research device is very cheap to implement and has many advantages for human life. So it is unique and very essential for human life.

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DESIGN OF AlAs/GaAs/Ge LATTICE MATCHED MULTI-JUNCTION SOLAR CELLS

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Abstract - This paper reports the theoretical design and performance analysis of AlAs/GaAs/Ge based triple junction solar cell. We have calculated the efficiency of the lattice matched solar cells, considering the effect of reflection coefficient. The efficiency of the proposed lattice matched triple junction solar cell is also compared with the lattice mismatched triple junction solar cells. The current matching is done by varying the thickness. The increase in surface recombination velocity and emitter thickness decreases the efficiency. However, the increase in minority carrier life time in emitter and base, doping density increase the efficiency. In order to get more accurate results, the effect of depletion width was taken into account. However, no significant change is observed between the results –without and with considering the depletion width. The efficiency of the proposed solar cell has been found approximately 43.5%. The effect of reflection coefficient also has been considered. The efficiency is found to be varied from 23 % to 37% with considering reflection loss. This simulated model shows that the proposed model can largely increase the efficiency with increasing the number of junctions.

Key words: multijunction; AlAs/GaAs/Ge; lattice matched; minority carrier lifetime; depletion width.

1. INTRODUCTION

Photovoltaic solar cell is becoming widespread and very important as a clean and gentle energy source for the earth. However, still the efficiency of conventional and commercially available solar cells is very low. To be competitive with the conventional energy source the efficiency of photovoltaic cell must be improved. Searches for new photovoltaic cells with higher efficiency are being conducted all over the world from the beginning of this decade. Attempts have been made to fabricate photovoltaic cells with materials other than silicon and with no lattice mismatch. The same time modifications in design are being carried out to reduce the reflected component of solar energy due to lattice mismatch.

Because of the limitations in the ability of a one-junction solar cell to utilize efficiently the photons of the broad solar spectrum, multifunction solar cells have been the focus of much theoretical and experimental work in the past few decades. Multi junction solar cell is being widely studied over the world as the promising approaches to increase the efficiency. It has been shown that, theoretically the

efficiency of MJ solar cells increases as it incorporates more & more junctions (Henry, 1980). However, practically there is a very little range of material that could be used to make these cells. A major challenge in achieving widespread use of solar cells lies in the identification of suitable materials with appropriate lattice and band gap matching. To improve the efficiency of multi junction solar cells, some challenges have been faced. These are lattice mismatch, band gap mismatch, recombination before drift, reflection at top surface (Kasap, 2005), top surface contact obstruction etc. Due to lattice mismatch, generated carrier will be recombined in the defect of the lattice. After considering the effect of lattice mismatch the efficiency of the proposed solar cell has been found approximately 43.5% & the approach targeting 50% efficiency is proceeding using the invert lattice mismatch quantum well solar cells (Takamoto, 2009). In this paper we have also find out the effect of anti reflection on MJ solar efficiency.

2. MODELING OF MJ SOLAR CELL

Solar cell design is the most important requirement to improve the efficiency of MJ solar cell.

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Currently used MJ solar cells are based on two or three layers of different material which are usually III-V semiconductors (Yamaguchi, 2003). But lattice constant of different junctions are not same. Due to lattice mismatch the efficiency decreases. So AlAs/GaAs/Ge based solar cell has been proposed for higher efficiency. For designing this solar cell, the materials are used in buffer layer, tunnel junction that have nearly same lattice constant and this help to improve the efficiency (Geisz et. al., 2005). These layer acts as antireflection coating which reduces the reflection of incident light. The figure 1. shows the schematic illustration of the proposed AlAs/GaAs/Ge MJ solar cell. The sub cells are arranged from bottom to top with lower to higher the band gap. Tunnel junctions are placed between the layers of a MJ to avoid the formation of junction as well as potential barrier between the layers. However dislocations at the interference of the GaAs and Ge are limiting the cell efficiency. This propagation often causes Shockly-Read-Hall recombination in the active cell regions.

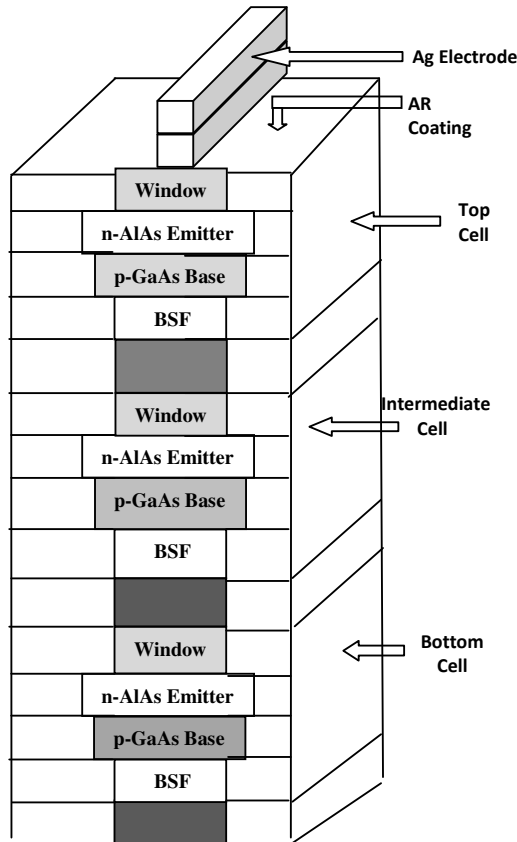


Fig. 1: Schematic illustration of the proposed lattice matched solar cells.

To reduce the number of dislocations and cease their propagation through the upper layers of the

junction cell, step graded buffer layers of InGaAs is used. Thus the lattice constant remains same due to small composition of In.

3. PERFORMANCE OF AlAs/GaAs/Ge-LATTICE MATCHED MJ SOLAR CELLS

However performance of solar cells depends on the choice of material used, the direction of light energy incident into the pn junction, the number of junctions between the cells, the matching of the lattice of the used compound alloys and so on.

The amount of light energy absorbed by the pn junction of solar cell is one of the important issues in performance evaluation. The less the reflection of incident light, the more efficient the solar cell is.



Fig. 2: Efficiency variation of solar cell with respect to reflection coefficient.

Figure 2. shows the graphical representation of reflectance or reflection coefficient and efficiency of lattice matched AlAs/GaAs/Ge-based multi junction solar cells. When the percentage of reflectance is increased then the efficiency of the solar cells is decreased.

The current densities for electrons and holes are:

$$J_n = q\mu_n n_p \xi + qD_n \frac{dn_p}{dx'}$$

And

$$J_p = q\mu_p p_n \xi - qD_p \frac{dp_n}{dx'}$$

In the case of an n on p junction with an n-type emitter and p-type base the expression for the top side of the junction is given by

$$D_p \frac{d^2 p_n}{dx'^2} + \alpha F(1 - R)e^{(-\alpha x')} - \frac{p_n - p_{no}}{\tau_p} = 0$$

Solving this equation the photocurrent is obtained a

$$J_p = \left[\frac{qF(1-R)\alpha L_p}{(\alpha^2 L_p^2 - 1)} \left(\frac{S_p L_p}{D_p} + \alpha L_p \right) - e^{-\alpha x_j} \left(\frac{S_p L_p}{D_p} \cosh\left(\frac{x_j}{L_p}\right) + \sinh\left(\frac{x_j}{L_p}\right) - \frac{S_p L_p}{D_p} \sinh\left(\frac{x_j}{L_p}\right) + \cosh\left(\frac{x_j}{L_p}\right) - \alpha L_p e^{-\alpha x_j} \right] \right]$$

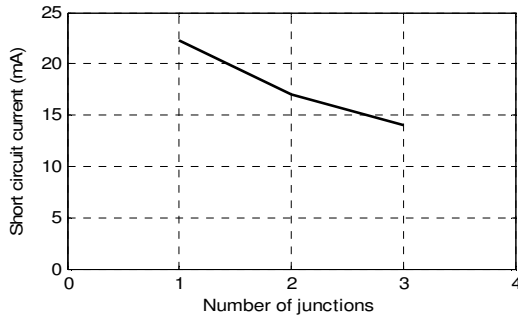


Fig. 3: Variation of short circuit current with number of junctions.

Open circuit voltage

$$V_{oc} = \frac{kT}{q} \times \ln\left(\frac{J_{ph}}{J_0} + 1\right)$$

Where,

$$J_0 = qn_i^2 \left(\frac{D_{nj}}{L_{nj}N_A} + \frac{D_{pj}}{L_{pj}N_D} \right), j = 1, 2, 3 \dots n$$

Short circuit current decreases as the number of junctions increases. Simulation result shows that with the increase of number of junctions from single to triple short circuit current decreases about 35%. This result is shown in figure 3. Figure 4 shows the variation of open circuit voltage with the number of junctions. Open circuit voltage increases with increasing the number of junctions. For choosing of a new junction material, care has been taken about lattice constant so that lattice mismatch does not create in designing of MJ solar cells.

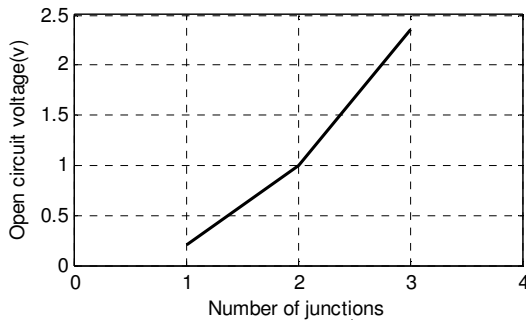


Fig. 4: Variation of open circuit voltage with number of junctions.

As the number of junctions i.e. the number of cells increases short circuit current decreases and open circuit voltage increases which consequently causes the increase of solar cell efficiency. Figure 5 shows the efficiency vs. number of junctions relationship. Simulation result shows that efficiency increases about 30% as the junction number increases from single to triple.

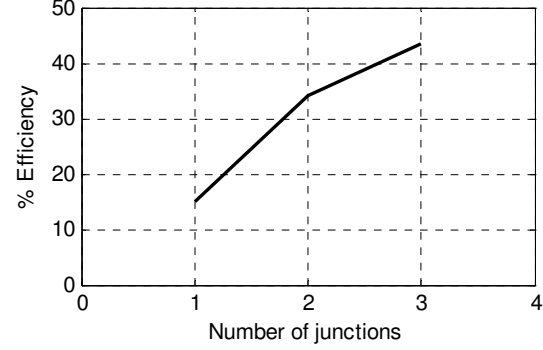


Fig. 5: Efficiency variation of solar cell with respect to number of Junction.

Surface recombination velocity influence on the short circuit current. Higher the recombination velocity, lower the short circuit current. Lattice matched solar cell causes minimum short circuit current which increases the efficiency of the solar cells.

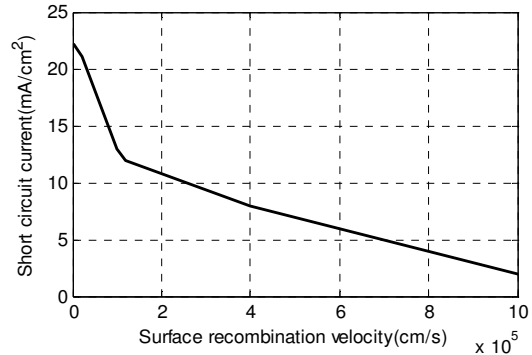


Fig. 6: Effect of surface recombination velocity on short circuit current.

Table 1: The Detail Simulation Results of Lattice Matched MJ Solar Cells.

Parameters	Ge	GaAs	AlAs
N_A	10^{16} cm^{-3}	10^{16} cm^{-3}	10^{16} cm^{-3}
N_D	10^{18} cm^{-3}	10^{18} cm^{-3}	10^{18} cm^{-3}
n_i	$2.33 \times 10^{13} \text{ cm}^{-3}$	$1.84 \times 10^6 \text{ cm}^{-3}$	57.16 cm^{-3}
N_C	$1.04 \times 10^{19} \text{ cm}^{-3}$	$6.0 \times 10^{18} \text{ cm}^{-3}$	$1.2 \times 10^{19} \text{ cm}^{-3}$
N_V	$4.45 \times 10^{19} \text{ cm}^{-3}$	$7.72 \times 10^{18} \text{ cm}^{-3}$	$4.62 \times 10^{19} \text{ cm}^{-3}$
J_o	$7.2 \times 10^{-3} \text{ A}$	$1.1 \times 10^{-14} \text{ A}$	$8.9 \times 10^{-25} \text{ A}$
V_{oc}	0.20V	0.7928V	1.33V
V_T	2.3228 V		

Table 2: Comparison table between lattice matched and mismatched triple junction solar cells.

Open circuit voltage V_{oc} (V)		Short circuit current J_{sc} (mA/cm ²)		Efficiency (η)	
Lattice matched	Lattice mismatched (InGaN)	Lattice matched	Lattice mismatched (InGaN)	Lattice matched	Lattice mismatched (InGaN)
2.3228	2.683	22	15.94	43%	37.73%

4. CONCLUSION

The theoretical design and performance of lattice matched AlAs/GaAs/Ge-based multi junction solar cells have been studied. The design and performance evaluation are made by developing a

simulation model which optimizes the design of lattice matched AlAs/GaAs/Ge MJ solar cells for high efficiency. The performance evaluation and theoretical analysis of efficiency and performance of the proposed model shows the efficiency approximately 44%. The lattice mismatch is made to about nil. This causes the surface recombination velocity higher and short circuit current less. The current of each junction are made equal by adjusting the thickness of the emitter. Some major challenges in fabrication such as tunnel junction, buffer layer, and anti reflection coating are solved. All these results show that the proposed AlAs/GaAs/Ge- based multi junction solar cell is an excellent candidate for future high efficient MJ solar cells.

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DESIGN OF VLSI PAD FRAME TOWARDS A LOW POWER I/O ARCHITECTURE WITH AN EFFICIENT FLOORPLANNING

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In today's VLSI field the exponentially increasing factor of integration takes the techniques of chip designing to be more cared about both switch level (eg. device, logic gate design, etc.) and chip level (eg. pad design, floorplanning, routing, etc.) as size of chip is continually decreasing and power consumption challenge is getting tougher. To design a complete & successful functional chip, pad frame design and floorplanning are also challenging. This study is an attempt to present a VLSI design of pad frame with less power consuming I/O architecture with an efficient way of floorplanning which includes block placement, global routing, detail routing. MAGIC is used as layout designing CAD tool to design the pad frame as it is the easiest and worldwide CAD tool for VLSI layout design, and for simulation purpose PSpice is used. This study presents details of the key research work, results, techniques and efficient way of pad frame design as well as floorplanning.

Key words: Pad; Pad-frame; Leaf-cell; Floorplanning; Global routing; Detailed routing.

1. INTRODUCTION

Number of transistors fabricated on a chip doesn't follow the Moore's law any longer since about 5 years. It is increasing exponentially and violating the law every day. With the rapid development of VLSI fabrication technologies, we have reached an era where the minimum feature sizes of the leading processes are well below 1 μ m. Such processes are called Deep Sub-Micron (DSM) processes [1]. More specifically we are in the pre-nanotech era where already the IBM fabrication processes available through MOSIS range from 45nm to 0.25 μ m in CMOS [2]. For educational experiment purpose 0.5 μ m and 0.6 μ m processes are very common today, and the process keeps changing. This changing scenario of the VLSI fabrication process and technologies takes more thought about pad design and floorplanning because both of them are process-specific, mostly pad design.

VLSI chip is a rectangular area with I/O pads arranged along the perimeter of the chip in which cells are laid out surrounded by routing channels. Cells (modules or blocks) are logic models of a rectilinear shape with a predefined internal layout.

Nets are physical wires that provide interconnections between cells [4].

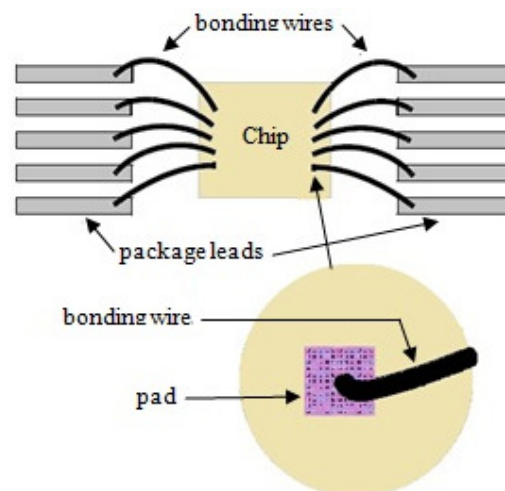


Fig 1: A precise view of pad and its position [10].

Nets are laid out on a reserved chip space known as a routing channel [4]. In simple, pads are the intermediate junction distributed around the edge of the chip to keep connection between the chip core and the outside world through the package leads.

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Pad design is a chip level design which is connected to the package leads by bonding wires.

Floorplanning is also a chip level design in which leaf cells are used as building blocks and wiring (routing) is done to connect the blocks to the pads [5] such that the congestion of bonding wires, parasitic effects between wires, and area consumption are reduced to possibly minimum.

The paper is organized as follows. Section 2 represents the design of leaf cells, section 3 describes the detail of pad frame designing, section 4 describes the block placement and routing with the designed leaf cells and pad frame for floorplanning purpose. Section 5 describes the results of the study, and section 6 concludes the paper.

2. LEAF CELL DESIGN

Leaf cells or leaf layouts are gate-level cells that are logic models containing up to a hundred transistors [3] used as blocks during floorplanning. In this study this is not the concern as the paper is focused on pad frame and floorplanning. So for the sake of simplicity a NAND, NOR, and inverter buffer are used as predesigned leaf cells for example. In our previous paper [6], the requirements and way of designing leaf cell is described. Figure 2 represents the layouts of predesigned cells.

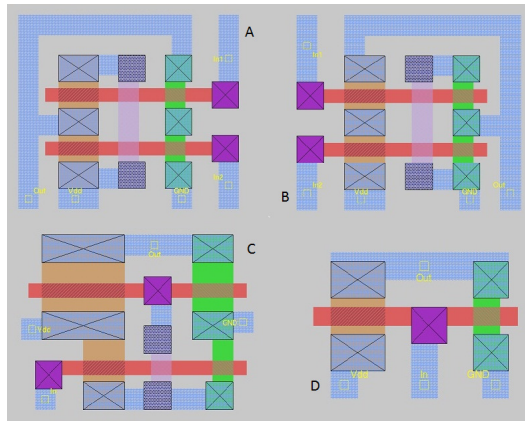


Fig 2: Optimized layout of a NAND gate (A), NOR gate (B), Inverter buffer (C), and a single Inverter (D) in sense of area consumption, hence power, with $W/L=3\lambda/2\lambda$ for nMOS and $W/L=6\lambda/2\lambda$ for pMOS. In the buffer stage W/L of 2nd stage inverter is double than 1st stage inverter.

3. PAD FRAME DESIGN

A chip is not very useful if it cannot be connected to the outside world. Pads do this connection job through the package leads. But unfortunately there are no true rules by MOSIS for generic pad design

except the minimum size of a pad is $90\mu\text{m} \times 90\mu\text{m}$ [2]. A pad is a large piece of metal to which the external wire is soldered and typically uses all layers of metal [7]. In this study purpose, 3 metal layers pad is designed with minimum area of $90\mu\text{m} \times 90\mu\text{m}$ and efficient contact placement which is reliable against bonding failure [8-9]. The pattern of vias over the pad is rectangular. It can be changed depending on the flexibility, choice of designer, or electromechanical optimization issues. The required commands and design methodology of the layout (pad in this case) are studied and described in our 1st paper [6]. Figures 3, 4, 5, and 6 below represent steps of the pad design.

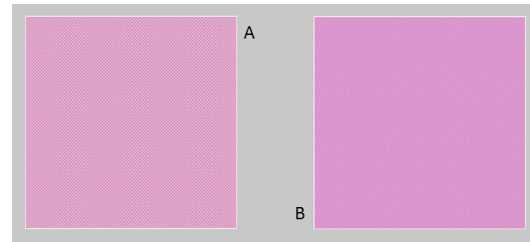


Fig 3: metal3 with minimum area of $90\mu\text{m} \times 90\mu\text{m}$ (A), metal2 over metal 3 with the same area (B).

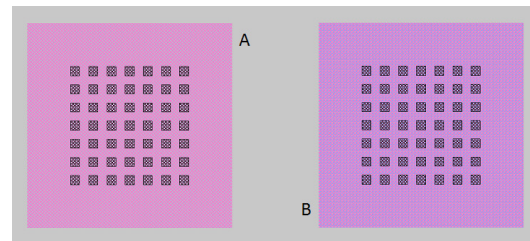


Fig 4: via2 between metal2 and metal3 (A), metal1 over figure A.

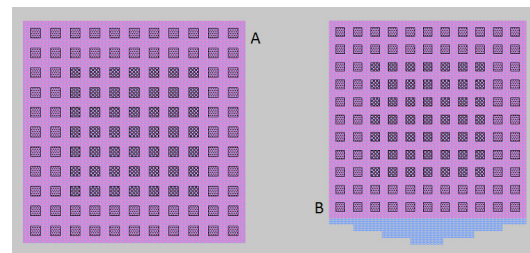


Fig 5: via1 between metal1 and metal2 at the perimeter of the pad to avoid bonding failure by expansion of metal1 due to high heat produced during welding (A), metal1 soldered to the pad for on-chip wire connection (B).

Pad placement is used as the seed for the cell placement [11]. Placing I/O pads around a VLSI chip boundary is a problem such that it leads to a reduction in the cost of cells placement. Pad

placement is typically done as the last stage in a VLSI layout design. However, some cell placement packages are sensitive to the pad placement and require such placement to be done first [12]. Normally the total chip layout in the die is covered with glass to protect it from further oxidization after fabrication. Since pads need to be connected to the package leads by bonding wire (generally gold or silver wire), some area over the pads must be kept away from glass covering for welding the bonding wires, which is called glass opening. In this study 60µmX60µm area is kept for glass opening. The predesigned leaf cells need total of 16 pins considering 3 pads for Vdd and 3 for GND. For a 16-pin package that is available in MOSIS the pad frame is arranged with 16 pads having 4 pads in each side of it and keeping 10µm distances from each other.

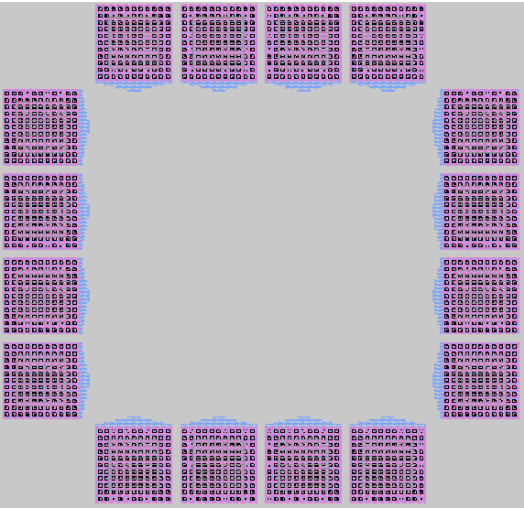


Fig 6: 16-pin pad frame with the designed three metal layer pads.

4. FLOORPLANNING

When designing a leaf cell, transistors, vias, and metals are used as the basic components. But floorplanning uses the designed leaf cells as the building blocks. Floorplanning is chip level design. It is divided into three phases: block placement, global routing and detailed routing. Global routing assigns wires to routing channels between the blocks; detail routing designs the layouts for the wiring [5]. Proper placement of logic blocks can reduce routing congestion between the I/O pads and logic blocks, connected to those and thereby helps to achieve good quality routing. Besides the logic block placement, exact positioning of the input-output pads, also known as pad frame generation, is quite significant to ensure quality placement [13]. In this study 1st of all 4 blocks of predesigned

modules are placed on assigned area for those. Then pins are assigned to each block. Block placement is given in figure 7 below that shows rational aspect ratio of designed device layouts and positions of their pins.

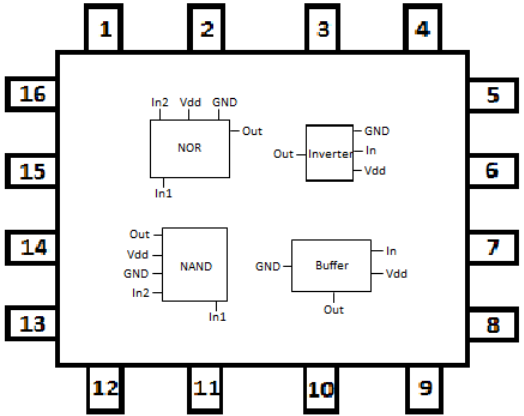


Fig 7: Block placement of 4 leaf cells.

The predesigned 4 leaf-cells have 18 terminals in total, including input, output, supply and ground. In the designed pad frame of 16 pads surrounding the chip core, 10 pads are assigned for inputs and outputs, 3 for power and 3 for ground. The pin configuration detail is given in table 1.

Table 1: Pin configuration.

Modules	Pin name	Pin#
NOR Gate	In1	15
	In2	1
	Out	2
NAND Gate	In1	11
	In2	12
	Out	14
Inverter	In	6
	Out	5
Inverter Buffer	In	7
	Out	8
GND and Vdd for all modules		Pin#
GND		9, 10, 13
Vdd		3, 4, 16

Conventionally and according to the MOSIS specification the pad is very larger than any single wire connected to it. So the current in each direction is limited by the outgoing wire, and to limit inductive voltage drop, several Vdd and Gnd can be used [5].

In floorplanning, routing is come after block placement. Routing can be done by manually using hand, or using interactive tools. In this study block

placement and routing is done by hand first, and then MAGIC “box” tool is used to complete the design. For global routing the Vdd ring and Gnd ring are drawn with 9λ , and in detailed routing, connections are given by metal of 3λ of width to balance the supply in each direction. The figure 8 below shows the complete pad layout with modules after floorplanning and block placement.

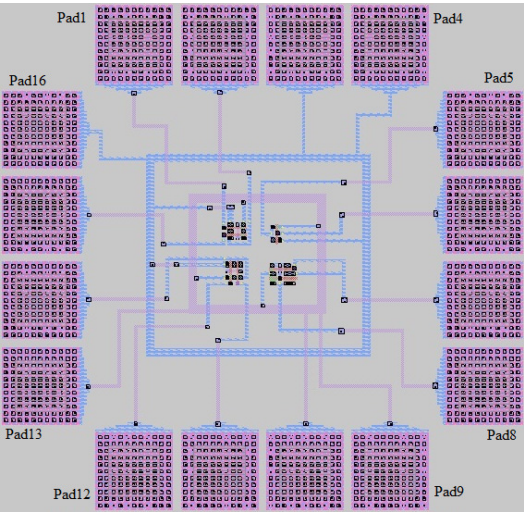


Fig 8: Leaf cells in designed pad frame with complete chip structure after block placement and routing.

5. RESULTS & DISCUSSION

The designed complete chip layout consumes total of $1967\lambda \times 1967\lambda$ or $491\mu\text{m} \times 491\mu\text{m}$ with the pad frame in CMOS $0.5\mu\text{m}$ process. This is very less area consuming and at the same time low power power consuming. The designed leaf cells dissipates power of 4.15 milliwatts, 1.14 milliwatts, 0.35 nanowatts, and 2.08 milliwatts respectively for NAND gate, NOR gate, Inverter Buffer, and single Inverter. The simulation results for the inputs-outputs of the modules are given in figures 9, 10, 11, & 12.

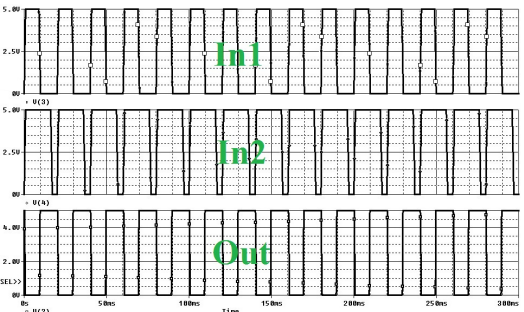


Fig 9: PSpice simulation result of designed NAND gate from the MAGIC extraction file.

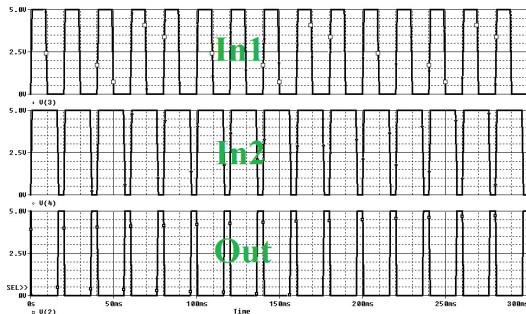


Fig 10: PSpice simulation result of designed NOR gate from the MAGIC extraction file.

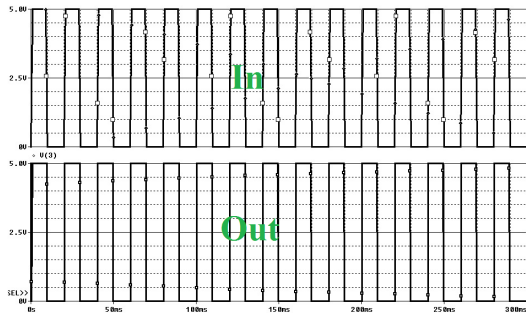


Fig 11: PSpice simulation result of designed Inverter Buffer from the MAGIC extraction file.

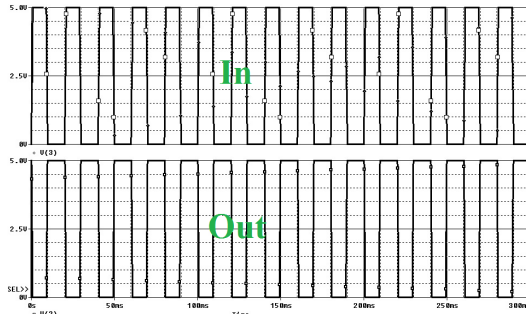


Fig 12: PSpice simulation result of designed single Inverter from the MAGIC extraction file.

Pads used for input and output signals require different supporting circuitry which is called I/O architecture. The main job of an input pad is to protect the chip core from electrostatic discharge (ESD). Output pads do the job of driving the large capacitances seen on the output pin [5]. Input and output pads also do the job of maintaining the signal directions. The pad driver and ESD circuit of each pad occupies a certain amount of space, disallowing any other circuitry within that space and increase the total power consumption and

dissipation of entire chip. Besides, there are also power/ground (P/G) pads and analog pads. Analog pads are not used in this study. An important problem in P/G network design is to use the minimum amount of chip area for wiring P/G networks, while avoiding potential reliability failures due to electromigration and excessive IR drops [14]. As the size and power consumption and dissipation of the I/O architecture depend on the on-chip core circuitry, pad size, pad generation or pad placement, etc., so these are some important concern in designing a low power complete chip.

In this study leaf cells are designed area-efficiently with ultra low power dissipations. Pads are designed with minimum area specification and reliable against bonding failure, and distributed equally around the edge of the chip as the order of pins is the fact to determine the routability of a system. They are sufficiently large to hold a wire and input or output circuitry but efficient in area consumption and power consumption as well. The chip core is fit in the mid of the pad frame. To reduce inductive voltage drop, 3 Vdd and 3 GND pads have been used which is maximum in this case. Block placement is done in a way that makes the routing path shorter. Wire bending is kept minimized to protect from parasitic inductive effect. Thus all the floorplanning job and pad frame design considerations is towards an efficient complete chip layout, hence the I/O circuitry is to be efficient corresponding to this whole work.

6. COLCLUSION

As fabrication technology keeps advancing, many deep sub-micron (DSM) effects have become increasingly evident and can no longer be ignored in VLSI design. Besides, increasing complexity and decreasing feature size have made the demand of more I/Os a significant problem to packaging technologies. So, a successful floorplanning and efficient pad frame design is very important and also challenging at the same time. This study is an attempt to design a pad frame with efficient floorplanning towards low power I/O architecture. It is also tried to make the on-chip circuitry area-efficient having ultra low power dissipation so that I/O architecture or circuitry goes followed by that efficiency. Further study may be focused on more robust and efficient pad frame design and floorplanning using interactive tools with different and new approach.

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DESIGN, SIMULATION AND PERFORMANCE ANALYSIS OF HIGH VOLTAGE MULTISTAGE PULSE FORMING NETWORK

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This paper presents design, simulation and performance analysis of high voltage multistage pulse forming network among two stages, four stages and ten stages system. A pulse forming network can be constructed using lumped energy storage elements like inductors and capacitors for 100 meters coaxial transmission line. The main purpose of the high voltage pulse forming system is to generate high voltage pulses within certain repetition rate using energy compression technique within very short time. Computer aided Orcad P-Spice simulation are suitable to analysis performance among various multistage pulse forming networks to conserve time and enhance efficiency. Detail design procedure with simulation results i.e., block diagram, circuit design, description of the system, simulation wave shapes and performance analysis among various multistage pulse forming networks are presented in this paper. Design steps are presented in a sequential manner that would be advantageous for the beginners as well as for the advanced readers who are interested to research with high voltage microwave pulse forming system.

Key words: High voltage pulse; Pulse forming network; Lumped element.

1. INTRODUCTION

The Pulse Forming Network (PFN) is a simple network of producing very High Voltage Pulse within certain repetition rate using energy compression technique. Distributed parameter model can be used for generating High Voltage Pulse. Generally, a Pulse Forming Network (PFN) can be constructed using lumped energy storage elements such as, Inductors and Capacitors. However, High Voltage (HV) Pulse with short duration in order of hundreds of nanosecond (ns) can not be produced by lumped elements.

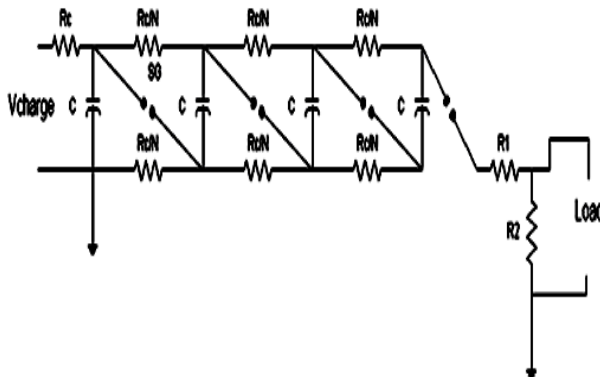


Fig. 1: Marx generator (multistage impulse circuit)

A Marx Generator is a clever way of charging a pulse forming network. It is nothing but a Multistage Impulse Generator, shown in figure- 1. Originally described by E. Marx in 1924, Marx generators are probably the most common way of generating short duration, high voltage impulses for testing when the voltage level required is higher than available charging supply voltages. In order to predict the output pulse under load mismatch conditions, the ideal model has been simulated for three possible conditions. If the Load impedance is equal to generator impedance, then it is called matched condition. If the Load impedance greater than the generator impedance then it is called Over- matched condition. Also, if the Load impedance is less than the generator impedance, then it is called Under- matched condition. Pulse forming network can be simulated using various software. In this work Pulse Forming Network System has been simulated using Orcad P-Spice. The results are compared with the existing ones. Here Orcad P-Spice Version No. 9.1 is used. SPICE is user friendly simulator widely used in circuit analysis. SPICE consists of a group of device files, one for each active circuit element, and one executable file, SPICE has a rich library for integrated circuits such as operational amplifiers, comparators

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etc. The user can create a model for part of a circuit and save it as a sub-circuit and then use this sub-circuit later.

2. GENERAL BLOCK DIAGRAM OF THE TOTAL SYSTEM

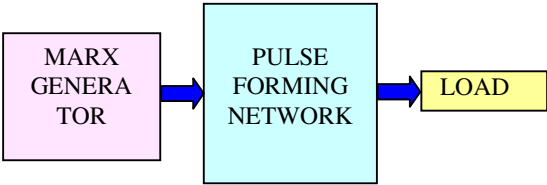


Fig. 2: General block diagram of the PFN

Figure- 2 shows the general block diagram of the total system. The Pulse Forming Network (PFN) is charged by a Marx generator to a high voltage and discharged through the load. We get the wave shapes across the load. For three conditions matched, Over-matched and Under-matched the wave shapes are analyzed respectively for two, four and ten stage. These two, four and ten stage circuits are nothing but some multistage L-C circuits.

3. CIRCUIT DESIGN OF DIFFERENT STAGE PULSE FORMING NETWORK

The simplest form of PFN can be constructed using L (Inductors) and C (Capacitors). The number of stages used in a real PFN depends on the duration of this pulse. The amplitude of the pulse depends on the magnitude of the charged voltage. In this paper several PFN's are simulated and the results are presented. The theory Circuit Model is used to analyze these PFN. Here consider a configuration of Circuit Model. The distributed parameters of the PFN supplied by the manufacturer's specification for 100 meter length are given below.

Table- 1
Manufacture's Specification

Inductance per meter, L	0.605 μ H
Capacitance per meter, C	0.1 nF
Series resistance per meter, R	157 μ F
Dielectric constant, ϵ_r	2.5
Characteristic impedance	50 Ω

3.1 A two-stage PFN

A two stage Pulse Forming Network (PFN) is simulated by Orcad P-SPICE Version No. 9.1. SPICE is a user friendly simulator widely used in circuit analysis. The values of inductor and

capacitor are estimated for 100 meter transmission line. Here two inductors and two capacitors are used. Charging voltage across each capacitor is 200 kV. Transition time of the closing switch in the P-SPICE schematics decides the pulse rise and fall times, which is of the order of 1 μ s.

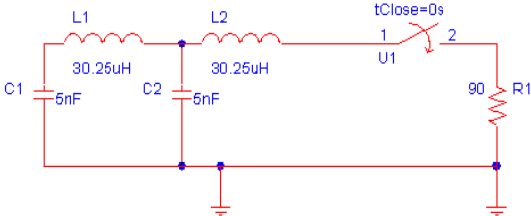


Fig. 3: PFN (Circuit model-2 stage)

Figure- 3 depicts a two stage PFN. The element values are calculated using the pulse specification. Here the parallel capacitors are charged with a high voltage source, and discharged through the load resistance R1. Inductances are used to obtain the flat top of the pulse.

3.2 A four-stage PFN

A four stage Pulse Forming Network (PFN) is designed by P-SPICE. Here four inductors and four capacitors are used. The values of inductor and capacitor are estimated for 100 meter transmission line. The power discharged across the load via a switch. The element values are calculated using the pulse specification.

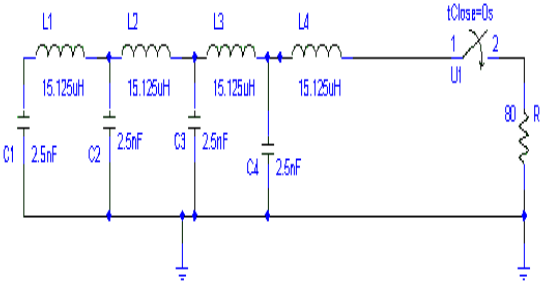


Fig. 4: PFN (Circuit model-4 stage)

Figure 4 depicts a 4-stage Pulse Forming Network (PFN). In this circuit, the values of capacitors (C) and inductors (L) are distributed in four identical sections.

3.3 A ten-stage PFN

A ten stage Pulse Forming Network (PFN) is simulated in figure below. Here ten inductors and ten capacitors are used. The values of inductor and capacitor are estimated for 100 meter transmission line. Here the circuit arrangement is largest among the three. The inductors are in the range of micro henrys and the capacitors are in the range of

nanofarads. Figure- 5 shows a ten stage PFN. The element values are calculated using the pulse specification.

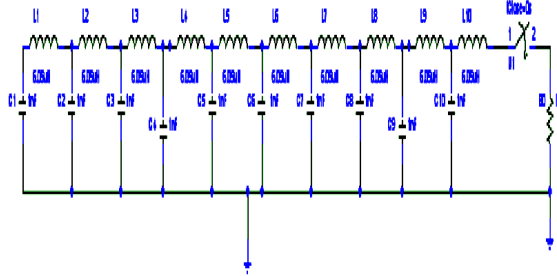


Fig. 5: Pulse forming line (Circuit model-10 stage)

4. RESULTS AND WAVE SHAPES

Now we see the wave shapes of two, four and ten stage circuits for matched, Over-matched and Under-matched conditions. X- axis represent voltage and Y- axis represent time. In this wave shapes voltage ranges from -200 kV to 200 kV and the time ranges from 0 sec to 20 μ sec. We compare among these wave shapes and determine that, which types of L-C circuit configuration are more efficient for high voltage (HV) pulse operation.

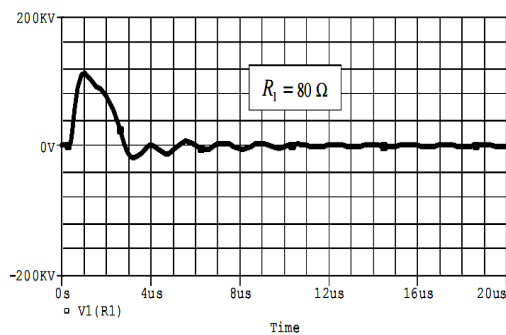


Fig. 6: Matched load for 2-stage circuit model (80 Ω)

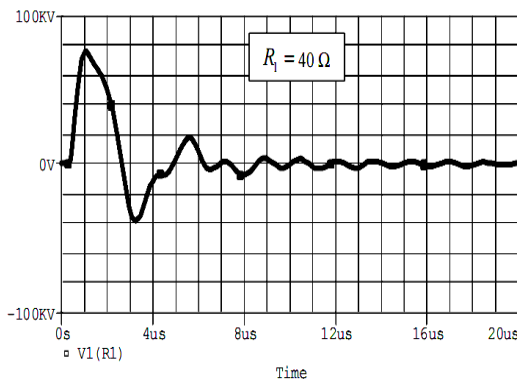


Fig. 7: Under- Matched load for 2-stage circuit model (40 Ω)

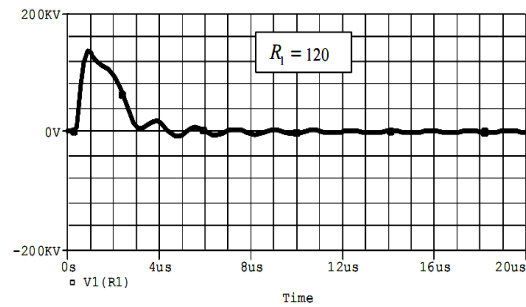


Fig. 8: Over- Matched load for 2-stage circuit model (120 Ω)

Figures 6, 7 and 8 depict the load voltage of two stage circuit for $R_1 = 80\Omega$, 40Ω and 120Ω respectively. When $R_1 = 80\Omega$, then matched condition (Load impedance = generator impedance) occurs, when $R_1 = 40\Omega$ then Under-matched condition (Load impedance < generator impedance) occurs and when $R_1 = 120\Omega$ then Over-matched condition (Load impedance > generator impedance) occurs. It can be seen from Fig. 7 that for $R_1 = 40\Omega$, the PFN becomes under matched and the negative pulse appear due to multiple reflections. The pulse duration is about 4μ s.

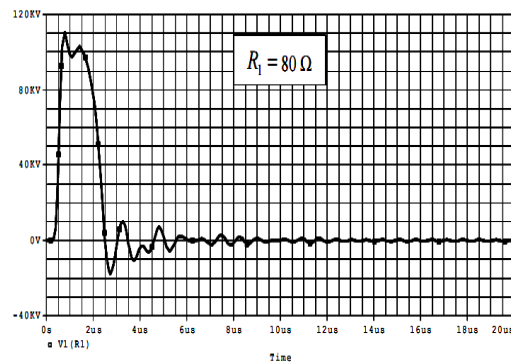


Fig. 9: Matched load for 4-stage circuit model (80 Ω)

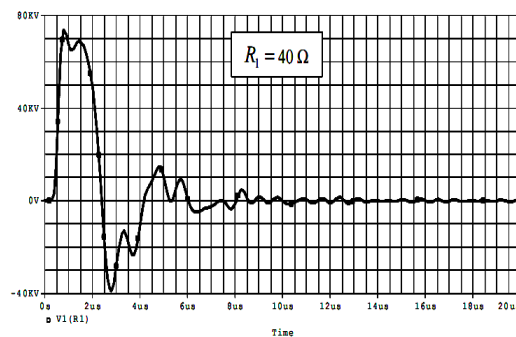


Fig. 10: Under- Matched load for 4-stage circuit model (40 Ω)

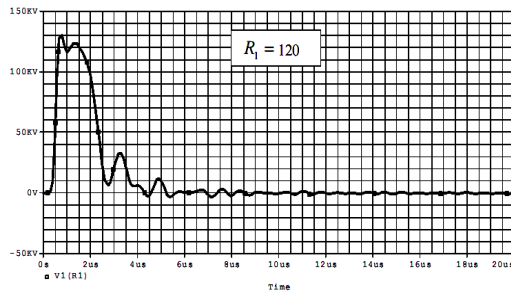


Fig. 11: Over- Matched load for 4-stage circuit model (120 Ω)

Figures 9, 10 and 11 depict the load voltage of four stage circuit for matched load (80 Ω), under-matched load (40 Ω) and over-matched load (120 Ω) respectively.

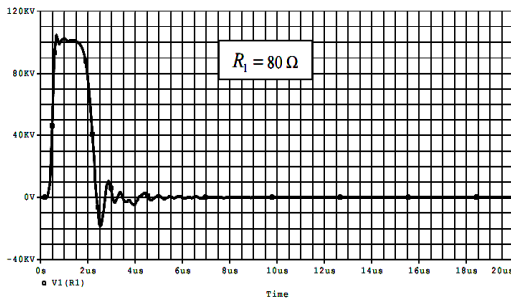


Fig. 12: Matched load for 10-stage circuit model (80 Ω)

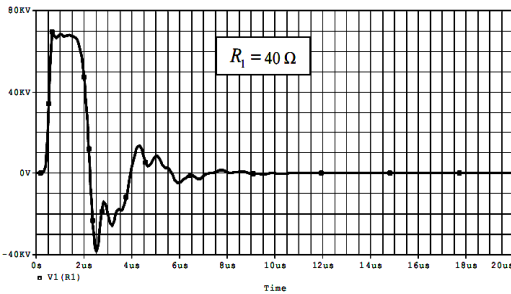


Fig. 13: Under- Matched load for 10-stage circuit model (40 Ω)

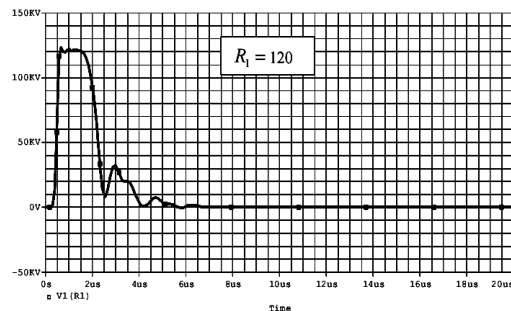


Fig. 14: Over- Matched load for 10-stage circuit model (120 Ω)

Figures 12, 13 and 14 depict the load voltage of ten stage circuit for matched load (80 Ω), under-matched load (40 Ω) and over-matched load (120 Ω) respectively. It can be seen from the simulation results that, as the number of stages are increased, the shape of the pulse become rectangular. For example, a 10-stage Pulse Forming Network is shown in Figure- 5, the output for $R = 80\Omega$, is closest to a rectangular pulse. The ringing near the discontinuities is due to the convergence failure.

5. CONCLUSIONS

In this paper, several PFN's are simulated results are presented for matched, Over-matched and Under-matched conditions. The number of stages are increased, the shape of the pulse become rectangular for each conditions. We get more accurate pulse. In practice, a PFN is charged by means of a high voltage power source and then rapidly discharged into a load via a high voltage switch, such as a spark gap or hydrogen thyatron. The load may be a high power microwave oscillator such as a klystron or magnetron, a flash lamp, or even an electromagnet. Depending upon the application, the output Pulse Repetition Rate (PRR) may range from a fraction of a thousand of Hz. The high voltage (HV) pulsed power technology has drawn renewed interest recently due to its indispensable applications in the fields of pulsed high power microwave (HPM) generation.

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DESIGNING BIREFRINGENCE OF INDEX-GUIDING PHOTONIC CRYSTAL FIBERS

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This paper presents birefringence tailoring of photonic crystal fibers using artificial defects along one of the orthogonal axes. The APSSTM software based on the finite difference method with anisotropic perfectly matched layer boundaries is used as the design tool. According to simulation, it is shown that it is possible to design very high birefringence of the order 10^{-2} by creating artificial defects in a double control configuration. The effects of axial artificial defects on fiber birefringence are also investigated. Photonic crystal fibers having such high birefringence are crucial for optical fiber based sensing applications. PACS No: (42.81.-i) Fiber Optics; (42.81.Gs) Birefringence, Polarization; (42.25.Lc) Birefringence

Key words: photonic crystal fiber, birefringence design, fiber design and characterization and finite difference method.

1. INTRODUCTION

Photonic crystal fibers (PCFs) [1] are made up of silica-air microstructure running down the entire fiber length. The silica-air microstructure contains microscopic air-holes arranged in a periodic or an aperiodic fashion [2]. Properties of such fibers are determined mostly by the positions and dimensions of air-holes [3]. A wide range of index contrast can be created between cores and claddings of these fibers (especially for index guiding PCFs that guide light based on the total internal reflection (TIR) mechanism) which effectively help tuning birefringence in addition to dispersion, leakage, and nonlinearity [4]. As a result PCFs are being considered nowadays in different areas of optics including both linear and nonlinear regimes [5].

A fiber birefringence although usually an undesirable property, it is crucial for many applications including signal processing, optical communication systems, and more specifically sensing applications [6]. In sensing applications, fibers are often required to maintain a linear polarization state in order to reduce polarization coupling [6]. In fiber-optic gyroscopes and polarimetric sensors where high temperature variations are present, birefringence PCFs are more suitable for such applications because undoped silica PCFs offer high temperature stability as well as high power sustainability. As a result Birefringent PCF designs have attracted much

attention over the past years [6]-[18]. There are various ways of designing birefringence in PCFs. Introducing anisotropic materials or applying stresses in the cladding region are among the ways that results in birefringence. Simply speaking in order to create birefringence it is essential to break the symmetry between two orthogonal axes. For PCFs, it is a general practice to change air-hole dimension of a pair of holes in either axis. In addition, considering fabrication constraints it is required to create defect near the core. Of the reported polarization maintaining (PM) PCFs [6]-[18] to date, PCFs [6, 8] modulates air-holes, [7] has a microstructure core, [9, 10] scale down air-holes dimension along one of the axes, and [11] uses a squeezed hexagonal lattice with elliptical air-holes. Again, PCFs [12, 13] have air-holes defect in the core, [14, 15] use rectangular lattice structures, [16, 17] use respectively a stress applying part and two scaled-up air-holes near the core, and [18] has a squeezed hexagonal lattice. These PCFs assume birefringence of the order 10^{-4} to 10^{-3} with various pitches. The PCF [11] with a squeezed hexagonal lattice and elliptical air-holes can provide birefringence of the order 10^{-2} , the highest birefringence reported to date. In this case, the pitch used is too small along the compressed axis. All these designs differ in birefringence magnitudes because of the variations in pitch values.

In this paper, we have presented three closely related designs for achieving highly birefringent fibers based on an octagonal cladding concept.

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Very high birefringence of the order 10^{-3} to 10^{-2} is confirmed by introducing artificial defects and a double control concept. We also have analyzed effects of artificial air-hole defects on the fiber birefringence. Although there are other ways of designing birefringence in the literature, such alternative designs for highly birefringent fibers might make the PCF technology valuable in future. Moreover, this type of investigation is also crucial for next generation PCFs where a PCF simply being superior to others with a single parameter can make its way for telecom and non-telecom applications [20].

2. PCF MODELS

Figs. 1-3 show PCFs with artificial axial defects. In the Fig.1 four pairs of air-holes are designated by numbers '1', '2', '3', and '4'. This figure contains four different axial defect cases of PCFs namely model-1, model-2, model-3, and model-4. Model-1 is similar to the structure of Fig.1 except numbered '1' holes are missing. Model-2 is similar to model-1 with numbered '2' air-holes are missing. Similarly, model-3 represents the model-2 with numbered '3' air-holes are missing and model-4 is similar to the model-3 with numbered '4' air-holes are missing. Figs. 2 and 3 show model-5 and model-6 respectively that represent respectively model-2 with two enlarged air-holes near the core and model-2 with 3 pairs of elliptical air-holes designated by numbers '1' and '2'. The fiber pitch is Λ and Λ' being the pitch between adjacent air-holes on a ring. The pitch Λ' is related to Λ by the relation $\Lambda' = 0.765\Lambda$.

3. SYNOPSIS OF THE SIMULATION METHOD

In the APSS [23], the finite difference method (FDM) [19] with perfectly matched layer (PML) boundary is used as the main simulation tool. The computational window was surrounded by perfectly matched layers (PMLs) which are considered the efficient boundary conditions for the PCF simulation. For sufficient accuracy a dense mesh was used in both axial directions. Once the modal effective refractive index, n_{eff} was obtained by solving an eigenvalue problem drawn from Maxwell equations using FDM, birefringence B , beat length L_B can be obtained using the following equations [10]-

$$B(\lambda) = |n_x(\lambda) - n_y(\lambda)| \quad (1)$$

$$L_B(\lambda) = \frac{\lambda}{|n_x(\lambda) - n_y(\lambda)|} = \frac{\lambda}{B(\lambda)} \quad (2)$$

Where, n_x is the real of n_{eff} along x -axis, n_y is the real part of n_{eff} along y -axis, and λ is the wavelength. A detail methodology of the FDM is provided in the appendix.

3. SIMULATION RESULTS

Fig. 4 shows wavelength response of birefringence of ordinary octagonal PCFs. Since ordinary octagonal fibers have eight-fold axial symmetry, they show very low birefringence. Fig. 1 depicts that the birefringence at 1550 nm is about 2×10^{-9} . Therefore, such octagonal cladding PCFs can be used for applications where polarization insensitivity is crucial. Fig. 5 shows birefringence of octagonal PCFs with four-different defect cases as is illustrated in Fig. 1. We use $d/\Lambda = 0.50$, $\Lambda = 1.50 \mu\text{m}$, and five-rings. It shows that fiber birefringence is directly related to the degree of defects. Increasing defects result in increased birefringence although the rate of increase differs. For example, the value of birefringence at 1550 nm is 2.95×10^{-3} for model-1 and it is 3.2×10^{-3} for model-2 resulting in an increase of 2.5×10^{-4} . Further defects, for instance, model-3 and model-4 although result in higher values but the changes are not noticeable. We have seen similar results for both the pitches 1.0 and 2.0 μm . This investigation clearly dictates that the model-2 can be considered as an optimum defect case. With this consideration we then investigate the effect of air-filling fraction or equivalently air-hole dimension relative to the pitch on the fiber birefringence. Figure 6 shows birefringence at 1550 nm of the model-2 for three different pitches, d/Λ , and five-rings. We see that birefringence of the model-2 can be as high as 8.25×10^{-3} and a corresponding beat length of 0.18 mm at 1550 nm for $d/\Lambda = 0.70$ and $\Lambda = 1.50 \mu\text{m}$. Decreasing the pitch to 1.0 μm results in a very high value of birefringence of the order 0.018. Again, increasing the pitch to 2.0 μm results in a birefringence of 4.2×10^{-3} for the same d/Λ .

The birefringence of model-2 can further be increased by using a double control technique i.e., using two large air-holes (model-5) in one of the axes nearest the core of the model-2 as shown in Fig.2. Diameters of these two air-holes are made 1.75 times larger than that of other air-holes. Fig. 7 shows the corresponding results for model-5 and model-2. It can be seen in the figure that the birefringence at 1550 nm for the model-2 is 3.2×10^{-3} and it is 4.42×10^{-3} for the model-5. This means an overall increase of 1.22×10^{-3} is achieved by the double control technique. Finally, the original model-2 is again modified as shown in Fig. 3. Here three pairs of elliptical air-holes are used with ellipticities $r_x/r_y = 0.67$ and 1.5 respectively for

numbered '1' and numbered '2' air-holes of Fig. 3. With this modification, Fig. 8 shows the simulation results. It is clear from the figure that a very high value of birefringence of the order 0.015 is possible with $d/\Lambda = 0.67$, and a relatively higher pitch of $\Lambda = 1.50 \mu\text{m}$.

In the light of above simulations, therefore, it is logical to conclude that the proposed octagonal structure PCFs may become potential alternative of the hexagonal fibers for both polarization insensitive and highly polarization maintaining applications.

4. DISCUSSION

We have used octagonal instead of conventional hexagonal structures for obtaining high values of birefringence. Such a structure is essential to implement the newly proposed double control concept. Moreover, octagonal structures offer wider single mode operation, higher nonlinearity, and few other advantages in comparison to hexagonal counterparts [24]. The only limiting factor for this structure is that the fabrication issue. Fortunately, fabrication precision and accuracy are advancing day by day. Reportedly the versatile stack and draw method can assemble structure of almost any size and shape [24]. It is forecasted that a fiber simply being superior to others to a single property would make the fiber technology valuable [25]. Therefore, we hope that the micro and nano-fabrication scientists will be able to find out a way to manufacture such structures in future.

5. CONCLUSION

Birefringence tailoring techniques as well as designs of highly Birefringent PCFs has been presented based the finite difference method. It has been shown by simulations that octagonal PCFs assume very low birefringence property in its ordinary form as well as very high birefringence of the order 10^{-2} by introducing axial artificial defects.

6. APPENDIX

Here we present a summary of discretization of the FDM method. The time-dependent Maxwell's equations can be written in the following form [21]:

$$\frac{\partial H}{\partial t} = -\frac{1}{\mu(r)} \nabla \times E \quad (3)$$

$$\frac{\partial E}{\partial t} = \frac{1}{\varepsilon(r)} \nabla \times H - \frac{\sigma(r)}{\varepsilon(r)} E \quad (4)$$

Where $\varepsilon(r)$, $\mu(r)$ and $\sigma(r)$ are the position-dependent permittivity, permeability and conductivity of the material, respectively. In FDM, Maxwell's equations are discretized in space and time by the well known Yee-cell technique on a discrete three-dimensional mesh. In photonic crystal fibers each of the above field components has take the

form $\phi(x, y, z) = \phi(x, y)e^{i\beta z}$, where ϕ denotes any field component and the propagation constant along the z -direction is β . When the z -derivatives are replaced by $i\beta$, the equations can simply be expressed in terms of the transverse variables only. Fig. 9 depicts a two dimensional unit cell over the fiber's cross section. Thus the x -component of Maxwell's first curl equation becomes-

$$\frac{\partial H_x}{\partial t} = -\frac{1}{\mu} \left(\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z} \right) \quad (5)$$

$$H_x^{n+\frac{1}{2}}(i,j) = H_x^{n-\frac{1}{2}}(i,j) - \frac{\Delta t}{\mu_{i,j}} \left[\frac{E_z^n(i,j+1) - E_z^n(i,j)}{\Delta y} - i\beta E_y^n(i,j) \right] \quad (6)$$

Where n denotes the discrete time step, and i and j denote the discretized grid points in the x - y plane, Δx and Δy are the intervals between two neighboring grid points, and Δt is the time increment respectively. In a similar way, rest of field components can be obtained.

In order to simplify the complex computation it is assumed that E_z , H_x , and H_y have components $\cos(\beta z + \phi)$ (with real amplitudes) and H_z , E_x , and E_y have components $\sin(\beta z + \phi)$ (with real amplitudes). Equation (6) then becomes

$$H_x^{n+\frac{1}{2}}(i,j) = H_x^{n-\frac{1}{2}}(i,j) - \frac{\Delta t}{\mu_{i,j}} \left[\frac{E_z^n(i,j+1) - E_z^n(i,j)}{\Delta y} - \beta E_y^n(i,j) \right] \quad (7)$$

Similarly,

$$H_y^{n+\frac{1}{2}}(i,j) = H_y^{n-\frac{1}{2}}(i,j) + \frac{\Delta t}{\mu_{i,j}} \left[\frac{E_z^n(i+1,j) - E_z^n(i,j)}{\Delta x} - \beta E_x^n(i,j) \right] \quad (8)$$

$$H_z^{n+\frac{1}{2}}(i,j) = H_z^{n-\frac{1}{2}}(i,j) + \frac{\Delta t}{\mu_{i,j}} \left[\frac{E_x^n(i,j+1) - E_x^n(i,j)}{\Delta y} - \frac{E_y^n(i+1,j) - E_y^n(i,j)}{\Delta x} \right] \quad (9)$$

$$E_x^{n+1}(i,j) = \frac{\varepsilon_{i,j} - \sigma_{i,j} \Delta/2}{\varepsilon_{i,j} + \sigma_{i,j} \Delta/2} E_x^n(i,j) + \frac{\Delta}{\varepsilon_{i,j} + \sigma_{i,j} \Delta/2} \left[\frac{H_z^{n+1}(i,j) - H_z^{n+1}(i-1,j)}{\Delta y} + \beta H_y^{n+1}(i,j) \right] \quad (10)$$

$$E_y^{n+1}(i,j) = \frac{\varepsilon_{i,j} - \sigma_{i,j} \Delta/2}{\varepsilon_{i,j} + \sigma_{i,j} \Delta/2} E_y^n(i,j) - \frac{\Delta}{\varepsilon_{i,j} + \sigma_{i,j} \Delta/2} \left[\frac{H_z^{n+1}(i,j) - H_z^{n+1}(i-1,j)}{\Delta x} + \beta H_x^{n+1}(i,j) \right] \quad (11)$$

$$E_z^{n+1}(i,j) = \frac{\varepsilon_{i,j} - \sigma_{i,j} \Delta/2}{\varepsilon_{i,j} + \sigma_{i,j} \Delta/2} E_z^n(i,j) + \frac{\Delta}{\varepsilon_{i,j} + \sigma_{i,j} \Delta/2} \left[\frac{H_y^{n+1}(i,j) - H_y^{n+1}(i,j-1)}{\Delta x} - \frac{H_x^{n+1}(i,j) - H_x^{n+1}(i,j-1)}{\Delta y} \right] \quad (12)$$

The time-stepping formulas are stable numerically if and only if

$$\Delta t \leq \frac{1}{c \sqrt{\Delta x^{-2} + \Delta y^{-2} + (\beta/2)^2}}$$

Where c is the speed of the light.

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Designing of Armature Winding Using Programming Technique Instead of Using Conventional Method

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Abstract - Armature winding of a machine is defined as an arrangement of conductors designed to produce emfs by relative motion in a heteropolar magnetic field [2]. When anyone wants to design armature winding for any types of machine they should keep remind some important factors such as coil span of each armature coil, emf being produced in the winding, polarity of brush so that no circulating current can flow, the sequence of different coil sides, find out is that winding is integrated or fractional slot winding. Hence, armature winding design in a conventional way takes great time and moreover the procedure for fractional and integrated slot winding is totally different. So in our work we are using programming language technique for designing armature winding which will take about 15 seconds for designing armature winding without any difficulties. In our work, we have used programming language c++ [4], both for calculation and winding layout drawing. The program has made it very easy for us to design an armature winding in a very short time.

Key words: Integrated slot winding, Fractional slot winding, Slot per pole per phase equation, dummy coil, and graphics of winding layout.

1. INTRODUCTION

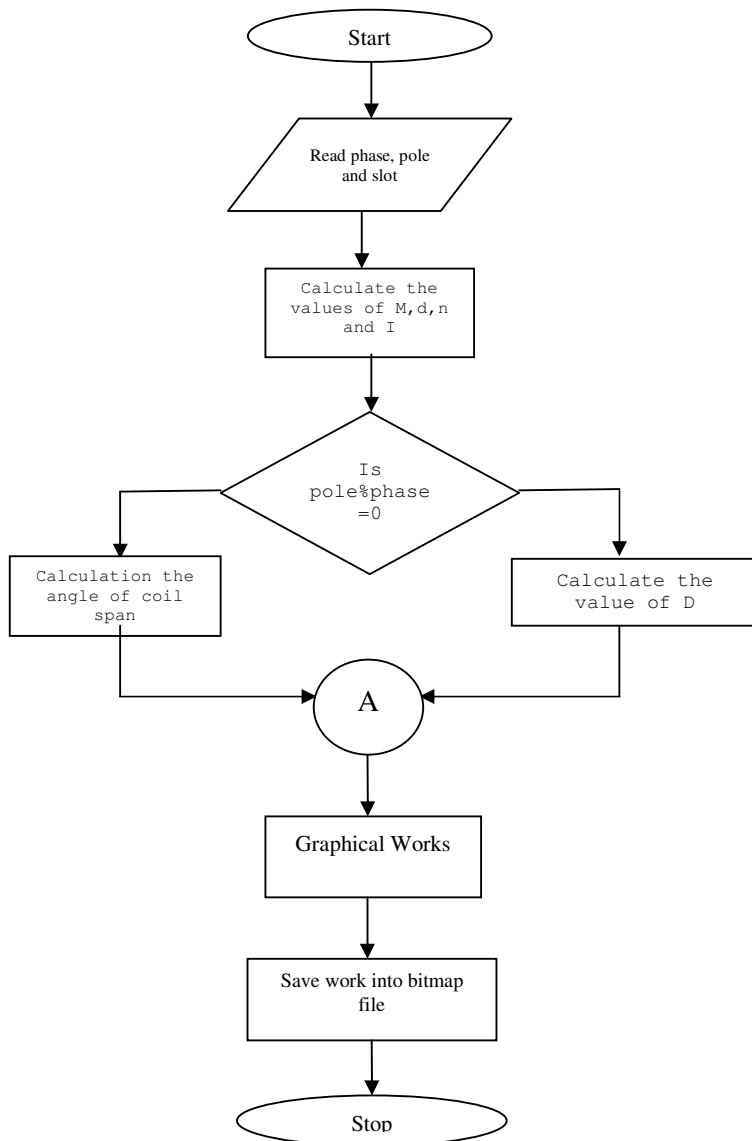
The paper deals with the designing of armature winding using programming technique. For designing armature winding, one should remember some important factors like back pitch, front pitch, coil span, coil sides, commutator pitch, condition of electrical symmetry [1,3] etc. Moreover, the direction of current and generation of emf in the winding should be considered. In addition the design procedure for the integrated slot winding and fractional slot [1] winding is totally different. In conventional way for designing the armature winding, anyone needs to remember all those above factor and then sit down with their pencil and paper for calculation of the front pitch, back pitch, coil span or is that fractional or integrated slot winding. So, for doing all this term together the probability of error increase in a great rate and it is also time consuming.

In the following paper, we do the above things by using programming language technique and it will also give us the full layout of the armature winding within a few seconds. The paper demonstrated a simple algorithm of how the slot of various phase

are distributed and what will be the sequence of pole phase group. By knowing the number of phase, number of pole and the number of slot, we can easily design the armature winding. Moreover, this algorithm gives us the full distribution of slot, the direction of current and the start and finishing point of the coil design.

2. The Modeling process

For armature winding design, we need to know the number of phase, number of pole and the total number of slots. Here from this above data, we need to determine the value of number of pole in unit(d), number of slot per phase in each unit(M) and no. of coil in each group(I and n). In the figure (1), we demonstrated a flow chart of our work. After determining the value of M, d, n and I we determine if the pole is divisible by the phase? If it does then we go through the angle procedure, if it does not then we calculate the value of D. After performing the calculation we have determined the distribution of slot into different phase then we completed our graphical work. The problem is done



in a Windows XP service pack-3 environment with C++.

Fig 1: Flow Chart of armature winding design.

3. Mathematical Expression

In the integral slot windings, every pole phase groups has the same number of series connected coils. But in fractional slot windings, all the pole phase groups do not have the same number of series connected coils as q is always a mix number. Since the fractional coils are impossible, the only alternative left is not to make all the phase group identical i.e. practical winding is only possible

when one pole phase group has one coil fewer than the others.

When, however it is found necessary to use a lamination that does not give an integral slot winding. Its number of slots must make it possible for all phases to have same number of coils. This means that if a lamination is to be used for a 3 phase machine the total number of slots should be divisible by 3 in order that each phase has the same number of coils.

Average number of slots per pole per phases,

$$q = S / (m * p) \quad [1]$$

$$= M / d$$

 So, Number of slot per pole per phase

$$= I \frac{n}{d} \quad [2]$$

Here, Phase= m ; Pole= p ; Slots= S ; Number of pole in a unit = d
 Number of slots per phase in each unit = M
 Number of slots in each unit = $m * M$
 Number of unit = p / d
 Each phase in a unit contains $(d - n)$ groups of I coil and n groups of $(I + 1)$ coils each. Double layer winding can be either
 I. Integral slot
 II. Fractional slot

When the number of slots per pole per phase is an integer, it is known as an integral slot winding. When the number slot per pole and also the number pole per phase are not integers then the winding is known as fractional slot winding.

To solve the problem, at first we calculate the value of a variable D (difference between two slots),

Where $D = \frac{1 + mMx}{d}$; Where x = the smallest integer value which makes D an integer
 In general the series is:

$1, 1 + D, 1 + 2D, 1 + 3D, \dots \dots \dots, [1 + (m * M - 1) * D - ymM]$; where y = an integer

The value of mM has to be subtracted from the terms which become larger than mM .

But, if pole is devisable by phase then no value of x can make D an integer and to solve this problem we have to proceed in another way:

Electrical angle between consecutive slots, = $(180 * p / S)$ degree

Number of slot in a unit = mM

Thus, the slot star of this winding will have mM phasors.

Using this angle we can distribute the slots in a unit into 360 degrees with a difference of angle between consecutive slot degrees.
Now the position of slots can be determined according to the value of the angle in ascending order

4. Result

The algorithm is developed both for the fractional and integrated slot winding. Here, we give the result of the two samples for fractional and integrated slot winding.

4.1. Fractional slot winding

Here for fractional slot winding we used 3 phase 4 pole and 78 slots. So, the calculation for the winding design are given below

$$q = \frac{S}{mp} = \frac{78}{3 \times 8} = \frac{13}{4} = 3 \frac{1}{4}$$

Number of slots per phase in each unit, $M=13$

Number of poles in a unit, $d=4$

$I=3$

$n=1$

Number of Units, $p/d = 8/4 = 2$

Each phase in a unit has

$d - n = 3$ groups of $I = 3$ coils each and

$n = 1$ group of $I + 1 = 4$ coils each

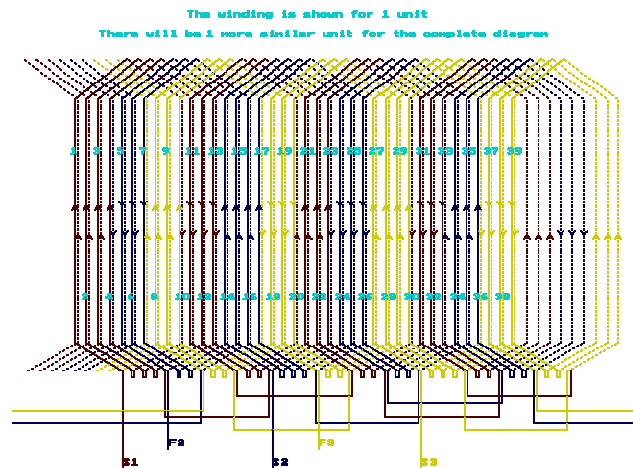
$$\text{We know, } D = \frac{1 + m \cdot M \cdot P}{d} = \frac{1 + 3 \cdot 13 \cdot P}{4}$$

The smallest value of P for D be an integer is, $P=1$,
 $D=10$

Each phase in a unit has

3 groups of 3 coils each and

1 group of 4 coils each



The distribution of slots is as below:

Phase=1

1 2 3 4 11 12 13 21 22 23 31 32
33

Phase=2

5 6 7 14 15 16 17 24 25 26 34 35
36

Phase=3

8 9 10 18 19 20 27 28 29 30 37 38
39

The winding layout for the fractional slot winding is

Fig 2: The winding layout of 3 phase 4 pole and 78 slots

4.2. Integrated slot winding

For fractional slot winding, we show the layout of 3 phase, 4 poles and 24 slot machine. The calculation for the integrated slot winding is shown in below

$$q = \frac{S}{mp} = \frac{24}{3 \times 4} = \frac{2}{1} = 2$$

Number of slots per phase in each unit, $M=2$

Number of poles in a unit, $d=1$

$I=2$

$n=0$

Number of Units, $p/d = 4/1 = 4$

Each phase in a unit has

$d - n = 1$ groups of $I = 2$ coils each and

$n = 0$ group of $I + 1 = 3$ coils each

$$\text{We know, } D = \frac{1 + m \cdot M \cdot P}{d} = \frac{1 + 3 \cdot 2 \cdot P}{1}$$

The smallest value of P for D be an integer is, $P=1$, $D=7$

Each phase in a unit has
1 groups of 2 coils each and
0 group of 3 coils each

The distribution of slots is as below:

Phase=1	1 2
Phase=2	3 4
Phase=3	5 6

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The winding layout for the integral slot winding is

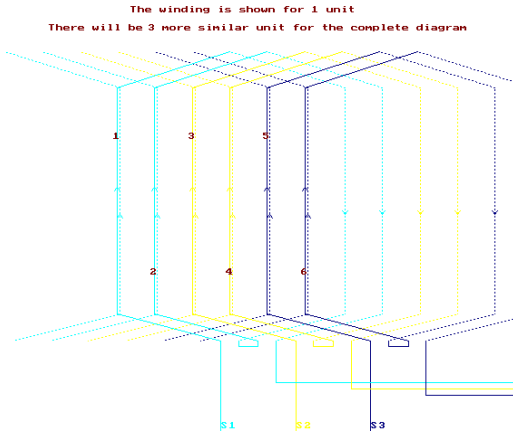


Fig 3: The winding layout of 3 phase 4 pole and 24

5. CONCLUSIONS

In this paper, an algorithm is developed for designing the armature winding .By knowing the value of phase, slot and the pole we can easily get the layout of armature winding. In our method both fractional and integral slot winding can be design without any calculation. This is a computer aided design. It has the advantage of eliminating tedious and time consuming hand calculation thereby releasing the designer from numerical drudgery to allow him devote time to grapple with physical and logical ideas. These computer aided designs also ensure the less error than hand calculating design.

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DEVELOPMENT OF AN EMBEDDED SYSTEM FOR LOW POWER MESSAGE DISPLAY

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ABSTRACT

Electronic display is now the most conventional means of presenting information all over the world. Due to its attractive brightness and simple operability, it is one of the most popular medium of presenting different types of information to the mass people. The display elements in an embedded system consume the major portion of the total power required to run the whole system. When large amount of display elements are used power dissipation issue becomes acute. In many cases special cooling arrangements like heat sink, cool air circulation, fan etc. are used to keep the system workable. The demand of low power consumption for embedded systems motivates to explore new approaches for managing power. This paper proposes an alternative approach to develop a low power consuming embedded system for message display by introducing a new scanning technique. In the proposed system a controller scans all the display units continuously to ensure that only one unit is on at any given time. In this way power consumption will be much lower than that of existing static display system. Here a 'Muslim Calendar' containing date, time and prayer times for five salah has been developed as a test case. Seven segment displays are used as display units.

Key Words: *Microcontroller, Scanning, Message, Display, Low Power*

1. INTRODUCTION

Electronic display-we see it everywhere, in computers, watches, DVD players and many other electronic devices to display numeric and some alphabetic characters. It is also used for showing messages in digital calendars, billboards, shopping malls, airports, stadiums and many other places. It is a commonly used and efficient way of displaying information. Although electronic display is widely used, power consumption is still an important issue. In an electronic circuit, the major part of the total power is consumed by the display elements. If a large amount of display units are used in a system then the power requirement to run the system will also increase proportionately. In that case extra cooling arrangements may be required to keep the system workable. So the demands of low power consumption for embedded systems are motivating new approaches to manage power dissipation issues.

2. BACKGROUND

A lot of research works have been done for displaying numeric digits of languages other than

English where the researchers used Seven

Segment Display or some modification on it [1-5]. Display is one of the major power consumers in modern computer system [6-7]. Power consumption is even more critical when multiple display units are used together for displaying message. In some cases, it needs extra cooling arrangements for heat dissipation. Researchers have proposed plasma screen or organic light-emitting devices (OLED) to reduce power consumption for display element [8-9]. So reducing the power consumption for display element is an important research area.

3. THE PROPOSED SYSTEM

This project concentrates on the power dissipation issues for display devices. A scanning technique has been introduced in the proposed to minimize the power consumption for display elements. The objective is to connect all the display elements in parallel with each other and turning only one unit on at a time for a very short period and move to the next unit. If each unit can be illuminated periodically in a very short span of time the human eye will see the entire message as

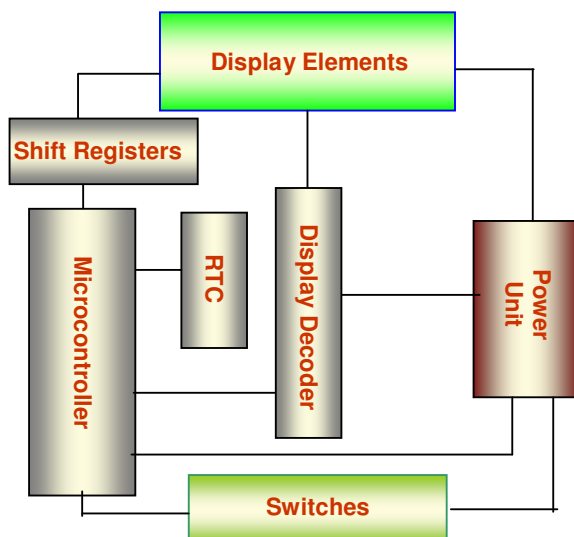
if all the units are turned on whereas only one unit is on at any given time.

Here seven segment displays are used as display units and as a test case a Muslim Calendar (displays Date, Time and Prayer times of Five Salah) is developed with 30 units of seven segment display. As the algorithm for illuminating display units follow the scanning technique only one unit of seven segment display is turned on at any given time. So theoretically the total power consumption for illuminating display units is reduced by 30 times. Hence 30 units of seven segment displays can be illuminated by only the power required by one unit.

4. BLOCK DIAGRAM OF THE SYSTEM

The basic units of the proposed system can be divided into 7 parts: Microcontroller, Display elements, Display Decoder, Real Time Clock (RTC), Shift Registers, Power Unit and Switches.

Here the microcontroller controls the input of the shift registers. The output of the shift registers are connected to the common cathodes of 30 seven segment displays. The microcontroller initializes all the output pins of the shift register at level 1 (sends logic 1 thirty times in the input of the shift registers), making all the seven segment displays to be turned off. At this point the microcontroller sends logic 0 once and logic 1 29 times so that each display receives the signal 0 sequentially while other displays receive signal 1. In this process, only one display is turned at a time and shifted sequentially.



The output pins of the display decoder are connected in parallel to all seven segment displays. The Microcontroller sends appropriate input for the decoder when corresponding seven segment display has logic 0 at its common cathode.

A real time clock is used to keep the date and time. The microcontroller reads time from the RTC each minute and changes the display clock and date accordingly. The prayer time table is loaded in the program memory of the microcontroller as an array of structure. The prayer times change with the change of day and month field of the date. There is a battery connected to the RTC so that it can keep the time and date when the main power is not available.

Three switches are used to set time and date. One switch is used to select which field of the time and date is to be changed. Other two switches are used to count up and count down the selected field. All these operation is controlled by the microcontroller.

5. SCHEMATIC DESIGN

Figure 2 shows the schematic design of the proposed system. The main part of the system is the Atmel ATMEGA88 microcontroller. All other components are connected to it and controlled by it. The four input pins (D0-D3) of the seven segment decoder (CD4511BE) are connected to the first four pins of port B (PB0-PB3) of the microcontroller. These pins are used to provide the appropriate data to be displayed by a particular seven segment display. The seven output pins (a-g) of the display decoder are connected to all seven segment displays' input pins (a-g) in parallel along with seven 100 Ω registers.

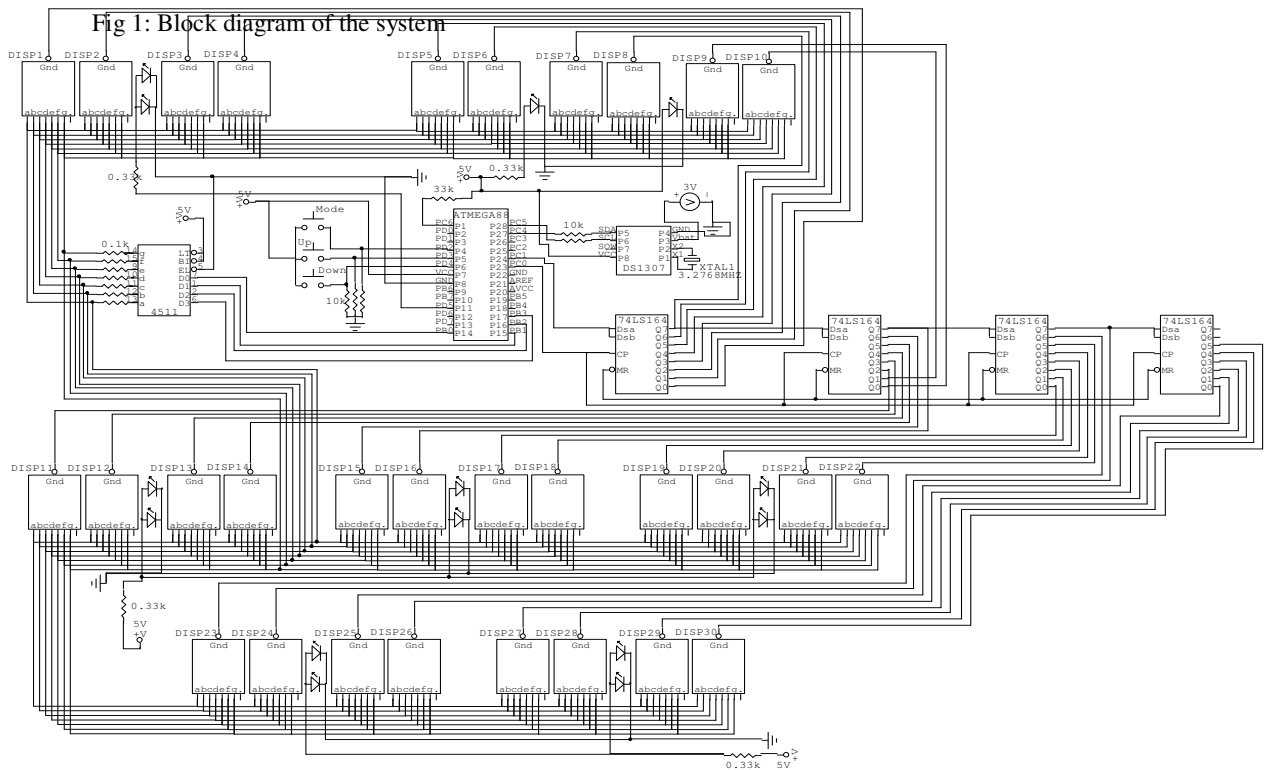


Fig 2: Schematic diagram of the proposed system

Four shift registers (74HC164) are used in this project. The input pins (Dsa & Dsb) of the first shift register are made short and is connected to the second pin of the Port C (PC1) of the microcontroller. The clock pin (CP) of the shift register is connected to the first pin of the Port C (PC0) of the microcontroller. Each pair of input pins of the rest three shift registers are made short just like the first one and is connected to the last output pin (Q7) of the immediate previous one. All the output pins of the shift registers are connected to the common cathode of the seven segment displays sequentially.

The SDA and SCL pins of the Real Time Clock is connected to the fifth (PC4) and sixth (PC5) pin of the Port C of the microcontroller. Two pull up registers are also connected to these pins. The SQW pin of the RTC is connected to the fourth pin (PC3) of the Port C of the microcontroller. A 3.2786 MHz crystal is connected to X1 and X2 pins of the RTC and a 3 volt battery is also connected to its V_{bat} and GND pin.

Three input switches are connected to the third fourth and fifth pin of Port D (PD2-PD4) of the microcontroller. These three pins are made ground with three 10kΩ registers.

6. RESULT

After putting all the components on the circuit board and programming the microcontroller the total system looks like as follows.

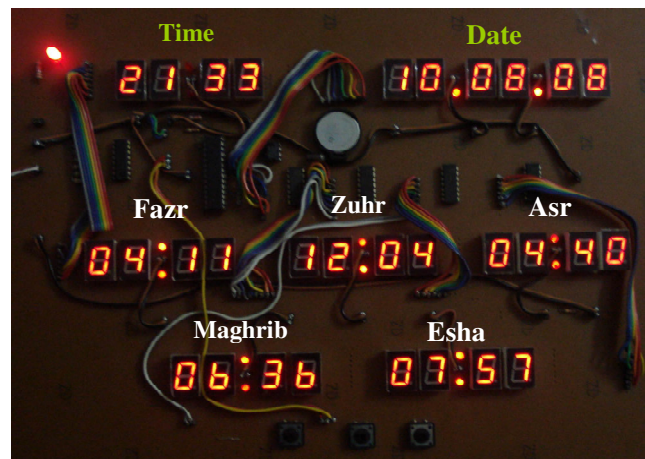


Fig 3: The Artview of the Proposed System

Here the first block of four (top left corner) seven segment displays shows time. First two units of this block represent hour while second two

represent minute. The second block of six (top right corner) seven segment displays represents date where the first, second and third two units of the block represent day, month and year respectively. The remaining five blocks of four seven segment displays represent the prayer times of five salah; Fazr, Zuh, Asr, Maghrib and Esha as labeled in the figure 3. Here each first two units of each block represent hour and the remaining two units of each block represent minute.

There are three buttons: Mode, Up and Down. The Mode button selects which unit of time or date is to be changed. Then the buttons Up and Down are used to count up or down respectively to set the selected unit of time or date.

Scanning technique is a power aware solution for message display. Here we have used 30 seven segment displays. But as scanning technique is applied, at any given time only one seven segment display is on. So, theoretically the system should consume $\frac{1}{30}$ times less power than it would take to make all the seven segment displays on at a time. But following table shows the practical senario.

Table 1: Current and Power Consumption by the Display Elements

Current and Power Consumptin for 30 Units of Seven Segment Displays		
	With Scanning Technique	Without Scanning Technique
Curren Consumption	25mA	75mA
Power Comsumption	0.13 watt	0.375 watt

So, in practical the power consumption is not as less as 30 times of the total power needed. But still it minimizes the power consumption to a considerable amount that is **65% less power** and **66% less current** are required to run the display units of the system when the scanning technique is applied.

Another important point is for the scanning technique only one Display Decoder is used. If this technique is not applied then 30 Display Decoders should be used for 30 seven segment display. Furthermore a microcontroller has limited number of pins. So, a commonly used

microcontroller may not be able to connect all the display decoders at a time due to its fixed number of pins. So, the solution enables a circuit to be operated in less power, less area hence less cost.

7. CONCLUSION AND FUTURE WORKS

Power management has a considerable importance in electronic circuits. In electronic displays, power consumption increases with the size and number of the display units. This project uses scanning technique to reduce power consumption. The embedded system developed as a test case demonstrates a power aware solution using scanning technique. The seven segment displays used as display units consume less power when scanning technique is used. Since the algorithm allows only one display unit to be illuminated at any given time rather than all the units receiving power, it consumes significant less power. The scanning technique in the embedded circuit requires only one Display Decoder for all the display units.

As stated, the project has 30 units of seven segment displays and by using scanning technique the total power consumption is reduced by 30 times (theoretically). But a common question may arise; will this technique work if the number of display units is increased by a significant number (1000 or more)? In that case some flickering will be experienced. This is because human eye can hold an image in the brain for only $\frac{1}{10}$ of a second. So if the scanning frequency is such that each display unit is illuminated for less than $\frac{1}{10}$ of a second, flickering will be observed, that is, power consumption factor will not be inversely proportionate to the number of display units as stated earlier.

To remedy this, the scanning technique can be modified in such way that a group of display units would be considered as a cluster. The total system can have number of clusters. The scanning technique will be applied on these clusters so that each cluster will be turned on at any given time. But in this case we need to use the same number of display decoders as number of display units in a cluster.

In future, the modified scanning technique (clustering approach) can be incorporated in other embedded systems with large number of display units. Some microcontrollers with built-in scanning mechanism are available in the market.

Future works can be done using those microcontrollers.

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DIRECT TORQUE CONTROL OF 4-SWITCH 3-PHASE VOLTAGE SOURCE INVERTER FED INDUCTION MOTOR DRIVE

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Abstract: This paper proposes a direct torque control (DTC) methodology for 4-switch 3-phase (4S3P), voltage source inverter (VSI) fed induction motor (IM) drive. In the proposed approach, instead of a conventional 6-switch, 3-phase inverter (6S3P) a 4S3P inverter is utilized. This reduces the cost of the inverter, the switching losses, and the complexity of the control board for generating pulse width modulated (PWM) signals. Furthermore, the proposed control approach reduces the computation for real time implementation. A proportional plus integral (PI) controller is used to process the speed error for generating reference torque to the IM. Two hysteresis controllers are used for torque and flux loops. The output of these hysteresis controllers with stator flux angle drives the switches into on or off state. Closed-loop control of the stator flux magnitude and the electromagnetic torque of the motor with Clarke's transformation are used in this study. The robustness of the drive system is tested for different perturbed operating conditions and found to work acceptably under these conditions.

Key words: Direct torque control; four switch three phase inverter; induction motor; robustness.

1. INTRODUCTION

More than two decades ago, DTC was introduced to give fast and good dynamic torque response. DTC can be considered as an alternative to the field-oriented control (FOC) technique (Takahashi and Noguchi, 1986, Depenbrok, 1988). In fact, a DTC scheme accomplishes the closed-loop control of the stator flux magnitude and the electromagnetic torque of the motor without the intermediary of any current loop or shaft sensor. To this end, the DTC scheme senses the stator currents and the dc-link voltage and processes them, together with the states of the inverter switches, to estimate the actual values of the controlled variables.

Many technical papers have appeared in the literature since the DTC was introduced in 1986, (Takahashi and Noguchi, 1986) mainly seeking to improve the performance of DTC of induction motor drives. Two of the major issues which are normally addressed in DTC drives are the variation of the switching frequency of the inverter used in the DTC drives with operating conditions and the high torque ripple for using torque hysteresis comparator. To improve the performance of DTC, researchers consider different analytical approaches

(Idris and Yatim, 2004, Casadei et. al., 1998, Bertoluzzo et. al., 2006). Idris and Yatim, 2004 and Casadei et. al., 1998, proposed a constant switching frequency torque controller to replace the conventional hysteresis based controller. In (Bertoluzzo et. al., 2006), the hardware of a DTC scheme is reduced by using only one sensor of current and by inserting it in the inverter dc link.

Nowadays, researchers are working not only for better performance of the drives but also trying to reduce the cost of the drives. Conventional six switch three phase (6S3P) inverters have been widely used for AC motor drives for the last few decades. But the reduction of the number of power transistor switches from six to four reduces the cost of the inverter, decreases the switching losses and complexity of the control algorithms instead of generating six PWM signals (Uddin et. al., 2006, Dzung et. al., 2007). A cost effective four switch three phase (4S3P) inverter is proposed for IM drives in (Uddin et. al., 2006). The authors show a performance comparison of the 4S3P inverter fed drive with 6S3P inverter fed drive in terms of speed response and total harmonic distortion of the stator current. But overshoot and undershoot can not be eliminated in the speed response of the drive system.

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The same authors propose fuzzy logic controller based control scheme for 4S3P inverter fed interior permanent magnet synchronous motor (IPMSM) drive. Vector control of induction motor using 4S3P inverter for high performance industrial drive systems is presented in (Dzung et. al., 2007). The authors verified the complete scheme by simulation and experimentally in a DSP environment.

This paper presents a new technique to improve the performance of direct torque controlled VSI fed IM drive by using four switches in the inverter circuit. A mathematical model of the drive system is utilized to analyze the transient and steady-state responses of the motor. The performance of the induction motor drive under sudden change of load torque and speed reversal condition is also investigated in order to verify the robustness of the proposed control scheme. The proposed 4S3P inverter fed IM drive is found acceptable considering its cost reduction and other advantageous features mentioned earlier.

2. MATHEMATICAL MODEL OF IM

The mathematical model of a 3-phase, Y-connected induction motor is expressed by the following equations in the $\alpha\beta$ stationary reference frame as (Crause et. al., 1995, Boldea and Nassar, 1999).

$$\begin{bmatrix} v_{\alpha s} \\ v_{\beta s} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} R_s + L_s p & 0 & L_m p & 0 \\ 0 & R_s + L_s p & 0 & L_m p \\ L_m p & L_m \omega_r & R_r + L_r p & L_r \omega_r \\ -L_m \omega_r & L_m p & -L_r \omega_r & R_r + L_r p \end{bmatrix} \begin{bmatrix} i_{\alpha s} \\ i_{\beta s} \\ i_{\alpha r} \\ i_{\beta r} \end{bmatrix} \quad (1)$$

$$T_e = \frac{3}{2} P_p (i_{\alpha r} [L_m i_{\beta s} + L_r i_{\beta r}] - i_{\beta r} [L_m i_{\alpha s} + L_r i_{\alpha r}]) \quad (2)$$

$$T_e = J \frac{d\omega_m}{dt} + B \omega_m + T_L \quad \text{and} \quad \omega_m = \frac{\omega_r}{P_p} \quad (3)$$

Where $v_{\alpha s}, v_{\beta s}$ are $\alpha\beta$ -axis stator voltages, respectively; $i_{\alpha s}, i_{\beta s}$ are $\alpha\beta$ -axis stator currents, respectively; $i_{\alpha r}, i_{\beta r}$ are $\alpha\beta$ -axis rotor currents, respectively; R_s, R_r are the stator and rotor resistances per phase, respectively; L_s, L_r are the stator and rotor inductances per phase, respectively; L_m is the mutual inductance, ω_e, ω_r and $\omega_{sl} (= \omega_e - \omega_r)$ are the synchronous, rotor, and slip angular speeds, respectively; P_p is the number of pole pairs, p is the differential operator, T_e is the electromagnetic developed torque, T_L is the load

torque, J is the rotor inertia, and B is the rotor damping coefficient.

3. FOUR SWITCH THREE PHASE INVERTER MODEL

In the 4-switch inverter, as shown in Fig. 1 a three phase system is obtained by connecting the phase 'c' terminal of the stator windings directly to the centre tap of the DC link capacitors. The single phase AC supply is rectified by the front-end rectifier. The capacitors are used to level the output DC voltage. The three phase voltages to the IM motor can be expressed as follows (Uddin et. al., 2006):

$$V_a = \frac{V_{dc}}{3} [4S_a - 2S_b - 1] \quad (4)$$

$$V_b = \frac{V_{dc}}{3} [4S_b - 2S_a - 1] \quad (5)$$

$$V_c = \frac{2V_{dc}}{3} [-S_a - S_b + 1] \quad (6)$$

Where, V_{dc} is the maximum voltage across the DC link capacitors, S_a and S_b are the switching states (0 or 1) of upper switches in the legs of phases 'a' and 'b' respectively.

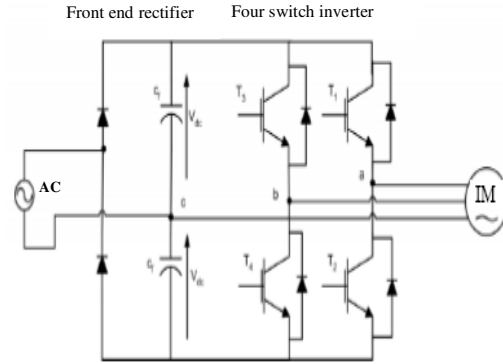


Fig. 1: 4-switch 3-phase inverter fed IM drive.

4. DIRECT TORQUE CONTROL SCHEME

The block diagram of a direct torque controlled IM drive system with the 4S3P inverter is shown in Fig. 2. The basic principle of DTC is to directly select stator voltage vectors according to the differences between the reference and actual torque and stator flux linkage. The stator flux linkage is calculated by integrating of difference between the input voltage and the voltage drop across the stator resistance as given by

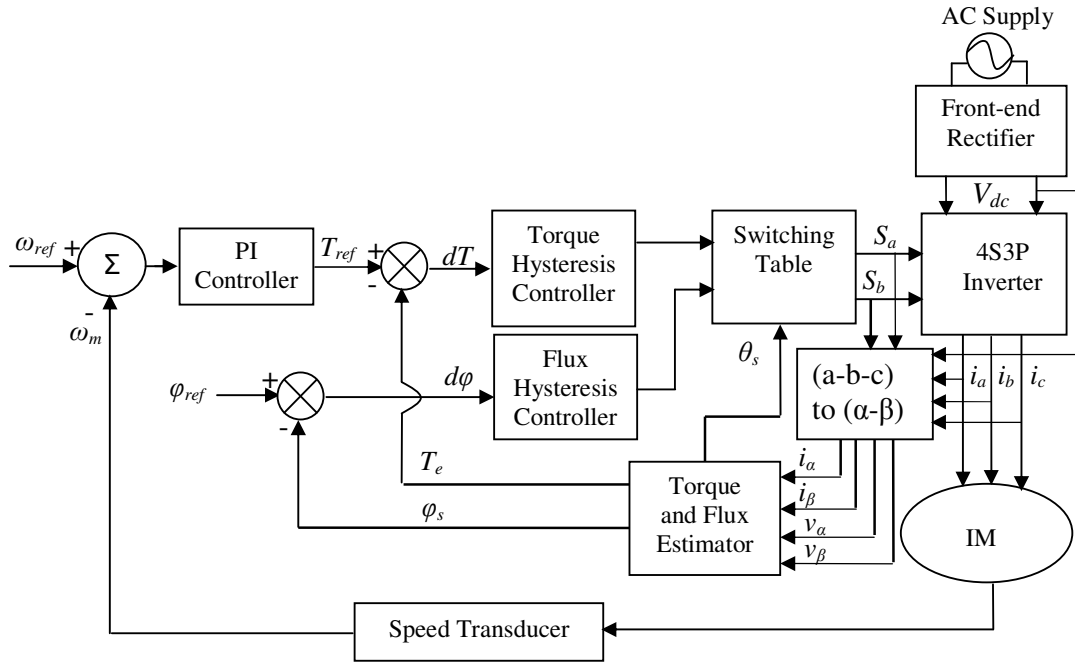


Fig. 2: System diagram of direct torque controlled IM drive.

$$\varphi_s(t) = \int_0^t (v_s - R_s i_s) dt \quad (7)$$

Where, v_s , i_s , and φ_s are the stator voltage vector, stator current vector, and stator flux vector, respectively.

The stationary 3-axes (a-, b-, c-) to stationary 2-axes (α -, β -) transformation is given by

$$x_{\alpha s} = x_a - 0.5 x_b - 0.5 x_c \quad (8)$$

$$x_{\beta s} = \frac{\sqrt{3}}{2} (x_b - x_c) \quad (9)$$

Where, x is either voltage or current vector.

The stationary α - and β - axis components of stator flux vector φ_s can be obtained as follows:

$$\varphi_{\alpha s}(t) = \int_0^t (v_{\alpha s} - R_s i_{\alpha s}) dt \quad (10)$$

$$\varphi_{\beta s}(t) = \int_0^t (v_{\beta s} - R_s i_{\beta s}) dt \quad (11)$$

The stator flux linkage vector is given by

$$\varphi_s = \sqrt{(\varphi_{\alpha s})^2 + (\varphi_{\beta s})^2} \quad (12)$$

and the angle θ_s is written as

$$\theta_s = \tan^{-1} \left(\frac{\varphi_{\beta s}}{\varphi_{\alpha s}} \right) \quad (13)$$

The electromagnetic torque can be estimated as follows:

$$T_e = \frac{3}{2} P_p (\varphi_{\alpha s} i_{\beta s} - \varphi_{\beta s} i_{\alpha s}) \quad (14)$$

The voltage vector plane of a 4-switch inverter fed system is divided into four sectors as shown in Fig. 3 (Ivonne et. al., 2008). When the flux linkage vector stands in sector S_1 , the application of voltage vector V_1 will increase the flux linkage amplitude and decrease the torque, whereas V_2 increases the flux linkage amplitude and increases the torque. Following this principle, a voltage vector switching table for the 4-switch inverter fed DTC system can be tabulated in Table 1. The torque and flux hysteresis comparators are two valued comparators and the output of these comparators are denoted as τ and Φ , respectively. τ or $\Phi = 0$ means that the actual values of these variables are above the reference and out of the hysteresis limit and τ or $\Phi = 1$ means that the actual values of these variables are below the reference and out of the hysteresis limit.

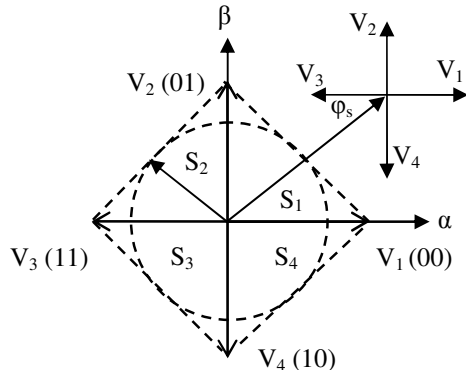


Fig. 3: Voltage vectors of a 4-switch 3-phase inverter fed system.

Table 1 Voltage vectors table

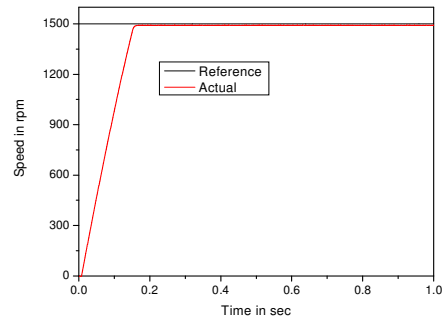
ϕ	τ	S_1	S_2	S_3	S_4
0	0	V_4	V_1	V_2	V_3
0	1	V_3	V_4	V_1	V_2
1	0	V_1	V_2	V_3	V_4
1	1	V_2	V_3	V_4	V_1

5. SIMULATION RESULTS

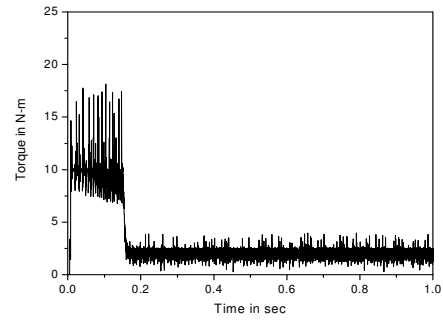
The effectiveness of the proposed control scheme has been verified by computer simulations under different operating conditions. A simulation model of the IM has been developed in the C++ environment. The name plate rating and motor parameters used in this simulation study are given in Appendix.

5.1 Starting Performance of the Proposed IM DTC Drive

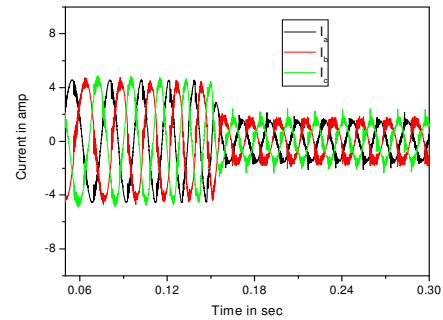
The motor was started with a command speed of 1500 rpm and load torque of 1.0 N-m from standstill condition. The motor reaches to the command speed at 0.16 second. Fig. 4 (a) shows the speed response of the proposed direct torque controlled IM drive. The actual speed follows the command speed accurately without steady-state error and oscillations. Fig. 4 (b) shows the estimated electromagnetic torque. It is observed that higher electromagnetic torque is generated during the motor acceleration. Difference between developed and load torques is due to viscous damping torque of the drive system. Fig. 4 (c) shows the starting current as well as the steady state current response and Fig. 4 (d) shows the trajectory of the stator flux linkage.



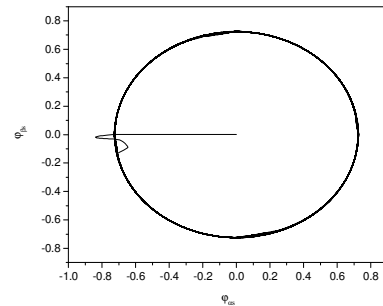
(a)



(b)



(c)

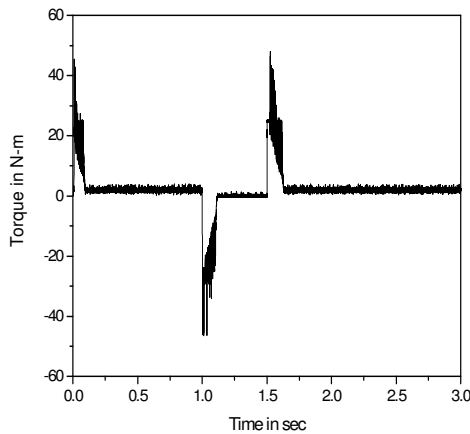
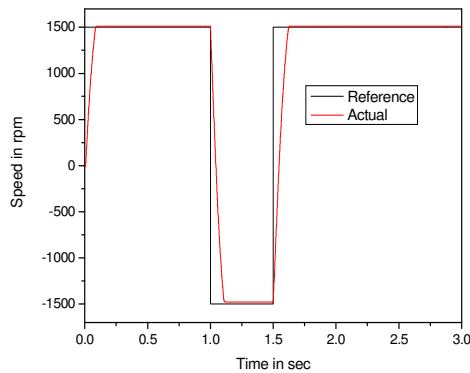


(d)

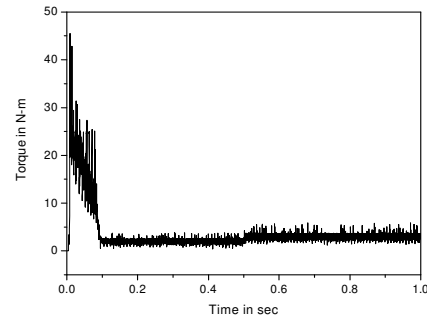
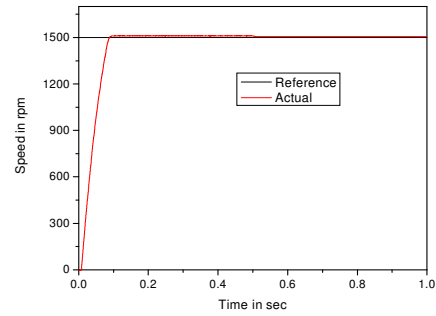
Fig. 4 (a) Simulated speed response, (b) Developed electromagnetic torque, (c) Current response, and (d) stator flux locus for the proposed 4S3P VSI-fed IM drive at a load torque 1.0 N-m.

5.2 Performance under Sudden Load and Speed Changes

The performance of the IM drive under different operating conditions was also investigated in order to verify the robustness of the proposed control scheme. Fig. 5 (a) shows the speed and torque response of proposed drive under speed reversal condition. It is observed that the motor speed follows the reference speed without any overshoot or undershoot. The load torque of the motor was suddenly increased from 1.0 Nm to 2.0 Nm at 0.5 second and corresponding speed and torque response are shown in Fig. 5(b). No dip in the speed response indicates the robustness of the proposed controlled drives against load disturbances.



(a)



(b)

Fig. 5 Simulated speed and torque response for the 4S3P VSI-fed IM drive for (a) speed reversal, and (b) change of load torque from 1.0 N-m to 2.0 N-m at $t=0.5$ sec.

6. CONCLUSION

A direct torque control methodology for 4-switch 3-phase inverter fed induction motor drive is presented in this paper. The control system needs very simple structure and is capable to estimate the torque and the stator flux acceptably. The results obtained and presented in this work indicate that the proposed control scheme produces very fast response of the IM drive without any overshoot and undershoot. The drive is also robust to load disturbances, and speed reversal conditions. Thus the proposed low cost control scheme is suitable for industry applications.

APPENDIX

The motor parameters are summarized below:

Rating: 3-phase, 1 hp, 415 V, 1.8A, 2-pole pair.

Parameters:

Stator resistance, $R_s = 13.25 \Omega$

Rotor resistance, $R_r = 16.818 \Omega$

Mutual inductance, $L_m = 0.7114 \text{ H}$

Stator self inductance, $L_s = 0.7359 \text{ H}$

Rotor self inductance, $L_r = 0.7359 \text{ H}$

Moment of inertia, $J = 0.0075 \text{ Kg-m}^2$

Damping coefficient, $B = 0.00107 \text{ Nm-sec/rad}$

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Economic impact of installing solar concentrator technology in rural Bangladesh

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This paper studies the viability of use of solar concentrator technology in solar cells for producing more electricity. Last couple of year many researchers are try to out a good result in solar electricity, we believe that we have made substantial progress towards providing a more flexible solar concentrator technology, which gives us more powerful electricity than usual solar electricity plant. Solar concentrator technology uses a large area of lenses or mirrors to focus sunlight on a small area of photovoltaic cells. This paper main focus on cost reduce and more electricity. We believe that it is possible to produce more than 35%-40% electricity at less than 30% of the present cost. This technology is more important for Bangladesh especially for rural area of Bangladesh, where electricity is not available.

Key words: PV system; CPV; concentrated technology; PV cost:

1. INTRODUCTION

Concentrator photovoltaic (CPV) systems use a large area of lenses or mirrors to focus sunlight on a small area of photovoltaic cells. If these systems use single or dual-axis tracking to improve performance, they may be referred to as Heliostat Concentrator Photovoltaics (HCPV). The primary attraction of CPV systems is their reduced usage of semiconductor material which is expensive and currently in short supply. Additionally, increasing the concentration ratio improves the performance of general photovoltaic systems.

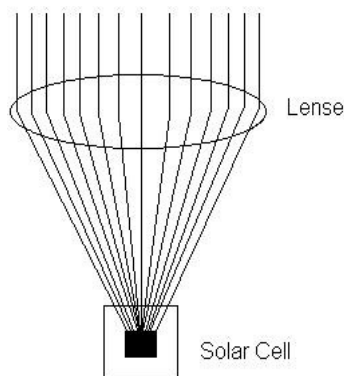


Fig: 1- A solar cell in sunlight collecting

Despite the advantages of CPV technologies their application has been limited by the costs of focusing, tracking and cooling equipment. However some of the ambitious projects using CPV technologies are taken in different parts of the world. [1]

2. Solar tracking technique for CPV

In CPV system sun light tracking is an important section. The popular and simple sun light tracking systems are given below.

2.1. Parabolic trough concentrator

A parabolic trough is a type of solar thermal energy collector. It is constructed as a long parabolic mirror (usually coated silver or polished aluminum) with a Dewar tube running its length at the focal point. Sunlight is reflected by the mirror and concentrated on the Dewar tube. The trough is usually aligned on a north-south axis, and rotated to track the sun as it moves across the sky each day. Alternatively the trough can be aligned on an east-west axis; this reduces the overall efficiency of the collector, due to cosine loss, but only requires the trough to be aligned with the change in seasons, avoiding the need for tracking motors. This tracking method works correctly at the spring and fall equinoxes with errors in the focusing of the light at other times during the year (the magnitude of this error varies throughout the day, taking a minimum value at solar noon). There is also an error introduced due to the daily motion of the sun across the sky, this error also reaches a minimum at solar noon. Due to these sources of error, seasonally adjusted parabolic troughs are generally designed with a lower solar concentration ratio. In order to increase the level of alignment, some measuring devices have also been invented. Heat transfer fluid (usually oil) runs through the tube to absorb the concentrated sunlight. This increases the temperature of the fluid to some 400°C. The heat transfer fluid is then used to heat

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steam in a standard turbine generator. The process is economical and, for heating the pipe, thermal efficiency ranges from 60-80%. The overall efficiency from collector to grid, i.e. (Electrical Output Power)/(Total Impinging Solar Power) is about 15%, similar to PV (Photovoltaic Cells)

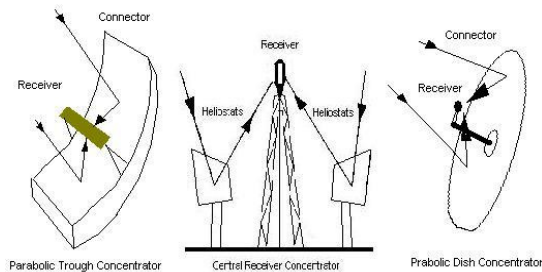


Fig:-2 Solar tracking technique.

2.2. Parabolic dish concentrator

A dish system uses a large, reflective, parabolic dish (similar in shape to satellite television dish). It focuses all the sunlight that strikes the dish up onto to a single point above the dish, where a receiver captures the heat and transforms it into a useful form. Typically the dish is coupled with a Stirling engine in a Dish-Stirling System, but also sometimes a steam engine is used. These create rotational kinetic energy that can be converted to electricity using an electric generator. [2]

The advantage of a dish system is that it can achieve much higher temperatures due to the higher concentration of light (as in tower designs). Higher temperatures lead to better conversion to electricity and the dish system is very efficient on this point. However, there are also some disadvantages. Heat to electricity conversion requires moving parts and that result in maintenance. In general, a centralized approach for this conversion is better than the decentralized concept in the dish design. Second, the (heavy) engine is part of the moving structure, which requires a rigid frame and strong tracking system. Furthermore, parabolic mirrors are used instead of flat mirrors and tracking must be dual-axis.

2.3. Power tower concentrator

Power towers (also known as 'central tower' power plants or 'heliostat' power plants) capture and focus the sun's thermal energy with thousands of tracking mirrors (called heliostats) in roughly a two square mile field. A tower resides in the center of the heliostat field. The heliostats focus concentrated sunlight on a receiver which sits on top of the tower. Within the receiver the concentrated sunlight heats molten salt to over 1,000 °F (538 °C). The heated molten salt then flows into a thermal storage tank where it is stored, maintaining 98% thermal

efficiency, and eventually pumped to a steam generator. The steam drives a standard turbine to generate electricity. This process, also known as the "Rankine cycle" is similar to a standard coal-fired power plant, except it is fueled by clean and free solar energy.

The advantage of this design above the parabolic trough design is the higher temperature. Thermal energy at higher temperatures can be converted to electricity more efficiently and can be more cheaply stored for later use. Furthermore, there is less need to flatten the ground area. In principle a power tower can be built on a hillside. Mirrors can be flat and plumbing is concentrated in the tower. The disadvantage is that each mirror must have its own dual-axis control, while in the parabolic trough design one axis can be shared for a large array of mirrors. [3]

3. Advance of CPV system

The largest solar electric generating plant in the world produces a maximum of 354 megawatts (MW) of electricity use CPV system and is located at Kramer Junction, California. Another plant is under construction in California of 850 MW under California energy commission. In Sothorn Nevada City have 110MW electric plant using Concentrating solar system. There is also small electricity producing plant in Austin city its produce 60 MW electricity. Now a day's USA are work with CPV system to produce more and more electricity.

3.1. Comparison between CPV and conventional Solar system:

	Solar CPV system	conventional Solar system
Size	Small	Big
Effective area	Very Big.	Normal.
Efficiency	High.	Low.
Construction	Simply hard.	Easy construction.
Capture ability	Sun light can be captured easily and quickly.	Sun light can be captured easily but not quickly.
Charging capability	Need 5-6 hour sunlight to charge a	Need 8-10 hour sunlight to charge a

	battery.	battery. [4]
Current capacity	For a given size we obtain minimum 40% more current then a conventional solar cell system. [5]	For a given size we obtain minimum 40watt current.
Reduced cost	It is possible to reduce 30% cost to use concentrating photovoltaic system (CPV) in solar panel.	The price of a solar system ranges from 25,000 taka (\$360) to 65,000 taka (\$940) depending on capacity. [6]

Table 1 shows a comparison between conventional solar system (PV) and Concentrator Photovoltaic technologies. A CPV system provides more economic and powerful electricity. By using solar concentrator technology we can get much more current than normal solar cells. An important aspect of CPV system is it delivers more solar power from a compact size of system which eliminates the need to build larger systems occupying big areas.

3.2. PV system Efficiency

Figure:-3 show the development of efficiency of different types of PV systems. Its is evident from the graph that the efficiency of a CPV system is much higher then a convention system.

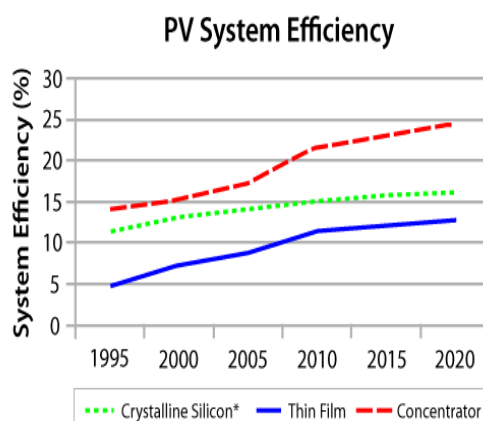


Fig-3: efficiency difference of PV system.

As conventional solar systems are still relatively expensive, but using highly efficient CPV systems will reduce the cost by 30%. [7]

4. Solar Photovoltaic (PV) technology in Bangladesh

Rural electrification through solar PV technology is becoming more popular, day by day in Bangladesh. Today, more than 230,000 households are using solar powered systems in Bangladesh. [8] Giving rise to opportunities for a whole new generation of entrepreneurs to make use of this new power supply for the poor Infrastructure.

Solar Home Systems (SHSs) are highly decentralized and particularly suitable for remote, inaccessible areas. In Bangladesh Solar program mainly targets those areas, which have no access to conventional electricity and little chance of getting connected to the grid within 5 to 10 years. It is one of its most successful programs.

Currently, SHSs can be used to light up homes, shops, fishing boats etc. It can also be used to charge cellular phones, run televisions, radios and cassette players. SHSs have become increasingly popular among users because they present an attractive alternative to conventional electricity such as no monthly bills, no fuel cost, very little repair, maintenance costs, easy to install any where etc.

4.1. Solar electricity necessary in rural area

This is some of the impact electricity is bringing to people's lives the people of rural Bangladesh need electricity badly to improve their life. Basically it is quite impossible to live up without electricity. Another most important thing is they are not economically well of so if they use electricity they can save there money to use costly fuel. Time spent by a child on studying is likely to be increased by about 6 percent under electric lighting than when kerosene lamp or dry cell battery is used.

Increase of electricity use at home leads to a decrease of 20 percent in children's school-days missed caused by illness, compared to non-electrified areas; Electricity use at home makes 18 percent more time available per day for listening to radio compared to areas without electricity. Time spent on household chores decrease by 6 percent in the electrified households compared to non-electrified households. [4]

Use of electricity at home increases the incidence of home business by about 8 percent compared to non-use of electricity at home. More security and income generation opportunities including reduced work load for women. Businesses such as rice mills, saw mills, grocery, tailoring shops, restaurants, market places etc with the help of SHSs have increased their income by extending working

hours after dusk. PV systems have opened up new opportunities for employment and income generation activities, such as community television centers, electronic repairing shops, mobile phone shops etc.

4.2. Bangladesh problem and opportunities

About 80% of the people in Bangladesh live in villages where the main source of income is agriculture. Another income source is fishing and small business. [9]

Most of the people are living below in average income level. In our country maximum village are not connected with national grids to give or served current to our rural area people.

This is really too hard to use solar panel to electricity at present costing rate. Most of these people are deprived of electricity, which is a necessity in today's life. Getting grid electricity to these villages has proved to be beyond their reach, thus making it much more reasonable to turn to renewable energy (which is available in Abundance and cheaper) for electrification.

Solar electricity of solar concentrator technology is very important in our country, there are no another way to develop our country or cant live properly without solar current.

Only 30% of the total population having access to the grid electricity clearly indicates the acute shortage of electrical power in Bangladesh. The scenario is far worse in rural areas Due to the shortage of power. Our country is one of the poor countries in the world, so economic problem is one of the major problems to develop national grid. We don't have much electricity to fill our expectation, and Bangladesh is the land of river, this is another reason of our country why the government face problem to develop electricity in all over the Bangladesh, for the reason of big river don't go there national grid line.

Bangladesh receives about 300 clear sunny days per year, [10] and this is enough to produce an enormous amount of solar energy in a sustainable way. For this reason, it is easy to develop solar electricity of solar concentrator technology forward in the right direction.

This is our great opportunity that we get more than 300 days sun light, if we able to set our solar concentrator technology than we can reduce energy source like fuel and gas. In our country Average solar radiation varies between 4 to 6.5 kWhm⁻²day⁻¹. And Maximum amount of radiation is available in the month of March-April and minimum in December-January.

4.3. Current status of solar electricity in Bangladesh

The Government of Bangladesh aims at providing electricity to its entire rural population by 2020 to help boost up social development and economic growth. In 2002, access to electricity in Bangladesh was about 30 percent. With the Rural Electrification Board connecting about 40,000 consumers every year, it would take more than 35 years to provide access to electricity to all. Furthermore, it is physically difficult and economically not feasible to bring the whole country under a grid based on electricity network because Bangladesh is a delta with more than 400 rivers. [11]. Access to electricity has increased to 38% from 30% in 2004. At the same time 80,000 consumers had been provided with Solar Home Systems (SHS), surpassing the original target of 50,000.

These households, connected by SHS, would have never received electricity if only conventional electrification methods had been used. Access to electricity has increased to 41% from 38% in 2006. Grameen Shakti (GS) and Rahim Afrooz are giving the rural people solar panel. GS has developed one of the most successful projects for popularizing Solar Home Systems to millions of rural villagers. Currently GS is one of the largest and fastest growing rural based renewable energy companies in the world. As of July 2007, GS has installed more than 100,000 SHSs in rural areas with more than 4000 SHSs installed per month. This success especially was the result of unique approach, blending market and social forces together to take world's most up to date technology to the rural people. The cost of a single unit of PV system as supplied by GS and RA is about 25000/- to 60000/- by capacity range of solar cell.

By using solar concentrator technology it is possible to reduce cost and get more current. If we use this technology we can reduce 30% [6] costs and get more electricity. This technology helps our rural people to get current. They waste their money. But they can't get proper light. To use this technology this people can change their life.

4.4. Comparison of costs between convention PV & Concentrator PV (CPV) systems

The following table contains a comparison between the cost of a CPV and normal PV system. Introduction of CPV system would reduce 1656 million taka from the period 2005/6 – 2009/10). The saving is noticeably large which could be reinvested in solar electricity to increase number of clients.

Year	Number of users	Total cost (Million Taka)		Cost reduction (Million Taka)
		PV system	CPV system	
2005/6	85000	680	476	
2007/8	215000	1720	1204	
2009/10	390000	3120	2184	
5 Years		5520	3864	1656

** The PV system user data and PV system cost collected from Grameen Shakti.

5. CONCLUSIONS

It is evident from the study that using concentrators on conventional solar photovoltaic systems increase the performance of the system. It increases the Efficiency, Sun tracking for increased energy production. It increases supply of solar electricity which is proved to be efficient and very cost effective for rural Bangladesh. If the Bangladesh use of concentrator technology (CPV) could be ensured then it would increase 40% more electricity and reduce 30% cost compared to conventional systems.

Introduction of the PV to CPV systems from the period 2005/6 to 2009/10, about more than one Lac household could be brought under solar electricity without spending addition money. I want say if solar electric generating plant established using CPV in rural area than it possible to remove darkness in our country to fulfill electricity demand, where national grid is not reached. Again focus in Bangladesh weather more than 300 sunny days in a year, so this is huge opportunity to build solar electric plant use CPV technology.

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Electrical, Hall Effect and optical properties of undoped Co thin films

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Undoped Co thin films have been prepared onto glass substrate by e-beam evaporation in vacuum at about 2×10^{-4} Pa. The thickness of the films ranges from 50 to 200 nm. The deposition rate of the films was about 0.93 nm s^{-1} . The as-deposited films have been annealed in open air for 4 hours at constant temperature of 523 K. Electrical resistivity for the as-deposited and annealed films has been measured as a function of temperature ranging from 303 to 451 K. The resistivity of as-deposited films on glass substrate is found to increase from 8.51 to $3.32 \mu\Omega\text{-m}$ as the thickness of the films increased from 50 to 200 nm. The resistivity of the films on glass substrate is increased after annealing. The activation energy is found to decrease with increasing film thickness. On the other hand, the grain size is increased with increasing film thickness. The activation energy of 50nm as-deposited Co film on glass substrate was found to 0.027 eV. It is decreased to 0.0086 eV for 200nm film. The grain size was found to increase with increasing film thickness. The Hall Effect measurement showed that the Hall coefficient of Co films on glass substrate is decreased with increasing film thickness. It is found to increase after annealing for both Co films on glass substrate. The carrier concentration was $13.3 \times 10^{19} \text{ cm}^{-3}$ for 100nm Co film on glass substrate. The refractive index is found to decrease with increasing film thickness for both as-deposited and annealed films on glass substrate. It is observed that the dielectric constant is strongly depends on thickness of the films. It is about 10 for 50 nm but decreased to only 2 for 200 nm films. These studies may be of importance for the application of this material in electronic and magnetic storage devices and magnetic sensor. Co thin films have been produced by electron beam bombardment heating technique and thickness measures in Fizeau fringes method. Electrical resistivity and Hall Effect studies are measured Van-der-Pauw technique. Optical studies is measured by Murman method.

Key words: Hall Effect, Dielectrice, Refractive index, Carrier, Mobility.

1. INTRODUCTION

Research and development on thin films has led to the conclusion that different classes of materials are of particular interest for different applications. Cobalt is of particular interest because the material has in recent a variety of applications spin-FET[1], spin-valve transistors[2-3], head for magnetic hard disk drives[4], MRAM[2,5], GMR[6,7,8-14], TMR[15-18], magnetic field sensor[19-21]. A large value of GMR ratio observed at room temperature in sputtered sample of Co/Cu layered structure if the Cu spacer layer thickness is chosen to make the oscillatory exchange coupling between Co layers [22-24]. Incorporating a ferromagnetic component into an integrated electronic device structure offers several advantages [25]. Therefore, an understanding of growth and micro-structural evolution of Co thin

layers, their corresponding crystal structures and associated magnetic and transport properties are of great technological interest. However, as per the best of our knowledge no report available in the literature correlates electrical, Hall Effect and optical properties of Co thin films on glass substrates. Therefore, in the present work, we have studied the electrical, Hall Effect and optical properties of Co thin films deposited on these substrates. The results obtained from different characterization techniques are analyzed and discussed.

2. EXPERIMENTAL

Undoped Co thin films have been produced onto glass substrates by electron beam bombardment heating technique in vacuum at about 2×10^{-4} Pa from pure solid Co obtained Japan. Before

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deposition, the deposition chamber was thoroughly cleaned with emery paper and cotton wool by wetting acetone and was then dried with a dried with a dryer. A small quantity of source materials was loaded into clean cermet hearth based on the source turret. The glass substrates were then first cleaned in chromic acid solution and then washed in distilled water. After washing and drying in hot air, the substrates were then again cleaned in acetone and dried in hot air, and were then again cleaned in acetone and dried in hot air, and were then used for deposition. Finally, the cleaned substrates were placed on the substrate holder about 0.1m above the source turret and the chamber bell-jar was placed on the base plate. A mechanical shutter was operated from outside, isolated the substrates from the evaporants. When the chamber pressure reduced about 2×10^{-4} Pa, the deposition was then started with 30mA by turning on the low-tension control switch. All films were deposited at room temperature.

3. EFFECT OF CURRENT ON DEPOSITION

To assess the effect of chamber current on deposition conditions, five Co films of variable thickness were deposited at variable current. The variation of deposition rate with deposition current Co thin films on glass substrate is shown in Fig-1. From this graph, it is seen that the deposition rate increases with increasing deposition current at constant time of 25sec. At higher current more samples evaporates from the source thus the deposition rate increases [26].

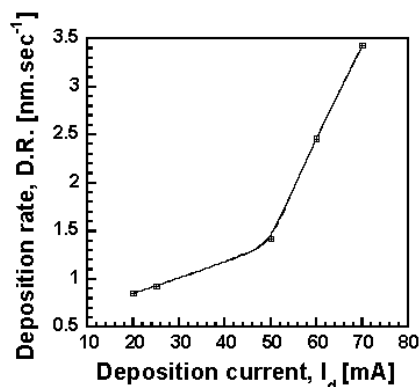


Fig-1: Variation of deposition rate with deposition current of Co thin films on glass substrate.

4. RESULTS AND DISCUSSION

In this section the results and discussions of various experimental studies on Cobalt thin films have been presented step by step. A brief description of electrical properties has been seen on variation of

resistivity, temperature coefficient of resistance with temperature and variation of $\ln \sigma$ with inverse temperature, variation of activation energy and grain size with thickness, size effect of co thin film. It is also seen that Hall Effect studies like variation of hall coefficient, carrier concentration with magnetic field. A brief description of optical studies is observed on variation of transmittance, refractive index and dielectric constant with wavelength.

4.1 ELECTRICAL PROPERTIES OF Co THIN FILMS

The resistivity of as-deposited Co thin films of thicknesses 50, 100 and 200 nm are shown in Fig-2(a). After annealing Co thin films of thickness 100 and 200nm, the resistivity is represented in Fig-2(b). The resistivity is changed with temperature for both as-deposited and annealed films. It is seen from the graphs that the values of resistivity increase with increasing temperature. This type of variation indicates the metallic behavior of the films[27]. It is evident from the graph that the resistivity increases when film thickness decreases. This follows Funchs-Sondheimer size effect theory [28-29].

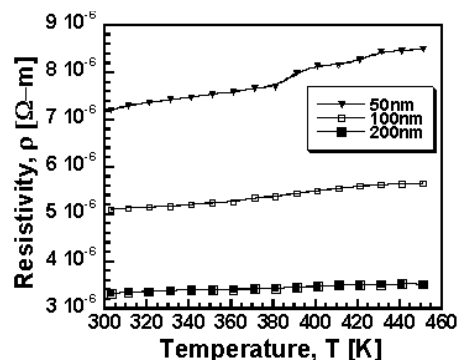


Fig-2(a): Variation of resistivity with temperature for as-deposited Co thin films on glass substrate.

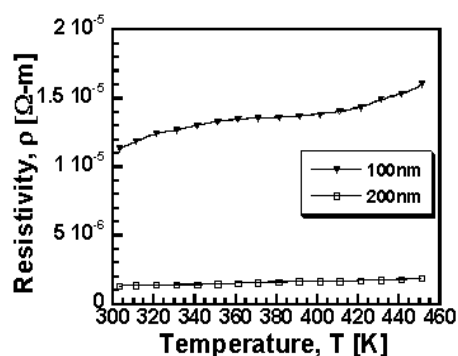


Fig-2(b): Variation of resistivity with temperature for annealed Co thin films on glass substrate.

Variation of Temperature Coefficient of Resistance (TCR) with temperature for both as-deposited and annealed Co films on glass substrate is shown in Fig-3(a) and 3(b). It is seen from the graphs that for both the cases the TCR is positive, which indicates, that films are metallic. The TCR value is anomalous for both the cases with variation temperature [30].

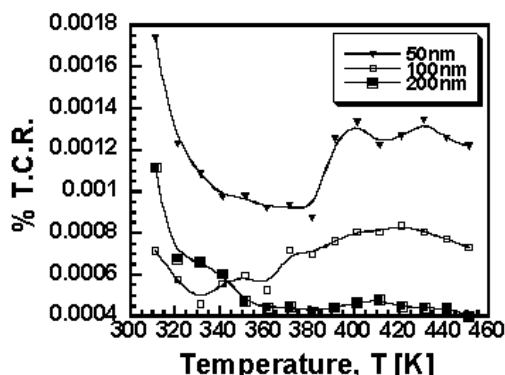


Fig-3(a): Variation of T. C. R (%) with temperature for as-deposited Co thin films on glass substrate.

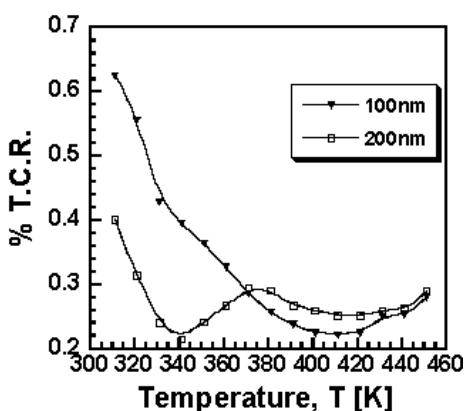


Fig-3(b): Variation of T. C. R (%) with temperature for annealed Co thin films on glass substrate.

It is observed that $\ln \sigma$ vs. $1/T$ curve is a linear and it is increased with inverse temperature for the as-deposited Co films. Grain sized is related to the potential barrier and according to Garter [31] grain size is inversely proportional to the activation energy. It is seen from Fig-4 and table-1 that the activation energy is found to decrease for Co films. It is also seen from the graphs that the grain size is increased with increasing film thickness. These agrees with the fact that the grain size depends on a lot of factors such as deposition condition, annealing temperature, dislocations, minor defects, stacking faults etc [32].

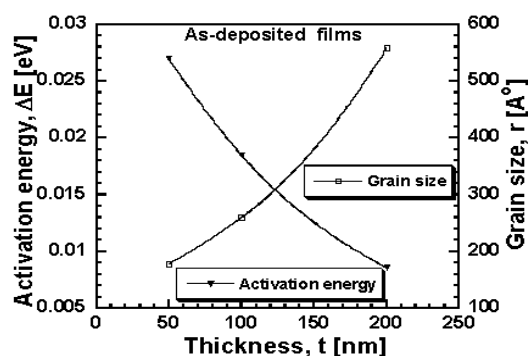


Fig-4: Variation of activation energy and grain size with thickness for as-deposited Co thin films on glass substrate.

Table-1: Activation energies and grain sizes evaluated for Co thin films.

Thickness, t [nm]	Activation energy		Grain size	
	Activation energy, ΔE [eV]		Grain size, r [Å]	
	As-deposited	Annealed	As-deposited	Annealed
50	0.027		177.78	
100	0.0185	0.0123	259.46	390.24
200	0.0086	0.0371	558.14	129.38

Variation of $\ln \sigma$ with thickness for Co films is shown in Fig-5. It is observed that the conductivity increases sharply with thickness up to 200 nm and above this there is no remarkable change in conductivity. The thickness dependence of conductivity is well in conformity with Fuchs-Sondheimer theory [27-28, 33-34].

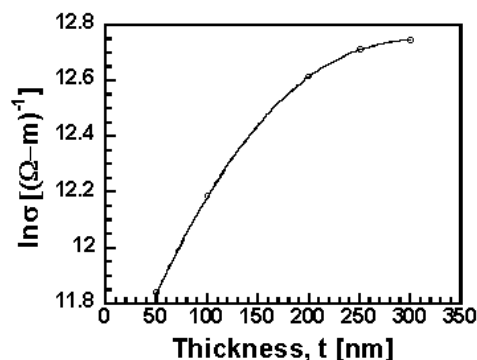


Fig-5: Variation of $\ln \sigma$ versus thickness for undoped Co thin films on glass substrate.

According to the theory of size effect, during the growth of the film discrete islands are formed on the substrate result in discontinuous film. The scattering of conducting electrons become large for this growth. In fact the film is highly resistive. But due to increase of the film thickness it become continuous, as a result the conductivity of the films

is increased. The conductivity of the films at the lower thickness may decrease sharply due to surface scattering. In addition to surface scattering, the usual lattice defect and grain boundary significantly contribute to conductivity. For the films at higher thickness increases in conductivity may be due to the formation of large crystallites. This type of work is done as NiO [35].

4.2 HALL EFFECT STUDIES OF Co THIN FILMS

Hall effect studies for both the as-deposited and annealed Co thin films on silicon and glass substrates have been carried out by Van-der-paw [36] technique. The effect of magnetic field on various parameters has been investigated by the Hall studies.

The Hall coefficient of as-deposited Co thin films of thicknesses 50, 100 and 200 nm are shown in Fig-6(a). The Hall coefficient of annealed Co thin films of thicknesses 100 and 200 nm, the Hall coefficient is represented in Fig-6(b). It is seen from the Figures that for both the cases Hall coefficient is always positive [37]. This indicates that the carrier in the Co thin films is always holes. It is also evident from the Figures that the Hall coefficient increases with increasing applied magnetic field. It is revealed that Hall coefficient is higher for films of lower thickness. After annealing, Hall coefficient increases from that for as-deposited films.

Fig-7(a) and 7(b) represent the variation of carrier concentration with magnetic field of Co thin films on glass substrate. It is observed from the Figures that for as-deposited films carrier concentration is lower than annealed films. It is also evident that for both the cases carrier concentration decreases with increasing applied magnetic field. Both the carrier concentration increase monotonically with the concentration of Co increased [38].

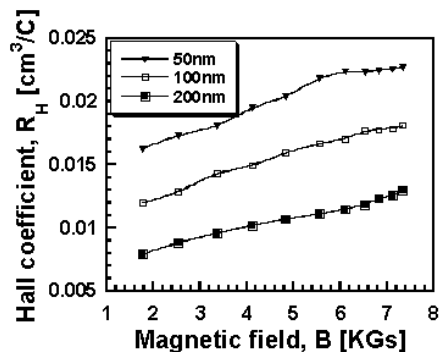


Fig-6(a): Variation of Hall co-efficient with applied magnetic field for as-deposited Co thin

films on glass substrate.

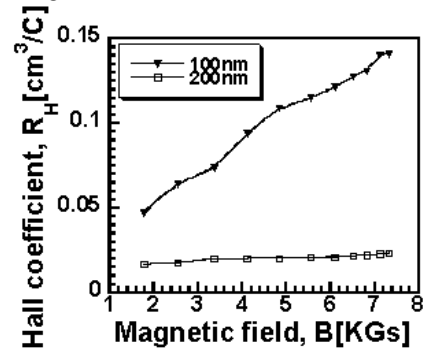


Fig-6(b): Variation of Hall co-efficient with applied magnetic field for annealed Co thin films on glass substrate.

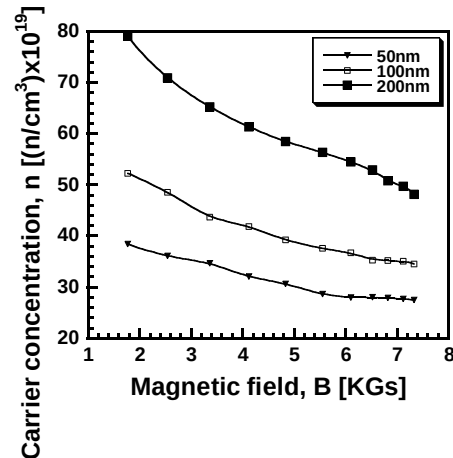


Fig-7(a): Variation of carrier concentration with applied magnetic field for as-deposited Co thin films on glass substrate.

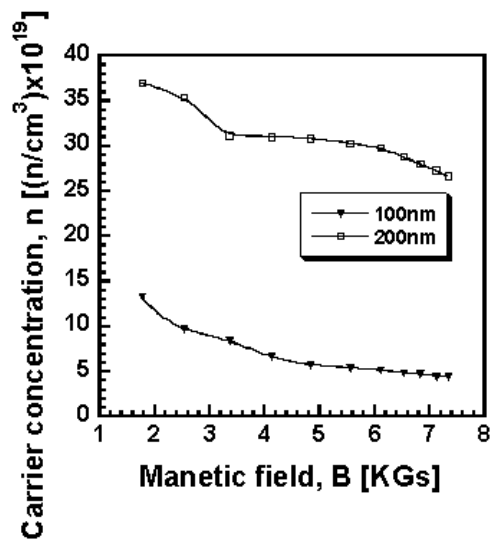


Fig-7(b): Variation of carrier concentration with applied magnetic field for annealed Co thin films

on glass substrate.

4.3 OPTICAL PROPERTIES OF Co THIN FILMS

Spectral transmittance $T(\lambda)$ and near normal reflectance $R(\lambda)$ of Co thin films on glass substrate have been measured at wavelength $370 < \lambda < 1100$ nm using SHIMADZU UV-visible spectrophotometer.

Fig-8 shows the variation of refractive index with wavelength of incident light. It is clear from the Figure that the refractive index increases with increasing wavelength but it is decreased with increasing film thickness. The value of refractive index of 200nm as-deposited film is 1.3 but it is increased to 1.8 for 50nm films at 400nm wavelength. Refractive index is non linear [39].

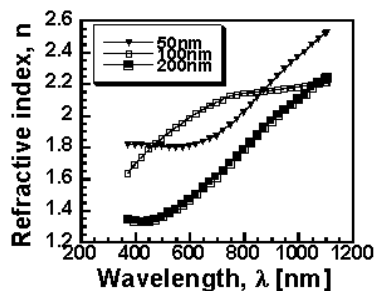


Fig-8(a): Variation of refractive index with wavelength for as-deposited Co thin films on glass substrate.

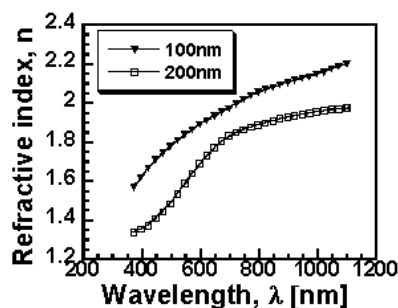


Fig-8(b): Variation of refractive index with wavelength for Annealed Co thin films on glass substrate.

The dependence of dielectric constant on wavelength for both the as-deposited and annealed Co thin films of different thicknesses is shown in Fig-9 (a) and 9(b). It is evident from the Figures that for the as-deposited films dielectric constant ranges from 1.91 to 10.91 and for annealed films it ranges from 1.88 to 7.1. The frequency dependence which is found to be similar to that for metal-dielectric composites. This compound can work as a metal-dielectric composite even in a form of single

crystal, a possible mechanism of which is suggested on the basis of the electronic configuration of Co ions [40].

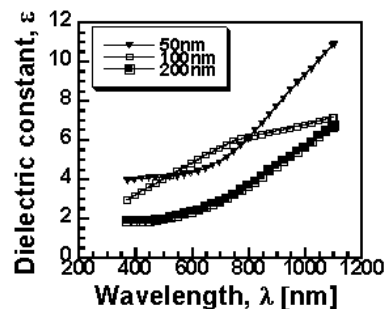


Fig-9(a): Variation of dielectric constant with wavelength for as-deposited Co thin films on glass substrate.

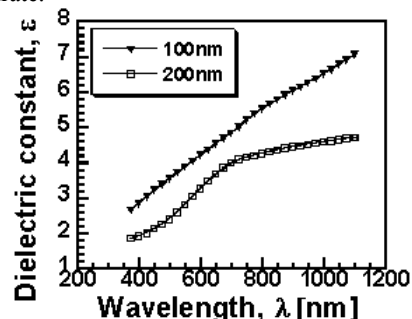


Fig-9(b): Variation of dielectric constant with wavelength for annealed Co thin films on glass substrate.

5. CONCLUSION

Various deposition parameters especially the chamber current has remarkable effects on the deposition of e-beam evaporated Co thin films. The thickness dependence of electrical resistivity is well in conformity with Funchs-Sondheimer size effect theory. The TCR and electrical resistivity studies exhibit metal behavior. The calculation of activation energy suggests that thermally activated conduction mechanism plays significant role in conduction process. Hall Effect studies of Co samples exhibit a p-type carrier. Optical studies exhibit high refractive index in the near infra-red region. At the same case, dielectric constant exhibit high in the near infra-red region.

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Experimental Analysis on Wireless Energy Transfer via Strongly Coupled Magnetic Resonances

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This paper describes a simple system of transferring energy wirelessly via strongly coupled magnetic resonance using non-radiative near field. Here the feasibility of transferring energy by using a small receiving self-resonant coil with respect to a large source self-resonant coil is experimentally verified. Experimental results show that a number of small coils can act as receiver at a time. Moreover, it is found that each receiving coil acts as a repeater; hence with the increase in number of the receiving self-resonant coil the efficiency increases. Experimental results also show that when the parameters of the source and receiving self-resonant coil are same, the efficiency of transferring energy is more than 62%; the distance of energy transfer is around 1.2 meter and any non metallic objects placed in between the source and receiving coil does not interrupt in the energy transfer mechanism. The future applying fields are wide, such as supplying power wirelessly to portable devices including laptops, cell phones, MEMS, pacemaker etc..

Key words: Wireless, Energy transfer, magnetic resonance, non radiative near field, coupling.

1. INTRODUCTION

Wireless power transfer concept existed since the 20th century by Nikola Tesla [1-3]. In his proposed system for power transfer over large distances involved extremely large electric fields which could cause a major health hazard. Therefore it was banned. Due to the recent advancement in technology, portable devices such as cell phones, lap top etc has become very popular. These portable devices need their battery to be recharged. To recharge them wirelessly the concept of wireless power transfer is again reconsidered [4-6].

Recently a group of MIT students were able to transfer power in watt range using strongly coupled magnetic resonance [7-8]. They used magnetic coupling to power up the source self-resonant coil. Another group of students from China were also able to transfer power up to 50W at a small distance using wire coupling self-resonant coils [9]. Both of the groups suggested that it could be possible to transfer power using a very small self-resonant receiving coil with respect to the source self-resonant coil. In this paper the feasibility of their suggestions are experimentally proven along with their previous work, using different size of coils having different diameters, different cross sectional area of the wire of the self-resonant coil and different helix length.

The concept we employed allows a source and a receiver to exchange energy efficiently over mid-range distance, with little or no loss of energy occurring to secondary objects. By mid range we mean that the separation between the two objects should be of the order of a few times of the size of the objects.

The wireless power transfer for mid-range or long range distances is done by electromagnetic radiation which is very harmful for biological tissues. Radiative transfer [10] is used to transfer information for communication purposes but if it is used for power transfer the efficiency becomes extremely low. It also requires Line Of Sight communication and if the radiation is omni directional efficiency is extremely low. Even if the radiation is made unidirectional it might be hazardous to the living organism, interrupting its Line Of Sight communication between the transmitter and receiver and also a sophisticated receiving mechanism is needed.

An alternative approach is used to overcome this obstacle by designing the transmitter and receiver at the same resonant frequency for the mid range energy transfer. When two objects have same resonant frequency there is a strongly coupled regime of operation [11]. If energy transfer is made in this regime, the efficiency is extremely high.

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This method supports mid range power transfer and also supports omni directional power transfer with no loss to the secondary object whose resonant frequency is different to that of the source and receiving self-resonant coil.

Considering the danger of the electric field, magnetic fields as well as magnetic systems are used to establish magnetic resonance [12]. This method is safer and does not involve health hazard. As previously stated for efficient power transfer between two objects they need to be operated in a strongly coupled regime. In our experiment we achieved this condition in MHz range (at initial setup) and KHz range (at second and third setup) of frequencies.

Resonant induction is widely used in many technologies available today (e.g. radio receiver [13]), yet their efficiencies are not very good at mid range distances. The strong-coupling regime, for which the resonance is a precondition, makes the power transfer efficient.

2. ENERGY TRANSFER VIA COUPLED MAGNETIC RESONANCES

Resonance is a way to transfer energy from one object to another. For example, if a tuning fork with a certain resonant frequency is stroked then it starts vibrating. If a second tuning fork having the same resonant frequency is brought close to first one then the second one starts vibrating at its maximum amplitude. It is due to the resonance phenomenon. The energy which makes the second fork phonating comes from sound wave generated by the first fork; the energy transfer medium is sound field. Every object has its own self-resonant frequency. Therefore any two objects having same self-resonant frequency can exchange energy efficiently in between them, only when they are in resonance.

Similar to sound energy transfer principle, electromagnetic resonance can be used for electric energy transfer mechanism. But it involves electric field radiation which is a major health hazard for the living beings. Considering the danger to people and other organisms in electric field, the magnetic field is safe and more suitable to be used as the energy-transfer medium. Therefore, in this experimental analysis magnetic resonance is used for energy transfer mechanism.

Let us consider a simple LC system consisting of an ideal capacitor and an ideal inductor connected in parallel as shown in figure 1. Assuming that an amount of energy was supplied to the system at

some instant (by placing a charge on the capacitor), and also considering there is no connection to the outside, energy may be stored in the system in two forms:

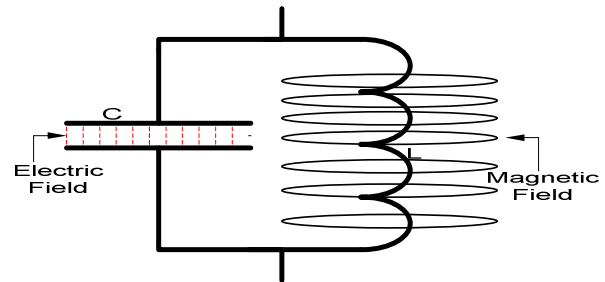


Fig. 1 A simple LC oscillating circuit.

1. Electric energy in the capacitance

$$U_C = \frac{1}{2} C V^2$$

2. Magnetic energy in the inductance

$$U_L = \frac{1}{2} L I^2$$

Where, I is the current flowing through the inductance L and V is the voltage across the capacitor C .

The presence of energy in the capacitor implies a voltage across the capacitor, and a consequent rate of change of current and stored magnetic energy in the inductance. Similarly, the presence of magnetic energy implies a current flowing in the inductance, and a consequent rate of change of voltage and stored electric energy in the capacitor. As a result there is an oscillation in the system, since the presence of energy in one form requires a rate of change of energy in the other. The total energy in this system remains constant as an ideal dissipationless condition is assumed [14]. Hence the electric field is trapped in the capacitor and forming a loop of variable magnetic field around the inductor as shown in the figure 1.

In practical case, an ideal capacitor and an ideal inductor cannot be found. Therefore there is a loss of energy occurring when electric energy is converted to magnetic energy and vice versa. Hence the oscillation frequency changes and to keep the oscillation frequency same the total energy of the system needs to be kept constant. For this reason energy needs to be supplied from an external source with the same frequency as the oscillating frequency of the system.

Two magnetic systems consisting of such LC circuit with same inherent resonant frequency will generate strong magnetic resonance and form a magnetic resonance system. If there are more than two resonators in effective range, they can also join the resonance system. One resonator can be

connected with continuous power supply to serve as the energy source and the other consuming the energy acts as receiver. Hence we are transferring energy from one place to another by using an invisible magnetic field instead of using electrical wires.

More the number of receivers, power transfer will be more efficient as with the increase of the receiving coils, the strength of the magnetic field will be increased. Moreover with the increase in resonant frequency the power transfer efficiency will be increased as the response of the secondary objects will be less. Power transfer efficiency will be maximum when the resonant frequency will be in the range 1 MHz to 50 MHz [8].

3. ARCHITECTURE OF ENERGY TRANSFER SYSTEM VIA COUPLED MAGNETIC RESONANCE

Fig. 2 Schematic diagram of energy transfer system via coupled magnetic resonance.

A simple system of energy transfer via coupled magnetic resonance is shown in figure 2. A high frequency pulse generator is connected with a LC system where inductor L_s and capacitor C_s constitute a self-resonant source coil to generate an alternative non-radiative magnetic field. The resonant frequency of LC circuit (source coil) is f_s . The high frequency pulse is generated by switching a high DC voltage using a metal transistor (NPN). A driving circuit is used to apply a voltage at the base of the transistor. The frequency of this driving circuit is assumed to be f_d . Experimentally found that when f_d is close or equal to f_s , energy is transmitted from source to receiving coil. Inductor L_r and capacitor C_r constitute the receiving self-resonant coil to produce resonance with the magnetic field which is generated by source self-resonant coil. The parameters of the receiving coil, L_r and C_r do not need to be identical with that of the source coil but only one condition needs to be satisfied that is $f_s = f_r$ for efficient energy transfer where f_r is the frequency of receiving resonant coil.

There are different equations for calculating the inductance for different shapes of a coil. As we are using circular loop coil in our resonant system thereby the coil inductance can be expressed as [15].

$$L = N^2 R \mu_0 \left[\ln \left(\frac{8R}{a} \right) - 1.75 \right] \quad (1)$$

Where, N = coil turn, $\mu_0 = 4\pi \times 10^{-7}$ (H/m) is the permeability of vacuum, R = radius of coil (m), a = radius of conductor section (m).

If inductor L and capacitor C in resonance circuit are determined, the circuit resonant frequency f could be calculated by using,

$$f = \frac{1}{2\pi\sqrt{LC}} \quad (2)$$

4. EXPERIMENTAL SETUP AND OBSERVATIONS

In the 1st setup for energy transfer experiment showed in the fig. 3. Here the parameters of source and receiving resonant coils are same. The diameter of inductance coil is 160mm, the diameter



Fig.3.Initial experimental setup for lightening a bulb

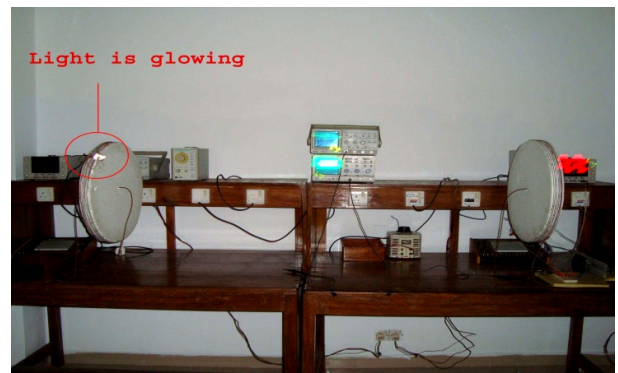


Fig. 4 The experimental setup for lightening a bulb at a distance 1.7 meter

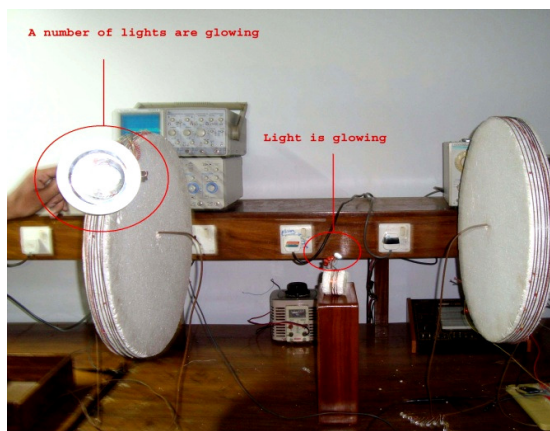


Fig. 5 The experimental setup for lightening a number of bulbs connected to the large resonance coil and a single bulb connected to a small resonance coil together.

of conductor section is 2.016mm and the coil turn number is 5. The parameter of capacitor connected with the inductance coil is 6.6nF with withstand voltage up to 630V. The applied voltage in the source self-resonant coil is 20V DC and the applied maximum current is 2A. The on-off control frequency of power transistor (NPN) is 700 kHz. Experimental result shows that the power transfer efficiency is more than 68%, and the maximum distance of energy transfer can reach up to 580mm.

In the second setup of energy transfer experiment showed by fig. 4, larger diameter self-resonant coils are used. The parameters of receiving self-resonant coil are same with the source self-resonant coil. The diameter of inductance coil is 50cm. The diameter of conductor section is 1.83mm and the coil turn number is 7. The value of the capacitor is 4.4nF that can withstand voltage up to 630V. The applied voltage in the source self-resonant coil is 20V DC and the applied maximum current is 3A. The driving frequency is 102 kHz. The experimental result shows that the transfer efficiency is still more than 62%. The transfer distance is nearly 1.2 meter which is longer than that by using small diameter self-resonant coils. Experiments of energy transfer show that transfer efficiency varies with the distance between the source and receiving self-resonant coils. With the increase of the distance between source and receiving self-resonant coil, the transfer power and efficiency are decreased.

In the third setup for energy transfer experiment is shown in figure 5. A self-resonant coil having small diameter is used as receiver which has different inductance and capacitance as coil diameter is different from the source self-resonant coil. The diameter of the inductance coil is 6 cm. The diameter of conductor section is 0.38mm and the

coil turn number is 23. The total capacitance is 25nF. The resonant frequency of this coil is same as the driving frequency f_d . If both of the receiver and source self-resonant coil have the same diameter of the helix and the same diameter of the conductor section, energy will only be transferred from source to receiver, when the frequency of the pulse generator is higher than the frequency of the self-resonant coils. Experimentally we have observed that using small receiving self-resonant coil with respect to source self-resonant coil, energy will be transmitted only, when the driving frequency and the self-resonant frequency of the small coil is same. To find the reason for this phenomenon further investigations are required. In the same arrangement if another receiving self-resonant coil with large diameter same as source self-resonant coil is brought, the energy transfer efficiency is increased significantly in the small self-resonant coil. Moreover, small self-resonant coil receive a constant power within 73 cm between the source and the large receiving self-resonant coil. It proves the feasibility of using a small coil to power up a portable device which we have observed experimentally. Up to 5 small self-resonant coils having the same parameters and resonant frequency have been used at a time during the performance of the experiment and it has been seen that the efficiency of the power received remains nearly constant for each self-resonant coil. This small self-resonant coil can be built in the printed circuit board (PCB) so that it can be fitted inside the portable device. Keeping the resonance frequency same, shape and size of the self-resonant coil can be changed to desired geometry.

An important feature is that energy transfer can go through various objects. Different kinds of objects were placed between the source and receiving self-resonant coils to verify this feature. Experiment result shows an uninterrupted transfer of energy. Non-metallic objects and liquids such as walls, books, wooden products, organic glass panels, water, leather, and textiles have no impact on power transfer. The impact of metallic objects on the system depends on different characteristics of metal conductor. It would have slight impact if the object with size less than the diameter of self-resonant coil, or which cannot generate a larger eddy current; If the metallic objects which can generate larger eddy current or form a close loop, are close to this system, the impact will be greater even block energy transfer.

In addition, it is found that when a LC resonant circuit with the same parameters and sizes of the source resonant circuit is placed between the source and receiving self-resonant coil, the energy transfer distance and power transfer efficiency can be

improved. More analysis and experimental study still need to be done to analyse the root of this phenomenon.

5. ANALYSIS OF EXPERIMENTAL RESULT

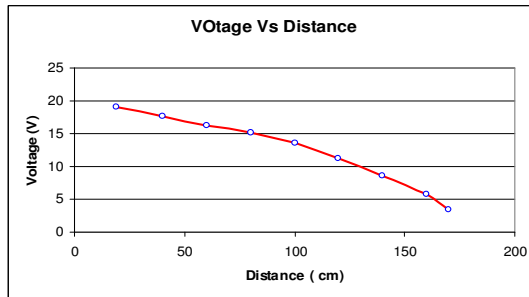


Fig. 6 Relationship between the induced voltages in the receiving self-resonant coil with the distance from the source self-resonant coil to receiving self-resonant coil.

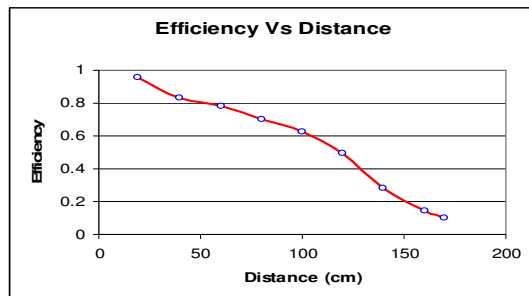


Fig. 7 Relationship between the power transfer efficiency with the distance from the source self-resonant coil to receiving self-resonant coil.

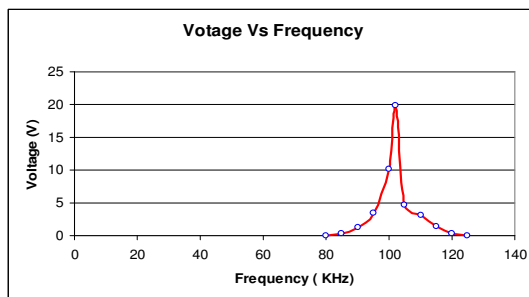


Fig. 8 Relationship between the induced EMF in the receiving self-resonant coil with different driving frequency f_d .

Fig. 6 demonstrates that the relationship between the induced voltages in the receiving self-resonant coil with the distance between the source self-resonant coil and receiving self-resonant coil when there is no load is connected with the receiving self-

resonant coil. Fig. 6 is plotted from the data found in the experimental setup-2.

Fig. 7 shows that the efficiency is around 62% for roughly 1.2 m distance after which the efficiency drops significantly. Fig. 7 is plotted from the data found in the experimental setup-2. An important feature is found when the receiving coil is close to the source self-resonant coil the energy drawn by the source self-resonant coil from the supply is less and it increases when the distance between the source self-resonant coil and the receiving self-resonant coil is increased. It is one of the built-in advantages of this system.

Fig. 8 shows the relationship between different driving frequencies (f_d) and induced EMF in the receiving self-resonant coil. The experimental result shows that when the induced voltage reaches the maximum, the driving frequency f_d is not completely consistent with the inherent resonant frequency of the LC resonant circuit, there existed a certain deviation. We found that inherent resonant frequency of LC resonance circuit is 79.34 kHz, while the induced EMF in the receiving self-resonant coil reaches the maximum when the driving frequency is 102 kHz. More experimental study still needs to be done to find the reason of this phenomenon.

7. CONCLUSIONS

A novel wireless energy transfer system has been proposed in this paper. The proposed system has a very simple architecture compared to other existing system. It has been experimentally verified that by making the receiving self-resonant coil very small with respect to the source self-resonant coil power can be transferred efficiently. Moreover a number of small self-resonant coils can act as a receiver at the same time keeping the efficiency nearly same. Nevertheless, there are still a lot of research and experimental work to be done to make the technology of wireless power transfer more practical.

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FAST INTER MODE DECISION ALGORITHM FOR H.264/AVC VIDEO STANDARD

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In this paper, a relative sum of absolute difference (RSAD) based fast inter mode decision algorithm is proposed for H.264/AVC video standard. The main idea is to determine the best inter mode based on RSAD cost instead of the rate-distortion cost. This approach can avoid most of the computationally intensive processes in the H.264/AVC mode decision, such as integer transform, quantization, variable length coding and pixel-reconstruction. It can solve the problem of SAD-based cost function for H.264/AVC mode decision in biasing to the smaller block size modes. The experimental results indicate that the proposed algorithm can reduce 60% to 68% of the total encoding time with negligible degradation in the rate-distortion performance. The proposed algorithm is also combined with SKIP mode early termination algorithm for further time saving and computation reduction. The enhanced algorithm could save up to 10% more of the encoding time with only a little rate-distortion degradation.

Key words: H.264/AVC, SAD Cost Function, Video Coding, Mode Decision, SKIP mode

1. INTRODUCTION

The newest video coding standard is known as H.264/AVC (Wiegand et al., 2003, and Sullivan and Wiegand, 1998) which greatly outperforms the previous standards in terms of both picture quality and compression efficiency. To achieve this superior coding performance, H.264/AVC adopts many advanced techniques, such as directional spatial prediction for intra frame coding, variable and hierarchical block transform, arithmetic entropy coding, multiple reference frame motion compensation, etc. It also uses seven different block sizes (16x16, 16x8, 8x16, 8x8, 8x4, 4x8 and 4x4) for motion compensation in inter mode coding. The purpose to employ variable block size coding is that large block modes (such as 16x16, 16x8 and 8x16) can be used for stationary image block prediction with high coding efficiency while small block modes can be used for high or complex image blocks with better prediction accuracy.

In the last few years, a number of fast mode decision algorithms (Jing and Chau, 2004, Wu et al. 2005, Kuo and Chan, 2006, Lin et al., 2006, Wei and Ngan, 2006) have been proposed to reduce the computational complexity. Kim et al. proposes an adaptive mode decision algorithm (Kim et al., 2004). Some of the aforementioned algorithms try to classify the MB into large partition or small partition and skip checking some unnecessary

modes. However, they still need to compute the rate-distortion costs of possible modes for the ultimate mode decision, which involve computationally intensive processes of image transformation. In H.264/AVC SAD and SATD-based cost functions are developed (<http://bs.hhi.de/~suehring/tml/download/Unofficial/>) as fast mode decision techniques. However, the major drawback is that the rate-distortion performance of the encoded video is quite degraded, which affects their practical implementation. In this paper, a relative sum of absolute value (RSAD) based fast mode decision algorithm is proposed, which can avoid rate-distortion cost computation while maintaining high rate-distortion performance of the H.264/AVC codec.

The rest of the paper is organized with section 2 introducing the rate-distortion cost functions for H.264/AVC standard. The proposed algorithm is described in section 3. The SKIP mode early termination algorithm is reviewed in section 4. The parameters selection technique is described in section 5. Simulation results are presented in section 6 and the conclusion is given in section 7.

2. RATE-DISTORTION COST FUNCTIONS FOR H.264/AVC

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In H.264 encoding process, the best MB coding mode is selected by computing the minimum RD cost of all possible modes and this cost is defined as

$$J_{RD}(\mathbf{S}, \mathbf{C}) = \text{SSD}(\mathbf{S}, \mathbf{C}) + \lambda \cdot R \quad (1)$$

where λ is the Lagrangian multiplier. The R is the number of bits for encoding the header information, motion vectors and quantized residual block, respectively. In equation (1), $\text{SSD}(\mathbf{S}, \mathbf{C})$ is the sum of the squared difference (SSD) between the original blocks $\mathbf{S}$ and the reconstructed block $\mathbf{C}$, and it can be expressed as:

$$\text{SSD}(\mathbf{S}, \mathbf{C}) = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} (s_{ij} - c_{ij})^2 = \|\mathbf{S} - \mathbf{C}\|_F^2 \quad (2)$$

where s_{ij} and c_{ij} are the (i, j) th elements of the current original block $\mathbf{S}$ and the reconstructed block $\mathbf{C}$, respectively. Moreover, N is the image block size ($N = 4$ in H.264 standard) and $\|\cdot\|_F$ is *Frobenius* norm. As the computation of spatial-domain SSD is very time-consuming so to accelerate the coding process, the JVT reference software provides a fast SAD-based cost function:

$$J_{\text{SAD}} = \begin{cases} \text{SAD}(\mathbf{S}, \mathbf{P}) + \lambda_1 \cdot 4K & \text{if intra } 4 \times 4 \text{ mode} \\ \text{SAD}(\mathbf{S}, \mathbf{P}) & \text{otherwise} \end{cases} \quad (3)$$

where $\text{SAD}(\mathbf{S}, \mathbf{P})$ is sum of absolute difference between the original block $\mathbf{S}$ and the predicted block $\mathbf{P}$. The λ_1 is also approximate exponential function of the QP, which is almost the square of λ , and the K equal to 0 for the probable mode and 1 for the other modes. This SAD-based cost function could save a lot of computations with quite significant degradation of coding efficiency. Thus, SAD is not an appropriate criterion to determine the best mode. Actually, the SAD values of different inter modes usually have the following relation: $\text{SAD}_{16 \times 16} \geq \text{SAD}_{16 \times 8} \geq \text{SAD}_{8 \times 16} \geq \text{SAD}_{8 \times 8}$. The reason behind is that the small partition motion estimation can always provide better prediction accuracy than the large mode motion estimation. According to this relationship, the J_{SAD} cost function is inclined to choose smaller block mode as the best mode since their SAD values are smaller. That's why J_{SAD} cost function is not appropriate for the best mode selection.

3. RSAD BASED MODE SELECTION ALGORITHM

3.1 Definition of RSAD Based Cost Function

The reason why H.264/AVC employs variable block-size modes is that sometimes the current MB cannot be well predicted by large partitions, which means the difference between the current MB and predicted MB is quite large. Thus, the MB should

be divided into smaller partitions for better motion compensation. On the other hand, if the current block can be well predicted by the large block mode, it is unnecessary to encode the block with smaller partitions which require more encoding complexity and more bits to represent the motion vectors and side information. Thus, we need to use an appropriate criterion to tell whether the current MB achieves adequate prediction accuracy or not. SAD value presents the difference between the current MB and predicted MB, so it can reflect the prediction accuracy of different modes. As mentioned earlier, J_{SAD} cost function is not appropriate for mode decision since smaller modes usually lead to smaller SAD values so that smaller block mode is inclined to be considered as the best mode. Therefore, we should admit the intrinsic SAD differences between small partitions and large partitions. Besides, we should realize that the SAD values are also significant in mode decision. A small SAD difference among different modes indicates that large partition may well predict the current MB without splitting into small partitions; while a large SAD difference means the prediction accuracy of small modes outperforms that of the large mode, so that the small mode is likely to be the best mode. Since the SAD difference covers a wide range and fluctuates greatly, it is difficult to claim whether the SAD difference is small or large. So, we can define a new parameter, relative SAD (RSAD) cost, to measure the SAD difference between two modes.

The RSAD cost between two modes, mode 1 (representing large partition) and mode 2 (representing small partition), is defined as below:

$$\text{RSAD}_{1 \rightarrow 2} = \frac{\text{SAD}_1 - \text{SAD}_2}{\text{SAD}_1} \quad (4)$$

where $\text{RSAD}_{1 \rightarrow 2}$ represents the relative prediction accuracy between mode 1 and mode 2. According to the definition of RSAD, a small RSAD cost indicates a small SAD difference between two modes, which means that their prediction accuracy is similar. In this case, mode 1 is likely to be a better choice since it needs fewer bits to encode its motion vectors. On the other hand, a large RSAD cost implies that mode 2 is more likely to be the better mode since its prediction accuracy obviously outperforms the large partition mode 1. Therefore RSAD is a new measure to select the better mode instead of the conventional costs such as SAD, SATD and RD cost.

3.2 RSAD Cost Function for Mode Decision

Based on the above idea, a threshold T_R can be predefined to tell whether the RSAD is small or large. If $\text{RSAD}_{1 \rightarrow 2} < T_R$, select the large partition mode 1 as the better mode; Otherwise select the small partition mode 2 as the better mode. It is

obvious that T_R affects the probability of mode 1 or mode 2 to be the selected. When T_R increases, mode 1 is more likely to be the better mode while a low T_R making mode 2 more likely to be the better mode.

How to select the threshold T_R is vital to this RSAD-based mode decision algorithm and which have to be robust for different types of block contents. In addition, T_R should also be adaptive to SAD of the mode 1 (SAD_1) as it indicates whether the large partition block is well predicted or not. If SAD_1 is small due to mode 1 is already well predicted then it is more likely to be the better mode, as a result we can use a larger T_R . In contrast, if SAD_1 is large, the mode 2 with small partition should have higher chance to be the better mode and T_R should be smaller. To implement this idea, we use another adaptive threshold T_S to distinguish whether SAD_1 is small or large. As a higher QP leads to rougher quantization, the error between the original block and reconstructed block will increase, then the overall SAD values will be higher, so the threshold T_R should be also increased.

Let us first introduce a RSAD-based mode selection algorithm for two modes only as follows:

Step I: Initialize QP value, T_S , T_{RS} , T_{RL} as QP.

Step II: Calculate the SADs of mode 1 and 2.

Step III: If $SAD_1 < T_S$, $T_R = T_{RS}$; else $T_R = T_{RL}$.

Step IV: Calculate $RSAD_{1 \rightarrow 2} = (SAD_1 - SAD_2) / SAD_1$.

Step V: If $RSAD_{1 \rightarrow 2} < T_R$, choose mode 1 as the better mode; Else, choose mode 2 as the better mode.

In this algorithm, the T_{RS} and T_{RL} represent the RSAD thresholds for small and large SAD blocks, respectively. Here, the above algorithm is very easy to demonstrate the concept of the RASD for mode decision, but it is not very suitable for practical implementation with more than two modes. In this algorithm, we need to compare $RSAD_{1 \rightarrow 2}$ with the

threshold T_R . If $RSAD_{1 \rightarrow 2} \leq T_R$,
 $RSAD_{1 \rightarrow 2} = (SAD_1 - SAD_2) / SAD_1 \leq T_R$, then
 $SAD_1 \leq SAD_2 + T_R \cdot SAD_1$.

Thus, the comparison between $RSAD_{1 \rightarrow 2}$ and T_R is equal to the comparison between SAD_1 and the compensated SAD_2 (SAD_2 plus $T_R \cdot SAD_1$).

3.3 RSAD-Based Cost Implemented for H.264/AVC Inter Mode Decision

H.264/AVC video standard supports seven inter modes of different block size and shapes, including mode 16x16, 16x8, 8x16, P8x8 (8x8, 8x4, 4x8, and 4x4). In this papers, $RSAD_{16 \times 16 \rightarrow 16 \times 8}$, $RSAD_{16 \times 16 \rightarrow 8 \times 16}$ and $RSAD_{16 \times 16 \rightarrow P8 \times 8}$ are employed for mode decision and we need to find the best mode among these

four inter modes. In order to present the algorithm clearly, compensated SAD values of mode 16x8, 8x16 and P8x8 are employed in the following algorithms. Then, the RSAD-based mode decision algorithm for H.264/AVC can be implemented as following algorithm for Inter modes 16x16, 16x8, 8x16, P8x8 selection:

Step I: Initialize QP value, T_{S1} , T_{RS1} , T_{RL1} , T_{S2} , T_{RS2} , T_{RL2} based on the QP.

Step II: Calculate the SAD cost of these four inter modes: $SAD_{16 \times 16}$, $SAD_{16 \times 8}$, $SAD_{8 \times 16}$ and $SAD_{P8 \times 8}$.

Step III: If $SAD_{16 \times 16} < T_{S1}$, then $T_{R1} = T_{RS1}$ and $T_{R2} = T_{RS2}$; else $T_{R1} = T_{RL1}$ and $T_{R2} = T_{RL2}$.

Step IV: Calculate compensated $SAD_{16 \times 8}$, $SAD_{8 \times 16}$ and $SAD_{P8 \times 8}$ with

$$SAD_{16 \times 8} = SAD_{16 \times 8} + T_{R1} \cdot SAD_{16 \times 16}$$

$$SAD_{8 \times 16} = SAD_{8 \times 16} + T_{R1} \cdot SAD_{16 \times 16}$$

$$SAD_{P8 \times 8} = SAD_{P8 \times 8} + T_{R2} \cdot SAD_{16 \times 16}$$

Step V: Best mode = arg min($SAD_{16 \times 16}$, $SAD_{16 \times 8}$, $SAD_{8 \times 16}$, $SAD_{P8 \times 8}$)

where T_{S1} , T_{RS1} , and T_{RL1} are SAD threshold and RSAD thresholds for selecting Inter modes of 16x8 and 8x16 partitions and T_{S2} , T_{RS2} , and T_{RL2} are SAD and RSAD thresholds for selecting Inter mode of P8x8. Based on this algorithm, we can determine the best inter mode by comparing the SAD of largest partition mode (Inter 16x16) and compensated SADs of the smaller partition modes. In this simplified algorithm, the RSAD has been implemented to only select the best mode from four Inter modes. Actually, Inter P8x8 contains four sub-modes: Inter S8x8, Inter S8x4, Inter S4x8 and Inter S4x4 modes. Similarly, we can implement the proposed RSAD-based mode decision algorithm to choose the best sub-mode among all possible sub-modes with another set of thresholds. The RSAD-based sub mode decision process can be summarized as:

Step I: Initialize QP value, T_{S3} , T_{RS3} , T_{RL3} , T_{S4} , T_{RS4} , T_{RL4} based on the QP.

Step II: Calculate the SAD cost of four sub inter modes: $SAD_{S8 \times 8}$, $SAD_{S8 \times 4}$, $SAD_{S4 \times 8}$ and $SAD_{S4 \times 4}$.

Step III: If $SAD_{S8 \times 8} < T_{S3}$, then $T_{R3} = T_{RS3}$ and $T_{R4} = T_{RS4}$; else $T_{R3} = T_{RL3}$ and $T_{R4} = T_{RL4}$.

Step IV: Calculate compensated $CSAD_{S8 \times 4}$, $CSAD_{S4 \times 8}$ and $CSAD_{S4 \times 4}$ with

$$SAD_{S8 \times 4} = SAD_{S8 \times 4} + T_{R3} \cdot SAD_{S8 \times 8}$$

$$SAD_{S4 \times 8} = SAD_{S4 \times 8} + T_{R3} \cdot SAD_{S8 \times 8}$$

$$SAD_{S4 \times 4} = SAD_{S4 \times 4} + T_{R4} \cdot SAD_{S8 \times 8}$$

Step V: Best submode = arg min($SAD_{S8 \times 8}$, $SAD_{S8 \times 4}$, $SAD_{S4 \times 8}$, $SAD_{S4 \times 4}$)

where T_{S3} , T_{RS3} , and T_{RL3} are SAD and RSAD thresholds for selecting Inter sum modes of s8x4 and s4x8 partitions and T_{S4} , T_{RS4} , and T_{RL4} are SAD threshold and RSAD thresholds for selecting Inter sub mode of s4x4.

4. REVIEW OF SKIP MODE EARLY TERMINATION ALGORITHM

In H.264/AVC, SKIP mode is employed to encode some static objects and background that almost remain the same in the adjacent frames (Choi et al., 2006). It usually, dominates among other modes and the motion vector is predicted by using the motion vectors of the neighboring MBs. As no residual block is encoded, the transform, quantization and entropy coding can be avoided. When the SKIP mode is selected, only a skip indicator is transmitted. Thus, if we can decide in advance whether the best mode is SKIP mode or not, the computationally intensive mode decision process can be omitted. SKIP mode is the best as long as the following conditions are satisfied (Choi et al., 2006):

- 1) The best motion compensation block size for this MB is 16x16.
- 2) The best reference frame is the previous frame.
- 3) The best motion vector is the predicted MV.
- 4) The transform coefficients of the 16x16 block size are all quantized to zero.

5. PARAMETERS SELECTION

As mentioned in section 3, the selection of the RSAD thresholds T_R and thresholds for classifying small and large SAD of the large partition is vital for the proposed. So, how to select those thresholds such that they are not sensitive to different video content is a vital task. In order to evaluate the best thresholds, at first we do not consider the sub-mode related parameters and only consider T_{RS1} , T_{RS2} , T_{RL1} , T_{RL2} and T_S . Here, we use the iterative searching method to obtain the optimal thresholds by the following algorithm:

Step 1: Initialize the threshold $T_{RS1}(0)$, $T_{RS2}(0)$, $T_{RL1}(0)$, $T_{RL2}(0)$ and $T_{S1}(0)$ for a specific QP value;
Step 2: Adjust the thresholds T_{RS1} , T_{RS2} , T_{RL1} , and T_{RL2} in order to achieve local minimum RD cost. Denote the updated threshold as $T_{RS1}(i)$, $T_{RS2}(i)$, $T_{RL1}(i)$, $T_{RL2}(i)$;

Step 3: Adjust the threshold T_{S1} in order to achieve smaller RD cost. Denote the updated threshold as $T_{S1}(i)$;

Step 4: Repeat Step 2 and Step 3 until the RD cost cannot be further reduced. Record the optimal values.

Based on the extensive simulation upon various types of video contents (low motion, medium motion and high motion), we find that the selection of the thresholds T_{RS1} , T_{RS2} , T_{RL1} , and T_{RL2} is nearly not varied with the video contents as shown in Table 1 and the relationship between T_{S1} and QP is also very robust, which is shown in Table 2. In addition, the optimal thresholds T_{RS3} , T_{RS4} , T_{RL3} , T_{RL4} and T_{S2} for sub-mode selection can also be obtained via the iterative searching method. These results are shown in Tables 3 and 4.

These optimal thresholds based on experimental results are also nearly not varied with the video contents. Such phenomenon is also found in other video sequences and QP factors but due to the limited length of the paper, we cannot list all of them here. Fortunately, we can select a group of optimal thresholds for $(T_{RS1}, T_{RS2}, T_{RL1}, T_{RL2})$ and $(T_{RS3}, T_{RS4}, T_{RL3}, T_{RL4})$ for practical implementation of the proposed RSAD-based mode decision algorithm, which are shown in Table 5. Moreover, a set of T_{S1} and T_{S2} thresholds are also selected based on the results of Tables 2 and 4 for different QPs, which are shown in Table 6. In practical implementation, we can use a table to store all the optimal T_{S1} and QP and use table-lookup method to decide those thresholds for a specified QP value.

Table 1: The optimal thresholds T_{RS1} , T_{RS2} , T_{RL1} , and T_{RL2} found based on simulation.

QP	20				24			
	T_{RS1}	T_{RS2}	T_{RL1}	T_{RL2}	T_{RS1}	T_{RS2}	T_{RL1}	T_{RL2}
Akiyo	0.15	0.30	0.03	0.07	0.15	0.30	0.03	0.07
Foreman	0.15	0.30	0.03	0.06	0.15	0.30	0.03	0.07
Stefan	0.15	0.30	0.03	0.07	0.15	0.30	0.03	0.07
QP	32				40			
	T_{RS1}	T_{RS2}	T_{RL1}	T_{RL2}	T_{RS1}	T_{RS2}	T_{RL1}	T_{RL2}
Akiyo	0.15	0.30	0.03	0.07	0.15	0.30	0.03	0.07
Foreman	0.15	0.31	0.03	0.07	0.15	0.30	0.03	0.07
Stefan	0.16	0.31	0.03	0.06	0.15	0.30	0.03	0.08

Table2: The optimal threshold T_{S1} found based on simulation.

	QP=20	QP=24	QP=32	QP=40

Akiyo	200	400	900	1550
Foreman	200	400	850	1500
Stefan	200	400	900	1500

Table 3: The optimal thresholds T_{RS3} , T_{RS4} , T_{RL3} , and T_{RL4} found based on simulation.

QP	20				24			
	T_{RS3}	T_{RS4}	T_{RL3}	T_{RL4}	T_{RS3}	T_{RS4}	T_{RL3}	T_{RL4}
Akiyo	0.20	0.40	0.10	0.20	0.20	0.40	0.10	0.20
Foreman	0.20	0.40	0.10	0.20	0.20	0.40	0.10	0.20
Stefan	0.20	0.40	0.10	0.20	0.20	0.40	0.10	0.20
QP	32				40			
	T_{RS3}	T_{RS4}	T_{RL3}	T_{RL4}	T_{RS3}	T_{RS4}	T_{RL3}	T_{RL4}
Akiyo	0.20	0.40	0.10	0.20	0.20	0.40	0.10	0.20
Foreman	0.21	0.40	0.10	0.20	0.20	0.40	0.10	0.20
Stefan	0.19	0.40	0.10	0.20	0.20	0.40	0.10	0.20

Table 4: The optimal threshold T_{S2} for P8x8 sub-modes found based on simulation

	QP=20	QP=24	QP=32	QP=40
Akiyo	150	200	450	800
Foreman	150	250	450	800
Stefan	150	200	450	800

Table 5: The selected thresholds for RSAD based mode decision algorithm.

T_{RS1}	T_{RS2}	T_{RL1}	T_{RL2}	T_{RS3}	T_{RS4}	T_{RL3}	T_{RL4}
0.15	0.30	0.03	0.07	0.20	0.40	0.10	0.20

6. EXPERIMENTAL RESULTS

The proposed algorithm was tested using the first 50 frames from many video sequences all in QCIF format. Here due to page limitation, the results of “Akiyo” sequences of low spatial detail and changes in motion, “Foreman” of medium motion changes with dominant luminance changes and. “Stefan” of panning motion and has distinct fast motion changes are listed. The experiment was carried out in the JVT JM9.6 encoder with the test parameters are listed as below:

- CABAC is enabled;
- GOP structure is IPPP;
- Max search range for motion estimation is 32;
- QP values are 20, 24, 32, and 40;

Compared with the original H.264/AVC encoder in terms of the rate-distortion optimization and computation time, the proposed algorithm achieves a little R-D performance degradation, as listed in Table 7, as well as considerable computation time reduction shown in Table 8.

Table 6: The relationship between T_s and QP

QP	20	24	32	40
T_{S1}	200	400	900	1500
T_{S2}	150	200	450	800

From the simulation results, we can conclude that the proposed RSAD algorithm can reduce the encode time by around 60% to 68% in different QP values. When we combine this with SKIP mode Table 7: R-D performance of RSAD-based mode decision algorithm

Sequence	QP	Δ Bit Rate %	Δ PSNR – dB
Akiyo	20	-0.05	-0.05
	24	-0.31	-0.05
	32	-0.22	-0.03
	40	-0.08	0
Foreman	20	+0.17	-0.09
	24	-0.07	-0.08
	32	-0.04	-0.06
	40	+0.72	-0.02
Stefan	20	+0.82	-0.09
	24	+0.50	-0.11
	32	-0.02	-0.10
	40	+0.65	-0.03

Table 8: Encoding time reduction of the proposed RSAD algorithm

QP	20	24	32	40
Akiyo	-67.8%	-67.2%	-64.3%	-62.3%
Foreman	-64.7%	-64.4%	-61.6%	-60.5%
Stefan	-65.7%	-64.2%	-62.7%	-59.8%

early termination scheme, it accompanied with a little higher rate-distortion degradation as shown in Table 9 but the computation time can be further

reduced up to 10%, as shown in Table X. The results imply that the combination of SKIP mode early termination algorithm leads to higher computational reduction in slow motion sequences than in high motion sequences. The result indicates

Table 9: R-D performance of RSAD-based mode decision algorithm combined with SKIP mode early termination algorithm

Sequence	QP	Δ Bit Rate %	Δ PSNR - dB
Akiyo	20	-0.08	-0.06
	24	-0.41	-0.06
	32	+0.32	-0.03
	40	+0.22	-0.02
Foreman	20	+0.20	-0.11
	24	-0.14	-0.09
	32	-0.06	-0.06
	40	+0.93	-0.01
Stefan	20	+0.78	-0.10
	24	+0.66	-0.11
	32	+0.09	-0.11
	40	+0.80	-0.04

Table 10: Encoding time reduction of the proposed RSAD algorithm combined with SKIP mode early termination algorithm

QP	20	24	32	40
Akiyo	-72.43%	-72.01%	-71.57%	-69.93%
Foreman	-66.48%	-65.46%	-65.49%	-64.96%
Stefan	-66.11%	-65.26%	-64.92%	-63.80%

that our proposed algorithm indeed outperforms some other fast algorithm in terms of video quality and compression ratio. Similarly, higher coding efficiency can be achieved in the large QP.

The encoding time is not the only criterion to evaluate an algorithm's efficiency. In the hardware implementation we mainly focus on the number of rate-distortion operations on different modes because the computation of rate-distortion cost is quite heavy in the coding process. From this aspect, our proposed algorithm is quite efficient since it determines the best mode only based on the RSAD cost function.

7. CONCLUSION

In this paper, a fast Relative SAD based inter mode decision algorithm is proposed for H.264 coding standard. This algorithm is motivated by the fact that SAD values can reflect the prediction accuracy among different inter modes. However, directly using SAD to determine the best mode has been proved to be not a satisfied choice. Thus, we

proposed a new RSAD cost function as the measure to decide the best inter modes among 16x16, 16x8, 8x16 and P8x8. and also best sub-mode of 8x8 blocks. Therefore, the tremendous computation of the rate-distortion cost can be skipped. Finally, we combine the proposed algorithm with SKIP mode technique and achieve further time saving and computation reduction. Experimental results indicate that the proposed algorithm reduced considerable encoding time as well as maintaining the quite similar rate-distortion performance.

ACKNOWLEDGEMENT

This research was partially supported by CASR grants memo: KUET/CASR10/26(30) of KUET, Khulna, Bangladesh.

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GROWTH AND CHARACTERIZATION OF MOVPE $\text{In}_x\text{Ga}_{1-x}\text{N}$ ($x \sim 0.4$)

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$\text{In}_x\text{Ga}_{1-x}\text{N}$ alloys are excellent candidate for future MJ solar cells. The InGaN material system poses many challenges which are extended into the performance of the devices. In this paper, the challenges related to the film growth are overcome individually for MOVPE growth. The InGaN film with indium contents 0 to 0.4 are successfully grown by controlling the fundamental growth parameters such as the precursor gas flow rates and temperature. The variation of TMI/(TMI+TEG) molar ratio shows a significant effect on the growing films. The formation of metallic In originates from the higher value of TMI/(TMI+TEG) molar ratio with low V/III ratio while the lower value of TMI/(TMI+TEG) causes the phase separation. It is also necessary to control the growth rate and epitaxial film thickness to suppress the phase separation in the material. The film quality of grown films is studied with increasing the In composition.

Key words: InGaN, MOVPE, Growth, Film quality, Electrical properties.

1. INTRODUCTION

Indium gallium nitride (InGaN) is an attractive semiconductor material for optoelectronics and high-temperature and high-power electronics. Especially, this material is a promising candidate for future multi-junction tandem solar cells with high conversion efficiency (Islam et al., 2008). InGaN alloys also have shown a higher degree of resistance to radiation damage than other photovoltaic materials in common use today (Walukiewicz et al., 2003). To realize a tandem solar cell based on InGaN, it is needed to grow InGaN alloys with In content from about 0.23 to 1 (Islam et al., 2008). GaN is the most extensively studied material and comparatively has matured among the III-nitrides, while the lower band gap InGaN, which is more useful for photovoltaic application, is still a topic of fundamental research. Although Ga-rich InGaN devices have been commercially realized, the growth and properties of this material still have not been well understood. Increasing the indium composition in InGaN during growth, poses many challenges in controlling phase separation and defect density due to the large difference in lattice as well as thermal expansion coefficient mismatch between InN and GaN and high volatility of In atoms. Therefore, a fundamental study of the growth of InGaN is an

important issue for fabricating high performance device.

In this paper the growth of InGaN has been discussed in details. The suppression of phase separation and metallic In incorporation has been investigated. To construct novel devices, it is of crucial importance to investigate the crystalline quality and electrical properties. In this paper, these properties are also studied.

2. EXPERIMENTAL PROCEDURE

The films are grown on (0001) sapphire substrates by using the metalorganic vapor phase epitaxy (MOVPE) with a horizontal reactor. A thin GaN buffer layer grown at low temperature (550°C) or a GaN template of about 1.4 μm thick grown at 1000°C is used as an interlayer. The InGaN films with thickness about 1.5 μm are grown at 750-900°C in the pressure of 150 Torr. Triethylgallium (TEG), trimethylindium (TMI), and ammonia (NH_3) are used as Ga, In, and N sources, respectively. Full width at half maximum (FWHM) of X-ray rocking curve (XRC) of different planes are also measured to evaluate crystalline quality. The mean tilt angle depends on (0002) FWHM and can be measured directly by ω -scan using X-ray diffraction (XRD). However, the twist angle can hardly be measured directly. Here, the method

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developed by Srikant et al. (Srikant et al. 1997) has been used to analyze the experimental data. In this method, every rocking-curve (0002, 10-13, 10-12, 10-11 and 30-32) was fitted into a pseudo-Voigt function. Finally, the twist has been obtained from the theoretical estimation. Electron concentration was measured with four-probe van der Pauw technique.

3. RESULT AND DISCUSSION

3.1 Effect of precursor gas flow

A systematic study of $\text{In}_x\text{Ga}_{1-x}\text{N}$ epitaxy is performed to get indium compositions in the range from 0 to 0.4 by MOVPE. The primary variables used to control the In composition is the precursor gas flow rates that is the TMI / (TMI + TEG) molar ratio. XRD data of the InGaN epi-layers are represented on the same scale in Figure 1 for comparison. The XRD data indicates the composition and quality of constituent materials in the epitaxy. The InGaN (0002) peaks which is clearly visible, indicate the respective indium compositions and another secondary InGaN peaks are also observed, which indicate the presence of phase separation in the material. The corresponding (0002) peak of GaN template is observed at around $2\theta = 34.6^\circ$. The peak observed at around 32.9° , (101) metallic indium indicates the amount of segregated indium droplets (Lu et al., 1997).

The InGaN films are grown at 800°C with a TMI / (TMI+TEG) molar ratio 0.2 to 0.74. Initially, the growth is conducted with TMI / (TMI+TEG) molar ratio of 0.2 where a secondary peak of InGaN is clearly observed. This may be due to the strain state in the material varies to a much greater extent due to the additional gallium species. It has also been reported that InGaN alloys are unstable over most of the composition range at normal growth temperature (Ho and Stringfellow, 1997) especially in the range of 0.2 (Koukitu and Seki, 1998). The reason is that at high temperatures, most of the input Ga deposits into the solid phase, whereas In remains in the vapor phase without deposition. Thus, inhomogeneity occurs and the inhomogeneous compositions in the unstable regions may be the reason of phase separation. To suppress the phase separation the TMI flow rate has been changed that means the TMI / (TMI+TEG) molar ratio has been increased to 0.38 which increases the InN incorporation in the InGaN films as well as suppresses the phase separation (Jani et al., 2007). Further increase of the TMI / (TMI + TEG) molar to 0.74, increases the In composition along with the formation of metallic indium in the film. Furthermore, the V/III ratio at TMI / (TMI+TEG) ratio 0.2 to 0.74 is 8600, 6600 and

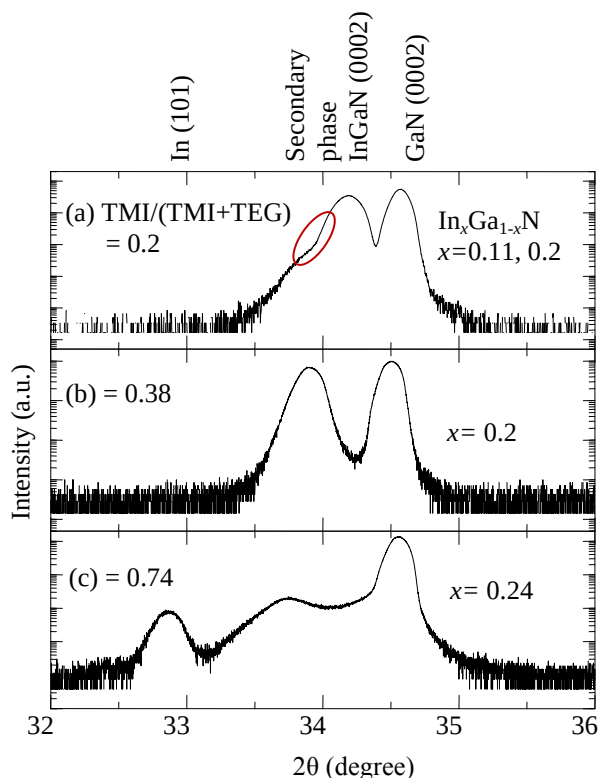


Fig. 1: XRD ω - 2θ profiles of InGaN films grown at 800°C with different TMI/(TMI+TEG) molar ratio.

4100 respectively. In case of higher TMI / (TMI+TEG) molar ratio, the formation of In peak is due to the dissociation of InN and condensation of

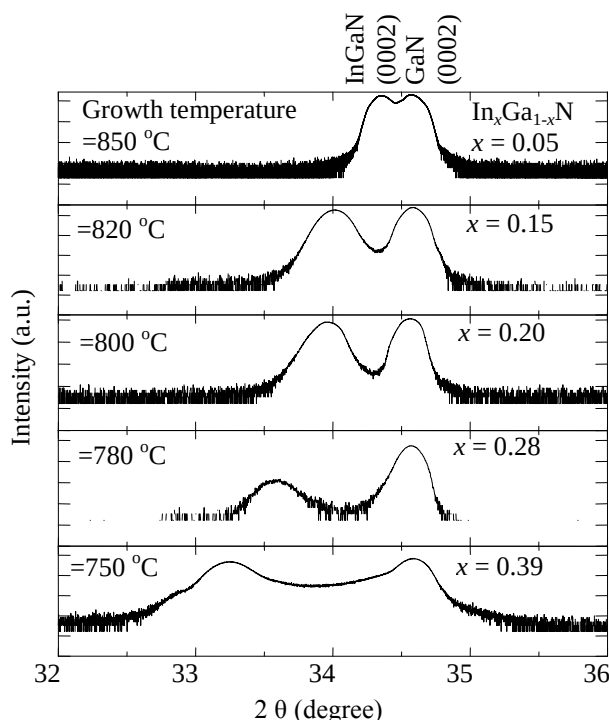


Fig. 2: XRD ω - 2θ profiles of InGaN films grown at 0.38 TMI / (TMI+TEG) molar ratio with different temperature.

indium on the growing surface at the low V/III ratio (Komaki et al., 2007). On the other hand, for higher V/III ratio (comparatively under N-rich condition), the In peak has been eliminated due to excess activated nitrogen on the growing surface.

3.2 Effect of growth temperature

From the results of the earlier paragraph, it is clear that the InGa_N film grown at 800 °C with TMI / (TMI + TEG) molar ratio 0.38 is without phase separation and metallic In incorporation. In order to control the In composition in the range of 0 to 0.4 the InGa_N film has been grown with the same (0.38) TMI / (TMI+TEG) molar ratio at a different temperature. Figure 2 shows the XRD ω -2 θ profiles of InGa_N films grown in the temperature of 750 °C ~ 850 °C. Finally, InGa_N films with an In content up to 0.4 has been successfully grown without phase separation as well as metallic In incorporation.

3.3 Controlling the In composition

Figure 3 (a) shows the variation of In composition as a function of TMI flow rate with a different temperature. Here the TMI / (TMI+TEG) molar ratio is 0.11 to 0.38 with a TEG flow rate of 100 sccm. The In composition increases with the increase of TMI flow rate although at lower TMI flow rate the films show phase separation. The variation of In composition as a function of growth temperature with different TMI / (TMI+TEG) molar ratio is shown in Fig. 3 (b). The result shows that In content in the InGa_N epi-layer is markedly decreased with increasing growth temperature indicating the evaporation of InN at high temperature because of high volatility of nitrogen over InN. In addition, it has been reported that the decomposition of InN starts from about 600 °C (Togashi et al., 2008). From the above figure it is clear that the In composition almost linearly varies with TMI flow rate as well as temperature up to

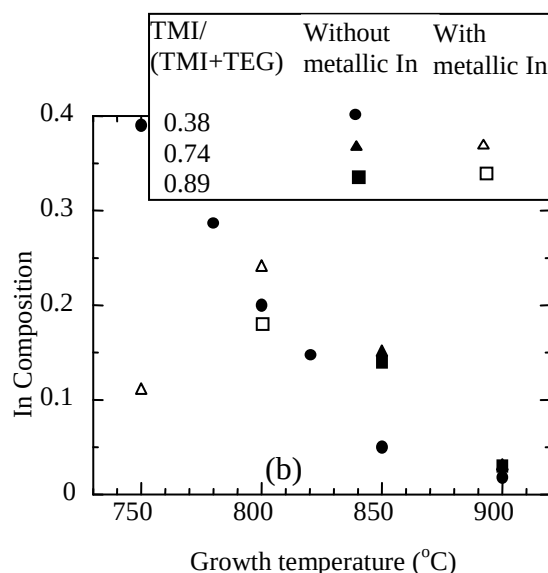
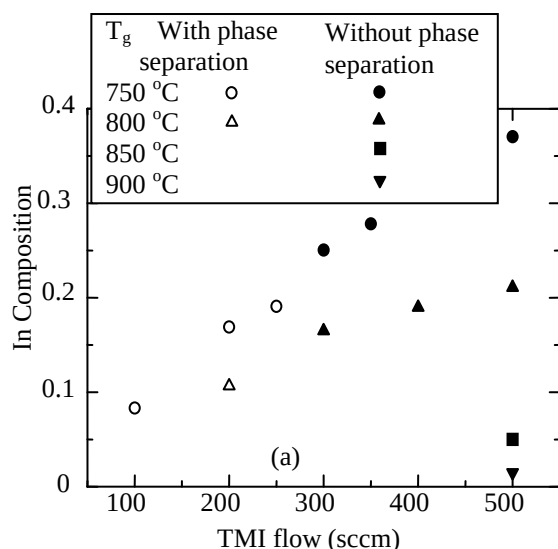


Fig. 3: Variation of In composition in grown InGa_N films, (a) as a function of TMI flow rate with different growth temperature, (b) as a function of growth temperature with different TMI/(TMI+TEG) molar ratio.

0.38 TMI / (TMI+TEG) molar ratio. When the TMI / (TMI+TEG) molar ratio is above 0.38, the In composition is changed by TMI / (TMI+TEG) ratio at higher temperature (>800 °C) while anomalous behaviour is observed at low temperature (≤800 °C).

3.4 Crystalline quality

The crystalline quality of the grown films is studied by XRD analysis. InGa_N has also been grown on GaN buffer in order to understand the film quality on buffer layer. The variation of tilt and twist of InGa_N epi-layers as a function of In composition grown on LT-GaN buffer or HT-GaN template is shown in Fig. 4. The tilt and twist of InGa_N epi-layer is higher throughout the whole composition grown on GaN buffer than that of template. This indicates using GaN template is effective for the growth of InGa_N. The tilt as well as twist of InGa_N grown on GaN template increases remarkably with the increase of In composition as can be seen from fig. 4 (a) and (b). It is also clear that up to around 0.08 In composition the tilt and twist increases linearly and the increasing tendency is not so high, while around 0.3 to 0.4 In composition, the increasing trend of tilt and twist is very high. More clearly we can explain these differences in this way. Since the InGa_N films are grown directly on the GaN template without any compositional graded buffer layer. The lattice mismatch and thermal expansion coefficient between InGa_N epi-layer and GaN template is responsible for the increase in tilt and twist with the raise of In composition. It is well-known that in lattice-mismatched hetero-

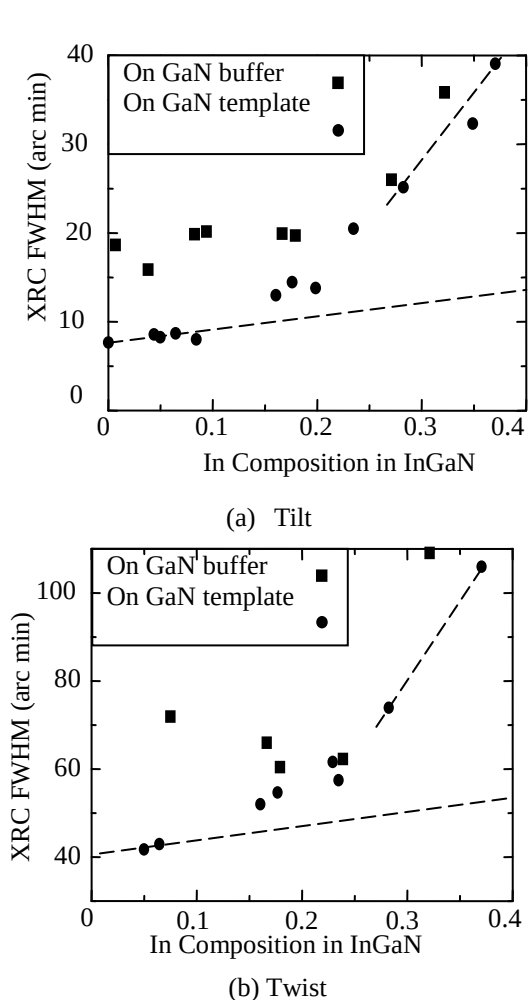


Fig. 4: Variation of (a) tilt, (b) twist as a function of In composition grown on GaN buffer or GaN template

epitaxial systems, pseudomorphic growth occurs for epilayer thicknesses less than the critical thickness; however, beyond the critical thickness, elastic strain energy is relieved with the formation of dislocation densities depending upon the lattice mismatch. In case of large lattice mismatch stepwise growth, when the film thickness exceeds the critical thickness, a high density of dislocations is introduced into the layers to relieve the strain at once. This builds up strong dislocation-dislocation interaction forces which prevent easy dislocation gliding. Therefore, most of the dislocations freeze in place and do not relieve the misfit strain efficiently. The film will, thus, introduce further dislocations to relieve the strain and make dislocation gliding more difficult as the growth proceeds. To improve the quality of InGaN epilayers, the incorporation of a compositional graded inter layer will be essential (Islam et al., 2010).

3.5 Electrical properties

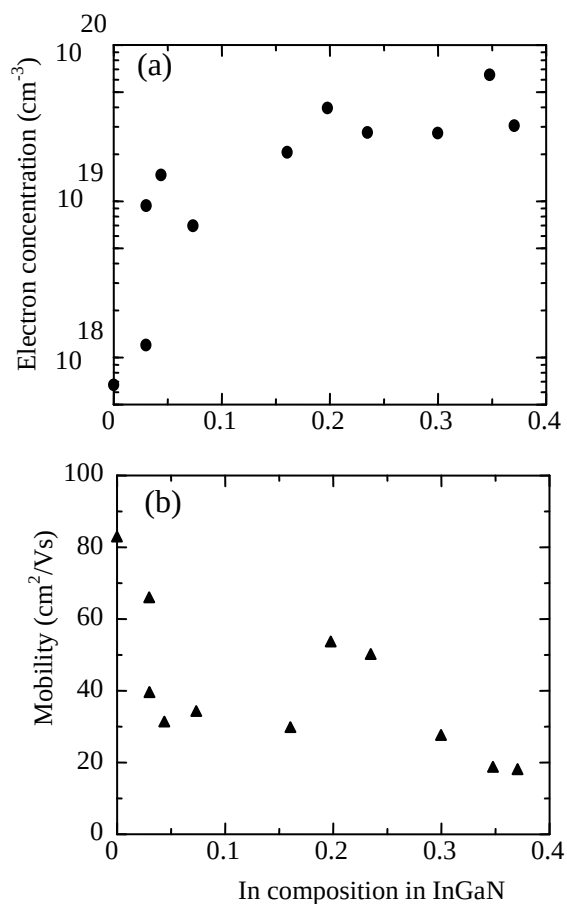


Fig. 5: Variation of (a) electron concentration, (b) mobility as a function of In composition grown on GaN template.

The control of electrical properties in III-Nitride semiconductor is very important for the fabrication of device. The quality of an electronic material is conventionally given in terms of its majority carrier mobility at low electric fields, measured by Hall effect, which simultaneously provides information on the carrier concentration. As-grown GaN and InN is always n-type with a very high background carrier concentration. The electrical properties of InGaN are found to be poor; carrier concentration was measured in the range of $10^{18} \sim 10^{20} \text{ cm}^{-3}$ and mobility in the range of 20-100 cm^2/Vs , for In composition up to 0.4. It can be seen from the figure that with the increase of In composition the electron concentration increases while the mobility decreases. The donor concentrations of InGaN are $10^{19} \sim 10^{20} \text{ cm}^{-3}$, while those of GaN and InN grown with the same reactor are $\sim 10^{18} \text{ cm}^{-3}$ (Fig. 5) and $10^{18} \sim 10^{19} \text{ cm}^{-3}$ (Yamamoto et al., 2006), respectively. Note that the tilt as well as twist that means defect density of InGaN films increases with the increase of In composition (Fig. 4). Such defects seem to act as donors. Therefore, it is

reasonable to conclude that the defect density is one of the candidates for high residual donors.

4. CONCLUSIONS

The understanding of various growth parameters such as the precursor gas flow rates and temperature is of immense importance for successful growth of high quality $\text{In}_x\text{Ga}_{1-x}\text{N}$ epi-layers. By controlling these parameters InGaN films with In composition in the range from 0 to 0.4 are successfully obtained without phase separation as well as metallic In incorporation by MOVPE. The variation of TMI/(TMI+TEG) molar ratio shows a significant effect on growing films. The formation of metallic In originates from the flow of higher value of TMI/(TMI+TEG) molar ratio during lower V/III ratio while the lower ratio of TMI/(TMI+TEG) causes the phase separation. The effective way to control the In composition of InGaN is found by temperature. Crystalline quality of grown films is markedly deteriorated with increasing In composition. The lattice mismatch and difference in thermal expansion coefficient between GaN template and InGaN epi-layer is primarily considered as the reason to deteriorate the film quality for higher In composition. The InGaN film grown on GaN template is found to show superior quality than the film grown on GaN buffer layer. The InGaN films with higher In composition show high residual donors. It is thought that the high defect density is responsible for the high residual donors in the grown film.

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IMPEDANCE MATCHED COMPACT ZIGZAG INVERTED-F ANTENNA FOR WI-FI OPERATION IN A LAPTOP

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Abstract—This paper presents an impedance matched compact zigzag inverted-F antenna (IFA) for Wi-Fi operation in a laptop. The antenna occupies very small area of $8 \times 18 \text{ mm}^2$. Also provides a high gain of 6.91 dBi with the peak return loss of -49.75 dB, VSWR of 1.006 and input impedance of 50.2045Ω at 5.5 GHz. This antenna covers a 10 dB return loss bandwidth of 609 MHz (5250 MHz~5859 MHz). In addition an impedance matching pie filter is used to ensure impedance matching between the source and the antenna. As well, the antenna has acceptable radiation characteristics.

Keywords: Inverted-F antenna (IFA); Compact Antenna; Matching Network (MN); Zigzag IFA; Wi-Fi

1. INTRODUCTION

Recently, the swift growth in wireless communication system leads to several growing demands with the designing of various portable devices require small, low profile and multi-function antenna. In order to satisfy these demands, inverted-F antenna (IFA) has been widely used in portable devices due to its compact, low profile configuration, ease of fabrication and favorable electrical performance. The wireless fidelity (Wi-Fi) operates in the 2.4 GHz band (2.4–2.484 GHz) and 5 GHz band (5.15–5.35 GHz, 5.47–5.725 GHz, and 5.725–5.875 GHz) (Pazin et. al., 2008, Wong and Lai, 2008, Wu et. al., 2005).

A T-shaped monopole antenna with dual shorted L-shaped strip-sleeves for dual operating band with bandwidth of 834 MHz (1962~2796 MHz) and 576 MHz (5328~5904 MHz) at lower and upper frequency bands respectively (Wu et. al., 2005), a internal composite monopole antenna for WLAN/WiMAX operation in a laptop computer covers triple operating band with bandwidth of 347 MHz (2371~2718 MHz), 600 MHz (3192~3792 MHz) and 841 MHz (5051~5892 MHz) at lower, middle and upper frequency band respectively (Wong and Chou, 2006), a modified two-strip monopole antenna for Wi-Fi and WiMAX applications (Chung et.al., 2009), internal wideband metal-plate antenna for laptop application covers a

wider bandwidth of 3.9 GHz (2.1~6.0 GHz) (Wong and Chou, 2005), flat plate antenna with shorted parasitic element for laptop applications with impedance bandwidth of 190 MHz (2330~2520 MHz, centered at 2.4 GHz) and 2140 MHz (4520~6660 MHz, centered at 5.5 GHz) for the 2.4 and 5.8 GHz WLAN band respectively (Wong et. al., 2005) have been proposed.

To provide the increasing demand and cover up the widespread applications of 5 GHz band (5.15–5.35 GHz, 5.47–5.725 GHz, and 5.725–5.875 GHz) for Wi-Fi operation a low profile antenna with wider bandwidth, high gain and less gain variation within the antenna bandwidth is desired. To meet up most of the mentioned requirements, the proposed zigzag inverted-F antenna (IFA) is one of the good candidates within the micro-strip printed antennas because of its compact size and good input impedance than other printed antennas.

In this article, we present a promising low profile antenna named zigzag inverted-F antenna (zigzag IFA) for 5.5 GHz Wi-Fi operations.

2. ANTENNA GEOMETRY

In designing the low profile antenna for Wi-Fi operation in a laptop, we examine the possibility of increasing antenna bandwidth, gain and

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maintaining the input impedance near about $50\ \Omega$ by using impedance matching network throughout the application bands with simplifying its structure using method of moments (MoM's) in Numerical Electromagnetic Code (Burke and Poggio, 1981). The cost of FR4 substrate is higher than the RT/duroid 5880. For the lower cost, in numerical analysis we considered the substrate permittivity of the antenna is $\epsilon_r = 2.2$ (RT/duroid 5880) with substrate thickness of 1.58 mm. Our attempt was to reduce the size of the antenna with improved gain for the 5.5 GHz Wi-Fi operation in a laptop.

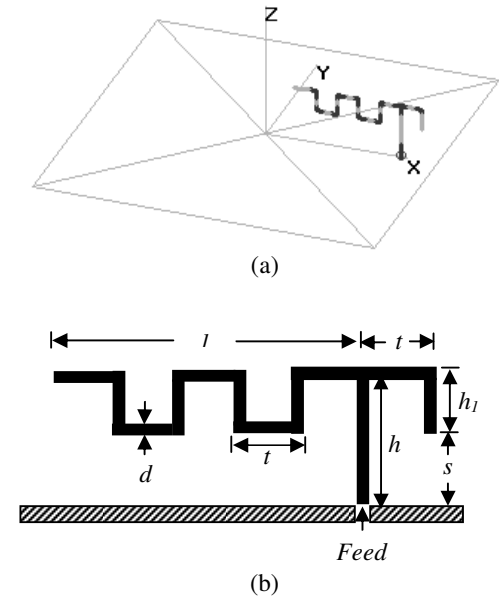


Fig. 1: Structure of zigzag inverted-F antenna (a) 3-D and (b) 2-D view.

The antenna is assumed to be feed by a $50\ \Omega$ coaxial cable, with its central conductor connected to the feeding point and its outer conductor connected to the ground plane. For impedance matching, we use pie type matching network as shown in Fig.4. Fig. 1(a) and Fig. 1(b) show the structure of zigzag IFA 3-D and 2-D view respectively. Here one leg of zigzag IFA directly connected to the feeding and another leg spaced s from the ground plane. In the analysis the dimensions of the ground plane considered as $60\text{ mm} \times 60\text{ mm}$. Fig. 2(a) represents the variation of return loss for different values of h_1 of zigzag IFA. From the analysis on Fig. 2(a) for the optimized value of h_1 , we see that when the value of $h_1=4\text{ mm}$, the antenna provides maximum return loss but gain reduces remarkably at the operating band as shown in Fig. 2(b). The return loss and gain variation for different values of t are shown in Fig. 3(a) and (b) respectively.

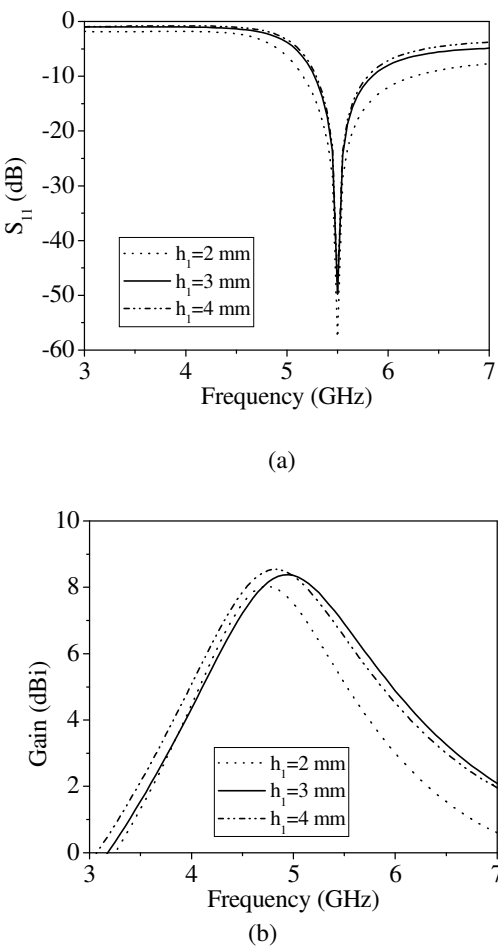


Fig. 2: Variation of (a) return loss and (b) gain of different value of h_1 of zigzag IFA.

Table 1. Dimension of the proposed antenna

Antenna name	Antenna parameters	Values (mm)	Dimension (mm ²)
Zigzag IFA	l	15	8×18
	t	3	
	$l+t$	18	
	h	8	
	h_1	3	
	d	2	
	s	5	

For the value of $t=4\text{ mm}$, the antenna provides high return loss but gain is very low for the required band. Besides the values of $t=2\text{ mm}$ and $t=4\text{ mm}$ does not cover the required 5.5 GHz band. Besides when the value of $t=3\text{ mm}$, the antenna fully covers the 5.5 GHz band for Wi-Fi operation. Table 1 represents the optimized dimensions of the proposed antenna of Fig.1.

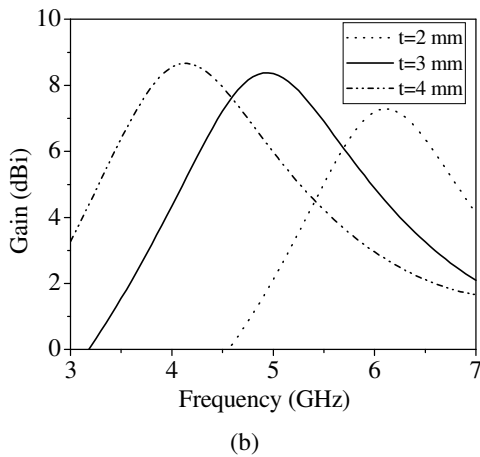
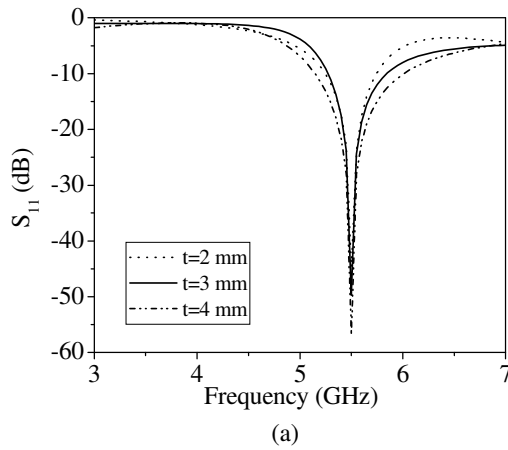


Fig. 3: Variation of (a) return loss and (b) gain for different values of t of zigzag IFA.

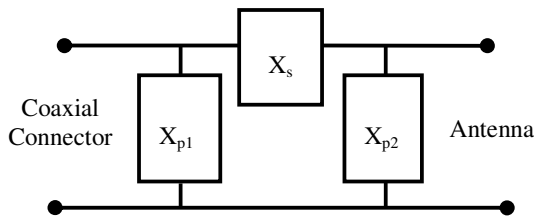


Fig. 4: Matching network (MN) for zigzag IFA

Table 2. Matching network parameters

Network parameters	Value
X_{p1}	0.25 pF
X_{p2}	0 pF
X_s	2.02 nH

3. SIMULATION RESULTS

The simulated return losses of proposed zigzag IFA with and without matching network (MN) are

shown in Fig. 5. From the simulation results, the zigzag IFA has return loss bandwidth of 609 MHz (5250~5859 MHz) and 1150 MHz (5750~6900 MHz). From the simulation result we see that the zigzag IFA without matching network covers a wider impedance bandwidth than the antenna with matching network. But the impedance bandwidth without matching network covers extremely little portion of the required operating band on the other hand, with matching network the antenna covers almost all portion of the 5.5 GHz Wi-Fi operating band with the peak value of the return loss is -49.75dB.

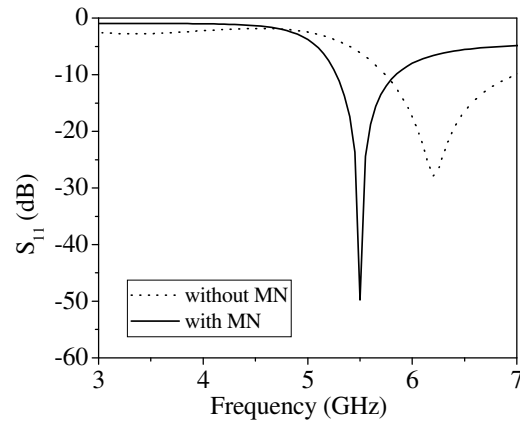


Fig. 5: Return loss variation of zigzag IFA with frequency

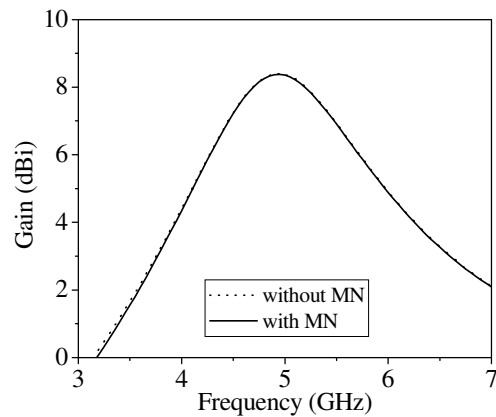


Fig. 6: Gain variation of zigzag IFA with frequency

The peak gain variation of the zigzag IFA as a function of frequency is shown in Fig. 6. From the obtained results, antenna peak gain varies from 7.84 to 5.46 dBi at within the 10 dB return loss bandwidth of the zigzag IFA. The value of VSWR of zigzag IFA is 1.006 at 5.5 GHz. So, the obtained

result indicates that the value of VSWR is very low and it is near to 1 as shown in Fig. 7.

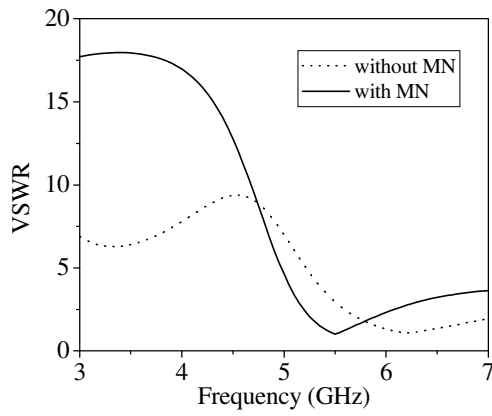


Fig. 7: VSWR variation of zigzag IFA with frequency

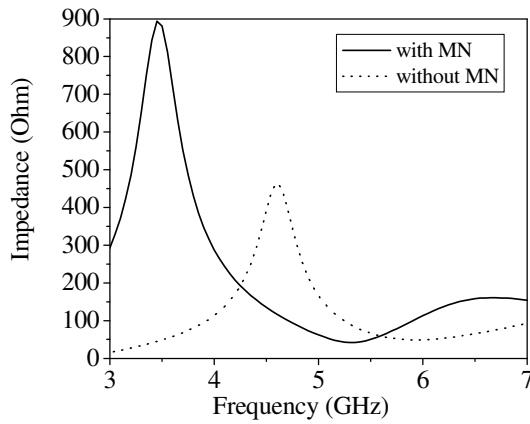


Fig. 8: Impedance variation of zigzag IFA with frequency

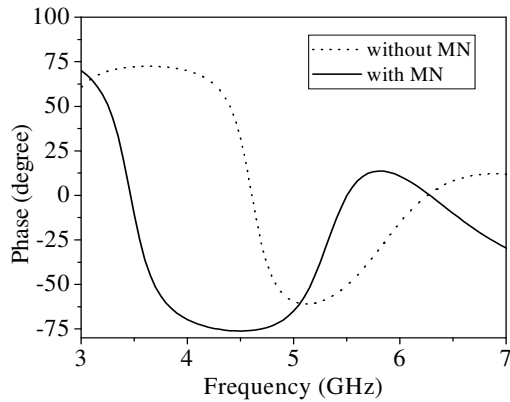
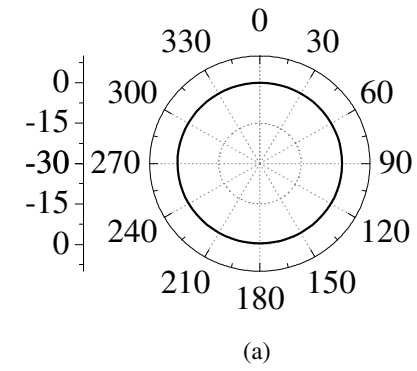
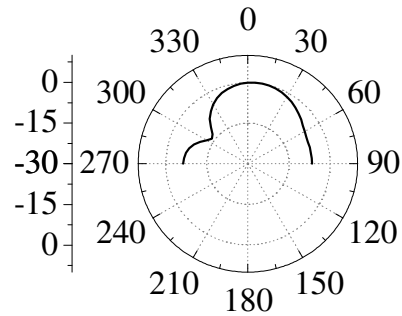


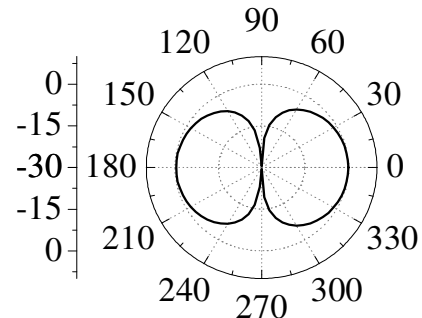
Fig. 9: Phase variation of zigzag IFA with frequency



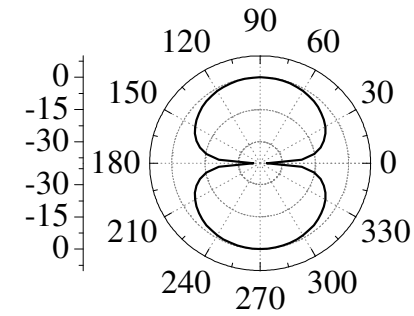
(a)



(b)



(c)



(d)

Fig. 10: (a) Total gain pattern in E-plane, (b) Total gain pattern in H-plane, (c) Vertical gain pattern in E-plane (d) Horizontal gain pattern in E-plane of zigzag IFA at 5.5 GHz.

Fig. 8 represents the antenna input impedance variation. From the obtained results, the input impedance of zigzag IFA is 66.70006Ω at 5.5 GHz without impedance matching network and the impedance away from 50Ω . So impedance matching network is necessary. Using matching network between the source and the antenna, the input impedance of zigzag IFA is found to be 50.20454Ω at 5.5 GHz and the impedance variation is very low within the operating band. So with impedance matching network the input impedance of the proposed antenna is near about 50Ω .

Fig. 9 represents the antenna phase shift causes due to the impedance mismatch as a function of frequency. Also, from the simulation study, the antenna offers a phase shift of -50.68816° without matching network. Besides with matching network the phase shift is -0.29023° . With matching network the phase shift of zigzag IFA closer to 0° all over the antenna bandwidth.

Peak gain comparison with the proposed antenna and reference antennas for Wi-Fi application are listed in Table 3. From the comparison table, proposed zigzag IFA has much higher gain than the antennas have been proposed earlier for 5.5 GHz Wi-Fi operation. Fig. 10 represents the radiation patterns of the antenna for 5.5 GHz resonant frequency of total gain in E and H-plane. The antenna's normalized total radiation in E and H-plane is almost omnidirectional at the 5.5 GHz Wi-Fi operating frequency. In overall considerations, zigzag inverted-F antenna is much better than all other antennas.

Table 3. Gain comparison between the proposed and reference antennas

Antenna	Peak Gain (dBi) at 5.5 GHz Wi-Fi
Zigzag inverted-F (Proposed)	6.91
T-shaped monopole (Wu et. al., 2005)	1.0
Composite monopole (Wong and Chou, 2006)	4.6–5.3
Metal-plate antenna (Wong and Chou, 2005)	4.6-5.2
Flat-plate antenna with a shorted parasitic element (Wong et. al., 2005)	4.2-5.7

4. CONCLUSIONS

Optimized impedance matched compact zigzag IFA for Wi-Fi application is proposed using numerical simulations. The antenna occupies extremely small area with bandwidth of 609 MHz (5250~5859 MHz). Moreover the gain of the antenna is high and the gain variation of the antenna is very low within the operating band. From the analysis, the gain, radiation pattern, return loss, input impedance, VSWR and phase shift of the antenna is suitable for the specified applications than the antennas proposed earlier. Due to the compact area occupied, the proposed antenna is promising to be embedded within the spacing between the casing of the laptop and the supporting metal frame of the display as an internal antenna employing 5.5 GHz Wi-Fi operation.

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IMPLEMENTATION AND RESULTS OF A MICROCONTROLLER BASED DUOBINARY ENCODER CIRCUIT FOR COMMUNICATION SYSTEM

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This paper presents microcontroller based practical circuit with results of a duobinary encoder (duobinary code from binary bit stream) for data communication system. Binary code has two level of bit sequence that is 1 and 0. On the other side, duobinary (DB) is a three-level code that is 1, 0 and -1 level. A duobinary encoder improves the digital system performance and the power efficiency of transmission. Microcontroller based duobinary encoder can encode the binary signal to duobinary signal by simple circuit operation with the help of microcontroller. The three bits comparison part of the encoding technique can be done by microcontroller portion very easily. Detail design procedures and outputs of the implemented practical circuits are presented in this paper.

Key words: Duobinary encoder; Digital design; Microcontroller application and Two input inverting adder circuit.

1. INTRODUCTION

An efficient use of channel bandwidth and transmitted power is achieved through duobinary coding scheme. A binary data stream can be encoded into a duobinary signal (three level data (1, 0, -1)) simply by adding the binary data stream with its one bit delayed stream or by a precoding technique. Duobinary transmission was first invented in 1960 but applied in 1990 in the fiber optic communication system [5]. The advantages of duobinary transmission over binary transmission [5] are many folds; it has a narrower bandwidth than binary format, it saves transmitted power as the dc level of the signal is lower, easy to implement, and it suffers less from Stimulated Brillouin Scattering (SBS). Many efforts have been given in this field by a number of researchers. Our topic is different from the other researchers who have done their research on the same area. To show in difference between our findings and others, we would like to explain their researches. In 1990 only duobinary encoder and decoder signals are shown by J. Builing [2]. In 2008, Y. C. Lu et al demonstrated that 100% driving voltage did not need for optimal duobinary system [4]. One of the

researchers Jiang who have shown that the complexity setup to the transmitter portion can be reduced by using a single-arm Mach-Zender modulator (MZM) for bandwidth 10 GB/s and for 252 km of uncompensated standard single mode fiber (SSMF) [6]. In 2003, Demir Öner explained about the advantages and disadvantages of different line codes including duobinary code [8]. A 3 dB bandwidth of Bessel Low Pass Filter could be used to generate electrical duobinary signals for 40 GB/s duobinary system which was designed by A. Rahman et al [10]. In 2009, another author S. W. Shaker et al designed and implemented duobinary turbo codes which are used in wireless digital communications system [13]. All the mentioned papers explained about the performance of duobinary transmission, the bandwidth of low pass filters, signal and comparison of line codes and modulation technique of communication system. But so far as we know that there is no paper explains about this duobinary encoder and decoder technique with detail circuit design. So our paper is unique that is microcontroller based schematic circuit design of a complete duobinary encoder (duobinary code from binary bit) and duobinary decoder (binary code from duobinary code) for data communication system. Again our proposed

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microcontroller based design circuit for duobinary encoder is cheaper, efficient and easy to implement compare with our previous design [11-12]. The circuit design of duobinary decoder is same but only modification is applied to the duobinary encoder part. One example of duobinary encoder and decoder bit sequence from binary is given below in figure 1.

Binary	1	1	0	1	1	0	0	1
NOT	0	0	1	0	0	1	1	0
EXOR	0	0	1	1	1	0	1	1
X	0	0	1	1	1	1	1	1
Y	1	1	1	0	0	1	1	0
Duobinary								
E_k	0	0	0	1	1	0	0	1
F_k	0	0	1	1	1	1	1	1
$\bar{A}$	0	0	1	0	0	1	1	0
A/Binary Original	1	1	0	1	1	0	0	1

Fig. 1: Example of a duobinary encoder and decoder bit sequence from binary bit stream

2. DUOBINARY ENCODER

The circuit which converts duobinary code from binary bit sequence is called duobinary encoder. This duobinary encoder is used for data communication system.

2.1 Block diagram of a duobinary encoder

The duobinary encoding technique is a part of transmitter portion. First binary bit is generated. Then it is encoded to duobinary bit sequence which is given below in figure 2. Our proposed circuit design is a new technique where the speed controlling operation has been done by a microcontroller (Atmega32) through assembly language program which is given as block diagram in the figure no 2. By the block diagram of figure no 2, the not operation, exclusive-or operation (one input of the exclusive-or is come from not operation and another input from the previous output bit of the exclusive-or operation), bit shifting and each three bits comparison are done by the microcontroller itself and it is given a fixed speed data stream having two levels 0 and 1. In the block diagram of figure 2, source is binary input. The inverting amplifier and two input inverting adder have been used for converting the three level bits (having 1, 0, -1) from two level bits (0 and 1). The

function of inverter is to generate the negative magnitude voltage.

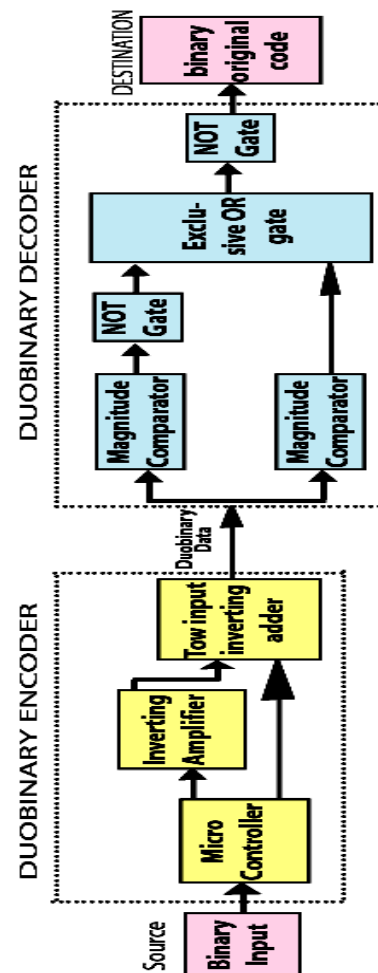


Fig. 2: Block diagram of duobinary encoder system

2.2 Algorithm of duobinary encoder

The conversion technique from binary to duobinary bit stream follows some rules called algorithm which is given below.

- Step 1: It contains three level means 1, 0, -1.
- Step 2: Duobinary code depends on comparison of every 3 bit numbers for each and every position.
- Step 3: If the neighbor 2 bits among 3 bits are same then it tends to change the state. If it is not same then it holds the level means 0 level.
- Step 4: Initially the level starts from -1.
- Step 5: If the signal is on state 1 and getting signal of state rise then it will be on state 1 level because 1 is the highest level in positive side.

Step 6: Similarly, if the signal is on state -1 and getting signal of state fall then it will be on state -1 level because -1 is the lowest level in negative side.

3. MICROCONTROLLER BASED CIRCUIT

Microcontroller is a programmable device which contains a microprocessor, random access memory (RAM), read only memory (ROM), registers etc as same as single chip computer. As microcontroller is a low cost programmable device, it is used in the automatic control application. For example robot, microwave oven, digital watch, mobile phone, electronic display and some conditions where logical circuit operation is difficult. Algorithm of the assembly language program for microcontroller of duobinary encoder is given below. Atmega32 type microcontroller is used in simulation circuit.

3.1 Algorithm for the program of the designed duobinary encoder circuit

- Step 1: Initialize the assembly program and all necessary registers.
- Step 2: Define output port and input port.
- Step 3: Take the desired number from inside the program.
- Step 4: Applying not operation of the desired program.
- Step 5: Applying exclusive-or operation (one input from current not operation and another input from ex-or operation of previous bit) of the number after not operation.
- Step 6: Compare each and every 3 (three) bit number after exclusive-or operation for step up, step down and step hold condition.
- Step 7: Take previous state data from output port for determine state condition.
- Step 8: Give the output data to the output port.
- Step 9: Loop.

3.2 Flow chart and description of assembly language program for duobinary encoder circuit

From the figure 3, initially all the necessary registers are declared as different suitable names. Then first take the desired number from program where the number is given by the user and can be changed before burning. Then the number is converted to 1's complement means not operation. Then save the first complement number to a register named initial. After that exclusive-or operation has been done between count and initial register. Previously count register has been zero so the not output data has done exclusive-or operation with the previous bit means by default 0. The result is shifted left and the 8 bit position has been saved

to the 8 bit position of a register. Increment count register after 1 bit exclusive-or operation and save the result to a register named first result. In this way the whole exclusive-or operation has been completed and it has been saved to the register named first result. Then the output ports have been declared and initially it should be x (portb 1) = 0 and y (portb 2) = 1. Next the exclusive-or output is shifted 1 bit and taken every three bits for comparison and taken the previous output data for determining state condition. The program has been given output data according to the compare result with 0, 1, 2, 3, 4, 5, 6 and 7. In this way the output results are got by two ports. One is x (port b1) and another is y (port b2).

In this way the program compares 3 bits numbers each and every time and gives the output result until the interrupt code is active. After this programming three types of output bits to the output ports X (port b1) and Y (port b1) can be obtained by the designed duobinary encoder circuit.

Table 1

Three cases or levels of duobinary encoder circuit

First case	X = 1, Y = 0	State rise = 1 level
Second case	X = 1/0, Y = 1/0	State hold = 0 level
Third case	X = 0, Y = 1	State fall = -1 level

From the above table 1, these outputs of PPIA / X (port b1) and PPIB / Y (port b1) have the values of positive and zero level logic voltage. But we need negative level logic means -1 level but there is no logic gate which will give -1 logic output. So we have to apply these programming outputs to the circuits called inverting amplifier and two inputs inverting adder circuit which is given below and finally 1level, 0 level and -1level logic voltage of duobinary coding can be obtained from the output of two inputs inverting adder circuit which is given below in the table no 2.

Table 2

Truth table that follows the duobinary three (1, 0, -1) level of the two input inverting adder

Input				Output
X	Y	E ₁	E ₂	
0	1	0	1	- 1 level
0/1	0/1	0/1	0/1	0 level
1	0	1	0	1 level

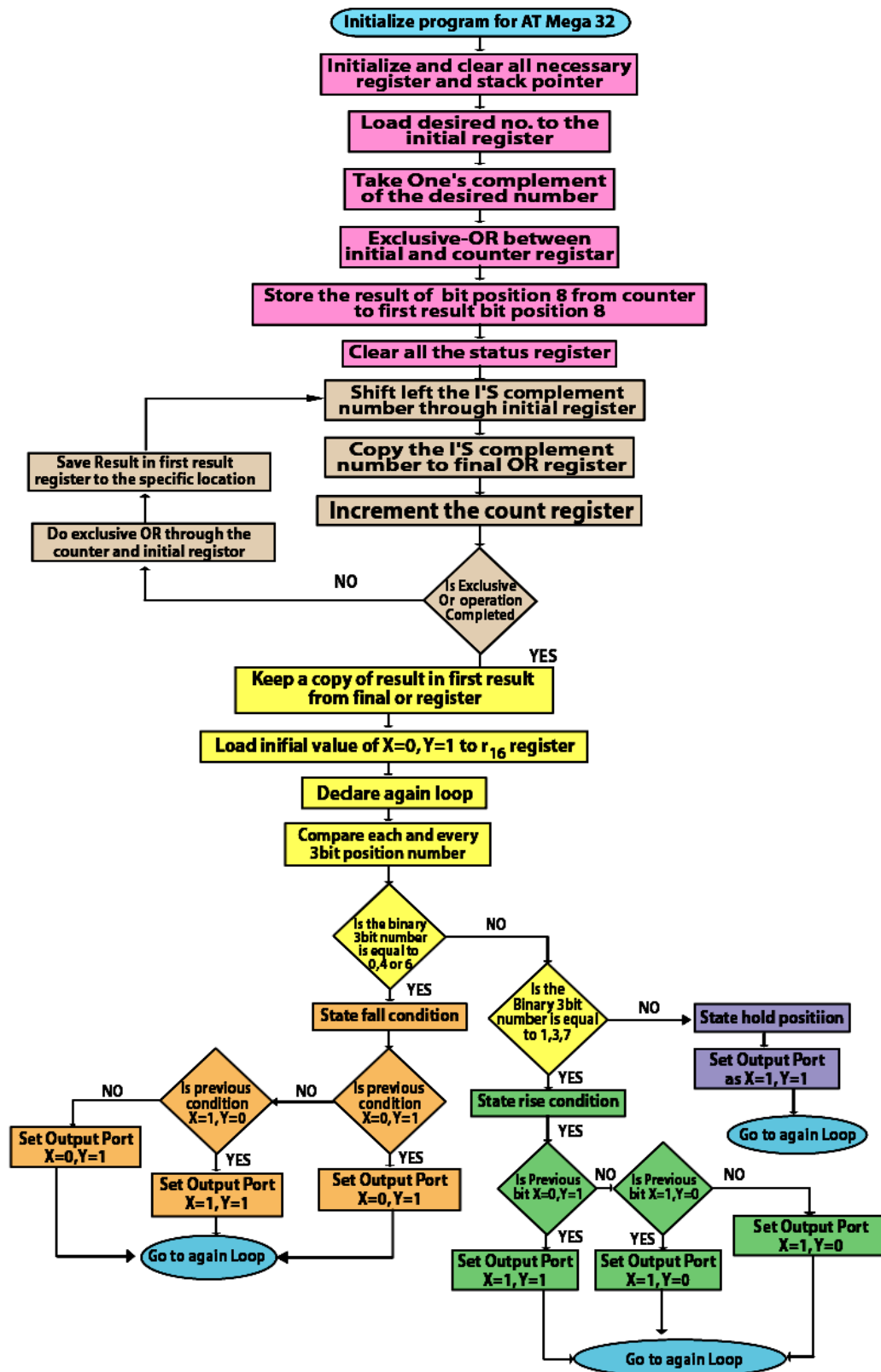


Fig. 4: Flow chart of assembly language program for duobinary encoder circuit

4. SIMULATION AND SCHEMATIC CIRCUIT OF DUOBINARY ENCODER

Proteus 7.6 software is used here which is basically electronic based simulation software. Atmega32 is used here for a microcontroller, LM358N is used for making inverting amplifier, two input inverting adder and magnitude comparator, IC74136 is for exclusive-or gate, IC7404 is for not gate, battery is for fixed dc power supply. Inverting amplifier is used for making x to $-x$ and result of two input inverting adder = $x-y$. Then the duobinary encoding can be achieved.

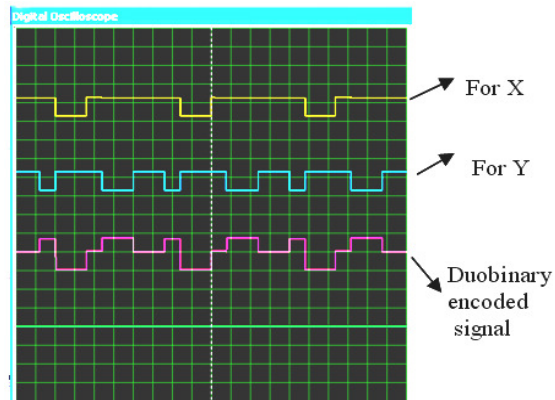


Fig. 6: Simulation result of duobinary encoder

6. IMPLEMENTED CIRCUIT AND RESULTS OF A DUOBINARY ENCODER

One microcontroller (Atmega32), five resistors with 100Ω each, two operational amplifiers LM358N and some wires are used to implement the duobinary encoder.

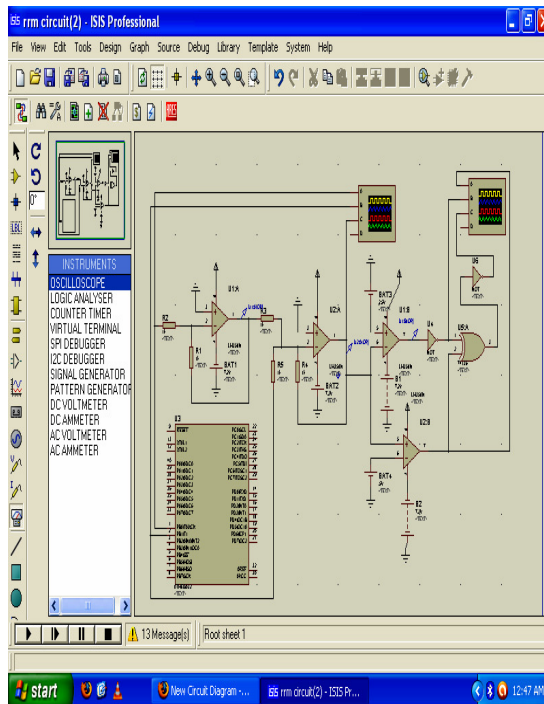


Fig. 5: Proposed schematic full circuit of duobinary encoding and decoding system

5. WAVE SHAPES AND RESULTS OF DUOBINARY ENCODER CIRCUIT

Figure 6 is the simulation result by Proteus 7.6 simulation software. The yellow shape of duobinary encoder represents X , blue shapes represents Y and red shape represents duobinary code in figure 6 which is the example of figure 1.

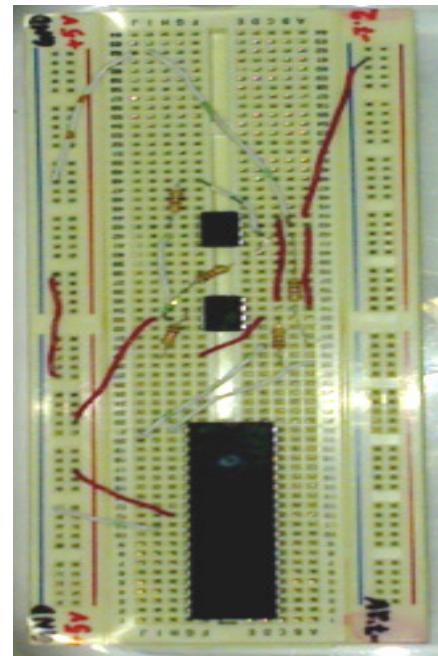


Fig. 7: Implemented designed full circuit of duobinary encoder system

After connecting the probes of an oscilloscope the wave shapes of duobinary encoder code can be obtained, has been given to the figure no 8 which are the 100 percent accurate results of the example of duobinary encoder as same as figure 1.

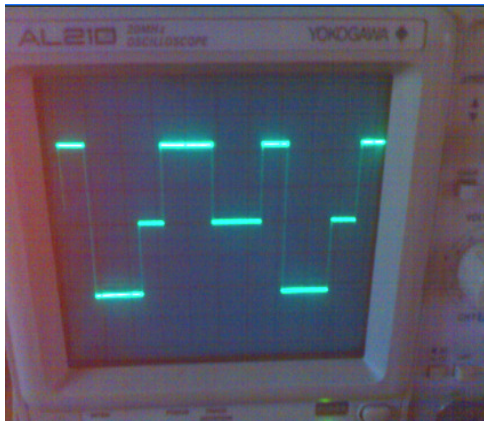


Fig. 8: Wave shapes of duobinary encoder from oscilloscope

7. CONCLUSIONS

The design circuit of duobinary encoder can be implemented any required place in communication system as duobinary has greater advantages than binary format. Our microcontroller based duobinary encoder generates low average power and that is why the duobinary data can travel long distance in communication system. Our proposed design circuit of duobinary encoder generates duobinary data at Mbps speed. Again proposed circuit design is a new technique where the speed controlling operation has been done by a microcontroller (Atmega32) through assembly language program and the not operation, exclusive-or operation, bit shifting and each three bits comparison are done by the microcontroller itself and a fixed speed data stream 0 and 1 are obtained. For this reason, the circuit becomes simple for the three bits comparison portion and additional clock pulse generator circuit is not need to the above proposed duobinary encoder circuit. So proposed design circuit is easy to implement, cheaper and more efficient than the previous design of duobinary encoder circuit. These circuits of duobinary encoder circuit gave hundred percent accurate results which are given in figure 1, 7 and 8 with respect to the time interval and bit sequence.

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IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN EMBEDDED SYSTEM FOR AUTOMATIC VOLTAGE REGULATOR

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Fuzzy logic control is being increasingly applied to solve control problems in areas where system complexity, development time and cost are the major issues. Engineers and researchers are today considering fuzzy logic algorithm in order to implement intelligent functions in embedded systems. In this paper, the application of a simple microcontroller to deal with a two variable input and a single output fuzzy logic controller has been tested for automatic voltage regulation of an inverter. A set of linguistic fuzzy control rules are set up which are conditional linguistic statements and establish the relationships between the inputs and the outputs, so that the output voltage of an inverter is stabilized. This paper discusses the low cost implementation of fuzzy algorithm in an 8-bit microcontroller using the tools and techniques to generate optimized fuzzy based real time code in C for ATmega32 microcontroller which will demonstrate how fuzzy logic might provide elegant and efficient solutions in the design of multivariable control based on experimental results rather than on mathematical models.

Key words: Voltage source inverter (VSI); pulse width modulation (PWM); fuzzy logic control (FLC); centre of gravity (COG); microcontroller

1. INTRODUCTION

In recent years, the distributed generation system using new energy sources has attracted much attention (Uematsu et. al., 2002). Since this distributed generation system links to a commercial source, a utility interactive inverter is required.

Pulse Width Modulation (PWM) inverters are of huge and great impact in many engineering disciplines. It plays a big role in the field of power electronics regarding voltage sources to vast amount of electronics equipments and machine controllers. In this case, some different levels of DC voltage are applied as an input for the inverter because there are new energy sources such as solar batteries and fuel cells provide different DC voltage levels. However, in certain applications, such as steel mills, paper mills, robotics, machine tools, the drive operates under a wide range of load change characteristics and the output voltage of an inverter vary substantially.

To overcome this drawback, we have proposed a scheme as shown in Fig. 1, based on the use of conventional DC-DC converter, followed by a PWM inverter where feedback and artificial intelligence control system is implemented.

Regulated output voltage is assured by varying the duty cycle of the PWM pattern with the use of fuzzy logic control algorithm using microcontroller. The control algorithm includes a complicated computation process to eliminate the variations in the load disturbance and systems parameters and also obtain high performance AC system. Designing a conventional controller presents problems since modeling the system is very difficult due to its non-linearity. For controlling such a complicated system, fuzzy logic control can be the best solution (Bor-SenChen et. al., 1999). Fuzzy logic controllers have the advantages of working with imprecise inputs, not needed an accurate mathematical model, and handling nonlinearity (Veerachary et. al., 2003). However, fuzzy technique, which has gained popularity in recent years, looks very promising for this application. The use of fuzzy logic in gate signals control in PWM voltage source inverter (VSI) is tackled, analyzed, and implemented in this paper, where MATLAB/SIMULINK simulation and experimental results are described. The results show how well this controller eliminates

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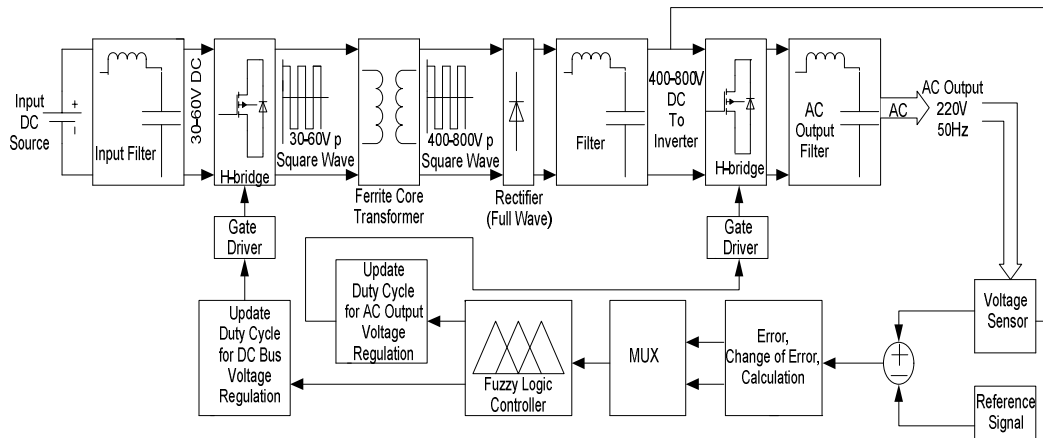


Fig. 1: Detailed block diagram of the systems proposed

the complexity and provides a very fast rise time for voltage stability of an inverter.

2. DESIGN CONSIDERATION

The full bridge inverter stage is designed with MOSFET power transistors as shown in Fig. 4. The drive signal for MOSFET power transistors is generated by the PWM (pulse width modulation) module contained in the microcontroller. The proper value of duty cycle is selected with the use of fuzzy logic control algorithm depending on the condition of inverter output voltage. With fuzzy logic, output voltage is stabilized while variation of the input range is 150V to 250V. For sensing the inverter output voltage, potential transformer is used to step down the output voltage and rectified by using full wave rectifier circuit. The output is then feed back to ADC0 pin of ATmega32 microcontroller. The ADC module contained in ATmega32 microcontroller is used to convert the voltage levels to digital value and can work on voltage up to 5V. A/D conversion is completed by using software program. With a 10-bit ADC over the full range of mains voltage (0~300V) scaled to 0 to 5V. The resolution is 300/1024 or 0.3V. This is too high a resolution called for. The rms value of the voltage is calculated by using the formula as given in (1).

$$V_{rms} = \sqrt{\frac{\sum_{n=1}^4 V_n^2}{n}} \quad (1)$$

Where n is the total number of sample taken and V_n is the n^{th} sampled voltage. If the output voltage decreases the V_{rms} voltage also decreases. The output voltage of inverter is rule-based.

The rules logic is built into the software developed where fuzzy logic control system is applied so that whenever V_{rms} voltage decreases or increases; duty cycle of PWM varies to regulate the output voltage. MATLAB simulation results are shown in Fig. 2 and Fig. 3. Normalized PWM and normalized output sine waves are shown in these figures. As the amplitude of the output voltage decreases, the duty cycle of each pulse in PWM increases to regulate the output voltage as observed in Fig. 2 and Fig. 3.

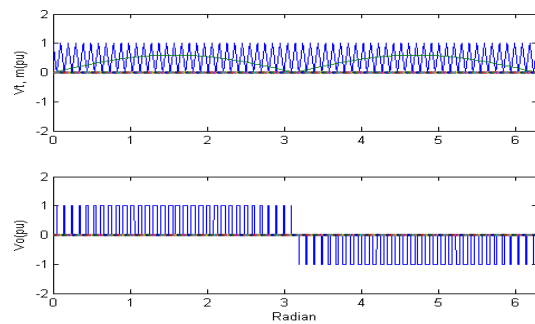


Fig. 2: PWM at normal condition

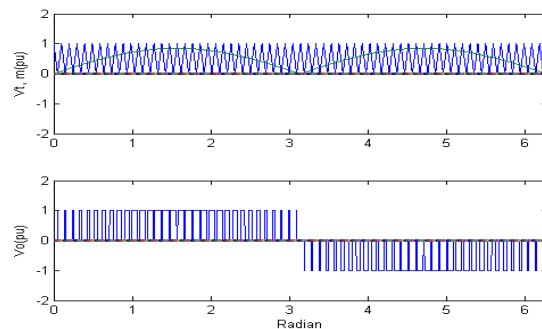


Fig. 3: PWM at loaded condition

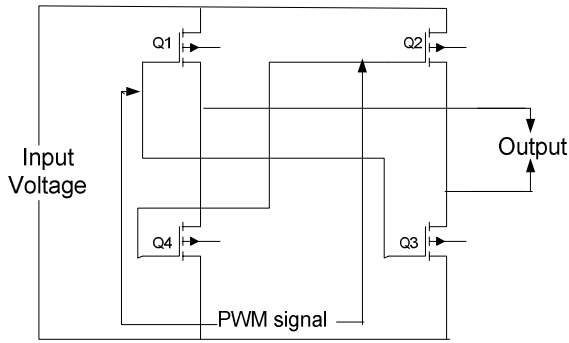


Fig. 4: Full bridge inverter circuit

3. FLC IMPLEMENTATION ON EMBEDDED SYSTEMS

The inputs to an AVR using fuzzy logic controller are usually an error voltage E and a change of error ΔE as given in (2) and (3) respectively.

$$E(n) = V(n) - V(n-1) \quad (2)$$

$$\Delta E(n) = E(n) - E(n-1) \quad (3)$$

E and ΔE are calculated and converted to the linguistic variables during fuzzification. Linguistic variables are non-precise variables that often convey a surprising amount of information. To simplify the control calculation, the values of error voltage E and change of error ΔE can be normalized with (4) before fuzzification process:

$$Y_s = \begin{cases} -1, Y < -Y^* \\ Y/Y^*, |Y| < Y^* \\ 1, Y > Y^* \end{cases} \quad (4)$$

Where, $Y^* = Y_{\max}$, so the scopes of error E and change of error ΔE will be $[-1, 1]$. Fig. 5 shows the relations between measured error and the linguistic term, such as positive small, positive medium and positive big. At some point the error is positive small and at some point the error is positive big the space between positive big and positive small indicates an error that is, to some degree, a bit of both. The horizontal axis in the following graph shows the measured or crisp value of error voltage. The vertical axis describes the degree to which a linguistic variable fits with the crisp measured data.

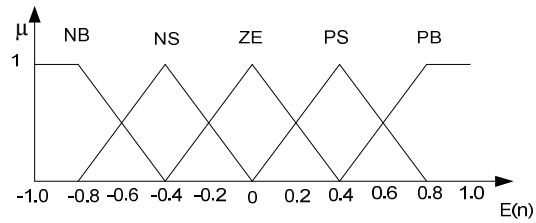


Fig. 5: The relationship between linguistics variable and error

To add the linguistics variable positive big to a computer program running in an embedded controller, translation the graphical representation into meaningful code is needed. The following C code fragment gives one example of how to do this. The function error- Positive Big () returns a degree of membership, scaled between 0 and 1, indicating the degree to which a given error can be positive big. This type of simple calculation is the first tool required for calculations of fuzzy logic operations.

```
char Error_Positive Big (int CRISP)
{
    if (CRISP < 0.4)
        return(0);
    else
    {
        if (CRISP >= 0.4)
            return(CRISP * 2.5);
        else
        {
            return(1);
        }
    }
}
```

Rule evaluation is done by using an algorithm where loops compare the antecedent value depending on the rule being evaluated in a repeated fashion until all rules are evaluated.

The fuzzy logic controller output is typically a change in duty ratio ΔD of the power converter. The linguistic variables assigned to ΔD for the different combinations of E and ΔE as shown in Table 1 which is based on a DC-DC conversion unit. If, for example, the error voltage E is PB, and ΔE is PS, then we want to largely increase the duty ratio, that is ΔD should be PB for very fast rise time of voltage stability.

Table 1. Fuzzy rule base table

$E \backslash \Delta E$	NB	NS	ZE	PS	PB
NB	NB	NB	NS	ZE	ZE
NS	NB	NS	ZE	ZE	PS
ZE	NB	ZE	ZE	PS	PS
PS	ZE	ZE	PS	PS	PB
PB	ZE	PS	PS	PB	PB

The final step in the fuzzy logic controller is to combine the fuzzy output into a crisp systems output. The result of the defuzzification has to be a numeric value which determines the change of duty cycle of the PWM signal used to drive the MOSFET of the H-bridge inverter. There are various methods to calculate the crisp output of the system. Centre of gravity (COG) method is used in our application due to better results it gives. The COG for our application is expressed mathematically, as given in (5).

$$\Delta D = \frac{\sum_{n=1}^4 Y[i] \times F[i]}{\sum_{n=1}^4 Y[i]} \quad (5)$$

Where $Y[i]$ is the i^{th} members of the output vector and $F[i]$ are the multiplying coefficients of the output membership function as shown in Table 1, and ΔD is the change of duty cycle, and this number represents a signed number which is added or subtracted from the present duty cycle to generate the next system response for voltage stability.

4. FIRMWARE DESCRIPTION

The overview of fuzzy logic control voltage stabilizer is shown in Fig. 6. Before entering the main control loop firmware initialize itself. The Liquid Crystal Display is used to display duty cycle. The information of output voltage, change of error voltage and duty cycle is used to tune fuzzy rules. The main loop is responsible for updating ADC value and calculating output voltage, error voltage and differential error voltage. Using these variables, duty cycle is calculated. The calculation is performed by using fuzzy logic algorithm based on a single chip ATmega32 microcontroller. Timer 1 generates interrupt in every 10ms. The interrupt signal from the timer 1 causes AD conversion started. The ADC value is used to calculate V_{rms} which is proportional to the output voltage.

5. TEST AND RESULT

The experimental result for the real time test of fuzzy voltage controller is shown in Fig. 7 where the control of DC bus voltage of DC-DC converter section is done using fuzzy logic algorithm. Fig. 7(a) shows the duty cycle of PWM signal for a fixed input voltage and Fig. 7(b) shows the increased duty cycle using fuzzy logic algorithm for decreased input voltage to obtain output voltage stability. RS232 communication was established with computer for monitoring the output DC bus voltage.

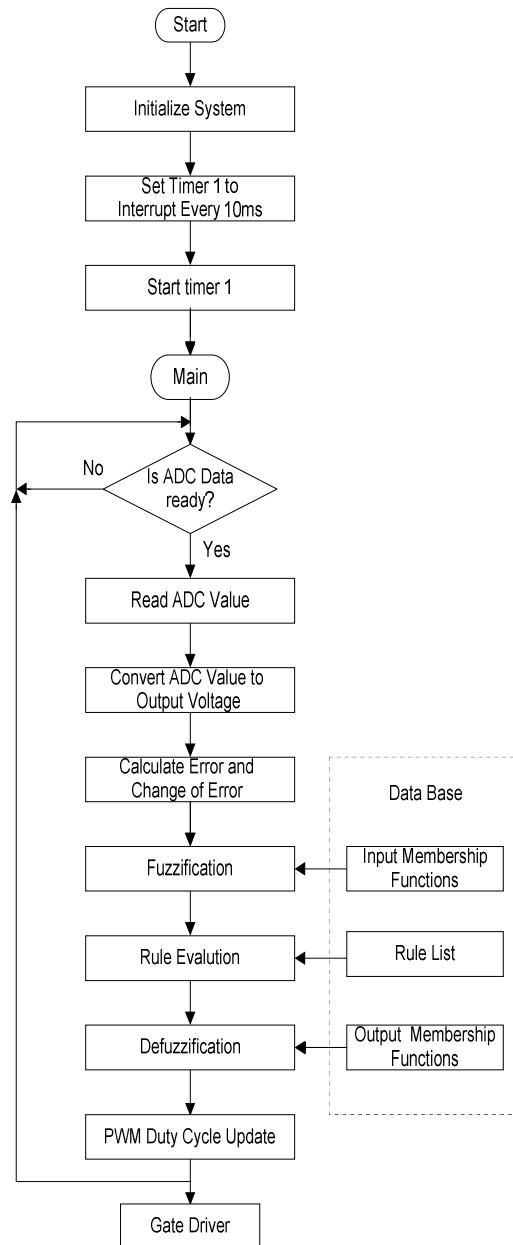
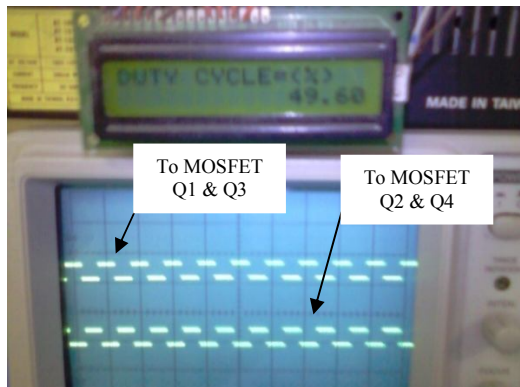


Fig. 6: Fuzzy AVR FIRMWARE

With the use of MATLAB code, online data of output voltage is plotted using serial communication as shown in Fig. 9. Continuous monitoring of the voltage showed that, output of the DC bus voltage is stabilized very fast for changed input voltage. Fig. 8 shows the MATLAB/SIMULINK simulation result of normalized output voltage using fuzzy logic control and without using fuzzy logic control for step input voltage change.



(a)



(b)

Fig. 7: Experimental layout for the real time test

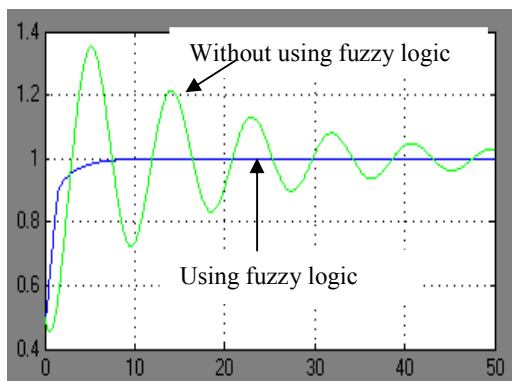


Fig. 8: MATLAB/SIMULINK result of fuzzy logic

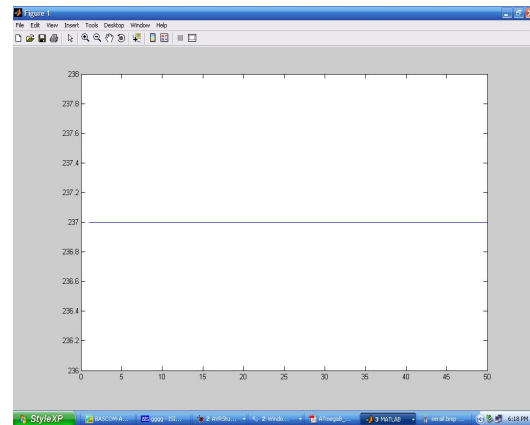


Fig. 9: Online output voltage monitoring using serial communication

6. CONCLUSION

This paper has demonstrated the implementation of fuzzy logic control for the control of fluctuated AC to a consumer home due to different levels of DC voltage as an input for the inverter and non linear load characteristic. The FLC is easy to implement and require a small amount of inexpensive components in compact size. The designed controller showed good ratification performance between 150V and 250V input and provide a stable output. The test result showed that, the controller provides a very fast rise time for voltage stability of an inverter within less then 1 second.

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IMPLEMENTATION OF BOOST CONVERTER FOR LOW POWER APPLICATION

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Abstract- This paper deals with a Boost converter for low voltages in battery or photovoltaic applications. The performance of the PWM Boost regulators is investigated theoretically as well as experimentally. In order to improve the transient time and inductor ripple current, the Boost converter is considered in both continuous and discontinuous mode. At first the steady-state performance is investigated to improve the inductor ripple current and it is investigated by using MATLAB simulation. It is shown that, the input ripple current of Boost converter can be substantially reduced by using different parameters. Then it is closely observed the transient time of Boost converter for those different values. And it is seen that, the output voltage goes to steady state after 1 ms, which is expected. A 60V dc Boost converter has been designed, realized and successfully tested in the laboratory. The Boost Converter has been implemented by using 555 timer to control the switching regulator. The output voltage has been controlled by a switching and sampling network. The switching function controls the operation of the device used in boost converter. The feedback has been taken from the output and is applied to a comparator circuit to produce the PWM signal for switching function. Another intension is to improve the changeover time of Boost Converter by using 555 timer to produce PWM instead of Conventional Comparator-Op amp method.

Keywords- Averaged models boost converter, circuit averaging dynamic phasors, modeling, power electronics, sampled-data models, simulation, state-space averaging, switched models., 555 timer.

1. INTRODUCTION

Step up choppers for DC to DC power conversion find widespread applications in different areas [1]. They are used to boost a varying DC input voltage to a higher stabilized DC output voltage or to draw a certain current from a DC power source. These features can be used to supply a 60V power from a 12V battery in automotive applications or to track the maximum point of power in photovoltaic systems.

The boost converter has the five basic components, namely a power semiconductor switch, a diode, an inductor, a capacitor and a PWM controller [2]. To illustrate the challenges in modeling and simulation of boost converter circuit, we built around the example of a boost dc-dc converter. The basic Boost converter, intended to provide a voltage step up function, is embedded in application ranging

from power factor corrected (PFC) rectifier circuits (whose input current is made to follow the wave shape of the input voltage) to circuits comprising the RF amplifier in cell phones [3].

Fig. 1 depicts a step-up or a PWM boost converter. It consists of dc input voltage source V_s , boost inductor L , controlled switch S , diode D , filter capacitor C , and load resistance R . The converter waveforms in the Continuous Conduction Mode (CCM) are presented in below. When the switch S is in the on state, the current in the boost inductor increases linearly and the diode D is off at a time. When the switch is turned off, The energy stored in the inductor is released through the diode to the output RC circuit [1].

Using Faraday's law for the boost inductor [4], we get the following equations

$$V_s DT = (V_o - V_s)(1 - D)T \quad \text{----(1)}$$

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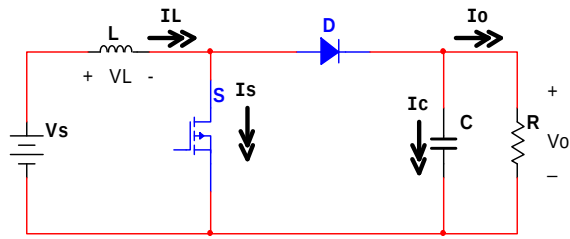


Fig. 1 Basic Boost Converter

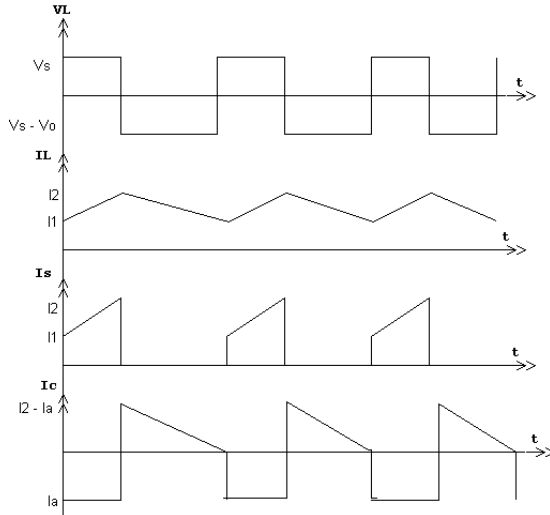


Fig. 2 Output of Ideal Boost Converter

The dc voltage transfer function turns out as follows:

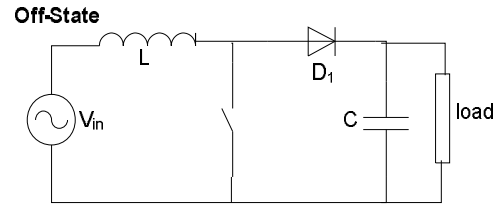
$$M_V = \frac{V_0}{V_s} = \frac{1}{1-D} \quad \text{-- (2)}$$

2. BACKGROUND OF BOOST CONVERTER

Analysis of the circuit is carried out based on the following assumptions. The circuit is ideal. It means when the switch is ON, the drop across it is zero and the current through it is zero when it is open. The diode has zero voltages drop in the conducting state and zero current in the reverse-bias mode. The time delays in switching on and off the switch and the diode are assumed to be negligible. The inductor and the capacitor are assumed to be lossless [7].

The circuit operation can be divided into two modes [1][8]. Mode-1 begins when transistor M is switched on at $t=0$. The input current, which rises, flows through inductor L and MOSFET 'M'. Mode-2 begins when transistor M is switched off at $t=t_1$. These are shown below:

Mode-1: (Switch off):

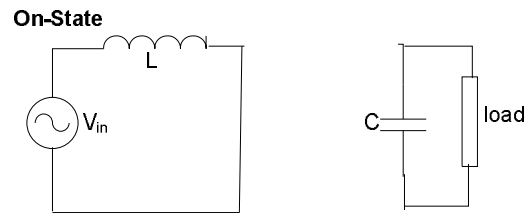


$$\frac{di_L(t)}{dt} = \frac{1}{L} [V_{in}(t) - V_c(t)]$$

$$\frac{dV(c)}{dt} = \frac{i_L(t)}{C} - \frac{V_c(t)}{RC}$$

$$V_0(t) = V_c(t)$$

Mode-2: (switch on)



$$\frac{di_L(t)}{dt} = \frac{1}{L} V_{in}(t)$$

$$\frac{dV(c)}{dt} = - \frac{V_c(t)}{RC}$$

$$V_0(t) = V_c(t)$$

- The basic principle of a Boost converter consists of 2 distinct states:
- In the On-state, the switch M is closed, resulting in an increase in the inductor current;
- In the Off-state, the switch is open and the only path offered to inductor current is through the fly back diode D, the capacitor C and the load R.
- These results in transferring the energy accumulated during the On-state into the capacitor.
- The input current is discontinuous, stepping between a very high inductor current and 0. The large ripple usually requires a large input bypass capacitor to reduce the source impedance.

3. CONTINUOUS CONDUCTION MODE

When a boost converter operates in continuous mode, the current through the inductor (I_L) never falls to zero [1][8].

Boost Converter operates in Continuous mode if the inductance and capacitance are greater than the critical value [1].

The output voltage for this mode can be written as

$$\frac{V_o}{V_i} = \frac{1}{1-K}$$

Where k is the duty cycle and it is less than 1.
The condition for continuous conduction is [4]:

$$f > \frac{RD[1-D]^2}{2L}$$

The circuit tends to become discontinuous,

- if the switching frequency f is decreased, or
- if the duty cycle D is reduced, or
- if the load resistance increases, or
- If the inductance used has lower value.

4. DISCONTINUOUS CONDUCTION MODE

In some cases, the amount of energy required by the load is small enough to be transferred in a time smaller than the whole commutation period. In this case, the current through the inductor falls to zero during part of the period.

Boost Converter operates in Discontinuous mode if the inductance and capacitance is less than the critical value [4][5][6].

The output voltage for this mode can be written as

$$\frac{V_o}{V_i} = 1 + \frac{V_i^2 * K * T}{2L * I_L}$$

Where,

$$\text{Critical Inductance } L_c = \frac{(1-K)R}{2f}$$

$$\text{Critical Capacitance } C_c = \frac{K}{2fR}$$

5. FILTER INDUCTANCE AND CAPACITANCE:

The ripple of Current depends on the value of inductance and ripple of Voltage depends on the value of capacitance. So if we desired the output voltage and current then we can also control the ripple of voltage and current by this formula [4][5][6]:

$$\Delta I = \frac{V_s K}{fL}$$

$$\Delta V_c = \frac{I_a K}{fc}$$

Here 'K' is the duty cycle.

6. COMPLETE CIRCUIT DIAGRAM OF PROPOSED BOOST REGULATORS

The most interesting aspect of the circuit is how an ordinary 555 (Operates as Free Running Multivibrator) is used to regulate the output voltage. Now, there are hundreds of switched mode controllers ICs on the market which are all better suited for this job than the 555. The problem with all these ICs is that if we build a nice NIXIE clock using them, and at one moment in the future the IC breaks down, it is more than likely that it is already obsolete and out of production. The 555 is (very) cheap, performs well enough and most likely will remain in production forever [6].

This can be realized by PWM control. The PWM control of a switched converter is achieved by comparing a reference signal V_{ref} with the feedback signal taken from the output voltage

The 555 timer act as PWM (Pulse Width Modulator) and it is controlled the duty cycle. The duty cycle of PWM is not fixed rather it changes continuously depends on output voltage. If the output voltage is varying then the duty cycle is also changed [9].

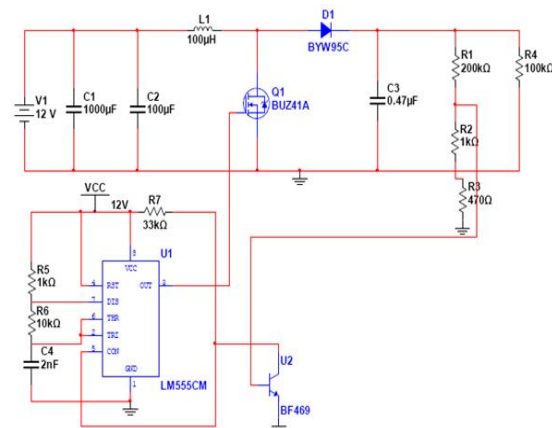


Fig. 3 simple 12-60 V Boost Converter using 555 timer

7. SIMULATION OF THE PROPOSED BOOST CONVERTER

Use *MATLAB* or Mathematical to do the numerical integration. We have complete freedom to employ other integration algorithms as well as to change the time sequences to suit our desire for a complete or just a crude model as we show below. The point to consider is whether or not we have the interest in becoming a computer programmer of power electronics problems as this is a very time intensive endeavor [4][5][6].

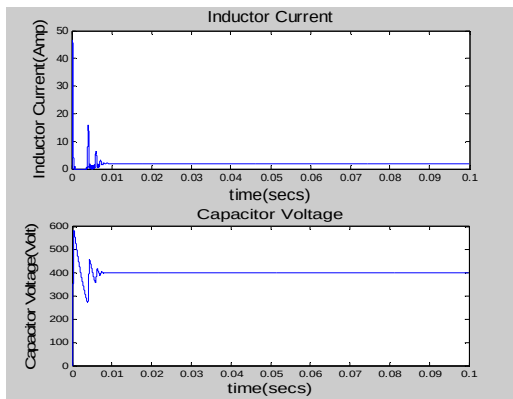


Fig. 4. Transient waveform in the Boost Converter example for $i_L(t)$ and $V_C(t)$. where $E=160[V]$, $L=0.33 [mH]$, $C= 22 [\mu F]$, $R=200 [\text{ohm}]$ $f=50[\text{KHz}]$, Duty Cycle = 66.67 %, $I_{ref}=0.5[A]$

8. BOOST CONVERTER OPERATES IN CONTINUOUS CONDUCTION MODE

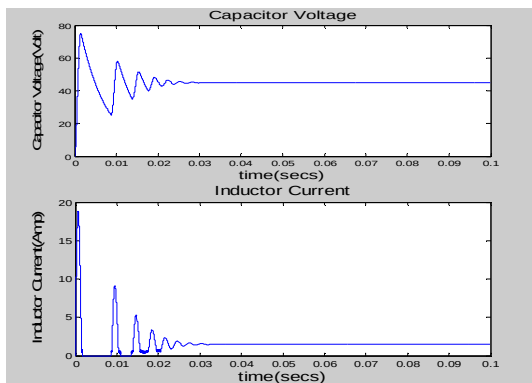


Fig. 5. Transient waveform in the Boost converter when operates in continuous conduction mode, for $i_L(t)$ and $V_C(t)$. Where $E=15[V]$; $L=150[\mu H]$; $C=220[\mu F]$; $R=30[\Omega]$; $f=25[\text{kHz}]$; Duty cycle=66.7[%];

9. BOOST CONVERTER OPERATES IN DISCONTINUOUS CONDUCTION MODE

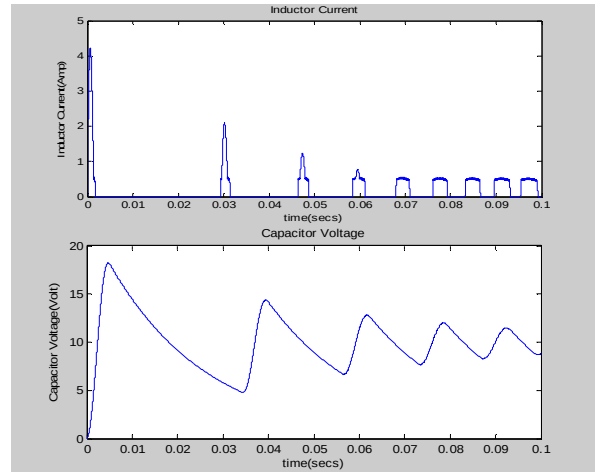


Fig. 6. Transient waveform in the Boost converter when operates in discontinuous conduction mode, for $i_L(t)$ and $V_C(t)$. Where $E=5[V]$; $L=250[\mu H]$; $C=220[\mu F]$; $R=100[\Omega]$, $f=25[\text{KHz}]$; Duty cycle=66.7[%];

10. RESULT AND ANALYSIS

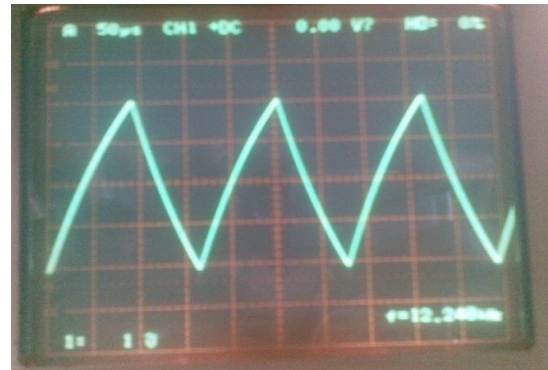


Fig. 7 Capacitor charging and discharging period of 555 timer

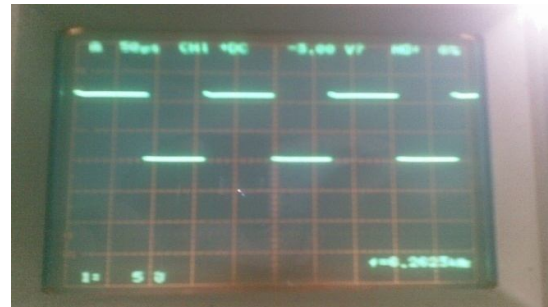


Fig. 8 Output of 555 timer



Fig. 9 Output of the Boost Converter

In our experiment we used only one supply that is DC 12V. The capacitor charging and discharging duration of 555 timer is obtained in **Fig. 7**. The output of the 555 timer is shown in **Fig. 8**. And it is observed that the pulse width which is generated by the timer is not constant initially rather it is varying depends on output voltage of Boost converter and after few moments when output voltage of the Boost converter is fixed then the gate pulse width of the Boost converter is same. That means the control voltage of 555 timer is same, so that the upper and lower threshold voltage is fixed and pulse generated by the 555 timer is same.

The output of the Boost converter is about **60 V** and it is constant remember we supply in the Boost converter is only **12 V** which is shown in **Fig. 9**.

11. DISCUSSION AND CONCLUSION

Boost converter is mainly used where high DC power is required and AC power is available. The power electronic converters as discussed in this paper gave an insight of how the unregulated voltage and current of the Boost converter can be improved. The output of the converter shows the fundamental frequency operation of 25 KHz along with high frequency switching harmonics which can be filtered using the conventional low-pass filter. Moreover, the magnitude of the fundamental Voltage and Current are also regulated to the desired value i.e. 45V and 0.5 [Amps]. Although this fundamental value of voltage and current is not fixed rather it depends on the reference value.

In the paper [3], it has been shown that, the inductor current as well as capacitor voltage goes to steady state after 4 ms. In the proposed model this value, shown in **Fig. 4**, is about 1 ms. Hence about 80 [%] improvements in the transient condition were achieved.

The inductor current goes to steady state condition within 4[ms] at an inductance of 150[μ H]. If this

value is increased to 250 [μ H] keeping other parameters fixed, the transient part of the inductor current does not die out even after 10 [ms].

In many industrial applications, DC-DC converter is required to convert a fixed-voltage DC source into a variable-voltage DC source. Like a transformer, DC-DC converter can be used to step down or step up a DC voltage source.

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IMPLEMENTATION OF PID CONTROL AND PWM TECHNIQUE IN EMBEDDED SYSTEM FOR RIPPLE FREE AND STABILIZED SINE WAVE INVERTER

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A microcontroller based PWM technique and advanced PID control of generating stabilized sine wave inverter with minimized harmonics is implemented in this paper. Our proposed technique is to keep the output voltage and frequency stable and constant within a certain range of load so that it can operate electrical and electronic devices efficiently. The designed inverter provides a range of operation between 25W to 660W. Ripple free and stabilized output voltage is obtained by using efficient filter design and implementation of PID control action in embedded system which is based on experimental results rather than on mathematical model. Appropriate Filter is designed by using Laplace transformation. Size of the transformer is reduced by high frequency switching. The design is simulated in Matlab, Proteus Design Suite software and finally the results are practically verified.

Keywords: PWM technique, PID control, Microcontroller, Voltage sensor, ADC, Duty cycle, Program flow chart, Simulation in Proteus and Matlab, Hardware implementation.

1. INTRODUCTION

Energy crisis are of special attention now-a-days. A need for reasonable power rating inverter is required to smoothly operate electrical and electronic appliances. Most of the commercially available UPS are actually square wave inverters or quasi sine wave inverters. Lights and fans can only be switched with the help of them and other electronic devices cannot be plugged into them as they damage them. Available sine wave inverters are very expensive and by examining the output wave, it is observed that it is not of good quality. Quality of output waveform of an inverter is determined by the harmonic contents present in it. An ideal Inverter should only have a fundamental harmonic component at the designed frequency and stable output voltage within its range. Square wave contains odd harmonics from which fundamental harmonic component can be extracted by applying higher order filter. Higher order filters in terms of

inductors and capacitors are physically unrealizable, its mathematical analysis becomes complex and gain of the system decreases drastically. Sine wave inverter is widely used in many commercial and industrial applications including uninterruptible power supplies, induction heating, variable frequency drives, electrical vehicle drives and HVDC links.

2. DESCRIPTION OF OUR PROPOSED DESIGN

Proposed technique is unique of its type because it is implemented through a low cost RISC microcontroller ATMEGA48 [configuration at <[http:// www.Atmel.Com](http://www.Atmel.Com)>]. The operating speed supported by ATMEGA48 is 20 MHz clock inputs. The reference voltage of the ADC module is 5 V with the resolution of 10 bits. High frequency PWM can be generated using this controller. A filter is connected at the output stage of the inverter

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to translate PWM to a sinusoid wave. The filter is designed in such a way that it removes harmonics. Voltage regulation is one of the important features of our inverter because we use PID control for regulating the output voltage. Our designed system parameters are given in Table 1:

Table 1: System Parameters

Power rating	660VA
Output voltage (regulated)	220 V
Peak output current	3A
Inverter switching frequency for square wave	16 kHz
Inverter switching frequency for sine wave	3.9 kHz
Maximum load (tested)	72 ohms

3. BLOCK DIAGRAM AND OVERVIEW

In the DC-DC converter section, a conventional configuration (Fig. 1), involving an input filter, a switching bridge, a ferrite core transformer, a bridge rectifier and an output filter, is used. The input dc, after passing through a low-pass filter is fed to the switching bridge circuit. The output of the switching bridge is an ac square wave of 12-30V peak which is then supplied to the primary of the ferrite core transformer. The turn's ratio of the transformer is so designed that the output peak voltage corresponding to 12V peak is 400V. To reduce the transformer size, the input dc voltage is first converted to high frequency square ac (16 KHz) and is then stepped up with the help of ferrite core transformer. The secondary voltage of the transformer is rectified and filtered with the help of ABS (absolute) circuit. Thus, we get a variable DC voltage at the converter's output. The variation of the output of the ABS circuit is due to the variation of input voltage source. The output of the DC-DC converter (output of the filter section) is fed to the PWM inverter section. Output of PWM inverter section passes through the LC passive filter resulting sinusoidal waveform, having very low distortion factor (DF). The filter is designed in such a manner so that it passes only the fundamental frequency, with very few harmonics and in the design it is also ensured that the phase shift between input and output of the filter at the fundamental frequency is negligible.

4. TRANSFORMER DESIGN

The ferrite core transformer used in the converter was designed, taking reference from [E. Lowdon 1999]. Core size and required number of turns in primary and secondary winding are calculated as given below. The targeted efficiency of the transformer is 96%.

5. CORE SIZE

The power handling capacity of a transformer core is determined by its area product W_a , where W is the available core window area, and a is the effective core cross-sectional area.

$$W_a = P_{dc} \cdot 108 \cdot \frac{S}{4eBfK}$$

Where, P_{dc} is output power, S is current density, e is transformer efficiency, B is flux density, f is switching frequency and K is winding factor. For our core, W_a was calculated to be 80cm^2 .

6. NUMBER OF TURNS

The number of turns is calculated using:

$$\frac{N}{V} = \frac{1}{28.64faB} \times 10^8$$

Where,

f = Frequency of operation of the transformer

a = Core cross section area, 1.24in^2

B = Flux density in the core, 1Kgass

The maximum primary voltage in our case is 30V, which requires primary turns of 4.23. And we have taken 6 turns, considering some safety margins. Now, for obtaining a 240V AC using a minimum of 12V DC, we need to provide at least 400V DC at the inverter bus. So, the required turns ratio is $400/12 = 33.33$. Hence, turns required in the secondary coil are $33.33 \times 10 = 333.3$. And considering some safety margin, we have used 335 turns.

7. FILTER DESIGN FOR FULL WAVE

RECTIFIER OUTPUT

After the bridge rectifier a low-pass filter is used to produce a low ripple dc voltage. The frequency of the ac signal is 16 kHz. Hence, the output of the bridge rectifier will contain fundamental and the higher harmonics of 16 kHz. Thus a LC filter of 10 kHz cut-off frequency would be enough. We chose $C = 330\mu\text{F}$ and $L = 2\mu\text{H}$.

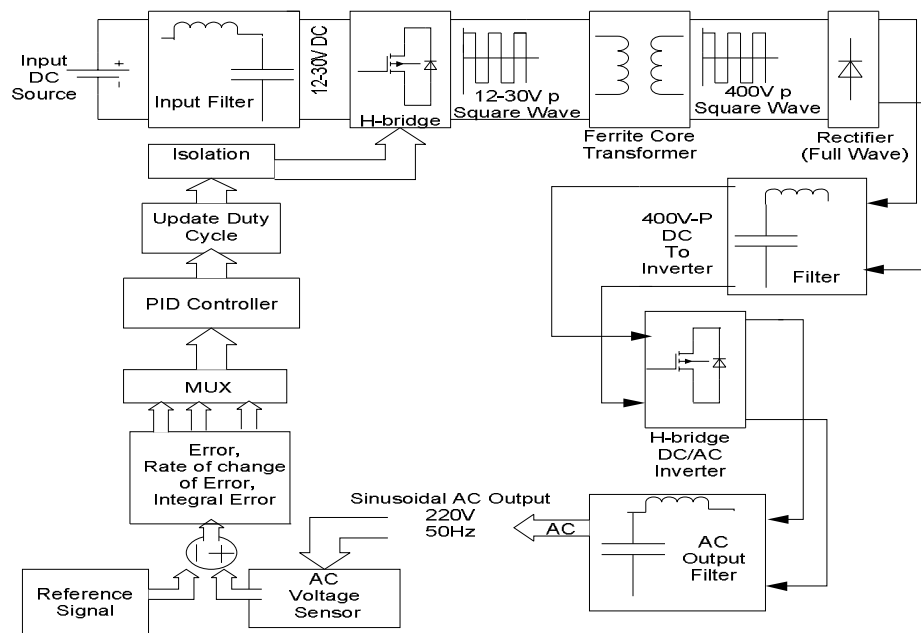


Fig. 1: Block diagram of complete system

8. PWM SIGNAL GENERATION

We compare a 50 Hz sine wave with a 3.9 KHz unity magnitude triangular carrier wave resulting a 3.9 KHz PWM wave.

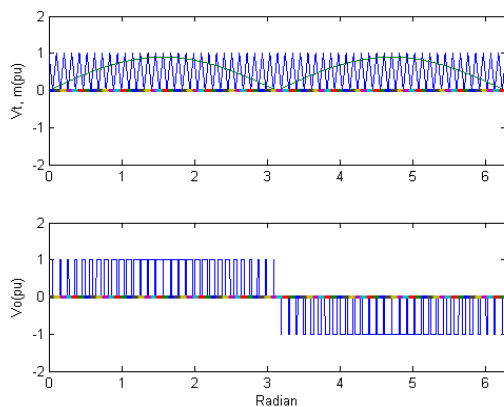


Fig. 2: Comparing Sine wave with Triangular wave and PWM signal generation in Matlab

The time period of output wave $2\pi \text{ rad} = 6.28 \text{ rad}$ which contain 78 PWM pulses and per PWM pulse equal to $256\mu\text{s}$. So total time of 78 PWM pulses equal to 0.02s which is expected

9. GENERATION OF SQUARE WAVE

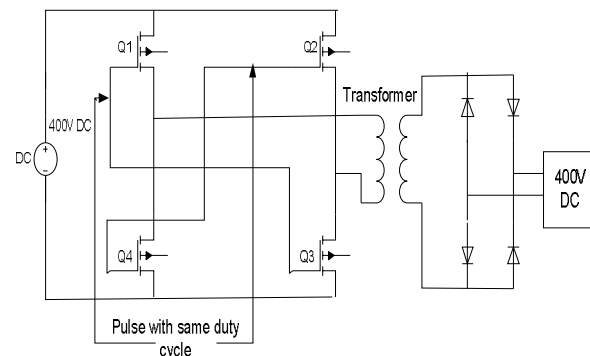


Fig. 3: Basic design of a Square wave inverter

In this section high frequency around 16 KHz pulse is applied to the MOSFET gate which makes square wave. Since the switching frequency is high so the size of transformer is less. The program flow chart for getting PID control square wave is shown in Fig. 5. Hardware implementation of gate pulse signal is shown in Fig. 4, Fig. 7 and Fig. 9 and output is shown in Fig. 6, Fig. 8 and Fig. 10.

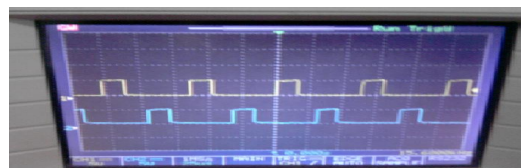
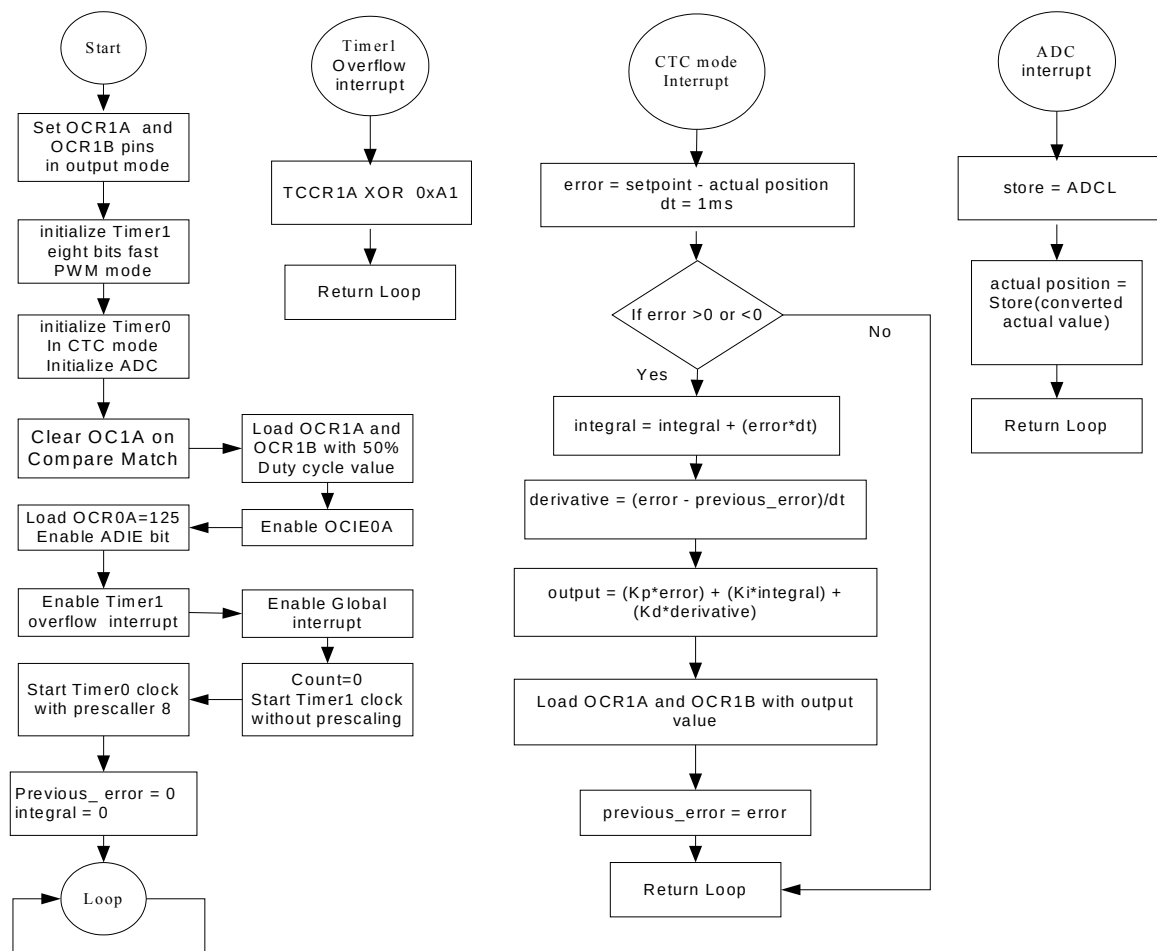


Fig. 4: MOSFET gate pulse with 50% duty cycle for minimum load.



Flow chart for PID control MOSFET gate pulse generation

Fig. 5: Program flow chart for square wave generation



Fig. 6: Square wave output



Fig. 7: MOSFET gate pulse with 70% duty cycle for medium load.

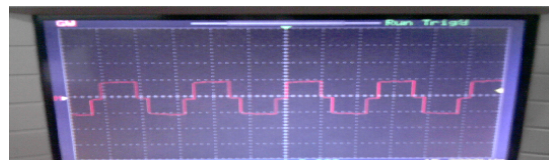


Fig. 8: Square wave output



Fig. 9: MOSFET gate pulse with 90% duty cycle for maximum load.

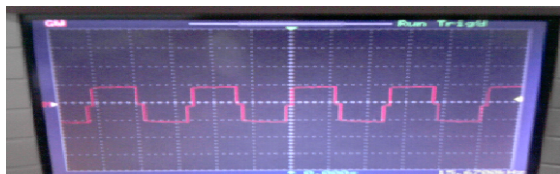


Fig. 10: Square wave output

10. GENERATION OF 50 HZ SINE WAVE SIGNAL

PWM signal from section 8 is now applied to the gate of MOSFET alternatively and resulting sine wave obtained in the Fig. 13 and Fig. 14 in proteus software and hardware implementation in Fig. 17 and Fig. 18.

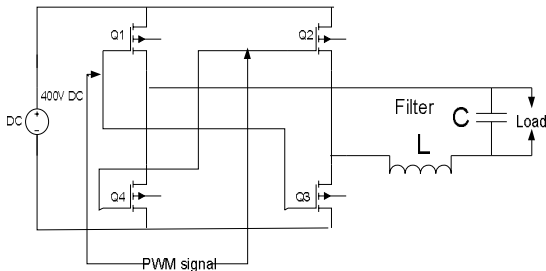
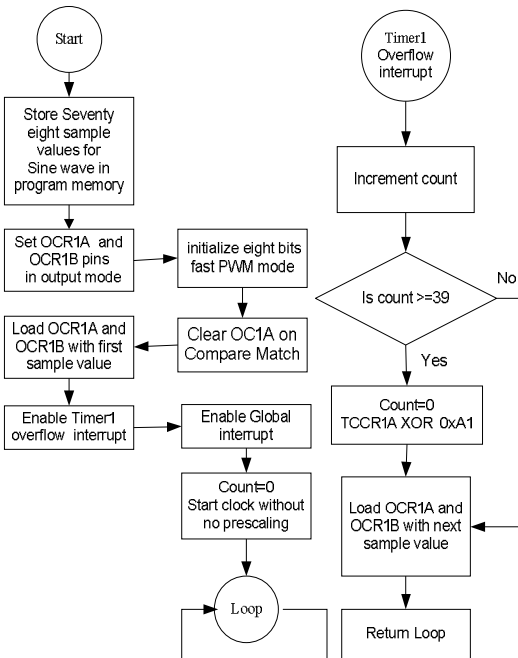


Fig. 11: Basic design of a Sine wave inverter



Flow chart for PWM signal generation
Fig. 12: Program flow for sine wave generation

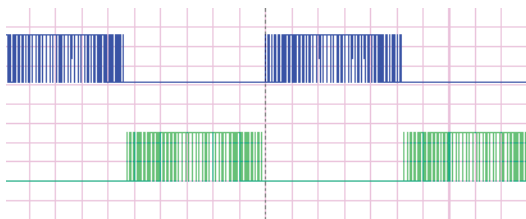


Fig. 13: PWM applied on two sides of bridge (Simulation in proteus)

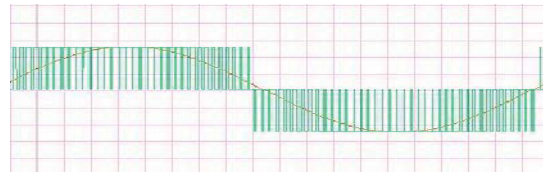


Fig. 14: SPWM at output of bridge (Simulation in proteus).

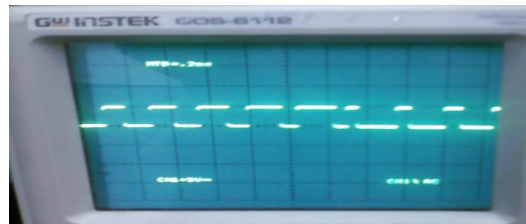


Fig. 15: PWM signal in expanded form (Hardware implementation)

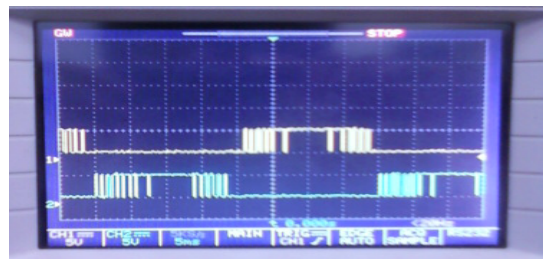


Fig. 16: PWM signal for sine wave (Hardware implementation)

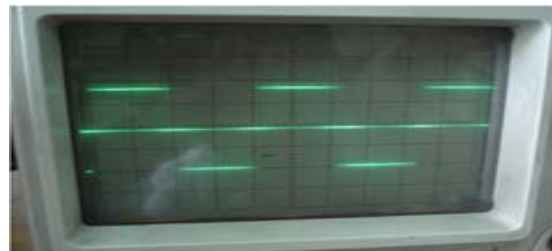


Fig. 17: PWM Square wave output signal (Hardware implementation)



Fig. 18: Sine wave output signal after filtering (Hardware implementation)

11. PID CONTROL

Most important features of our sine wave inverter is PID control for getting stabilised output voltage. From Fig. 1 we see the feedback error voltage is properly processed by PID section which determine the appropriate duty cycle for the DC to Square wave converter section input pulse. As a result we minimize the output voltage variation due to instant loading effect on our inverter and quick recovery time which we observe in Fig. 19, Fig. 4, Fig. 7 and Fig. 9.

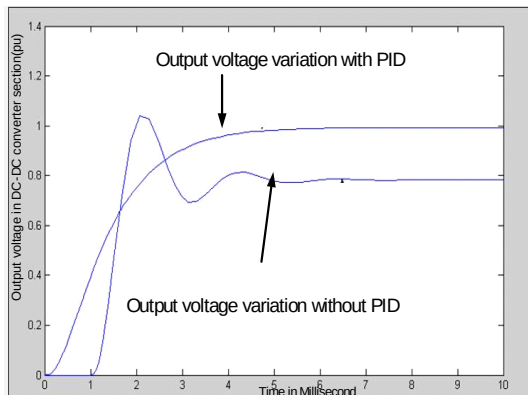


Fig. 19: Output voltage variation control of DC-DC converter section with PID (Simulation in Matlab).

12. CONCLUSION

Simulation results and practical implementation of the sine wave inverter proves that output sine wave is voltage regulated, ripple less and stabilize output. For the use of this sine wave inverter in transformer less UPS, DC-DC step up converter can be used. Different electronic appliances are tested by this sine wave inverter.

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LINEARIZATION OF VOLTAGE-CONTROLLED OSCILLATOR BY MICROCONTROLLER BASED PLL FREQUENCY SYNTHESIZER

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Abstract

Today's mobile communications systems demand higher communication quality, higher data rates, higher frequency of operation, more channels per unit bandwidth, low power consumption and smaller size. One important part of the communication systems design is the synthesized oscillator. Typical synthesized oscillators combine a Voltage Controlled Oscillator (VCO) with a Phase-Locked Loop (PLL) IC, frequency reference (e.g. Crystal/TCXO) and a loop filter. This paper describes the evaluation of the PLL and VCO and relates those evaluations to information that will allow the circuit designer to optimize the whole oscillator design including the loop filter. Few experimental results are also presented. It is found that the designed circuit works very well. After the synthesizer has been designed and built, the synthesizer is locked very sharp and correctly in time. The spectrum contains many spurious frequencies. The loop bandwidth is higher as expected. The phase noise is lower than expected. So, noise of the synthesizer keeps them as small as possible. In the PLL system to change the receiving frequency from 38.445 MHz to 38.429 MHz and now we have perfect reception.

Key words: PLL, VCO, synthesizer, linearization, microcontroller

1. INTRODUCTION

Phase-locked loops (PLLs) are widely used in frequency synthesizers for wireless communication systems [1]. A PLL based on a charge-pump is preferred over other types because it has a wide capture range and zero static phase offset. In practice, non idealities of the charge-pump degrade the performance of the entire loop. One of the non idealities of the charge-pump is the current mismatch. The mismatch between the charging current and the discharging current causes a phase offset and reference spurs in PLL [2]. Frequency synthesizers form the basis of most radio system designs. The critical part of the communication system design is the synthesized oscillator, where the Voltage Controlled Oscillator (VCO) is used to generate the Radio Frequency (RF) output frequency. The Phase Locked Loop (PLL), which is analog type, i.e. different from a pure digital PLL, is used to stabilize and control the frequency. In fact, RF amplifiers used in communication systems should be highly linear [3]. The phase locked loop (PLL) method of frequency synthesis is now the most commonly used method of producing high frequency oscillations in modern communications

equipment to achieve stability and linearity [4]. PLL circuits are now frequently being used to demodulate Frequency Modulated (FM) signals, making obsolete the Foster-Seerly and ratio detectors of early years. Other applications for PLL circuits include Amplitude Modulated or AM signal demodulators, FSD decoders, two-tone decoders and motor speed controls. While designing the VCO PLL circuits, various design parameters should be optimized to obtain linearity [5]. In this paper, we have described how linearization of voltage-controlled oscillator circuit is achieved by using a microcontroller based PLL frequency synthesizer. The experimental results are shown in the oscillograms. Then the output voltage versus frequency curve is plotted to show the linearity of the circuit. Future scopes of this work have also been suggested.

2. PLL FREQUENCY SYNTHESIZER

Basic block diagram of PLL frequency synthesizer is shown in Fig. 1. A synthesizer is a device which takes an input, or source frequency and from it produces an output frequency. The direct synthesizer produces an output which is directly

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proportional to the input, i.e. input and output frequencies are related by a multiplication factor N as given in equation (1).

$$f_{out} = Nf_{in} \quad (1)$$

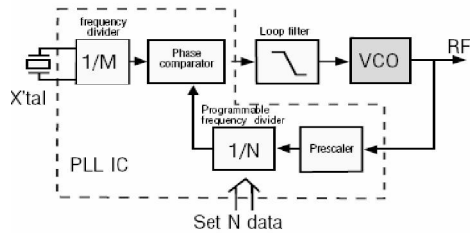


Fig. 1 Basic block diagram of PLL frequency synthesizer

Figure 2 shows the basic block diagram of a phase locked loop. The VCO is “locked” to the reference frequency, f_{ref} , by dividing it by some integer R , the VCO output, f_{out} , by some integer N , and then comparing the phase of the two signals, generating an error signal. This error signal is then amplified and filtered to remove phase comparison frequency components and modify the phase response of the loop to provide closed loop stability. It is always the case that the reference is a higher quality frequency source than the VCO. The output frequency is then given by equation (2).

$$f_{out} = \frac{N}{R} f_{ref} \quad (2)$$

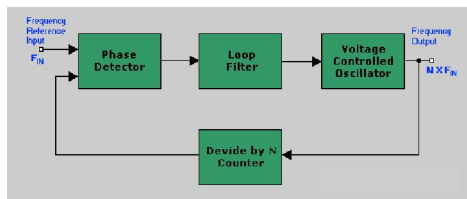


Fig. 2 Basic diagram of a phase locked loop

The output of a VCO and crystal oscillator can be fed into a phase detector. The phase detector (PD) compares the phase of the input signal and the divided output signal. The PD generates different output depending on the type of phase error (lead, lag or none). The type of the detector used in this work produces outputs of two square wave signals (one for positive phase error and one for negative) whose pulse-width depend on the size of the phase error. In a loop where the input frequency exceeds either the maximum RF or reference input frequency of a synthesizer it may be necessary to use a fixed divide by M prior to the $\div N$ or $\div R$ functions. M has been used to highlight the difference between M and N . N will be referred to as the division performed by the synthesizer IC used to form the basis of the PLL. The value of M

will however limit the step size the synthesizer may perform as the output frequency will now be, assuming the M division is prior to the $\div N$.

$$f_{out} = \frac{MN}{R} f_{ref} \quad (3)$$

This results in a minimum step size of $M \cdot f_{comp}$.

3. DESIGN METHODS

The basic specifications for a frequency synthesizer are given in Table 1.

Table 1 Specification of frequency synthesizer

Specification	Requirement
Frequency tuning range	2.33 GHz 50 MHz
Step size	500 KHz
Phase error contribution	≤ 3 rms
Lock time	400 μ s for a ± 20 MHz step to 200 Hz of final frequency
Charge pump current (I_{cp})	5 mA
K_{vco}	45 MHz/V
Division range (N)	4560 to 4760
Reference frequency (f_{ref})	10 MHz
Phase margin	45°

From these few parameters, we first need to estimate the loop bandwidth of the synthesizer. Two “rules of thumb” [6], which may help to approximate the frequency of the loop bandwidth, are given in equations (3) and (4).

$$\text{Switching time} = \frac{50}{f_{comparison}} \quad (3)$$

$$\text{Switching time} = \frac{2.5}{f_{loop\ bandwidth}} \quad (4)$$

4. HARDWARE IMPLEMENTATION

The receivers we have built around the TV tuner trainer of model ETT101. The basic block of this TV tuner receiver is shown in Fig. 3. The signal into the antenna comes to the TV tuner. A TV tuner is actually just a down converter for RF signals. It can be programmed to any frequency from 46 to 860 MHz and it down convert the RF signal to an IF signal which should be about 33-39 MHz. The signal then leaves the TV tuner and enters a SAW filter. This is a sharp filter that rejects all frequencies except 33-39 MHz. As you understand the SAW filter is wide because a TV signal is about 6 MHz wide. We will still use this filter since we can't find any narrow filter for this frequency and it works good. After the filter, there is a FM receiver with excellent performance. It is a FM receiver and

it is tuned to the IF frequency and demodulates the IF signal to an audio signal. Under the FM receiver there is a PLL synthesizer. The TV tuner will set the large step of tuning and the PLL synthesizer of the FM receiver will set the fine tuning.

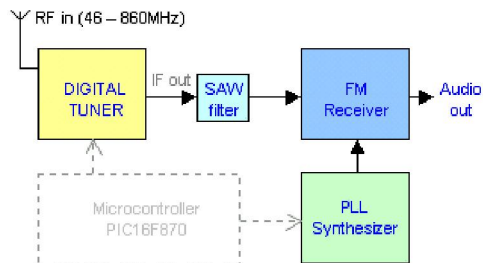


Fig. 3 Block of TV Tuner

The receiver unit also needs power supplies of DC +5 V, +12 V and +33 V to work. The +33 V is the tuning voltage and draw very little current so any small step up converter will work. We try to make the ripple as low as possible in the step up converter to get better performance. The tuner also needs some kind of antenna to work. Most tuners use 75 Ω impedance wires and dipole antenna. Figure 4 shows the connection diagram at the bottom of the trainer board that has been interfaced with the TV tuner, FM receiver as well as microcontroller IC.

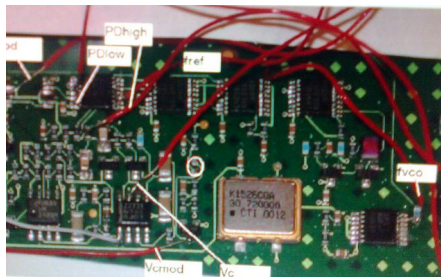


Fig. 4 Connection diagram of the trainer board

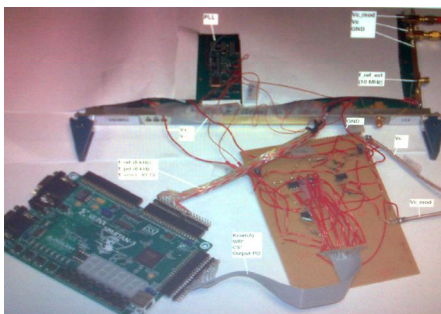


Fig. 5 Circuit interfaced with the trainer board

Fig. 5 shows the interfacing circuit diagram designed in this work. Our designed circuit using the microcontroller has been interfaced with the TV

tuner and FM receiver unit through the output ports of the microcontroller. We have interfaced with the PLL synthesizer so that the faults in the receiver can be identified and remedial measures can be taken. Mainly two different ICs LMX2306 and SA615 have been connected to the ports of the microcontroller IC PIC16F870. A separate power supply circuit has also been designed using IC 7805 to get the +5V DC for the different ICs of the designed circuit.

5. RESULTS AND DISCUSSIONS

After the hardware implementation, we need to take some experimental data to verify our work. We received data at 86.555 MHz of frequency. For this purpose, we used a circuit that has the block diagram as shown in Fig. 6.

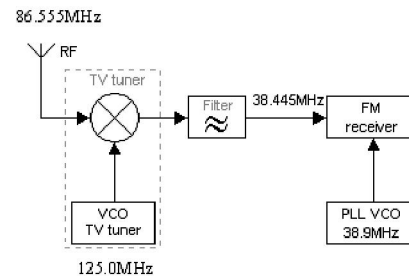


Fig. 6 Block diagram of the data collection circuit

One example shows below how the PLL corrects the tuner's frequency.

RF TV tuner = VCO TV tuner - RF FM receiver
VCO TV tuner = RF TV tuner + RF FM receiver
and number of tuner steps are: VCO TV tuner / 62500 = number of steps required.

So, if RF TV tuner frequency is 86.555 MHz, that of RF FM receiver is 38.445 MHz, then the VCO TV tuner frequency is $86.555 + 38.445 = 125$ MHz. That means we need $125 \times 62500 = 2000$ steps exactly. Now, if the frequency is changed to 86.580 MHz, then the RF TV tuner frequency is 86.580 MHz and that of RF FM receiver is 38.445 MHz then the VCO TV tuner frequency is $86.580 + 38.445 = 125.025$ MHz. That means, we need $125.025 \times 62500 = 2000.4$ steps.

Since the tuner only can't jump in decimal steps, the tuner will not reach this frequency. If we still set the TV tuner step to 2000, the VCO TV tuner will be $2000 \times 62500 = 125$ MHz. Since we wanted the RF TV tuner to be = 86.58 MHz, the RF FM receiver must be $125 - 86.580 = 38.420$ MHz.

As we see the frequency is 38.429 MHz (-25000 Hz) from the 38.445 MHz. To correct this deviation we use the PLL system to change the receiving frequency from 38.445 MHz to 38.429 MHz and now we have perfect reception.

Various experiments have been performed and results have been observed for the tested PLL frequency synthesizer. Of them, few oscillograms have been provided here from Figs. 7-8 taken at various test points. The output of the oscillator is at the test point 1 at which the frequency is 1000 Hz as shown in Fig. 7. It is set by changing the variable resistor. The output of the oscillator is connected to the clock input of the D-type flip-flop. It divides this frequency by a factor of 2. This is observed at test point 2 as shown in Fig. 8. The output of the D-type flip-flop is connected to the channel A input of the PLL whose output is at test point 3 and it is 1500 Hz but is not shown here for brevity.

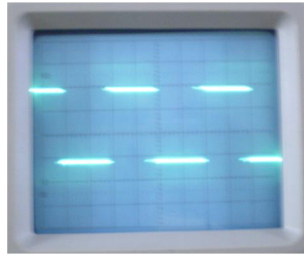


Fig. 7 Waveform at test point 1 ($f = 1000$ Hz)

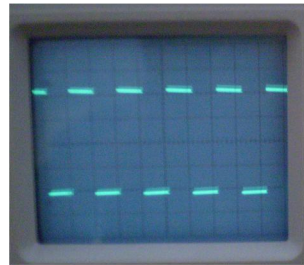


Fig. 8 Waveform at test point 2 ($f = 500$ Hz)

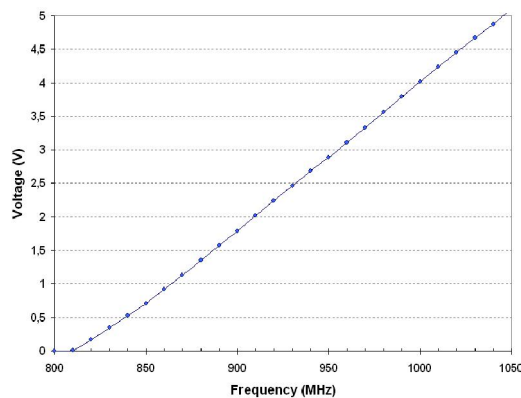


Fig. 9 Frequency vs. voltage characteristics curve

The hardware is connected to the PC through its COM1 port. Using the software all the data is transferred from the hardware through this port to the PC by scanning VCO voltage and frequency. From the measured data, it is seen that as the

voltage to the PLL goes from 0 V to 5.0 V, the VCO frequency goes from 800 MHz to 1050 MHz. The plot is shown in Fig. 9. From the plot it is seen that the curve is very much linear.

7. CONCLUSIONS

The purpose of this work is to develop and test a method of correcting variations in the tuning sensitivity of voltage-controlled crystal-oscillators in the phase-locked loops. A method has been developed to amplify or attenuate the control voltage of the VCXO in order to make the tuning curve linear. Extra circuits and a microcontroller are added to the loop for measuring the tuning sensitivity of the VCXO and to compensate for the deviation. After the synthesizer has been designed and built, the synthesizer is locked very sharply and correctly. The synthesizer locks in time. In the PLL system, if we change the receiving frequency from 38.445 MHz to 38.429 MHz. Experimental results show that the system is working very well.

Microprocessor or digital signal processors (DSP) can be employed with this scheme for faster calculation of the frequency or re-tune the VCO.

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MAGIC IN VLSI A Precise Demonstration on MAGIC towards VLSI Layout Designing

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Development of VLSI is a unique era in microelectronics, more precisely in integrated circuit industry. VLSI is the field which involves packing more and more logic devices into smaller areas combining thousands or many more than that of transistors into a single chip. But the design of very large scale integrated circuit is far beyond human ability. Therefore, Computer Aided Design (CAD) tools are heavily involved in the design process. This is highly expensive and technological at the same time. Unfortunately 3rd world countries are lagging far behind in this arena. This study represents a brief demonstration on one of the VLSI designing CAD tools known as MAGIC. The study includes a brief and precise direction from the software installation to the way of IC fabrication with a design of CMOS inverter and its simulation as example. It also includes why MAGIC should be the choice in academic purpose as well as industrial especially in 3rd world countries, along with its limitations and superiority.

Key words: VLSI; Magic; CAD Tools; Designing CAD tools; Manhattan design; Cygwin/X; Tcl/Tk

1. INTRODUCTION

According to the law of Gordon Moore (1960), the number of transistors that can be placed on an integrated circuit would be approximately double every two years [1]. This number has grown non-linearly to a dramatically high value, which is about two billion on a quad-core Itanium designed by Intel in 2009 [2]. Still the number is significantly increasing, and the growing sophistication of applications continually adding new levels of complexity [1]. So it is needed to use CAD tools that can do minimize the complexity and help to improve the VLSI design. What CAD does is mainly automates the design process making it much easier. CADs are categorized on the basis of works they handle like Design Entry tool, Analysis and Verification tools, Synthesis tools and so on [1]. In this paper MAGIC is demonstrated, which is a designing CAD tool for VLSI.

Magic is an interactive tool for creating and modifying 2-D VLSI circuit layout. It is written by John Ousterhout and his graduate students at UC Berkeley in 1980's, and is widely known as the earliest tool used for circuit layout [7]. It allows the

designer to place colored polygons that represent physical layers that form the complex circuitry on a chip [12]. MAGIC permits only Manhattan designs (those whose edges are vertical or horizontal), i.e. design strictly by rectangle shapes [5].

2. INSTALLATION

Most VLSI CAD tools are based on UNIX or Linux platforms [3]. Typically, MAGIC also runs under Linux or UNIX. But most of the PC users use MS Windows platform [8]. In order to use MAGIC under Microsoft Windows, it needs some intermediate applications [3, 9], those take a bit difficulty. First of all it is needed to install Cygwin (an implementation of RedHat Linux) which is a set of powerful tools to assist developers in migrating applications from UNIX/Linux to the Microsoft Windows platform [10]. Cygwin is a free open source software. Other needed applications are X11, and Tcl/Tk (together of Tcl & Tk). X11 is one of the packages of Cygwin that makes an environment to open window(s) of the desired application on Windows platform [9]. Tcl (Tool Command Language) is a very powerful dynamic scripting language, and Tk (Toolkit) is a graphical

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user interface toolkit [11]. In this study the test is done in Windows 7 Ultimate and Windows XP SP2 using Cygwin/X (together of Cygwin & X11) v1.7.7-1, Tcl/Tk 8.5.0, and Magic 7.5.107v.

2.1 Portability

After completing all installations the directory “C:\Cygwin” (root directory for MAGIC defined by the MAGIC writer) is all that is needed. It can be transferred to another PC for using MAGIC there. To do that, Cygwin directory is transferred to just “C:\” of another PC so that the path of root directory remains as previous (C:\Cygwin). The directory can be compressed by making it a zip file for easier transfer. After transferring the Cygwin directory a shortcut of “C:\Cygwin\Cyging.bat” is made in the new PC to its desktop. Icon path of the desktop shortcut is changed to “C:\Cygwin\Cygwin.ico”. Now all is set and Magic can run as on previous PC.

2.2 Running Magic

To run, Magic it is needed to run X-server first (which is come after installing X11). To do that Cygwin command window is opened form desktop. To open X-server with multiwindow and nlock features, “XWin –multiwindow –nolock” is entered in the command prompt. An X icon is supposed to appear on the task bar. Then the command window is to be opened again (after closing or minimizing it). Finally just “magic” (to open Magic) is typed. Two windows are supposed to appear; one is for command and another is for layout (in figure 1). Then Cygwin command window is kept minimized because closing this window will close the windows of Magic.

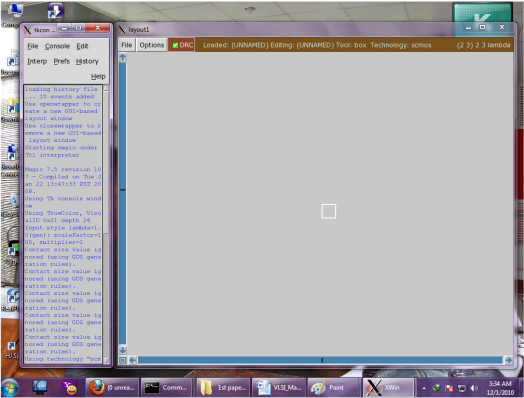


Fig 1: MAGIC windows on Windows 7.

3. DESIGNING BY MAGIC

During layout designing in MAGIC, maintaining the design rules are fairly easy with the use of

“grid” which is the unit of lambda (λ) that makes it possible to design towards the scalable technology. Table 1, 2, 3, and 4 represent a description of some useful commands for layout and post-fabrication verifications.

To start designing it is also important to know about Graphics Tools. Among 4 types of graphics tools in MAGIC (BOX tool, WIRING tool, NETLIST tool, and RSIM tool) BOX tool is used most often (default in MAGIC), which is sufficient for basic designing [6]. The purpose of the BOX tool is to specify a rectangular area of the layout for editing. The left and right mouse buttons are used to position the box. Graphics tools can be changed by pressing the spacebar with mouse pointing into the layout window. Selected tool is used to show on the status bar in MAGIC (in figure 2).

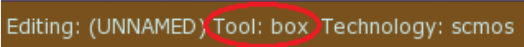


Fig 2: BOX tool selected in MAGIC 7.5

3.1 Command Sets

Commands can be invoked in MAGIC in 4 ways: by (I) typing long commands on the keyboard, (II) typing single-character macros on the keyboard, (III) pressing icons on toolbar in MAGIC and (IV) pressing mouse buttons on the existing layout paintings in the same window. All commands will be invoked as long as the cursor is in the MAGIC layout window creating or selecting a box to edit.

Long commands are preceded by a semicolon ";" or colon ":", but it is not must. Commands can be abbreviated [4]. Macros are used to be a single lower case or upper case key stoke from keyboard. Commands are case sensitive. Table 1, 2, 3, and 4 represent some commands with their descriptions.

Table 1: Some useful commands

Command	Macro	Description
grid	g	Switches grid view on or off.
zoom <i>value</i>		Zooms in or out by a factor.
zoom 0.5	z	Zooms out by factor 2.
zoom 2	Z	Zooms in by factor 2.
view	v	Shows the whole drawing fit to window.
help <i>command</i>		Gives a brief of specified command.
help		Gives a brief of all commands.

macro		Displays all current Macros.
save <i>name</i>		Saves the design with given name and ".mag" extension.
save		Saves all the changes.
load <i>name</i> .mag		Loads <i>name</i> .mag into the window. If it is doesn't exist, Magic creates a new empty layout field.
quit		Exits Magic.

"Paint" can be abbreviated to "pai". To select the entire area lies within the whole drawing "a" is pressed after "s". Label name can be anything but in practice it is necessary to label the supply wires (nodes) as Vdd! and GND! exactly (the ! means that the node spans the entire drawing by electrically connecting, and it is global) [6].

Table 2: Basic painting commands

Command	Mac	Description
paint <i>layer</i>		Paints the defined layer
select	s	Selects area of cell in current layout. Toggles cells if there are more than one connected.
select more	S	Creates and selects new topmost cell on the existing layout.
select area	a	Selects entire area of selection.
what		Tells what's selected.
erase <i>layer</i>		Erases paint underneath the box.
delete	d	Deletes everything that's selected by "a".
undo	u	Rolls back to previous status.
redo	U	Get back to current status.
label <i>name</i>		Creates label for extraction and simulation purpose usually.
erase label		Erases the label from topmost cell of the box.
erase labels		Erases all labels that lie within the area of the box.

Table 3: Some basic common layers' name

Layer	Abbr	Mac	Description
nwell	nw		pMOS substrate.
pwell	pw		nMOS substrate.
ndiffusion	ndiff	F1	n ⁺ source/drain areas.
green	gr		

pdiffusion	pdiff	F2	p ⁺ source/drain areas.
brown	brf		
polysilicon	poly	F3	Gate oxide; slice of polysilicon and silicide.
red	p		
metal1	m1	F5	1 st layer metal.
blue			
metal2	m2	F6	2 nd layer metal.
purple			
metal3	m3	F7	3 rd layer metal.
nwcontact	nnc		m1 to nwell contact (tie).
pwcontact	ppc		m1 to nwell contact (tie).
ndcontact	ndc	F9	m1 to ndiff contact.
pdcontact	pdcc	F10	m1 to pdiff contact.
polycontact	pc	F11	m1 to poly contact.
m2contact	via	F12	m2 to m1 contact.
m3contact	via2		m3 to m2 contact.
ntransistor	nfet		Direct nMOS.
ptransistor	pfet		Direct pMOS.

Layers' name come with command "paint" to draw out or "erase" to erase out, like "paint ndiffusion" or "pai ndiff". In case of simple design "nwell" and "pwell" usually are not used in drawing, because those are used to be automatically created when ".mag" file is converted into ".cif" file in MAGIC.

Table 4: Movement commands

Command	Description
move <i>direction</i>	Moves to defined direction by 1 λ .
move <i>direction value</i>	Moves to the defined direction by given values of λ .
move up 10	Upward moving by 10 λ .
stretch <i>direction</i>	"stretch" is similar to "move" except that it stretches and erases as it moves.
stretch <i>direction value</i>	
stretch up 10	"copy" is similar to "move" except that a copy of the selection is left behind at the original position.
copy <i>direction</i>	
copy <i>direction value</i>	Flips selection upside down.
copy up 10	
upsidedown	Flips selection sideways.
sideways	Rotates selection clockwise by 90°
clockwise	Rotates the selection clockwise by multiple of 90°.
clockwise <i>degrees</i>	

rotate	Rotates the selection counter clockwise by 90°.
rotate <i>degrees</i>	Rotates the selection counter clockwise by multiple of 90°.
array <i>Xvalue Yvalue</i>	Makes matrix of selection of x*y.
array 9 9	Makes matrix of selection of 9*9.

The directions of move, stretch, and copy will be up, down, left, and right only, and 8, 2, 4, 6 are the macros of stretch for the directions respectively. Macros "f" and "r" are used respectively instead of "sideways" and "clockwise".

To invoke command from toolbar, it is needed to open the "Toolbar" from "Option" menu in the layout window, then press the middle button (left and right button at a time for two button mouse) of mouse on toolbar icon after creating a box (in figure 3).

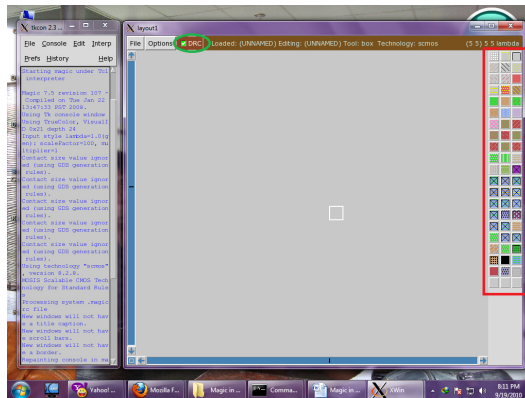


Fig 3: MAGIC's windows with toolbar (inside red rectangle) on Windows 7

To invoke command from existing painting the middle button (left and right button at a time for two button mouse) of mouse is to be pressed on any painting in the layout that is to be painted in the box.

3.2 Starting Designing

According to top-down design abstraction of digital VLSI system, starting the implementation of a chip layout on MAGIC takes a necessity of schematic circuit model [1]. Figure 4 shows the schematic (left) and layout of a CMOS inverter in MAGIC (right), which makes more sense of this design demonstration. Before starting with the layout a VLSI designer should know the basics of MAGIC and starts from the technology file.

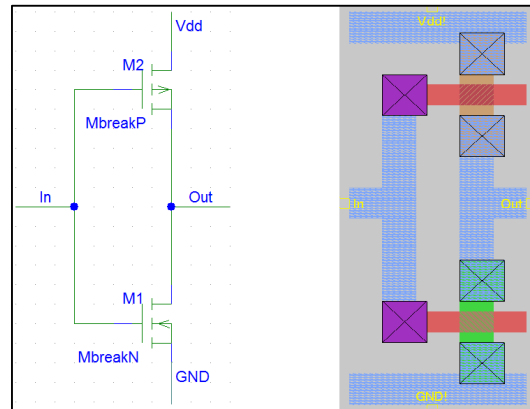


Fig 4: Schematic diagram of a CMOS inverter in PSpice 9.1 Student Version (at left), and corresponding layout in MAGIC 7.5 (at right)

The technology of VLSI depends mainly on the length of transistor channel, because it is the key to optimize speed of an entire chip. Technology is the process of silicon that is standardized by fabrication facilities. The process composition is accepted by design houses to use their electrical parameters. The technology file consists of minimum dimension of devices allowed by process, electrical characteristics and on-silicon-spacing layout design rules. The modern digital VLSI is preferred as SCMOS (Scalable CMOS) technology because of less power consumption and also cost of producing it. MAGIC uses a lambda (λ) based architecture of scalable layout designing system. Lambda is the unit scale that is used to define the minimum technology geometry increment on the die (a piece of wafer), the processed silicon of the design layout [6]. A square of the grids in MAGIC's layout window is one unit for lambda. The term "scalable" means that designed layout can be modified with the change of technology that is changing the value of lambda (λ). Default value of lambda in MAGIC is 1.0 μ m for SUPERTEX 2 [6].

3.3 Design Rule Checking

Design rules specify how far apart various layers must be, or how large various aspects of the layout must be for successful fabrication. MOSIS SCMOS Design Rules specify the complete set of design rules defined by the MOSIS VLSI fabrication service [6]. Design Rule Checking is performed automatically in MAGIC as long as DRC is checked on status bar in layout window (inside green oval in figure 3). When error occurs, MAGIC informs immediately by splattering small white dots around the area of concern. The command "drc why" or macro "?" tells the occurred error in selection. Design Rule Checking can be off by

command "drc off" or un-checking DRC, and on by command "drc on" or checking DRC.

In figure 4, "ndiff", "pdiff", "poly", "pc", "ndc", "pdc", and "m1" layers are used to create an inverter layout with their minimum width (3, 3, 2, 4, 4, 4, and 3λ respectively) keeping the minimum distances between all of them with default SUPERTEX 2.0 μ m process. The layout is saved as "inverter" that creates "inverter.mag".

3.4 Simulation and Fabrication

After a circuit layout is drawn, it is needed to test its performance by simulating it. To do that layout has to be extracted to generate simulation information needed to run simulation tools such as Spice or IRSIM. The command "extract" or "ext" generates separate ".ext" (inverter.ext in this case) file for ".mag" file. If the layout includes subcells then all subcells can be extracted by "extract all". The "extract cellname" extracts a specified cell. The extraction file of the designed inverter contains information like below:

```
timestamp 1290837166
version 7.5
tech scmos
style lambda=1.0(scna20_orb)
scale 1000 1 100
resistclasses 26670 59550 23860 19690 27260 2000000 49 26
2505830
node "0" 44 423 2 -7 ndc 19 18 0 0 0 0 0 0 0 0 0 25 22 0 0 0 0
node "1" 72 423 -14 -7 pdc 0 0 30 22 0 0 0 0 0 0 0 33 26 0 0 0
0
node "3" 272 5770 -16 -2 p 0 0 0 0 54 54 0 0 0 0 0 34 28 0 0 0
0
node "2" 116 1880 -14 0 pdiff 19 18 30 22 0 0 0 0 0 0 0 80 54
0 0 0 0
device mosfet nfet 2 -2 3 -1 2 3 "Gnd!" "3" 4 0 "0" 3 0 "2" 3 0
device mosfet pfet -14 -2 -13 -1 2 6 "Vdd!" "3" 4 0 "1" 6 0 "2" 6
0
```

Then "exttospice inverter.ext" generates "inverter.spice" file for simulation using PSpice. The conversion to PSpice from the ".ext" file is given below:

```
* SPICE3 file created from inverter.ext - technology: scmos
M1000 2 3 1 Vdd pfet w=6u l=2u
+ ad=30p pd=22u as=30p ps=22u
M1001 2 3 0 Gnd nfet w=3u l=2u
+ ad=19p pd=18u as=19p ps=18u
C0 3 gnd! 5.8fF
```

Latter the input signal is added to the PSpice file. Commands scripts to file for plotting and transient analysis are added to the file. Simulation plot is shown in figure 5.

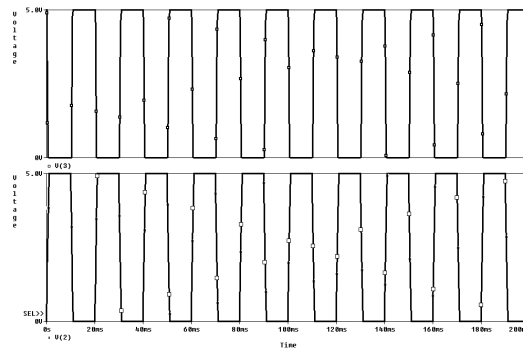


Fig 5: Simulation result of designed inverter in PSpice 9.1 Student Version with 5 volt power supply and input (at upper) with the corresponding output (at lower).

Fabrication is the physical implementation of chip according to designed layout. The most familiar VLSI fabrication service is MOSIS (Metal-Oxide Semiconductor Interface Service), which supports MAGIC. For fabrication ".mag" file has to be converted into CIF (Caltech Intermediate Form) file which is to be sent to the fabrication service to manufacture. The command "cif" generates separate ".cif" (inverter.cif in this case) file for ".mag" file with the default style of lambda. To change the style of lambda for a different process "cif istyle lambda=0.6(gen)" and "cif ostyle lambda=0.6(gen)" commands have to be invoked before "cif" in case of 1.2 μ m process for example. To open the generated CIF file command "cif read inverter.cif" is to be invoked after "cif istyle lambda=0.6(gen)" (this command is not needed if the default style is not being changed). Then to see the layout "s" > "a" > "x" (x to expand) macros are to be invoked with mouse pointing into the layout window.

4. JUSTIFICATION OF MAGIC

After all this demonstration above it is clearly seen that MAGIC is very easy to use and understand. Though the installation process is a little bit difficult, but once it is installed the portability makes it much flexible for further use. One of the significant features of MAGIC is that its design style is based on Mead-Conway "scalable CMOS" which means it uses "lambda-based" dimensions which makes it easier to write technology file for different manufactures. The most advanced feature of MAGIC is its liberal Berkeley open-source license [3]. MAGIC is not only a color painting tool for layout but also it can provide additional operations including Built-in Design-Rule-Check (DRC), Built-in Hierarchical circuit extractor and some other useful functions such as plowing tools and routing tools for stretching and interconnecting

circuits respectively [3], those are not concerned here because of keeping simplicity.

Most VLSI layout designing software cost about \$10,000 (a simple student version of "Cadence" costs about \$25,000), which is unaffordable for a university or small industry of 3rd world countries. Stolen softwares are incomplete and prevent from any updates for any latest technology. So, the cost free legal license of MAGIC is the main advantage in this case.

5. CONCLUSION

It is proposed that this study represents basic and most precise demonstration of MAGIC from its installation to fabrication of designed layout which can be a perfect entrance to the world of VLSI designing for the VLSI students or beginners of VLSI design. Because it is not possible to develop electronics sectors tremendously without VLSI, and with an artistic and creative sense MAGIC could be the platform that can make someone a successful VLSI designer. Very important aspects of MAGIC design i.e. lambda, DRC and extraction tools are described here. An inverter was demonstrated and simulated to confirm its operations. All necessary commands used in MAGIC software are presented here. Further study may be focused on full functional low power custom chip design using MAGIC, and advance demonstration of MAGIC.

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Microcontroller Based Automatic liquid Level Control Modeling

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Abstract - This work presents a design technique for the implementation of the water level control system bybased on the use of a single-chip microcontroller. The proposed model system offers the following attractive features: (1) application of the electrode and conductivity of water for sensing the height of water in reservoir (2) using the obtained water level for defining on-off condition of the water pump. (3) Water supply availability checks option to protect the motor. (4) The system will be on run mode only at the predefined time sequence to avoid the power failure due to load shedding and programmable on time select option for motors. Water reservoir is filled using single-phase induction motors. The system can operate by using manual control or automatic control and also available for monitoring and displaying the process status on microcontroller-based control board. Very low power control with backup power supply system. In addition this control system scheme can be used in home and industry sector to reduce the wastage of water, money, time and manpower. This modern control system provides a simple and economical mechanism providing automatic water pump control operation. This control system can also be used in teaching and demonstrating in the control engineering laboratory.

Keywords: *Microcontroller, automatic control system, water level sensor, time control sensor, manual and automatic control.*

INTRODUCTION

Presently, it is becoming increasingly advantages in carry out information processing and control functions using digitally methods. It is well known fact that the digital control system can offer high accuracy and high-speed response. These are the reasons that cause a strong motivation to design and implement the automatic control system based on the digital controller. Actual systems and controllers are widely implemented in the discrete-time domain since they employ microprocessors or computers in general. Recently, a variable structure control in the discrete-time domain has much received the attention. Therefore, this work presents an technique to implement the modeling of the water level control system based on the use of the commercially available microcontroller (uC) without

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using the personal computer (PC). The system model is designed using a popular commercial microcontroller ATMEGA8, single phase induction motors and some electrodes as water level detector sensors and variable resistance of material as a time control sensors. The main benefit of the proposed control system modeling is able to employ as an educational tool for teaching and demonstrating in the control-engineering laboratory. The implementation and experimental results can be shown to demonstrate the usefulness of the proposed control scheme. Furthermore, it is to be expected as this control system can be modified to other actual systems for collecting and controlling the physical data, such as, pressure, temperature and etc

PROPOSED CONTROL SCHEME

Therefore, in this work the automatic water pump controller is used to control the water pump motor. The motor gets automatically switched on when water in the overhead tank (OHT) falls below the lower limit. Similarly, it gets switched off when the tank is filled up. The circuit is simple, compact and economical. It works off a 12V DC power supply and consumes very little power. The circuit can be divided into two parts: controller circuit and motor drive circuits.

The controller circuit is one which is used for the purpose of controlling the water pump action. When the water level reaches a maximum level the motor turns off and when the water level goes below the minimum level the motor turns on automatically.

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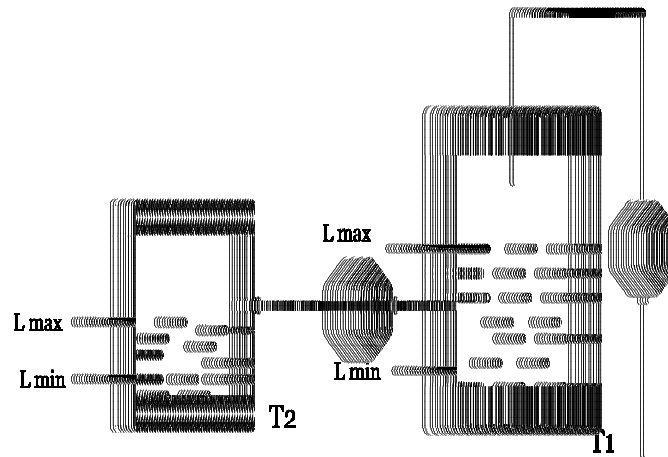


Figure 1 Proposed automatic water level control system .
 (Where T1= Reservoir1 and T2= Reservoir2,
 Lmax= water level maximum and Lmin= water level minimum)

Figure 1 shows Motor1 is used for reservoir1. It can operate only under certain conditions. If the conditions are fulfilled then motor will turn on. Otherwise it will remain off. Here we briefly describe about the condition given-To turn on the motor it will first sense that, whether water at the supply is available or not. If water is available at the supply end then it will turn on. Again the sensor will sense the level of the water in the reservoir1. If water is under the lower level of the reservoir1 then it will start filling up the reservoir. And when water reaches the upper level of the reservoir1 motor will turn off automatically. Again we can control the motor running time by using timing control. Suppose we have to run the motor for 40 min every time. After passing this 40 min motor will turn off. Here two more conditions to be considered, that in some case it may happen that motor already ran for 40 min but reservoir1 filled up just over lower level, motor will turn off. Again water can reach the upper level of the reservoir1 before 40 min gone by, at this condition motor will also turn off. According to condition given, motor1 can not run more than 5 times in a day.

Motor2 is used for reservoir2. It has some conditions also. They are-Sensor will first sense the requirement of the water at reservoir2. if the reservoir2 is empty, or water level is under the lower level of the reservoir. After satisfying the above condition sensor will sense the availability of water at reservoir1. If water level is more than the lower level of the reservoir1, microcontroller will check out the selected times (9am-10am, 1pm-2pm, 8pm-9pm) of the day selected for turning on the motor. If the time matches with the selected time, then it will turn on the motor. If the water at the reservoir1 is available but reservoir2 is already filled up, then motor will turn off.

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If the water at the reservoir2 is under filling state but reservoir1's water crosses its lower level, motor will turn off. Again we can control the motor running time by using timing control. Suppose we have to run the motor for 40 min every time. After passing this 40 min motor will turn off. Here two more conditions to be considered, that in some case it may happen that motor already ran for 40 min but reservoir1 filled up just over lower level, motor will turn off. Again water can reach the upper level of the reservoir1 before 40 min gone by, at this condition motor will also turn off. Again motor2 can not run more than 3 times in a day. Both the motors can not run simultaneously.

Active controls provide complete automation from Start to End in the Water Supply Scheme. Since water invariably corrodes most equipment, Active Controls' emphasis has been to supply equipment that is not affected by water corrosion; meaning no maintenance

Development of the system can be divided into two parts i.e., hardware and software. Since the development board comes with well-defined ports and communication interfaces, hardware implementation was not a time consuming task. Most of the development time went into writing the software to drive the board.

HARDWARE

Figure 1 shows the configuration of microcontroller based control scheme, which is applied to control the water level of the system. It mainly contains a microcontroller (μC), level sensors, time sensors, relay and motor drive circuit ,two ac motors M1 and M2 and manual control system.

We used AVR AT-Mega-8 as our controlling device. It takes decision according to state of the water level of tank. To drive the microcontroller it is required to write software according to the need. Sensor sends signal to the microcontroller and it takes decision according to the signal.

Water level sensors, and more particularly to a water level sensor for sensing water levels by detecting the electric conductivity of water using reference and measuring electrodes. To detect water level we use 6 electrodes. Two electrodes are used for minimum and other 2 are used for maximum level detection. And rest two are used for connectivity, i.e. create current

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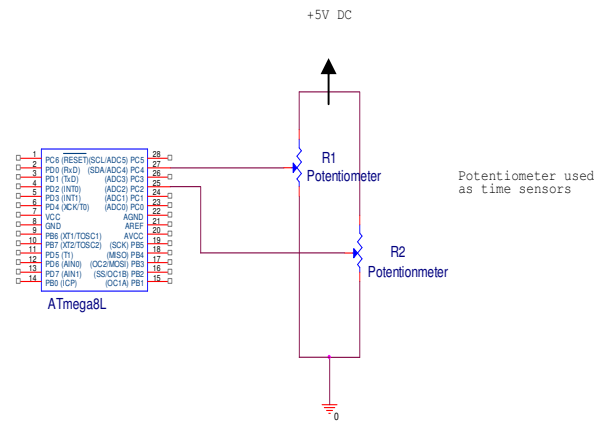
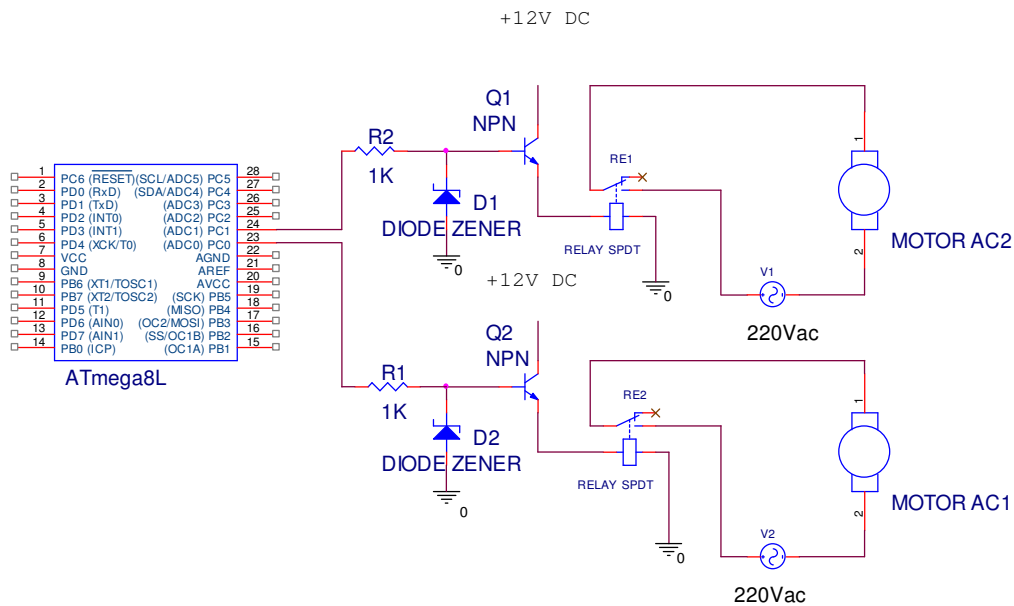


Figure 3 Time sensors and connection diagram with microcontroller

Time sensor is made by a potentiometer. We can vary the timing control according to the value of pot. We know that a potentiometer has two fixed and variable leg. If we give power supply to a fixed end and connect another fixed end to the ground we can get variable output voltage by varying the variable part of the potentiometer. Similar kind of theory we applied here. We gave 5V supply to one fixed end of the Potentiometer. And another fixed point to the ground. And the variable portion is connected to the microcontroller's ADC input. This input is worked as sense of timing control.



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Figure 4 schematic diagram of control unit

When the reservoir will empty we need to fill them. To fill them we use pumps, which are driven by motor. To drive the motors, we need to supply 220V ac. However, we use relays to isolate the high voltage circuit from low voltage circuit. Sensing the tank to be empty microcontroller will give pulse to the base of a transistor operating the relay portion. And this relays control the operation of 220 V ac motors.

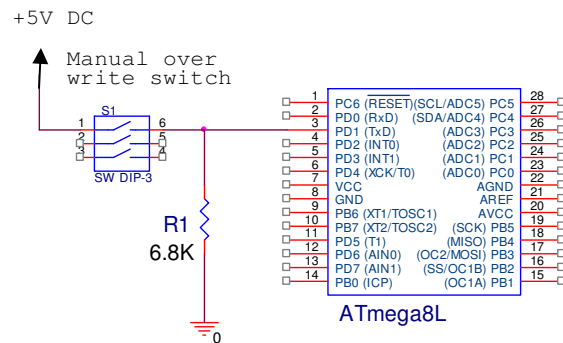


Figure 5 Manual over-write switch with microcontroller

A push-pull switch is connected to microcontroller. We used this switch for manual overwrite purpose. In time of operation a motor can be burned out, or we may have to replace or test it. We can not do this by running the system on. For the purposes written above we have to standby the system by using manual overwrite control, which has priority over automated control system.

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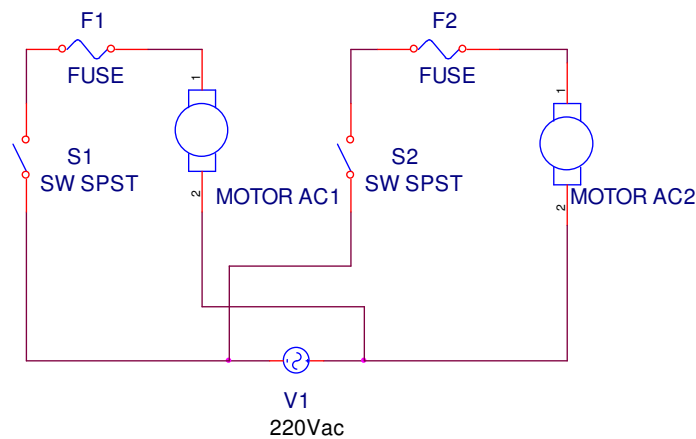


Figure 6 Simplified diagram for manual control system

We have another two switch connected in parallel to the motors. After disconnected the automated system we can still run the motor by using these two switches. In automatic system we can not run both the motor simultaneously. But after using manual overwrite switches we can run both the motors by using those parallel switches. So we can use parallel switches in any condition depended on users wish.

SOFTWARE

As mentioned earlier, software development was seen as a major portion of the entire research project. A complete flowchart of the automatic pump control system is shown in Figure 7. For configure our μC we use embedded C, at platform of AVR studio-4. For downloading the software from pc to μC , we use Ponyprog software.

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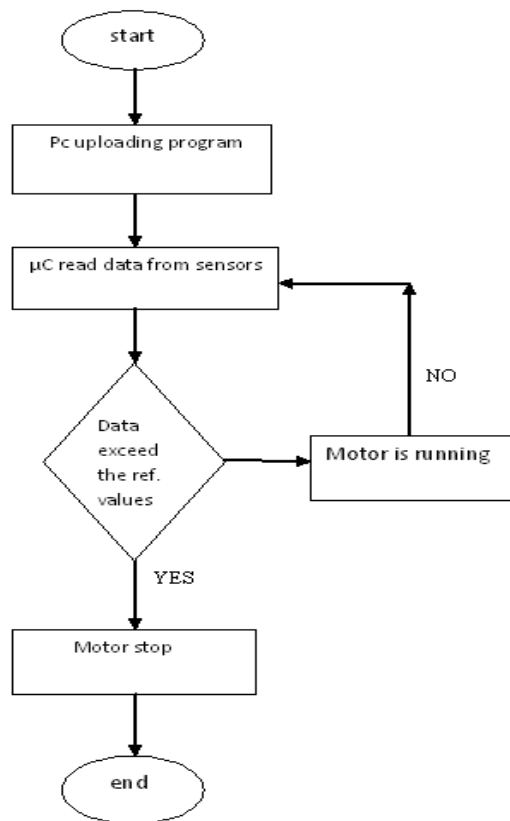


Figure 7 Microcontroller operation flow-chart for automatic control system

CONCLUSION

In this paper , the alternative technique in which microcontroller based automatic and manual control system are use to control the water level. The proposed control system provides many features, such as electrodes can be applied for detecting the water level in the tank and this control system consume very little power.

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MODIFIED INTRA_4×4 PREDICTION MODE SCHEME FOR H.264/AVC VIDEO CODING

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In this paper, we propose a modified intra_4x4 prediction mode scheme is proposed for H.264/AVC, which can improve the prediction accuracy for areas without unified orientation. In our scheme, the upper right part of one 4×4 block mainly employs vertical prediction while the lower left part mainly uses horizontal prediction, predicting both vertical and horizontal directions in one block. The proposed scheme uses simple prediction equations with fixed weighting coefficients. Experimental results show that WCP is very competitive while comparing to other Intra_4×4 prediction algorithms.

Key words: Video coding, intra prediction, prediction mode, distance based weighted prediction (DWP), H.264/AVC.

1. INTRODUCTION

Joint Video Team (JVT) of ITU-T Video Coding Experts Group (VCEG) and ISO Motion Picture Experts Group (MPEG) has released the latest standard for video coding, which is known as H.264 or MPEG-4 Part 10 Advanced Video Coding (AVC)(www.ee.uta.edu/dip/courses/ee5356/H264sytems.pdf, Wiegand et al. 2003). The directional spatial prediction for intra coding is one of the significant contributions of H.264/AVC. In contrast with previous standards, intra prediction in H.264 is applied in spatial domain instead of transform domain, which utilizes the correlation between adjacent blocks to remove spatial redundant information in an image.

Many efforts have been done to simplify the intra coding in H.264. Fast intra mode decision algorithms were proposed to reduce the number of modes that needed calculation according to some criterion (Meng et al, 2003, Kim et al. 2004). Besides, fewer efforts on the intra prediction modes innovations were raised, either by altering the reference pixels (Min-hua Zhou, 2002) or by exchanging the order of intra prediction (Kim et al. 2004). Most of the algorithms can reduce the time complexity remarkably, but few can improve the coding efficiency.

Recently, distance-based weighted prediction (DWP) method and its simplified version integral DWP (iDWP) (Shengsheng et al. 2008) were

proposed to improve prediction efficiency, where the weighted prediction is done by coefficients which are inversely proportional to the distances between current pixel and its reference pixels. Although these methods give some improvement, they are computationally complex. This inspires us to propose a novel intra prediction mode called weighted cross prediction (WCP), which combines the vertical and horizontal predictions to replace the DC mode in Intra_4x4 prediction. The fixed weighting coefficients in our approach have a lower computation complexity with a comparable performance to DWP and iDWP.

The rest of this paper is organized as follows. We briefly introduce the intra prediction in H.264 in Section 2. In section 3, we describe our proposed method in details and analysis about the simulation results will be given in section 4. Finally, conclusions will be drawn in section 5.

2. INTRA PREDICTION TECHNIQUE IN H.264/AVC

The intra predictions in H.264/AVC are performed in a block-based manner, by referring to the neighboring samples of previously coded blocks which are left to and/or above the block to be predicted. In luminance prediction, nine optional prediction modes are provided for every 4x4 block, named as vertical, horizontal, DC, diagonal-down-left, diagonal-down-right, vertical-right, horizontal-

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down, vertical-left and horizontal-up prediction. Vertical, horizontal and DC modes, which are specified similar to the modes in Intra_4×4, with plane prediction compose all the four prediction modes for 16×16 luma block. The Intra_4×4 prediction is suitable for the parts with significant details, while the Intra_16×16 is applied to the smoother areas. The encoder chooses the best prediction mode to minimize the Lagrangian cost function, which takes both distortion and bit rate into consideration (www.ee.uta.edu/dip/courses/ee5356/H264systems.pdf).

Figure 1 illustrates 16 samples of 4×4 block (labeled as a-p) which are predicted by previous-decoded samples in the neighboring blocks (labeled as A-M), when using the Intra_4×4 prediction. For vertical or horizontal modes, the pixel values are extrapolated by upper samples or left samples, while other directional modes utilize the linear weighted average of reference samples. For the DC mode, all the predicted pixels are formed by means of upper and left samples.

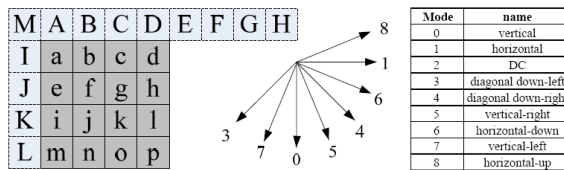


Fig.1 Intra_4x4 prediction modes

In Intra_4x4 prediction, each block can be predicted using either the DC mode or one of the eight directional modes. As we know, these eight directional modes are used to predict the regions with unified orientations. Therefore, it is better if the remainder, DC mode, can be used to predict some areas that the textures have no unified orientation. However, using DC mode to predict such areas is not very accurate because it uses one value to predict all pixels in the block, which can not show any kind of variations between them. Since the Intra_4×4 DC mode can not provide accurate prediction for some areas without unified directions, we replace DC mode with WCP mode, which is much simpler than DWP and iDWP (Shengsheng et al. 2008).

3. PROPOSED INTRA PREDICTION ALGORITHM

Statistics show that the vertical and horizontal predictions are more frequently used than other modes, implying higher correlations between the reference samples and the pixels to be predicted in these two directions (Zhang et al. 2004). Therefore,

it is possible to enhance the intra prediction accuracy by employing more such directional predictions, which inspires us to design WCP to replace DC mode in Intra_4×4, via combining vertical and horizontal predictions.

Furthermore, because only the upper and left reference samples are available, we divide the block into three parts: the diagonal, upper right part and lower left part. Since the diagonal pixels have the equal distance between the upper and left reference, they can be predicted by both the corresponding upper and left reference samples. However, the upper right pixels are closer to the upper reference while the lower left pixels closer to the left ones. Therefore, we mainly use the upper reference samples as the major component for the upper right part prediction while using the left reference samples for the lower left part. In other words, we use the vertical prediction as the major component for the upper right part, while employing the horizontal prediction as the major component for the lower left part.

Since correlation between pixels exists in both vertical and horizontal direction, we cannot only use the vertical or horizontal prediction directly in a 4×4 block. As a result, when we predict the upper right part, we use the left predicted pixel to adjust the vertical prediction, while using the upper predicted pixel as an adjuster to the horizontal prediction for the lower left part similar to (Baocai et al. 2006).

As illustrated in Figure 2, $P_{i,j}$ ($0 \leq i, j \leq 3$) denotes the predicted value of the pixel in the i th row and j th column of current 4×4 block. U_j and L_i denote the reference samples reconstructed from upper and left blocks respectively.

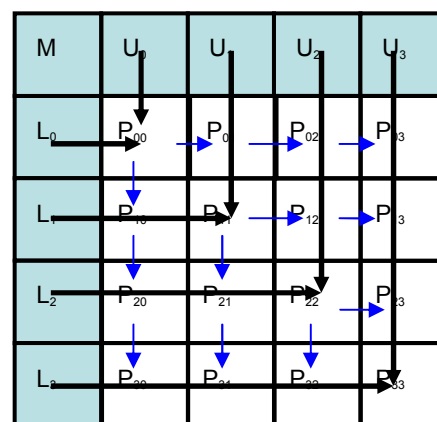


Fig. 2 Illustration of intra 4x4 prediction

In order to make a weighted prediction, a larger coefficient 3/4 is assigned to the major reference samples while a smaller coefficient 1/4 to the adjustment ones. The denominators 4 make the division operation to be implemented by shift operation. $P_{i,j}$ can be calculated as:

$$P_{i,j} = \begin{cases} (3U_j + P_{i,j-1} + 2) \gg 2 = [(U_j \ll 1) + U_j + P_{i,j-1} + 2] \gg 2 & i < j \\ (L_i + U_j + 1) \gg 1 & i = j \\ (3L_i + P_{i-1,j} + 2) \gg 2 = [(L_i \ll 1) + L_i + P_{i-1,j} + 2] \gg 2 & i > j \end{cases}$$

Since some of the predicted values are based on the other predicted values, we have to compute the predicted values in the following order. The diagonal pixels should be computed first, which are only based on U_j and L_i . Then, the upper right and lower left parts can be computed. The material expressions of WCP are listed as follows. It can be seen that the longer the distance between the reference sample and the pixel is, the smaller the coefficient becomes.

$$\begin{aligned} P_{0,0} &= \frac{1}{2}U_0 + \frac{1}{2}L_0 & P_{1,1} &= \frac{1}{2}U_1 + \frac{1}{2}L_1 \\ P_{2,2} &= \frac{1}{2}U_2 + \frac{1}{2}L_2 & P_{3,3} &= \frac{1}{2}U_3 + \frac{1}{2}L_3 \\ P_{0,1} &= \frac{3}{4}U_1 + \frac{1}{4}P_{0,0} = \frac{3}{4}U_1 + (\frac{1}{8}U_0 + \frac{1}{8}L_0) \\ P_{0,2} &= \frac{3}{4}U_2 + \frac{1}{4}P_{0,1} = \frac{3}{4}U_2 + (\frac{3}{16}U_1 + \frac{1}{32}U_0 + \frac{1}{32}L_0) \\ P_{1,2} &= \frac{3}{4}U_2 + \frac{1}{4}P_{1,1} = \frac{3}{4}U_2 + (\frac{1}{8}U_1 + \frac{1}{8}L_1) \\ P_{0,3} &= \frac{3}{4}U_3 + \frac{1}{4}P_{0,2} = \frac{3}{4}U_3 + (\frac{3}{16}U_2 + \frac{3}{64}U_1 + \frac{1}{128}U_0 + \frac{1}{128}L_0) \\ P_{1,3} &= \frac{3}{4}U_3 + \frac{1}{4}P_{1,2} = \frac{3}{4}U_3 + (\frac{3}{16}U_2 + \frac{1}{32}U_1 + \frac{1}{32}L_1) \\ P_{2,3} &= \frac{3}{4}U_3 + \frac{1}{4}P_{2,2} = \frac{3}{4}U_3 + (\frac{1}{8}U_2 + \frac{1}{8}L_2) \\ P_{1,0} &= \frac{3}{4}L_1 + \frac{1}{4}P_{0,0} = \frac{3}{4}L_1 + (\frac{1}{8}U_0 + \frac{1}{8}L_0) \\ P_{2,0} &= \frac{3}{4}L_2 + \frac{1}{4}P_{1,0} = \frac{3}{4}L_2 + (\frac{3}{16}L_1 + \frac{1}{32}U_0 + \frac{1}{32}L_0) \\ P_{2,1} &= \frac{3}{4}L_2 + \frac{1}{4}P_{1,1} = \frac{3}{4}L_2 + (\frac{1}{8}U_1 + \frac{1}{8}L_1) \\ P_{3,0} &= \frac{3}{4}L_3 + \frac{1}{4}P_{2,0} = \frac{3}{4}L_3 + (\frac{3}{16}L_2 + \frac{3}{64}L_1 + \frac{1}{128}U_0 + \frac{1}{128}L_0) \\ P_{3,1} &= \frac{3}{4}L_3 + \frac{1}{4}P_{2,1} = \frac{3}{4}L_3 + (\frac{3}{16}L_2 + \frac{1}{32}U_1 + \frac{1}{32}L_1) \\ P_{3,2} &= \frac{3}{4}L_3 + \frac{1}{4}P_{2,2} = \frac{3}{4}L_3 + (\frac{1}{8}U_2 + \frac{1}{8}L_2) \end{aligned}$$

We also compare the computation complexity between iDWP and WCP. The computation complexity of iDWP to predict one pixel includes 1 multiplication, 2 additions, 1 subtraction, and 2

shifts, which is an approximation to DWP (Kim et al.). The number of operation to predict one pixel in WCP is 2.75 additions and 1.75 shifts in average, which is less complex than iDWP

4. SIMULATION RESULTS AND DISCUSSIONS

The proposed algorithm is simulated on the JM software (<http://iphome.hhi.de/suehring/ttml/>) version 10.2. The performance of WCP is compared with intra prediction scheme of H.264 in terms of the average PSNR (dB) and the bitrate (kbits/s) for several test sequences including both CIF and QCIF format. In the experiment, all the sequences have 100 frames (30Hz), compressed with all Intra prediction by applying four quantization parameters: QP=20, 24, 28, and 32. The test conditions are indicated as follows:

- (a) Intra 16x16 and Intra 4x4 are used;
- (b) RD Optimization is used;
- (c) The entropy coding method is CABAC;
- (d) The 8x8 transform is disabled;
- (e) The adaptive rounding is disabled.

Since our proposed method is for low complexity intra prediction, we only compare the simulation result of WCP and iDWP here. The simulation results for WCP and iDWP are listed in table 1 and table 2.

Table 1. Simulation results of CIF sequences

Sequence (CIF)	WCP		iDWP	
	Δ PSNR (dB)	Δ bitrate (%)	Δ PSNR (dB)	Δ bitrate (%)
Bus	0.09	-0.96	0.13	-1.35
Stefan	0.08	-0.78	0.10	-0.95
Mobile	0.06	-0.48	0.06	-0.44
Foreman	0.02	-0.23	0.02	-0.30
average	0.06	-0.61	0.08	-0.76

Table 2. Simulation results of QCIF sequences

Sequence (QCIF)	WCP		iDWP	
	Δ PSNR (dB)	Δ bitrate (%)	Δ PSNR (dB)	Δ bitrate (%)
Salesman	0.07	-0.86	0.11	-1.28
News	0.06	-0.55	0.09	-0.89
Claire	0.04	-0.53	0.06	-0.67
average	0.06	-0.65	0.09	-0.95

The increase of PSNR is calculated when the bitrates are equal while the decrease of bitrate is calculated when the PSNRs are the same. The rate-

distortion (RD) curves of Bus and Salesman sequences are shown in Figure 3 and Figure 4. A constant performance gain is obtained by WCP over H.264 with an average PSNR improvement of 0.06 dB which reaches its maximum of 0.09 dB in CIF sequences. In QCIF sequences, the average PSNR increase is 0.06 dB. It can be seen that the result of WCP is comparable to iDWP. In mobile sequence, the performance is even better than iDWP. In addition, WCP shows a better performance in CIF than in QCIF sequences suggesting its better suitability for high resolution sequences.

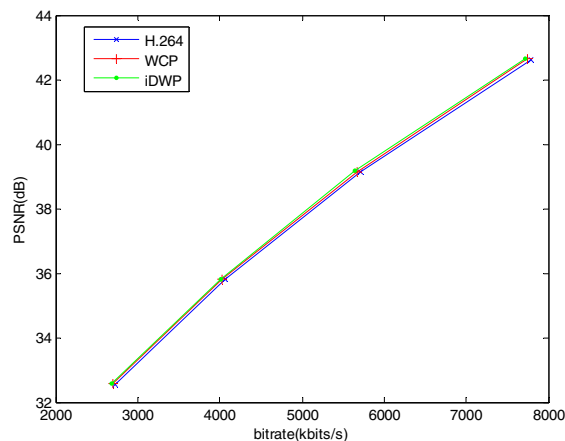


Fig. 3 RD curve for "Bus" sequence

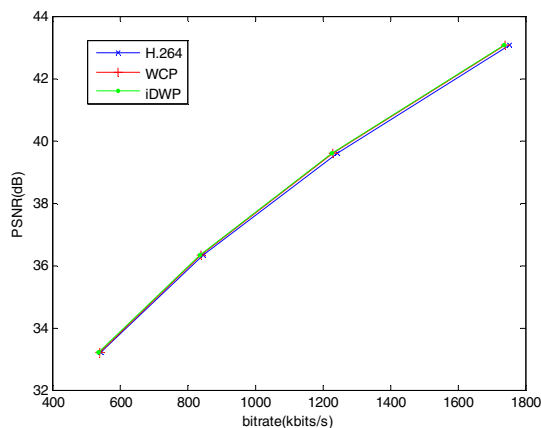


Fig. 4 RD curve for "Salesman" sequence

5. CONCLUSIONS

WCP is proposed to replace DC mode in Intra_{4×4} to solve the problem that DC mode used in the regions with no unified direction. To improve the prediction accuracy, we utilize the vertical prediction as the major approach on the upper right part, while the horizontal prediction as the major approach on the lower left part, which includes both vertical and horizontal predictions in one block. The experimental results show improvements

compared to the original H.264 with DC mode and WCP gives comparable RD performance to iDWP with lower computation complexity.

ACKNOWLEDGEMENT

This research was partially supported by CASR grants memo: KUET/CASR10/26(30) of KUET, Khulna, Bangladesh.

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PERFORMANCE ANALYSIS OF A SIMPLE POWER QUALITY CONDITIONER FOR MITIGATION OF HARMONICS

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Power quality issues are gaining significant attention due to the increase in use of equipment that are sensitive to distortions or dips in supply voltages. At the same time, the usage of static power converters has been growing tremendously to provide controlled electric power in various applications such as arc furnaces, computer power supplies and adjustable speed drives. The nonlinear characteristics of these power converters create poor power factor, low system efficiency, interference in nearby communication networks and disturbance to other consumers due to increased harmonics, negative sequence and reactive power components of current from AC mains. To curb this, regulations apply in many places that limit the distortion and unbalance that a customer can inject to a distribution system. These regulations may require the installation of active filter on customer premises to reduce harmonics. In this paper behavior of a simple converter circuit has been analyzed experimentally to find its effectiveness for cost effective solution as power conditioner. The circuit consists of four diodes and one MOSFET has been used at the input of a resistive loaded single phase rectifier circuit to mitigate harmonics. It is found that the total harmonic distortion (THD) is reduced; power factor and efficiency are improved. The work has also been simulated by ORCAD simulation software and it is found that simulation results matched closely with those of experimental results.

Key words: Power Quality, Unified Power Quality, Harmonic Mitigation, Power Quality Conditioner, Reactive Power

1. INTRODUCTION

The advances in the power semiconductor devices have led to the increase in the use of power-electronic converters in various applications such as heating, lighting, ventilating and air conditioning applications, large rated dc and ac drives, adjustable speed drives (ASDs), HVDC systems, in process technology such as electroplating, welding units etc., battery charging for electric vehicles, power supplies for telecommunication systems etc [1-4]. And many of these use ac to dc conversion by various rectifiers. Rectifiers are non-linear circuit elements and generate harmonic currents. The non-sinusoidal harmonic currents drawn by the rectifiers are injected into the ac power lines /transformers /source causing a number of problems for the power distribution network and for other electrical systems in the vicinity of the rectifier deteriorating the power quality at the point of common coupling (PCC), thereby affecting the nearby consumers [5-7]. Consequently, design and development of

rectifiers with improved waveforms has gained importance for stringent power quality regulation and strict limit on total harmonic distortion (THD) of input current placed by standards such as IEC 1000-3-2 and IEEE 519-1992 [8-10].

Several methods have been employed for improving the input current wave shape and power factor of rectifiers which include both active and passive means. Among the passive wave shaping methods, the novel method, using an input L-C parallel resonant tank proposed by P. D. Ziogas [11] in 1990, is worth mentioning. However, further improvement of the input power factor is difficult to achieve, and the input current's total harmonic distortion is still high, which is the main disadvantage of the novel topology. To overcome the weakness, Yanchao in 1996 [12] proposed an improved passive wave shaping method where a capacitor is placed in parallel between the parallel resonant tank and the rectifier bridge, which could compensate the reactive power and absorb the

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distortion power. As a result the improved method has a better filter feature and the higher input power factor than the novel method. Though the passive methods are attractive for their simplicity, reduced cost and reliability [9, 13-14] but they are bulky and fail to provide satisfactory results. On the other hand, the active methods using high frequency switching technique to shape the input current with small size filter are much preferred [10, 15]. Although due to design complexity and cost of the additional circuitry often found them to be unacceptable in low power applications. In 1991, a novel active power factor correction method for power supplies with three phase front end diode rectifiers is proposed and analyzed by A. R. Prasad and P. D. Ziogas [16]. The implementation of this method requires the use of an additional single switch boost chopper. This method does not deal with total harmonic distortion but the power factor is near unity. Based on the analysis of the novel active power factor correction of three phase diode rectifiers by A. R. Prasad and P. D. Ziogas [16], M.A. Khan et al. in 2007 [17] designed a single phase rectifier with switching on AC side for high power factor and low total harmonic distortion. This method uses a single MOSFET switch on the ac side to provide alternative path for input current to flow and hence make it continuous. The rectifier is connected to the ac mains through a series combination of inductor and capacitor, which keeps the input current smooth and in phase with the supply voltage. The simulated results revealed that the total harmonic distortion is reduced and overall efficiency is improved significantly.

2. OBJECTIVE

In this paper behavior of a simple converter circuit has been analyzed experimentally to find its effectiveness for cost effective solution as power conditioner. The circuit consists of four diodes and one MOSFET has been used at the input of a resistive loaded single phase rectifier circuit to mitigate harmonics. The work has been simulated by ORCAD simulation software and the simulation outcomes have been verified with those of experimental results.

3. CIRCUIT DESCRIPTION

Fig. 1 shows the schematic diagram of the circuit present here for making the current continuous. When the switch (M1) is ON or closed, it provides an alternative path when all the diodes (D1 to D4) are reverse biased. Since input current flows naturally when the supply voltage approaches its maximum value (positive or negative), the switch should be triggered off during that period. For the

rest of the period, the switch should be turned ON and OFF with continuously varying duty cycle. The duty cycle should be smoothly varying, starting with maximum ON period and reaching to minimum ON period as the supply voltage sweeps through its zero to maximum values. The ON time initially should be high to ensure the increase of input current to a reasonable value, so that during smaller OFF periods current does not fall appreciably and thus remains smooth. As the supply voltage increases, the ON period should decrease accordingly to prevent the input current from rising indefinitely and also to allow input current sufficient time to fall accordingly during the OFF period. This concept reveals that the duty cycle of the switching should be varied like a rectified cosine function with a frequency twice that of the supply.

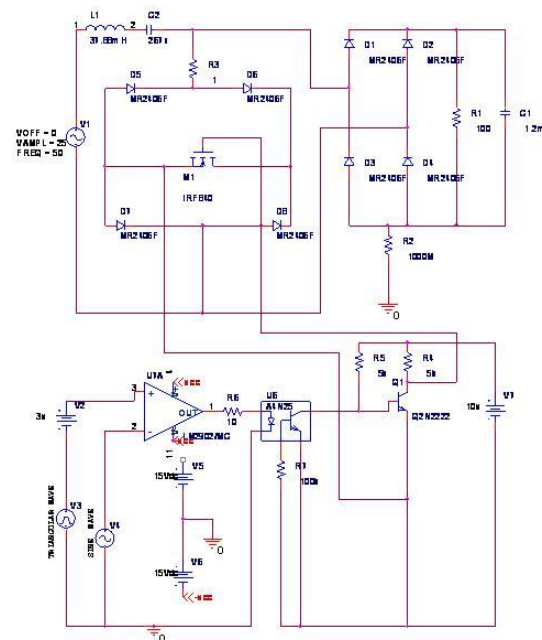


Fig. 1: Single phase diode rectifier with switching on input side

The inductor (L1) connected in series with the supply makes the current smoother by eliminating any sharp variation that might exist. However, the inductance value required for this purpose may become large, causing a significant portion of supply voltage to be dropped across it. This would result in unacceptably low output voltage. Moreover, the phase difference between input current and supply voltage in this case would be also unacceptable. Therefore a capacitor (C2) has been connected in series with L1 to keep the current in phase with the supply voltage.

3.1 The Switching Scheme

The objective of the switching scheme is to enhance the continuity of the input current by providing it an alternative path through closing an electronic switch. A MOSFET (IRF 840) is used as the switch because of its high switching speed compared to other semiconductor switches. The gate pulses have been generated by a PWM module which mainly consists of an opamp, an opto-coupler and BJT. A 4 KHz triangular wave is compared with a 50 Hz sinusoidal signal to generate the gate pulses in order that the duty cycle can be smoothly varying, starting with maximum ON period and reaching to minimum ON period as the supply voltage sweeps through its zero to maximum values, so as to make the input current sinusoidal and in phase with input voltage. The opto-coupler is used to provide necessary ground isolation between the PWM module and the switch while producing the pulses. The BJT amplifier is connected for increasing the voltage level at about 10 volts to drive the switch.

3.2 Input Filter Design

The values of L1 and C2 forming the input filter are chosen in such a way that its resonant frequency equals that of the supply frequency which is 50 Hz. This produces a selectivity due to which only the fundamental frequency component of the input current can flow unimpeded and causes negligible voltage drop across the LC combination. For a given supply frequency the value LC constant can be found as-

$$\begin{aligned} X_L &= X_C \\ \Rightarrow 2\pi f L &= \frac{1}{2\pi f C} \\ \Rightarrow LC &= \frac{1}{4\pi^2 f^2} = 10.132 \times 10^{-6} \end{aligned}$$

The values of the series L-C filter are adjusted to produce a series resonance at supply frequency with the intention to keep the input current in phase with the supply voltage and to improve the overall system efficiency.

3.3 Output Filter Design

A simple capacitive input dc filter is used to reduce the ripple content of the output voltage of the single phase rectifier. The ripple factor RF can be found from

$$RF = \frac{1}{\sqrt{2}(2f_r RC - 1)}$$

Where f_r is the ripple frequency = 100 Hz. Considering the ripple voltage to be reduced to 1% after filtering, the value of RC constant can be found as 0.12855. Again, for the n th harmonic

ripple current to pass through the filter capacitor, the capacitance value should be so chosen that the load impedance must be much greater than that of the capacitor. That is, $R \gg \frac{1}{2\pi f_r C}$. Allowing for

a dc load of 100Ω the value of the output filter capacitor C1 is taken 1.2 mF.

4. RESULTS AND DISCUSSION

The converter circuit was simulated by ORCAD simulation software with various combinations of input filter L, C values and was verified with practical examination to find its effectiveness for cost effective solution as power conditioner.

Initially the total harmonic distortion of the input current of a single phase rectifier has been studied as a power quality problem. Fig. 1 shows the non-sinusoidal input current wave shape of the supply mains due to rectification action. The high current peaks cause harmonic distortion of the supply current and low power factor.



Fig.2: The non-sinusoidal input current wave shape of the supply mains due to rectification action

This results in a poor power quality, voltage distortion, poor power factor at input ac mains, slowly varying rippled dc output at load end and low efficiency. Thus the switching scheme has been developed exploiting a single MOSFET switch driven by rectangular gate pulses whose duty cycle is continuously varied over the period of supply voltage. The switch provides an alternative path for the input current makes it sinusoidal during the periods when due to the reverse biasing of rectifier diodes input current causes to flow otherwise.

Simulating the circuit using ORCAD for various combination of LC filter, we get the wave shapes of input current and its frequency spectrum, output voltage waveforms, samples of which are presented

in Fig. 3 and the summary of the simulation results is given in Table 1.

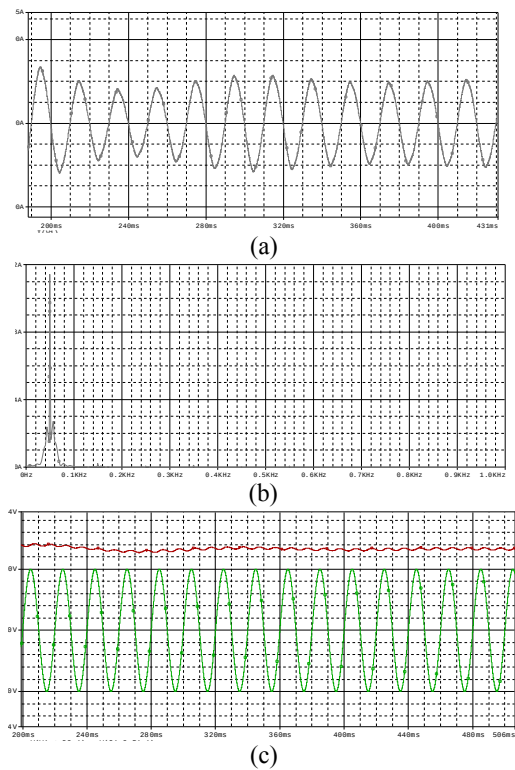


Fig. 3: wave shapes of (a) input current, and (b) its frequency transform, (c) output voltage along with supply voltage for $L=37.88\text{mH}$ and $C=267.5\mu\text{F}$

Table 1. Summary of the simulation results

Input filter		THD	Vin	Iin	Vout	Iout	H	P.f.
L (mH)	C (μF)	(%)	(V)	(A)	(V)	(A)	(%)	
160	64	2.46	11.3	1.24	12.5	0.82	73.15	0.95
37.88	267.5	3.55	11.3	0.6	14.3	0.42	89.21	1
44.8	226.16	4.02	4.11	0.22	4.26	0.19	86.53	0.99

The simulation output shows that the THD of the input current has been improved significantly, power factor has been close to unity and the overall efficiency has also been enhanced.

Additionally using simulation the total harmonic distortion (THD) and the efficiencies of the prototype are calculated for various switching frequencies and the efficiency vs. switching frequency curve is plotted as shown in Fig. 4. From the curve it is clear that the efficiency is more for a switching frequency of 4 KHz. Thus we employed

the switching frequency of 4 KHz in practical implementation of the circuit.

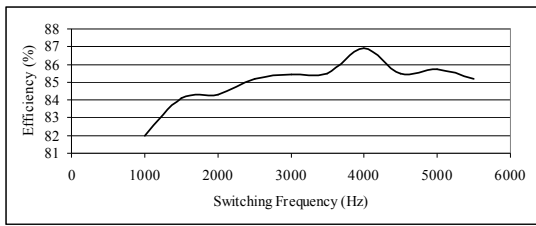


Fig. 4: Circuit efficiency for various values of switching frequency

Finally, the simulation results have been verified with practical results obtained from a laboratory setup as shown in Fig.5. The converter circuit has been implemented practically keeping the switching frequency of gate pulse at 4 KHz. The input side LC filter has been adjusted to give the desired series resonance by varying inductor and capacitor bank. When the gate pulses were applied to the MOSFET and the input resonant filter was tuned, a dramatic change was observed in the input current wave shape like the simulation outcome.

It was one of the significant parts of our practical work to measure the THD and keep it in allowable range. We used Virtual Instrument Kit (VIK) to measure THD. VIK is a special instrument which measure THD with a probe connected to the node where THD is to be measured, and is interfaced with computer through parallel port. From the computer we can view frequency spectrum graphically and measure THD directly using VIK.



Fig. 5: Laboratory setup of the simple power quality conditioner

A sample of wave forms of the gating signals, the input current and the output voltage obtained from practical realization of the circuit for various filter combinations is shown in Fig. 6. Also the summary of results of the practical implementation is illustrated in Table 2.

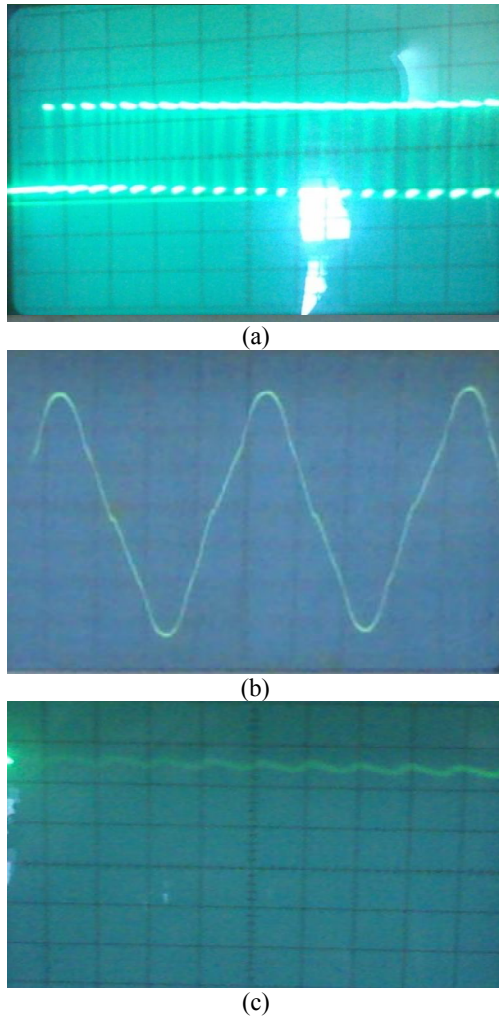


Fig. 6: sample experimental wave forms of (a) gating signals, (b) input current and (c) output voltage for $L=37\text{mH}$ and $C=267.5\mu\text{F}$

Table 2. Summary of the experimental results

Input filter		THD (%)	V_{in} (V)	I_{in} (A)	V_{out} (V)	I_{out} (A)	η (%)	P.f.
L(mH)	C(μF)							
37	267.5	4.92	11.3	0.89	12.83	0.628	86.74	0.969
44.8	226.1	4.29	4.11	0.542	4.72	0.39	82.65	0.92
63	160.1	7.26	4.82	0.625	4.96	0.435	71.47	0.83

The experimental outcome demonstrates close resembles to the simulation output. The THD of the input current has been considerably improved compare to that without conditioner and, power factor has been close to unity and the overall efficiency has also been better. A comparative study on simulation and practical data is demonstrated by bar charts as shown in Fig. 7 & 8.

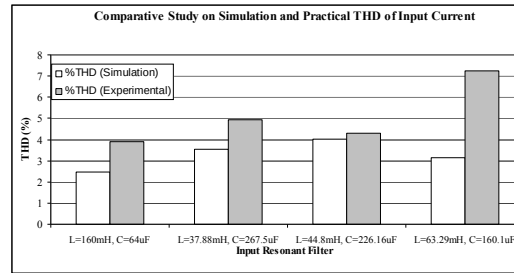


Fig. 7: %THD of input current for different LC combination (simulation & experimental)

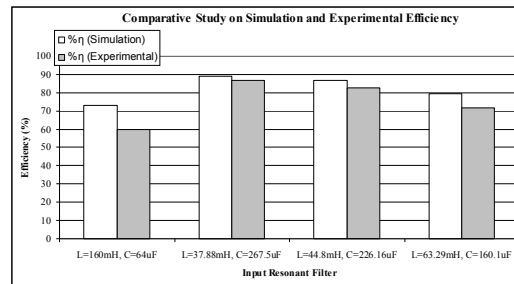


Fig. 8: Efficiency of the system for different LC combination (simulation & experimental)

With the deployment of the power conditioner circuit the performance of the single phase rectifier has been improved appreciably as demonstrated by simulation and practical implementation. The total harmonic distortion (THD) is reduced; power factor and efficiency are improved and simulation results matched closely with those of experimental results. The best result of efficiency is obtained for input filter parameter $L=37\text{mH}$, $C=267.5\mu\text{F}$ and switching frequency of 4 KHz. In this case THD of the input current is about 4%, efficiency more than 86% and power factor is close to unity. Also the output voltage is found to be greater than the input voltage amplitude. This is important because as the output voltage becomes higher than the supply voltage amplitude, the rectifier diodes are reverse biased and the current can flow naturally only when the switch is turned on.

5. CONCLUSION

In this paper a scheme for improving the input current wave shape and power factor of a single phase rectifier has been successfully analyzed experimentally and also by simulation to find its effectiveness for cost effective solution as power conditioner. The simulation outcomes matched closely with those of experimental results. However, the experiment has been conducted in low power levels and low voltages. If power levels would be high it would offer more desirable results

as switching power would be minimized to enhance the overall system efficiency. Moreover, the effects of different types of loads on required switching frequency, duty cycle variation and efficiency should also be studied. The use of IGBTs instead of MOSFET may have significant effect in reducing the THD and the efficiency may still go up. For that the input and the output filter circuits should be designed accordingly.

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PROSPECT OF GRID CONNECTED SOLAR PV POWER PLANT IN BANGLADESH

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Bangladesh is situated between 20.30 - 26.38 degrees north latitude and 88.04 - 92.44 degrees east which is an ideal location for utilization of solar energy. Daily average solar radiation varies between 4kWh/m^2 to 6.5kWh/m^2 . Average annual solar irradiance is nearly $1,900\text{kWh/m}^2$ which is sufficient to operate a grid connected solar photovoltaic (PV) power plant with a generation of megawatt (MW) ranges. Nowadays in Bangladesh approximately 40 MW of power is being produced from solar PV panels which includes only off grid stand alone systems. Still now there is no grid (11kV or above) connected PV power plant in Bangladesh. As there is no fuel cost in PV generation and it produces pollution free green energy with nominal maintenance cost, this can be an attractive choice to mitigate the power crisis in Bangladesh. But huge land requirement and large installation costs are the main drawbacks. In this paper we have described the prospect of large scale PV generation in Bangladesh to support the national grid along with costing and technical factors.

Key words: photovoltaic; solar irradiance; grid connected; green energy; power crisis

1. INTRODUCTION

The fossil fuels used for generation of electricity are depleting fast. This is more applicable in case of Bangladesh. Although there is a rising hope that Bangladesh might discover sizable quantity of fossil fuel but that may not last long given the projected growth in economic activities. Thus the issue of sustainable development is gaining steady momentum. The renewable energies being inherently sustainable and environment friendly, are gaining popularity. All developed countries and many developing countries in their energy planning have included renewable energies as important sources of energy for the next century. Many countries are planning to develop renewable energies (PV, wind, hydro) to cover 10% to 40% of their energy needs within couple of decades. However, no such effort is seen in Bangladesh although Bangladesh has a good prospect in the field of solar technology.

2. PV TECHNOLOGY OVERVIEW

Solar energy is the radiant energy that the sun produces. This is the result of a process called nuclear fusion - the joining of smaller atoms to form a larger atom.

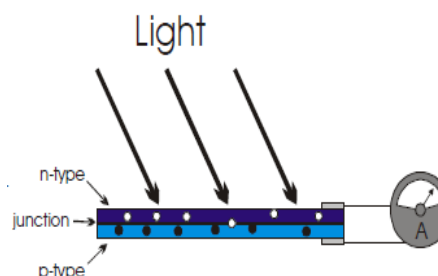


Figure 1: electricity generation from photovoltaic device

A solar cell or photovoltaic (PV) cell is a device that converts light into electric current using the photoelectric effect. The first solar cell was constructed by Charles Fritts in the 1880s. Although the prototype selenium cells converted less than 1% of incident light into electricity, both Ernst Werner von Siemens and James Clerk Maxwell recognized the importance of this discovery. Following the work of Russell Ohl in the 1940s, researchers Gerald Pearson, Calvin Fuller and Daryl Chapin created the silicon solar cell in 1954. These early solar cells cost 286 \$/watt and reached efficiencies of 4.5–6%. Nowadays there are varieties of solar cells with different technologies and efficiencies. A grid connected photovoltaic system is solar system where the output of the PV array is

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connected to feed into the grid supply. Grid interconnection of photovoltaic (PV) power generation system has the advantage of more effective utilization of generated power. However, the technical requirements from both the utility power system grid side and the PV system side need to be satisfied to ensure the safety of the PV installer and the reliability of the utility grid. Clarifying the technical requirements for grid interconnection and solving the problems are therefore very important issues for widespread application of PV systems.

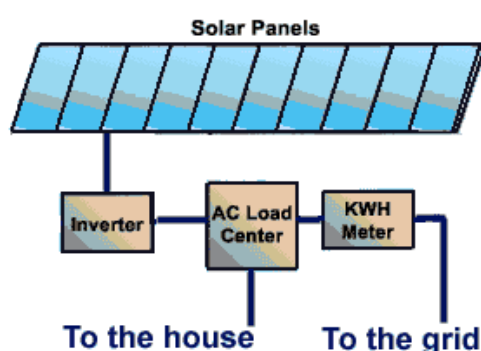


Figure 2: grid connected PV system

In a grid connected PV system, the DC power generated by the PV modules in the system is converted to AC by power conditioning unit (inverter) and fed into the local loads. Any excess solar power is supplied to the power line, and any shortfall is made up with grid electricity. During non sun hours, residence loads are supplied by utility grid alone.

3. PRESENT POWER SCENARIO IN BANGLADESH

At present Bangladesh has a requirement of about 6,000 megawatts electricity but production hovers around 4,000 megawatts.^[1]

Bangladesh as a developing country has lowest coverage of electricity which stands around 32 per cent of the total population and the rural areas of Bangladesh, where 76 per cent of the population live, is seriously deprived of the electricity facility. The electrification rate of the country is now 42% but the rural areas are not as developed as the urban areas seeing that their electrification rate is only 23% (against 79% or urban areas)^[2]. Bangladesh has a large unsatisfied demand for commercial energy with most of the supply limited to urban areas.

Different types of power plants generate electricity and synchronize it with the national grid. There are

some isolated diesel power stations at remote places and islands which are not connected with the National Grid. Terminal voltages of different generators are 11 kV, 11.5 kV and 15.75 kV. In the Eastern Zone (eastern side of river Jamuna), electricity is generated from indigenous gas and a small percentage through hydro power. In the Western Zone, Coal and imported liquid fuel is used for generation of electricity.

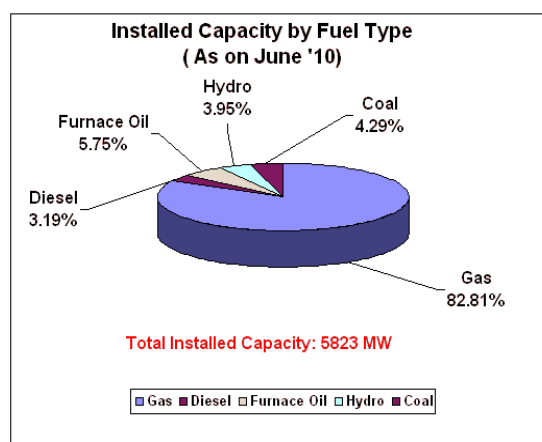


Figure 3: installed capacity by fuel type^[1]

The fuel cost per unit generation in the Western Zone is much higher than that of the Eastern Zone. Therefore, as a policy, low cost electricity generated in the Eastern Zone is transferred to the Western Zone through the 230 kV East-West Inter connector transmission line.^[1]

Bangladesh is now passing through a crisis period when short supply of power and energy seriously hampers production in agriculture and industry. The country almost entirely depends on conventional sources of energy like gas, oil and diesel to meet its energy demand. But imported oil is too costly and gas reserve is depleting day by day. This situation demands harnessing other energy resources among which solar energy is a vital one.

4. RENEWABLE ENERGY CONSUMPTION

The most viable sources of renewable energy in the country are solar, wind, biomass and biogas. Nowadays in Bangladesh approximately 40 MW of power is being produced from solar PV panels which includes only off grid stand alone systems and mini grid systems (connected to the low level transmission line)^[3]. At present contribution of solar and wind energy in electricity generation is only 0.9%.

Although Solar Home Systems (SHS) are now gradually becoming popular in Bangladesh and

have obtained good dimension, grid-connected PV systems can be good power sources in cities and in remote areas where power generation in the existing grid is needed to be increased.

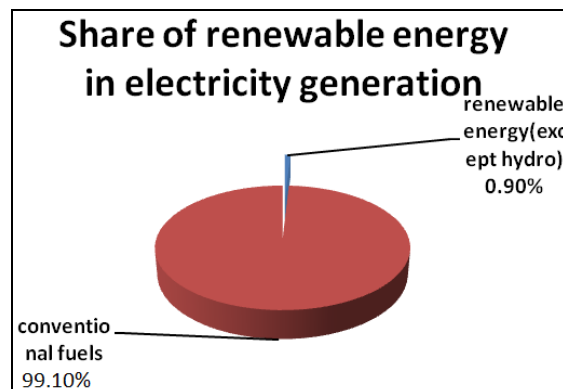


Figure 4: renewable energy share in electricity generation

There are different organizations, entrepreneurs implementing solar energy program in Bangladesh which includes Solar Home System(SHS), Centralized (AC) System, Centralized(AC) market electrification, water pumping, rural clinic, roof top PV mini-grid system, telecommunications, railway signaling, refrigeration, cyclone shelters etc, ICT training centers, community places etc. But still now there is no grid (11kV or above) connected PV power plant in Bangladesh.

4. PV POWER PLANT: PERSPECTIVE BANGLADESH

Bangladesh is situated between 20.30 - 26.38 degrees north latitude and 88.04 - 92.44 degrees east which is an ideal location for solar energy utilization. Daily average solar radiation varies between 4 to 6.5 kWh per square meter. Maximum amount of radiation is available on the month of March-April and minimum on December-January. There is a good prospect of harnessing solar power in Bangladesh. Maximum amounts of radiation are available in the month of March-April and minimum in December-January. Solar energy resource study map has illustrated prospect of solar radiation in Bangladesh (Figure-5).

The country's economy operates at low levels of commercial energy consumption, which is a crucial bottleneck to economic development. The country has nevertheless had an economic growth higher than 5% for a few years, which led to an increase of the electricity demand of 10% per year (around 500 MW per year). But against current demand of about

6000 MW estimated, an average of about 1,000MW has fallen short in capability out of 5823 MW installed capacity due to old age. Additionally, about 1,300 MW has fallen short in availability due to lack of maintenance and shortage of gas supply.

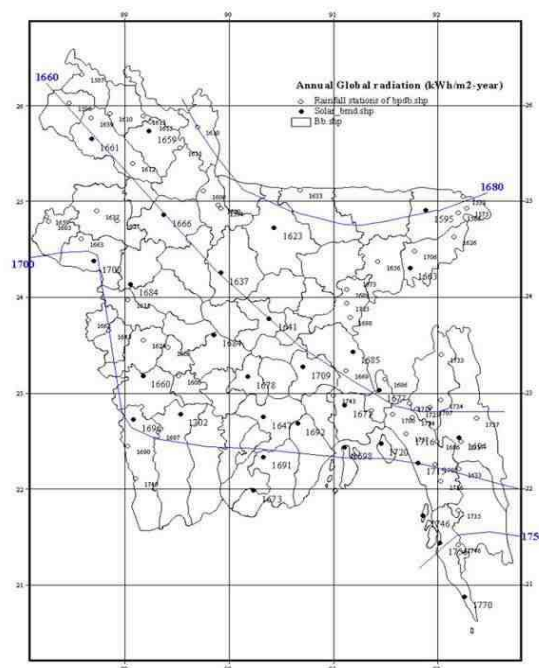


Figure 5: Global radiation values for different locations have been estimated from the measured and estimated values of sunshine duration

Under these circumstances, the Government of Bangladesh (GoB) launched the REREDP (Renewable Energy Research & Development Program) to provide remote rural populations with electricity through grid extension and Solar Home Systems (SHS). As there is no fuel cost in PV generation and it produces pollution free green energy with nominal maintenance cost, this can be an attractive choice to mitigate the power crisis in Bangladesh.

Grid-connected PV power systems are being installed in cities in different countries of the world. Government policies are being framed to encourage and popularize this system by providing necessary regulations and incentives in many developed and developing countries. From the gradual decrease of prices and increased rate of installation of the systems in the cities all over the world it can be easily comprehended that this system will become an important source of electricity in a very short time in the urban areas. Currently Bangladesh is experiencing the acutest load shedding in its

history. Solar PV power plant can minimize this crisis by producing green energy.

5. COSTING & OTHER FACTORS

Like any commodity, the electricity price of a PV system depends on costs of the individual components, transportation and installation costs. There may also be associated costs of designing the system and purchasing land (particularly for large-scale projects). In a PV system, the capital cost determines the production costs of the generated solar power. No cost is incurred for fuels and there is a nominal running cost. The total price is very difficult to define because it varies with application, size of system and location.

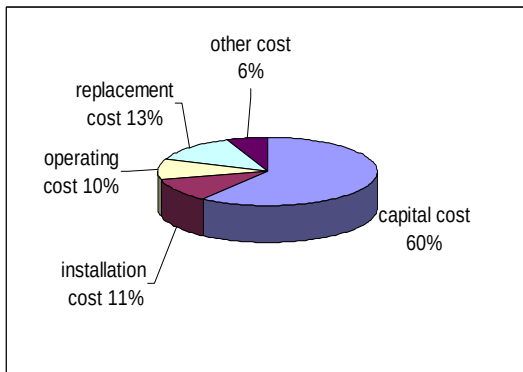


Fig: distribution of cost for a typical grid-connected PV system

PV pricing has fallen 40% in 2 years. The trend of PV system costing is shown bellow-

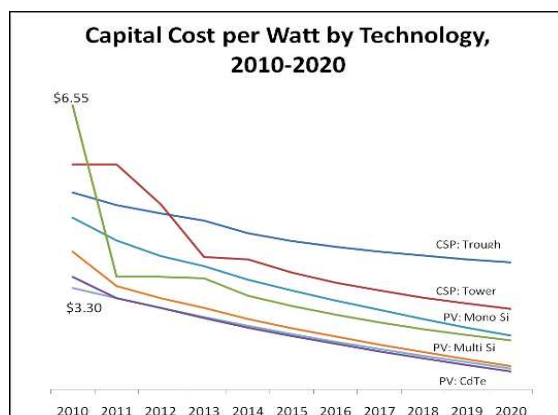


Fig 6: solar technology costing in future [5]

The cost of electricity generation from solar is higher till now compared to the other conventional fuels but it is a source of clean energy from an environmental viewpoint. So power utility company can introduce green pricing.

6. CASE STUDY: TYPICAL STATISTICS OF A 1 MW SOLAR PV POWER PLANT

Annual Irradiance	1900kWh\m ²
Electricity Output	1 MWp
Land Required	5 acres(maximum)
Investment Cost	\$7 millions
Maintenance Cost	2% of investment cost
Life time	25 yrs
Output Voltage	11kV

Table 1: features of 1MWp solar PV plant [6]

6. ENVIRONMENTAL BENEFITS

Almost all energy production and use involves some form of pollution of our environment. Each different source of energy, from fossil fuels to nuclear, pollutes in a different way and to a different degree.

Global warming is caused by the tendency for some gases like carbon dioxide which trap heat in the earth's atmosphere. This seems to be causing a gradual increase in the average world temperatures, melting of the ice caps, rising ocean levels, and changes in weather patterns. Pollutants such as nitrous oxides help to create smog and haze, and make it difficult for elderly people and people with lung problems to breathe. All these pollutants are emitted from conventional power plants.

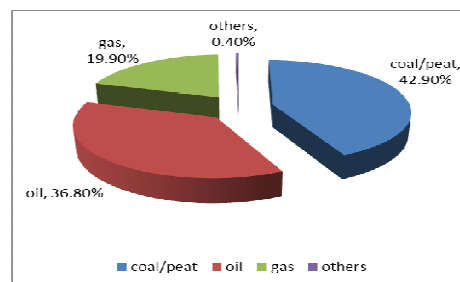


Figure 7 :CO₂ emission by different fuels (total CO₂ emission 29382 Mt) [7]

Solar Power uses the sun to produce electricity. This does not produce any pollution. No other energy can be as environment-friendly as the solar energy. This natural resource does not pollute the air when being converted into electricity by solar panels or other thermal devices. A solar power

plant allows a reduction of up to 10 tons CO₂ per kWp.^[4]

7. CONSTRAINTS

The major obstacles to rapid expansion of PV systems in Bangladesh are as follows:

- The main hindrance is the high installation cost of PV system due to high price of the PV module in international market. Huge land requirement is another problem.
- The lack of awareness about the PV technology.
- Absence of proper planning and design
- Less financial incentives from the government

8. CONCLUSION

Grid electrification is essential for economic development in Bangladesh. There are more than 87,000 villages in Bangladesh and most of them are not connected to the national grid. At the same time, the country has very limited fossil fuel reserve for electricity generation. PV grid electricity generation system could be effective to extend the grid connection and available power for all. It is found that the per unit electricity production cost from the PV system is cost-competitive with grid-connected diesel power generation. If clean development mechanisms, carbon tax and oil price increase are considered, the unit cost would be lower than the grid connected diesel power generation. Due to the high initial investment cost of PV grid system, there should be favorable policies for this sector. The instruments that can be applied to encourage renewable energy technologies promotion are incentives, consumer credit schemes, capacity building and to establish a renewable energy service authority. So it is high time the Government of Bangladesh should take necessary steps and provide proper facilities for green electrification in Bangladesh.

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Solar energy: Its prospects in Bangladesh

RADIATION FROM A LARGE CIRCULAR LOOP ANTENNA FOR A SERIES OF FOURIER HARMONIC CURRENT DISTRIBUTION

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It has been a challenging problem since long to determine analytically the properties of a large circular loop antenna. A large circular loop antenna cannot maintain a uniform current distribution. In this paper the radiation pattern of a large circular loop antenna has been calculated using a Fourier series of harmonic current distribution resembling that used by Pocklington. The results have good qualitative agreement with those obtained by different recent numerical methods.

Key words: Bessel function, intensity pattern, loop radius, non-uniform current distribution, 3D pattern.

1. INTRODUCTION

It is long well-known that for very small loops the current is almost constant, greatly simplifying the derivation of the radiated field expressions [1]. As the loop radius increases, the current distribution becomes initially sinusoidal [2], and finally incorporates a large number of Fourier modes [4-11]. Then it arises a question of convergence of the resulting series. In this paper the far fields are calculated by using the current distribution obtained by [2]. The far fields are obtained in Fourier-Bessel series in a novel form which converges rapidly.

2. FORMULATION OF THE PROBLEM

The geometry of the problem is shown in Figure 1. A thin conducting circular loop lies in the xy-plane. The current flows from $\Phi=0^\circ$ to $\Phi=360^\circ$.

The general expression of the vector magnetic potential at an arbitrary observation point (x,y,z) be [3]:

$$\tilde{A}(x,y,z) = \frac{\mu}{4\pi_c} \int_C I_e(x',y',z') \frac{e^{-jkR}}{R} dl' \quad (1)$$

where,

$$I_e(x',y',z') = \hat{a}_x I_x(x',y',z') + \hat{a}_y I_y(x',y',z') + \hat{a}_z I_z(x',y',z') \quad (2)$$

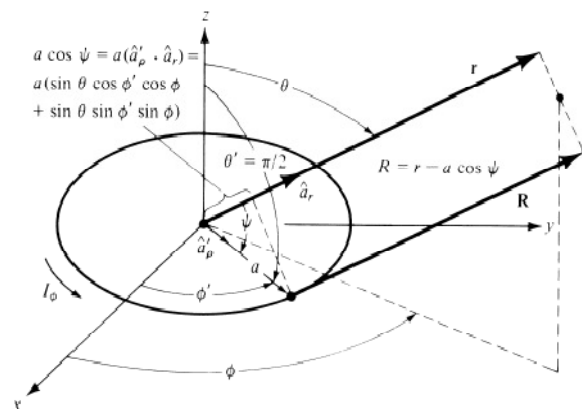


Fig. 1: Geometry of the circular loop antenna
Here, the source coordinates are designated as primed and the observation coordinates are designated as unprimed. In dealing with Now, the current components can be converted from Cartesian (x,y,z) to cylindrical (ρ,Φ,z) coordinate by using the following formulae:

$$I_x = I_\rho \cos \phi' - I_\phi \sin \phi' \quad (3)$$

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$$I_y = I_\rho \sin \phi' + I_\phi \cos \phi' \quad (4)$$

$$I_z = I_z \quad (5)$$

The unit vectors can be converted from Cartesian to spherical coordinate by utilizing the following formulae:

$$\hat{a}_x = \hat{a}_R \sin \theta \cos \phi + \hat{a}_\theta \cos \theta \cos \phi - \hat{a}_\phi \sin \phi \quad (6)$$

$$\hat{a}_y = \hat{a}_R \sin \theta \sin \phi + \hat{a}_\theta \cos \theta \sin \phi + \hat{a}_\phi \cos \phi \quad (7)$$

$$\hat{a}_z = \hat{a}_R \cos \theta - \hat{a}_\theta \sin \theta \quad (8)$$

Using the above equations, the expression for current becomes

$$I_e = \hat{a}_R \{ I_\rho \sin \theta \cos(\phi - \phi') + I_\phi \sin \theta \sin(\phi - \phi') + I_z \cos \theta \} \\ + \hat{a}_\theta \{ I_\rho \cos \theta \cos(\phi - \phi') + I_\phi \cos \theta \sin(\phi - \phi') - I_z \sin \theta \} \\ + \hat{a}_\phi \{ -I_\rho \sin(\phi - \phi') + I_\phi \cos(\phi - \phi') \} \quad (9)$$

Since the current is flowing in the ϕ' -direction, therefore the above equation is reduced to,

$$I_e = \hat{a}_R I_\phi \sin \theta \sin(\phi - \phi') + \hat{a}_\theta I_\phi \cos \theta \sin(\phi - \phi') \\ + \hat{a}_\phi I_\phi \cos(\phi - \phi') \quad (10)$$

The distance R can be expressed as,

$$R = \sqrt{r^2 + a^2 - 2ar \sin \theta \cos(\phi - \phi')} \quad (11)$$

$$\text{and} \quad dl' = ad\phi' \quad (12)$$

Using equations (10), (11) and (12), the spherical components of $\tilde{A}$ become,

$$A_\phi = \frac{\mu a}{4\pi} \int_0^{2\pi} I_\phi \cos(\phi - \phi') \frac{e^{-jk\sqrt{r^2 + a^2 - 2ar \sin \theta \cos(\phi - \phi')}}}{\sqrt{r^2 + a^2 - 2ar \sin \theta \cos(\phi - \phi')}} d\phi' \quad (13)$$

$$A_R = \frac{\mu a}{4\pi} \int_0^{2\pi} I_\phi \sin \theta \cos(\phi - \phi') \frac{e^{-jk\sqrt{r^2 + a^2 - 2ar \sin \theta \cos(\phi - \phi')}}}{\sqrt{r^2 + a^2 - 2ar \sin \theta \cos(\phi - \phi')}} d\phi' \quad (14)$$

$$A_\theta = \frac{\mu a}{4\pi} \int_0^{2\pi} I_\phi \cos \theta \cos(\phi - \phi') \frac{e^{-jk\sqrt{r^2 + a^2 - 2ar \sin \theta \cos(\phi - \phi')}}}{\sqrt{r^2 + a^2 - 2ar \sin \theta \cos(\phi - \phi')}} d\phi' \quad (15)$$

The harmonic current distribution to be used here is based upon Fourier Analysis [2] having resemblance with that obtained by Pocklington [4]. It is expressed as

$$I_\phi = I_0 J_0(ka) + \frac{4I_0}{\pi} \sum_{v=1}^{\infty} \frac{\sin \frac{v\pi}{2}}{v} J_v(ka) \cos(v\phi') \quad (16)$$

Figure 2 represents the numerical plot of I_ϕ as a function of Φ for different values of the electrical length, ka of the loop. Figure 3 represents the numerical plot of I as a function of ka for different values of the azimuthal angle, $\Phi = 0^\circ$ and $\Phi = 180^\circ$.

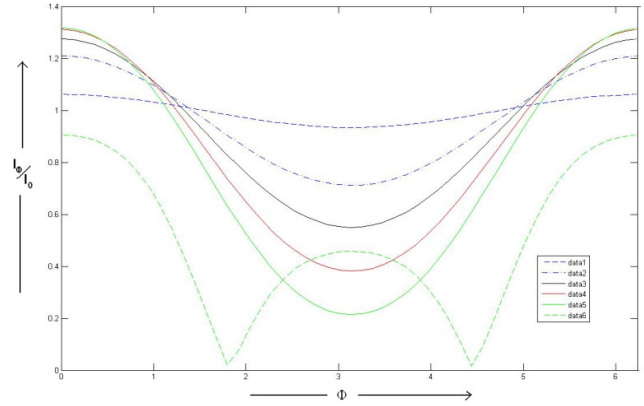


Fig. 2: Numerical current distribution along the circular loop

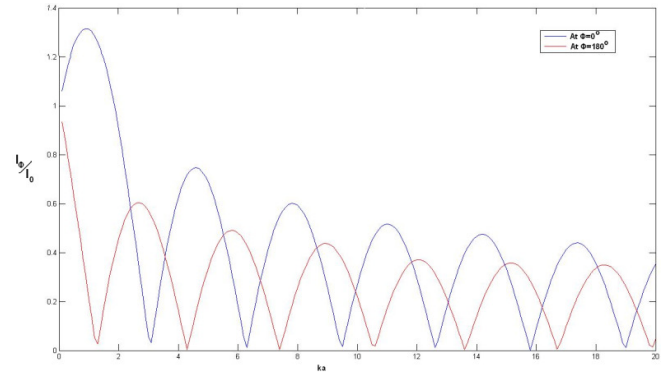


Fig. 3: Numerical current distribution for different values of the electrical length, ka at the feed point at $\Phi = 0$ and at the opposite point at $\Phi = 180^\circ$

For large circular or large circular loop, the distance R can be approximated for far field region as,

$$R \approx \sqrt{r^2 - 2ar \sin \theta \cos(\phi - \phi')} \quad (17)$$

for $(r \gg a)$

Using binomial expansion, ultimately we have,

$$R \approx \begin{cases} r - a \sin \theta \cos(\phi - \phi') \\ r \end{cases} \quad (18)$$

The term $r - a \sin \theta \cos(\phi - \phi')$ is considered for phase and r is considered for amplitude.

Replacing the value of I_ϕ and R, we have,

$$A_\phi \approx \frac{\mu a I_0 J_0(ka) e^{-jkr}}{4\pi r} \int_0^{2\pi} \cos(\phi - \phi') e^{jka \sin \theta \cos(\phi - \phi')} d\phi' \\ + \frac{\mu a I_0 e^{-jkr}}{\pi^2 r} \left\{ \sum_{v=1}^{\infty} \frac{\sin \frac{v\pi}{2}}{v} J_v(ka) \times \int_0^{2\pi} \cos v\phi' \cos(\phi - \phi') e^{jka \sin \theta \cos(\phi - \phi')} d\phi' \right\} \quad (19)$$

Now, the Bessel function has the following useful properties [2],

$$\int_0^{2\pi} \cos n\alpha \cos(\beta - \alpha) e^{j\beta \cos(\beta - \alpha)} d\alpha = \pi \{ j^{n+1} J_{n+1}(p) + j^{n-1} J_{n-1}(p) \} \cos n\beta \quad (20)$$

$$\int_0^{2\pi} \cos n\alpha \sin(\beta - \alpha) e^{jp \cos(\beta - \alpha)} d\alpha = \pi \{j^{n-1} J_{n-1}(p) - j^{n+1} J_{n+1}(p)\} \sin n\beta \quad (21)$$

$$\int_0^{2\pi} \cos(\beta - \alpha) e^{jp \cos(\beta - \alpha)} d\alpha = j2\pi J_1(p) \quad (22)$$

$$\int_0^{2\pi} \sin(\beta - \alpha) e^{jp \cos(\beta - \alpha)} d\alpha = 0 \quad (23)$$

Using the above formulae we have,

$$A_\phi \approx j \frac{\mu a I_0 J_0(ka) J_1(ka \sin \theta) e^{-jkr}}{2r} \quad (24)$$

$$-\frac{\mu a I_0 e^{-jkr}}{\pi r} \sum_{v_{\text{odd}}} \frac{1}{v} J_v(ka) \{J_{v+1}(ka \sin \theta) - J_{v-1}(ka \sin \theta)\} \cos v\phi$$

Similarly, we can obtain,

$$A_R \approx \frac{\mu a I_0 \sin \theta e^{-jkr}}{\pi r} \sum_{v_{\text{odd}}} \frac{1}{v} J_v(ka) \quad (25)$$

$$\{J_{v-1}(ka \sin \theta) + J_{v+1}(ka \sin \theta)\} \sin v\phi$$

$$A_\theta \approx \frac{\mu a I_0 \cos \theta e^{-jkr}}{\pi r} \sum_{v_{\text{odd}}} \frac{1}{v} J_v(ka) \quad (26)$$

$$\{J_{v-1}(ka \sin \theta) + J_{v+1}(ka \sin \theta)\} \sin v\phi$$

Now, for far field region, the electric and magnetic field components [3] can be approximated as,

$$E_R \approx 0 \quad (27)$$

$$E_\theta \approx -j\omega A_\theta \quad (28)$$

$$= -j \frac{k\eta a I_0 \cos \theta e^{-jkr}}{\pi r} \sum_{v_{\text{odd}}} \frac{1}{v} J_v(ka) \{J_{v-1}(ka \sin \theta) + J_{v+1}(ka \sin \theta)\} \sin v\phi$$

$$E_\phi \approx -j\omega A_\phi \quad (29)$$

$$= \frac{k\eta a I_0 J_0(ka) J_1(ka \sin \theta) e^{-jkr}}{2r} + j \frac{k\eta a I_0 e^{-jkr}}{\pi r} \sum_{v_{\text{odd}}} \frac{1}{v} J_v(ka) \{J_{v+1}(ka \sin \theta) - J_{v-1}(ka \sin \theta)\} \cos v\phi$$

$$H_R \approx 0 \quad (30)$$

$$H_\theta \approx -\frac{E_\phi}{\eta} \quad (31)$$

$$H_\phi \approx \frac{E_\theta}{\eta} \quad (32)$$

where, η is the intrinsic impedance of the medium. Therefore we have the average power density,

$$\tilde{W}_{av} = \frac{1}{2} \text{Re}[\tilde{E} \times \tilde{H}^*]$$

$$= \frac{1}{2\eta} [E_\theta^2 + E_\phi^2] \hat{a}_R = W_r \hat{a}_R$$

where,

$$W_r = \frac{1}{2\eta} [E_\theta^2 + E_\phi^2] \quad (33)$$

Finally, the radiation intensity can be found from,

$$U = r^2 W_r \quad (34)$$

3. NUMERICAL RESULTS

The numerical results of U are shown in Figures 4-8 for different values of the electrical length, ka .

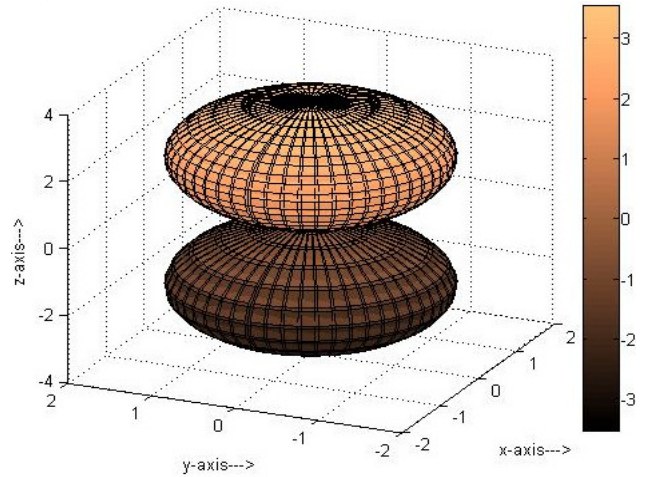


Fig. 4: 3D radiation pattern of a large circular loop antenna for $ka=0.314$

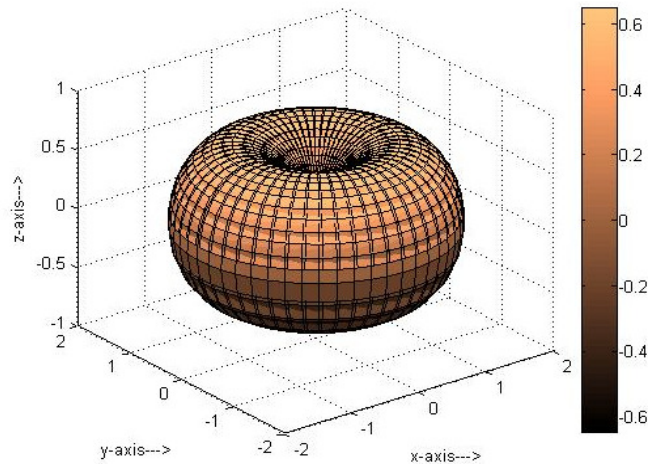


Fig. 5: 3D radiation pattern of a large circular loop antenna for $ka=1.00$

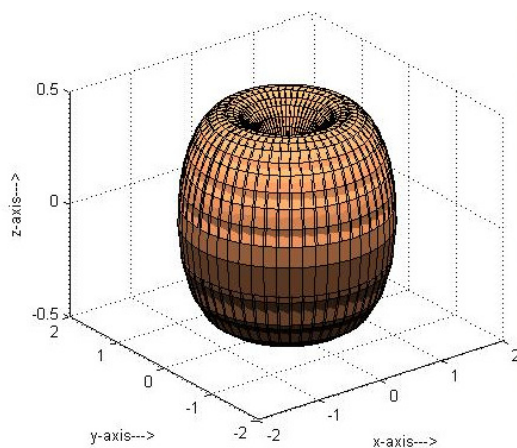


Fig. 6: 3D radiation pattern of a large circular loop antenna for $ka=1.5$

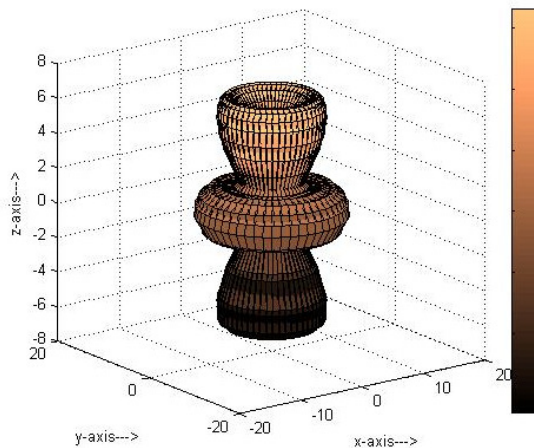


Fig. 7: 3D radiation pattern of a large circular loop antenna for $ka=5.0$

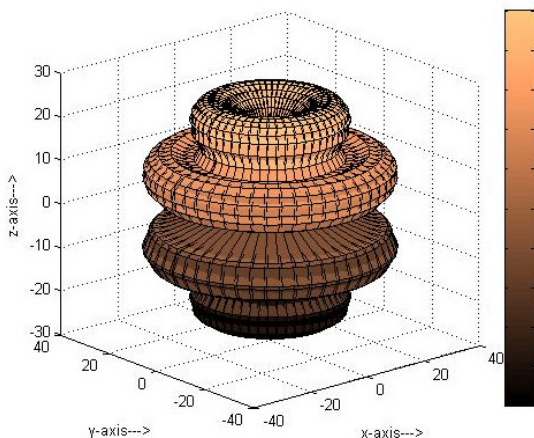


Fig. 8: 3D radiation pattern of a large circular loop antenna for $ka=7.0$

Diverse radiation patterns are observed for different values of ka . For $ka=1.0$ and 1.5 ,

almost omnidirectional pattern is observed. The results have qualitative agreement with those obtained in [5-12].

4. CONCLUSION

Far field radiation pattern of a large circular loop antenna has been obtained by using a non-uniform harmonic current distribution. 3D radiation patterns for $ka= 0.314, 1.0, 1.5, 5.0$ and 7.0 has been obtained by straightforward numerical calculation of the radiation intensity pattern. The far field has been obtained in Fourier Bessel series converging rapidly for v upto 21. The general feature is omnidirectional power pattern upto $ka=2.0$. Above this value, side lobes are observed.

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RECURRENT NEURAL NETWORK BASED COST EFFECTIVE FOUR SWITCH THREE PHASE INVERTER FED SYNCHRONOUS RELUCTANCE MOTOR DRIVE

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Abstract: This paper proposes a cost effective position sensorless control methodology for Synchronous Reluctance Motor (SynRM) drive. In this control scheme, instead of a conventional Six Switch Three Phase (SSTP) inverter a Four Switch Three Phase (FSTP) inverter is used. This improves the cost-effectiveness, volume-compactness and reliability of the three phase inverters. The control system estimates the motor stator flux and its position using a Recurrent Neural Network (RNN). A simulation model of the drive system is developed and analyzed in order to validate the proposed approach. The robustness of the drive system is tested for different operating conditions. Simulation results show that the proposed drive system provides a fast speed response and good disturbance rejection capability.

Key words: Four switch three phase inverter; flux estimation; recurrent neural network; sensorless control; and synchronous reluctance motor.

1. INTRODUCTION

In recent years, Synchronous reluctance motors are becoming popular due to their inherent advantages such as low cost, mechanical simplicity and robust structure. A SynRM is superior to an Induction Motor (IM) due to the absence of rotor copper losses, to brushless motor due to economical rotor structure. Thus these motors are gaining increasing interest as a possible alternative of other ac motor drives (Litvinov and Davydenko, 2010). SynRM has salient poles without any winding or permanent magnet on the rotor. The flux linkage of the SynRM is directly proportional to the stator currents as the rotor circuit of the motor is opened. Thus, the torque of a SynRM can be controlled by controlling the stator currents [Chiang et al., 2003]. Besides, the motors operate at synchronous speed so they need simple controller than any other AC machines (Mostafa and Dawo, 2009).

Driving a SynRM requires the rotor position information to control the motor torque which is generally detected by position sensors such as an encoder or a resolver. But these position sensors not

only increase the cost of the drives but also decrease the system reliability. Therefore, many papers on position sensorless drive of SynRM have been published.

An Adaptive Input–Output Feedback-Linearization (AIOFL) controller has been designed in (Zarchi et al., 2010) for maximum rate of change of torque control of an encoderless three phase SynRM drive. Variable structure control strategy using the sliding mode technique has been the focus of many studies for sensorless SynRM control. The application of sliding mode controller is proposed in (Mostafa and Dawo, 2009) for robust speed control of Synchronous reluctance motor drive. A sliding mode controller based on Gaussian radial basis function neural network is utilized in (Chen et al., 2009) for SynRM system robust stabilization. In (Hofmann and Sanders, 2000), the authors developed a refined design of a high-speed SynRM drive with minimized eddy-current losses in the rotor. The authors also proposed position sensorless vector control strategy based on stator flux estimation (Hofmann et al., 2004).

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Nowadays, many research and development projects have been also developed to reduce the cost of the power converter. The conventional SSTP inverter was popular since the last few decades. But these inverters have some disadvantages such as losses in the six switches, complexity of the control algorithms and generating six PWM logic signals. So researchers are working to find out a substitute of the SSTP inverter. In (Saravanasundaram and Thanushkodi, 2008), an ac to ac converter with least amount hardware is proposed for three-phase IM drive. A cost effective FSTP inverter is proposed for IM drive in (Uddin et al., 2006). The authors showed a performance comparison of the FSTP inverter fed drive with SSTP inverter fed drive in terms of speed response and total harmonic distortion of the stator current. The same authors proposed fuzzy logic controller based control scheme for FSTP fed interior permanent magnet (IPM) synchronous motor drive (Uddin et al., 2006). A vector control technique for IM using FSTP inverter is presented for high performance industrial drive systems in (Dzung et al., 2007). The authors verified the complete vector control scheme by simulation and experimentally in a DSP environment. A RNN based stator flux and position estimator is proposed in (Halder and Ghosh, 2010) for sensorless control of a FSTP fed interior permanent magnet synchronous motor drive. The authors showed that with the RNN, accurate estimation is possible both under transient and steady-state conditions.

This paper considers two ideas to reduce the cost of the SynRM drive system; the first one is to reduce the inverter size and the other is to eliminate the need for position sensor. The performance of the proposed cost effective position sensorless SynRM drive has been investigated through simulation studies. The close loop vector control scheme of the drive system has been simulated in C++ environment. The hysteresis controller is used to control the motor current so that it can follow the command current as close as possible to the sinusoidal reference. The performances of the drive system have also been studied for sudden change of load torque and speed reversal conditions.

2. SYNCHRONOUS RELUCTANCE MOTOR MODEL

A mathematical model of the SynRM is required for proper simulation of the system. The dynamic model which describes the behavior of the SynRM in the synchronously rotating d-q reference frame can be expressed as follows (Mostafa and Dawo, 2009):

$$v_d = R_s i_d + L_d \frac{di_d}{dt} - \omega_r L_q i_q \quad (1)$$

$$v_q = R_s i_q + L_q \frac{di_q}{dt} + \omega_r L_d i_d \quad (2)$$

Where the v_d and v_q are d- and q- axis terminal voltages, respectively. The i_d and i_q are, respectively, d- axis and q- axis torque producing currents. The L_d and L_q are the d- and q- axis synchronous inductances, respectively. The R_s is the stator resistance and ω_r is the angular speed of the rotor.

The developed electromagnetic torque is given as:

$$T_e = \frac{3P_p}{2} (L_d - L_q) i_d i_q \quad (3)$$

The mechanical motion of the SynRM can be expressed as:

$$T_e = T_L + J_m \frac{d\omega_m}{dt} + B_m \omega_m \quad (4)$$

and

$$\omega_r = p_p \cdot \omega_m \quad (5)$$

Where P_p , T_L , J_m , ω_m , and B_m are the number of pole pairs, the load torque, the moment of inertia of rotor, the mechanical speed of rotor, and the viscous friction coefficient, respectively.

3. FOUR SWITCH THREE PHASE INVERTER MODEL

Fig. 1 shows the power circuit of four switch inverter fed SynRM drive. A three phase system is obtained by connecting the phase 'c' terminal of the stator windings directly to the centre tap of the dc link capacitors. The single phase ac supply is rectified by the front-end rectifier. The capacitors are used to level the output dc voltage. If V_{dc} is the maximum voltage across the dc link capacitors, and S_a , S_b are the states of power switches for each phase, then three phase voltages of the SynRM can be expressed as follows (Uddin et al., 2006):

$$V_a = \frac{V_{dc}}{3} [4S_a - 2S_b - 1] \quad (6)$$

$$V_b = \frac{V_{dc}}{3} [4S_b - 2S_a - 1] \quad (7)$$

$$V_c = \frac{2V_{dc}}{3} [-S_a - S_b + 1] \quad (8)$$

If $S_a = 1$ then T1 is on and T2 is off;

If $S_a = 0$ then T1 is off and T2 is on;

If $S_b = 1$ then T3 is on and T4 is off;

If $S_b = 0$ then T3 is off and T4 is on.

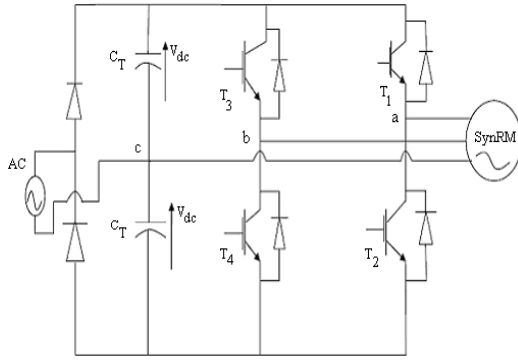


Fig. 1: Power circuit of the drive system.

4. PROPOSED CONTROL SCHEME

The proposed control scheme of the drive system is shown in Fig. 2. The high performance control strategy is implemented in closed loop using PI controller. This requires speed error to be processed in closed loop to generate the torque producing component of the stator current, i_q^* . The magnetizing component of the stator currents i_d^* along with i_q^* are used to generate the reference currents i_a^* , i_b^* , and i_c^* . Two independent hysteresis current controller with a suitable hysteresis band are used to command the motor currents i_a , and i_b to follow the reference currents. The hysteresis controllers also generate four switching signals which will fire the power semiconductor switches of the three phase inverter to produce the actual voltages to the motor.

The reference currents are formulated as follows:

$$i_a^* = i_d^* \cos \theta - i_q^* \sin \theta \quad (9)$$

$$i_b^* = i_d^* \cos(\theta - 120^\circ) - i_q^* \sin(\theta - 120^\circ) \quad (10)$$

$$i_c^* = i_d^* \cos(\theta + 120^\circ) - i_q^* \sin(\theta + 120^\circ) \quad (11)$$

The stationary 3-axes (a-, b-, c-) to stationary 2-axes (α -, β -) transformation is given by

$$x_{s\alpha} = x_a - 0.5 x_b - 0.5 x_c \quad (12)$$

$$x_{s\beta} = \frac{\sqrt{3}}{2} (x_b - x_c) \quad (13)$$

Where, x is either voltage or current vector.

5. RNN BASED STATOR FLUX ESTIMATION

The recurrent neural network is a single layer neural network with input and output nodes. The output nodes act as summing nodes and in this study the two output variables, i.e., α - and β -components of stator flux linkage are fed to the input with unit delay operator. The value of activation function at the output node is taken unity. The common inputs for both the outputs are α - and β - components of stator voltage and current which results in the following matrix equation:

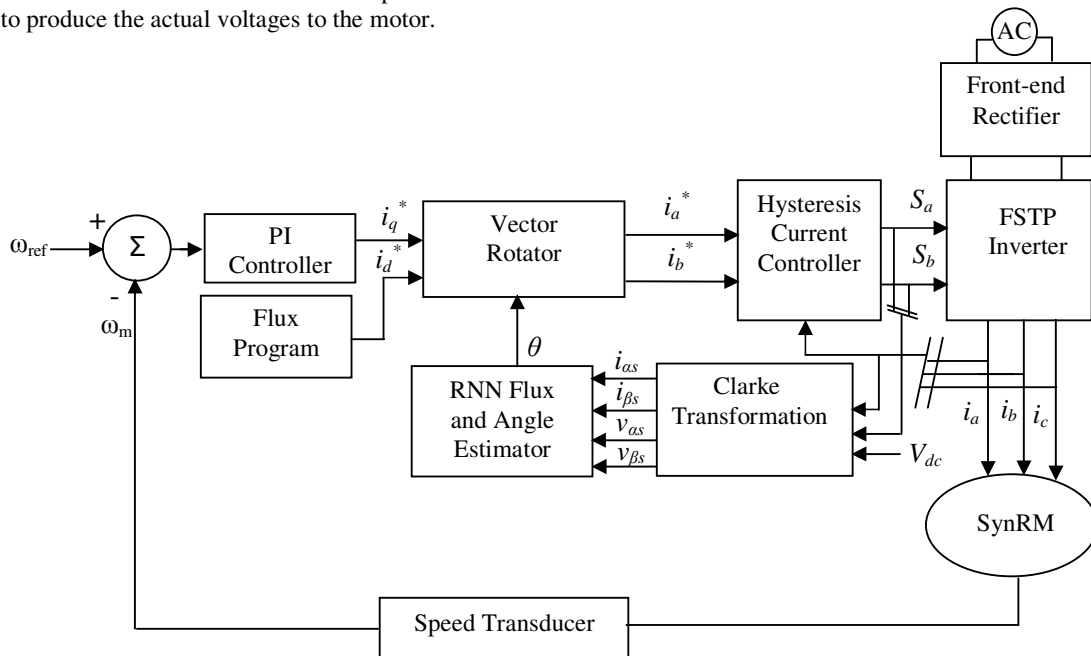


Fig. 2: Proposed Control Scheme of the SynRM.

$$\begin{bmatrix} \lambda_{\alpha s}(k+1) \\ \lambda_{\beta s}(k+1) \end{bmatrix} = \begin{bmatrix} W_{11} & W_{12} \\ W_{21} & W_{22} \end{bmatrix} \begin{bmatrix} \lambda_{\alpha s}(k) \\ \lambda_{\beta s}(k) \end{bmatrix} + \begin{bmatrix} W_{13} & W_{14} \\ W_{23} & W_{24} \end{bmatrix} \begin{bmatrix} v_{\alpha s} \\ v_{\beta s} \end{bmatrix} + \begin{bmatrix} W_{15} & W_{16} \\ W_{25} & W_{26} \end{bmatrix} \begin{bmatrix} i_{\alpha s} \\ i_{\beta s} \end{bmatrix} \quad (14)$$

The inputs are connected to the output node through the weights W_{11} , W_{12} , W_{21} , W_{22} etc. as indicated by the line segments and shown in Fig. 3. Each output node is also connected to the corresponding recurrent input node through weights. The weights indicated by the different line segments are adjusted by training the neural network.

Estimated angle of reference pole,

$$\theta = \tan^{-1} \left(\frac{\lambda_{\beta s}}{\lambda_{\alpha s}} \right) \quad (15)$$

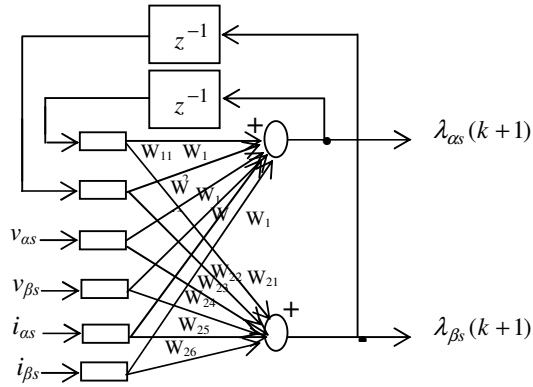


Fig. 3 Stationary α - and β - axis stator flux estimation by recurrent neural network

6. SIMULATION RESULTS

The objective of computer simulation is to verify the control strategy proposed in this study for different operating situations. The prototype 0.37 kW SynRM used in this drive system is a three phase machine, the parameters of which are reported in Table 1.

Table 1: SynRM specifications used for simulation

Number of pole pair: P_p	1
Stator resistance: R_s	4.2 Ω
d -axis inductance: L_d	0.328 H
q -axis inductance: L_q	0.181 H
Motor inertia: J_m	0.00076 kg-m ²
Friction coefficient: B_m	0.00012 N-m/rad/sec

6.1 Starting Performance of the SynRM Drive

The effectiveness of the proposed flux estimator along α - and β - axis needs to be verified before implementing it in the drive system. Real flux components calculated from exact values of motor variables are computed and compared with the estimated flux components and rotor angle. Fig. 4 (a) & (b) show the estimated α - and β - axis stator flux respectively. It can be noted that accurate estimation is possible by the proposed recurrent neural network under both transient and steady-state conditions. Fig. 4 (c) shows the estimated angle which follows very closely the actual angle deduced from machine model.

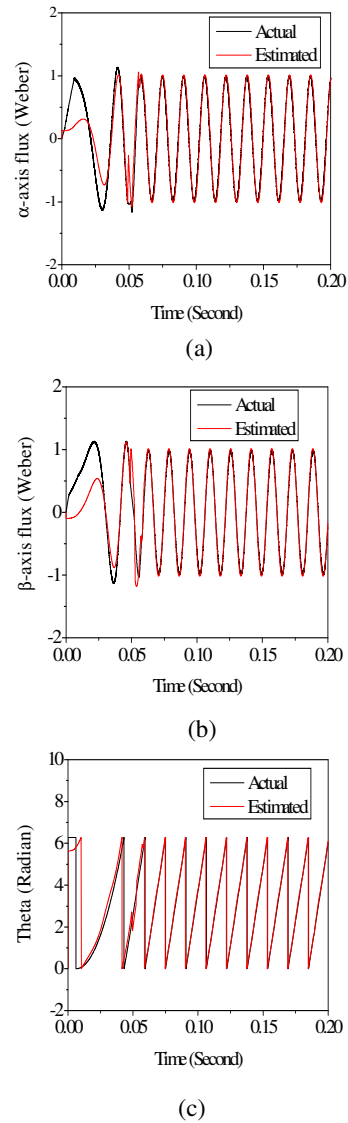


Fig. 4 (a) α -axis components of estimated and actual flux, (b) β -axis components of estimated and actual flux, and (c) Estimated and actual rotor angle for the SynRM drive.

6.2 Starting Performance of the SynRM Drive

From standstill condition, the motor was started with a command speed of 100 rad/sec and load torque of 0.2 N-m. The motor reaches to the command speed at 0.06 second. Fig. 5 (a) shows the speed response of the SynRM drive. The motor follows the command speed accurately without any steady-state error and oscillations.

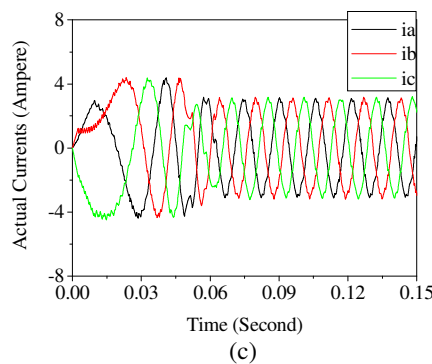
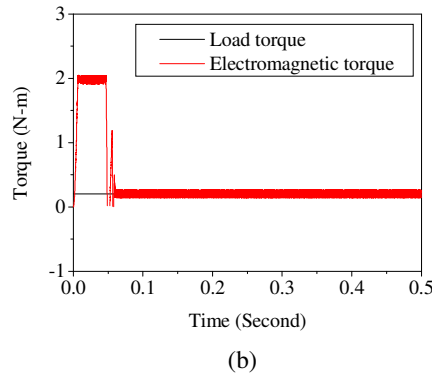
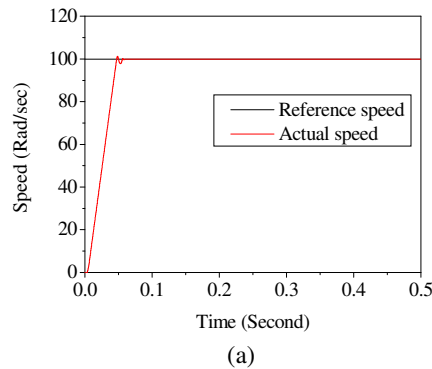


Fig. 5 (a) Simulated speed response, (b) Developed electromagnetic torque, and (c) Three phase currents under transient and steady-state condition.

Fig. 5 (b) shows the developed electromagnetic torque of the drive under starting condition. It is observed that higher electromagnetic torque is generated during the motor acceleration. Some oscillations in electromagnetic torque is noticed which is due to switching of the devices with

hysteresis controller. Difference between developed and load torques is due to viscous damping torque of the drive system. Fig. 5 (c) shows the actual currents of the three phases respectively.

6.3 Performance under Different Operating Conditions

To verify the robustness of the proposed drive system, the performance of the SynRM drive was also investigated under different operating conditions. The load torque of the motor was suddenly increased from 0.2 N-m to 1.2 N-m at 0.5 second. The corresponding speed response of the drive is shown in Fig. 6 (a). The speed slightly falls but no oscillation in speed is noticed due to this load torque disturbance. To examine the performance of the drive system under speed reversal condition, the command speed was reversed from 100 rad/sec to -100 rad/sec at 0.4 second and again to 100 rad/sec at 0.8 second. Fig. 6 (b) shows the corresponding speed response which confirms the robustness of the drive system.

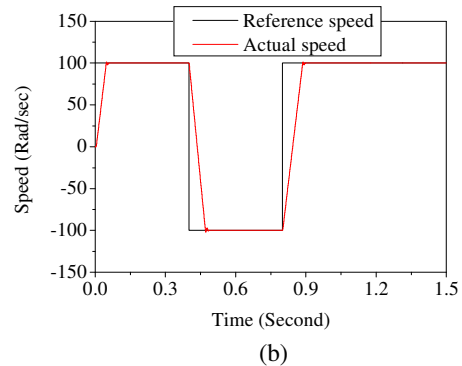
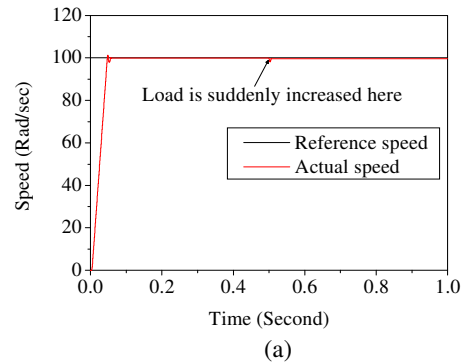


Fig. 6 Simulated speed response for (a) sudden change of load and (b) speed reversal condition.

7. CONCLUSIONS

A position sensorless vector control scheme with recurrent neural network for FSTP fed SynRM drive has been presented. The results obtained and presented in this work indicate that the proposed

control scheme produces very fast response of the SynRM drive. The drive also shows good performance in speed operation under the effect of load disturbances and reversal of speed. Thus this cost effective drive system fulfills the demand of present industry applications.

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RED LIGHT VIOLATION MONITORING AND REPORTING USING MICROCONTROLLER CONTROLLED WIRELESS COMMUNICATION

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Traffic accidents are now one of the main causes of death and economic loss in most of the developed countries. Noncompliance with traffic laws is severely impeding the safety of the road traffic system. In this paper a system for monitoring and reporting incidences of red light violations at the traffic intersection has been proposed. A prototype of the system was build and verified experimentally. The system comprises an infrared (IR) transmitter and receiver unit for detection of red light violation whereas for identifying the vehicle, microcontroller triggered wireless mobile network has been used. The microcontroller was programmed to automatically send message containing the car license no, date and time of breaking the rule to the numbers of traffic control units stored previously to the cell phone directory. Upon detection of the offender, the corresponding action can be performed by the traffic monitoring system. The proposed system is simple, cheap, reliable, and exempted from the effects of bad weather conditions, improper lightings etc. and thus more suitable for detection of a violation and identification of the vehicle involved.

Key words: Red Light Violation; IR transmitter and receiver; Microcontroller; Wireless communication

1. INTRODUCTION

Traffic signals, through use of time separation, are designed to reduce motor-vehicle crashes at intersections involving conflicting traffic movements. Noncompliance with traffic laws is severely impeding the safety of the road traffic system. According to an in-depth investigation of road accidents in France, 92% of traffic accidents are preceded by at least one traffic law violation [1].

In most of the developed countries traffic accidents are now one of the main causes of death and economic loss [2]. According to the Road Safety Action Program of European Commission, more than one million accidents a year cause over 40,000 deaths and nearly two million injuries on the roads. In addition, the direct and indirect cost has been estimated at 160 billion Euros, which is nearly two percent of the EU's GNP. Unfortunately these thrilling numbers are increasing every year [3]. In Bangladesh road accidents claim on an average 12,000 lives annually and lead to about 35,000 injuries [4]. Everyday around eight persons die in road accidents and the number of accidents has increased by 43% between 1982 and 2000, while

the number of fatalities has increased by around 400% within the same period [5]. This indicates that not only the occurrence of accidents is on the rise the severity of accidents is also increasing.

But motorization is increasing even faster than road death and injury [6]. Many low income countries have experienced rapid growth in their motor vehicle fleet. As said by the Bangladesh Road Transport Authority (BRTA) official statistics, the number of registered vehicles up to 2003 at Dhaka city in Bangladesh was 3,03,215 and the number increases to 5,62,815 as on June 2010 [7]. Over the years, crash statistics have deteriorated due to the ever-growing number of vehicles on the road and the increasing vehicle-miles traveled, and this situation is becoming a major concern of Federal, State and local authorities. Many drivers do not comply with traffic signal indications [8]. More than one million motor-vehicle crashes occur annually at traffic signals in the United States [9-13] and a major cause of such crashes is drivers disregarding traffic signals. A review of 4,526 police-reported crashes in four U.S. cities found that running red lights and other traffic-control devices such as stop signs is the most frequent type of collision in urban areas and the occupant injuries

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occurred in 45 percent of the red light running crashes, compared with 30 percent for other crash types [14]. This indicates that reductions in red light running crashes would be especially beneficial in reducing urban crash losses.

Monitoring of traffic intersections for red-light violations has historically been done in-person by one or more law enforcement officers [15]. But, the proliferation of intersections, combined with budget pressures, increase number of vehicles on the road and other resource limitations, have caused police departments to employ automated tools for intersection monitoring [16, 17]. Among some existing automated systems, fixed-position cameras, commonly named as red light cameras, increasingly are being used in many foreign countries since the 1970s [18, 19] to help communities enforce traffic laws by automatically photographing vehicles whose drivers run red lights. Over time there have been some minor variations and automatic enforcement has been extended to several types of violations and new technologies for detecting violations as well as for identifying the violating vehicles has appeared [17, 20]. Probably the most notable developments have been systems involving the use of digital video recording [21] with image processing, and systems for electronic recognition and identification of a vehicle. But though certain countries have used photo-enforcement with some degree of success, current systems of traffic enforcement using photographic techniques have disadvantages that generally do not facilitate effective automation and validation of the photographs required for effective use as legal evidence. For instance, the film-camera systems have required white light illumination generally in the form of flash units, to provide sufficient light to capture violation images in poor ambient light or at night. The use of flash illumination may be detrimental at night to oncoming traffic and has the potential to cause temporary driver blindness and consequent safety risks as well as preventing authorities from deploying systems covertly. Moreover, the detection system is invariably unable to provide a trigger point that is sufficiently consistent to ensure that the positioning of vehicles at the time of imaging is identical. Where digital cameras are used, systems either require the availability of high-speed communications lines to meet the demands of communicating high-resolution images, or else images and data must be collected manually.

2. OBJECTIVE

In this research we have thought out of a system which is simple, cheap, reliable, and of course

offers at least some fundamental advantages over the conventional automated systems. Here we have used microcontroller controlled wireless communication system which makes the system not only automatic but also flexible. Also it makes the system simple to track the vehicle even when the number of traffic is large and also helps the system to keep in pace with the motion/running body.

3. DESCRIPTION OF THE SYSTEM

The overall traffic violation processing system of the proposed design is shown in Fig. 1. The controlling system mainly comprises (i) detection of the violation, and (ii) identification of the vehicle involved.

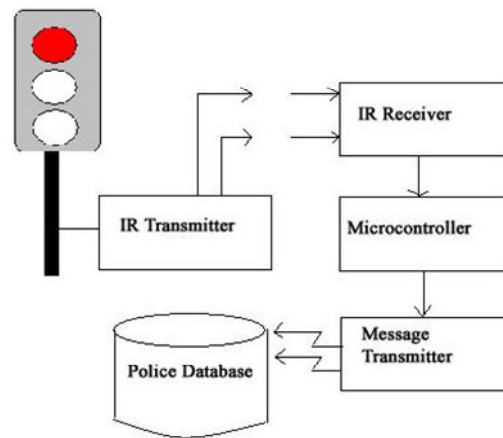


Fig. 1: Block diagram of the proposed traffic violation processing system

The IR transmitter and IR receiver cover the violation detection unit, while, for identifying the vehicles microcontroller triggered mobile communication system is used. For purposes of explanation, numerous specific details are set forth in order to provide an understanding of the present invention.

3.1 Detection of Violation

Fig. 2 shows the violation detection unit of the proposed scheme. Most conventional traffic surveillance systems use intrusive sensors, which include inductive loop detectors [22, 23] micro-loop probes, pneumatic road tubes, piezoelectric cables and other weigh-in-motion sensors for detection of violation. Some technologies are common to systems for detecting different violations, whereas, others are particularly tailored to the detection of specific kinds of violations. In our proposed system, infrared radiation (IR) transmitter and receiver units are used as a wireless sensor network with detection accuracy as good as

that of inductive loop for detection of traffic signal violation.

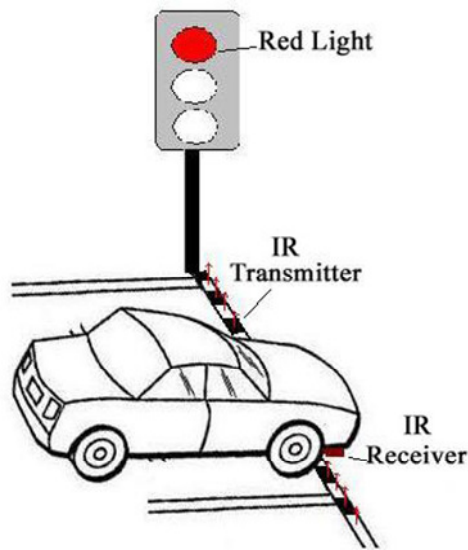


Fig. 2: Violation detection unit

When the red light on the signal post is ON, it will switch on the IR transmitters to continuously emit IR signals. The IR detector will be equipped in-car at the lower part of the vehicle. As soon as an alleged offender commits an offense at an intersection by violating the red light and crossing the line where he should stop, the IR detector in the car will receive the IR signal from the IR transmitter.

3.2 Identification of the Vehicle Involved

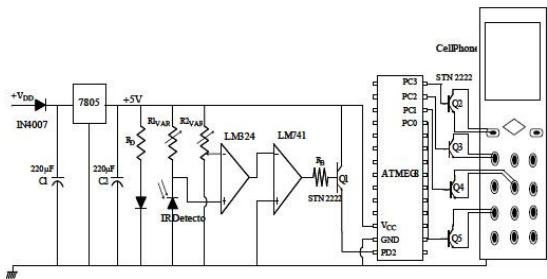


Fig. 3: Circuit diagram of the unit for identification of vehicle violating traffic rule

The hardware unit embracing the identification of vehicle violating the traffic rule mainly consists of a microcontroller operated automatic mobile communication system as shown in Fig. 3. The IR detector is connected through operational amplifiers (LM 324 and LM 741) to the base of the transistor Q1. The transistor output is attached to the input of the microcontroller unit. The microcontroller is

interfaced with mobile through four transistors connected to the bidirectional I/O port PC0~3 of the microcontroller. When the IR detector receives signal from the IR transmitter, it passes the signal to the operational amplifier. The operational amplifier compares a reference voltage with the voltage change made by the IR detector receiving the IR signal and supply base current to the transistor Q1 connected at the output. The transistor will turn on and give an interrupt signal to the microcontroller. The microcontroller sends pulse to the Port C according to interrupt subroutine and triggers the transistors Q2 ~ Q5 to activate the mobile. In accordance with the program loaded in the microcontroller an interrupt /sending message option will be performed by the cell. A message containing the car license no, date and time of breaking the rule is set to send automatically to the number(s) of traffic control unit stored previously in the cell phone directory. The law enforcing agency can easily identify the owner of the vehicle from the message received and can take appropriate actions against rule violation.

3. RESULTS AND DISCUSSION

The proposed microcontroller based traffic rules violation monitoring and reporting system has been implemented with a laboratory model and verified experimentally. Fig. 4 shows the experimental setup of the proposed system. A remote control toy-car was equipped with the IR detector and the microcontroller operated mobile unit. Two IR LEDs (Light Emitting Diode) in series with a 100 Ω resistor supplied by 5V dc supply has been used as IR transmitter. A Photodiode fastened at the lower part of the car was used as IR detector to receive IR beam transmitted from the transmitter. The road was modeled with wooden frame and to house in the transmitter unit across the road a glass pane was used to bridge the pathway.

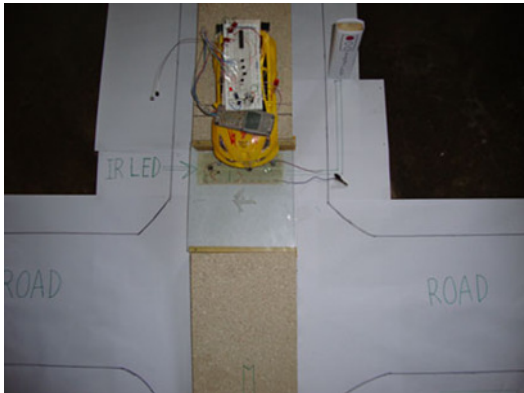


Fig. 4: Experimental setup of the proposed system

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This way the laboratory model has substantiated the proposed scheme effectively. The system automatically monitored, reported and identified the disobedient offender using the simple microcontroller based wireless communication network. The effectual realistic execution of the research outcome can be intended to alleviate the high intensity of road traffic accident by effectively control the violation of traffic rule.

On the other hand, the proposed scheme is effective, and free from the effects of bad weather conditions, improper lightings etc. It can easily track the vehicle even when the number of traffic is large. Thus it is expected that the proposed system

5. CONCLUSION

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Reduction of PAPR in OFDM Using SLM for Different Route Number

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Abstract-Orthogonal Frequency Division Multiplexing (OFDM) is considered to be a promising technique against the multipath fading channel for wireless communications. Peak to average power ratio (PAPR) is a major drawback of multicarrier transmission system which leads to power inefficiency in RF section of the transmitter. In this paper, we present PAPR reduction on selected mapping (SLM) method using different route number. Simulation result shows that the PAPR reduces when route number increases.

Keywords: Orthogonal Frequency Division Multiplexing, Peak to Average Power Ratio, Power Amplifiers, Selected Mapping, Complimentary Cumulative Distribution Function.

I. Introduction

Orthogonal frequency division multiplexing (OFDM) is one of the most attractive techniques for fourth generation (4G) wireless communication. It effectively combats the multipath fading channel, improves the bandwidth efficiency and increases system capacity so as to provide a reliable transmission [1]. OFDM is to split a high rate data stream into a number of lower rate data streams and modulated by subcarriers. These subcarriers are overlapped with each other. The symbol duration increases for lower rate data streams, the relative amount of dispersion in time caused by multipath delay spread is decreased. Inter symbol interference (ISI) is eliminated almost completely by introducing a guard time in every OFDM symbol.

OFDM faces several challenges. The key challenges are large peak to average power ratio (PAPR) due to non linearity of amplifier, phase noise problems of local oscillator, frequency offset due to Doppler shift or difference between transmitter and receiver. Large peak to average power (PAP) ratio distorts the signal if the transmitter contains nonlinear components such as power amplifiers (PAs). The nonlinear effects on the transmitted OFDM symbols are spectral spreading, inter modulation and changing the signal constellation. Therefore the PAs requires a back off which is approximately equal to the PAPR for distortion less transmission. This decreases the efficiency for amplifiers.

Researchers have been proposed several PAPR reduction techniques. These techniques are divided into two groups. There are signal scrambling techniques and signal distortion techniques. Block coding techniques [1, 2], selected mapping (SLM) [3], partial transmit sequence (PTS) [4, 5] etc are signal scrambling techniques. Signal distortion techniques are peak windowing [2], envelope scaling [6], peak reduction carrier [7], clipping and filtering [4].

In this paper, we have investigated PAPR reduction on selective mapping (SLM) method using different route number in OFDM system.

II. PAPR dilemma in OFDM

Let us consider, X_k ($k=0, 1, \dots, N-1$) denote the input data symbol whose period is T . Then the complex representation of an OFDM symbol is given as:

$$x(t) = \sum_{k=0}^{N-1} x_k \cdot e^{j2\pi\Delta f t} \quad 0 \leq t \leq NT \quad (1)$$

Where N is the number of subcarriers, and $\Delta f = 1/NT$ is the subcarrier spacing. The samples are denoted by x_n ($n=0, 1, \dots, LN-1$) for the OFDM symbols with the sampling rate L . We consider the sampling rate (Nyquist rate) which corresponds to the case of $L = 1$. The amplitude of the n th sample of an OFDM symbol is given as $r_n = \underline{\underline{\Delta}} |x_n|$. As N is a sufficiently large number, r_n is considered to be approximately equal to a Rayleigh random variable. The probability density function (pdf) is given as [4]:

$$f_R(r_n) = \frac{2r_n}{P_{in}} e^{-r_n^2/P_{in}}, r_n \geq 0 \quad (2)$$

Where, $P_{in} = 2\sigma^2$ is the input power of the OFDM signal.

The PAPR of the OFDM symbol is defined as the ratio of the peak power and the average power [8]:

$$PAPR = \frac{P_{peak}}{P_{average}} = 10 \log_{10} \frac{\max[|x_n|^2]}{E[|x_n|^2]} \quad (3)$$

Where P_{peak} represents output peak power, $P_{average}$ means output average power. $E[\cdot]$ denotes the expected value, x_n represents the transmitted OFDM signals which are obtained by taking IFFT operation on modulated input symbols X_k . Mathematical, x_n is expressed as:

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k W_N^{nk} \quad (4)$$

For an OFDM system with N sub carriers, the peak power of received signals is N times the average power when phase values are the same. The PAPR of baseband signal will reach its theoretical maximum at $PAPR (dB) = 10 \log N$. If N is large enough, based on the central limit theorem, the real and imaginary parts of x_n have Gaussian distribution and its envelope will follow a Rayleigh distribution. This implies a large PAPR.

The Crest Factor (CF) is defined as the ratio between maximum amplitude of OFDM signal $s(t)$ and root mean square (RMS) of the waveform. The CF is defined as [9]:

$$CF(s(t)) = \frac{\max[|s(t)|]}{\sqrt{E[|s(t)|^2]}} = \sqrt{PAPR} \quad (5)$$

III. Selected mapping (SLM) method

The complementary cumulative distribution function (CCDF) of the original signal sequence PAPR above a threshold $PAPR_0$ is written as $Pr(PAPR > PAPR_0)$. Accordingly K statistical independent signal waveforms, CCDF can be rewritten as $\{PAPR > PAPR_0\}^K$ so that the probability of PAPR that exceeds the same threshold will drop to a small value [3].

The probability of PAPR larger than a threshold z can be written as $P(PAPR > z) = 1 - (1 - \exp(-z))^N$. Assuming that M OFDM symbols carry the same information and they are statistically independent of each other. In this case, the probability of PAPR greater than z is equals to the product of each independent candidate's probability. This process can be written as [1]:

$$P\{PAPR_{low} > z\} = (P\{PAPR > Z\})^M = ((1 - \exp(-z))^N)^M \quad (6)$$

In SLM method, firstly M statistically independent sequences which represent the same information are generated and then the resulting M statistically independent data blocks $S_m = [S_{m,0}, S_{m,1}, \dots, S_{m,N-1}]^T, m=1,2,\dots,M$ are then forwarded into IFFT operation simultaneously. Finally, at the receiving end, OFDM symbols $x_m = [x_1, x_2, \dots, x_N]^T$ in discrete time domain are acquired and then the PAPR of M vectors are calculated separately. Eventually, the sequences x_d with the smallest PAPR will be elected for final serial transmission. Fig. 1 illustrates the basic structure of SLM method for reducing the high PAPR.

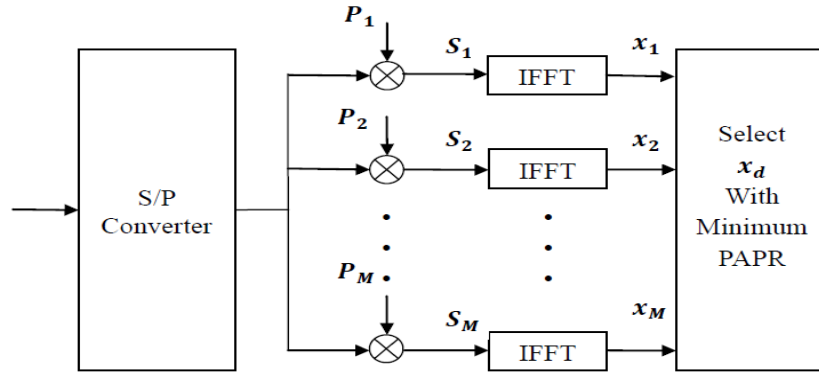


Fig. 1: Basic principles of SLM method

This method can significantly improve the PAPR performance of OFDM system. Assuming that for a single OFDM symbol, CCDF probability of PAPR larger than a threshold is equals to p . The general probability of PAPR larger than a threshold for k OFDM symbols can be expressed as p^k . It can be verified that the new probability obtained by SLM algorithm is much smaller compared to the former. Data blocks S_m are obtained by multiplying the original sequence with M uncorrelated sequence P_m .

The different pseudo random sequences $P_m = [P_{m,0}, P_{m,1}, \dots, P_{m,N-1}]^T, m=1,2,\dots,M$ where $P_{m,n} = e^{j\varphi_{m,n}}$ and stands for the rotation factor. $\varphi_{m,n}$ is also known as the weighting factor is uniformly distributed in $[0, 2\pi]$. The N different subcarriers are modulated with these vectors respectively so as to generate candidate OFDM signals. This process can also be seen as performing dot product operation on a data block X_n with rotation factor P_m [1].

$$S_m = [X_0 P_{m,0}, X_1 P_{m,1}, \dots, X_{N-1} P_{m,N-1}]^T, m=1,2,\dots,M \quad (7)$$

M OFDM frames from frequency domain to time domain by IFFT. The entire process is given by

$$x_m(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n P_{m,n} e^{j2\pi n \Delta f t}, 0 \leq t \leq NT, m=1,2,\dots,M \quad (8)$$

Finally, the one which possess the smallest PAPR value is selected for transmission. Its mathematical expression is given as [1, 8]:

$$x_d = \arg \min_{1 \leq m \leq M} (PAPR(x_m)) \quad (9)$$

Where, $\arg \min (\cdot)$ represent the argument of its value is minimized.

At the receiver, in order to correctly demodulate the received signal, it is necessary to know which sequence is linked to the smallest PAPR among M different candidates after performing the dot

product. Hence, the receiver is required to learn information about selected phase vector sequence and ensure that the vector sequence is received correctly.

IV. Result and discussion

It seems that that the ability of PAPR reduction using SLM is affected by the route number M and subcarrier number N . Therefore, simulation with different values of M and N and the results exhibits some desired properties of signals representing the same information. Comparison of PAPR reduction performance with different values of M while N is fixed at 128. Rotation factor is defined as $P_{m,n} \in [\pm 1, \pm j]$. The algorithm executes 10000 times, over sampling factor is 8 and QPSK mapping is adopted as modulation scheme in each sub-carrier. Route numbers $M=2$, $M=4$, $M=8$, $M=16$ are used. Therefore, practically, compromise the computing complexity and improvement of performance, we usually take $M \leq 8$.

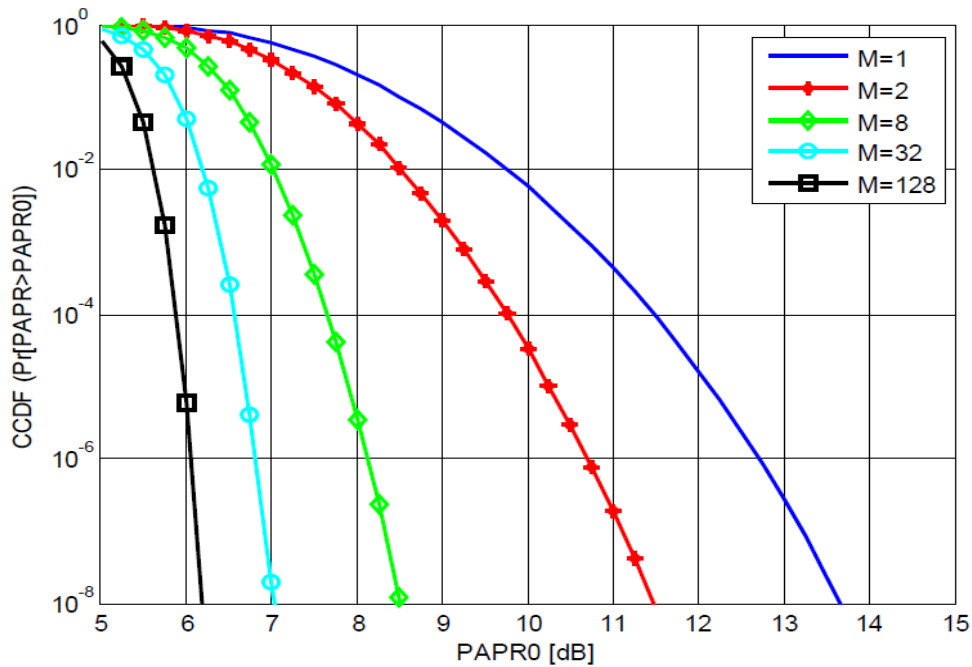


Fig. 2: Theoretical CCDF vs PAPR curves using SLM method [1]

Fig. 2 shows the theoretical CCDF curves as a function of PAPR distribution when SLM method is used. The number of N subcarriers is 128. M takes the value of 1 (without adopting SLM method), 2, 8, 32 and 128. It is seen in Fig. 2 that route number (M) increases, PAPR of CCDF distribution reduces.

From Fig. 3, it can be observed that the proposed SLM method displays a better PAPR reduction performance than the original OFDM signal. If the probability is set to 1% and then the CCDF curves with different M values are compared. The PAPR value of case $M=2$ is about 1dB smaller than the unmodified one $M=1$. Under the same condition, the PAPR value of case $M=16$ is about 3dB smaller than the original one $M=1$. The performance difference between $M=8$ and $M=16$ cases is less than 0.5dB. This proves that it will not be able to achieve a linear growth of PAPR reduction performance with further increase the value of M (like $M \geq 8$), the PAPR reduction performance of OFDM signal will not be considerably improved.

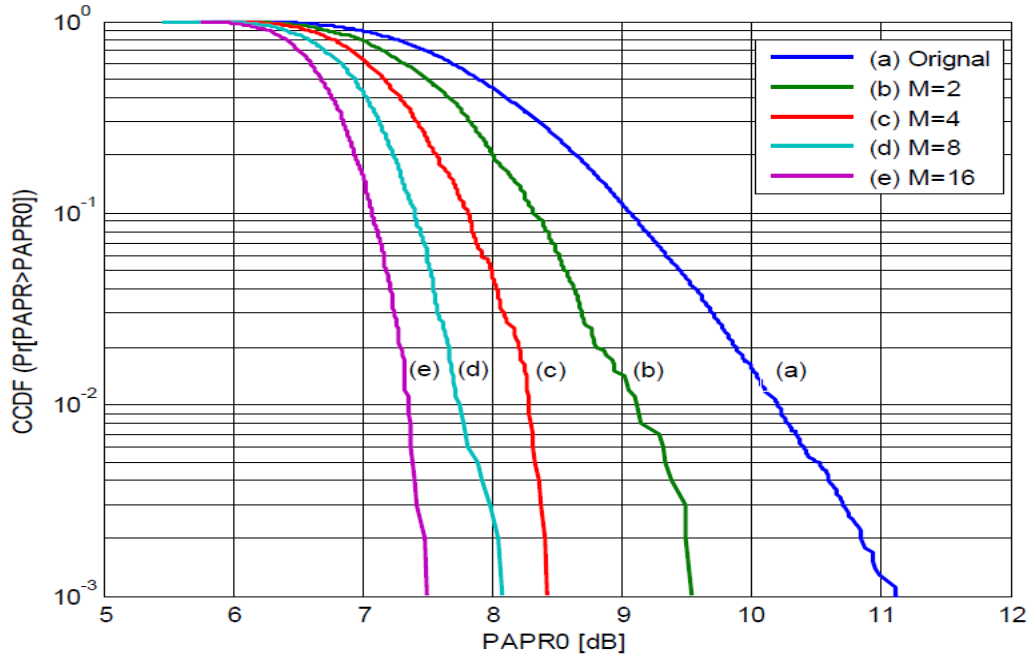


Fig. 3: Simulation CCDF vs PAPR performances with different values of M

V. Conclusion

In this paper, we presented modified SLM technique to reduce PAPR. The selected technique provides us with a good range in performance to reduce PAPR. SLM algorithm adapted to any route number that means it can be used for different OFDM systems with different number of carriers. It is particularly suitable for the OFDM system with a large number of subcarriers (more than 128). The proposed technique reduces PAPR, decrease the BER over conventional techniques, and improve the spectrum efficiency, where the proposed technique is evaluated in presence of nonlinear power amplifier.

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Share Market Price Prediction Using Artificial Neural Network (ANN)

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ABSTRACT

Share Market is an untidy place for predicting since there are no significant rules to estimate or predict the price of share in the share market. Many methods like technical analysis, fundamental analysis, time series analysis and statistical analysis etc are all used to attempt to predict the price in the share market but none of these methods are proved as a consistently acceptable prediction tool. Artificial Neural Network (ANN), a field of Artificial Intelligence (AI), is a popular way to identify unknown and hidden patterns in data which is suitable for share market prediction. For predicting of share price using ANN, there are two modules, one is training session and other is predicting price based on previously trained data. We used Backpropagation algorithm for training session and Multilayer Feedforward network as a network model for predicting price. In this paper, we introduce a method which can predict share market price using Backpropagation algorithm and Multilayer Feedforward network.

Keywords: Artificial Neural Network (ANN), Prediction, Artificial Intelligence (AI), Backpropagation (BP), Multilayer Feedforward Network, Neural Network (NN).

1. Introduction

A share market is a place of high interest to the investors as it presents them with an opportunity to benefit financially by investing their resources on shares and derivatives of various companies. It is a chaos system; meaning the behavioral traits of share prices are unpredictable and uncertain. To make some sort of sense of this chaotic behavior, researchers were forced to find a technique which can estimate the effect of this uncertainty to the flow of share prices. From the analyses of various statistical models, Artificial Neural Networks are analogous to nonparametric, nonlinear, regression models. So, Artificial Neural Networks (ANN) certainly has the potential to distinguish unknown and hidden patterns in data which can be very effective for share market prediction. If successful, this can be beneficial for investors and financiers and that can positively contribute to the economy.

There are different methods that have been applied in order to predict Share Market returns. Tang and Fishwick[1]; Wang and Leu [2] provided a general introduction of how a neural network should be developed to model financial and economic time series. During the last decade, Artificial Neural Networks have been used in share market

prediction. One of the first such projects was by Kimoto *et al.* [3] who had used ANN for the prediction of Tokyo stock exchange index. Minzuno *et al.* [4] applied ANN again to Tokyo stock exchange to predict buying and selling signals with an overall prediction rate of 63%. Sexton *et al.* [5] theorized that the use of momentum and start of learning at random points may solve the problems that may occur in training process in 1998. Phua *et al.* [6] applied neural network with genetic algorithm to the stock exchange market of Singapore and predicted the market direction with an accuracy of 81%.

This paper demonstrates Back propagation method for training the Neural Network and Multilayer Feed forward network in order to forecast the share values. The aim of this paper is to use ANNs to forecast Bangladesh Stock Exchange market index values with reasonable a degree of accuracy.

2. Prediction Method Analysis:

Trading shares and commodities were primarily based on intuitions. As the trading grew, people tried to find methods and tools which can accurately predict the share prices increasing their gains and minimizing their risk. Many methods like

fundamental analysis, technical analysis, and machine learning method have all been used to attempt predictions of share prices but none of these methods have been proven as a consistently applicable prediction tool.

2.1 Fundamental Analysis

Fundamental analysis is the physical study of a company in terms of its product sales, manpower, quality, infrastructure etc. to understand its standing in the market and thereby its profitability as an investment [7]. The fundamental analysts believe that the market is defined 90 percent by logical and 10 percent by physiological factors. But, this analysis is not suitable for our study because the data it uses to determine the intrinsic value of an asset does not change on daily basis and therefore is not suitable for short-term basis. However, this analysis is suitable for predicting the share market only in long-term basis.

2.2 Technical Analysis

The technical analysis predicts the appropriate time to buy or sell a share. Technical analysts use charts which contain technical data like price, volume, highest and lowest prices per trading to predict future share movements. Price charts are used to recognize trends. These trends are understood by supply and demand issues that often have cyclical or some sort of noticeable patterns. To understand a company and its profitability through its share prices in the market, some parameters can guide an investor towards making a careful decision. These parameters are termed Indicators and Oscillators [7]. This is a very popular approach used to predict the market. But the problem of this analysis is that the extraction of trading rules from the study of charts is highly subjective, as a result different analysts extract different trading rules studying the same charts. This analysis can be used to predict the market price on daily basis but we will not use this approach because of its subjective nature.

2.3 Machine Learning Methods

Machine learning approach is attractive for artificial intelligence since it is based on the principle of learning from training and experience. Connectionist models [8] such as ANNs are well suited for machine learning where connection weights adjusted to improve the performance of a network.

3. Challenge in Prediction of share market price:

The main problem in predicting share market is that the share market is a chaos system. There are many variables that could affect the share market directly or indirectly. There are no significant relations between the variables and the price. We cannot draw any mathematical relation among the variables. There are no laws of predicting the share price using these variables.

4. Our System Architecture:

For this kind of chaotic system the neural network approach is suitable because we do not have to understand the solution. This is a major advantage of neural network approaches [9]. On the other hand in the traditional techniques we must understand the inputs, the algorithms and the outputs in great detail. With the neural network we just need to simply show the correct output for the given inputs. With sufficient amount of training, the network will mimic the function [9, 10]. Another advantage of neural network is that during the training process, the network will learn to ignore any inputs that don't contribute to the output [9, 10].

For our system, there is a training phase where some parameters named weights are found from this section and Backpropagation Algorithm is used for this training phase. These weights are used in prediction phase using same equations which are used in training phase. This is our basic Architecture of our System and this approach is known as a Feedforward Network. There are a lot of inputs in share market which impact share price. But all the inputs are not used in our system because their impact are not significant in share market price. We used 5 inputs for the system. The inputs are: General Index (GI), P/E ratio, Net Asset Value (NAV), Earnings per Share (EPS) and volume. Then we normalized the data set according to the network and feed the data to the network.

4.1 Backpropagation with Feedforward NN:

Back-propagation algorithm [8, 11, 14] is basically the process of back-propagating the errors from the output layers towards the input layer during training sessions. Back-propagation is necessary

because the hidden units have no target values which can be used, so these units must be trained based on errors from the previous layers. The output layer has a target value which is used to compare with calculated value. As the errors are back-propagated through the nodes, the connection weights are continuously updated. Training will occur until the errors in the weights are adequately small to be accepted. On the other hand the computational complexity of Back-propagation Algorithm is only $O(n)$. These features of the algorithm are the main criteria for predicting share prices accurately.

The main steps using the Backpropagation algorithm as follows:

- Step 1: Feed the normalized input data sample, compute the corresponding output;
- Step 2: Compute the error between the output(s) and the actual target(s);
- Step 3: The connection weights and membership functions are adjusted;
- Step 4: IF Error > Tolerance THEN goto Step 1 ELSE stop.

5. MODEL ANALYSIS

We used feedforward neural network which has a input layer with 5 neurons, a hidden layer which has 5 neurons and a output layer with single neuron. The backpropagation algorithm has been used for training the network.

5.1 Training Phase:

There are two phases 1st is the training phase and 2nd is the prediction phase. The training phase can be divided into two parts, the propagation phase and the weight update phase.

In the propagation phase 1st the input data is normalized for feeding the network into the input nodes using the formula:

$$v' = \frac{v - \min A}{\max A - \min A} (\text{new_max}A - \text{new_min}A) + \text{new_min}A$$

Here,

V' = Normalized Input.

V = Actual Input.

Min A, Max A = Boundary values of the old data range.

New min A, New max A = Boundary values of the new data range. In this case it is -1 and 1 because the backpropagation can only handle data between -one to one. [12]

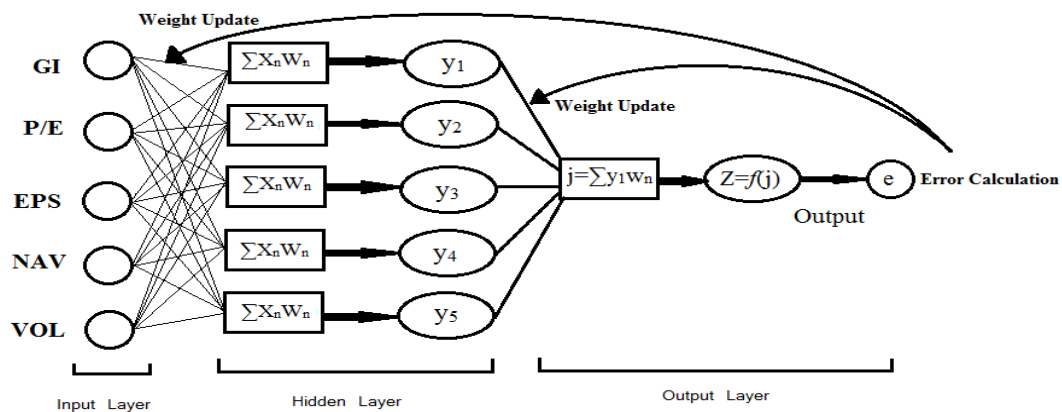


Fig 1: Training phase

From the figure 1 we can see that, the normalized input data are fed into the input layer, then the weights are multiplied with the each input data and enter into the neurons of hidden layer, the function of a single neuron are described in the figure 2, in our model we used single hidden layer. In our model the hidden layer neurons has the same functions as the input layers neurons .After that each neuron passes the output to the next neuron of the output layer. The output layer calculate the in the same way as the hidden layer neuron and

generate the final out put which is the compared with the real output and calculate an error signal 'e'.

$$e = \frac{\text{actual output} - \text{ANN output}}{\text{actual output}}$$

The error 'e' is generated from the Propagation Phase is used to update the weight using the following formula:

$$\text{Updated Weight} = \text{weight(oid)} + \text{learning rate} * \text{output error} * \text{output(neurons i)} * \text{output(neurons i+1)} * (1 - \text{Output (neurons i+1)}).$$

The above process is done in every weight matrix in the network for updating weight .The Phase 1 and Phase 2 procedure repeatedly used until the sum of square error is zero or close to zero.

Like the figure 2 each neuron is composed of two units. First unit adds products of weights coefficients and input signals [12]. Then this output enter into the second unit of the neuron which contains the nonlinear activation function, in our model we use sigmoid function as our activation function [13]. The formula of sigmoid activation is:

$$f(x) = \frac{1}{1 + e^{-\text{input}}}.$$

5.2 The prediction phase:

When the neural network is trained then it is ready for prediction. After training with acceptable error the weights are set into the network then we give the trained network the input data set of the day which price we want to predict. The trained network then predicts the price using the given input data set.

6. Input Data:

Here is a brief description about the inputs that affect the share price:

6.1 General Index (GI): General index is a number that measure the relative value of a section of share market. It reflects the total economic condition of the market. If the general index goes down then it means the economic condition of that particular market is relatively in poor condition.

6.2 Net Asset Value (NAV): The Net asset value (NAV) of a company is the company's total assets minus its total liabilities. NAV is typically calculated on a per-share basis.

$$\text{NAV} = (\text{Net asset of a company} - \text{Liability}) / \text{Total number of outstanding share}$$

NAV is also calculated each day by taking the last market value of all securities owned plus all other assets such as cash, subtracting all liabilities and then dividing the result by the total number of shares outstanding.

NAV reflects the financial condition of the company. We can judge the company reputation by the NAV.

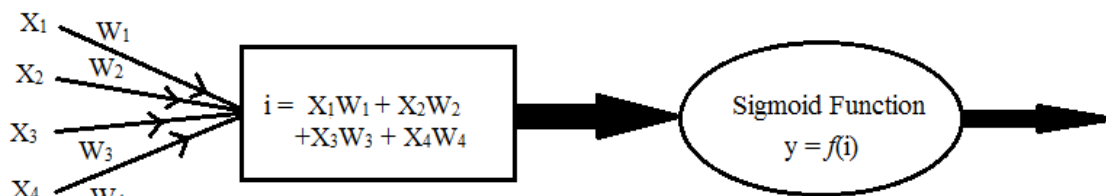


Fig 2: A Single Neuron

6.3 P/E ratio: The P/E ratio makes a relationship between the share price and the company's earnings. The P/E ratio of a share is a measure of the price paid for a share relative to the annual net income or profit earned by the firm per share.

$P/E \text{ ratio} = \text{Share Price} / \text{Earnings Per Share}$.

If P/E ratio rises then there is a tendency of the company share price falls, the higher P/E ratio then the higher probability to decrease the price.

6.4 Earnings per Share (EPS): Earnings per share (EPS) is a comparison tool between two companies. Earnings per share serve as an indicator of a company's profitability.

$EPS = \text{Net Earnings} / \text{Number of Outstanding Shares}$.

For output we use the Price of the share. Using this data set we trained the network.

6.5 Share Volume: Share volume can be calculated in two different types the daily share volume and the monthly share volume. the total number of share is sold in a particular day is called daily share volume. In monthly share volume is the sum of the trading volumes during that month.

7. Simulation and performance analysis:

Using the developed system to predict the future stock values with Feedforward Neural Networks

we can do some analysis to know the performance of the Back-Propagation Algorithm.

By using the past historical data of ACI pharmaceutical company which include only 2 inputs, we tried to predict stock values for future 4 days of July from Back-Propagation algorithm we are now able to compare the predicted values with the real values. Table 1 and Figure 3 show the prediction and real values of the ACI pharmaceutical Company. The input past historical data is from 01-07-2010 to 22-07-2010.

The average error of the 1st simulation was 2.60 percent.

DATE	Predicted Price TK	Actual Price TK	Error (%)
23-07-2010	420.42	427.9	1.74
26-07-2010	420.13	414.7	1.30
27-07-2010	436.13	426.7	2.20
30-07-2010	435.42	414.0	5.17

Table 1: Predicting price, Actual price and Error (%) of ACI pharmaceutical using 2 input datasets.

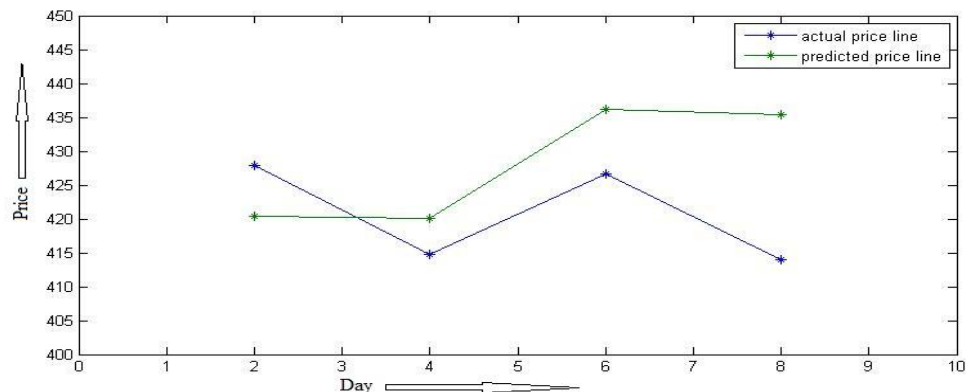


Fig - 3: Graphical representation of Predicting and Actual price of ACI pharmaceutical using 2 input data sets.

For the second simulation we used the past historical data of ACI pharmaceutical company which include only 5 inputs, we tried to predict stock values for future 8 days of November. Table 2 and Figure 4 show the prediction and real values of the ACI pharmaceutical Company. The input past historical data is from 1-9-2010 to 31-10-2010. The average error of the 2nd simulation was 1.53 %.

DATE	Predicted Price (TK)	Actual Price (TK)	Error (%)
01-NOV-2010	392.7	395	0.58
02-NOV-2010	393.3	387	1.62
03-NOV-2010	392.5	392	0.12
04-NOV-2010	392.0	390	0.51
08-NOV-2010	392.8	389	0.97
09-NOV-2010	392.5	385	1.94
10-NOV-2010	392.5	380	3.28
11-NOV-2010	392.3	380	3.23

Table 2: Predicting price, Actual price and Error (%) of ACI pharmaceutical using 5 input data sets.

The more input data we have the better training and get more close results. This means that, more the available data for predicting financial markets, the greater the chances of an accurate forecast. But the sum squared error was high for the 5 input dataset than the 2 input data sets but the prediction error was minimal.

7.1 Observation:

1. We observed that when we take 2 inputs for prediction the sum squared error was high. But when we take 4 inputs the sum squared error was minimized. But when we take 5 input then the sum squared error is higher than the 4 input technique.
2. When we take the data of share market in a sequential date, we can predict the share price nearer to the actual price. But if we take the data of discontinuous date the difference between the predicted price and actual price was relatively high.
3. In the training time if any input changed suddenly at a high rate then the prediction was not near to the actual price.

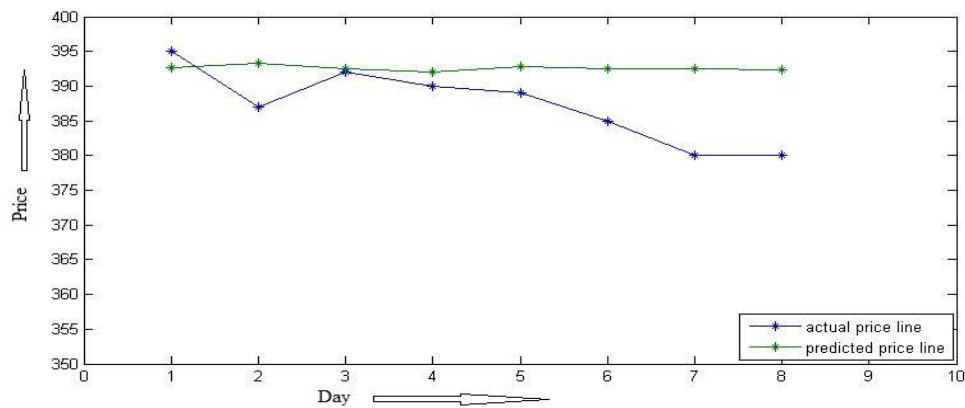


Fig - 4: Graphical representation of Predicting and Actual price of ACI pharmaceutical using 5 input data sets.

8. Conclusion:

As researchers and investors strive to out-perform the market, the use of neural networks to forecast stock market prices will be a continuing area of research. The ultimate goal is to increase the yield from the investment. It has been proven already through research that the evaluation of the return on investment in share markets through any of the traditional techniques is tedious, expensive and a time-consuming process. In conclusion we can say that if we train our system with more input data set it generate more error free prediction price.

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SMART ROOM CONTROL UNIT USING STANDARD RC5 REMOTE CODE

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Remote control electronic products are available in the market but such type, which is called Smart Room Control unit including, Remote control switching more than 2048 devices, remotely speed control of a single phase induction motor, automatic water level control of an overhead tank, remotely opening and closing a door, monitoring room temperature is not available by using a single control unit. This type control unit is very useful in the modern world in the case of domestic application, which makes the most common work easy & smart. Often manually control the above systems is very bored. Now a day's remote control TV is more common so by using this TV remote to make a Smart Room Control unit is so interesting & more economical. In this paper we present how a control unit can be made by using TV remote which can control 2048 devices & finally the Successful practical performance of the transmitting and receiving/controlling unit will be presented. There are different type TV remotes in the market. Each has own distinct remote coding and decoding scheme for data transmission and reception. We have chosen RC5 coding and decoding scheme of Philips TV remote. In this paper RC5 decoding system will be presented by a complex program algorithm. This program algorithm is implemented in the embedded system. This paper discusses the low cost implementation of program algorithm in an 8-bit 8051 microcontroller using artificial techniques to control the above appliances.

Keywords: RC5 encoding and decoding, Modulation and Demodulation, Microcontroller, infrared ray, phototransistor, Program Flow Chart, Transmitting and Receiving Unit, Dc motor Direction control switching, Temperature sensor, ADC, LCD, LASER, transmitting and control unit photos etc.

1. INTRODUCTION

Use of IR (infrared ray) light as a method for wireless communication has become popular for remote control applications. In my project widely used RC5 coding scheme is used. Before going discussion to my project a brief explanation is necessary for IR transmitter & receiver scheme.

2. INFRARED LIGHT

Infrared actually is normal light with a particular color. We humans can't see this color because its wavelength of 950nm is above the visible spectrum. Unfortunately for us there are many more sources of Infrared light. The sun is the brightest source of all, but there are many others, like: light bulbs, candles, central heating system. Therefore we have to take some precautions to guarantee that our IR message gets across to the receiver without errors.

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3. MODULATION

Modulation is the answer to make our signal stand out above the noise. With modulation we make the IR light source blink in a particular frequency. The IR receiver will be tuned to that frequency, so it can ignore everything else. Modulation also increases the distance by boosting the power because if we apply constant power then the lifetime of IR LED will be reduced.

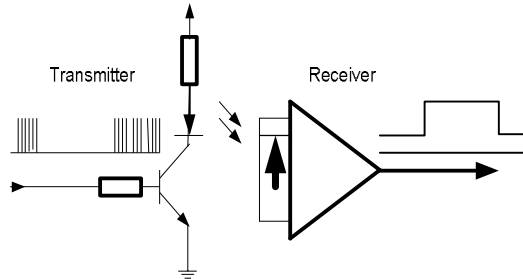


Fig. 1: Modulated signal Transmitter & Receiver.

In the Fig. 1 we can see a modulated signal driving the IR LED of the transmitter on the left side. The detected signal is coming out of the receiver at the right side.

4. THE INFRARED DETECTOR MODULE

For selecting an infrared detector module we have to follow the following criteria to get maximum efficiency

- Select an infrared detector module that has maximum spectral sensitivity at the same wavelength of the infrared LED.
- Detector module operates at the exact frequency of our modulated data carrier

5. RC5 CODING SCHEME

Table 1. RC5 frame format

Start bits	Control bit	Address Bit	Command Bits (Data)
St2 St1	Ctrl	A4 A3 A2 A1 A0	C5 C4 C3 C2 C1 C0

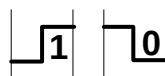


Fig. 2: Bi-phase coding

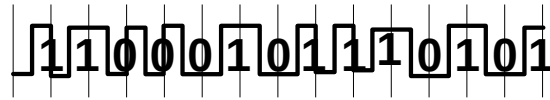


Fig. 3: Example of transmission

The RC5 code is a 14-bit word bi-phase coded signal (see Table 1). The time period for representing one bit is 1.778ms. The two first bits (St1, St2) as shown in Table 1 are start bits, always having the value “1”. The next bit is a control bit (Ctrl), which is toggled every time a button is pressed on the remote control transmitter. Five system bits (A4, A3, A2, A1, and A0) hold the system address. The command sequence is six bits long (C5, C4, C3, C2, C1, C0), allowing up to 64 different commands per address. The bits are transmitted in bi-phase code as shown in Fig. 2. An example where the command 0x35 is sent to system 5 is shown in Fig. 3.

6. SWITCHING SEVERAL DEVICES

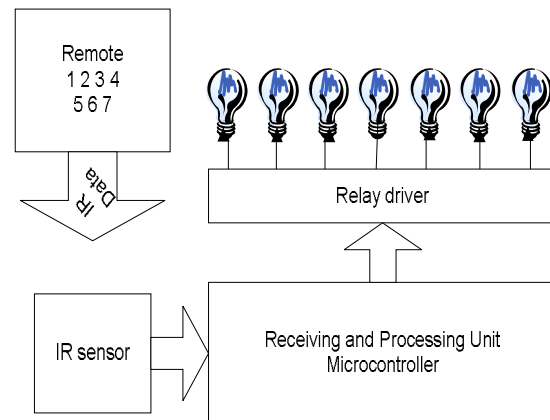


Fig. 4: Block diagram for switching several devices

At remote 1 to 7 as shown in Fig. 4 buttons are encoded for controlling seven loads such as lights. Before pressing any button the status of the 14 bits data word is 00000000000000 & no data will be sent without pressing any button. When we press button 1 then 11100000000001 data will be sent. If we hold down the same button then the same data will be repeated at every 131ms. Similarly when we will press buttons 2, 3, 4, 5, 6, 7 then 11100000000010, 11100000000011, 11100000000100, 11100000000101, 11100000000110, 11100000000111 data will be sent respectively. When the above IR modulated data irradiates the IR receiver then micro controller starts the program for decoding & storing the data to its registers & according to command the micro controller gives 1 (5V) or 0 (Zero volt or GND) to the corresponding output Pin such as P0.0 to P0.6 of AT89C51 microcontroller [Mazidi and Gillispie 2007], which activate or deactivate the transistor (here saturation

mode or cutoff mode) for relay driving purposes. In this way we easily control load (light) on/off.

7. SPEED CONTROL OF A SINGLE PHASE MOTOR

The remote button as shown in Fig. 5 is encoded for controlling speed of a single-phase motor (FAN). When pressing this button then corresponding data (11100000001101) will be sent which will be received by

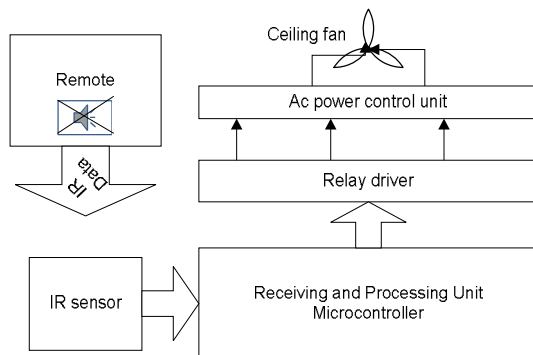


Fig. 5: Block diagram of speed control of a single-phase motor.

micro controller & according to command the micro controller will give 1 (5V) or 0 (0V or GND) to the corresponding output Pin such as P0.7, P2.5, P2.6, P2.7 of AT89C51 microcontroller [Mazidi and Gillispie 2007]. Here relays are used to change the resistance value of the variable resistance so that firing angle of the TRIAC will be changed. In this way we easily control the speed of a single-phase motor (FAN).

8. WATER LEVEL CONTROL OF AN OVERHEAD TANK

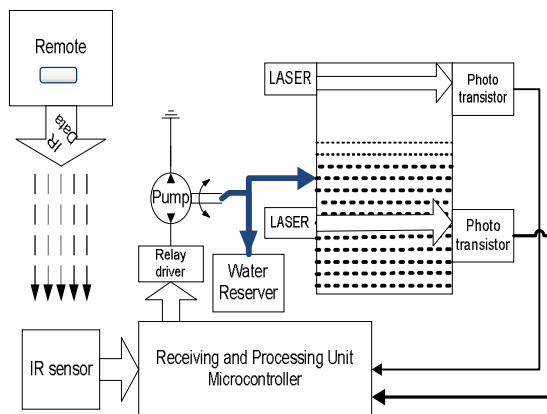


Fig. 6: Block diagram of water level control of an overhead Tank.

The remote button as shown in Fig. 6 is encoded for controlling the motor of the overhead tank. When pressing this button then corresponding data (11100000001100) will be sent which will be received by micro controller & according to command the micro controller will give 1(5V) or 0 (0V or GND) to the corresponding output Pin such as P2.2 of AT89C51 microcontroller [Mazidi and Gillispie 2007], for relay driving purposes. In this way we easily control the motor. Further detail when motor will start then water level will be rising & as soon as it touch the upper level then it will block the path of LASER transmitter & thus the output of the phototransistor receiver will be changed (from 0V To 5V) & this changing state will be sensed by the AT89C51 microcontroller [Mazidi and Gillispie 2007] Input Pin P2.0, which further processed & give the output 0 (0V) to the P2.2 of AT89C51 microcontroller [Mazidi and Gillispie 2007] for stopping the motor. Again when water level will decrease for uses of water then as soon as it will drop to lower threshold level it will open the path of LASER transmitter & thus the output of the phototransistor receiver will be changed (from 0V To 5V) & this changing state will be sensed by the AT89C51 microcontroller [Mazidi and Gillispie 2007] Input Pin P2.1 of which further processed & will give the output 1 to the port for starting the motor. In this way water level is limited between lower & upper level.

9. OPENING\ CLOSING A DOOR

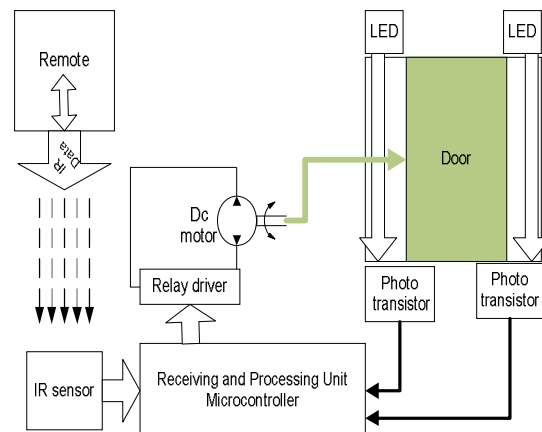


Fig. 7: Block diagram of closing/opening a door.

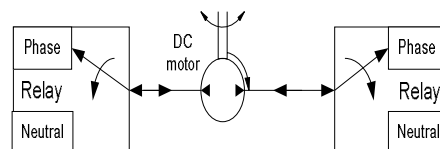


Fig. 8: Block diagram of the direction Control of the motor

The remote button as shown in Fig. 7 is encoded for controlling the door open & close. When pressing the upper portion of this button then corresponding data (11100000010000) will be sent which will be received by micro controller and according to command the micro controller will give 1(5V) & 0 (0V or GND) to the corresponding output Pin such as P2.3 & P2.4 of AT89C51 microcontroller [Mazidi and Gillispie 2007] for relay driving purposes. In this way we easily control the door open & close. Further detail when motor will start to one direction then door will be moved for opening or closing purpose & when the door just cross the path of line of sight LED & phototransistor then phototransistor output will be changed (From 0V To 5V) & this changing state will be sensed by the micro controller input Pin P1.6 or P1.7 of AT89C51 microcontroller [Mazidi and Gillispie 2007] which further processed & will give the output 0 (0V) to the output Pin P2.3 & P2.4 of AT89C51 microcontroller [Mazidi and Gillispie 2007] for stopping the motor & thus door will not thrust the wall. When pressing the lower portion of this button then corresponding data (11100000010001) will be sent which works as like as the upper portion of this button but in opposite direction. Here two sensors are used for properly speed control of the door motor. From above block as shown in Fig. 8 we see that when any one relay acts as switch then the current flow in one direction & as a result the motor rotate at the certain direction & when another relay acts as switch & the other stays normal position then the current flows in the reverse direction & as a result the motor rotate at the reverse direction. In this way we can easily control the door open & close.

10. TEMPERATURE MONITOR

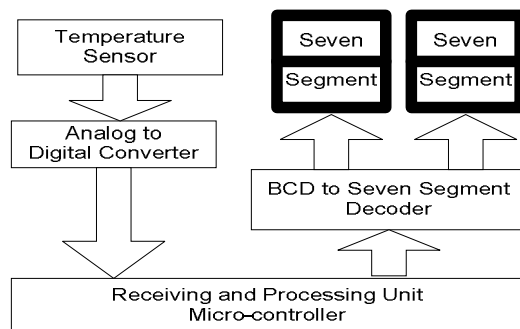


Fig. 9: Block diagram of the temperature monitor.

At first the temperature sensor senses the environment temperature then it gives analog voltage to the analog to digital converter (ADC). Then this analog voltage is converted to the 8 bits data by ADC0804 [configuration at <<http://www.Alldatasheet.com>>] in 1(5V) & 0 (0V) format.

This 8 bits data accept by the AT89C2051 micro controller input port1 [Mazidi and Gillispie 2007] which further process according to its program, & gives 4 bits data to the output Port3, which is input of the 7 segments SN74LS47 [configuration at <<http://www.Alldatasheet.com>>] decoder for displaying temperature value in decimal format. Also many AVR microcontrollers (such as ATMEGA8 [configuration at <<http://www.Atmel.com>>]) have own ADC. So we can use this ADC to take analog data & by its instruction we can convert analog to digital data and can send this digital data to PORT or by programming it can display to LCD as shown in Fig. 10.

11. COMPLETE CIRCUIT DIAGRAM

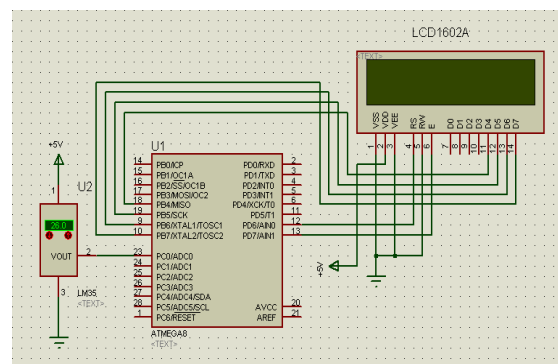


Fig. 10: circuit diagram of temperature display Unit

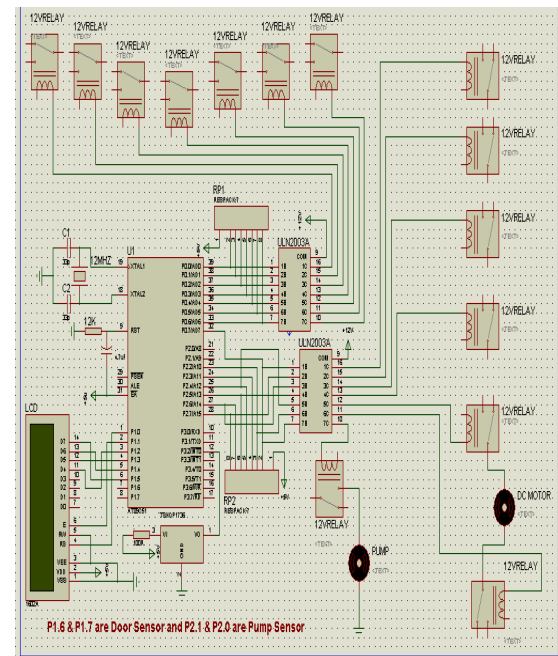
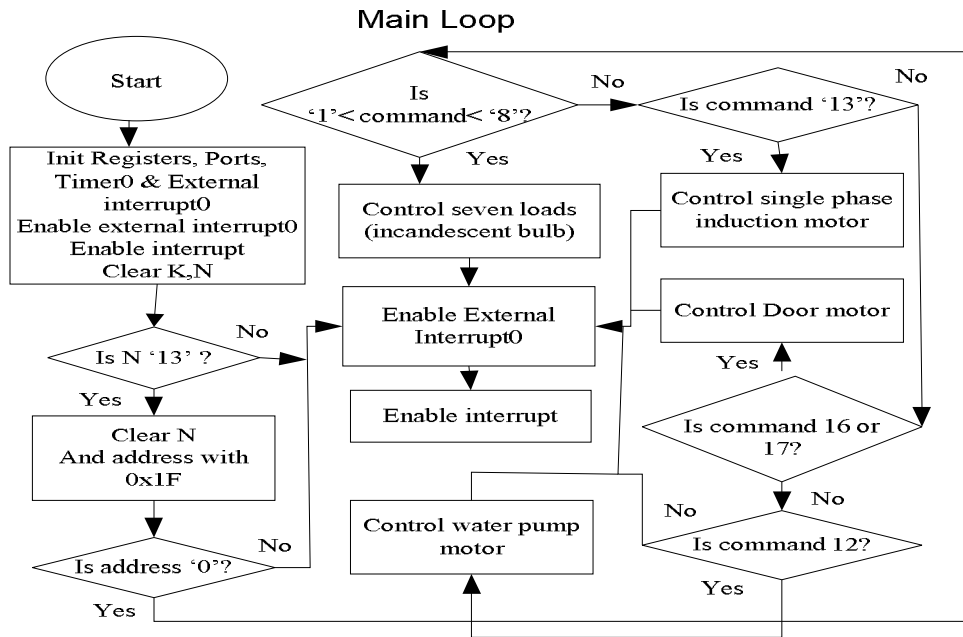
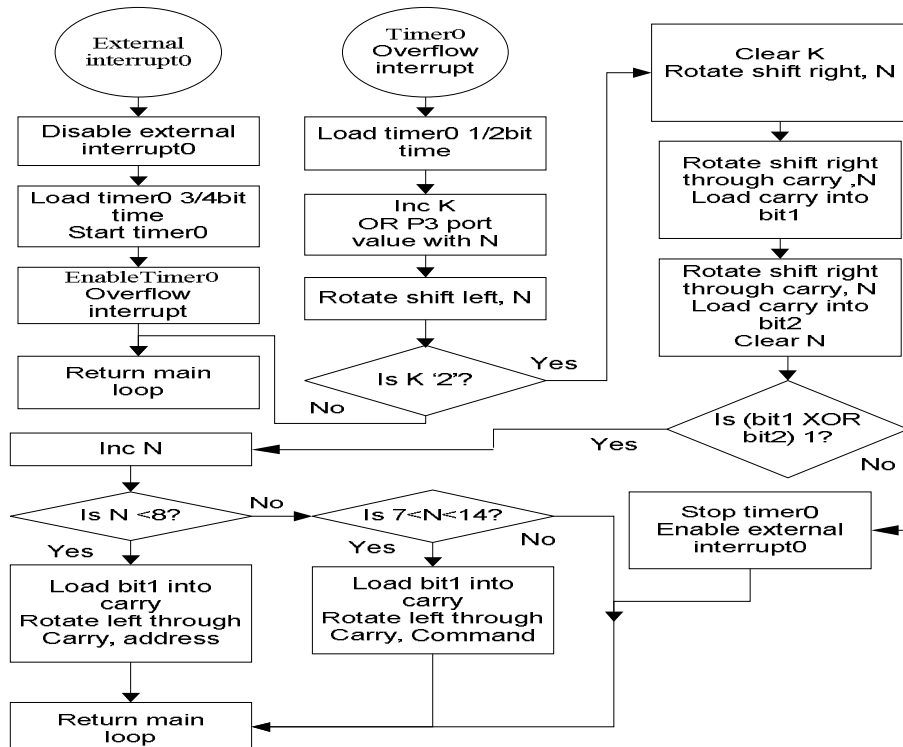


Fig. 11: circuit diagram of Control Unit

12. PROGRAM FLOW CHART



Flow chart of External interrupt & Timer0 over flow interrupt



13. PICTURE OF MY COMPLE PROJECT

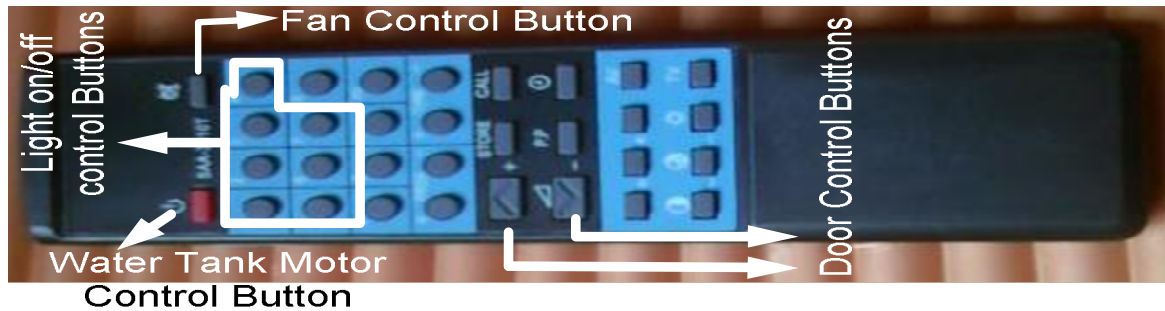


Fig. 12: Transmitter (Remote)

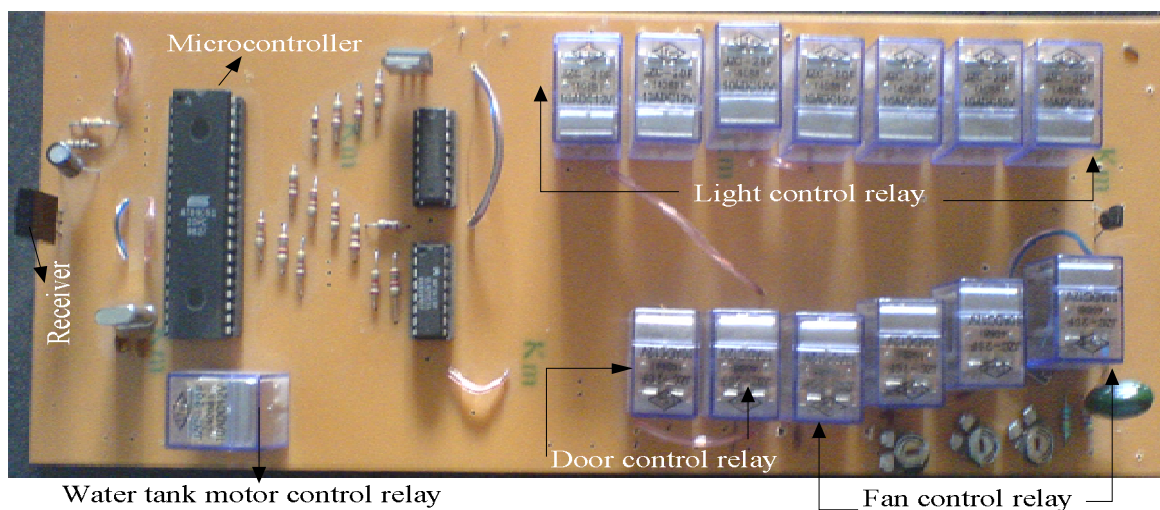


Fig. 13: Receiving & Processing unit

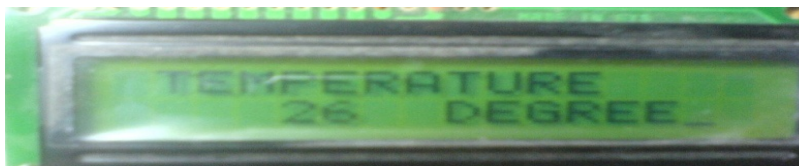


Fig. 14: Temperature display on the LCD

14. RESULT AND CONCLUSION

The overall performance of the project is very good & the response is so fast that as soon as the remote bottom is pressed it corresponding load activates simultaneously. In some case such as temperature display error about $\pm 0.1^{\circ}\text{C}$. But it is negligible. My control unit responses from 35 feet's distance away. By using the idea of my project it is possible to design Universal receiver, Message transmitter and receiver, Automatic speed control of a single phase motor using fuzzy logic, Remote Control Traffic System, Robot, Car, Timer, Voltmeter, and Ammeter etc.

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PARAMETERS MEASUREMENT OF CIRCULAR SHAPED CABLES USING IMAGE PROCESSING TECHNIQUES

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Cable Parameter measurement is very important for various industrial applications. In general procedure this measurement is very laborious and time consuming. In general cases, the result obtained is not always satisfactory because of different core shape. In this paper, we introduce an image processing technique for measuring the cable parameters efficiently, rapidly, and automatically. For measurement, we only require a cross-sectional image of a cable to determine its parameters. The primary goal in this paper is to measure the thickness and diameter of cable insulation layers, based on image processing techniques. For capturing the cross section image, a magnifying glass and a high definition digital camera is used. Canny and morphological operation is used to extract the edge and refilling the edge of the cable. In order to fit the shape of cable, least-square ellipse fitting method is employed. Finally, cable insulation parameter is measured by using calibration coefficient. We successfully measure the parameters of different types of cable and comparing these values with their physical measurement. We obtain 0.17 to 0.50 percent measurement errors which represents that our proposed method is efficient and economic for cable parameter measurement.

Key words: Cable Parameter; Circular Shape Detection; Image Processing Technique; Geometric parameters; Measurement error

1. INTRODUCTION

In conventional way of cable parameters measurement, the procedure is much complex and time consuming. Hence, a process is required in industrial works where precision and efficiency both is of essence. Digital image processing is introduced in this case where it not only increase measuring flexibility but also increases its accuracy and efficiency. Measuring and testing of the insulation thickness and diameter of wire and cable is very much important for safety of electricity, material, equipment and personnel. Proper testing of wiring system after installation is essential to guarantee good operation in latter procedures. The cabling system needs to be measured after installation and the results of those measurements should be documented for later uses. Measurement is also used when cabling problems are suspected. However, the traditional method has enormous disadvantages due to worker involvement, vision tedium, and obviously time consumption. Computer vision is the branch of computer science concerned with the analysis of images to extract information

of any sort. In computer vision, an image can be analyzed as required. So, a new method based on image processing is implemented to define the parameters of a cable. Some typical examples of the cables with single-core and multiple cores are shown in Fig.1.

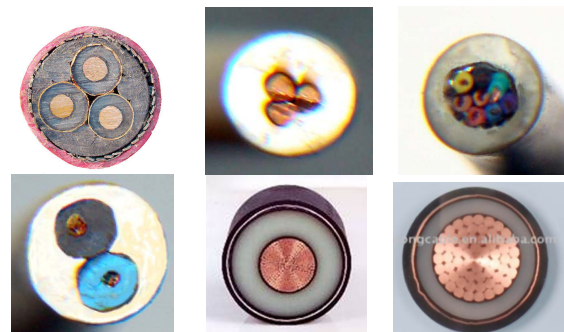


Fig. 1: Various types of cables

In this method, for cable parameter measurement, the cable image is collected by using high definition camera. Then Gaussian filter is used for

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smoothing purpose. A simple cable has many deformities and unusual substances within it. These produce unwanted value change in the picture and can be considered as noise. Thus a filter is required to eliminate these noises and the process here is called smoothing. Then the smoothed image is converted into its gray scale image.

A color image has three data for every pixel. This data is not required when we need to identify the cable parameters. The next step is to detect the edges. For edge detection, canny algorithm is used. A Canny algorithm is a renowned algorithm to detect edges where a certain amount of value change is measured and marked as long as the change is over that threshold. After the Canny operation it can be observed that there are certain deformities in the curves. Sometimes it is not continuous even sometimes the curves have a tendency to be bent more or less than expected. So, refilling these curve points is required and in this case morphological operation is used. Finally, in order to fit the shape of cable, curve fitting algorithm is used. This curve fitting makes the system simpler and faster and different than other methods.

Authors in (Fan and Zou, 2008) measure the cable insulation parameters based on an image processing techniques. They used binary edge detection and binary morphological operation for extracting the edge of the cable. The authors in (Shan et al., 2009) measured the cable insulation parameters by employing background segmentation. The authors in (Fan and Wang, 2009) improved the method mentioned in (Shan et al., 2009) by employing Canny edge algorithm (Canny, 1986) for edge detection. All above previous methods, they use single core cable.

Instead of using the previous methods mentioned in (Shan et al., 2009, Fitzgibbon et al. 1999), our method provide greater flexibility, require less time and can be used for more than one layer of circular wire. Moreover, in our proposed method there is no prior foreground and background segmentation which is often required in cable parameter measurement in (Shan et al., 2009). Compared to method mentioned in (Fan and Zou, 2008), (Shan et al., 2009), or (Fan and Wang, 2009), our proposed method uses not only single core cables but also multi-core cables, which is the most faster and efficient method.

The entire paper is organized as follows. Section 2 discusses the composition of hardware system. Section 3 covers the acquisition and processing of the image where it also includes smoothing, color conversion, edge detection, refilling, curve fitting

and system calibration. Section 4 describes the analysis of data and results of the entire work. Finally, section 5 concludes the whole work with future additions.

2. HARDWARE SYSTEM SETUP

This measurement consists of image acquisition, image analysis, and result output. In our paper, image acquisition includes magnifying glass and high definition camera, acquisition software, and computer. But it would better to employ a video digital microscope and a CCD camera for capturing the image of the cable. We process the image in a Windows XP service pack-2 environment with Microsoft Visual C++ where OpenCV software (<http://sourceforge.net/projects/opencv/>) is used for ease and efficiency. It mostly accomplishes image filtering, image conversion, edge detection, refilling curve, and curve fitting

3. ACQUISITION AND PROCESSING OF IMAGES

3.1 Image Acquisition

Acquisition is partly a manual system that involves acquiring the image of the cable cross section and then inserting it in our processing environment. It can be evolved to an automated system by interfacing it with a computer but that is not our primary goal. The cable can be of any size. Cable of very small cross section makes the image quite unclear so a magnifying glass is included. Once an image is acquired we use this image as the input of our C/C++ program for further processing.

3.2 Image Smoothing

We know that the actual gathered images contain noises in the process of formation, transmission, reception, and processing. Even the actual image that we acquire has some problem of its own. The cable often has deformities and unnecessary substances. These are also accounted as noises. Noises deteriorate the quality of the image, blurring image and inundating features. This brings difficulties to the analysis. Therefore, the main purpose is to remove the image noise in the stage of pre-treatment. We use Gaussian filtering for image smoothing. In this purpose, we use the two-dimensional isotropic Gaussian distribution form which is shown in (1).

$$G(x, y) = \frac{p(x, y)}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

In Eq. (1), p is the pixel value at any position of the image. This smoothing removes small-scale texture and noise for given spatial extent. The distribution

has a degree of smoothing or quality of smoothing which is denoted by σ , where σ is the standard deviation. The σ value is calculated by $\sigma=(n/2-1)\times 0.3+0.8$, where $n=3$ for horizontal or vertical kernel. The standard deviation value enables the user to make fine adjustments to the amount of spatial averaging that occurs in the image. Increasing the value of standard deviation results in an increase in the size of the Gaussian kernel mask and causes the Gaussian filter to remove more spatial frequencies from the specimen image.

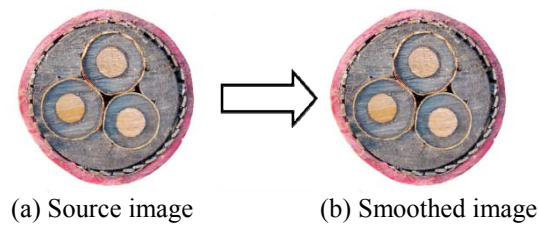


Fig. 2: Image smoothing

Larger standard deviations offer greater noise reduction but more blurring of edges. We used a track bar to vary the smoothing level. For Gaussian smoothing 3 by 3 blocks size is taken in our program. Figure 2 shows the image smoothing operation of a 3-core cable, where the left image (a) represents the source raw image and (b) represents the smooth image.

3.3 Color conversion

The image we acquire is an RGB color image. All three data types Red (R), Green (G) and Blue (B) are not necessary to determine the circular objects in an image. So we consider this extra data to be a burden and want to reduce these three into one parameter. Therefore, we convert it to a gray scale image. To convert any color to a gray scale representation of its luminance, one must obtain the values of its red, green, and blue (RGB) primaries in linear intensity encoding, by gamma expansion. We use (2) to convert the color image to the gray scale image.

$$Gray = 0.299 \times R + 0.587 \times G + 0.114 \times B \quad (2)$$

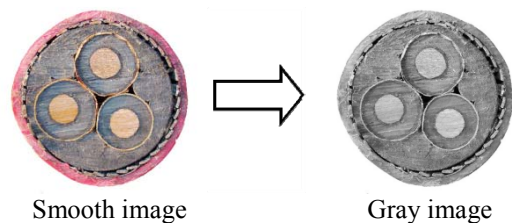


Fig. 3: Color to gray image conversion

The weights depend on the exact choice of the RGB primaries, but are typical. Usually, after performing the smoothing operation we convert the color image into gray image. Figure 3 shows the resulted gray image from color image.

3.4 Edge Detection

The Canny algorithm [5] is that it tries to assemble the individual edge candidate pixels into contours. These contours are formed by applying a hysteresis threshold to the pixels. This means that there are two thresholds, an upper and a lower. If a pixel has a gradient larger than the upper threshold, then it is accepted as an edge pixel; if a pixel is below the lower threshold, it is rejected. If the pixel's gradient is between the thresholds, then it will be accepted only if it is connected to a pixel that is above the high threshold. Canny recommended a ratio of high: low threshold between 2:1 and 3:1. Canny also introduced the notion of non-maximum suppression, which means that given the pre-smoothing filters, edge points are defined as points where the gradient magnitude assumes a local maximum in the gradient direction. We use 2 track bars for varying the threshold parameters. Figure 4 represents the extracted edges from gray images using canny edge detector.

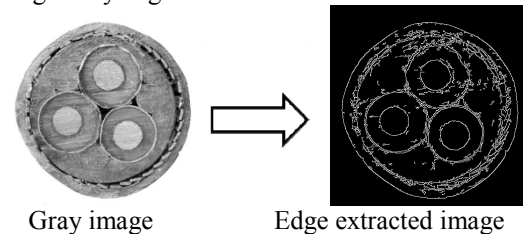


Fig. 4: Edge extraction from the gray image

3.5 Advanced Morphological Operations

The morphological transformations are used in removing noise, isolating individual elements, and joining disparate elements in an image. Morphology can also be used to find intensity bumps or holes in an image and to find image gradients. There are three primary morphological functions: erosion, dilation, and hit-or-miss. Others are special cases of these primary operations or are cascaded applications of them. Dilation expands a region & erosion reduces. Moreover, dilation will tend to smooth concavities and erosion will tend to smooth away protrusions. Of course, the exact result will depend on the kernel, but these statements are generally true for the filled convex kernels typically used. Advanced morphological transformations include using erosion and dilation as basic operations. After the edge of the image is detected, we reconstructed the image by morphological operation. There are different types of morphological operations used in OpenCV

library (<http://sourceforge.net/projects/opencv/>). This includes opening, closing, morphological gradient, top hat and black hat. We use morphological gradient here for reconstructing or refilling the edge so that curve fitting will be much better. Figure 5 shows the morphological image output from edge image.

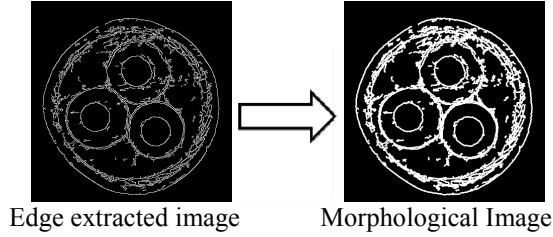


Fig. 5: Morphological operation on edge image

3.6 Curve Fitting

Curve fitting is the process of constructing a curve or function that has the best fit to a series of data points, possibly subject to constraints. In our experiment, first we detect contours in the morphological image then fit the contours to each ellipse particularly. This recognition of contour then ellipse makes our work simpler and faster. Let us represent a general conic by an implicit second order polynomial (Fitzgibbon et al. 1999).

$$F(\mathbf{a}, \mathbf{x}) = \mathbf{a}\mathbf{x} = ax^2 + bxy + cy^2 + dx + ey + f = 0 \quad (3)$$

where $\mathbf{a} = [a \ b \ c \ d \ e \ f]^T$ and $\mathbf{x} = [x^2 \ xy \ y^2 \ x \ y \ 1]^T$. $F(\mathbf{a}, \mathbf{x}_i)$ is called the 'algebraic distance' of a point (x, y) to the conic $F(\mathbf{a}, \mathbf{x}) = 0$. The fitting of a general conic may be approached by minimizing the sum of squared algebraic distances $D_A(\mathbf{a}) = \sum_{i=1}^N F(\mathbf{x}_i)^2$ of the curve to the N

data points $\mathbf{x}_i$. In order to fit ellipses we would like to constrain the parameter vector $\mathbf{a}$ so that the conic that it represents is forced to be an ellipse. We check the appropriate constraint which is the discriminant, $b^2 - 4ac$ be negative [6]. After the system is solved, ellipse center and axis can be extracted.

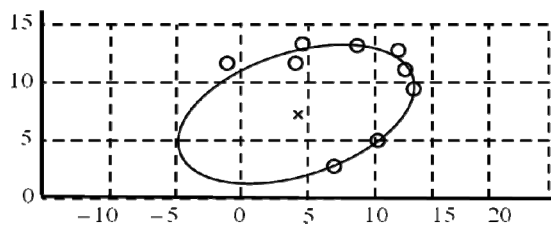


Fig. 6: Ellipse fitting using least square method

From an ellipse perimeter, we calculate the diameter of the circular object. The circumference of an ellipse is $l = 4aE(\epsilon^2)$, where, a is the major axis, E is the elliptical integral of the second kind, and ϵ is eccentricity which is given by, $\epsilon = \sqrt{a^2 - b^2} / a$. By least square method, we can fit ellipse from some discrete spatial points, which is shown in Fig. 6. After measuring the circumference of the ellipse, we divide the result by π to have the diameter of the same circumference's circle.

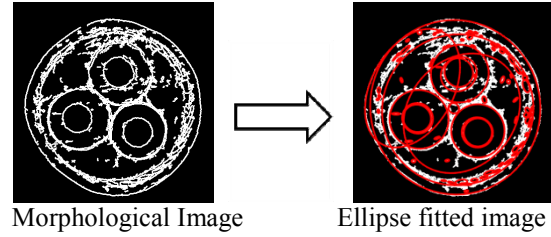


Fig. 7: Determination of ellipse of morphological image

So many ellipses are detected in the ellipse fitting step, which is shown in Fig. 7. We eliminate the unnecessary ellipses by two steps:

Step1: Small ellipse elimination: We used a track bar for removing the smaller ellipses.

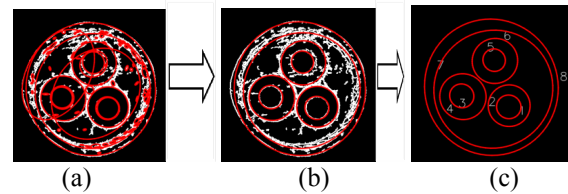


Fig. 8: Removing of unnecessary ellipses from ellipse fitted image. (a) Ellipse fitted image (b) Image after elimination (c) Ellipses/circles only

Step 2: Higher eccentric ellipse elimination: We used a track bar which changes the acceptable ratio of minor and major axes to remove the unnecessary ellipses.

The major and minor axes of the detected ellipses and their average values are directly found from the images, as shown in Fig. 8. These average values are the required parameters for measuring the diameter and length. As an example, we obtain 8 ellipse/circles from the ellipse fitted image.

3.7 System Calibration

For calibrating the system we calculate a calibration constant k , which is multiplied with the measured parameter to have the real value. For calculating the calibration constant k we need two values. (i) A

standard known diameter (d) value is taken, and (ii) For the known diameter the pixel diameter value (d_{pixel}) is found from the program. Then the calibration constant is given in (4).

$$k = d / d_{\text{pixel}} \quad (4)$$

In the proposed method, at first the image is collected by the computer. Then after processing the image, the diameter can be measured in the calibrated measurement. The actual length L is measured by (5)

$$L = kN \quad (5)$$

where, N is the number of pixels.

4. EXPERIMENTAL ANALYSIS

In the previous section, we discuss different image processing techniques for measuring the physical parameters of a multi-core cable. We have collected several specimens of single core cable and multi-core cable. In the previous section, we show the image processing steps of a multi-core cable. As an example, by using vernier caliper, we measure the inner and outer diameter of outer layer, which is shown in Table 1. In case of vernier method, we place the scale in different places and then take a few data. Then for getting the desired diameter or thickness, we average those data. Therefore, the length, or thickness, or diameter of the specimen is calculated by Eq. (6).

$$\text{Total reading} = \text{M.S.R} + \text{V.S.R} \times \text{V.C} \quad (6)$$

Table 1: Inner and outer diameter of outer layer

Core 1		Core 2		Core 3	
Vernier method	Proposed method	Vernier method	Proposed method	Vernier method	Proposed method
10.12	10.13	10.31	10.18	10.17	10.14

Where, M.S.R, V.S.R, and V.C represent the main scale reading, vernier scale reading, and vernier constant, respectively. On the contrary, we measure the length by our proposed method which is shown in Table 1. From the measurement, the percentage error is 0.0988%, 1.26%, and 0.294% for core-1, core-2 and core-3 respectively.

Table 2: Data for inner and outer diameter of outer layer

Inner layer (diameter)		Outer layer (diameter)	
Vernier method (mm)	Proposed method (mm)	Vernier method (mm)	Proposed method (mm)
50.21	50.30	59.30	59.12

We measure the inner and outer diameter of the outer layer of the sample specimen, which is shown

in Table 2. From our procedure, the inner layer diameter is 50.30 mm whereas the vernier caliper gives 50.21 mm. The percentage error is 0.30% for the outer diameter and 0.17% for the inner diameter. We also measure the outer diameter of inner cores of the sample specimen, which is shown in Table 3. From the measurement, the percentage error is 1.06%, 0.25%, and 0.82% for core-1, core-2 and core-3 respectively.

Table 3: Outer diameter of inner cores

Core 1		Core 2		Core 3	
Vernier method	Proposed method	Vernier method	Proposed method	Vernier method	Proposed method
18.8	18.6	20.4	20.35	20.67	20.50

In order to compare our method with the conventional method, we also took a very small diameter cable of millimeter range (i.e. sample 2). The flow diagram of the image processing method is shown in Fig. 9.

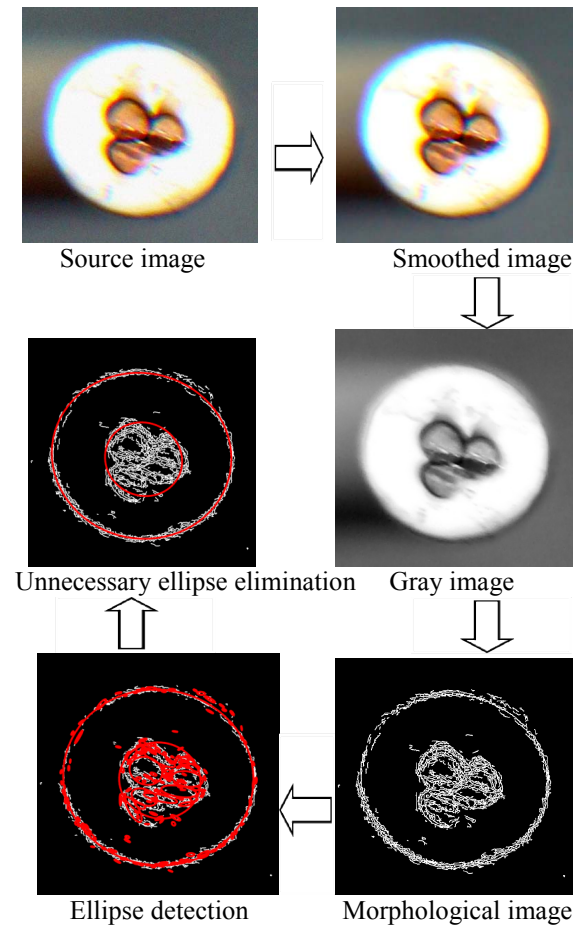


Fig. 9: Diameter Measurement of a cable using proposed image processing technique (sample 2).

For the sample-2, the following measurements are noted: M.S.R = 3mm, V.C= 0.05mm, V.S.R = 4. Hence, total diameter = $(3 + 4 \times .05) = 3.2$ mm. System calibration constant is measured as, $k = d / d_{\text{pixel}}$. Here, $d = 3.3$ mm and $d_{\text{pixel}} = 314$ mm. Thus, $k = 0.01050955414$. This calibration constant is used in our program to measure the diameters of different layers. The measurement is shown in Table 4.

Table 4: Conventional method and proposed method for cable diameter measurement (sample 2).

Inner Layer(diameter)			Outer Layer(diameter)		
Vernier measurement (mm)	Average Value (mm)	Proposed Method (mm)	Vernier measurement (mm)	Average Value	Proposed Method (mm)
1.4 1.38 1.35 1.35 1.45 1.25	1.36 3	1.366	3.2 3.1 3.2	3.167	3.173

From Table 4, the outer diameter is found 3.173mm in our method, whereas in classical method it is found 3.167mm. The percentage error is 0.19%. Similarly, the inner diameter is found 1.366mm in our proposed method, whereas it is 1.363mm by classical method. Here the percentage error is only 0.22%. Therefore, the observed result is better enough for measuring the cable physical parameter. From the above inner and outer diameter we can easily determine the cable physical parameter.

From above results, our work shows a better performance than the conventional method. The limitation of the proposed work includes the use of gray image as the input since we can get almost similar gray images from different color images and canny edge detector uses only gray image as input.

5. CONCLUSIONS

In this paper, we introduced a new procedure for measuring cable diameter using morphological operation and ellipse fitting method. Ellipse fitting method provides rapid action and improves performance. By using this method anyone hopefully get better result than other previous method. It provided greater flexibility and required less time than other conventional method. Diameter can be measured for several circular layers of any

wire and we achieved higher degree of automation. This method can be used for determining very small diameter of any cable. In this paper, we measured the circular diameter of cable insulation layer for electric and optical cables using image processing techniques. In most cases, the error is not greater than 0.5%. The system makes use of high definition digital camera with USB interface without any additional acquisition card. Our future plan is to use canny algorithm for color image, which will give more accuracy

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STEADY STATE ANALYSIS OF A CCI-FED INDUCTION MOTOR DRIVE WITH FIELD ORIENTATION CONTROL

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Abstract- A definite relation exists between the flux level, torque and slip speed of a vector controlled induction motor drive. An untuned vector controller generates an inappropriate slip frequency that changes the operating flux of the machine. This affects the electromagnetic torque linearity and steady state performance including excess energy loss of the drive system. Proper selection of the magnetizing level reduces the energy loss as well as improves the steady state performance of the machine. This paper presents an analysis of field orientation controlled induction motor drive under steady state conditions. A power loss model of the induction motor is developed to select magnetizing level of the motors. Linear model of the induction motor with constant nominal parameters and nonlinear model with magnetic saturation by variable magnetizing inductance are considered in the analysis. The magnetizing inductance is expressed as a polynomial for a more realistic representation of a saturated induction machine. It is observed that the d-and q- axes current components affect the performance of the motor. This study also considers the effects of changes in machine variables and parameters on torque and speed response and power losses.

Key words: Steady state; field orientation control; flux level; minimum loss; magnetic saturation.

1. INTRODUCTION

Induction motors have been used as work horse of industries for a long age due to their inherent constructional advantages. The motor has a complex structure comprising of mutually coupled magnetic and electric circuits. When the stator coils are excited by balanced electrical source, flux produced in the stator core sweeps past to the rotor core. The mutual flux system is common to coils both in stator and rotor and is responsible for the effective operation of the motor. The leakage flux is responsible for causing voltage drop in the coils. Due to mutual coupling between stator and rotor coils, rotor receives power by induction. Like dc motor in an induction motor it can be assumed that the flux of rotor and perpendicular mmf in the stator or vice versa generates the electromagnetic torque. Other viewpoint assumes power developed in the rotor resistance as a measure of torque expressed in synchronous watts.

The performances of field-oriented induction motors with magnetic saturation have been reported in the literatures (Levi and Vuckovic, 1989, Vas

and Alakula, 1990, Krishnan and Doran, 1987, Lorenz and Novotny, 1990). The d-q dynamic linear model of the field oriented induction motor drive has been extended to include the influence of saturation effects of the magnetizing flux linkage in (Levi and Vuckovic, 1989). In (Vas and Alakula, 1990), a model of the field oriented induction motor in the space-vector formulation is used to study the drive dynamic performance in the field weakening region. The influences of changes of the magnetizing inductance and rotor resistance on drive performances are the subjects of the publications in (Krishnan and Doran, 1987, Lorenz and Novotny, 1990). In (Ojo and Vipin 1990), the researcher takes a different analytical approach to consider the simultaneous effects magnetizing inductance and rotor resistance variations due to temperature changes simultaneously. The effects of magnetic flux saturation on the performance of a current regulated field oriented induction motor drive in analytical form are shown in (Ghosh and Bhadra, 1997). Flux saturation also degrades the steady state performance of the induction motor drive due to the increased core losses. A study of

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the nature of copper and core loss components reveals that their trends conflict when the core loss increases, the copper loss tends to decrease. However, for a given load torque, there is an air-gap flux density at which the total loss is minimized. Hence, an electrical loss minimization process ultimately comes down to the selection of the appropriate operating air-gap flux density. Many researchers analyzed the effects of selecting flux level for minimizing the losses. They have established different loss models of induction motor. The model based controller computes losses by using the machine model and selects a flux level that gives minimum losses (Kirschen et. al., 1985, Lim and Nam, 2004, Dong and Ojo, 2006, Sul and Park, 1988) neglecting the leakage fluxes. A new power loss model of the induction motor based on constant parameters is proposed in (Nasiruddin and Nam, 2008). The analyses are equally applicable to current source or voltage source inverter fed induction motor drives.

This paper endeavors to develop constant parameter and magnetic saturation based mathematical models of the induction motors to study the steady state performances of induction motor drives under parameter deviation conditions. It considers variations in current along reference axes to deduce the machine characteristics for different operating and parameter deviation conditions. Steady state speed response under parameter deviation conditions are also considered in the analysis maintaining the power loss in the motor is minimum.

2. MATHEMATICAL MODELING

Under the usual assumptions, an induction motor in terms of d-q synchronous reference frame variables is expressed in steady state conditions as (Garces, 1980):

$$v_{ds} = R_s i_{ds} - L_s \omega_e i_{qs} - L_m \omega_e i_{qr} \quad (1)$$

$$v_{qs} = \omega_e L_s i_{ds} + R_s i_{qs} + L_m \omega_e i_{dr} \quad (2)$$

$$T_e = Jp \omega_m + B \omega_m + T_L \quad (3)$$

$$T_e = (3/2)P_p L_m (i_{qs} i_{dr} - i_{ds} i_{qr}) \quad (4)$$

Where,

v_{ds} and v_{qs} = the dq-axis stator voltages; i_{ds} and i_{qs} = the dq-axis stator currents; R_s and R_r = the stator and rotor resistances; L_s and L_r = the stator and rotor leakage inductances; L_m = the mutual

inductance; ω_m = the angular speed of the motor; $\omega_{sl} (= \omega_e - \omega_r)$ = the slip angular speed; T_e = the developed torque; T_L = the load torque; J = the moment of inertia; B = the rotational damping coefficient; P_p = the number of pole pairs; $p \equiv d/dt$.

The current components along the reference axes are:

$$\begin{aligned} i_{ds} &= i_s \cos \theta \\ i_{qs} &= i_s \sin \theta \end{aligned} \quad (5)$$

If the field orientation is established, q-axis rotor flux is forced to set zero by aligning d-axis along the rotor flux. With this, the following important relations are obtained:

$$\psi_r = \psi_{dr} = L_m i_{ds} \quad (6)$$

$$\omega_{sl} = \frac{1}{\tau_r} \frac{i_{qs}}{i_{ds}} \quad (7)$$

$$I_{qr} = -\frac{L_m}{L_r} i_{qs} \text{ and } i_{dr} = 0 \quad (8)$$

$$T_e = (3/2)P_p \frac{L_m}{L_r} \psi_{dr} i_{qs} \quad (9)$$

Where, $\tau_r (= L_r / R_r)$ is the time constant of the rotor. Hence, only q-axis stator current controls the developed electromagnetic torque if rotor flux is maintained constant.

3. ANALYSIS OF MAGNETIZATION CHARACTERISTICS

A proper magnetic model of the machine is required to have an exact idea about the performance of the IM drives. This study considers nonlinear magnetizing inductances to represent the induction motors with saturation. From the experimental data the true magnetization characteristic can be evaluated (Ghosh and Bhadra, 1997, Bhadra, 1982). If V be the applied rms voltage to an IM, the mutual flux linkage can be written as:

$$\psi_m = \frac{\sqrt{2}V}{\omega_e} = f(i_{mag}) \quad (10)$$

To obtain the above characteristic, the machines under test were driven at synchronous speed by an auxiliary motor and the stator was supplied from a constant frequency variable voltage source. From the recorded ammeter, voltmeter and wattmeter data after subtracting the stator resistance and leakage-reactance drops, the magnetizing

inductances are shown in Fig. 1 for a squirrel cage induction motor (SCIM). All necessary information of the motor including nominal parameters in table 1 is given in the Appendix.

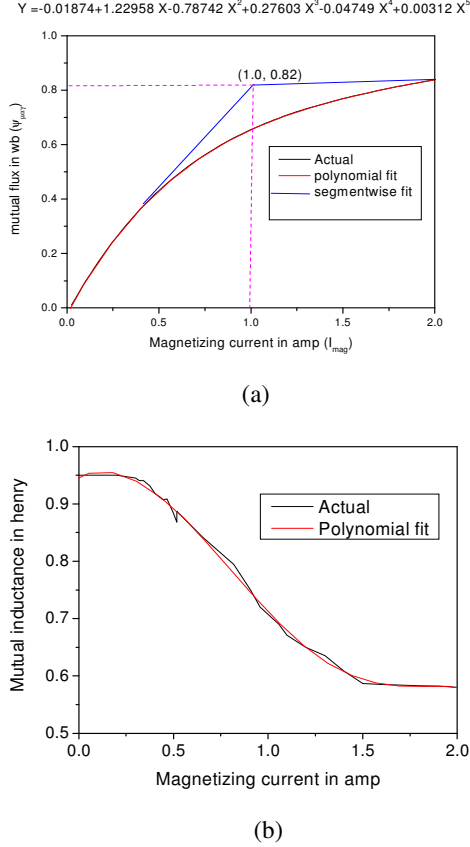


Fig. 1: Magnetization characteristics (a) true saturation characteristic and (b) magnetizing inductance.

4. POWER LOSS MODEL OF INDUCTION MOTOR

The total power loss model is developed based on (Nasiruddin and Nam, 2008) as follows:

$$R'_r = \left(\frac{L_m}{L_r}\right)^2 R_r \quad (11)$$

$$L'_s = \sigma L_s \quad (12)$$

$$L'_m = (1 - \sigma) L_s \quad (13)$$

$$R_t = R'_r \parallel R'_f \quad (14)$$

$$R_d = R_s + \frac{(\omega_r L'_m)^2}{R'_f + R'_r} \quad (15)$$

$$R_q = R_s + R_t \quad (16)$$

$$P_{loss, total} = R_d i_{ds}^2 + R_q i_{qs}^2 \quad (17)$$

Study on total power loss by varying the d-axis stator current for different torque output was carried out with and without considering saturation and shown in Fig. 2. It is shown that for constant current operation at lower value of i_{ds} the total power loss is higher. The loss decreases exponentially and reaches at minimum around $i_{ds} = 0.8$ A. So, by controlling the i_{ds} the loss in IM can be controlled.

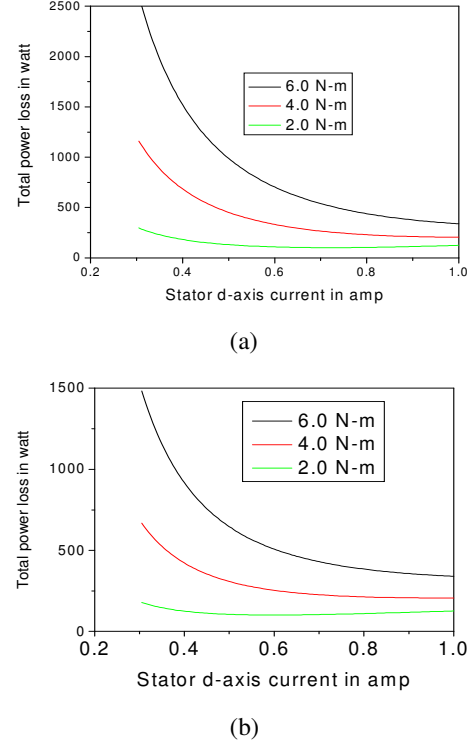


Fig. 2: Variations of total power loss with I_{ds} for different motor torques considering (a) without saturation (b) with saturation.

5. STEADY STATE ANALYSIS

For current controlled drives, the input current to the stator is considered as control variable. This current may be analyzed to the components along the field axis, i_{ds} and perpendicular to field axis, i_{qs} . These current components are internally related to each other and generate magnetizing current i_m as follows:

$$i_m^2 = (i_{ds} + i_{dr})^2 + (i_{qs} + i_{qr})^2 \quad (18)$$

Using (7) the current components along d-axis and q-axis under the field orientation is:

$$i_{ds} = \frac{R_r i_{qs}}{L_r \omega_{sl}} \quad (19)$$

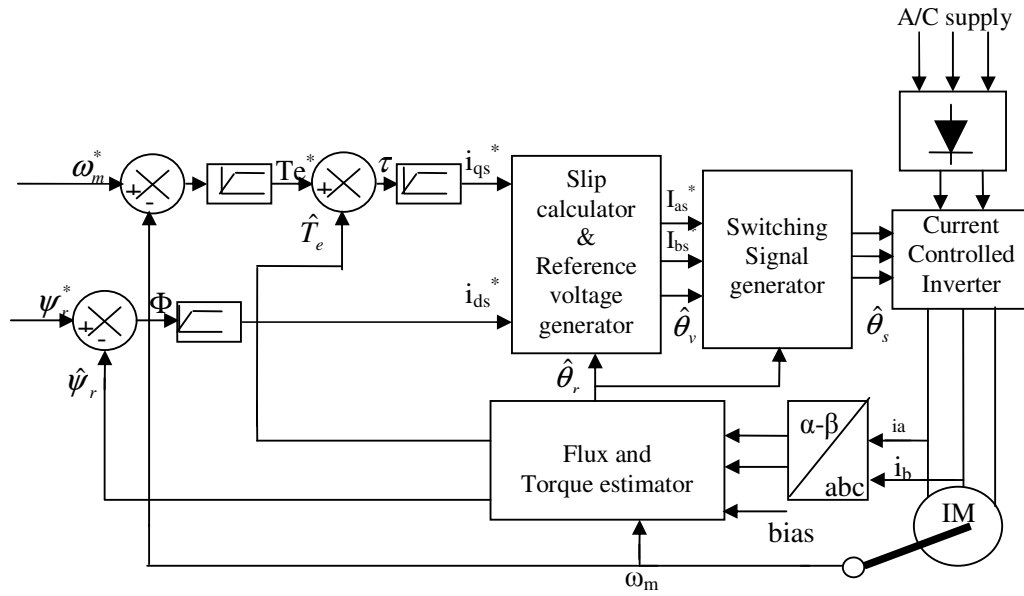


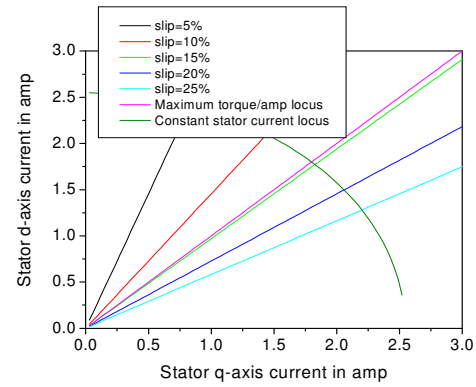
Fig. 3: Proposed IM Drive System

A control scheme to produce the reference current components and actual phase currents are shown in Fig. 3. A plot of i_{qs} versus i_{ds} along with $i_s^2 = i_{ds}^2 + i_{qs}^2$ for different slip speeds with field orientation and nominal parameters is shown in Fig. 4(a). It is evident that slip plays a vital role to correlate the current components along synchronous d-and q- axes. Maximum torque per ampere curve implies $i_{ds} = i_{qs}$ and shown in Fig. 4(a). In Fig. 4(b), the exponentially decreasing characteristics indicate slip speed variation and the inverted characteristics indicate stator q-axis current variation both with respect to stator d-axis current.

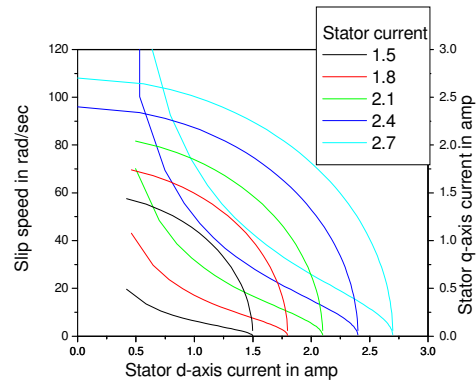
The electromagnetic torque developed by the IM under field orientation can be written as:

$$T_e = \frac{3}{2} P_p \frac{L_m^2}{L_r} i_{ds} i_{qs} \quad (20)$$

Considering nominal parameters, the torque characteristics as a function of i_{qs} satisfying $i_s^2 = i_{ds}^2 + i_{qs}^2$ are shown in Fig. 5(a) increases from zero reaches a maximum and then decreases again to zero. The family of curves is due to different values of i_s as shown in the figure. It can be shown that the maximum value of electromagnetic torque is proportional to i_s^2 . The magnitude of stator current i_s and its components d- and q- axis play



(a)



(b)

Fig. 4: (a) Steady state characteristic of d- & q- axis stator currents for different slip speeds with field orientation and nominal parameters (b) Slip speed and q-axis current as function of d-axis current for different stator input current.

role in torque generation as indicated in (20). Fig. 5(b) shows the variation of d- and q-axis components of stator current to produce electromagnetic torques of different percentage of rated torque as a function of stator q-axis current.

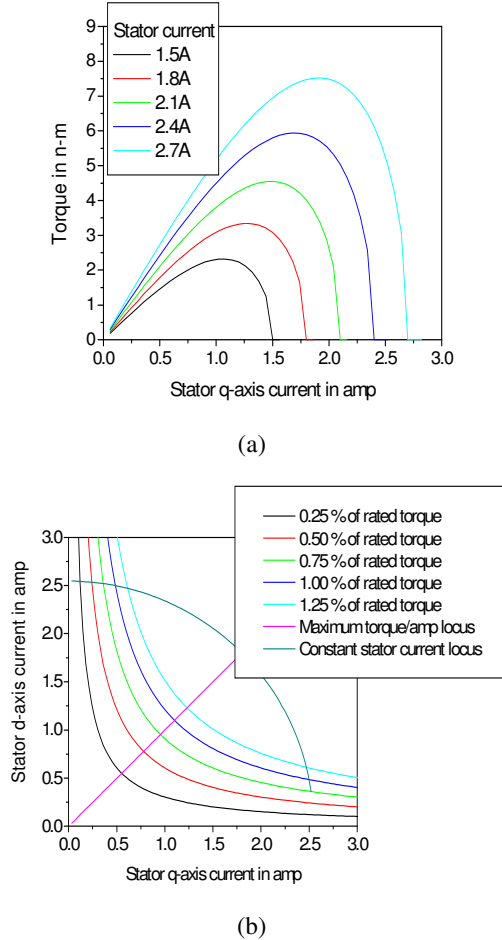


Fig. 5: Variations of (a) electromagnetic torque (b) d-axis current as a function of stator q-axis current.

In current controlled drive systems the command d- and q-axis components of currents can be written in terms of stator current vector i_s^* and angle made by it with the d-axis (say φ^*) as:

$$i_{ds}^* = i_s^* \cos \varphi^* \quad (21)$$

$$i_{qs}^* = i_s^* \sin \varphi^* \quad (22)$$

Accuracy of the angle φ^* is required to maintain field orientation condition of the drive system. In the present study the variation of φ $[0.75 \varphi^* - 1.25 \varphi^*]$ is considered to evaluate the ratio of torque which is written as:

$$\frac{T_e}{T_e^*} = \left(\frac{L_m}{L_m^*} \right)^2 \frac{L_r}{L_r^*} \frac{\sin \varphi \cos \varphi}{\cos \varphi^* \sin \varphi^*} \quad (23)$$

Here L_m and L_r are calculated from saturation model and L_m^* and L_r^* are nominal values and are constants. The variations of ratio of torque (T_e/T_e^*) as function of (φ/φ^*) are shown in Fig. 6. The error in stator current angle with respect to the rotor flux causes inaccurate computation of i_{qs} and i_{ds} . If magnetic saturation model is considered the inductances L_m and L_r change especially for higher values of i_{ds} that causes deviation of developed electromagnetic torque. The characteristics are greatly affected by the differences in the values of command torques. The ratio falls drastically at higher desired reference torque T_e^* , say 6 N-m as the angle ratio is greater than unity. On the other hand, the ratio increases at lower reference torque for the ratio of angles greater than unity. The command torque values are calculated with nominal parameters of the machine. The actual torque values are calculated using magnetic saturation model of the machine. This is why the ratio does not become unity when angle ratio is unity.

Fig. 7 shows the speed response of the current controlled IM under parameter deviation condition. The power loss in IM is ensured to minimum by controlling the i_{ds} at 0.8 A. It is also observed that the speed response with stator resistance deviation is quite acceptable.

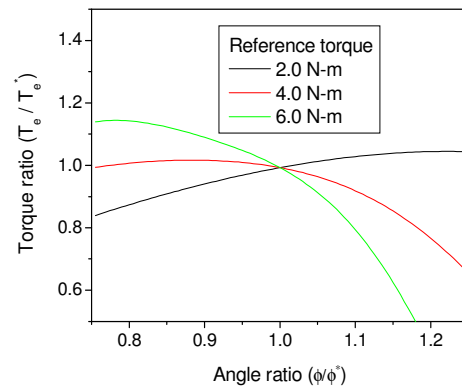


Fig. 6: Effect of current angle error on the motor performance on torque ratio as functions of (φ/φ^*) .

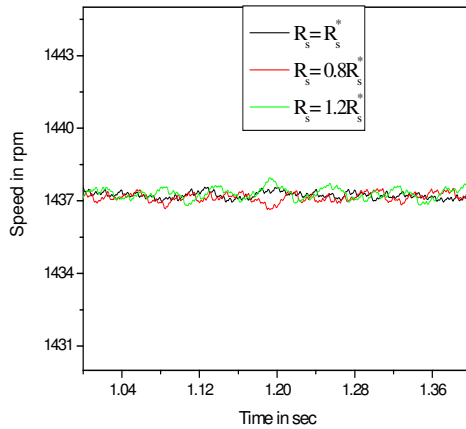


Fig. 7: Simulation on no load speed response with $i_{ds} = 0.8A$.

6. CONCLUSIONS

Steady state analysis of current fed drives to produce electromagnetic torque has been carried out using different viewpoints and considerations. The relations between the d- and q-axis currents are indicated. For field orientation controllers, i_{ds} , i_{qs} , and slip speeds are interrelated. These current components and slip speed affect torque generation. The maximum value of torque is found to appear at equal values of d- and q-axis components of current which can be visualized from Fig. 4(a). The errors in angle calculation for different torque outputs have a tendency to increase with the angle ratio for lower torques. But for high values of reference torque the characteristic is reverse in nature. The speed response of the motor at steady state with stator resistance deviation is found acceptable considering minimum power loss. However, the characteristics provide an idea to select the flux level in a field oriented induction motor controller. Hence, by controlling the flux producing current in IM the generated torque can be maximized and the power loss can be minimized.

APPENDIX

Name plate data: 3-phase; 415V; 1.8A; 1 hp; 50 Hz; 4-pole; Y-connected.

Parameters:

Stator resistance, $R_s = 13.25 \Omega$

Rotor resistance, $R_r = 16.818 \Omega$

Mutual inductance, $L_m = 0.7114 \text{ H}$

Stator self inductance, $L_s = 0.7359 \text{ H}$

Rotor self inductance, $L_r = 0.7359 \text{ H}$

Moment of inertia, $J = 0.0075 \text{ Kg-m}^2$

Damping coefficient, $B = 0.00107 \text{ Nm-sec/rad}$

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Structural properties and temperature dependence of resistivity of pure Co material deposited Co/Si(001) and Co/glass thin films

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Cobalt (Co) thin films have been prepared by e-beam evaporation technique on glass, Si(001) and GaAs(001) substrates at a pressure of about 2×10^{-4} Pa. The thickness of the films 100 nm. The deposition rate of the films was about 0.93 nms^{-1} . The as-deposited films have been annealed in open air for 4 hours at constant temperature of 523 K. X-ray diffraction (XRD) study reveals that 100nm Co films on glass substrate are microcrystalline in nature. Scanning Electron Microscopy (SEM) study of 100nm Co films on silicon and glass substrates indicate that there are no sign of grains in as-deposited films, and the surfaces are almost smooth and homogenous while they are seen to exhibit a number of grains in the films after annealing and the surfaces become rough. The elemental compositions of 100nm Co films on silicon and glass substrates have been estimated by Energy dispersive analysis of x-ray (EDAX) study. After a series of successive heating and cooling cycles of as-deposited films, the resistivity curves remain almost constant, this indicates the stabilization of the sample structure in the temperature range studied. These studies may be of importance for the application of this material in electronic and magnetic storage devices. Co thin films have been produced by electron beam bombardment heating technique and thickness measures in Fizeau fringes method. Electrical resistivity are measured Van-der-Pauw technique.

Key words: Resistivity, Homogenous, Microcrystalline, Atomic weight, Amorphous.

1. INTRODUCTION

The Co and Co-based thin film structures have attracted interest of several researchers in recent years due to their possible applications in many areas of technology, such as magnetic data storage, spin valve and microelectronic devices [1–3]. Recently, the area of growth of magnetic thin films on compound semiconductor substrates is being developed as being interesting from both the scientific and technological points of view in connection with spintronics [4–6]. Study of metal silicides has been a topic of intense basic and technological interest because of their potential applications in semiconductor industry as Schottky barriers, gates, Ohmic contacts, etc. [7-8]. The effect of silicide formation on the generation and the removal of defects is an important issue for better understanding of the mechanism concerning silicide formation. Wen et al. [9], through electrical measurements, reported that the implantation induced interstitials in Si were totally eliminated through the formation of Titanium Silicide (TiSi₂) by the injection of vacancies. Similarly, silicidation

reactions of metals on Si implanted with various species were also investigated [10] and it was found that the complete annihilation of implantation induced defects depends critically on the distance between the silicide/Si interface, the location of the original amorphous/crystalline interface, the annealing temperature, time etc.

2. DISCUSSION AND RESULTS

The SEM micrograph of as-deposited and annealed Co thin films of thickness 100nm on the silicon substrate and glass substrate are shown in Fig. 1,2, 3 and 4[11]. The SEM images are also shown that there are no remarkable grains and impurities for the annealed Co films [12-14]. So, the surface study of as-deposited Co thin film on the silicon substrate exhibits very good smooth and homogeneous nature throughout the entire surface. The surface study of as-deposited Co film on the glass substrate exhibits smooth and homogeneous nature throughout the entire surface. Then the surface studies of annealed Co films on the silicon substrate and glass substrate do not exhibit smooth and

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homogeneous nature throughout the entire surface.

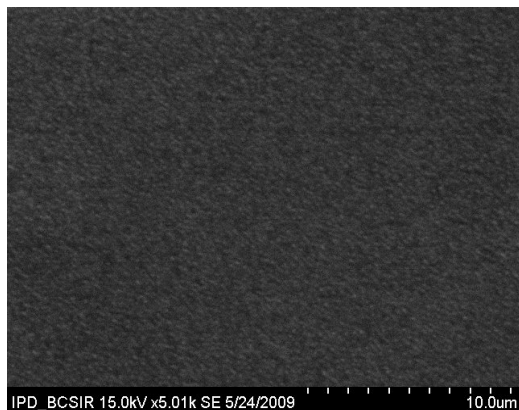


Fig.1 SEM image of 100nm as-deposited Cobalt thin films on Silicon substrate.

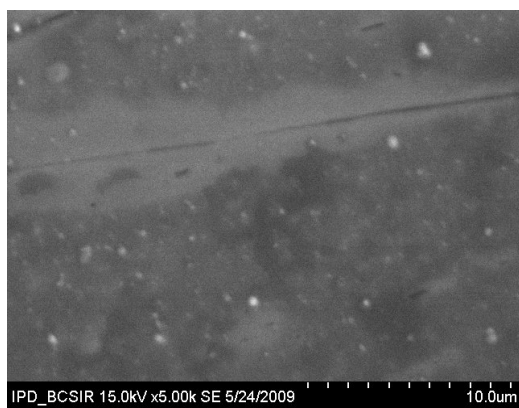


Fig.2 SEM image of 100nm annealed Cobalt thin films on Silicon substrate.

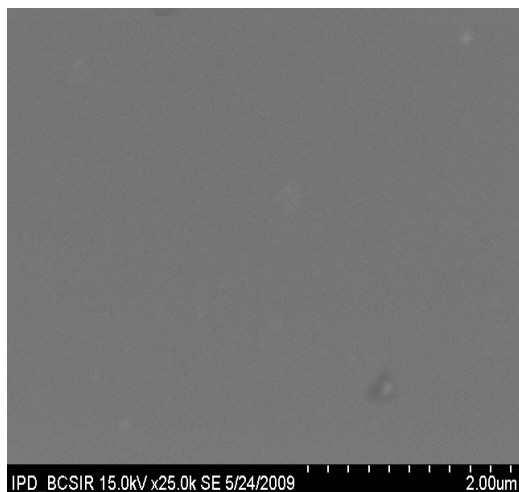


Fig.3 SEM image of 100nm as-deposited Cobalt thin films on Glass substrate.



Fig.4 SEM image of 100nm annealed Cobalt thin films on Glass substrate.

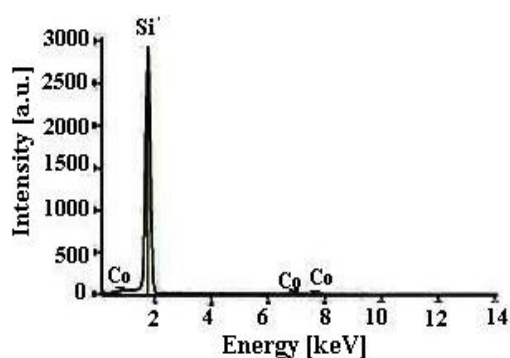


Fig.5 EDX image of as-deposited Cobalt thin film 100nm of Silicon substrate.

The EDX image of as-deposited 100nm Co films on silicon substrate is shown in Fig. 5. It is seen that the intensity of peaks is very high. This peak is from silicon substrate. On the other hand the intensity for Co is low. This is due to the fact that the volume of the Co materials in the exposed area was less than that of silicon material. Only two peaks (one for Si and other for Co) indicate that there are no impurity atoms in the as-deposited film. After annealing, the EDX image of 100nm Co films on silicon substrate is shown in Fig. 6. Extra one peak oxygen is seen. The atomic weight of Co and Si is shown in tables-1 and 2 [15].

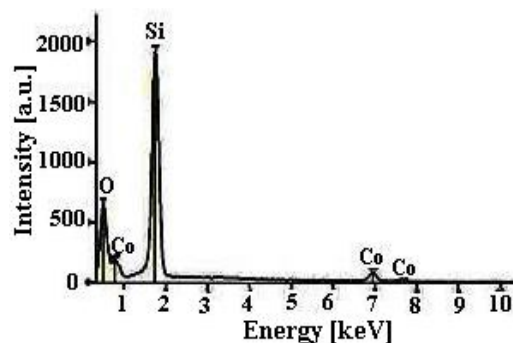


Fig.6 EDX image of annealed Cobalt thin film 100nm of Silicon substrate.

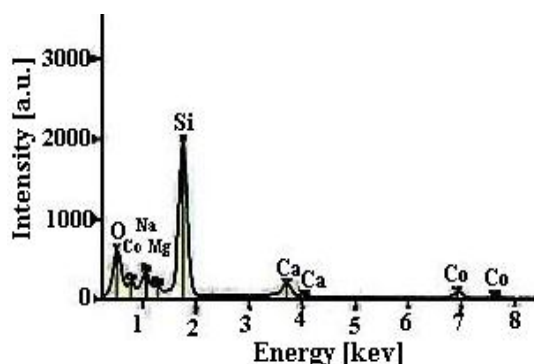


Fig.7 EDX image of as-deposited Cobalt thin film 100nm of Glass substrate.

The EDX image of as-deposited 100nm Co films on glass substrate is shown in Fig. 7. The EDX image shows many peaks. The peaks are from silicon(Si), oxygen(O), sodium(Na), magnesium(Mg), calcium(Ca) and cobalt(Co). The origin of these peaks is the glass substrate. On the other hand the intensity for Co is low. This is due to the fact that the volume of the Co materials in the exposed area was less than that of glass material. After annealing, the EDX image of 100nm Co films on glass substrate is shown in Fig. 8. The atomic weight of Co, Si, Ca, Mg, Na and O is shown in tables-3 and 4.

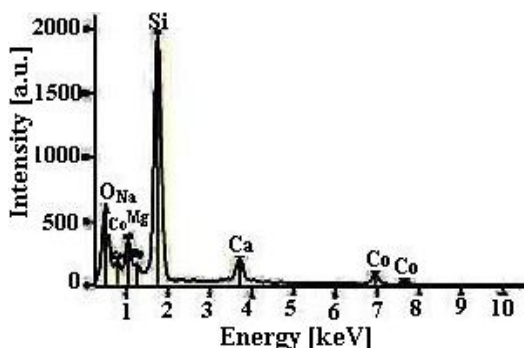


Fig.8 EDX image of annealed Cobalt thin film 100nm of Glass substrate.

Table 1. Elemental composition of as-deposited Co thin film on silicon substrate.

Element	Net Counts	Weight %	Weight % Error	Atom %	Atom % Error
Si	54128	98.25	+/- 0.78	99.16	+/- 0.79
Co	122	1.75	+/- 0.57	0.84	+/- 0.28
Total		100.00		100.00	

Table 2. Elemental composition of annealed Co thin film on silicon substrate.

Element	Net Counts	Weight %	Weight % Error	Atom %	Atom % Error
O	11121	48.26	+/- 1.24	65.18	+/- 1.67
Si	34827	39.32	+/- 0.43	30.26	+/- 0.33
Co	1709	12.42	+/- 0.67	4.55	+/- 0.25
Total		100.00		100.00	

Table 3. Elemental composition of as-deposited Co thin film on glass substrate.

Element	Net Counts	Weight %	Weight % Error	Atom %	Atom % Error
O	10509	43.18	+/- 1.10	59.91	+/- 1.53
Na	3069	6.36	+/- 0.25	6.14	+/- 0.24
Mg	559	0.63	+/- 0.12	0.58	+/- 0.11
Si	34707	32.85	+/- 0.35	25.96	+/- 0.28
Ca	3305	5.75	+/- 0.35	3.18	+/- 0.19
Co	1905	11.22	+/- 0.84	4.23	+/- 0.32
Total		100.00		100.00	

Table 4. Elemental composition of annealed Co thin film on glass substrate.

Element	Net Counts	Weight %	Weight % Error	Atom %	Atom % Error
O	10536	43.65	+/- 1.11	60.13	+/- 1.54
Na	3113	6.36	+/- 0.58	6.10	+/- 0.56
Mg	574	0.64	+/- 0.13	0.58	+/- 0.12
Si	35419	33.35	+/- 0.35	26.17	+/- 0.28
Ca	3391	5.91	+/- 0.35	3.25	+/- 0.19
Co	1712	10.10	+/- 0.83	3.78	+/- 0.31
Total		100.00		100.00	

Fig. 9 presents the XRD patterns of 100nm as-deposited and annealed Co thin films. The XRD patterns corresponding to as-deposited film shows a remarkable peak around $2\theta=44^\circ$ indicating that the as-deposited Co film is mostly microcrystalline in nature [16]. XRD patterns of 100nm Co thin film annealed at 250°C for 4 hours show microcrystalline nature. According to XRD results the Co thin films are hexagonal-close-packed (hcp) system. The d_{hkl} values are calculated from the intensity peak of the XRD spectra for Co thin films. The comparison between observed d_{hkl} values and the standard d_{hkl} values yields (hkl) values from the standard ASTM Card# 00-01-1294 [17]. The (hkl) values are tabulated in Table-V. Its pattern shows the hcp crystal structure. Its pattern corresponding to this closely matches with highly oriented cobalt film in (002) plane [18-20].

Table 5. Data for Co thin films

d_{hkl} (observed) [Å]	d_{hkl} (ASTM Card# 00-01-1294) [Å]	hkl	Status
2.05799	2.04	002	As-deposited Annealed

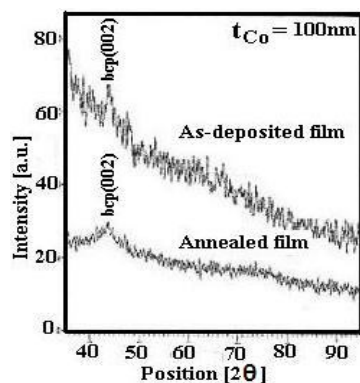


Fig.9 XRD patterns of 100nm as-deposited and annealed Co thin films on glass substrate.

Variation of resistivity with temperature for a typical undoped Co sample of 100nm thickness deposited on the silicon substrate as shown in Fig. 10. As observed in the Fig. 10, the heating and cooling are almost reversible after four cycles of operation in the investigated temperature range. The heating and cooling rate was so manually maintained that it keeps a 4K/min for each operation with a 9 min of interval in between the cycles. During the first step of the heat treatment, Co thin film shows increase in resistivity in the temperature range. In Fig. 10, AB shows the first heating cycle, which represents the increasing of resistivity up to 473K. BC represents the first cooling cycle in air. In cooling cycle, it is observed that the resistivity decreases with decreasing temperature but does not follow the heating cycle BA. It is also noticed that in cooling cycle, the resistivity shows slightly an upward tendency that is negligible and after 9min of interval in between the cooling of first and heating of second cycle, the resistivity is approximately the same point to C.

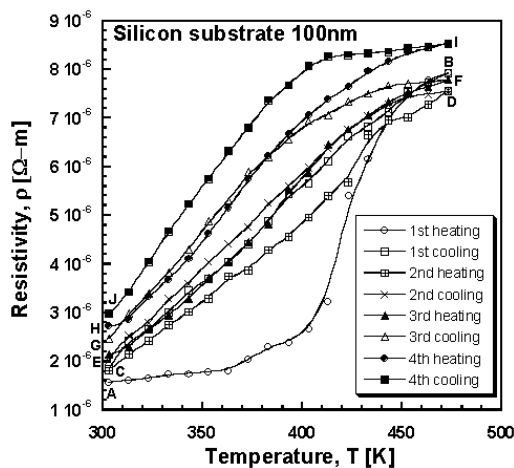


Fig.10 Resistivity vs. temperature curves for a 100nm thick undoped Co thin film on silicon substrate.

During the second step of the heat treatment, Co thin film shows a sharp increase in resistivity in the temperature range. In Fig. 10, CD shows the second heating cycle, which represents the increasing of resistivity up to 473K. The second heating cycle, CD goes below the first cooling cycle, CB. DE represents the second cooling cycle in air. In cooling cycle, it is observed that the resistivity decreases with decreasing temperature but does not follow the heating cycle DC. It is also noticed that in cooling cycle, the resistivity shows slightly an upward tendency that is negligible and after 9min of interval in between the cooling of second and heating of third cycle, the resistivity is approximately the same point to E.

During the third step of the heat treatment, Co thin film shows a sharp increase in resistivity in the temperature range. In Fig. 10, EF shows the third heating cycle, which represents the increasing of resistivity up to 473K. FG represents the third cooling cycle in air. In cooling cycle, it is observed that the resistivity decreases with decreasing temperature but does not follow the heating cycle EF. It is also noticed that in cooling cycle, the resistivity shows slightly an upward tendency and after 9min of interval in between the cooling of third and heating of fourth cycle, the resistivity drops to G from H.

During the fourth step of the heat treatment, Co thin film shows a sharp increase in resistivity in the temperature range. In Fig. 10, HI shows the second heating cycle, which represents the increasing of resistivity up to 473K. IJ represents the fourth cooling cycle in air. In cooling cycle, it is observed that the resistivity decreases with decreasing temperature but does not follow the heating cycle HI. Heating and cooling effect observed that fourth cycle resistivity is higher than others cycle.

At the time of heat-treatment in air, it seems that in the virgin state of the film, these molecules have an empirical binding energy which is then supplied to the sample in post deposition. This type of observation is also noted in Zing Oxide (ZnO) and Indium Oxide (In_2O_3) films [21-23]. It may be mentioned that the sample Co was the as-deposited on the silicon substrate.

3. CONCLUSION

The XRD patterns corresponding to as-deposited film shows a remarkable peak around $2\theta=44^\circ$. XRD results the Co thin films are hcp system. Its pattern corresponding to this closely matches with highly oriented cobalt film in (002) plane. XRD study reveals that 100nm Co films on glass substrate are

microcrystalline in nature. SEM study of 100nm Co films on silicon and glass substrates indicate that there are no sign of grains in as-deposited films, and the surfaces are almost smooth and homogenous while they are seen to exhibit a number of grains in the films after annealing the surfaces become rough. The elemental compositions of 100nm Co films on silicon and glass substrates have been estimated by EDAX study. The EDX image of as-deposited 100nm Co films on glass substrate is peaks from silicon(Si), oxygen(O), sodium(Na), magnesium(Mg), calcium(Ca) and cobalt(Co). On the other hand the intensity for Co is low. This is due to the fact that the volume of the Co materials in the exposed area was less than that of glass material. The EDX image of as-deposited 100nm Co films on silicon substrate peak is very high. On the other hand the intensity for Co is low. This is due to the fact that the volume of the Co materials in the exposed area was less than that of silicon material. The interfacial resistance (IR) at the Co/glass interface is zero.

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TRANSCIEVER CIRCUITS FOR PULSE BASED ULTRA WIDEBAND

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Abstract—Despite the fact ultra-wideband technology has been around for over 30 years, there is a newfound excitement about its potential for communications. In this paper we is specifically focused on a software radio transceiver design for impulse-based UWB with the ability to transmit a raw data rate of 100 Mbps yet encompasses the adaptability of a reconfigurable digital receiver. Here we introduce a transmitter and receiver of pulse based ultra wideband modulation. Direct sequence spread spectrum has become the modulation method of choice for wireless local area networks, and personal communication systems, because it's numerous advantages such as jammer suppression, code division multiple access, and ease of implementation. Spread spectrum systems are most favourable for indoor communication needs and digital radio links, where most of the applications are found. We also observe its characteristics and complete the modulation techniques. The latter includes bit error rate testing for a variety of modulation schemes and wireless channels using a pilot-based matched filter estimation technique. Ultimately, the transceiver design demonstrates the advantages and challenges of UWB technology while boasting high data rate communication capability and providing the flexibility of a research test bed.

Keywords— ultra-wideband (UWB), Direct sequence spread spectrum (DSSS), wireless local area networks (WLAN's), personal communication systems (PCS), code division multiple access (CDMA).

I. INTRODUCTION

Ultra-wideband is a radio technology that can be use at very low energy levels for short-range high-bandwidth communications by using a large portion of the radio spectrum. The concept of UWB was

formulated in the early 1960s through research in time-domain electromagnetic and receiver design, both performed primarily by Gerald F. Ross[1]. Through his work, the first UWB communications patent was awarded for the short-pulse receiver, which he developed while working for Sperry Rand Corporation. Throughout that time, UWB was referred in broad terms as "carrier less" or impulse technology. After that UWB was coined in the late 1980s to describe the development, transmission, and reception of ultra-short pulses of radio frequency (RF) energy. For communication applications, high data rates are possible due to the large number of pulses that can be created in short time duration[2-3]. Due to its low power spectral density, UWB can be used in military applications that require low probability of detection. UWB also has traditional applications in non cooperative radar imaging, target sensor data collection, precision locating and tracking applications. UWB communications transmit in a way that doesn't interfere largely with other more traditional 'narrow band' and continuous carrier wave uses in the same frequency band[4-6]. However first studies show that the rise of noise level by a number of UWB transmitters puts a burden on existing communications services. This may be hard to bear for traditional systems designs and may affect the stability of such existing systems.

In this paper we focused on a software based radio transceiver design for impulse-based UWB with the ability to transmit a raw data rate of 100 Mbps yet encompass the adaptability of a reconfigurable digital receiver. Here we also introduce a transmitter and receiver of pulse based ultra wideband modulation. Direct sequence spread spectrum (DSSS) has become the modulation method of choice for wireless local area networks (WLAN's), and personal communication systems (PCS), because it's numerous advantages, such as jammer suppression, code division multiple access (CDMA), and ease of implementation.

II. SYSTEM MODEL

The designed model for the transceiver is shown in Fig-1, consists of a hierarchical system where blocks represent subsystems and oscilloscopes are placed along the path for display purposes. The DPSK DSSS modulation and dispread techniques are mainly use for

designing the whole transceiver with the exception of receiving the signal using Bi-phase modulation. The design for pulse based UWB is divided into three parts as DSSS DPSK transmitter where transmitter part is separately designed, DPSK DSSS transceiver where received signal has dispread with some propagation

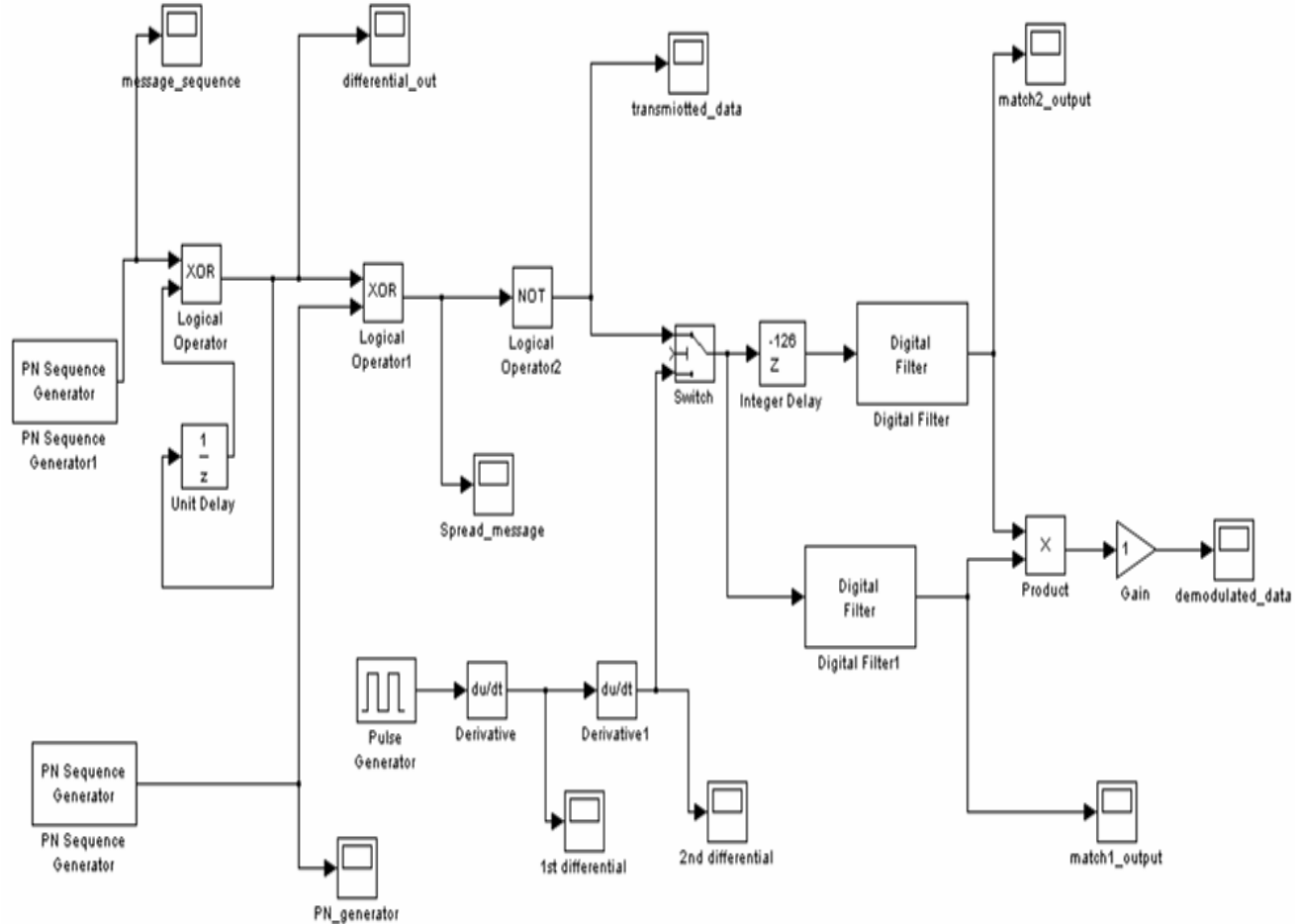


Fig. 1. Simulink model of DPSK DSSS Transceiver.

delay, DPSK DSSS transceiver with Bi-phase modulator and matched filter where original signal has recovered. The data signal, rather than being transmitted on a narrow band as is done in microwave communications, is spread onto a much larger range of frequencies (RF bandwidth) using a specific encoding scheme. This encoding scheme is known as a Pseudo-noise sequence, or PN sequence. Direct sequence spread spectrum has become the modulation method of choice for wireless local area networks, and personal communication systems.

III. DPSK TRANSMITTER

DPSK DSSS transmitter consists of PN Sequence generator which generates a sequence of pseudo random binary numbers

using a linear-feedback shift register, XOR used for mixing data, Unite delay used for delayed data and oscilloscopes are placed along the path for display purposes. Here, PN Sequence generator is used as both generating message and a sequence of pseudo random binary numbers for spreading process. When differentially encoding an incoming message, each input data bit must be delayed until the next one arrives.

The delayed data bit is then mixed with the next incoming data bit. The output of the mixer gives the difference of the incoming data bit and the delayed data bit. The differentially encoded data is then spread by a high-speed pseudo noise sequence (PN). This spreading process assigns each data bit its own unique code, allowing only a receiver with the same spreading to dispread the encoded data. The 63-bit pseudo

noise sequences (PN) used in this papers are generated by a 6th order maximal length sequence is given by,

$$g(x) = x^6 + x^5 + 1 \quad (1)$$

The maximal length spreading sequence uses a much wider bandwidth than the encoded data bit stream, which causes the spread sequence to have a much lower power spectral density. The transmitted signal is then given by,

$$x(t) = m(t) c(t) \quad (2)$$

Where $m(t)$ is the differentially encoded data, and $c(t)$ is the 63 chip PN spreading code. For recovering of message sequence, we XOR the modulated signal with same type of 63-bit pseudo noise sequences (PN). Here we also use a unite delay to find the original signal. The signal recovering process is successfully done with some propagation delay which was obvious because of some noise & losses.

IV. DPSK RECEIVER

Before demodulating the receiving signal is modulated by Bi-phase modulation technique then signal is split into two parallel paths and fed into two identical matched filters with the input to one having a delay of 63 chips. The outputs of the two matched filters are denoted by $x_1(t)$ and $x_2(t)$ and are given by

$$x_1(t) = d(t - t_0) R_c(t) \quad (3)$$

$$x_2(t) = d(t - t_0 - T_b) R_c(t - T_b) \quad (4)$$

Where T_b the data is bit period, and $R_c(t)$ is the autocorrelation function of the 63-chip pseudorandom sequence. Since there are exactly 63 chips per data bit the PN sequence is periodic with T_b so

$$R(t) = R_c(t - T_b) \quad (5)$$

The two outputs of the matched filters are then mixed and then low pass filtered and the original message is recovered

V. RESULTS AND DISCUSSION

Following the analytical approach presented in section III and IV, we evaluate the simulation result of UWB technology. The simulations are performed using matlab, and the proof-of-concept is valid as the BER curves are slightly worse than theoretical values for a perfectly matched receiver due to the imperfections in the template caused by noise and aperture delay variation. Fig. 2 shows the original input message sequence that is generated from a PN sequence generator. Then, the incoming message are differentially encoded by using mixer and unite delay where each input data bit has delayed with Unit delay until the next one arrives where the delayed data bit is then mixed with the next incoming data bit. Fig. 3 shows such a differential output of the original message signal.

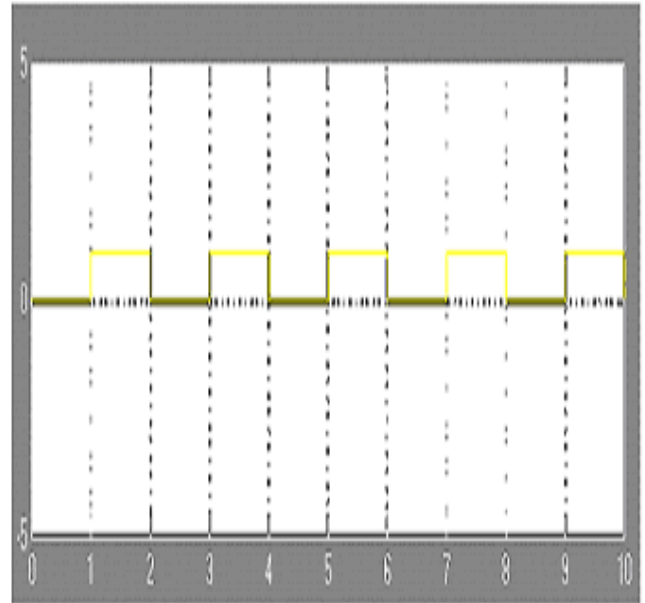


Fig2: Original transmitted message signal.

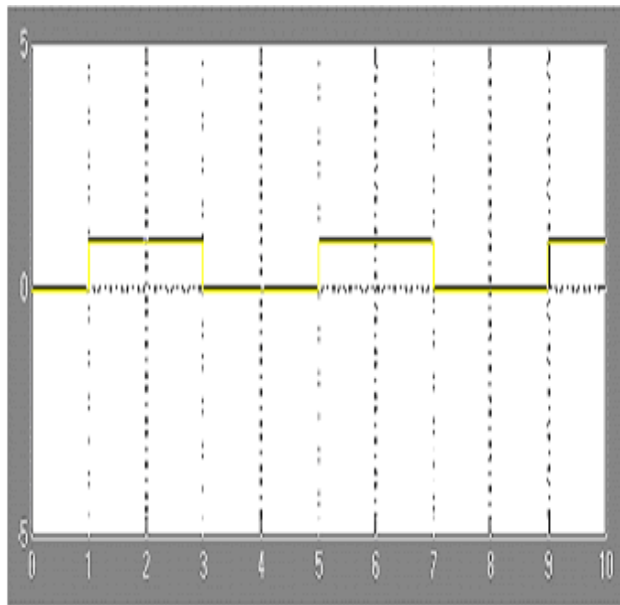


Fig3: Differential output of original message signal.

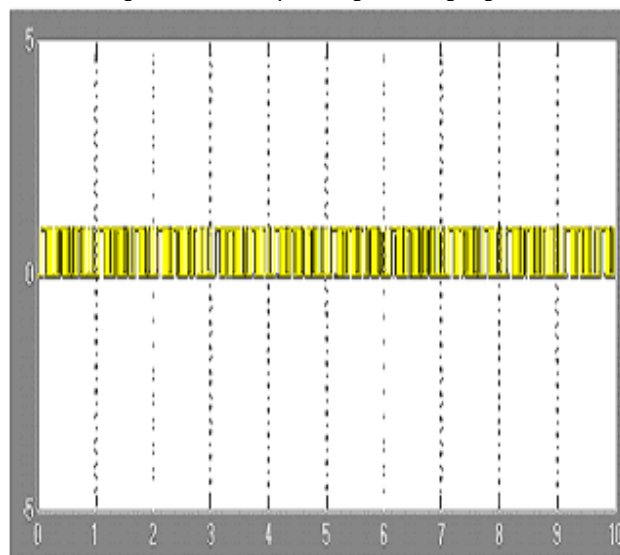


Fig.4 Output waveforms of Simulink DPSK DSSS Transmitter

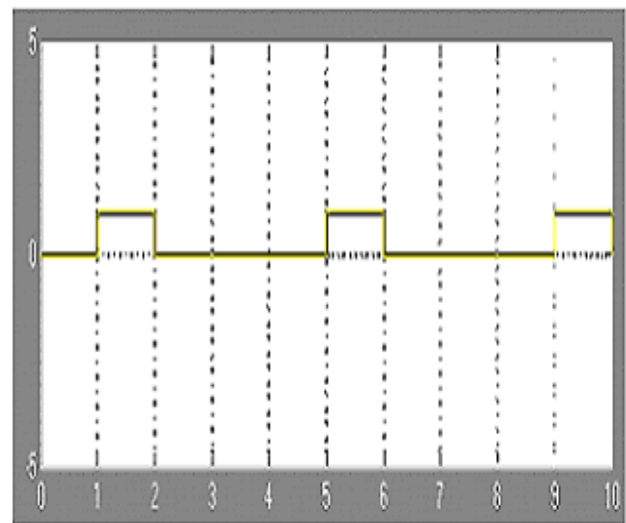


Fig5: Original recovered output signal.

Eventually the mixer will give the difference of the incoming data bit and the delayed data bit. The differentially encoded data is then spread by a high-speed 63-bit pseudo noise (PN) Sequence generator which is generated by a 6th order maximal length sequence. This spreading process assigns each data bit its own unique code which is shown in Fig. 4. , allowing only a receiver with the same spreading to disperse the encoded data.

For recovering of message sequence in the receiving part of DPSK DSSS transceiver, the modulated signal has been disperse using same type of 63-bit pseudo noise sequences and also use a unite delay to find the original signal. The signal recovering process is successfully done with some propagation delay which was obvious because of some noise & losses. Fig. 5 denoted the differential output of receiver side and the recovered messages.

VI. CONCLUSIONS

We have analyzed the performance of UWB technology using Time Hopping (TH) technique. The results from the system simulation were very encouraging for the UWB receiver design presented in this paper. It was also shown by increasing the number of averaged pilot pulses in the pilot-based matched filter template, better performance can be obtained, although the data rate will suffer. Performance for multipath was also examined (albeit for perfect synchronization) and was close to the theoretical values. Finally, use of the template sliding matched filter synchronization routine led to worse BER performance when compared with perfect synchronization results. Although these simulations were specific in terms of data bits and number of multipath, other simulations were successfully run on a smaller-scale varying these two parameters. The results of the system simulation give a solid foundation for the design as a whole, but also will assist in the future with issues such as the implementation of receiver algorithms within the FPGA and determining timing limitations when the receiver is being constructed.

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UNIFIED POWER QUALITY CONDITIONER (UPQC): DEVELOPMENT OF HARDWARE USING FACTS TECHNOLOGY

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Unified Power Quality Conditioner (UPQC), a relatively new device, can be used simultaneously in voltage or current control mode in power distribution system. But development of hardware with appropriate control circuit is a challenging task. In the voltage control mode, the UPQC can force the voltage of a distribution bus to be balanced sinusoids. At the same time it can also control perform load compensation resulting in the drawing of balanced sinusoidal currents from the distribution system bus in the current control mode. In this paper the hardware of the voltage source converter used for UPQC together with details of microcontroller based control philosophy has been presented.

Key words: Flexible AC Transmission Systems, Distribution STATCOM, Power Quality, Unified Power Quality, Voltage Source Converter.

1. INTRODUCTION

The successful development of FACTS devices (Flexible AC Transmission System) is promoting major changes in controlling power flow in the transmission and distribution sectors of electric power utilities [1-4]. The voltage of a line can be controlled by means of a compensator located at the receiver end of the line. The compensator delivers or draws reactive power in order to compensate for the unbalance or distortion. Traditionally, these compensators have been rotating machines or static var compensators that require large capacitors and inductors. Today, it is possible to replace these machines and devices by a switching converter, a dc capacitor, and a group of transformers. This static synchronous compensator (STATCOM), has numerous advantages over previous compensators. First, it acts much faster and can respond to voltage fluctuations in a matter of one cycle. Second, it can generate far more reactive power when the system voltage is low.

In order to maintain constant sinusoidal terminal voltage and to meet reactive power demand of the rapid perturbations in load, feedback control system becomes essential. Recent trends in the development of processor technology and use of

feed back control techniques in power industrial environment have helped in growth of newer types of integrated computer control strategies for utility's voltage control.

FACTS devices are modified to serve in distribution network and, through a modification of a unified power flow controller (UPFC) the unified power quality conditioner (UPQC) [1]. Such solution can solve different power quality problems, such as: sags, swells, voltage imbalance, flicker, harmonics and reactive currents.

UPQC usually consists of two voltage-source converters (VSC) sharing the same capacitive DC link. One of the converters is an active rectifier (AR) while other is a series filter (SF) with a LC ripple filter and transformer isolation from power supply network.

Extensive research has been directed to control the Voltage Source Convert (VSC) through easily available simple microcontroller in the market. In this paper a thorough investigation on the control of a VSC of the UPQC has been presented. The performance results are also presented in the paper.

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2. POWER AND DRIVER CIRCUITS

The power circuit of the VSC is shown in the Fig.1, where RC snubber protections and fuse protections are inserted. Although a DC supply is shown at the left supply in the test circuit, it would be replaced by a suitable capacitor in the practical STATCOM. The three-phase terminals at the right are connected to the supply in parallel and series configurations with a DC link capacitor in between to make a UPQC.

Fig.2 shows the driver circuits for all the IGBT devices shown in Fig.1. Microcontroller generated appropriate pulses are given to the inputs of the optocoupler ICs used as isolation from power circuit to control circuit. The output of the driver circuit is connected to the gate of the respective the IGBT as marked in the figures. The pulses, we get from the microcontroller are not sufficient to run the IGBT. So, these pulses are amplified by the driver circuits.

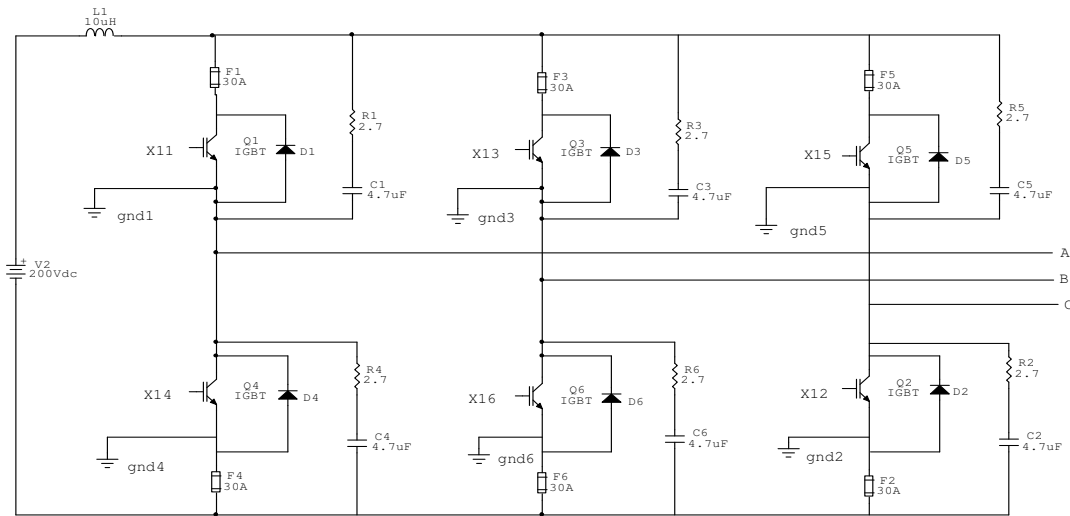


Fig 1 Power circuit with RC snubber and fuse protections

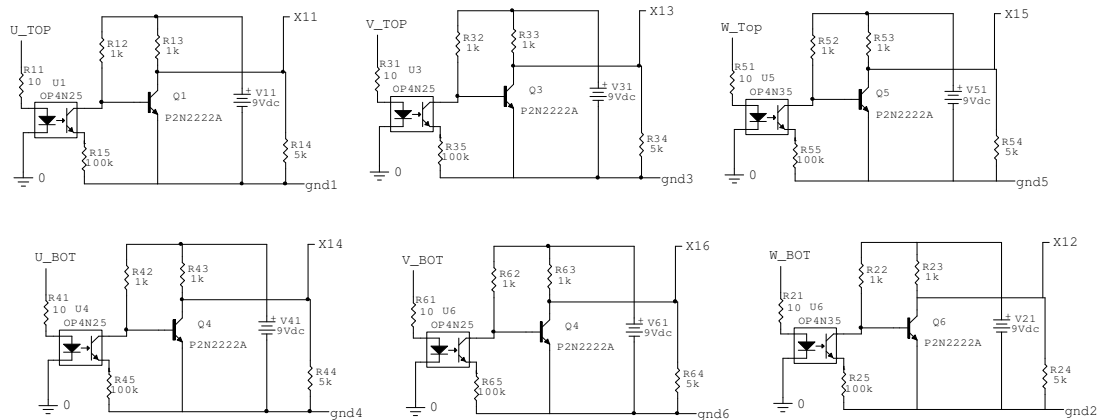


Fig.2 Driver Circuits

3. MICROCONTROLLER BASED CONTROL

For gate pulse generation, easily available popular PIC16F72 microcontroller is used. It belongs to the Mid-Range family of the PIC micro devices. Its program memory contains 2K words, which

translate to 2048 instructions, since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 128 bytes. There are 22 I/O pins that are user configurable on a pin-to-pin basis [5]. Since instruction sets of this microcontroller are unable to efficiently handle mathematical operations common to many algorithms that are repeatedly executed in

time-critical loops, an off-line calculations are made and the data are used for PWM pulse generation. This gives a good experience on using microcontroller based control system. Fig. 3 shows the microcontroller used to interface to the gate drive circuits of Fig.2.

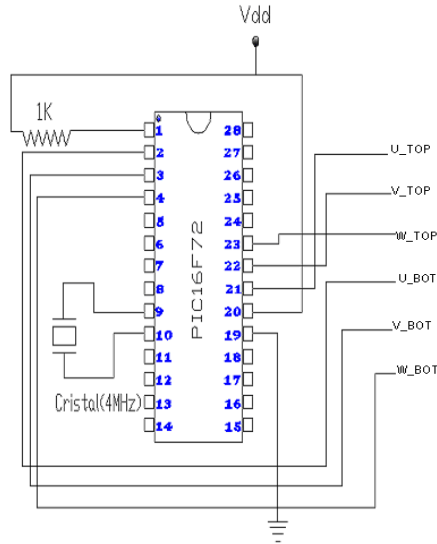


Fig. 3 Connection diagram of PIC16F72 for six phase SPWM signal generation for IGBT gate driver circuit.

4. SPWM SIGNAL GENERATION

4.1 ASSUMPTIONS FOR CALCULATIONS

Let us assume that we have to generate a 50 Hz sine PWM. For this we need a triangular carrier wave with 10 times the frequency of the desired sine wave. For simplicity we denote the factors with some symbols whose are listed below.

V_s = instantaneous voltage of the sine wave

V_m = maximum amplitude of the sine wave

f = frequency of the sine wave (50 Hz)

t = time

T = period of the sine wave (20 ms)

τ = half of the period (10 ms)

V_c = instantaneous voltage of the reference triangular wave

V_{cm} = maximum amplitude of the reference triangular wave

M = modulating index (0.8 is considered here)

4.2 EQUATIONS AND TIME CALCULATION

We have the equation of the sine wave is-

$$V_s = V_m \sin \omega t \quad (1)$$

For determining t_1 according to Fig. 4 we get the equation for straight line containing t_1 is

$$V_c = - \frac{V_{cm}}{\tau/10} (t_1 - \tau/10) \quad (2)$$

And the equation for the sine wave remains

$$V_s = V_m \sin \omega t_1 \quad (3)$$

For determining t_1 according to figure 4.1 we get the equation for straight line containing t_1 is

$$V_c = - \frac{V_{cm}}{\tau/10} (t_1 - \tau/10) \quad (4)$$

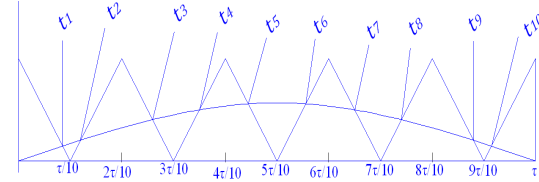


Fig.4 Comparison of positive half cycle

For t_1 we can equalize the two equations as below-

$$\begin{aligned} - \frac{V_{cm}}{\tau/10} (t_1 - \tau/10) &= V_m \sin \omega t_1 \\ \Rightarrow - \frac{(V_{cm}/V_m)}{(\tau/10)} (t_1 - \tau/10) &= \sin \omega t_1 \\ \Rightarrow - \frac{(1/M)}{(\tau/10)} (t_1 - \tau/10) &= \sin 2\pi f t_1 \\ \Rightarrow - \frac{1.25}{(\tau/10)} (t_1 - \tau/10) &= \sin (2\pi \times 50) t_1 \\ \Rightarrow - \frac{1.25}{(10ms/10)} (t_1 - 10ms/10) &= \sin 100\pi t_1 \end{aligned} \quad (5)$$

Solving (5) we get the value of t_1

$$t_1 = 800.8429071 \text{ us}$$

Similarly solving the equation considering the straight line containing t_2 we get the value of t_2

$$\begin{aligned} \frac{1.25}{(10ms/10)} (t_2 - 10ms/10) &= \sin 100\pi t_2 \\ \Rightarrow t_2 &= 1.323 \text{ ms} \end{aligned} \quad (6)$$

Solving the equation considering the straight line containing t_3 we get the value of t_3

$$\begin{aligned} - \frac{V_{cm}}{\tau/10} (t_3 - 5\tau/10) &= V_m \sin \omega t_3 \\ - \frac{1.25}{(10ms/10)} (t_3 - 30ms/10) &= \sin 100\pi t_3 \\ \Rightarrow t_3 &= 2.444299507 \text{ ms} \end{aligned} \quad (7)$$

Similarly other instants $t_4 - t_{10}$ are calculated and all are summarized below.

- $t_1 = 801\mu s$
- $t_2 = 1.323ms$
- $t_3 = 2.444ms$
- $t_4 = 3.738ms$
- $t_5 = 4.224ms$
- $t_6 = 5.776ms$
- $t_7 = 6.262ms$
- $t_8 = 7.556ms$
- $t_9 = 8.677ms$
- $t_{10} = 9.199ms$

By subtracting the two consecutive times we find out the duration of pulses. This duration together with the logic states for 10ms are shown in Table 1. These are done only for sinusoidal half wave length for 10 ms from where we create the logic states of PWM signals. Now for the other phases and their

logic states we have to calculate the phase shift of the subsequent phases in terms of delay in ms or μs .

Table 1: Duration of Pulses

Amplitude States	No.	Durations
0	1	$801\mu s - 0 s = 801\mu s$
1	2	$1.323 ms - 801\mu s = 522\mu s$
0	3	$2.444 ms - 1.323 ms = 1.121 ms$
1	4	$3.738 ms - 2.444 ms = 1.294 ms$
0	5	$4.224 ms - 3.738 ms = 486\mu s$
1	6	$5.776 ms - 4.224 ms = 1.552 ms$
0	7	$6.262 ms - 5.776 ms = 486\mu s$
1	8	$7.556 ms - 6.262 ms = 1.294 ms$
0	9	$8.677 ms - 7.556 ms = 1.121 ms$
1	10	$9.199 ms - 8.677 ms = 522\mu s$
0	11	$10 ms - 9.199 ms = 801\mu s$

From 0 s to 40 ms (2 cycles) sequentially we get the six logic states for every time intervals which are shown in Fig. 5 and Fig.6.

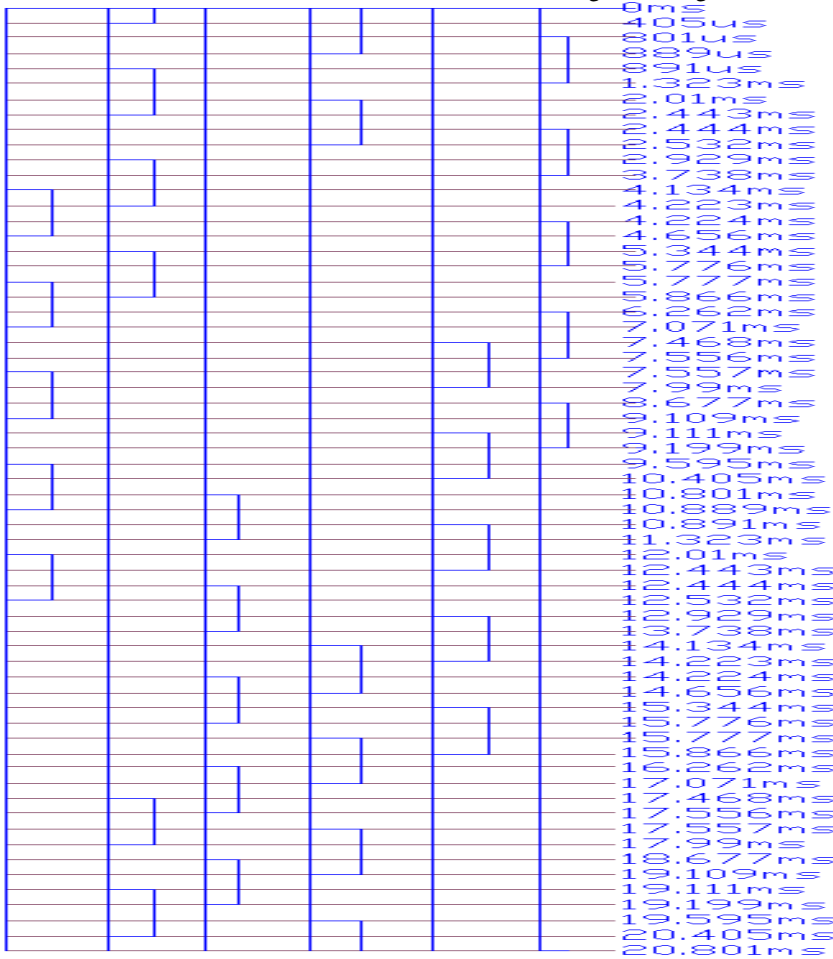


Fig.5 1st half logical states of six phase pulses

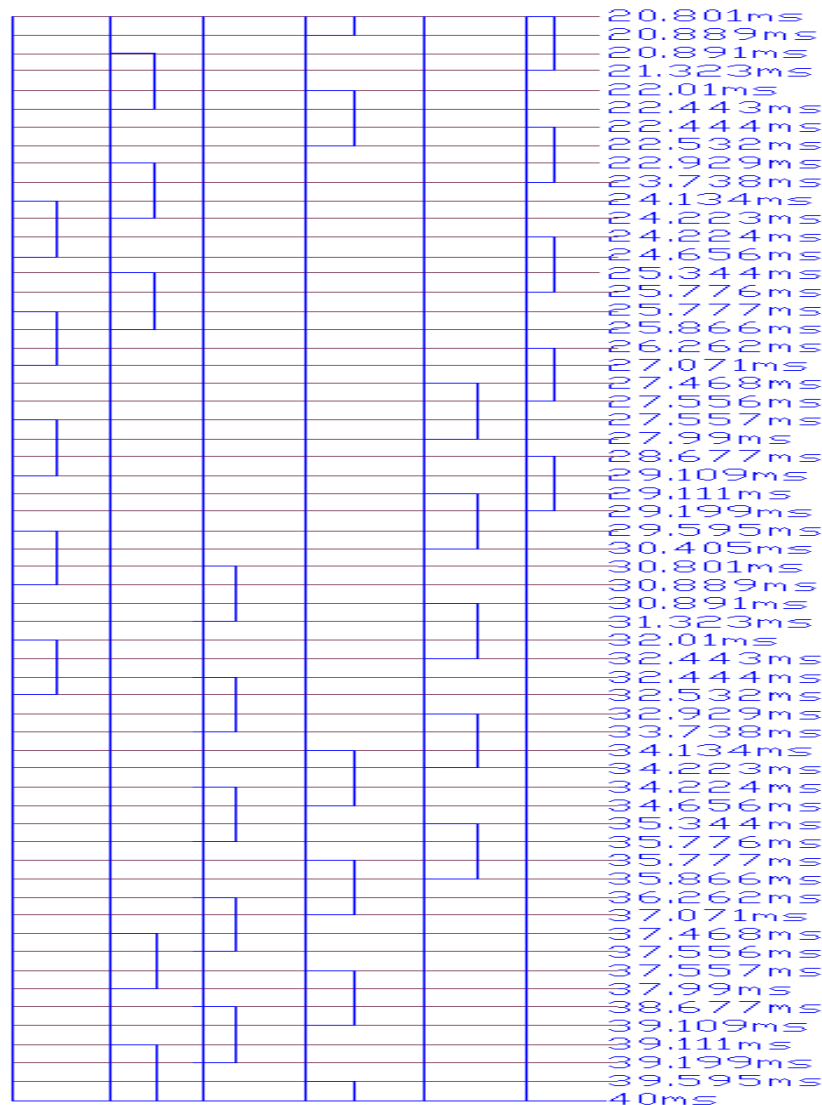


Fig.5 2nd half logical states of six phase pulses

The waveforms of gate pulses for all the devices for the duration of 40 ms as mentioned above are shown in Fig, 6,

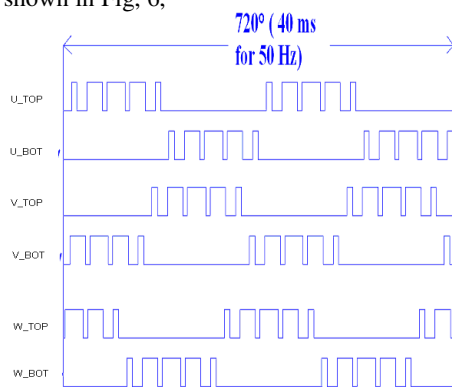


Fig. 6 Three phase waveforms in terms of six gate signals

5. RESULTS AND DISCUSSION

The experimental setup of the hardware based on the circuit configurations mentioned before is shown in Fig. 7.

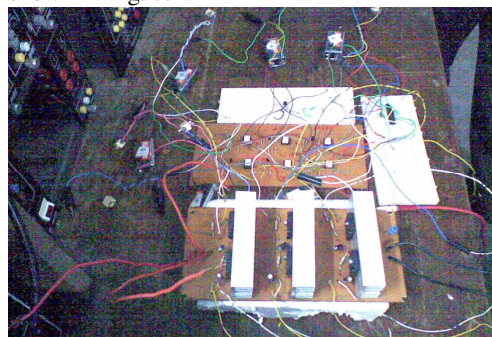


Fig. 7 Experimental Setup

Suitable software has been developed for PIC16F72 microcontroller using mikroC programming language using the logic states and durations as mentioned before. The pulses we get from the microcontroller is enough to run the driver circuits of IGBTs. The high magnitude of the pulse is 4.98 volts when it is connected to the gates of the IGBTs. Output from the driver circuits for different phases are shown Fig.8 to Fig.10.

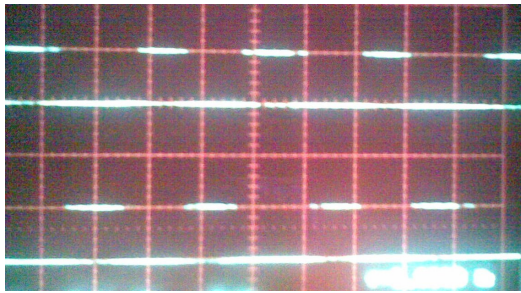


Fig 8: Pulses at U_TOP and U_BOT

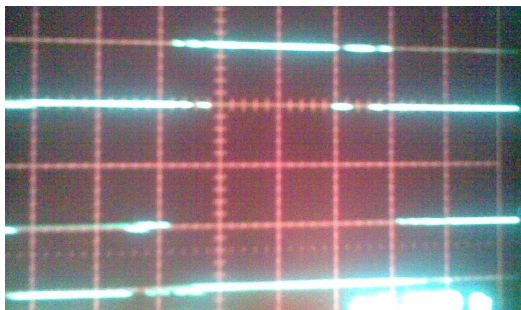


Fig 9: Pulses at V_TOP and V_BOT

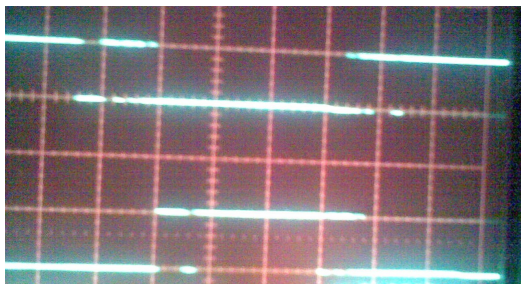


Fig. 10: Pulses at W_TOP and W_BOT

It is observed that the output obtained from the experimental closely matches with those of theoretically obtained results.

6. CONCLUSION

FACTS based three phase UPQC system can be implemented to address the power quality issues such as to eliminate voltage distortions or dips, to improve voltage regulation etc with the integration of shunt and series active filter etc. Hardware details of the VSC used for UPQC have been given

in this paper. SPWM technique used in this paper for improving power quality is more sophisticated, reliable, economical and feasible, has the ability to suppress certain number of harmonics depending on number of pulses per half cycle in the PWM wave. They also have compatibility with today's digital microprocessor/microcontroller and lower power dissipation. It is observed that as simple PIC16F72 microcontroller is able to generate the required pulses. Complete system integration of an UPQC is of further interest.

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5. MICROCHIP - PIC16F72 Data Sheet

VARIATION OF NONLINEAR REFRACTIVE INDEX AND NONLINEAR ABSORPTION CO-EFFICIENT OF LiNbO_3 CRYSTAL DUE TO VARYING WAVELENGTHS

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The nonlinear refractive index, n_2 and the absorption co-efficient, of an undoped z-cut photorefractive LiNbO_3 crystal has been investigated here by the Z-scan technique using a continuous wave (cw) laser beam from a multiline argon-ion laser at two different wavelengths. Here both the sign and magnitude of the measured n_2 and are considerably different from each other. In the present work, the Z-scan measurement shows that LiNbO_3 has both negative and positive nonlinear refractive index and its magnitudes are $0.67 \times 10^{-7} \text{cm}^2 \text{W}^{-1}$ and $0.64 \times 10^{-7} \text{cm}^2 \text{W}^{-1}$ at the wavelengths of 514 nm and 488 nm respectively. A fit of the absorption co-efficient data gives the value of to be $6.8 \times 10^{-3} \text{cmW}^{-1}$ and $-18 \times 10^{-3} \text{cmW}^{-1}$ at the 514 nm and 488 nm.

Key words: Z-scan; LiNbO_3 ; Nonlinear refractive index; Nonlinear absorption co-efficient.

1. INTRODUCTION

Refractive index changes induced by light are commonly described by the relationship

$$n = n_0 + n_2 I \quad (1)$$

where, n_0 is the linear refractive index, n_2 is the nonlinear refractive index coefficient and I is the intensity of the light beam. When a Gaussian beam impinges on a nonlinear medium, the light intensity at the centre of a beam is larger than that of the edge; as a result, the refractive index of the medium is maximum along its optical axis, and decreases radially as a function of distance from the center of the beam, which is responsible for the refractive index being spatially inhomogeneous. This light-induced refractive index change can have a considerable effect on laser beam propagation in a nonlinear medium, which leads to the well known self action effect phenomena, such as self-focusing, self de-focusing, self-phase modulation, self-bending, beam fanning, and multiple ring patterns (Prasad and Williams, 1991, Shen, 1984, Brugioni and Meucci, 2002, Henari and MacNamara, 1993, Khoo and Wood, 1997, Abdeldayem and Witherow, 1994). A

lot of materials have been found to exhibit laser-induced refractive index changes, such as liquid crystals, solid crystals, fullerenes etc.

The reliable Z-scan technique (Sheik-Bahae et al., 1989) is a simple sensitive, single beam method to determine both the nonlinear refractive index and the nonlinear absorption co-efficient of a given material. This method has sensitivity comparable to interferometric methods. This technique has been extended to other measurements such as laser beam quality measurement (Agnesi et al., 1990), two color time-resolved thermal lensing (Castillo et al., 1990), nondegenerate two photon absorption, and nondegenerate nonlinear refractive index (Sheik-Bahae et al., 1992). It has also been used for the investigation of Gaussian beam propagation (Banerjee et al., 1991). In the Z-Scan technique, a sample is scanned along the optical axis in the focal region of a single Gaussian TEM_{00} beam. The transmission through the sample, with and without an aperture in the far field is then recorded.

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The transmission with an aperture (closed aperture) characterizes the sign and magnitude of the nonlinear index, while the transmission without an aperture (open aperture) characterizes the nonlinear absorption. This is a simple and sensitive technique for measuring the change in phase induced on a laser beam upon propagation through a nonlinear material. It gives both the sign and magnitude of this phase change, $\Delta\phi_0$, which is simply related to the nonlinear refractive index, n_2 .

In 1990, a sensitive measurement of the optical nonlinearity was presented using a single beam (Sheik-Bahae and Said, 1990). Employing the Z-scan technique, a sensitivity of better than $\lambda/300$ wavefront distortion was achieved in n_2 measurements of BaF_2 using a picoseconds frequency-doubled Nd:YAG laser pulse. They demonstrated this method for ZnSe at 532 nm where two-photon absorption was present and n_2 was negative. In 1995, beam waist change in a photorefractive LiNbO_3 crystal was presented during the Z-scan measurement (Henari et al., 1995). Their experimental results showed that the minimum beam waist had been broadened and they measured the sign of the nonlinear refractive index as negative and the magnitude was found to be $1.5 \times 10^{-7} \text{cm}^2 \text{W}^{-1}$. In 1996, Both the sign and the magnitude of n_2 of LiNbO_3 with a picoseconds pulsed laser at 532 nm was investigated (Li et al., 1996). They observed the sign of the n_2 as positive and the magnitude to be $0.53 \times 10^{-14} \text{cm}^2 \text{W}^{-1}$. In 2007, Optical nonlinearities of periodically poled LiNbO_3 crystal was investigated by the same technique with a cw beam at 532 nm (Chen et al., 2007). They observed the sign nonlinear refractive index as negative and the magnitude to be $0.13 \times 10^{-7} \text{cm}^2 \text{W}^{-1}$. The nonlinear refractive index of LiNbO_3 determined using the Z-scan technique, with a picoseconds pulsed laser at 532 nm, is different in both sign and magnitude from the obtained result using a cw laser beam at 514 nm with a low laser power. So there is much room for investigation of the sign and magnitude of n_2 and β of LiNbO_3 at different wavelengths. Furthermore, LiNbO_3 is an important nonlinear optical material with a variety of applications. Nonlinear optical properties of LiNbO_3 have been subjected to numerous investigations. Therefore, in order to clear the ambiguity of the sign and magnitude of n_2 of LiNbO_3 , an experimental investigation was undertaken to find the nonlinear refractive index and nonlinear absorption co-efficient of LiNbO_3 by the Z-scan technique using a cw laser beam at 514 nm and 488nm respectively.

2. EXPERIMENTAL DETAILS

The geometry of the experiment is shown in Fig.1.

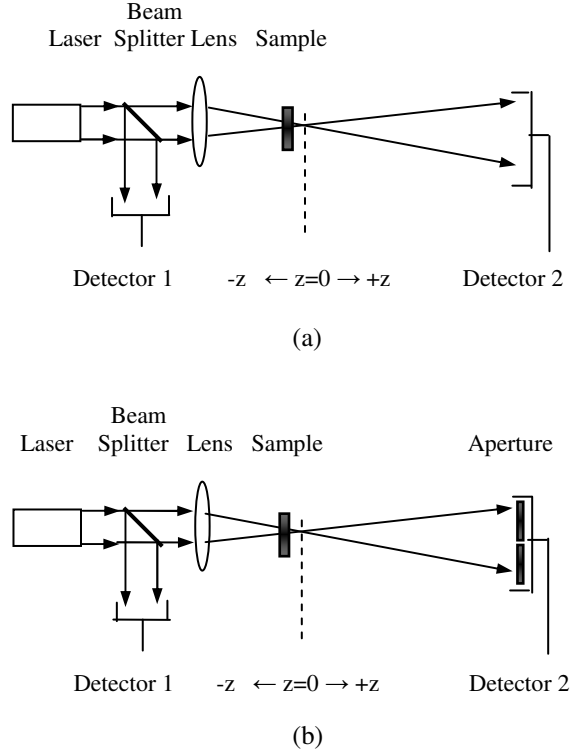


Fig 1: (a) Experimental setup for open aperture Z-scan measurements. (b) Experimental setup for closed Z-scan measurements.

The experiment was performed using an air cooled multiline Ar-ion laser operating at the wavelength of 457-514 nm. A 5276 lines/cm diffraction grating was used to separate the wavelengths. Among the various diffracted light waves, the wavelength of 514 nm was chosen for the measurement. This beam was separated into two parts by a beam splitter. The reflected part was taken as the reference beam representing the incident light and the transmitted beam was focused by a convex lens, with a focal length of 252 mm, to achieve the focal waist radius of $\sim 24 \mu\text{m}$. The sample was mounted on a linear translator and was moved with a high degree of precision. The c-axis of the sample was set parallel to the gradient direction of the Gaussian beam, i.e., the z-axis. This beam was made to pass through the LiNbO_3 sample (thickness of 1 mm). The open aperture Z-scan measurement was then performed on the crystal. The ratio of the power of two beams was determined as a function of the crystal position. The

second detector was used as a reference to control the possible temporal variations of the laser power. In every position of z , the measurement was made after the build-up of the beam distortion. By plotting the ratio of the signal of two detectors as a function of z , The Z-scan trace was obtained as shown in Fig. 2. For the closed aperture Z-scan measurement, an aperture was inserted in front of one of the detectors to select the central part of the beam. The size of the aperture (1 mm in diameter) was much smaller than the beam size in the plane of the aperture, and the lens-aperture distance was much larger than the scanning range. In every position of z , the measurement was made, after the build up of the beam distortion. This experiment was repeated for the wavelength of 488nm. The Z-scan method cannot be used to obtain a quantative result for the light-induced change in refraction because this is only possible through the fitting process. If the beam preserves its circular cross section, the material parameter, n_2 and β can be determined from the fitting of the Z-scan traces.

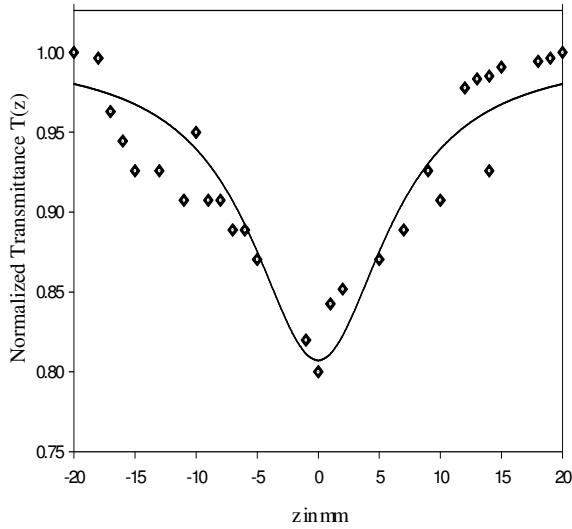


Fig. 2 Measured open aperture Z-scan trace of a 1 mm thick LiNbO_3 sample using a multiline Argon-ion laser at $\lambda = 514$ nm. The solid line shows the theoretical fit.

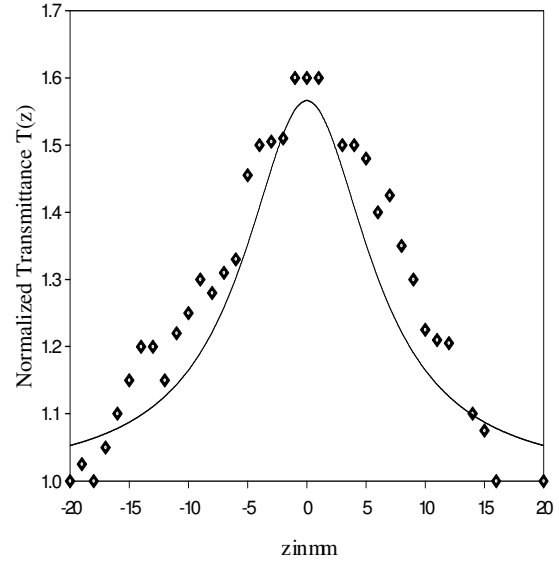


Fig. 3 Measured open aperture Z-scan trace of a 1 mm thick LiNbO_3 sample using a multiline Argon-ion laser at $\lambda = 488$ nm. The solid line shows the theoretical fit.

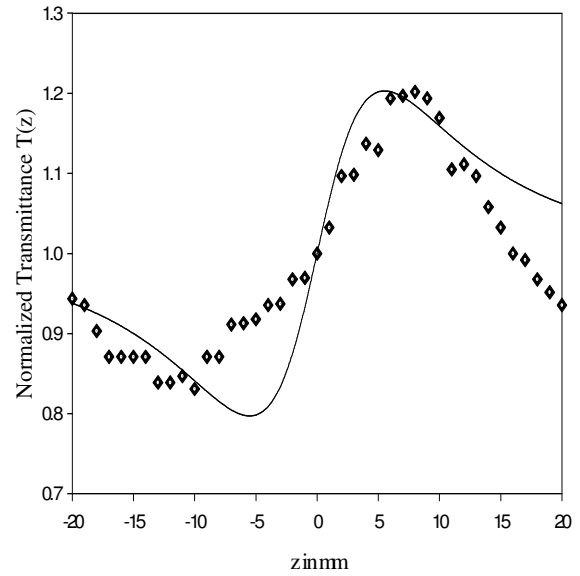


Fig. 4 Measured closed Z-scan trace of a 1 mm thick LiNbO_3 sample using a multiline Argon-ion laser at $\lambda = 514$ nm indicating the negative nonlinearity. The solid curve is a theoretical fit with $\Delta\phi_0 = -1.05$ and $s = 0.2$

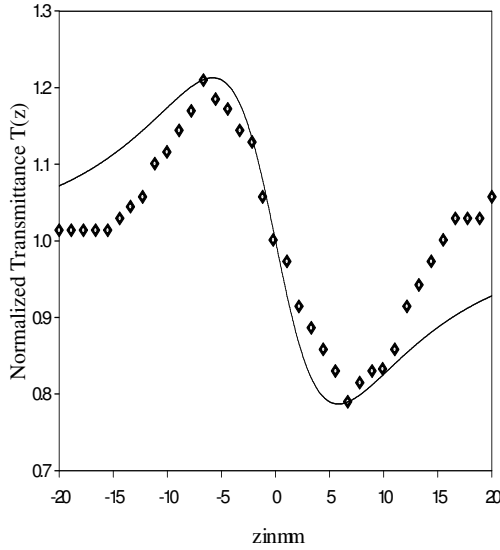


Fig. 5 Measured closed aperture Z-scan trace of a 1 mm thick LiNbO₃ sample using a multiline Argon-ion laser at $\lambda = 488$ nm indicating the positive nonlinearity. The solid curve is a theoretical fit with $\Delta\phi_0 = 1$ and $s = 0.25$

3. RESULTS AND DISCUSSION

For the open aperture Z-scan measurement the normalized transmittance can be written as (Henari et al., 1995),

$$T(z) = 1 - \left(\frac{q_0(z)}{2\sqrt{2}} \right) \quad (2)$$

With

$$q_0(z) = \frac{I_0 \beta L_{\text{eff}}}{\left(1 + \frac{z^2}{z_0^2}\right) \alpha} \quad (3)$$

where, β is the nonlinear absorption co-efficient of the sample,

I_0 is the intensity of the laser beam at the focus ($z = 0$),

$L_{\text{eff}} = \frac{1 - e^{-\alpha L}}{\alpha}$ is the effective length of the sample,

$z_0 = \pi \omega_0^2 / \lambda$ is the confocal parameter, where ω_0 is the Gaussian beam waist radius at the focus,

α is the linear absorption coefficient and λ is the wavelength of the laser .

Fig. 2 and Fig. 3 show the measured open aperture Z-scan trace of a 1 mm thick LiNbO₃ sample using a multiline Argon-ion laser at $\lambda = 514$ nm and 488 nm respectively. The solid lines in these two figures are the theoretical curve while the symbol is the experimental data. By fitting, the obtained nonlinear absorption co-efficient was $6.8 \times 10^{-3} \text{ cmW}^{-1}$ and $-18 \times 10^{-3} \text{ cmW}^{-1}$ at the 514 nm and 488 nm respectively. Fig. 4 shows transmittance changes as a function of position of the sample used to measure normalized peak-valley transmittance difference, ΔT_{p-v} . The normalized transmittance for the closed aperture Z-scan is given by (Henari et al., 1995) ,

$$T(z, \Delta\phi_0) = 1 + \frac{4\Delta\phi_0 x}{(x^2 + 9)(x^2 + 1)} \quad (4)$$

Here, $x = z/z_0$ and $\Delta\phi_0$ is the on-axis phase change caused by the nonlinear refractive index of the sample. The solid line in Fig. 4 and Fig. 5 are obtained from fitting the above equation using $\Delta\phi_0 = -1.05$ and $\Delta\phi_0 = 1$ respectively. The value of on-axis phase change can also be calculated from the peak-valley transmission difference using the following equation (Sheik-Bahae et al., 1989):

$$\Delta T_{p-v} = 0.405(1 - s)^{0.25} |\Delta\phi_0| \quad (5)$$

where, $s = 1 - \exp(-2r_a^2/\omega_a^2)$ is the aperture linear transmittance with r_a denoting the aperture radius and ω_a denoting the beam radius at the aperture in the linear regime. The non linear refractive index, n_2 is given by (Henari et al., 1995)

$$n_2 = \frac{\Delta\phi_0 \lambda \alpha}{2\pi I_0 (1 - e^{-\alpha L})} \quad (6)$$

where $I_0 = 2P/\pi\omega_0^2$ is the on-focus intensity inside the sample with P the laser power and α ($\sim 0.665 \text{ cm}^{-1}$) the linear absorption coefficient. The peak-valley sequence of Fig. 4 indicates a self-defocusing effect, i.e., LiNbO₃ has a negative refractive nonlinearity but the peak-valley sequence of Fig. 5 indicates a self-focusing effect, i.e., LiNbO₃ has a positive nonlinearity. Using the value of operating laser power, $P = 14.4 \text{ mW}$, the on-axis intensity inside the sample, $I_0 = 13.24 \times 10^6 \text{ Wcm}^{-2}$ and $11.72 \times 10^6 \text{ Wcm}^{-2}$ are measured respectively and at this value of I_0 , the measured value of the refractive index of LiNbO₃ crystal is $-0.67 \times 10^{-7} \text{ cm}^2 \text{W}^{-1}$ and $0.64 \times 10^{-7} \text{ cm}^2 \text{W}^{-1}$ at the wavelengths of 514 nm

and 488 nm respectively. The first result is in good agreement with the experimental results reported by Fryad. Z. Henari et al. (Henari et al., 1995). It is found that the sign of nonlinear refractive index of LiNbO₃ induced by a cw laser beam at wavelength of 514 nm is negative and the magnitude is $0.67 \times 10^{-7} \text{ cm}^2 \text{ W}^{-1}$ and whereas the sign of n_2 is positive and the magnitude is $0.64 \times 10^{-7} \text{ cm}^2 \text{ W}^{-1}$ at the wavelength of 488 nm. This observed discrepancy seems to be significant.

4. CONCLUSION

We have presented an investigation of the nonlinear refractive index of pure z-cut LiNbO₃ crystal by the Z-scan technique using a cw laser beam from an air-cooled multiline Ar-ion laser at two different wavelengths of 514 nm and 488 nm. By fitting, the nonlinear absorption co-efficient of LiNbO₃ is found to be $6.8 \times 10^{-8} \text{ cm W}^{-1}$ and $-18 \times 10^{-8} \text{ cm W}^{-1}$ at the 514 nm and 488 nm respectively, using the normalized peak-valley transmittance difference, the nonlinear refractive indices $-0.67 \times 10^{-7} \text{ cm}^2 \text{ W}^{-1}$ and $0.64 \times 10^{-7} \text{ cm}^2 \text{ W}^{-1}$ are measured. The first result is same in sign to the result observed previously using a cw laser beam at the wavelength of 514 nm. However the second result exhibits a positive sign at the wavelength of 488 nm which is in agreement with the result observed by a picoseconds pulsed laser at the wavelength of 532 nm. Further investigations are in progress in this issue to be done at different wavelengths to verify these results. The origins of our observed nonlinearities are believed to be attributed to the photorefractive effect in the LiNbO₃ crystal.

ACKNOWLEDGEMENT

We gratefully acknowledge the Department of Physics, SUST for providing the research facilities to enable us to carry out the research and we are also indebted to Prof. Md. Younus and Prof. S. M. Saiful Islam of the Dept. of Chemistry, SUST for their help with the experimental setup.

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VLSI DESIGN OF AN ULTRA-LOW-POWER FUNCTIONAL CHIP USING MIRROR-AMPLIFIER FOR PRECISION SENSOR APPLICATIONS

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Device density in VLSI today enforces the process of chip designing much more complex; whereas MAGIC CAD tools made the IC design in this work, comparatively easier. Study on various amplifiers for sensor applications showed that their powers ranged from a few milliamperes to a few hundred milliamperes at the submicron fabrication processes by MOSIS, but within the affordable cost. Objectives of lowering the power at least by 1000 times in those fabrication processes engaged this research towards completing a new design, called the mirror-amplifier. This design is verified for precise functional behavior for the sensor and total power consumption, using MAGIC extractor and PSPICE electrical simulation tools. A compact model chip layout made silicon area more efficient for MOSIS tiny-chip fabrication in 0.6 μ m processes. To make even more economical, a multi-die placement technique was applied to the chip layout for this tiny-chip in silicon area of 1500 μ mX1500 μ m. MOSIS design rules for multi-die fabrication was verified for process scribe-lines and die packaging. This paper presents details of the key research works, results, completed chip layout and packaging of the chip.

Key words: Mirror-Amplifier; Compound Device; Mixed-Signal Chip; Precision Sensor; Chip Package.

1. INTRODUCTION

As MOS Integrated Circuits (ICs) have come to dominate analog, digital, and mixed-signal electronic circuit designs over the last 15 years [1], the pressure to reduce system cost has favored all-CMOS solutions over systems that mix bipolar and CMOS chips or use Bi-CMOS technology [2]. In current design practices, bipolar devices are usually found only in very-high performance wired and wireless designs, where extreme device specifications (high f_t , low noise, and superior matching) require high-yielding, power-efficient components [3]. Similarly, compound semiconductor devices are used only in the case of very high-speed circuits in applications running at GHz level with low power [1]. With a continuing reduction of MOS transistor channel lengths, modern CMOS silicon processes offer transistor with a higher cut off frequencies [4]. So as it is known that CMOS technology is capable to implement radio frequency (RF) transceivers, recently many researches on radio frequency (RF)

ICs in GHz-level-band have been accelerated because of the potential Industrial, Scientific, and Medical (ISM) band and the wireless vehicular radar applications [5-6, etc.]. CMOS processes that have been developed primarily for logic are now also used as amplifier and sensor [7]. Several researchers have presented CMOS amplifiers for an optical receiver with external photo detectors [8-10, etc.]. Most of these amplifiers depend on analog CMOS process technologies. Recently, there have been attempts to use standard digital CMOS technologies since there are more demands to have analog and digital circuits on same chip allowing a very high bandwidth and very low power at the same time [10].

Today's electronics industry is increasingly focused on the consumer marketplace, which requires low-cost high-volume products to be developed very rapidly. This, combined with advances in deep sub-micron technology has resulted in the ability and the need to put entire systems on a single chip. As more of the system is included on a single chip, it is

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very likely the chip will contain both analog and digital sections, which make the IC, design procedure a lot more complex [11]. The increasing complexity and decreasing feature size have made the demand of IC products more compact with more facilities and low power and fabrication cost. With this thought as a goal, this paper presents a proposal of ultra low power mixed signal mirror-amplifier with its VLSI design and packaging that can be used as precision sensor. The proposed circuit is basically composed of two differential amplifiers as mirror-amplifier having a NAND gate between them. Hence the designed chip is composed of both analog and digital signal handling capability with high bandwidth (GHz). In science and industry, accuracy is the degree of conformity of a measured or calculated quantity to its actual, nominal, or some other reference value. We cannot have accuracy without precision. Precise characterization to the degree of mutual agreement requires a series of individual measurements, values, or results. Op-amp with high DC open-loop gain combined with low input offset voltages and offset bias currents can be used as precision sensor [12]. In this study CMOS differential amplifiers have done this job with mirror architecture.

2. CIRCUIT DESIGN

The figure 1 represents the schematic of the mirror-amplifier circuit. Construction of this circuit consists of two differential amplifiers creating mirror architecture and a NAND gate between them makes it also digital compatible. It contains total of 14 MOS transistors in which 6 of them are p-MOS (M1-M6), and rest 8 are n-MOS (M7-M14). The operation of the circuit is done by total of five input terminals (Vsensor, Vbias, Clock, and two ChipEN) and one output terminal Vout with constant DC supply of 5V.

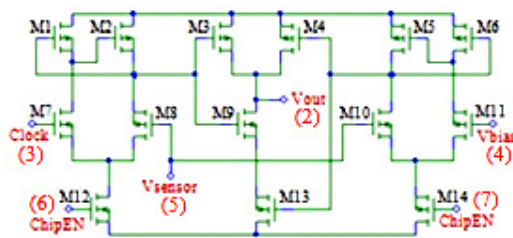


Fig 1: PSpice schematic of the mirror-amplifier.

3. CIRCUIT LAYOUT

To design the concerned schematic of mirror-amplifier in VLSI layout structure MAGIC 7.5 is used with the process configuration of 0.6μm that is supported by MOSIS with a package of

1500μmX1500μm tiny-chip die. The figure 2 below represents the VLSI layout of the mirror-amplifier. The total design of the circuit layout consists of 3 portions, where 2 of them are differential amplifiers acting as input stage with mirror architecture and the rest-one is output stage in the form of NAND gate. Dimensions of MOS transistors are chosen according to the requirements of optimization. Lengths of all MOS transistors are same that is 2λ but for the input stage the ratio of p-MOS to n-MOS widths is 6:3 and for the output stage is 12:6. For designing a single transistor, p-diffusion and n-diffusion are used for p-MOS and n-MOS respectively with poly-silicon to make the gate. In the whole circuit layout layer-1 and layer-2 metals are used for connecting nodes (wires), where poly contact, p-diffusion contact, n-diffusion contact and via-1 contacts are needed as contact materials. The layout has area of 126λX59λ or 37.8μmX17.7μm in 0.6μm CMOS process.

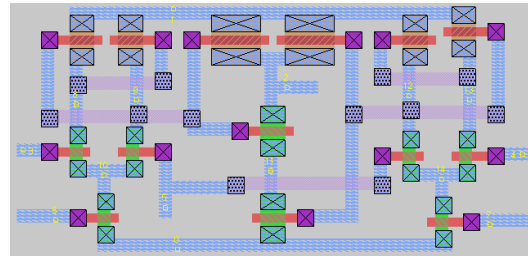


Fig 2: VLSI layout of the mirror-amplifier.

4. SIMULATION RESULTS

To verify the circuit operation and get the output toggle point for an optimized precision sensing operation towards ultra low power dissipation, simulation is done in two steps in this study. In the 1st step, Output is taken with respect to node 4 with 0.9V DC (threshold) supply at node 5 and 0V to 2.5V clock pulse at node 3. In this case output toggles and get steady at 2.5V (above threshold) giving a power dissipation of 8.41 milliwatts. It is found that Hysteresis at threshold voltage level causes dynamic power loss [13]. This design has flexibility of voltages to bias CMOS circuitry.



Fig 3: 1st step simulation result from the MAGIC extraction file of the designed layout using PSpice.

In the 2nd step, output is taken with respect to node 5 with 2.5V DC supply at node 4 that is got in the 1st step. Clock pulse is still 0V to 2.5V. In this case output toggles and get steady at 0.9V that is the threshold voltage of MOS transistor. Power dissipation is 9.13 nanowatts in this case. Thus system is improved for ultra-low-power operation.

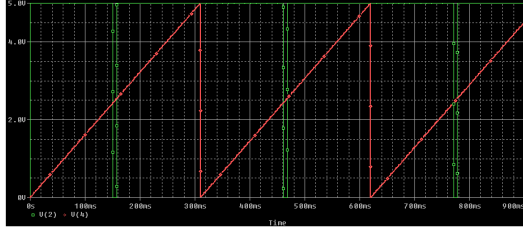


Fig 4: 2nd step simulation result from the MAGIC extraction file of the designed layout using PSpice.

One of the goals of this paper is to achieve low-power circuit designs, which already satisfied in the 1st step simulation techniques. But it showed sign of dynamic power losses due to Hysteresis. Among several solution of Hysteresis, one is adding external feedback resistor to the chip. The 2nd step simulation technique was taken for the better operation of the designed circuit. This way the output becomes single shot output as the sensor voltage ramps from 0V to 5V.

5. CHIP LEVEL DESIGN

The chip level design procedures come with the steps of pad frame design, pin configuration, floor planning etc. Pad is designed with the dimension of 90 μ mX90 μ m according to the MOSIS specifications and 60 μ mX60 μ m glass opening over the pad for bonding purpose [14]. The pad frame consists of 16 pads in total. The designed mirror-amplifier is set in the pad frame that consumes total of 1967 λ X1967 λ or 590.1 μ mX590.1 μ m in CMOS 0.6 μ m processes. So for multi-die placement for economical consideration, the total silicon size (MOSIS Tiny Chip at 0.6 μ m process) of 1500 μ mX1500 μ m is divided into 4 sub-dies with the scribe lines of 50 μ m. Hence the total area needed for this multi-die placement is 1380.2 μ mX1380.2 μ m which is very efficient for this design.

Floor planning can be done manually by hand, or by using interactive tools. In this study floor planning is done manually and then implemented by MAGIC. Total pin configuration of the multi-die placement is given in the table 1, and figure 5, 6 represent the view of the complete ICs as floor-planned with single mirror-amplifier and dual mirror-amplifier respectively.

Table 1: Pin configuration

Die	Modules	Pin Name	Pad #
Sub-die # 1,2	Single mirror-amplifier	Vdd	4
		GND	13
		EN1	16
		EN2	3
		Clock	1
		Bbias	2
		Vsensor	15
		Vout	14
	NAND gate	Vdd	4
		GND	13
		In1	6
		In2	8
		Vout	7
	Sense amplifier	Vdd	4
		GND	13
		EN	11
		Q	12
		Qbar	10
		Vout	9
Sub-die # 3,4	Mirror-amplifier#1	Vdd	4
		GND	13
		EN1	16
		EN2	3
		Clock	1
		Bbias	2
		Vsensor	15
		Vout	14
	Mirror-amplifier#2	Vdd	4
		GND	13
		EN1	10
		EN2	7
		Clock	11
		Bbias	6
	Inverter	Vsensor	9
		Vout	8
		Vdd	4
		GND	13
		In	12
		Vout	5

Figure 5 represents the chip layout of a single mirror-amplifier with an extra NAND gate and a Sense Amplifier. This chip is placed in the top sub-dies (die # 1 and 2). NAND gate is designed with larger width for higher current driving purposes. It can also be used as inverter by tying two inputs. So it can work as inverted output buffer. Also it can be connected to the output pin of the mirror-amplifier to have halt-run feature. The logical operation of this halt-run operation is given in the table 2. The output of the amplifier can be halted by logic '0' and be running by '1'. Both NAND and the Sense Amplifier can be used for electrical characterization purposes after fabrication.

Table 2: Halt-run operation of the sub-die # 1 and 2

Halt Bit to NAND Input1	Mirror- Amp Out Bit to NAND Input2	NAND Output	Status
0	1	1 (no-change)	Halt
0	0	1 (no-change)	Halt
1	0	1 (inverted)	Run
1	1	0 (inverted)	Run

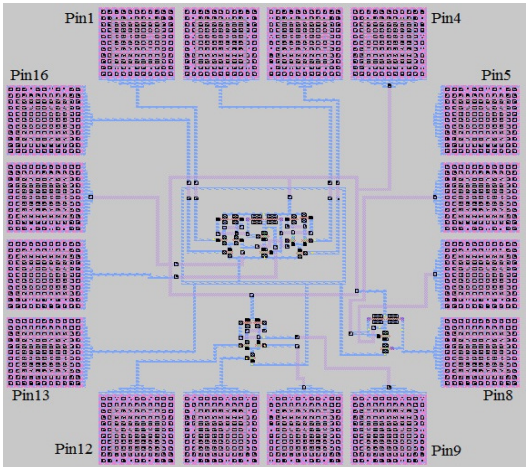


Fig 5: Sub-die chip layout of a single mirror-amplifier with a NAND gate and a Sense amplifier

Figure 6 shows the chip layout of dual mirror-amplifier with an extra inverter. This chip is to be placed in sub-die # 3 and 4. The inverter is also designed with larger width for higher current driving purposes. It can be used when the output of the mirror-amplifier needs to be inverted.

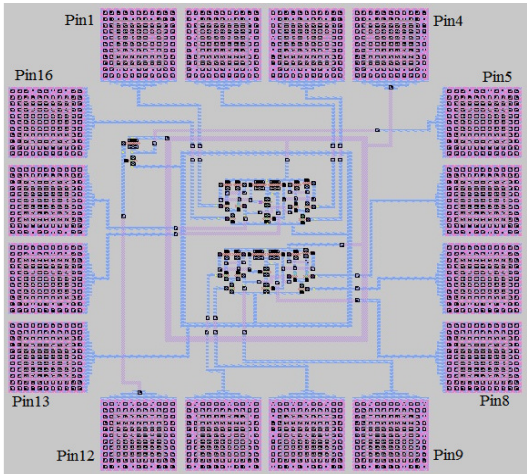


Fig 6: Sub-die chip layout of dual mirror-amplifier with an additional inverter

6. CHIP PACKAGING

The package serves a variety of important needs. Its pins provide manageable solder connections. It gives the chip mechanical support. It conducts heat away from the chip to the environment [15]. The package structure corresponding to the designed chip layout can be served by MOSIS. For this design purpose a plastic compound-molding package is chosen from MOSIS in which the pads are connected to the package leads by gold bonding wire. It is an open cavity (where die sits in and then bonded) package with lid. Top of packaged chip called the lid and it is loose to be opened. This gives advantages to go in the package and complete special electrical tests like: die probing (electrically connected needles touching components on silicon), component thermal tests, microscopic visual tests like damage by short circuit, moisture effect tests etc. The table 3 below shows the other identifications of the chosen package, and the figure 7 and 8 show the designed multi-die chip after cut along the scribe lines. Those separated 4 sub-dies are placed in the package individually.

Table 3: Identifications of the chosen package

Package part number	OCP_QFN_5X5_16A
Package manufacturer	SEMPAC
Package size	5mmx5mm
Die placement cavity	3.1mmx3.1mm
Pins	16

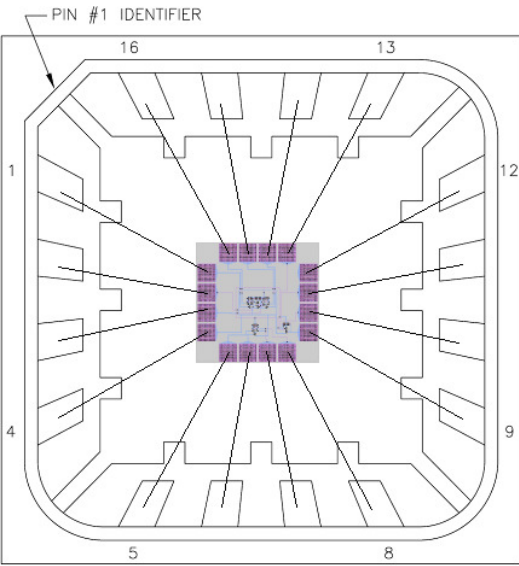


Fig 7: Bonding diagram of the single mirror-amplifier sub-die in SEMPAC package

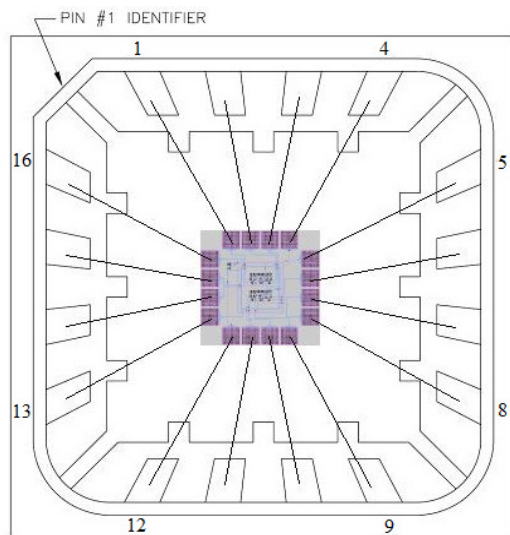


Fig 8: Bonding diagram of the dual mirror-amplifier sub-die in SEMPAC package

7. CONCLUSION

The VLSI technology is going to enter in the nano-tech era. With the practice of designing nano-power chip many problems are raised and power managing challenge is got tougher. In this study an ultra-low-power mirror-amplifier is designed in CMOS 0.6 μ m process for precision sensing application, which dissipates power of 8.41 milliwatts in the 1st experiment and latter 9.13 nanowatts in the 2nd experiment by choosing the correct biasing setups. For economic consideration multi-die placement is done with a suitable package by SEMPAC. Four sub-dies are designed in two groups for characterization purposes. One design has a NAND buffer that can provide an additional operation for halt and run functions. Further study may be focused on more enhanced mirror-amplifier design with more efficiency and power reduction.

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A MODEL ON INDUSTRIAL INFORMATION SYSTEM (IIS)

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ABSTRACT

In the globalization era , rapid data communication and sufficient information is important to make the right decision at the right time . Especially in the apparel industry , customer orders fluctuate a lot due to rapid change of the taste of the customer. This has a significant impact on master production scheduling and consequently on time performance (i. e. on-time delivery). On-time delivery also depends on proper information sharing among various departments of the garments industry. Furthermore, an inaccurate production plan also affects actual production. At present, various organizations/ industries in Bangladesh are using traditional methods for controlling information flow such as maintaining documentary books, which are time consuming. Recently, few organizations have installed computerized system instead of traditional systems. In this research work a software tool has been developed for smooth flow of information from one department to another. This software tool captures the information of total production, production date, production rate etc. The software tools are built using PHP with My-SQL database. By changing some attributes, majority of apparels industry could apply this software to maintain its resources.

Key words: - Information sharing, online data flow and store, online data retrieval

INTRODUCTION: -

In most organizations, information flows at the heart of workplace activities. The effective management of information requires information technology, and that technology is therefore crucial to organizational success. Information technology comes in many forms—networked personal computers, software applications, the Internet, and more—but one thing all types of information technology have in common is that their effective use depends upon human users. People put the technology to work in managing information, and people are ultimately responsible for whether information technology succeeds or fails [1]. Over the last 15-20 years the apparel sector has been in a state of continuous restructuring. A combination of technological and socio-economic changes, production cost, liberalization , and the emergence of important international competitor from Asia and the Mediterranean region are influencing the apparel manufacturing sector of Bangladesh. Apparel

companies are facing increasing competition and cost pressures. Hence efficient information flows within inter department seem to be an important key factor for apparel industries in Bangladesh to

improving better coordination among them. In this paper, we report on our development of a conceptual model, based on the IIS Model, which considers the specific requirements for smooth flow of information within various department of an apparel industry. We explain. how we developed our *Industrial Information System* (IIS) model and discuss the characteristics of its success dimensions.

RESEARCH BACKGROUND

The web based information system has several advantage and overcome some traditional problems. These includes : (1)single data entry to minimize human error ; (2) real-time online ordering function; (3) multi-level password controls (so that different functions have different access levels controlled by their respective authorized people).Some software companies now-

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a-days are making software on the basis of production information system [2], Human resource information system etc. They make software according to companies demand. Although that software is very much strong in structure, this software are not cheapest and easier to maintain. So most of the apparel industry are not capable to use these software. Basically the research of making this tool is come from current production flow processes .PHP language and MYSQL database (XAMPP) is used to develop this software.

OBJECTIVE

- To find out a feasible information flow model for an apparel industry of Bangladesh.
- To develop a model on Industrial Information System (IIS).

2.1. INFORMATION - A RESOURCE

Information is 'live' as it is required to be updated all the time and is renewable. It is substitutable and transportable and can be made to travel. The all round exponential growth of information makes it necessary that information is collected, stored, and retrieved in various fields so that it could be usefully exploited as and when needed. Information is an important driver that companies have used to become both more efficient and more responsive. The tremendous growth of the importance of information technology is a testimony to the impact that information can have on improving a company. Like all the other drivers , however, even with information , companies reach a point when they must make the trade-off between efficiency and responsiveness .

Information is considered as the sixth resource, the other five being men, machines, materials, money and methods. Figure 2.1 illustrates the flow of information in a production organization along with other resources [3].

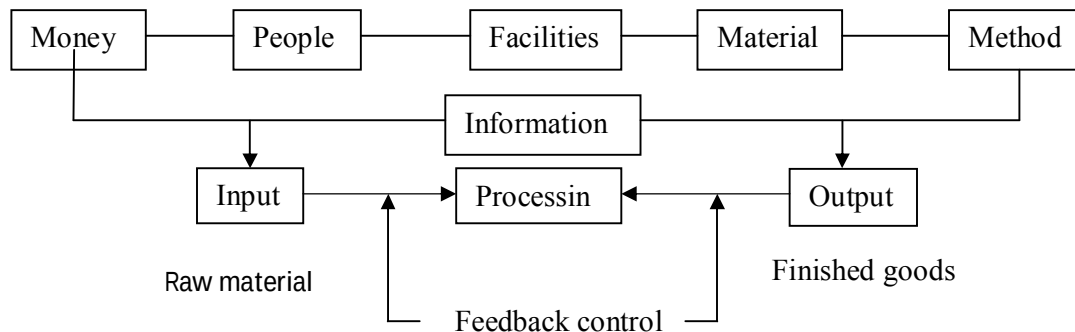


Fig 1. Information as a Resource

2.2 INFORMATION

Generally information define as :

- knowledge communicated or received concerning a particular fact or circumstance; news: information concerning a crime.
- knowledge gained through study, communication, research, instruction, etc.
- the act or fact of informing[4].

According to World English Dictionary information define as[5]:

- knowledge acquired through experience or study.
- knowledge of specific and timely events or situations; news

2.2.1 INFORMATION FLOW

Information flow is the graphical representation of data collection, data processing, and report distribution throughout an organization. [6] In the developing country like Bangladesh, the information flow between various department within an organization is paper based is shown in fig.2.

2.2.2 INFORMATION SYSTEMS

Beynon-Davies defines an information system as an example of a system concerned with the manipulation of signs. An information system is a type of socio-technical system. An information system is a mediating construct between actions and technology. [7]

An information system can also be considered a semi-formal language which supports human decision making and action. Information systems are the primary focus of study for the information systems discipline and for organizational informatics [8].

The types of information systems are, data warehouses, enterprise resource planning, enterprise systems, expert systems, global information system. [9]

2.2.3 INFORMATION TECHNOLOGY

- Information Technology, or IT, is basically just studying and developing computer systems. IT employees at a company are usually in charge of troubleshooting computer problems as well.
- Information Technology refers to an entire industry. IT is based on using computers and software to manage information. It

performs complex functions required to supply information to various departments. [10]

2.2.4 IMPORTANCE OF INFORMATION TECHNOLOGY

- Information technology is used for storing, protecting, processing, securing, transmitting, receiving and retrieving information. In business establishments, information technology is used for solving mathematical and logical problems. Information technology helps in project management system. Firstly, planning is done, then the data is collected, sorted and processed and finally, results are generated. It helps managers and workers to investigations about a particular problem, conceive its complexity and generate new products and services, thereby improving their productivity and output [11].
- Information technology is important because it is used in everyday life to make things simpler to do. Information technology professionals make difficult tasks easier to do and manage. [12]

2.3 INFORMATION FLOW IN APPAREL INDUSTRY

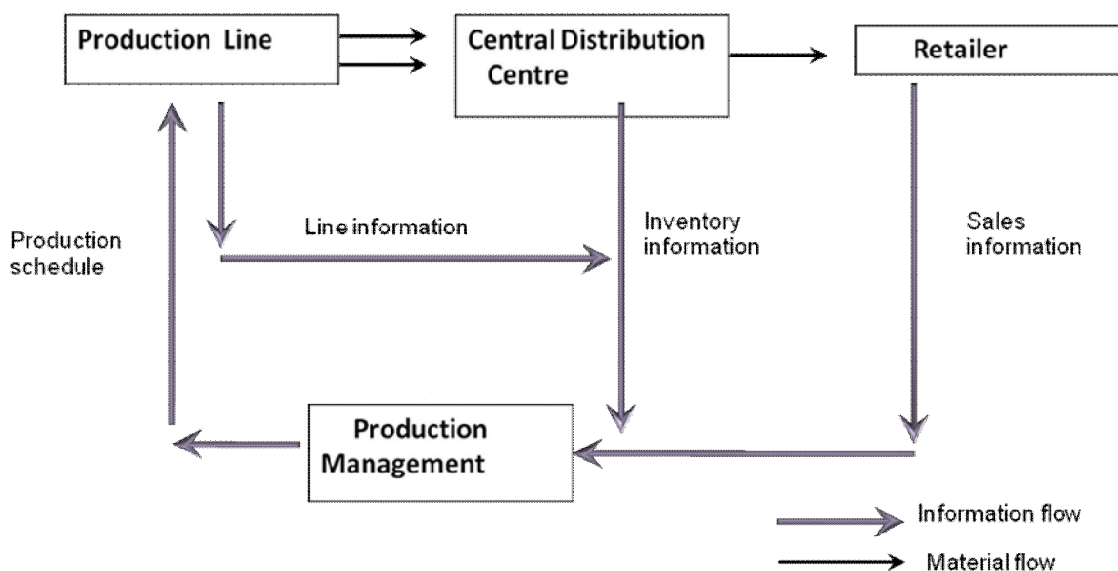


Fig 2: information and material flow chart for apparel manufacturing

At present many software solution are available in market for proper flow of information. Some of them are

Cantel Systems - Cantel Apparel Management System (CAMS) (*For Medium-Sized Businesses*) Complete apparel web solution. Helps you manage the entire supply chain from vendors to sales-reps.

PKIM - Adaptive Garment Manufacturing Software (*For Medium to Enterprise Businesses*) Designed to provide centralized control to the production flow from sales order entry to shipping process in garment manufacturing systems.

Dant Software Solutions - Dant Fashion Software (*For Small to Medium Businesses*) Software that has been specifically designed to utilise the style, colour, and size requirements that the apparel industry requires.

Fast React Systems - Fastreact Enterprise (*For Medium to Enterprise Businesses*) Specialized professional planning and management tool that provides the apparel,

footwear and textile industries with much improved visibility, coordination and communication.

Niche Fashion Technology - Niche Garments (*For Small to Medium Businesses*) Apparel management software specifically designed to meet the needs of the small to medium sized clothing manufacturer and wholesaler.

But those software are very costly. So Small and medium apparel can't use those software. We have developed a web based software which can be used at low cost.

2.4 STEPS OF RESEARCH METHODOLOGY

Necessary steps of research methodology are described in bellow

2.4.1 Identify scope of the research

Scope of work and study related to theories of production was identified.

2.4.2 Gather necessary data and user requirement

Study was performed to identify the problem of apparel industry.

Data was gathered by interviewing and documentation to find causes of problems.

Survey was performed to design the new system for solving the problems.

Data analysis was done to design new system.

2.4.3 Design new system

In addition, we design functions, input, output, user interface and database that using the data from collected data.

2.4.4 Develop the software/program

The software was developed by using XAMPP for Windows Version 1.4.16, which includes MySQL version 4.1.14 to create database and PHP version 5.0.5 as a program tool .

2.4.5 Testing and debugging each module

The software was tested as a prototype in a specific apparel industry.

2.5 Organization of software

In the apparel Industry, the administrative internal organizations have been cooperated between departments as following: - Human Resource Department ,Marketing Department , Financial Department , Purchasing Department ,Store Department, Research and Development Department, Production Department consists of Cutting, Printing, Embroidery, Sewing, Washing, Finishing, Shipping etc.

In the current production process and information flow, related document and interview related departments are as following

1. Cutting Department

Cutting department is responsible for cutting process.. They starts from receiving order from customer. They needs to keep data about order quantity, cutting percentage, balanced quantity, cutting quantity, completed quantity, sending quantity, sending time and provide these data to administrative department.

2. Printing Department

Printing department is responsible for printing process. They starts from receiving data and raw material from Cutting Department .They needs to keep data about sending quantity, sending date,

factory name, received quantity, received date, balanced quantity and provide these data to administrative department.

3. Embroidery Department

Embroidery department is responsible for Embroidery process. They starts from receiving data and raw material from Printing Department . They needs to keep data about sending quantity, sending date, factory name, received quantity, received date, balanced quantity and provide these data to administrative department.

4. Sewing Department

Sewing department is responsible for sewing process. They starts from receiving data and raw material from Embroidery Department . They needs to keep data about input quantity, output quantity, balanced quantity, and provide these data to administrative department.

5. Washing Department

Washing department is responsible for washing process. They starts from receiving data and raw material from Sewing Department .They needs to keep data about sending quantity, sending date, factory name, received quantity, received date, balanced quantity and provide these data to administrative department.

6. Finishing Department

Finishing department is responsible for finishing process. They starts from receiving data and raw material from Washing Department .They needs to keep data about packaged quantity, poly quantity, balanced poly, complete quantity, data update time and provide these data to administrative department.

7. Shipping Department

Shipping department is responsible for shipping process. They starts from receiving data and raw material from Finishing Department .They needs to keep data ship quantity, shipping date, cut short quantity, order short quantity and provide these data to administrative department.

2.6 Application Software (IIS) Overview

An important task for the purpose of information flow and storage is to create database. A database plays an important role for information storage . To implement industrial information system we develop application software and a database

system. During software development one thing is very important to us that software should be flexible in use and to be simple to suit existing communication system. In figure we shows layout of software . Due to the page limitation details software could not be described. Software is developed with the help of PHP and it is linked with MYSQL (XAMPP, a combination of) PHP and MYSQL) for the purpose of data storage .The new system will help to share information among various department such as Cutting, Printing, Embroidery, Sewing, Washing, Finishing, Shipping . The program will show necessary information in planning process for each department functions. The developed new system is composed by two sections; that are design database and functions of programs or user interfaces design. The button given below the company name shows information related to the particular department .After clicking any particular type of department the top management can see all information available in the database(fig 4). The top management retrieves the required data from the database.The top management can print all information or any particular information with respect to that database. The particular department can add, remove or update this database with particular information (fig 5). The new system has multi-level password controls so that different functions have different access levels controlled by their respective authorized people (fig 1).

Snapshot of industrial information system (IIS) is given below :

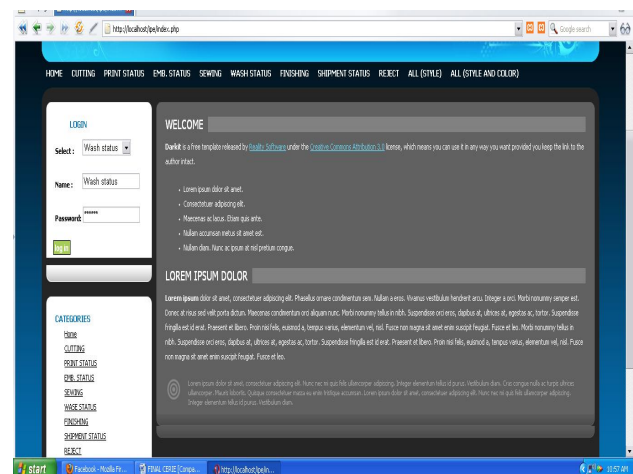


Fig 3:-Application software overview (01)

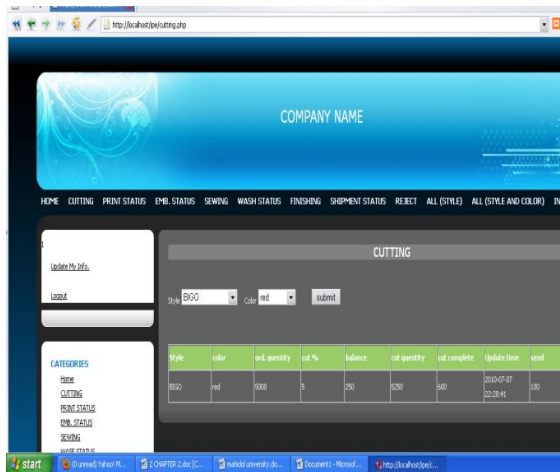


Fig 4:-Application software overview (02)



Fig 5 :- Application software overview (03)

2.6 Research Equipments and Tools

2.6.1 Hardware CPU : Intel Pentium Processor IV RAM : 128 MB Hard disk : 20 GB Peripherals : Monitor, Keyboard, Mouse, Diskette and CD ROM Drive

Operating system : Microsoft Windows
Design tool : Dream Weaver Mx 8.0
Development tool : XAMPP for Windows Version 1.4.16,

Conclusion

A windows-based application software tool related to the Industrial Information System has been developed. Using this tool management of an industry can recognize the different activities and information of its various production department. Considering all the observations it is significant that this tool can play a vital role in any industry. This study left several issues to be addressed. the study captures a primarily cross-sectional view of model constructs. Perceptions will change over time as new department introduced in organization.

The areas of future research of this paper are given below:

1. Human resource Management Engaged with this database can easily communicate with headquarter.

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APPLICATION OF FIXED TIME PERIOD MODEL FOR OPTIMIZING INVENTORY LEVEL: A CASE STUDY IN A PHARMACEUTICAL COMPANY

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This paper focuses on a case study to determine the optimum levels of inventory of a pharmaceutical product. A fixed time period model was developed with different service levels. It is found from the study that a significant amount of inventory investment can be saved while providing 99% service level. So the capital involved in unnecessary inventory can be used for other quality issues and the competitive advantage can help the company to increase its market share day by day.

Key words: Inventory; Optimum level; Service level; Fixed Time Period Model; Capital Investment; Stock.

INTRODUCTION

The control and maintenance of inventory is a problem common to all organizations in any sector of the economy. The problems of inventory do not confine themselves to profit making institutions but likewise are encountered by social and nonprofit institutions. Inventories are common to farms, manufacturers, wholesalers, retailers, hospitals, churches, prisons, zoos, universities, and national, state, and local governments. Indeed, inventories are also relevant to the family unit in relation to food, clothing, medicines, toiletries, and so forth.

1.2 Significance of the study

Inventory is very important because it helps the company respond quickly to customer demand, which is an important element of competitive strategy. It also represents one of the largest controllable resources in many companies.

Therefore, inventories of finished goods (that is, independent-demand inventories) of the correct items, within a reasonable distance of points of demand, play an important role in a company's ability to compete in a market for standardized products. So we are going to conduct a thesis on inventory control of finished goods in a particular pharmaceutical industry with some objectives.

OBJECTIVES

This dissertation focuses on two main objectives:

- To identify inventory management system of selected Pharmaceutical company.
- To identify optimum level of inventory by using fixed time period model.

LITERATURE REVIEW

Inventory is a detailed list of those movable items which are necessary to manufacture a product and to maintain the equipment and machinery in good working order. The quantity and the value of every item is also mentioned in the list. [3]

Inventory is the stock of any item or resource used in an organization.

Inventory is actually money kept in the store room.

2.1 Inventory system

An inventory system is the set of policies and controls that monitors level of inventory and determines what levels should be maintained, when stock should be replenished, and how large order should be.

2.2 The purpose of inventory: In a just-in-time manufacturing environment, inventory is considered waste. However, in environments where an organization suffers from poor cash flow or lacks strong control over (i) electronic information transfer among all departments and all significant suppliers, (ii) lead times, and (iii)

quality of materials received, inventory plays important roles.

2.3 Functions of inventories

1. Separate different operations from one another and make them independent, so that each operation (starting from raw material to finished product) can be performed economically.
2. Maintain smooth and efficient production flow.
3. Purchase in desired quantities and thus nullify the effects of changes in prices or supply.
4. Keeps a process continuously operating.
5. Create motivational effect. A person tempted to purchase more if inventories are displayed in bulk.[3]

The inventory may be classified into followings: [3]

- Raw inventory
- In-process inventory
- Finished inventory
- Indirect inventory

RESEARCH METHOD

This paper focuses a case study to identify the inventory control system and determine the optimum levels of inventory of a product in Incepta Pharmaceuticals Ltd. by using different service level in fixed time period model. Data are collected from different sources at different time by making questioner and interview.

3.3.2 DEVELOPING A CASE STUDY

Many well-known case study researchers such as Robert E. Stake, Helen Simons, and Robert K. Yin have written about case study research and suggested techniques for organizing and conducting the research successfully. This introduction to case study research draws upon their work and proposes six steps that should be used:

- Determine and define the research questions
- Select the cases and determine data gathering and analysis techniques
- Prepare to collect the data
- Collect data in the field

- Evaluate and analyze the data
- Prepare the report

FINDING FROM THE CASE STUDY

This chapter presents the findings from the case study conducted. The case study has been conducted in **Incepta pharmaceuticals limited**. The objective of this case study has been to search for different aspects of inventory control, more specifically their current policy for inventory control of particular finished good.

4.2.1 Incepta pharmaceuticals inventory system

Usually the company focuses on the raw material inventory system among the four types stated above (discussed in article 2.4). The reasons behind that are raw materials lead time is long and raw materials are very expensive. For managing of raw material inventory they first collect forecasted demand from marketing department. Then they follow different methods of inventory control for dependent demand system such as MRP I(Material Requirement Planning), MRP II(Manufacturing Resource Planning), BOM(Bill Of Materials), MOQ(Minimum Order Quantity), EOQ(Economic Order Quantity) etc. They use well organized excel sheet for managing inventory of raw material and they review daily the updated information of inventory by using internet and by intranet(head office and factory). They keep inventory for following materials:

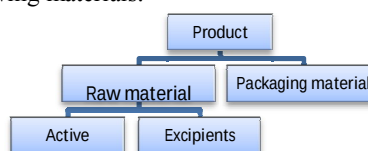


Fig 4.2.1(a): Materials requirement for final product.

4.2.2 DEMAND FOR PANTONIX 20 TABLET

Forecasted and actual monthly demand data for PANTONIX 20 TABLET for the year of 2007, 2008 and 2009(up to July) are shown in figure below:

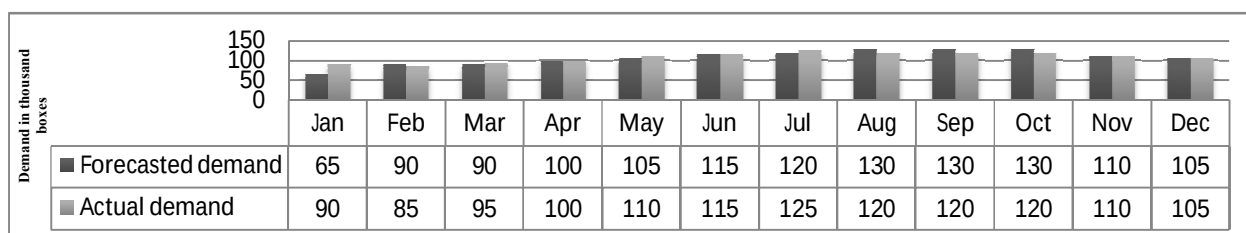


Fig 4.2.2 (a): Forecasted and actual demand in the year 2007

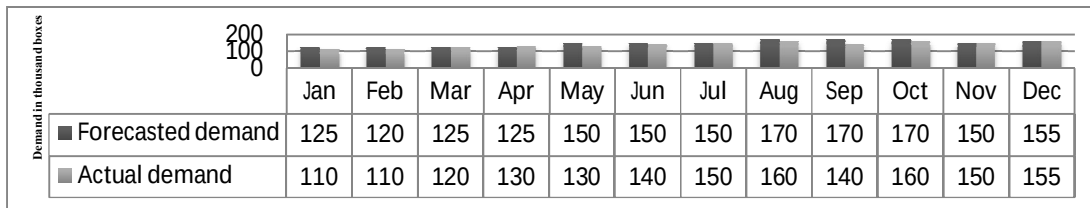


Fig 4.2.2 (b): Forecasted and actual demand in the year 2008

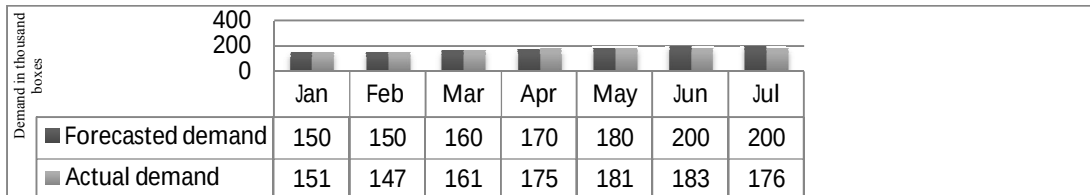


Fig 4.2.2 (c): Forecasted and actual demand in the year 2009

4.3 KEY FINDINGS

Following key findings are found from case study

- Company's current practices for inventory control.
- Forecasted and actual demand data for Pantonix 20 Tablet.
- Time required in different phases of production of Pantonix 20 Tablet

ANALYSIS

Analysis on the findings of the case study conducted in the selected company has been presented in this chapter. A proposal has been made for developing strategy to find optimum inventory level of Pantonix 20 Tablet by using the scientific inventory model (Fixed time period model).

5.3 Assumptions:

- Demand for the product is constant and uniform throughout the month.
- The lead time (i.e. time from order to receipt) is constant for finished goods.
- Cost per unit of product is constant.
- Raw materials for the product are available for instant supply.
- All production related resources (e.g. equipment, machineries, labor etc.) are available for meeting the demand.
- Transportation facilities are available without any disturbance.

Pantonix 20 Tablet is very fast moving product (i.e. high sales volume) and this is one of the major products of the company. For this reason, **the company does not want to take any risk of stock out for this product**. So order quantity calculated with service level 100%.

5.4 Calculations with service level 100%:

Taking into account 12 months (2007) of data

T = The number of days between reviews = 0.5 month = 15 days

L = Lead time in days (time between placing an order and receiving it) = 0.33 month = 10 days.

P = Service level desired expressed as a fraction = 100% = 1.00

= Forecasted average monthly demand = 107.50 thousand boxes.

z = Number of standard deviations for a specified service level = 4.5

$E(z)$ = Expected number units short from a normalized table where $\sigma = 1$

= Standard deviation of demand over the review and lead time = _____

= Standard deviation of the monthly demand.

$$\sigma_{dm} = \sqrt{\frac{\sum_{i=1}^n (di - \bar{d})^2}{n}}$$

$$\sigma_{dm} = \sqrt{\frac{(65 - 107.5)^2 + (90 - 107.5)^2 + (90 - 107.5)^2 + (100 - 107.5)^2 + (105 - 107.5)^2 + (115 - 107.5)^2 + (120 - 107.5)^2 + (130 - 107.5)^2 + (130 - 107.5)^2 + (130 - 107.5)^2 + (110 - 107.5)^2 + (105 - 107.5)^2}{12}}$$

$$\sigma_{dm} = \sqrt{352.08} = 18.76388 \text{ thousand boxes.}$$

$$\sigma_{(T+L)} = \sqrt{(T+L)\sigma_{dm}^2} = 17.09471 \text{ thousand boxes.}$$

$$E(z) = \frac{\bar{d} T(1-p)}{\sigma_{(T+L)}}$$

$$E(z) = \frac{107.5 \cdot 0.5 \cdot (1-1)}{17.09471} = 0.00$$

From table 1 given in appendix B: $z = 4.5$

Order quantity (in thousand boxes):

$$q = \bar{d} (T+L) + z \sigma_{(T+L)} - I$$

$$q = 107.50 \cdot (0.5 + 0.33) + 4.5 \cdot 17.09471 - I$$

$$q = 166.1512 - I$$

With this level, proposed inventory throughout the year is shown graphically.

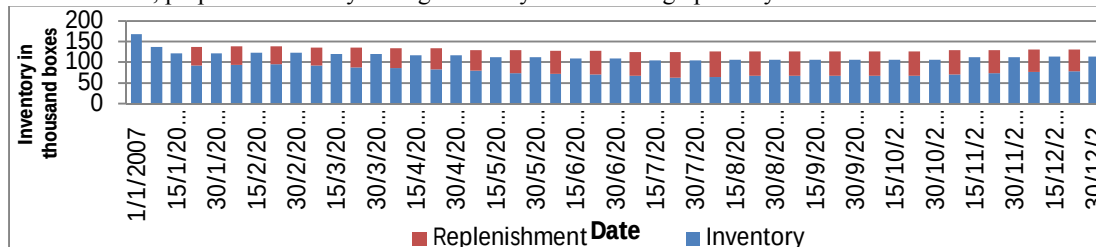


Fig 5.4(a): Proposed inventory and replenishment of order for the year 2007.

Review period and order placed at 1st and 15th of every month.

Replenishment of order received at 10th and 25th of every month.

Service level is 100%.

The company maintained inventory for 3 months shown in Fig 5.4(b). Here at 1 January 2007 the inventory were 245 thousand boxes. After 15 days it is reviewed and order is placed for the quantity of subtracted present inventory from next three months demand. Therefore, at 15 January 2007 the inventory was 200 thousand boxes. So order is placed for $(263 - 200) = 63$ thousand boxes. This is received after 10 days (lead time). At 25 January 2007, the inventory level decreased but for replenishment, the inventory becomes from 170 thousand boxes to 233 thousand boxes. Thus the company maintain inventory in this way throughout the year. Detailed calculation is attached in appendix C Table 3.

Similarly existing practice of company inventory and replenishment of order for the year 2008, 2009 (up to July) and proposed inventory and replenishment of order for years are calculated next.

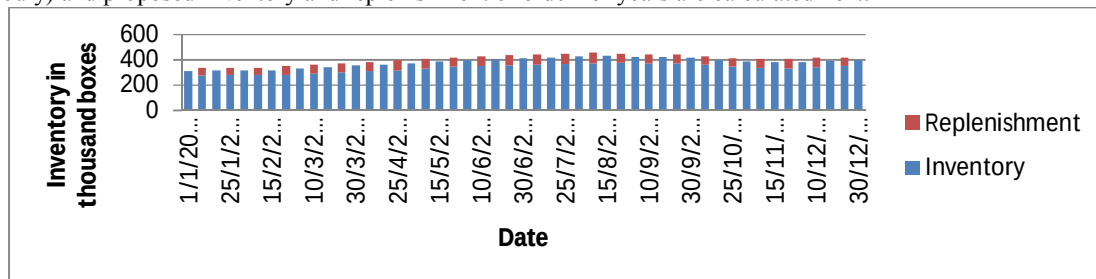


Fig 5.4(c): Existing practice of company inventory and replenishment of order for the year 2008.

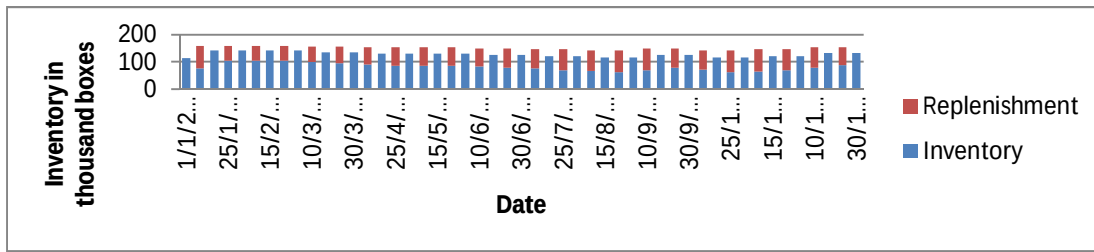


Fig 5.4(d) : Proposed inventory and replenishment of order for year 2008.

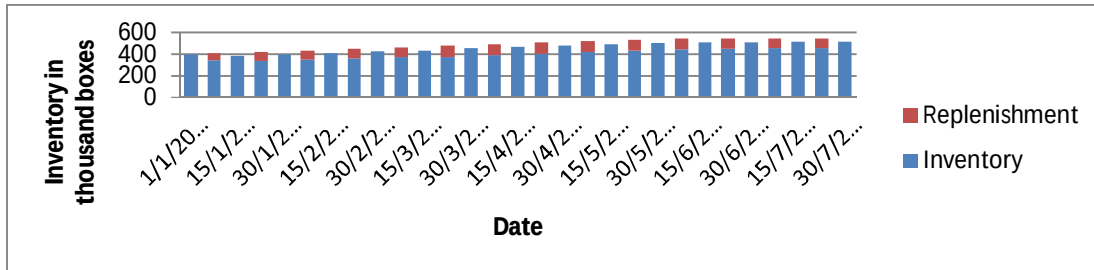


Fig 5.4(e): Existing practice of company inventory and replenishment of order for the year 2009.

This figure shows the company's inventory level throughout the year 2009.

$$\begin{aligned}
 \text{Order quantity (For year 2009): } q &= \bar{d} (T+L) + z \sigma_{(T+L)} - I \\
 &= 172.86 * (0.5+0.33) + 4.5 * 13.77368 - I \\
 &= 143.4714 + 61.98156 - I \\
 &= 205.453 - I
 \end{aligned}$$

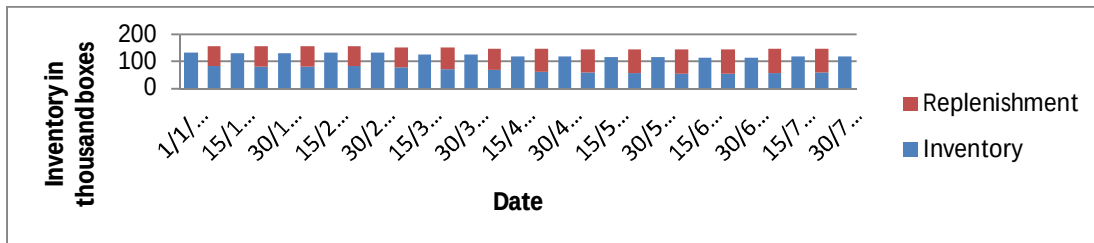


Fig 5.4(f): Proposed inventory and replenishment of order for the year 2009.

Comparison between company's inventory level and proposed inventory level is shown next.

5.5 Compare (for service level 100%):

From above calculations at every month's end, inventory level is compared for company's existing practice and proposed level of inventory. Average inventory level also compared between company's existing practice and proposed level of inventory.

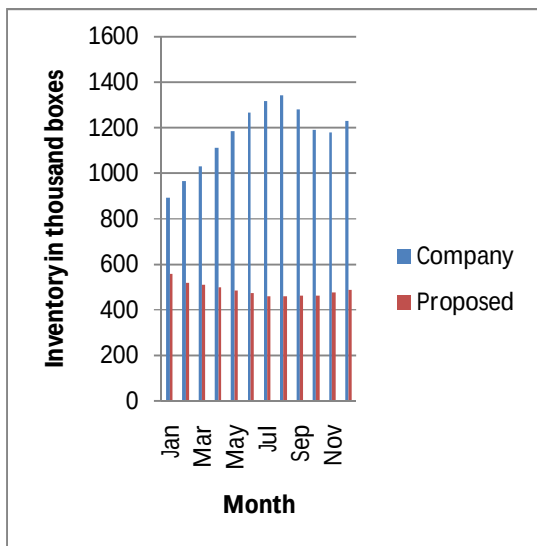


Fig 5.5(a): Comparison between company's inventory level and proposed inventory level for year 2007.

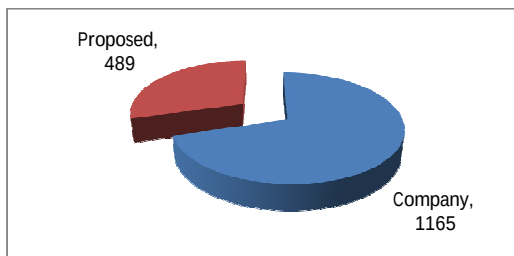


Fig 5.5(b): Comparison between company's and proposed monthly average inventory level (in thousand boxes) for year 2007.

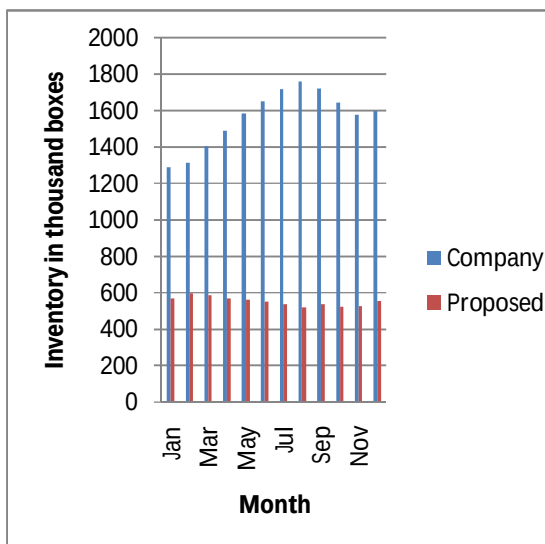


Fig 5.5(c): Comparison between company's inventory level and proposed inventory level for year 2008.

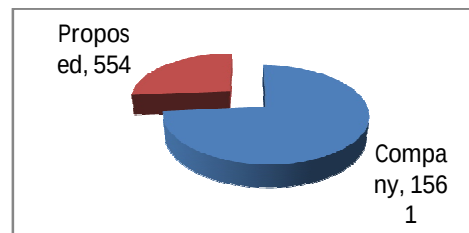


Fig 5.5(d): Comparison between company's and proposed monthly average inventory level (in thousand boxes) for year 2008.

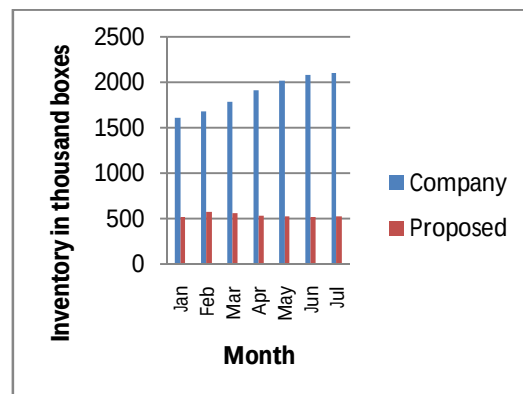


Fig 5.5(e): Comparison between company's inventory level and proposed inventory level for year 2009.

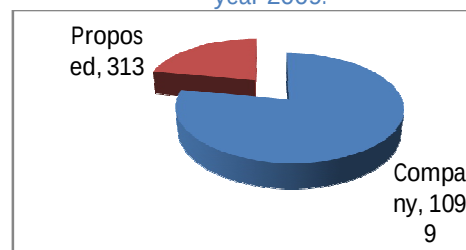


Fig 5.5(f): Comparison between company's and proposed monthly average inventory level (in thousand boxes) for year 2009.

5.6 Monthly capital cost involved at different years:

For 100% service level monthly capital cost involved is calculated.

1 box contain **50** tablets

Total cost/pcs **1.889145** tk.

For year 2007:

Companies average inventory: $1165.3472 * 1000 * 50 = 58267361$ pcs/month.

So capital cost involved, C1 = 110075494 tk/month.

Proposed average inventory: $489.1187 * 1000 * 50 = 24455935$ pcs/month.

So capital cost involved, C2 = 46200807 tk/month.

According to company's model extra capital involved = $(C1-C2) = 63874687$ tk/month.

For year 2008:

Companies average inventory: $1560.99 * 1000 * 50 = 78049306$ pcs/month.

So capital cost involved, C1 = 147446455 tk/month.

Proposed average inventory: $553.813736 * 1000 * 50 = 27690687$ pcs/month.

So capital cost involved, C2 = 52311723 tk/month.

According to company's model extra capital involved = $(C1-C2) = 95134733$ tk/month.

For year 2009(up to July):

Companies average inventory: $1098.7778 * 1000 * 50 = 54938889$ pcs/month.

So capital cost involved, C1 = 103787527 tk/month.

Proposed average inventory: $312.75534 * 1000 * 50 = 15637767$ pcs/month.

So capital cost involved, C2 = 29542010 tk/month.

According to company's model extra capital involved = $(C1-C2) = 74245517$ tk/month.

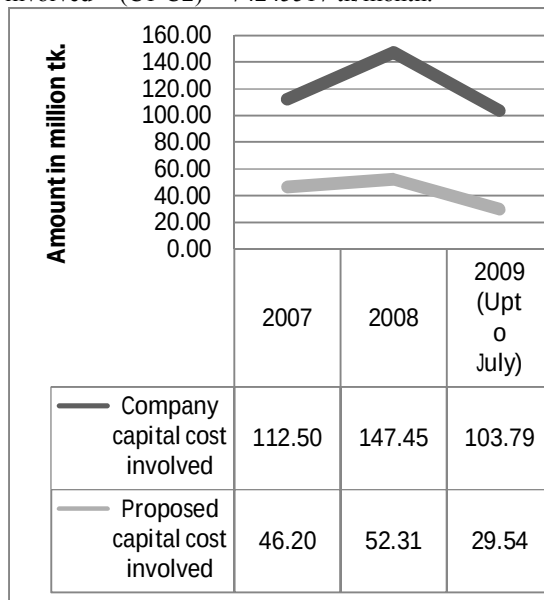


Fig 5.6: Compare between capital costs involved in million tk/month.

Inventory means, “money kept in store room”. This Fig. shows that in proposed model, capital cost involved is less and it is clearly visible that if company’s inventory model is used then large amount of capital kept in store room.

5.7 Benefits from reduced inventory level:

For inventory huge capital cost is involved. This amount of money can be used elsewhere to get benefit. Let the money is deposited in Bank with 7% interest. Using simple interest we calculate the benefit.

Interest, $I = \text{principal amount (P)} * \text{interest period (n)} * \text{interest rate (i)}$.

For year 2007: $P = 63874687 * 12 = 766496244$ tk;
 $i = 7\% = 0.07$; $n = 1$;

Interest, $I =$

Similarly for year 2008: $F = 1285438314$ tk;

Benefit = 143821517 tk = 14.38 crore tk;

For year 2009(upto July): $F = 545741371$ tk;

Benefit = 26022752 tk = 2.60 crore tk ;

5.8 Causes for maintaining huge inventory:

Pantonix 20 Tablet is very fast moving product (i.e. high sales volume) and this is one of the major products of Incepta pharmaceutical company. For this reason, **the company does not want to take any risk of stock out for this product**. They keep one month safety stock in central warehouse.

Other reasons are:

- To meet fluctuating demand at different depots(16).
- To avoid unexpected problems in transportation.
- To avoid raw materials unavailability.
- To meet the demands during off production.

If Incepta pharmaceutical company can take some risks then inventory can be reduce. So order quantity has been calculated with service level 99.73% which is equivalent to $\pm 3\sigma$ standard deviation.

5.9 Calculations with service level 99.73%:

Taking into account 12 months (2007) of data

$T =$ The number of days between reviews = 0.5 month = 15 days

$L =$ Lead time in days (time between placing an order and receiving it) = 0.33 month = 10 days.

$P =$ Service level desired expressed as a fraction = 99.73% = 0.9973

= Forecasted average monthly demand = 107.50 thousand boxes.

$z =$ Number of standard deviations for a specified service level = 1.983684

$E(z) =$ Expected number units short from a normalized table where $\sigma = 1$

= Standard deviation of demand over the review and lead time =

= Standard deviation of the monthly demand.

$$\sigma_{dm} = \sqrt{\frac{\sum_{i=1}^n (di - \bar{d})^2}{n}}$$

$$E(z) = \frac{107.5 * 0.5 * (1 - 0.9973)}{17.09471} = 0.008489$$

From table 1 given in appendix B: $z = 1.983684$

Order quantity (in thousand boxes): $q = \bar{d}(T+L) + z\sigma_{(T+L)} - I$

$$\sigma_{dm} = \sqrt{352.08} = 18.76388 \text{ thousand boxes.}$$

$$\sigma_{(T+L)} = \sqrt{(T+L)\sigma_{dm}^2} = 17.09471 \text{ thousand boxes.}$$

$$E(z) = \frac{\bar{d}T(1-p)}{\sigma_{(T+L)}}$$

$$107.50 * (0.5 + 0.33) + 1.983684 * 17.09471 - I = 123.1355 - I$$

With this level, proposed inventory throughout the year is shown graphically.

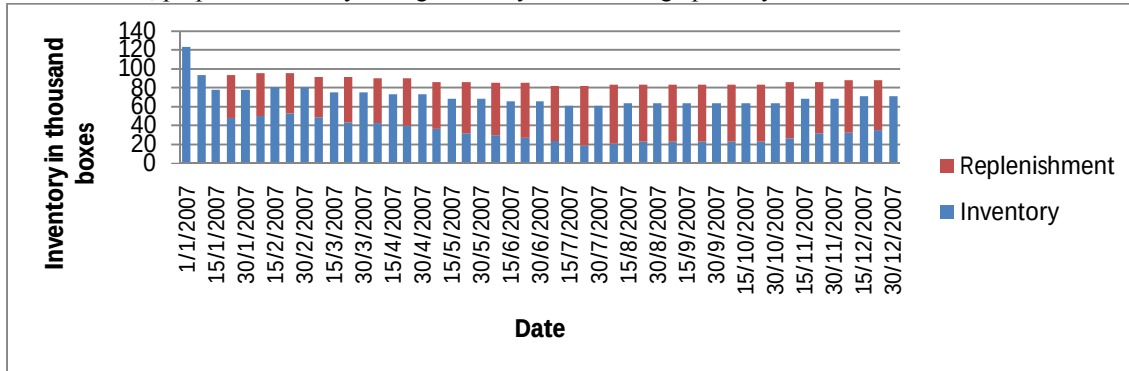


Fig 5.9(a) Proposed inventory and replenishment of order for the year 2007.

Review period and order placed at 1 and 15 of every month.

Replenishment of order received at 10 and 25 of every month.

Service level is 99.73% (6 σ).

Fig 5.4(a) shows that at 1st January 2007 the inventory was 123 thousand boxes. Now gradually inventory is consumed. After 10 days at 10th January 2007, the inventory was 93 thousand boxes as 30 thousand boxes consumed. Similarly after 5 days at 15th January 2007 the 78 thousand boxes remain and an order placed for (123 - 78=) 45 thousand boxes. After 10 days (which is the lead time) the order is received. At 25th January 2007, the inventory level decreased but for replenishment, it reached from 78 thousand boxes to 93 thousand

boxes. In this way inventory is calculated throughout the year. Similarly we also calculate inventory level of Pantonic 20 Tablet for year 2008 and 2009(up to July).

Order quantity (For year 2008):

$$q = \bar{d}(T+L) + z\sigma_{(T+L)} - I = 146.67 * (0.5 + 0.33) + 1.863089 * 16.35373 - I = 121.7333 + 30.46845 - I = 152.2018 - I$$

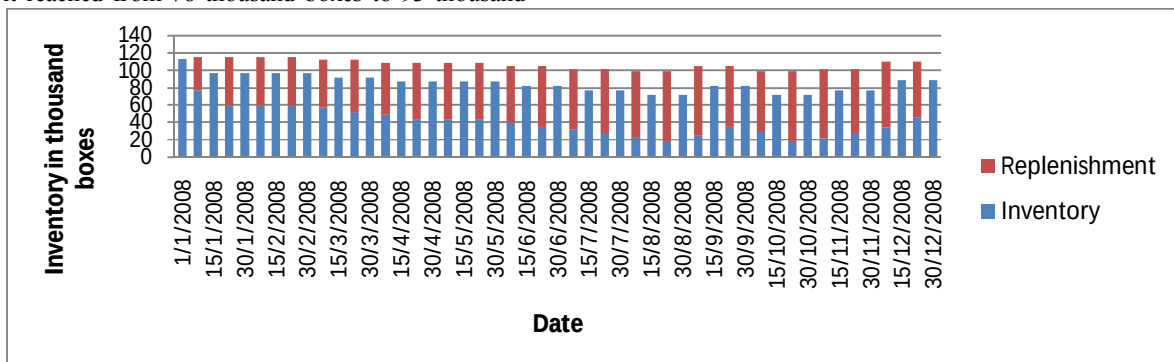


Fig 5.9(b): Proposed inventory and replenishment of order for year 2008.

Order quantity (For year 2009): $q = \bar{d}(T+L) + z\sigma_{(T+L)} - I$

$$= 181.67 * (0.5 + 0.33) + 1.726444 * 13.77368 - I$$

$$= 143.4714 + 23.77949 - I = 167.2509 - I$$

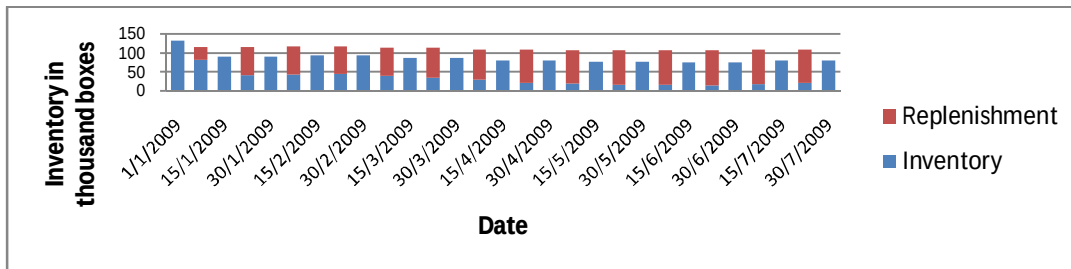


Fig 5.9(c): Proposed inventory and replenishment of order for the year 2009.

5.10 Compare (for service level 99.73%)

Now we compare our proposed inventory level (for service level 99.73%) with company's inventory level.

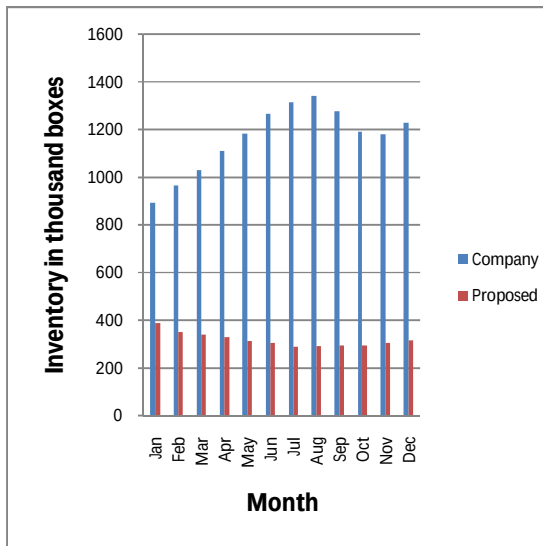


Fig 5.10(a): Comparison between company's inventory level and proposed inventory level for year 2007.

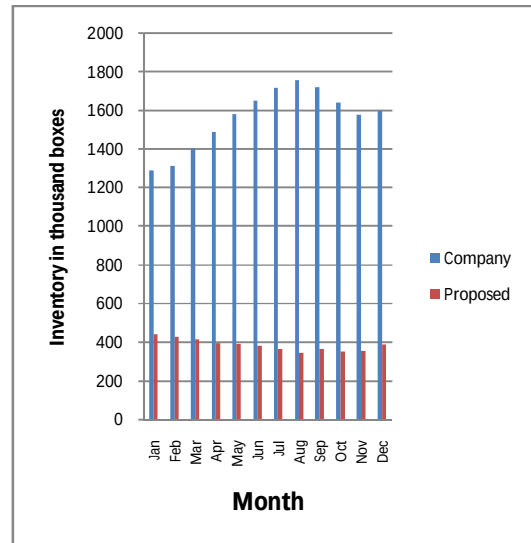


Fig 5.10(c): Comparison between company's inventory level and proposed inventory level for year 2008.

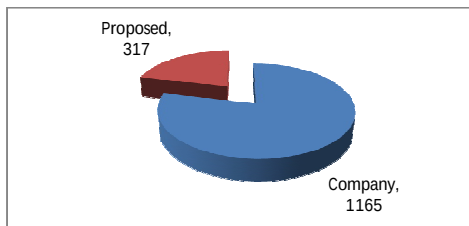


Fig 5.10(b): Comparison between company's and proposed monthly average inventory level (in thousand boxes) for year 2007.

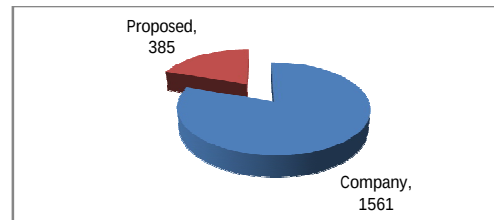


Fig 5.10(d): Comparison between company's and proposed monthly average inventory level (in thousand boxes) for year 2008.

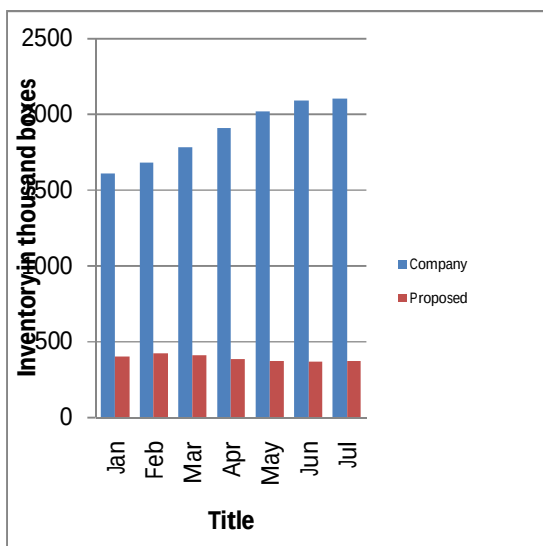


Fig 5.10(e): Comparison between company's inventory level and proposed inventory level for year 2009.

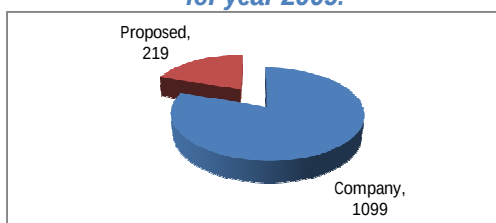


Fig 5.10(f): Comparison between company's and proposed monthly average inventory level (in thousand boxes) for year 2009.

5.11 Monthly capital cost involved at different years

For 99.73% service level monthly capital cost involved is calculated.

1 box contain **50** tablets

Total cost/pcs **1.889145** tk.

For year 2007:

Companies average inventory: $1191 * 1000 * 50 = 59550000$ pcs/month.

So capital cost involved, C1 = 112498585 tk/month.

Proposed average inventory: $317 * 1000 * 50 = 15852797$ pcs/month.

So capital cost involved, C2 = 29948232 tk/month.

According to company's model extra capital involved = $(C1 - C2) = 80127262$ tk/month.

For year 2008:

Companies average inventory: $1561 * 1000 * 50 = 78050000$ pcs/month.

So capital cost involved, C1 = 147447767 tk/month.

Proposed average inventory: $384 * 1000 * 50 = 19245702$ pcs/month.

So capital cost involved, C2 = 36357921 tk/month.

According to company's model extra capital involved = $(C1 - C2) = 111174871$ tk/month.

For year 2009(up to July):

Companies average inventory: $1099 * 1000 * 50 = 97850000$ pcs/month.

So capital cost involved, C1 = 184852838 tk/month.

Proposed average inventory: $227 * 1000 * 50 = 11340033$ pcs/month.

So capital cost involved, C2 = 21422967 tk/month.

According to company's model extra capital involved = $(C1 - C2) = 82364560$ tk/month.

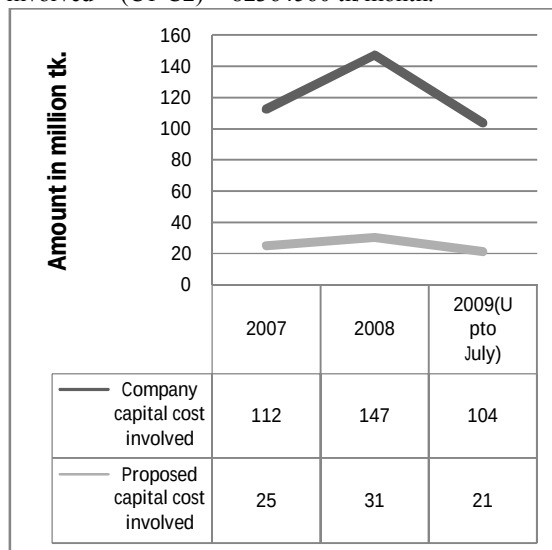


Fig 5.11: Compare between capital costs involved in million tk/month.

Inventory means “money kept in store room”. This Fig. shows that in proposed model, capital cost involved is less and it is clearly visible that if company's inventory model is used then large amount of capital kept in store room.

5.12 Benefits from reduced inventory level (with service level 99.73%)

For inventory huge capital cost is involved. This amount of money can be used elsewhere to get benefit. Let the money is deposited in Bank with 7% interest. Using single payment compound amount factor we calculate the benefit.

Future sum, $F = \text{present principle sum} * (1 + \text{nominal amount interest rate} / \text{compounding})$

periods per year) ^{compounding} periods per year * no of annual periods

$$= P * (1 + r/m)^{m*n}$$

For year 2007: $P = 80127262 * 12 = 961527144$ tk;

$r = 7\% = 0.07$; $m = 12$; $n = 2.7$;

$$\diamond F = 1160926509 \text{ tk};$$

Benefit $(F - P) = 199399364.9$ tk = 19.93 crore tk;

Similarly for year 2008: $F = 1502168915$ tk;

Benefit = 168070463.4 tk = 16.8 crore tk;

For year 2009(upto July): $F = 1037863481$ tk;

Benefit = 49488760.89 tk = 4.95 crore tk ;

Similarly we calculate with 98% service level for reduce more inventory.

5.13 Benefits from reduced inventory level (with service level 98%)

If the company takes more risk (i.e. calculate inventory level with 98% service level in fixed time period model) then fluctuating demand can be meet without any stock out with more reduced inventory level. Increased benefit is shown below.

For year 2007: $P = 87467414 * 12 = 1049608968$

tk; $r = 10\% = 0.1$; $m = 12$; $n = 2.7$;

$$\diamond F = 1373413016 \text{ tk};$$

Benefit $(F - P) = 323804048$ tk = 32.38 crore tk;

Similarly for year 2008: $F = 1659430811$ tk;

Benefit = 258440879 tk = 25.84 crore tk;

For year 2009(upto July): $F = 1107360460$ tk;

Benefit = 74564885 tk = 7.45 crore tk ;

RESULTS

From evaluation on the inventory system of Pantonix 20 Tablet, it is visual that the company holds average 1166 thousand box/month (for 2007) as inventory. As this product has high sales volume so the company does not want to take any risk of stock out of this product. Therefore at first use 100% service level in fixed time period model for calculating the proposed level of inventory. From analysis we found that average inventory 490 thousand box/month (for 2007) is required. For this service level there is no stock out occurred. If the industry holds this proposed level of inventory then 58% capital investment could be saved. Then conduct cross study for different service level. If 99.73% ($= \pm 3\sigma$) service level is used then there is no stock out and 72% capital investment could be saved (for 2007). Similarly for 98% service level inventory level can be reduced more without any stock out.

CONCLUSION

It is visual that the company keeps huge inventory of selected product. This inventory can be reduced by applying fixed time period model.

CHANGE OVER TIME REDUCTION IN GARMENTS INDUSTRY THROUGH SMED METHODOLOGY.

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Abstract

The Single Minute Exchange of Die (SMED) is one important lean tool to reduce waste and improve flexibility in manufacturing processes allowing lot size reduction and manufacturing flow improvements. SMED reduces the non-productive time by streamlining and standardizing the operations for exchange tools, using simple techniques and easy applications. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. This rapid changeover is the key to reducing production lot sizes and thereby improving flow. There has a great applicability of SMED method in RMG sector. Several implementations have proven that the SMED method really works in practice and reductions of even 90% and more are feasible in some situations [1]. As RMG sector is a large industrial sector in Bangladesh; Change over time reduction can play a vital role for improving productivity as well as economic development for the country. It is found that a significant amount of time per style, per month can be minimized by applying this method. The implementation has enabled reduction in setup time, through company's internal resources reorganizations without the need for significant investment.

1.Introduction:

Single-Minute Exchange of Die (SMED) is one of the many lean production methods for reducing waste in a manufacturing process[1] that has a great impact of any Manufacturing Industries such as Garments Manufacturing Industries. In Bangladesh garment Industries carry on a maximum economic growth of whole economic development but most of the garment

industries is lacking behind to a great extent in concern of Productivity, Efficiency, Customer satisfaction level etc. so to cover up some of the lacking, it must be developed a standardized process of minimizing change over time to increase productivity, Efficiency, Customer service level and profit via waste elimination. Today's garment industries are continuously reached in highly competitive environment of

fashion and technology among to fill the customer satisfaction where Lean Manufacturing tools have a great excellence.

SMED is that it has a lot of other effects which come from systematically looking at operations; these include stockless production, inventory freeing floor space, reduce production time, elimination setup error and setup time, Elimination of unusable stock. [2]

2. Problem Formulation:

Garments manufacturing system is a technological process of making a complete part by arranging several man and machine according to these sequential operations where that's have some of term and condition to maintain the customer satisfactory level e.g. quality. When manufacturing products is in large scale, some of Internal & External activities & several tool exchanges take place for the same product where changeover time always play a vital role for slow production. A rapid changeover is widely acknowledged as an essential prerequisite to flexible, responsive production. The SMED system is a method that make possible to perform equipment setup and changeover operations under 10 minutes.

3. Methodology:

- Survey and screening the situation of implementation area.
- Activity classification.
- Transforming internal into external activities.
- Improvement, internal activities minimization.

- External activities improvement.
- Standardization and forming the SMED procedures.

3.1. Survey and screening the situation of implementation area:

Initial & final surveying have been done into the sewing floor to find out the feasibility of SMED method implementation. All activities have to be recorded in detail; some of the activity contributes to obtaining even worse result. So that SMED method implementation has a great significant in sewing section.

3.2. Activity classification:

This step is comprised of recorded activities divided into two groups: the internal and external ones.

External activities are all the set up activities that can be preformed while machine is in operation. Internal set up activities are the ones that can be performed only if the machine is not in operation.

3.2.1. The Internal Activities are:

- Layout preparation
- Trial production
- Cleaning Machine surface
- Cleaning work surface
- Needle change
- Stitch adjustment
- Stitch measurement
- Guide adjustment
- Nose change
- Looper adjustment
- Tension adjustment
- Thread change
- Needle positioning
- Trim adjustment

- Fixing new tools

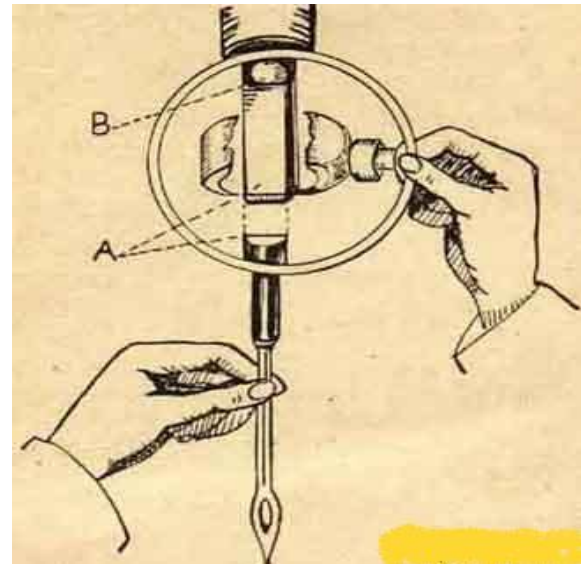
3.2.2. The External Activities are:

- Pre Production Meeting.
- Provision of trim card.
- Getting cut panel from cutting section.
- Getting threads & accessories from store.
- Giving instruction about new style from supervisors.
- Provision of Layout and line balancing sheet.
- Provision of production sheet.
- Getting instruction for next job.
- Getting material for the next job from stores.
- Getting tools for the next job from tool stores.
- Returning tools for the last job to tool stores.

3.3. Transforming internal into external activities:

3.3.1. Needle change:

To reduce the change over time Needle clamping system should be more reliable & less time consuming event. According to existing system Needle is push into upper position to hold it the needle holder then tighten the supporting screw.



Pic-1. Needle changing system

Redesign system will be Electromagnetic clamping when machine is started or switch on an electromagnetic field will be create around the Needle holder then Needle is positioning into the seated position for left turn. But when it will need to change then just power off the machine and right turn to remove the Needle.

3.3.2. Trial Production:

Trial production is done for the purpose of checking mainly product quality & some of product special specification such as size measurement, sewing quality, and stitch tension etc. During trial production instruction is given that what's wrong and what's right. If somewhat will wrong of any process then supervisors & in charge gives them proper specification. Production managers, Quality manager, Floor in charge, supervisors are responsible for trial production.

Redesign system will be production manager and quality manager will have provide proper product specification, quality specification and others necessary specification for the responsible persons Quality controller, floor in charge, line Chief, and supervisors at least 2 or 3 days ago before final production.

3.3.3. Layout preparation:

In previous system the production peoples are responsible for layout preparation. In their layout there were some of problems for consuming more time. That was:

- No process sequence.
- Product not smooth flow.
- Products are not totally forward flow.
- Straight layout
- Product transportation waste was high
- Consume more space
- Manpower & Machine allocation was not limited way
- Process layouts are frequently changed.

Redesign system will be Layout preparation must be done according to PMTS analysis which will totally helpful for SMV calculation, Man & Machine allocation, Target setting & Efficiency calculation & also preventive for these problems of process sequence, space, product transportation, man & machine allocation, layout change.

3.3.4. Thread Change:

It's one of the most common internal activities in sewing line. Each sewing Machine have required only one thread stand with one running style color thread

and the thread stand is attached in front of the sewing table with a handle. When a new style is introduced into the sewing line then thread stand is filled by another color thread in the basis of style color.

Redesign system will be that each thread stand must be separated into two sections. One section will contain running style color thread and another section contains upcoming style color thread. When running style production will be finished then it will not need to change thread stand, just move the thread stand to the sewing machine with a suitable operating length.

3.3.5. Cleaning Machine Surface:

Cleaning Machine surface is an internal activity which also be performed frequently because of removing dust from machine surface. When it will be done machine must be switched off and this operation is performed by hand brush that's not reliable and quick cleaning operation.

Redesign cleaning procedure must be more effective by using portable vacuum hand cleaner without stopping machine. A portable vacuum cleaner is also a mechanical device that uses a draft of air to remove dust from a short distance of machine surface very quickly with adjustable pressure which will be more effective to change over time reduction such as lean implementation.



Pic-2. Portable hand vacuum cleaner [1].

4. Improvement, internal activities minimization:

Some of internal activities can be improved by using 5S method. These are:

- Stitch adjustment
- Stitch measurement
- Trim adjustment
- Fixing new tools
- Guide adjustment
- Nose change

These above internal activities have a great effect to change over time minimization. in the way of:

- Visually set the tools, at hand of operator (5S)
- Using connectors that may be rapidly exchanged for all tool power sources (5S)
- Using as many locating pins for accurate tool positioning as possible (SMED)
- Cranes with sliding transporters (SMED)
- Using cranes for heavy tools only (SMED)
- Using standard tools as possible (SMED)

5. External activities improvement

All of the external activities (mention above) are possible to improvement by 5S implementation.

- Placing visual markings for easier and faster identification (5S)
- Using check list to prevent unpredictable events in resources preparation (5S)
- “At hand” tool organization (5S)
- Work place organization that decreases tool search time (5S)

5.1. Pre-Production Meeting:

Before starting test cutting & sewing Pre-Production Meeting will held to make sure everyone is aware of all about the style and execute the style respecting all quality points and to minimize communication gaps and to get a know how of the order starting from cutting section to finishing section. The meeting will attended by Quality Assurance Manager, Cutting & sewing-In-Charge and respective line Mechanic. During the meeting following points will have discussed as per the agenda mentioned the following.

- Introduction of the style - Assistant General Manager / Factory Manager
- Fabric & Accessories status – Store-In-Charge
- Pattern, Cut marks etc – Pattern In Charge
- Quality points – QA Manager
- Special Operations – Technical Manager
- Line Layout, Allocation of workers, Target setting, Line balancing – IE Dept.

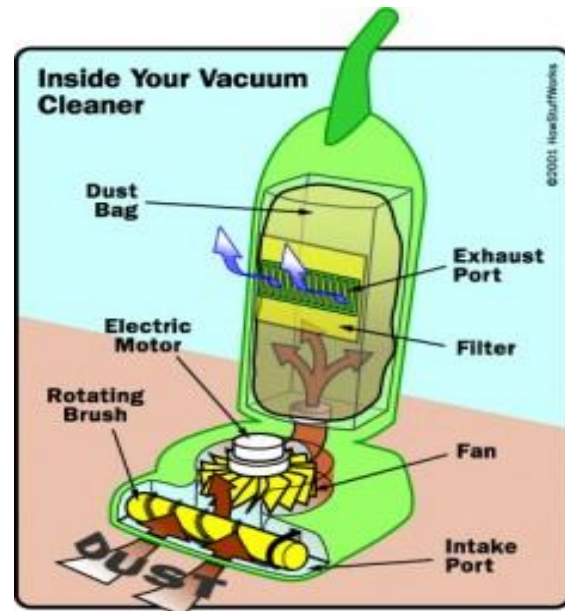
- Ironing, Folding & Packing – Finishing-In-Charge

Meeting minutes are recorded & circulated to all concerns.

5.2. Cleaning work surface:

Cleaning work surface is an External activity which must be performed frequently in garment production floor with manual brush that's have a great effect to lean implementation such as change over time. By using tradition cleaning system huge dust would not possible to clean at a time. so that cleaning time is not totally improved.

Redesign procedure of cleaning will be more reliable & less time consuming event than traditional system by using vacuum cleaner. A vacuum cleaner is a mechanical device that uses a draft of air to remove dust or other particulate matter from dry surfaces so easily & quickly. An electrically powered fan is used to produce a zone in which the air pressure is below atmospheric pressure, causing a draft of air to flow through the material to be cleaned, carrying the small practices with it.



Pic-3. Vacuum cleaner [3].

6. Data Table:

Here data are collected for basic T-shirt from one production line (style-Henze Basic T-shirt).

Table-1. Layout preparation.

Existing scenario of Layout preparation		Redesign scenario of Layout preparation	
Associated activities	Total Time(sec)	Associated activities	Time (sec)
Sample Introduced	28800	Sample Introduced	1500
Layout preparation		Operation Breakdown	600
Man & M/C allocation		PMTS analysis	900
Verification of each process		Layout preparation & Man & M/C allocation, Target setting	5400
Finalization			
Total	28800	Total	8400

Table-2. Trial production.

Process	Fre q.	Total Time	Process	Fre q.	Actual Time (sec)
Back & Front match	1	7	Back & Front match		6
Shoulder joint	2	50	Shoulder joint		20.4
Rib joint	2	18.6	Rib joint		15.6
Rib open	1	22	Rib open		19.8
Rib tack	1	9	Rib tack		6.6
Rib close	2	46	Rib close		12
Bk nk pipng & lebel place mark	2	48	Bk nk pipng & lebel place mark		12.6
Piping close with label & lebel make	3	104.6	Piping close with label & lebel make		32.4
Sleeve Hem	3	102.5	Sleeve Hem		20.4
Sleeve Match	1	16.2	Sleeve Match		14.4
Sleeve Join	3	110.6	Sleeve Join		31.8
Care & Name label make	2	15	Care & name label make		12.6
Side seam	2	112.3	Side seam		40.8
Sleeve open & close Tack	3	125	Sleeve open & close Tack		34.8
Body Hem	2	51.5	Body Hem		16.8
Total		838.3	Total		285

Table-3. Needle change.

Existing System		Redesign System	
Process	Time/change	Process	Time
Plain M/C	112	Plain M/C	66
F/L M/C	75	F/L M/C	38
O/L M/C	92	O/L M/C	48
Total	279	Total	152

Table-4. Thread Change.

Existing System				Redesign system		
M/C	No. of thread stand	Time/change	Total time	No. of thread stand	A.T/change	Ttl time
Plain	7	261	1827	7	81	567
O/L	9	432	3882	9	192	1728
F/L	3	780	2340	3	660	1980
Total			8049	Total		4275

Table-5. Cleaning Machine Surface:

Existing system				Redesign system		
M/C type	No of M/C	Cleanin g Time/M /c	Total Time	No of M/C	Cleanin g Time/M /c	Total Time
Plain	7	118	826	7	40	280
O/L	9	175	1575	9	65	585
F/L	3	124	372	3	50	150
Total			2773	Total		1015

Table-6. Cleaning work surface:

Existing System		Redesign System	
Cleaning Time/Line	Total Time	Cleaning Time/M/c	Total Time
640	640	140	140
Total	640	Total	140

Table-7. External Activities improvement.

External Activities Improvement (through 5S)	
PP meetings	-Develop a systematic away to concern at about every stage of GMT manufacturing process.

	-Develop an effective Instruction about production peoples.	Total Time (in Hour)	11.494 Hrs	3.96 Hrs	7.53 Hrs
Getting cut panel from cutting section	-Cut panel are distributed according to sewing line capacity. -Lead time reduction. -Accumulation of Bundle Quantity.	Table-9. External Activities improvement after implementation.			
Getting thread & accessories	-Reduction of Lead time. -Reduction of manpower.	External Activities	Improvement (Through 5S)		
Getting Instruction about new style	-production people have already concern about new style from PP meeting.	PP meetings	Systematic, time saving & greater attention, accurate timing.		
Arranging tools	-Necessary tools are fixing in right place for quick operation such as Needle, scissor, thread, measurement tape, screw driver etc.	Getting cut panel	Sort, sustain, and lead time improvement.		
Layout & Line Balancing	-Reduction of excessive manpower. -Allocated man & machine in every sewing line. -Improve operation. -combined operation.	Getting thread & Accessories	Lead time improvement, advanced functioning		
		Arranging Tools	Sort, standardized & sustain		
		Line Balancing	Advanced approach, better accuracy.		

8. Conclusion:

Only one change over time has been considered including Internal and External activities and change over saving time has found 7.5 hours per Style. It's carry on a better savings with higher productivity & sustainable manufacturing procedure for garment industries.

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- [2], [3] <http://www.y920.com>

7. Result:

Table-8. Activities duration before and after Implementation and time savings.

Internal Activities	Duration Before Improvement (SMED)	Duration After Improvement (SMED)	Time Saving
Layout Preparation	28800	8400	20400
Trial production	838.3	285	553.3
Needle change	279	152	127
Thread change	8049	4275	3774
Cleaning M/C surface	2773	1015	1758
Cleaning work surface	640	140	500
Total Time (in Sec)	41379.3 sec	14267 sec	27112.3 sec

CONSTRUCTION AND VISUALIZATION OF A DIGITAL FACTORY USING 3D MODELING SOFTWARE

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ABSTRACT

The interactive visualization of 3D objects has revolutionized such fields as engineering, medicine, entertainment and education. In fact there are a board range of applications including CAD, visual simulation and multimedia presentations where 3D model are used to give virtual world more realistic detail. Digital manufacturing is a technology to facilitate effective product developments & agile productions by digital environments representing the physical & logical schema & the behavior of real manufacturing system including manufacturing resource, process & products. A digital factory as a well designed & integrated environment is essential for success applications of this technology. In this research, we constructed a sophisticated digital factory of a toy company's general assembly shop by measuring & modeling using parametric methods. It is expected that this method is very much useful for construction of a digital factory, & helps to manage diverse information & re-use 3D models.

Key words: digital factory; modeling; software; manufacturing

1. INTRODUCTION

As customer demand diversify & global competition among toy companies become fierce, the companies are striving to discover new paradigms & technologies for rapid development of products. Digital manufacturing is a technology to facilitate effective product development & agile productions by digital environments representing the physical & logical schema & the behavior of real manufacturing system including manufacturing resource, process & products. A digital factory as a well designed & integrated environment is essential for success applications of this technology. In this research, we constructed a simple production facility of a toy factory's general assembly shop by measuring & modeling using parametric methods. It is expected that this method is very much useful for construction of a digital factory, & helps to manage diverse information & re-use 3D models.

At the design stage of a production system at a factory, designer can evaluate the feasibility design environment, detect the factory & it can be used for factory management. The development of virtual engineering factory is expected to be valuable by means of a 3-dimentional modeling system & animation based simulation package by taking into account the real data of a factory. A 3D model of a

factory has been modeled by using 3D studio max software. Participant can navigate through virtual factory & examine the virtual factory from different points. Thus 3D modeling & animation based simulation technique provides a fast, effective method of visualizing & experiencing new designs which can be easily modified. Designer can design & see different types of layout of factory before making final decision to choose the best one. The animations of different machines were also successfully done.

Virtual reality (VR) started from an unknown science & progressed into a highly exclusive, yet known science. The technology was born from the merging of many disciplines including psychology, cybernetics, computer graphics, database design, electronics, robotics & telepresence. There are many emerging and evolving concepts and definitions of virtual reality. Any representation that emulates reality (i.e. a drawing, a photograph, a movie, an audio recording) is, in a sense, a virtual reality. The term Virtual Reality (VR) is used by different people with many meanings. Virtual Reality (VR) is the computer aided simulation of a 3D model that one can interact with in order to get a better sense of object [1]. Virtual reality can also be defined as a synthetic computer generated (and hence virtual) environment within which a person can navigate &

interact with the virtual objects as the person would in the real world (reality) [1].

2. LITERATURE REVIEW

VR originated in 1960's, the person accredited with pioneering the concept of VR is Dr. Ivan Sutherland, who made ground breaking contribution to the computer graphics & immersive interaction at Harvard & University of Utah [2]. He showed that, a person with the aid a light pen could interact with the computer via a display surface. Engineering based applications within all areas of academic, commercial & industrial life are increasing. It is generally acknowledged that most of the growth in the VR industry has been due to the demands for VR in the entertainment sector.

Virtual environments are made up of 3D graphical images that are generated with the intention between the user & the objects in that environment. The term virtual environment (VE) describes a computer-based generation of an intuitive perceivable & experience able scene of a natural or abstract environment [2]. VE application will contribute to enhancing the qualities of human-computer interaction, the importance of which, in view of increasing complex information and communication applications, is constantly rising.

In the 1917's, Hollywood started to realize the power of VR in the film industry due to its potential to create extra ordinary visual scenarios. Films such as 'Star Wars', followed by 'Terminator' and 'Jurassic Park' are just some of the films that benefited immensely from VR and computer graphics. Recently Pentagon has conducted a Virtual Nuclear War Game to predict its consequence.

3D digital models can be freely constructed in this virtual environment [3]. The precise measurement of the digital model in size and forms is close to the real architecture. From a great deal of digital modeling research in color, material, lighting by Sasada [4], Lui [5] and etc., we can find that the simulation is nearly real. This not only enables to receive more feedbacks in the designing process, but also helps non-professionals to fully understand the designing content.

3. CONSTRUCTION OF A DIGITAL FACTORY

A digital factory is integrated infra-structure for digital manufacturing including CAD & simulation models of machines, equipments, work cells, lines & plants. Fig.1 has shown a general procedure to construct a digital factory. It takes much time, cost, & resources, so effective action plans & objectives are essential. To construct a digital factory, 3D CAD & simulation model must be implemented. Both modeling works need considerable time, cost, & efforts. So technologies developments for an effective measuring & geometric modeling, a knowledge based CAD & simulation, & reuse models are essential. In addition to this technologies, systematic planning, determinations of detailed scopes & model maintenance are also very important.

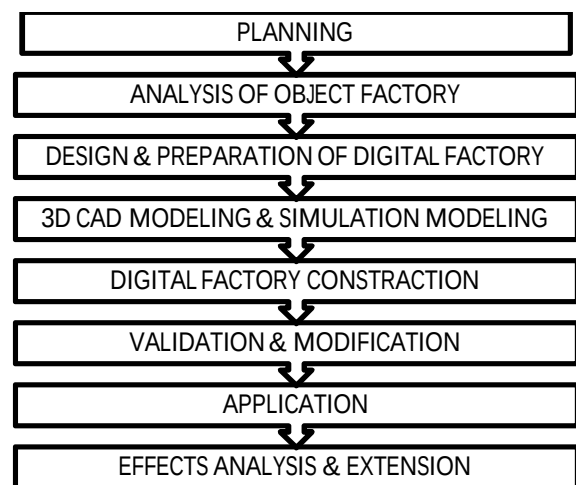


Figure 1: Procedure to construct a digital factory.

Areas & effects of digital manufacturing for toy companies are as below:

- Environments for digital engineering
- Design & operation of a factory
- Validation & evaluation of products & processes
- Line simulations
- Inspections & quality managements
- Visualization of product, process & resources

3.1 Geometric Modeling

3D geometry modeling CAD system such as AutoCAD is widely used in engineering design. AutoCAD is very suitable as a graphics editor for geometric modeling, especially for 3D geometric

modeling. Although AutoCAD is powerful for geometry modeling, it can't be used as the tool for complex system motion verification. AutoCAD do not have the dynamic simulation capabilities. AutoCAD provides some primary 3D objects, such as box, cone, wedge ball etc., which are often used in 3D modeling. In order to create a realistic virtual model of the studio as a 3DS file. Similarly virtual model for modification, the virtual model was imported into AutoCAD as a DXF (Data Interchange Format) file. A DXF file is an ASCH (American Standard Code for Information Interchange) coded file, of an AutoCAD drawing for importing and exporting to and from other software packages [2]. Fig 1 illustrates the process of converting a realistic AutoCAD MODEL INTO 3D Studio virtual model.

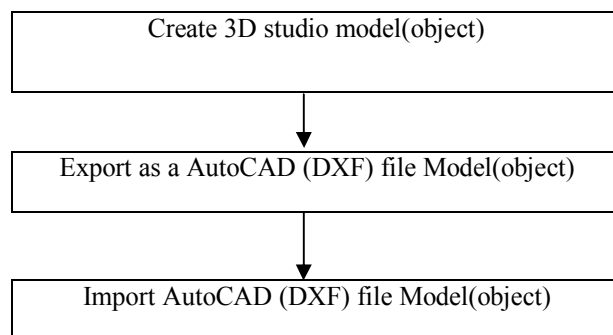


Figure 2(a): Conversion process of a 3D studio virtual model to an AutoCAD model.

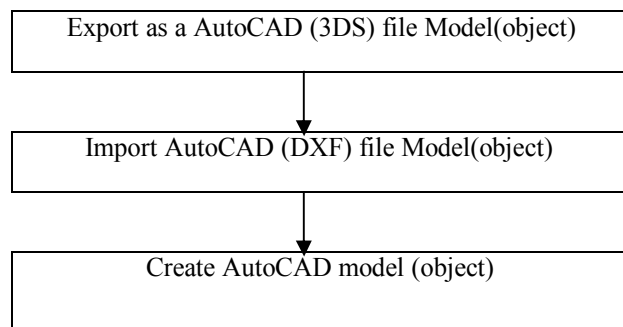


Figure 2(b): Conversion process of an AutoCAD model.

3.2 Application of Virtual Engineering Factory Planning:

The typical applications of virtual factory planning are:

- i. Planning and verification of machine setup.
- ii. Determination of production sequence of workshop machines.
- iii. Analysis of different alternatives of layout of workshop.
- iv. Planning and verification of material logistics.
- v. Aisle planning.

3.3 Advantages of Virtual Workshop Planning:

The typical advantages of virtual workshop planning are as follows:

- a. More precise planning results compared to conventional tools.
- b. Exchange of knowledge among different experts in the planning team.
- c. Taking into account various influential factor such as workplace safety, accessibility and production tools.
- d. Reduction of planning time and errors.
- e. Planning results can be used for the purpose of training and education.
- f. Documentation of company know-how.
- g. Planning results can be used for the purpose of training and education.

3.4 Requirements for Digital Factory Modeling:

In order to build the virtual workshop, which is similar to a real workshop, there might be many requirements in modeling the elements of manufacturing system. Among a number of requirements, the authors emphasize that the following three ones are most important to develop a modeling system for virtual factories [6]:

a. Visualization: The most important requisite is that a virtual workshop should be visualized with reality .with good visualization, one can easily and observe how each system elements works in the manufacturing systems.

b. Detailed descriptions: Each elements needs its detailed description, not only for its visualization, but also for calculating a number of its attributes, for example, when you want to put a work piece into a box, you have to know the shapes and dimensions of the work piece and the box in order to check whether the box can contain the work piece or not.

c. Flexibility: The modeling system should present a flexible way of modifying a virtual workshop in order to cope with the change of machines, layout and other facilities. Any facility to create computer-generated models of virtual objects and environments that can be interactively explored in 3D and modified and recreated in offers enormous potential for concurrent engineering and for integration of manufacturing activities generally [7]. The designer would be able to quickly visualize the product concept and represent alternative design solution.

The basic requirement for virtual engineering workshop facilities planning is, first of all, the availability of all objects in virtual environment. If this requirement is fulfilled simple production facilities planning are possible.

The system development was divided into two main parts [7]:

- i. Construction of a virtual environment: This part provides experience of creating virtual object and placing them in the virtual environment with associated real world. Properties in order to illustrate how models are created.
- ii. Use of virtual environment: This part encourages exploring different attributes of the virtual environment within two broad categories which are factory walk through and visualization of different sections of the factory.

4. SIMULATION USING 3D STUDIO MAX

Modeling and editing panel: The cornerstone of 3D Studio MAX is an advanced 3D modeling and animation environment. One can perform 2D drawing, 3D modeling, and splinebased animation within the unified workspace. Modeling, editing and animation tools are always available in the command panels and tool bar.

Lights & Camera: Designer can create light objects using the light category of creating a panel. Ambient light is found in the Environment dialog by choosing Rendering/Environment. The lights can cast shadows, project images, and create volumetric effects for atmospheric lighting. 3D Studio Max also supports real-world camera controls for lens length, field of view, and motion control such as truck, and pan.

Materials: 3D Studio Max contains a sophisticated Material Editor that floats in its own window above the scene. One can use the Material Editor to create highly realistic materials by defining hierarchies of surface characteristics.

Animation: The user can begin animating his scene at any time by clicking the animation button. This button can be clicked again to move back and forth between modeling and animation. The users can extensive control over his animation with the 3D Studio Max Track View. This is a window into time where one can edit animation keys, set up parametric animation controllers or display and adjust motion curves for all of your animated effects.

Rendering: The 3D Studio Max render includes advanced features such as analytical, motion, volumetric, lighting, and environmental effects [8].

Modeling objects in 3D Studio Max: The latest technology in modeling is utilized in this project by combining 3D Studio Max software and AutoCAD with Supers cape VRT for object drawing. 3D Studio Max is a three-dimensional modeling and animation based package. It has the facilities to add, subtract, combine, and can add material to object, to perform 2D drawing, 3D modeling, and splinebased animation within the unified workspace. Modeling, editing and animation tools are always available in the command panels and toolbars.

The designer can draw 2D and convert it to 3D by using tool bars and can view in front view, top view, and in perspective view. This software helps the designer to change an initial profile of a model, thus updating the previous model and its current drawing. Moreover it helps viewing the model at the same time in different ways.

5. CONCLUSION

This paper presents a parametric method for effective construction of a digital factory. For a toy general assembly shop, we defined object-oriented schema for diverse objects, & define modeling parameters. Finally the digital general assembly shop is made by integrations of 3D models of diverse equipments.

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DEICING TECHNOLOGY FOR MODERN MILITARY AND COMMERCIAL AIRCRAFT WING SURFACES

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An airplane wing ice detector has been designed and found to have some extra advantages over many commercially available snow/ice detectors on airplane wings. The system has been tested extensively and has proved to be accurate and reliable. A new type of graphite sensor has been designed which is self-cleaning; very low power, easily mountable and replaceable. This graphite sensor is implemented in the system to detect the presence of ice and measure ice thickness accurately. A comparative discussion of this system with some of the commercial systems will be presented in this paper. A novel technique using DSP-based real-time application of the system will be discussed in this paper. This paper discusses about better safety to both modern military and commercial aircrafts and the advancements of the future technology.

Key words: Sensor; DSP; Real-Time Application; Differential Amplifier, Threshold Detection

1. INTRODUCTION

Water particles from atmosphere deposit as ice on aircraft wing surfaces at lower altitude below 25000 feet during operation of an aircraft in flight. Thus it makes the military missions imperative to achieve effective flight mission. Also for commercial aircraft's safety requires knowing risk of icing condition to avoid catastrophic situation. For aircraft in the take-off mode, the FAA has ruled that no ice is to be present on critical flight surfaces [1]. Recent study has shown that ice roughness heights of as little as 0.005 inches can reduce maximum lift capability by 20% and roughness of 0.03 inches will decrease lift by 40% [2]. Such tremendous degradation of aerodynamic efficiency occurs as a result of ice accumulation with possible consequences of stalling, problem of drag and loss in performance to the airplane. As a vital part of flight safety, the flight crew must be informed of ice and icing conditions.

Technical literatures about ice detection and information of commercially available deicing systems have been reviewed to understand functionality, advantages and disadvantages of

those systems [3]. Some systems employ mechanical apparatus such as cylinders to collect ice, with light path sensing, vibration or resonance variation, stiffness sensing, hot rod for specific heat sensing etc. These systems have some limitations. An airplane wing ice detector/deicing system has been designed and found to have some extra advantages over many commercially available snow/ice detectors placed on airplane wing surfaces [4]. In this paper we describe a new design of an ultra low-power, easily replaceable graphite sensor which is self-cleaning, thus making the sensor virtually maintenance free. A larger model of this graphite sensor has been tested extensively. It has proved to be very accurate and reliable to detect the presence of ice and measure the ice thickness.

2. SYSTEM DESIGN AND SETUP

An amplifier consisting two op-amp circuits is designed to process very low power signal information from sensors. The dangerous level of icing condition is detected with the processed signal voltage that is proportional to ice thickness by TI DSP system (TMS3206711 DSK). A computer setup with DSP system simulates and computes the

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actual thickness of ice detected on the sensor. The system requires calibration only once at amplifier stages during initial setup of DSP for signal capture and thus digital conversion of ice-thickness that becomes proportional to resistance of the sensor. As a part of calibration, the computer also calculates the multiplier factors for sensor values. Figure 1 shows the block diagram of system setup.

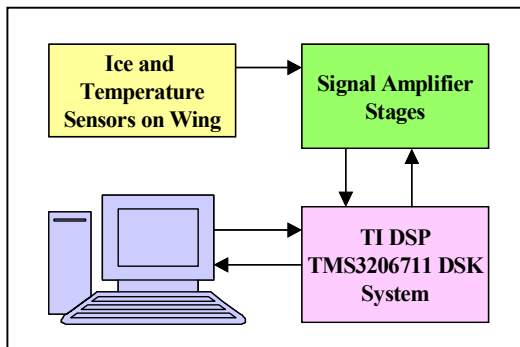


Fig 1: Block diagram of the system

The ice sensor should be placed on upper front surface of the airplane wing at airflow transition area where ice buildup occurs. This area is very important for airplane lift factor. Any roughness on this area can cause loss of flight efficiency. Such loss of flight efficiency results in turbulence and drag thus flight safety degrades tremendously. The sensors are placed along the path of airflow in parallel thus there is no issue of airlift due to the sensor placement. Also this placement can maintain minimum force on the sensor caused by airflow. This system also needs a temperature monitoring capabilities. The temperature sensor allows system to detect lower temperature for ice buildup conditions only. Thus preventing any false detection of water accumulation i.e. rain drops on i.e. sensor or wing surface of airplane while on ground. Figure 2 shows the deicing system sensors placed on the aircraft wing surface. The transition area is indicated by ice buildup region.

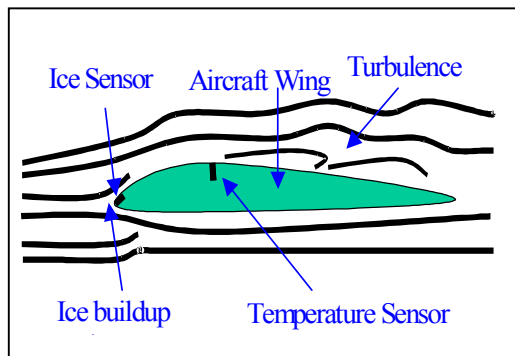


Fig 2: Sensors on aircraft wing surface

3. BASIC PRINCIPLES OF THE SENSOR

The sensor unit uses two probes that are electrically conductive using a very low current ranging between few micro amps only at low voltage. These probes are non-corrosive by environmental effects on the wing surface. The resistive medium at steady state condition is considered as air. In this condition, sensor read the resistance of air was about $4\text{ M}\Omega$. Figure 3 represents the equivalent electrical circuit diagram for initial test setup of sensor. The resistance of the sensor drops to about $20\text{ K}\Omega$, when probes conduct through water making about 0.01-inch thick film.

In this deicing application, the sensor is very small in size. The detection process occurs by water particles between the probes creating a low current path. Water particles at very low temperature freeze and thus the aerodynamic quality of an airplane wing degrades. Also it creates a similar current path between the sensor probes. It continues with low current path between probes until the ice is melted away and break the path.

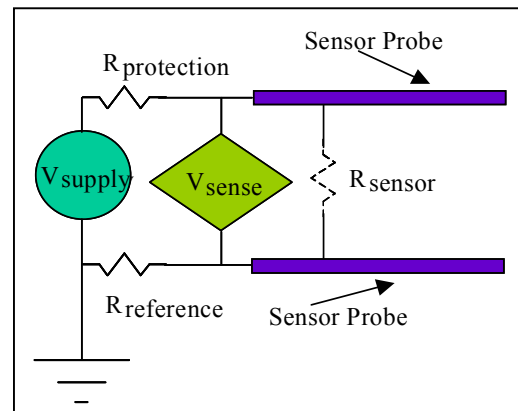


Fig 3: An equivalent sensor circuit.

This small sensor can detect only a localized area where detection is important. The size of the sensor probes can be made longer for different aerospace applications where continuous detection process is required for distributed area. There are three resistors associated with this circuit. $R_{protection}$ is used to prevent the system from short circuit situations. Value of the resistor is about $200\text{ }\Omega$ and it can easily be ignored for calculation, as the other resistance values are so large. V_{sense} is measured when V_{supply} value is non-zero. A shunt resistor with value above $3\text{ M}\Omega$ can be placed in parallel with Virtual R_{sensor} for checking sensor's proper connection as an option. This resistance value can be ignored also as the ice detection resistance is

much lower than this value. This circuit in figure 3 forms a potential divider network and the resistance of the sensor can be expressed as:

$$R_{\text{sensor}} = (R_{\text{ref}} * V_{\text{sense}}) / (V_{\text{supply}} - V_{\text{sense}})$$

The logical conditions are determined from the equivalent circuit of the sensor. Table 1 determines these conditions. The threshold can be adjusted within a very wide range of sensed medium from

Table 1: Condition of monitored zone

R_{sensor} Resistance	Logical Condition
< 2 KΩ	Sensor line short circuit
< 30 KΩ (Ice threshold adjustable)	Ice detected
>30 KΩ and <2.5 MΩ	No ice detected
> 2.5 MΩ	Sensor open circuit

30 KΩ to 2.5 MΩ. So this type of sensor can be used to determine presence of non-icing conditions also. The R_{sensor} values are changed when in the presence of ice from very high values of air resistance to few thousand times smaller values of water resistance.

4. REAL-TIME TESTS AND RESULTS

Figure 4 shows the actual circuit implemented and tested. The sensor had about 0.9 inches long and 0.1 inches wide graphite probes. It was used to detect water and ice.

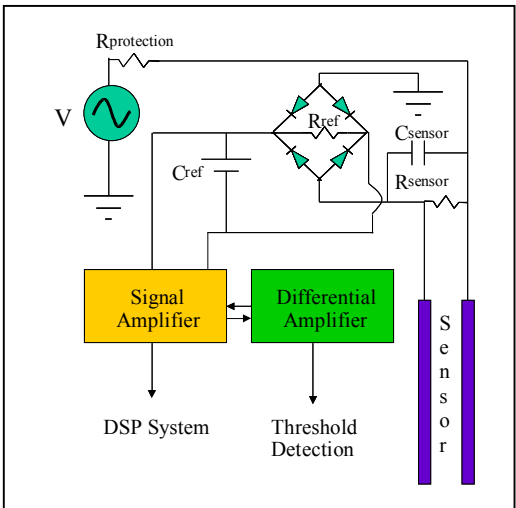


Fig 4: A practical sensor and circuit system.

This small width is adequate as the critical thickness for the presence of ice is very small during flight. Also the sensing threshold stays within the smaller voltage range.

Increasing the length of probes can increase accuracy of ice thickness measurement. The C_{sensor} is negligible for deicing application, as the length of probes is very small to create air-gap capacitance. In most cases this capacitance can be ignored if only to detect ice.

C_{ref} is an optional capacitor used in parallel in order to help stabilizing the DC effect of the R_{ref} in the circuit. This circuit used high frequency input signal to the sensor.

The input high frequency applied to the sensor prevents ionized contaminants to attach on the surface of the sensor probes. The polarity of the probes switch at the same rate of the input frequency and ionized contaminants are always repelled thus the sensor maintenance is reduced and also longer life of this sensor can be obtained.

The localized sensor data showed linearity of the curve in figure 5. This linearity also determines that the capacitance between the probes is negligible.

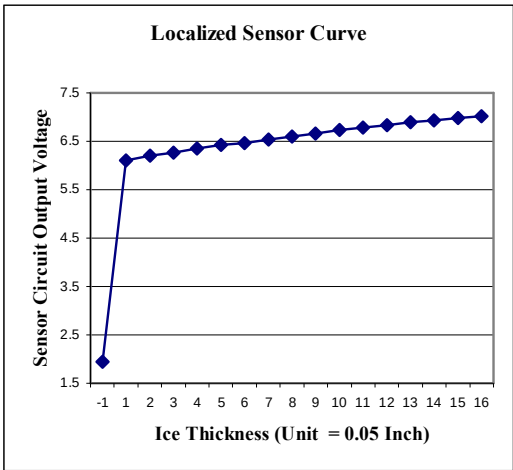


Figure 5: Plot of data from the localized sensor system shows voltage linearity with ice thickness.

The threshold shift at amplifier output was from 1.94 volts to 6.12 volts in localized sensor as expected. The detection of ice was done easily with this threshold variation. The linear curve shows the linearity of ice resistance with thickness. Then the slope of the curve was determined from collected data. With the amplifier and the sensor setup, the experiment results showed that 12.267 mV of threshold changed for every 0.01 inches of ice thickness.

5. ADVANTAGES AND DIS-ADVANTAGES

There are a number of advantages of this sensor and circuit setup over some other sensors found on aircraft. They are:

1. The design is very practical and sensor can be easily placed on wing surface. Then the circuit can be easily adjusted and calibrated for steady state condition.
2. The system is associated with temperature sensing capabilities increase system accuracy to determine presence of ice.
3. This sensor can be driven at high frequency with a very low current rectification circuit.
4. The system has built-in short-circuit protection where electrical burnout does not occur and thus safety is increased.
5. The sensor probes are capable of self- cleaning and removes ionized contaminants increasing life of sensor and making it maintenance-free.
6. In continuous distribution sensor setup, the sensor probes can be connected in series to increase the coverage of sensing length or area on aircraft surface.
7. A number of ice sensors can be connected in parallel to a single sensing node of network to increase the number of sensing zones.

There are some disadvantages of the system that can also be avoided carefully:

1. Steady state conditions need to be recalibrated if numbers of sensors are changed.
2. Graphite sensors in this system were brittle under pressure. Other conductive, non-corrosive materials may need to be identified.
3. Increasing the sensor length reduces value of R_{sensor} and increases value of C_{sensor} and thus increasing non-linear function of ice thickness.

6. THE SYSTEM OPERATION

The system has been tested and found to operate without any error for detecting ice buildup. The system does not have any effect on its operation due to flow of air and air pressure through airplane wing surface. Also there is no capacitive effect on the sensor because of its small sized probes. So the system's measurement of ice thickness stays linear.

The electronic circuit was designed for sensor signal amplification. A logical operation flow for the system was implemented for ice detection and deicing actions. Figure 6 represents the logical flow of the system operation.

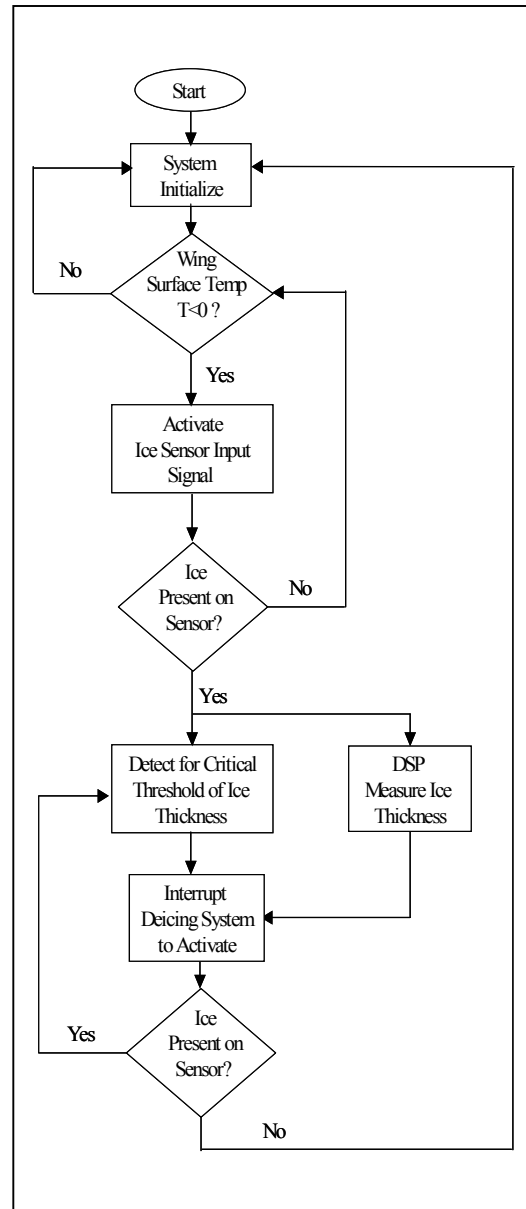


Fig 6: The logical flow of the system operation

When temperature is above the icing condition, the system disregards the presence of water particles between the sensor probes. So rain water particles flowing over wing surfaces is completely ignored. This feature gives an extra advantage over some other systems used on many aircrafts today as the chance of erroneous sensing is avoided.

When temperature of water at freezing point, the system sends signal for ice detection. Also this signal is used for repelling the ionizing contaminants from the sensor probes for cleaning. The DSP system generates information about thickness of ice buildup on wing surface and the computer system computes the thickness. System simulates notification to the airplane crew's display. Also the system is activates deicing system in the wing when it detects ice thickness reaching the critical threshold.

7. FUTURE ADVANCEMENTS

First, we need to place this system on commercial airplane wing surface. The probes in this case should be made with durable graphite or other electrically conductive material like carbon fiber materials. Then test the system during actual flight and also on ground in very cold weather.

This system can be improved for future high-speed avionic transports where space flights will be initiated. The wing concepts are different with smaller wing areas to obtain high-speed transports in future. For such transports at low altitude below 25000 feet, it will become absolutely crucial to achieve precision system for deicing. Sensors must be designed smaller and their materials should be very strong to withstand high pressure and temperature. Today's technologies for military combat airplanes are already implementing such smaller wing concepts for achieving high-speed. Deicing technology for such aircrafts can be developed using this design concept.

To increase airplane safety standards, a number of ice sensors can be placed on known areas of each wing where ice accumulation occurs. This way the accuracy of the deicing system can also be increased. To improve airplane's technical standards, this new approach will apply less number of wires for sensors. This will implement a logical array technique that can allow very less number of wiring harnesses needed for these sensors. An algorithm for such mixed signal technique is currently being investigated and a suitable design approach of a control circuitry is under consideration for future deicing system.

Other design considerations include redesign of sensors where they can be very small. Currently a design idea is being implemented where the sensor probes will be 0.06 inch thick and also they will be less than 0.25 inch long. These sensor probes will be tested on airplane when ready. For its smaller resistive surface area and thus reduced conductance, it becomes an ultra-low power sensor.

Also it can easily be mounted and replaced on the wing surfaces at multiple locations.

As the system uses very low power sensor, it may suffer from induced noise and capacitance due to long wires running in the wing from the deicing system to the sensor during a real flight. The future high-speed transports can have low power embedded circuitry on sensor probe module on wing surface and thus cancel the effects of induced noises. This approach can also increase the bandwidth for high-speed signal generation between the sensor and the deicing system.

7. CONCLUSION

Design of localized sensor is implemented for airplane deicing system that can detect icing conditions accurately. The results from the experiments verify that this deicing system can help avoid the critical icing accumulation causing impairment of military, aerospace missions and commercial flights. The results found from the experiments also show that the sensor is very linear with the thickness of ice and it was 12.267mV per 0.01 inch of ice thickness. The sensor principle and circuitry is described here. Also the block diagram and the logical flow of the system are presented here. The advantages and disadvantages of the system are discussed here. The improvements including implementation of smaller, very sensitive, 0.06-inch thick and 0.25-inch long ice sensors for the future flights of military, space and commercial flights are also discussed.

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Design, Construction and Testing of an Earth Tube Heat Exchanger (ETHE)

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ABSTRACT

In this project, attempts have been made to determine the soil temperature below the ground level. It was expected that the temperature would fall with the depth and after a certain level there would be no fluctuation of earth temperature. The purpose of this investigation was to find out if the environment prevailing at a reasonable depth could be used for supplementing the design of heating or cooling processes. A design for such a system has been presented using the data collected in the experiments. The system does both provide cooling in summer and warming in winter. In winter the system warms up the ambient (cold) air by as much as 10°C at night. In summer cools the ambient (hot) air also by as much as 12°C during the day. The constructed ETHE has been tested and the COP obtained for both cooling and warming mode is much higher than that of the conventional air conditioning system. The COP of an ETHE depends on the temperature difference between ambient and comfortable temperature. With the increase of this temperature difference COP is also increased. Initial installation cost of an ETHE is much lower than that of a conventional air conditioning unit. Also electric costs and greenhouse gases and other pollutants are considerably reduced and maintenance costs decreased.

Keywords: ETE, COP, Temperature Difference, Cost Analysis.

1. INTRODUCTION:

Earth-Tube Heat Exchanger (ETHE) is a device that enables transfer of heat from ambient air to deeper layers of soil and vice versa. The idea is that as the air travels through the pipes, it gives up some of its heat to the surrounding soil, entering the house as cooler air. This will occur only if the earth is at least several degrees cooler than the incoming air. During cold season when air is slowly drawn using a small fan through plastic pipes buried at this depth, it will be heated providing natural climate control with much less energy than conventional heating and cooling. The soil serves as a heat sink in the summer and as a heat source in the winter, thus giving almost year round temperature modification.

2. DESIGN OF THE SETUP

There are basically three configurations, an open 'fresh air' system, a closed loop design, or a combination. An attempt has been made for designing an open loop system in which following design parameter were considered.

Tube diameter: Optimum tube diameter varies widely with tube length, tube costs, flow velocity, and flow volumes. Diameters between (2 and 18 inches) 15.2 and 45.7 centimeters appear to be most appropriate.

Tube Location: Earth temperatures and, consequently, cooling tube performance vary significantly from sunny to shady locations. Where possible, the inlets in open loop systems and the cooling tubes themselves should be placed in shady areas.

Tube Depth: Tubes should be buried at least (6 feet) 1.8 meters below ground level. Only rarely is burying them more than (12 feet) 3.7 meters justifiable. When digging trenches at these depths, cave-ins are an extreme hazard, and appropriate precautions should be taken.

Earth Temperature: The temperature of the earth at depths of (20–100 feet) 6.1–30.5 meters remains about two to three degrees higher than the mean annual air temperature. At depths less than (10–12 feet) 3.1–3.7 meters, earth temperatures may be strongly influenced by air temperatures and may vary during the year, depending on the location. Near the surface, earth temperatures closely correspond to air temperatures.

Tube Length: There is no simple formula for determining the proper tube length in relation to the amount of cooling desired. Local soil conditions, soil moisture, tube depth, and other site-specific factors should be considered to determine the proper length.

Soil Properties: The amount of heat conducted and how widely it is diffused varies from one soil type to another. The moisture content of the soil is a major influence on conductivity and diffusivity, and accounts for large variations on how heat moves through the earth.

3. EXPERIMENTAL SETUP FOR INITIAL DATA ACQUISITION

For placing the thermocouples in order to measure temperature of different ground levels a suitable site is selected at north side of Mechanical Engineering Building, KUET campus. Deep hole with about 6 inch diameter and about 11 feet depth was prepared to place the pipe with thermocouples at different level.

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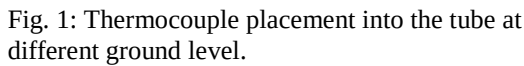


Figure 2: Temperature measuring setup

For winter season the data of 23rd December 2008 has been shown on the fig 3.

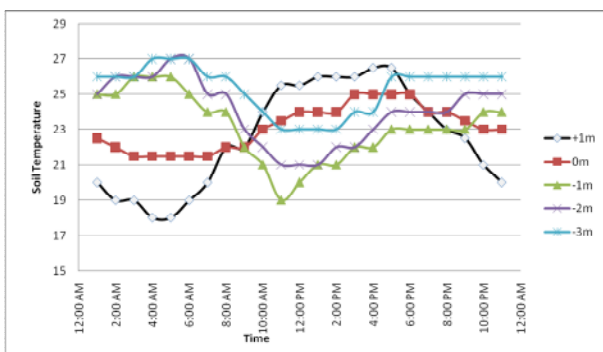


Fig. 3: Soil temperature at various depths and ambient Temperature at KUET campus, Khulna at 23rd December, 2008.

From the figure it is seen that the temperature difference occurs maximum at the lowest level of the ground where we have determined to experiment. For summer season the data of 4th April, 2008 has been shown on the fig.4

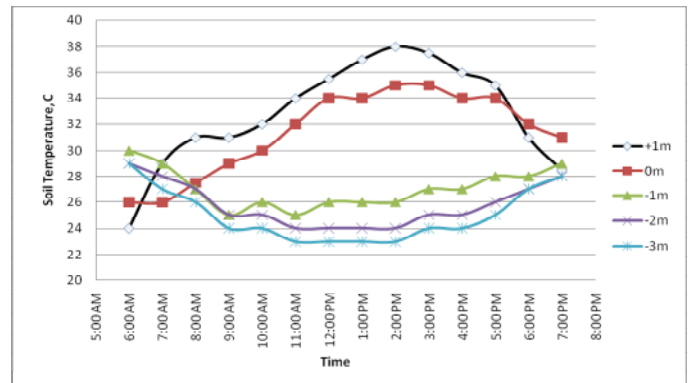


Fig. 4: Soil temperature at various depths and ambient temperature at KUET campus, Khulna at 19th April 2008.

From these data the deepest position at 3m were selected for placing the ETHE as there is little fluctuation and wide difference of temperature was noticed.

4. FINAL INSTALLATION

According to the design proposed the arrangement was installed at a depth of 3 m under the ground level.

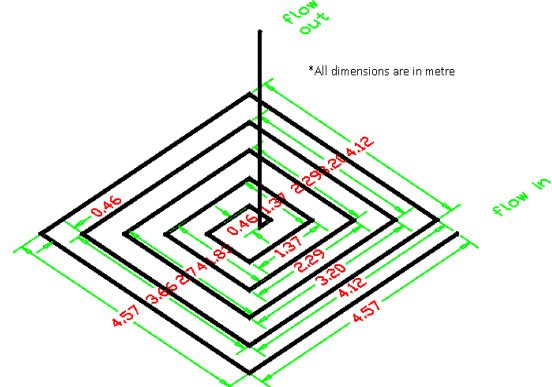


Fig 5: Three Dimensional Concept of the ETHE.

Data were taken during both summer and winter season. Temperature was measured at different distance of the tube to observe the change in air temperature with tube length. To do this several temperature sensor were placed at a certain distance on the tube. The sensors were calibrated properly before taking the data.

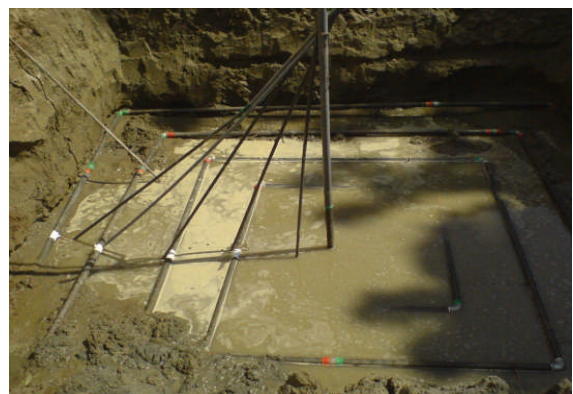


Fig 6: Final installation of ETHE

Table 1: Air Temperature inside ETHE and Soil Temperature at 21.01.09

Time	T _{+1m} (°C)	T _{0m} (°C)	T _{-1m} (°C)	T _{-2m} (°C)	T _{-3m} (°C)	T _{Room} (°C)	T ₀ (°C)	T _{18.5} (°C)	T _{34.3} (°C)	T _{46.7} (°C)	T _{55.2} (°C)	T _{60.4} (°C)	T ₈₂ (°C)
12:00pm	23.5	24	24	25	26	23.5	23.5	23	24	24	25	25	25
01:00am	23.5	24	24	25	26	24	23.5	23	24	24	25	25	25
02:00am	23.5	25	24	25	26	24.5	23.5	23	23	24	25	25	25
03:00am	23.5	25	24	26	27	25	23.5	24	24	25	25	26	26
06:00am	22.5	24	24	25	26	25	22.5	22	23	24	25	25	25
07:00am	22.5	24	23	25	26	25	22.5	22	23	24	24	25	25
08:00am	23	24	23	25	25	25	23	23	23	24	24	25	25

Table 2: Air Temperature inside ETHE and Soil Temperature at (26.03.09)

Time	T _{+1m} (°C)	T _{0m} (°C)	T _{-1m} (°C)	T _{-2m} (°C)	T _{-3m} (°C)	T _{Room} (°C)	T _A (°C)	T ₀ (°C)	T _{18.5} (°C)	T _{34.3} (°C)	T _{55.2} (°C)	T _{60.4} (°C)	T ₈₂ (°C)
10:30am	23.5	24	24	25	26	29	34	26	32	28	26	25	25
11:30am	23.5	24	24	25	26	29	35	27	32	29	27	26	25
12:30pm	23.5	25	24	25	26	29.5	36	28	33	30	28	26	24
01:30pm	23.5	25	24	26	27	30	37	30	33	31	29	26	24
02:30pm	23.5	25	24	26	27	31	36	32	32	30	29	25	24

These results can be more accurately illustrated by plotting a graph.

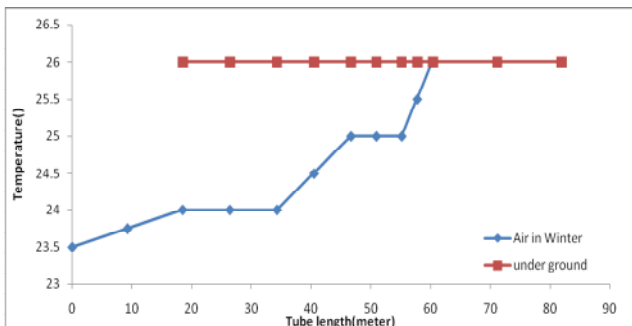


Fig. 7: Air Temperature inside ETHE and Under Ground Temperature under 3m depth at 3:00 AM (21 January 2009) at different length of ETHE.

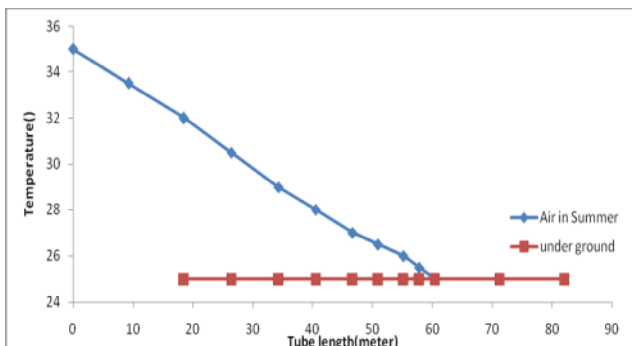


Fig. 8: Air Temperature inside ETHE and Under Ground Temperature under 3m depth at 11:30 AM (26 March 2009) at different length of ETHE.

5. RESULT AND DISCUSSION:

The design was made for a single room placed at the 1st floor of ME building in which the cooling load was calculated as 4496.6 watt. To meet this cooling load requirement with the obtained temperature difference between the ETHE and room the mass flow rate requirement was found 0.319 kg/s. The required length and diameter of the tube was calculated by using various empirical heat transfer relations and the diameter was taken as 1.5 inch and the length 82 m including the inlet and outlet pipe. PVC pipe was used for the inlet and outlet pipe to reduce heat loss in the surrounding while passing through it. This air flow can be supplied by using a blower of 0.5 hp (373 Watt). Therefore the Coefficient of Performance (COP) at cooling mode for the designed ETHE is

$$COP = 4496.6/373 \quad \text{So, } COP = 12.1$$

But there was some heat loss occurred at the outlet pipe and therefore the actual heat transferred was found as 2569.5 and hence the COP was found as 6.95 which is also a very good result because to meet the cooling load of the proposed room with conventional air conditioning system, the COP was calculated as 3.17.

Again the heating load for the same room during winter season was found as 2758 watt. To satisfy this heating load with the obtained temperature difference between room and ETHE the mass flow requirement was calculated as 0.304 kg/s. This air flow can be supplied by using a blower of 0.5 hp (373 Watt). Therefore the Coefficient of Performance (COP) at cooling mode is

$$COP = 2758/373 \quad \text{So, } COP = 7.4$$

But due to heat loss occurred at the outlet pipe and the actual heat transferred was found as 765.3 and hence the COP was found as 2.07 which is also a good result.

6. CONCLUSION

From this study, it came to the conclusion that this system is not suitable for sole preheating or cooling of air. Due to its limitation of cooling or heating air up to a limited temperature, its capacity is limited. It can be used as a secondary system in order to reduce load from the primary and costly cooling system in order to save energy and cost. It has important potential for cooling as it is investment competitive with air-conditioning. During summer it can be used as bypass heat exchanger on exhaust air. From Bangladesh perspective, Earth Tube Heat Exchanger can be used in places where lands are available. In rural places where Air conditioning facilities are not common and there are large fields available, ETHE can be employed there for conditioning room for both human and livestock buildings. It can also be used for grain storages in the locality.

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DEVELOPMENT OF SIMULATION SOFTWARE FOR DESIGNING DUCT OF AIR CONDITIONING SYSTEM

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ABSTRACT

The optimal layout and sizing of duct systems has become more and more a concern for HVAC system designers. Although most duct systems are designed either by an HVAC contractor or a consulting engineer, many plant designers often find it necessary to alter a duct system design to correct obvious flaws. Not only duct system modifications are made to clear obstructions, but also they are sometimes made for obvious economic reasons. The original design may include high cost, unnecessary transitions and special fittings. An experienced sheet metal person can quickly spot these anomalies in a duct design. However, modifications to a duct design must be made carefully to ensure that the system will work as intended. Rather than performing initial design or modifying someone else's design, it is a good idea to analyze proposed duct systems with simulation software to ensure that they will work properly. So in this project simulation software is developed to design an economic air conditioning duct system. This software is helpful to determine the duct sizes and pressure losses in each duct section both in main duct sections as well as branch duct sections by following equal friction method and static regain method. It is also used to determine pressure required at blower/fan exit and the capacity required for the blower. When duct-sizing calculations are done manually, it needs a big amount of money and time but by using this software a designer can design a duct system in a fraction of the time required by analytical method.

Keywords: HVAC, Duct Design, Equal Friction Method, Static Regain Method.

1. INTRODUCTION

The purpose of heating, ventilation and air condition (HVAC) system is to provide occupants with thermal comfort, controlled humidity, proper ventilation, and air filtration. Ducts are used in HVAC systems to deliver and remove air. It also delivers a part of the supply air, ventilation air. As such, air ducts are one method of ensuring acceptable indoor air quality as well as thermal comfort. However, a poorly designed or constructed HVAC duct system may result costly system, uncomfortable, noisy and contaminated environment inside the room. A duct system is often called ductwork. Planning ('laying out'), sizing, optimizing, detailing, and finding the pressure losses through a duct system is called duct design. The strategic placement of the fan and the optimal routing of ductwork help to create a system that is both economical and easily balanced. However, system layout is a task that requires experience and engineering judgment. At present, the layout stage of duct design cannot be aided much by the computer. The best solution is the use of simulation software's in these situations to help the designer in performing interference checks.

Simulation software's are based on the process of imitating a real phenomenon with a set of mathematical formulas. It is essentially, a program that allows the user to observe an operation through simulation without actually performing that operation. Simulation software's are widely to design equipment so that the final product will be as close to design specs as possible without expensive in process modification.

Proposed software is developed with Microsoft Visual C# which is a programming environment used to create graphical user interface (GUI) applications for the Microsoft Windows family of operating systems. It is an object-oriented programming (OOP) language.

2. DESIGN FACTORS OF AIR DUCT SYSTEM

A well designed air duct system, either commercial or industrial, must consider most of the following system design factors [3]:

- i. Space Availability;
- ii. Space Air Diffusion;
- iii. Noise Levels;

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- iv. Duct Leakage;
- v. Duct Heat Gain and Losses;
- vi. Balancing;
- vii. Fire and Smoke Control;
- viii. Initial Investment Cost;
- ix. System Operating Cost.

3. DUCT DESIGNING METHODS

The most common methods of air duct system design are:

- a. Equal Friction Method,
- b. Static Regain Method, and
- c. Velocity Reduction Method.

The principle of the Equal Friction Method is to size a system's ductwork for a constant pressure loss per unit length of duct. At the higher air flow rates, however, it may be necessary to limit the velocity so as not to generate objectionable noises. Once the system is sized, the total pressure losses for the main and branch sections from junction-to-junction /fan/terminal may be calculated and the total pressure grade line plotted.

The static regain method is a design procedure in which the ducts are sized so that the increase in static pressure (static regain) at each take-off offsets the pressure loss of the succeeding section of ductwork. This method is especially suited for high velocity installations having long runs with many take-offs or terminal units.

The Velocity Reduction Method consists of selecting the velocity at the fan discharge, and designing for progressively lower velocities in the main of each junction or branch duct. The return air ductwork is sized similarly, starting with the highest velocity at the fan suction and decreasing progressively in the direction of the return intakes. With the ducts sized and the fittings known, the total pressure losses can be calculated, the pressure gradients plotted, and the minimum pressure loss or critical path of the system established.

4. GENERAL RULES OF DUCT DESIGN

- i. Study the plans of the building and arrange the supply and return outlets to provide proper distribution of air within each space. Adjust calculated actual air quantities for duct heat gains or losses and duct leakage. Also, adjust the supply, return, and/or exhaust air quantities to meet space pressurization requirements.
- ii. Select outlet sizes from manufacturers' data.
- iii. Sketch the duct system, connecting the supply outlets and return intakes with the central station apparatus, taking cognizance of the building construction,

and avoiding all structural obstructions and equipment. The space allocated for the supply and return ducts often dictates the system layout and the shape of the ductwork.

- iv. Determine the size of main and all branches by the selected design method.
- v. Calculate the total pressure requirements of all duct sections, both supply and return, and then plot the total pressure grade line.
- vi. To design a system with the minimum owning and operating costs, repeat steps 4 and 5 with different duct sizes. It is necessary to estimate the cost of the initial design and the incremental cost variations due to the redesigns.
- vii. Layout the system in detail. If significant duct routing and fitting variations have occurred from the original design, recalculate the pressure losses.
- viii. Redesign the duct branches to minimize the balancing necessary by dampers.
- ix. Analyze the design for objectionable noise levels and specify sound attenuators as necessary.
- x. Select the fan.

5. METHODOLOGY FOR SOFTWARE DEVELOPMENT

Object-oriented programming (OOP) is based on the scientific classification principles of ordering and naming groups within subject fields. In this software the concepts of classes and objects are applied with graphical user interface (GUI). Some tool such as label, text box, button, radio button, tab control, group box and data grid view are used in this software to provide the friendly input and output environment for the user. There are options to select the duct designing method and then to calculate the duct sizes and pressure losses by providing the required input in this software. The inputs and outputs of the software for the different method are as follows:

Table 1: Inputs & Outputs for Equal Friction Method

Inputs	Outputs
• No. of main duct section • Friction Rate • Loss co-efficient • Static Pressure at each outlet • Aspect Ratio (for rectangular duct) • Length of each section • Discharge through each section	• Diameter of each section • Velocity pressure • Frictional Pressure drop • Total Pressure drop in each section • Rectangular duct sizes. • Capacity of blower

Table 2: Inputs and Outputs of Static Regain Method

Inputs	Outputs
- No. of main duct section - Static Regain Factor - Velocity at Blower Exit - Static Pressure at each outlet - Aspect Ratio (for rectangular duct) - Length of each section - Discharge through each section	- Diameter of each section - Velocity pressure - Frictional Pressure drop - Pressure Loss in each section - Pressure Regain in each section - Rectangular duct sizes. - Capacity of blower

And the flowchart for developing the software is:

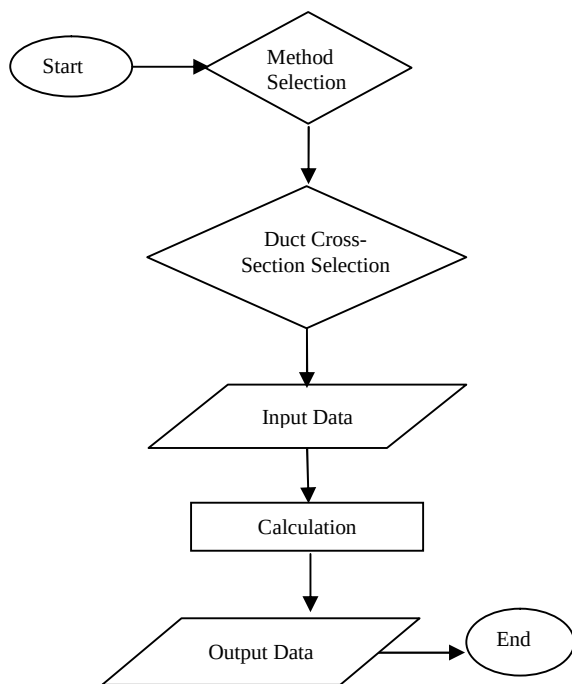


Fig 1: Flowchart for developing the software

6. FEATURES OF THE SOFTWARE

The steps required to use the software are: If the software is opened, then the interface as shown in Fig 2 will be displayed from which the method can be selected for calculation.

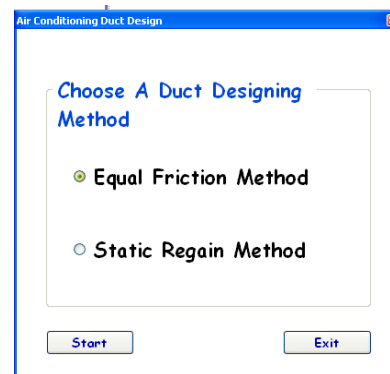


Fig 2: Duct designing method interface

Upon choosing the method of calculation by clicking 'Start' button the following interface appears which asks for some input according to the method used.

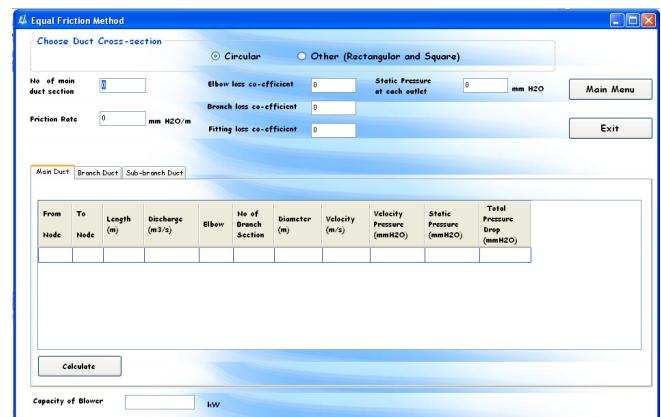


Fig 3: Equal Friction Method interface for circular duct

After giving the required inputs in the respective fields the 'Calculate' button is pressed and the desired outputs are obtained.

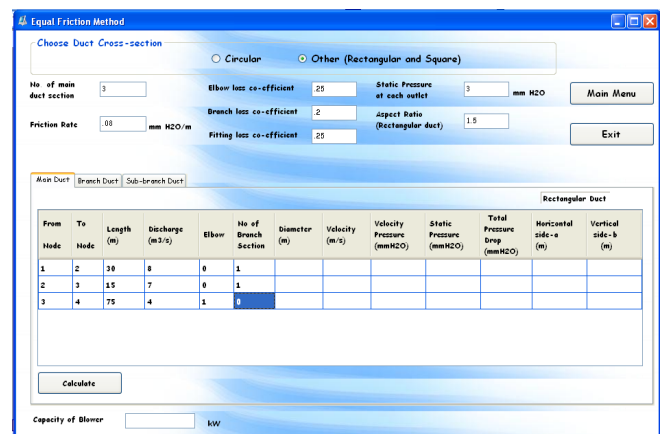


Fig 4: Equal Friction Method interface after giving all inputs for main duct.

After pressing the calculate button, the software may provide the output as shown in Fig 5.

Equal Friction Method

Choose Duct Cross-section: ☐ Circular ☒ Other (Rectangular and Square)

No. of main duct section: 3 Elbow loss co-efficient: 25 Static Pressure at each outlet: 3 mm H₂O

Friction Rate: 0.08 mm H₂O/m Branch loss co-efficient: 2 Aspect Ratio (Rectangular duct): 1.5

Fitting loss co-efficient: 25

Buttons: Main Menu, Exit

Tab: Main Duct | Branch Duct | Sub-branch Duct

From Node	To Node	Length (m)	Discharge (m ³ /s)	Elbow	No. of Branch Section	Diameter (m)	Velocity (m/s)	Velocity Pressure (mmH ₂ O)	Static Pressure (mmH ₂ O)	Total Pressure Drop (mmH ₂ O)	Horizontal side-a (m)	Vertical side-b (m)
1	2	10	8	0	1	1.0589	9.0841	5.055934	2.4	2.4	1.193427	0.795751
2	3	15	7	0	1	1.0075	8.7788	4.721823	1.2	1.28352	1.135784	0.757189
3	4	75	4	1	0	0.8182	7.4970	3.545473	6	13.7259	0.922328	0.414885

Buttons: Calculate

Capacity of Blower: 0.394100709945622 kW

Fig 5: Equal Friction Method interface with inputs & outputs for main duct

Similarly the specification for the branch duct and sub-branch ducts can be obtained by putting input required data at the specified field and pressing calculate button.

7. DISCUSSION AND CONCLUSION:

A real problem has been formulated and analyzed both manually and by using software with both methods. From the comparison, there are very small differences between the results obtained by the software and the results obtained analytically (due to round up values are taken). Therefore the software is able to provide the accurate results. If the calculation of static regain method is done manually, then so much iteration is avoided. But in this software, it is programmed for more iteration for accurate results. The manual calculation may take so much time to give results. On the other hand, the software may give the results immediately after giving the required inputs.

The software is developed for designing any air conditioning duct by using two conventional duct designing methods such as equal friction method and static regain method. The software gives the accurate results in comparison to manual method. It is also useful for economical duct designing, which not only reduces the cost of designing duct but also reduces the cost of fabrication. It also reduces the time for designing air conditioning duct. Generally, static regain method gives duct sizes more than the duct sizes obtained by equal friction method and the software provides the same requirements. Comparing the two methods, users can make decision to choose the required duct designing method.

In the present state of the software, a duct designer can easily design air conditioning duct with the help of this software. This software can be developed in such a way that, it will show the 3D or 2D duct layout graphically with the numerical output. This software can be developed for other modern duct designing methods. This software can be also used for cost analysis for the designed duct.

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Effect of EGR ratio to control particulate matter emission from diesel engine
combustion by using High –Speed combustion model.

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Abstract: Diesel engine attract market attention due to its high thermal efficiency among other IC engine. To design diesel engines adapted to future exhaust gas regulations, it is important to develop a driving mode simulator to estimate vehicle performance and exhaust emissions. For the driving mode simulator with simple and high-speed calculation characteristics, the authors use a diesel combustion model based on the Hiroyasu model. In this study, we examine the effect of EGR on particulate matter emission , like: Ethylene, CO, NO_x, etc. For this we are varying EGR ratio during operation cycle. We use Tsurushima reduced kinetic model together with characteristic mixing time scale. Direct introduction of the reaction model to the basic combustion model did not give good simulation result for experimental data. However by introducing mixing time scale to take into account local heterogeneity of the mixture, the simulation accuracy was significantly improved. The result shows possibility of simulating the rates of heat release and emissions including ethylene and CO for the different EGR ratio.

Key word: EGR, Combustion model, Ethylene, CO, NO_x ,Diesel engine

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EFFECT OF MICRON SIZE PARTICLE CONTENT ON TRIBOLOGICAL BEHAVIOURS OF POLYMER MATRIX COMPOSITES

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The use of polymers and polymer matrix composites, in various tribological applications, has become state of the art because of their many attractive properties such as high strength to weight ratio, low friction, self lubricating behaviours, low noise under service, corrosion resistance, etc. As a result, in many applications, metallic components are replaced day by day. In this study polyester based composites have been developed by adding various inorganic micron size filler materials such as graphite, silica, silicon carbide, etc. of varying proportions (1, 2.5, & 5 wt%). The developed composites were then characterized by wear & tensile tests. Initiative has also been taken to investigate the wear mechanisms of the developed composites by optical microscope and SEM. Experimental results, for all composites, showed a decrease in tensile strengths with increase in the filler contents. However, the wear rate has been found to decrease for graphite and silicon carbide particle reinforced composites. In this paper, experimental results that have been obtained will be presented and underlying reasons of property variations will be discussed.

Keywords: Polymer Matrix Composites, Micron size particles, Inorganic filler, Wear, Wear mechanism.

1. INTRODUCTION

Over the past decades, thermoplastic composites are numerously used in the tribological purposes such as seals, gears, bearings, etc. Various features makes the polymer matrix composites so promising in practical applications, e.g. high strength to weight ratio pre-requisite for the aircraft body, self lubricating behaviours necessary in bearings, cages, rotating nuts, gears, etc. It has been found that short fiber reinforcement, e.g. reinforcement by carbon, glass and steel fibers, can generally improve the creep resistance and compressive strength of the polymer composites and result in enhanced wear resistance [1]. A number of materials mostly inorganic (graphite, molybdenum disulphide, talc, silicon fluid, etc.) are used as lubricant. It has been mentioned earlier that polymers, in general, are self lubricating because of their layered lattice structure and they are usually anisotropic. Their structure allow them to be easily sheared, and therefore they lower the friction when placed between sliding metal surfaces and provide a shear plane of lower strength than those of the two sliding surfaces [2-3]. The use of graphite as a particulate filler has been reported to improve tribological behavior in composites.

The use of inorganic fillers is increasing not only to reduce the cost of the composites but also to meet several requirements, which could not been achieved by using reinforcement and resin ingredients alone. In order to improve the friction and wear properties many researcher modified polymers using different ingredient. The Wear rate of high density polyethylene was reduced by CuO and Pb₃O₄ and for polytetrafluoroethylene was reduced by ZrO₂ and TiO₂ [4-5]. Bahadur et al. found that the compounds of copper such as CuO and CuS were very effective in reducing the wear rate of PEEK, PTFE, Nylon and HDPE [6-8].

The objective of this research work is to develop polyester based composites reinforced with various inorganic fillers with their varying proportions and also to characterize the friction and wear properties of the developed composites. In this paper, initiative will be taken to present and discuss various tribological features observed in the research work for the developed composites.

2. MATERIALS USED AND EXPERIMENTAL PROCEDURE

2.1 Materials Used

Polyester resin was used as the matrix system, which is thermosetting. There are two parts in matrix system, one is the polyester resin itself and other is the hardener (MEKP: methyl ethyl ketone peroxide). Various micron size inorganic particles such as graphite, silicon carbide and silica were used as reinforcing particles.

2.2 Resin Preparation

The micron size particles (graphite, silicon carbide and silica) were mixed with the polyester by varying 1 to 5 wt%. For mixing the particle in the resin, a mechanical mixture was used. During mixing air bubbles were formed. If the bubble is present in the resin after mixing, it induces detrimental effects on the properties of the composites. For that reason, vacuum was applied to the mixture of polyester and micron size particle for about 30 minutes. Once the bubbles were completely removed from the mixture, hardener (1.5%) was added in it. The mixture was then mechanically stirred for about 2 minutes and vacuum was again applied for 10 minutes to remove the bubble produced during the hardener mixing.

2.3 Composite Fabrication

Hand lay-up process was used to manufacture all composites in this study. A mould releasing agent was used to the mould surface before casting for removing the composites from the mould easily. A level gauge was also used to ensure the uniform thickness of the sample. After de-molding, the composites were treated for post curing, which was done at 70°C for 2 hours in an oven. The size of the laminate was 125mm X 125mm X 10mm. Then the samples for testing were prepared from the laminate. The details of composites are shown in Table 1.

Table 1. Details of composites developed.

Sample Code	Matrix	Filler	Wt%
P(P)	Polyester	Nil	
P(C)	Polyester	Graphite	1, 2.5 & 5
P(SiC)	Polyester	SiC	1, 2.5 & 5
P(SiO ₂)	Polyester	Silica	1, 2.5 & 5

2.4 Test Procedure

2.4.1: Tensile test: Tensile tests were carried out using the Instron Universal testing machine accordance to ASTM D3039 standard (rectangular specimens). The gauge length was 25 mm and the cross head speed was 5 mm/min. The tensile load, stress and modulus were computed from the stress-strain curves of the composites.

2.4.2 Fractography: The fracture surfaces of the tensile test specimens were analyzed. For observing the fracture surface, scanning electron microscope (SEM) was used, which was operated at 30 kV. Samples were mounted with carbon tape on stubs. In order to improve the electrical conductivity of the fracture surface of the composites, gold coating was applied by sputtering technique.

2.4.3 Wear test: A pin-on-disc type wear test setup (Fig. 1) was used for experiment. The dimension of the pin is 5 mm diameter and 12 mm length. The counter surface disc was also made from the same material of the pin itself. The pin was initially weighed using a digital electronic balance. The test was conducted under 5.7 N load, where the disc rotation was 1050 rpm. After conducting the test, final weight was measured in the same balance. A minimum of three trials were conducted to ensure repeatability of test data.

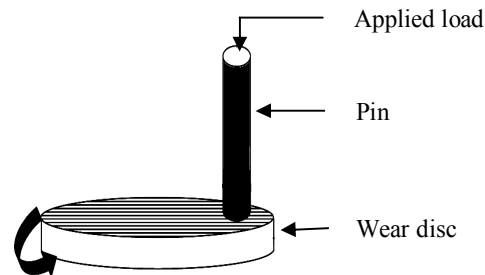


Fig. 1: Pin-on-disc type wear test.

3. RESULTS AND DISCUSSION

3.1 Macrostructure

The cast samples of polymer matrix composites containing various types of fillers (graphite, silicon carbide and silica) are shown in Fig. 2(a) and the close-up views of these discs are shown in Fig. 2(b). These close-up views show the dispersion of particles, which is observed in the matrix from the macrostructures.

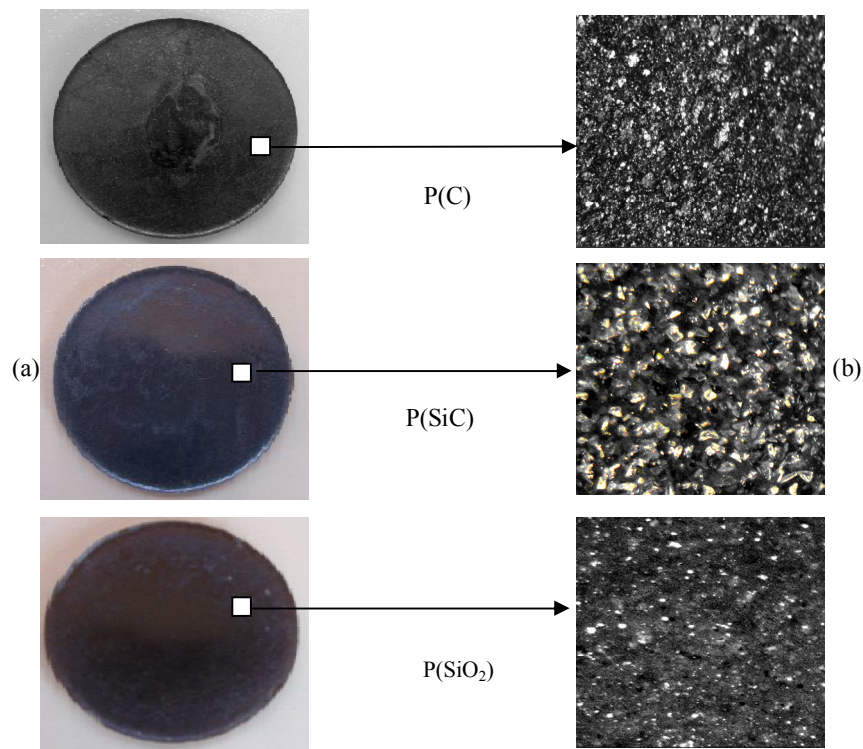


Fig. 2. Macrographs of cast composites are shown in first column (a) and close-up views (micrographs) of these cast samples are shown in the second column (b). Note: Particle dispersion in the polymer matrix seems to be more or less uniform.

3.2 Tensile Test

The load vs. % of filler graph is shown in the Fig. 3. It shows the effect of reinforcement particles on the load bearing capacity of the developed composites. It is observed that addition of any reinforcement particle improved the tensile strength of the pure polyester to a certain limit. After certain percentage of filler, the load bearing capacity of the composites is tremendously decreased. Because, initially when particle is added, it occupies the interstitial of resin molecules and causes mechanical bonding. For that reason, the strength of composites is increased. But when more and more reinforcement particle is added, resin particles are separated by the reinforced particles as shown in Fig. 4. Only reinforced particles can not give enough strength. So, the strength of composites decreases above an optimum level of filler materials. From the Fig. 3, the load bearing capacity of the reinforced composites increases around 1 wt. % of the filler content and then decreases. So, it can be said that the optimum level of reinforcement is around 1 wt%.

Fracture characteristics of the composites depend on the bonding at the interface of the fillers and matrix. In this system, only mechanical bonding is present at the interface of the filler and matrix. The SEM fractographs of the fracture surface of tensile specimens the developed composites are shown in Fig. 5. The fiber/matrix debonding can contribute to the failure process. In this study, transgranular fracture is occurred for all samples. For P (SiC) and P (SiO₂) composites crack initiations may be occurred from coarse particles (Figs. 5c & 5d).

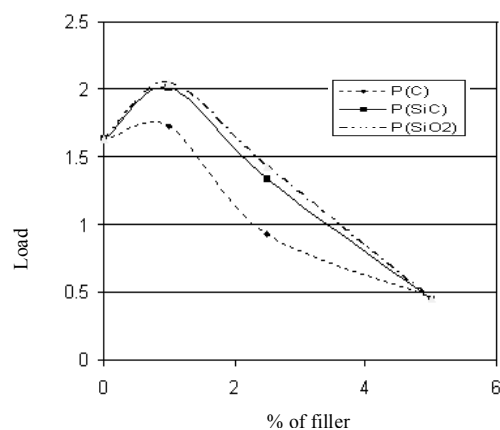


Fig. 3: The load vs. % of filler curves of the composites.

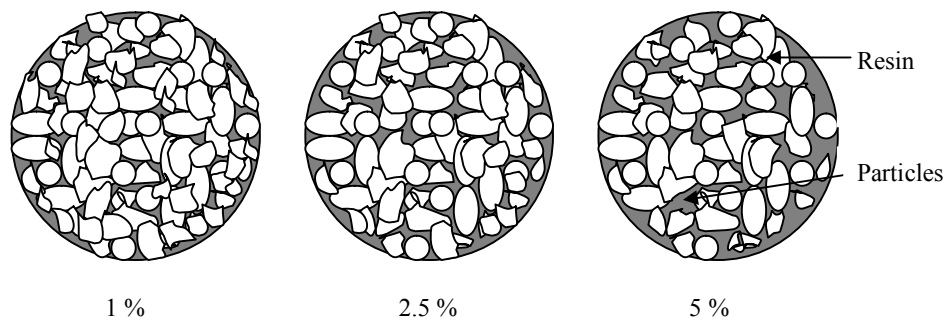


Fig. 4: Schematic diagram showing the effect of increasing amount of reinforcing particles in the composites.

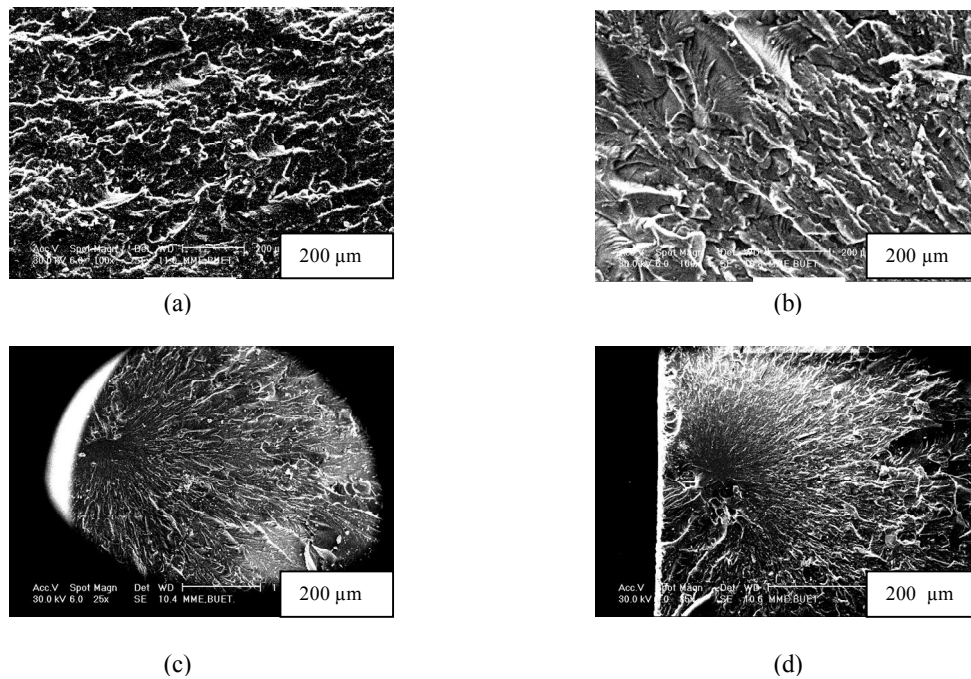


Fig. 5: SEM micrographs on tensile fracture surfaces of (a) polyester, (b) P(C), (c) P(SiC) and (d) P(SiO₂).

3.3 Wear test

The graph of wt. loss vs. % of filler content is shown in Fig. 6. Composite reinforced with silica resulted lowest wear resistance and that wear resistance further decreased with increase in the % of particle. The graphite particles work as self lubricating media [14]. As a result, wear rate of the graphite reinforced composite decreased gradually with increase in the filler content and then became to be fixed. Although, SiC reinforced composites showed slightly more wear rate, however, the trend of wear rate was found to be similar to that of graphite reinforced composites. Similar observation has also been made by other investigators [9].

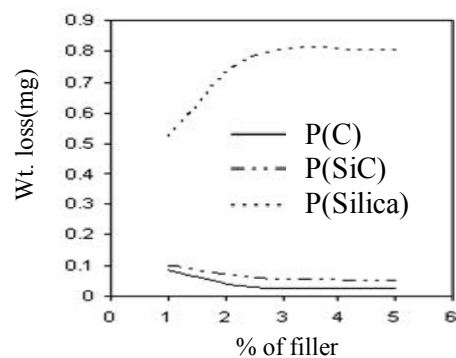


Fig. 6: The wt. loss vs. % of filler graph of the composites

The worn surfaces of the counter face parts resulted due to wear tests are shown in Fig. 7(a) and close-up views of worn faces are shown in Fig. 7(b). The effect of particles in the matrix can be observed from these figures. Particles are detached from the matrix and deformed the matrix severely which is called stress whitening. Stress whitening refers to the phenomenon where polymer materials are deformed to a certain extent and become visually white in color and at the same time their transparencies are decreased. The graphite particles are coherent with the matrix for its structure. As a result, the wear rate and stress whitening in P(C)

are lower than the other composites. But in the case of P(SiO₂) composite, the silica particles cause more localized deformation in the matrix because of its severe abrasive nature. Silica particles restrict the plastic deformation zone and increase the intensity of the localized deformation. As a result the stress whitening is also increased in the case of silica particle reinforced composite. In the case of the P(SiC) composite, the wear rate also decreases, but wear rate is greater than the P(C).

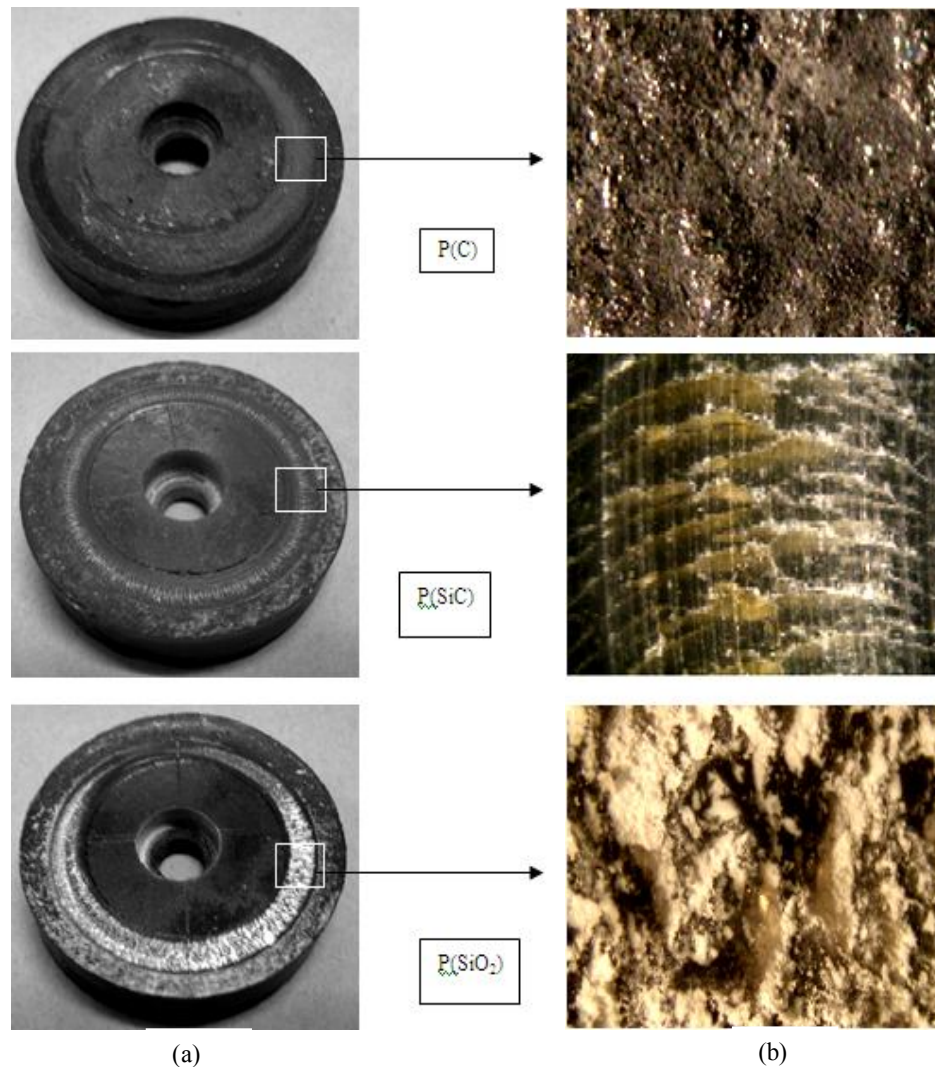


Fig. 7: Counter faces in wear test are shown in first column in figure (a) and close up view of these disc are shown in second column in figure (b).

4. CONCLUSIONS

In this study polyester matrix graphite, silicon carbide and silica micron sized particle reinforced composites wear developed and their tensile and wear resistance were characterized. Experimental results suggest that the tensile and wear properties did not follow similar trends for all composites. Initially, tensile strengths for all composites were found to increase; however, for higher amount of filler contents, tensile strengths were decreased. On the other hand, wear rates of graphite and silicon carbide particle reinforced composites were found to decrease gradually and then it became fixed. However, silica reinforced composite resulted higher wear rate with increase in the filler content from the beginning.

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ERGONOMICS AND THE PREVENTION OF MUSCULO-SKELETAL STRAIN AND BACK INJURIES.

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ABSTRACT

As technology becomes more complex, so ergonomics is undoubtedly destined to play an increasingly important role in industrial production and industrial health and safety. At the workplace, ergonomics places equal emphasis upon greater system efficiency and improved health of the individual. Ergonomics must be involved in fitting the tool and machine to the worker by design, fitting the worker to the machine by selection and training, and the optimization of the ambient environment to suit the man or the adaptation of the man to tough environmental conditions. Ergonomics aims to promote efficiency, safety and comfort at work situation in industry through better relationship between man, his tools and the work environment. This paper deals about the injuries such as backaches, neck aches, and other muscular strains due to bad seating and incorrect working posture and how to prevent them by designing of workstation that will be very comfortable and convenient to work at. The paper also discusses the optimal conditions for the workers, reduction of physical workload, improvement of working postures and facilitating psycho-sensorial functions in instrument handling, and so on.

Key words: Back injury, Workstation design, Human factor, Productivity and Anthropometry.

1. INTRODUCTION:

The word ergonomics comes from the Greek ergo means work and nomos means law [1]. So Ergonomics means laws of work. Ergonomics is used to fit the job to the worker. In the USA, it is called human factors. Human factors focuses on human beings and their interaction with products, equipment, facilities, procedures, and environments used in work and every day living. The emphasis is on human beings and how the design of things influences people. Human factors, then, seeks to change the things people use and the environments in which they use these things to better match the capabilities, limitations, and needs of people. Human factors has two major objectives. The first is to enhance the effectiveness and efficiency with which work and other activities are carried out. Included here would be such things as increased convenience of use, reduced errors, and increased productivity. The second objective is to enhance certain desirable human values, including improved safety, reduced fatigue and stress, increased comfort, greater user acceptance, increased job

satisfaction and improved quality of life. The approach of human factors is the systematic application of relevant information about human capabilities, limitations, characteristics, behavior, and motivation to the design of things and procedures people use and the environments in which they use them. In many industries ergonomics is implemented primarily as a means of reducing high injury rates and high insurance premiums. In the USA, a worker's compensation premiums often amount to 15% of the salary. This is because there are many back injuries due to materials handling and injuries to the joints in the arms, shoulders and neck due to poor work posture. The scope for the application of ergonomics in our working environment is tremendous. The correct matching of man, technology, task and organization to form a total entity capable of higher job performance is now an important function of management, and the ergonomic approach can go a long way to help meet this objective.

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1.1 Ergonomics aspects

Ergonomics has two distinct aspects: Firstly study, research, and experimentation, in which determine specific human traits and characteristics that need to know for engineering design; Secondly application and engineering, in which design tools, machines, shelter, environment, work tasks, and job procedures to fit and accommodate the human and equipment in the environment to assess the suitability of the designed human-machine system and to determine possible improvements [2].

1.2 Man- machine- environment interaction:

At the workplace, ergonomics places equal emphasis upon greater system efficiency and improved health of the individual. Ergonomics must be involved in fitting the tool and machine to the worker by design, fitting the worker to the machine by selection and training, and the optimization of the ambient environment to suit the man or the adaptation of the man to tough environmental conditions. To fulfill the general aim of ergonomics in integrating man-machine and man-environment relations, the interaction between these elements must be optimized. This approach has to consider (1) the operator's interaction with the tool, (2) the immediate workplace around him, and (3) the work environment in which he has to work.

2. WORKPLACE AND ANTHROPOMETRY

Backaches, neck aches and other muscular strains due to bad seating and incorrect working posture are common in industry, where many jobs require people to remain sitting or standing in a fixed posture for a long period of time. It is common to find in many industries and offices glaring examples of poor work design. Chairs, tables, workbenches, tools and machines are introduced without any consideration of their relationship to one another. Incorrect and awkward postures associated with either the level of working height or with the poor design of the machine could result in discomfort and fatigue. In addition, neglect of ethnic and anthropological differences through the unthinking importation of foreign technology developed in a different cultural and social framework can have a generally negative effect.

Workplace design and layout should conform to ergonomic principles, while both physical and physiological aspects of the working environment should be considered. The use of ergonomics is essential in such areas as working posture, tool design and workplace layout, together with environmental factors such as ventilation and

lighting. Temperature and humidity should be kept at a comfortable level through the use of ventilation systems. The noise level should be low enough not to cause interference with communication and distraction from work. Lighting has to be adequate and glare should be minimized.

Work organization is an important factor to be considered for reducing musculo skeletal strain at the workplace. Measures such as reducing the work rate in paced operations, reducing shift length, and the provision of extra rest breaks have proved helpful in repetitive operations. Tasks consisting of lifting, pushing, or pulling objects without the assistance of mechanical devices are referred to as "manual material handling". Manual material handling tasks carry a high risk of injury not only because of the interaction between the worker and the object itself but also because there is a potential for overloading the body's supporting structure, the musculo- skeletal system. Lifting of heavy objects presents a high risk of over-exertion injuries and cumulative damage to the soft tissues around the spine. These injuries to the back constitute the largest single category of worker's compensation claims in many developed countries, amounting to 25% of all disability cases.

A workstation may be defined as a place within the workplace where equipment or instrumentation is positioned in such a convenient way that users can perform their tasks properly [3, 4]. Workstation design deals with choosing and arranging equipment, machinery, tools, and accommodations for users so that workflow and organization are optimized. Workstation design is the object of several recent developments in ergonomics, particularly regarding increasing level of competition and technological development in modern enterprise environments among others. In the design of workstations, designers are often faced with the task of eliciting components to be included in the project Workstation components (WCs) may be divided into two major groups [5]: a) functional such as work seats, worktables, machinery, and accessories, and b) environmental, related to psychological, social, and climatic inputs that affect worker's behavior. The best choice takes into consideration ergonomic criteria, such as anthropometric and biomechanical characteristics, and commercial criteria, such as warranty length and service level provided by manufacturers.

2.1 Anthropometry in workstation design

The basic philosophy of ergonomics is to design workstations that are comfortable, convenient and productive to work at. Ideally, workstations should be designed to fit both the body and the mind of workers. By the use anthropometric design principles it is possible for a variety of people to

find physical comfort at workstation. On the other hand, by not taking into consideration these physical requirements, one may create bad work postures, which lead to fatigue, loss of productivity and sometimes injury. Anthropometry is not only a concern about appropriate working height, but also about how the operator can easily access controls and input devices. Typically the normal reach area (NRA) dimensions are presented as 5th, 50th and 95th percentile curves. In theory, using the 5th percentile curve results in a design within which the majority (95 %) of operators could comfortably perform the intended tasks.

3. ERGONOMICS AND THE PREVENTION OF MUSCULO-SKELETAL STRAIN

Musculo - skeletal problems have been reported as occurring in a wide range of industries. The National Institute for Occupational Safety and Health (NIOSH) in the USA reported that 15-20% of workers employed in construction, food preparation, the electronic industry, clothing and bag manufacturing, and clerical work are at risk for cumulative trauma disorders. Cumulative musculo skeletal problems are not the result of single events; they stem from (a) the repeated performance of certain tasks (b) bad working posture (c) application of force, and (d) inadequate rest. There are two major factors that can affect the health and performance of industrial operators through their musculo-skeletal system: static load and awkward posture.

(1) static muscle load: when tools or equipment are used in situations where the arms have to be held for extended periods, such as during grinding operations, muscle of the shoulders, arms and hand may be loaded statically. This loading can result in fatigue and reduced capacity to continue the work, and it may produce soreness in the muscles. The primary strategy to prevent musculo-skeletal trauma is the use of ergonomic principles to modify hand tools and to improve workstation design and work practices. Workload should be distributed between hands and feet wherever feasible. The following ergonomic rules are suggested for repetitive use: The tool should be designed for operation with a straight wrist-bend the tool handle, not the wrist. Use power tools whenever feasible. Make tool light- heavy tools should be suspended or otherwise counterbalanced. Handle surfaces should be so shaped as to contact the largest possible surface of the inner hand and fingers, distributing the forces evenly and not creating power points.

(2) Awkward posture: the necessity to adopt one posture, or a very limited range of awkward work positions, may result in wrist and hand fatigue, and

difficulty in sustaining a proper work position. The primary strategy to prevent cumulative trauma disorders is the use of ergonomic principles (a) to modify hand tools, (b) to improve workstation design, and (c) to improve work practices.

3.1 Back injuries at work

Back pain is one of the most common work-related injuries and is often caused by ordinary work activities such as sitting in an office chair or heavy lifting. Applying ergonomic principles - the study of the workplace as it relates to the worker - can help prevent work-related back pain and back injury and help maintain a healthy back. The goal of an ergonomics program in industry is to adapt the workplace to a specific worker, dependent on the job description, required tasks and physical make up of the employee performing those tasks. Two types of situations typically cause people to begin having back pain or to sustain a back injury while on the job: (a) Non-accidental injury, where pain arises as a result of normal activities and requirements of the task. Poor body mechanics (such as slouching in an office chair), prolonged activity, repetitive motions, and fatigue are major contributors to these injuries. This may occur from sitting in an office chair or standing for too long in one position. (b) Accidental injury results when an unexpected event triggers injury during the task. A load that slips or shifts as it is being lifted, and a slip and fall or hitting one's head on a cabinet door are typical examples. These accidents can jolt the neck, back and other joints with resulting muscle strain or tearing of soft tissue in the back

3.2 Back injury from physically demanding jobs

Occupations that are physically demanding and require repetitive lifting (such as in nursing or heavy industry) are at greatest risk for both non-accidental and accidental back injury. For example, many healthcare workers have back problems because patients are of different stature and weight with varying needs. Often, the patients need help changing position, rising from a chair and walking. Similarly, the physical effort needed on an accident or fire scene to release a trapped person or save a life is unpredictable. The same problems occur in the construction industry where consistencies of tasks are a challenge.

3.3 Office chair back injuries

People who sit most of the day, such as those who work at a computer while sitting in an office chair, is also at high risk for non-accidental back injury. Office ergonomics, or computer ergonomics, can help minimize the risk of repetitive injury, such as carpal tunnel syndrome, and the risks associated

with prolonged sitting in an office chair, such as neck strain, lower back pain and leg pain.

4. PREVENT BACK INJURY

There are certain basic ergonomic guidelines that may help an employee avoid back pain or back injury:

- Develop a job description based on the forces present in a particular work environment; the time spent performing the task and the biomechanics (which define human motions and seated posture in an office chair) used in the task.
- Use body posture as a tool that can be changed to meet the job demands with minimum stress on the muscles, ligaments, bones and joints.
- Learn and use appropriate body mechanics to limit extra mechanical stress in completing the task.
- Maintain fitness and flexibility and develop a reserve of strength.

4.1 Identifying poor posture and risks

Many potentially harmful situations that lead to back injury can be identified and avoided by following four basic rules of thumb:

1. Prolonged static posture is the enemy. The healthy body can only tolerate staying in one position for about 20 minutes. That is why sitting on an airplane, at a desk in an office chair, or at a movie theatre becomes uncomfortable after a short time. Standing in one place, such as standing on a concrete floor at an assembly line for extended periods of time tends to cause back pain. Holding the same position slowly diminishes elasticity in the soft tissues (muscles ligaments and tendons in the back). Then, stress builds up and causes back discomfort and/or leg discomfort.
The solution is simple. Whether you're sitting in an office chair or standing in a line, change positions frequently. Just move. Stand or sit, stretch, take a short walk. After returning to the standing or sitting posture, use an alternate posture for just a few moments and some of the tissue elasticity needed to protect the joints will return.
2. Frequent or repetitive stretching to the end range of motion or awkward, angled postures can bind the joints. Unlike jobs that require long-term seating in an office chair, jobs that require frequent repetitive motion can cause great discomfort. Such jobs involve lifting from the floor, lifting overhead, moving bulky

loads, or using rotational force or twisting while handling material and which signal back injuries might be on the way.

3. Heavy loads offer greater risk. If the job requires moving heavy or bulky objects, it is important to have the proper tools or get help.
4. Fatigue from sitting in an office chair for days, from work or from insomnia can make people move more awkwardly. If one is overtired or feels fatigued, it is advisable to avoid lifting heavy objects alone or quickly.

If following these ergonomic rules of thumb is a frequent problem, the worker is at risk of sustaining or aggravating a back injury.

4.2 Manual Material Handling to Prevent Back Injury

Any job that involves heavy labor or manual material handling may be in a high-risk category. Manual material handling entails lifting, but also usually includes climbing, pushing, pulling and pivoting, all of which pose the risk of injury to the back. Lifting from the floor places strain on the structures in the lumbar spine. Ergonomic lifting techniques involve the use of a diagonal foot position, and getting as close to the load as possible. The load should be kept as close to the body as possible when standing up.

It is easier to move loads that are waist high than ones that are on the floor. Stacking pallets to raise the height of the load is one ergonomic solution. A scissors lift will mechanically raise the load to a comfortable lifting level. Repetitive lifting from the floor is particularly risky, so try to get the material off the floor. Keep all loads as close to one's center of gravity as possible. Carrying loads on one shoulder is safer for long and narrow material. This would include construction material or rolls of carpet. When lifting anything with a handle, place one hand on one knee to get additional leverage and use a diagonal foot position. Carrying two objects of the same weight will balance the load as long as the weight of the load is reasonable.

When climbing with a load, "three-point" contact is important for safety. This means two hands and a foot or both feet and a hand must be in contact with the ladder or stairs at all times. If the load is bulky, get another person or a mechanical device to assist. Manual material handling may require pushing or pulling. Pushing is generally easier on the back than pulling. It is important to use both the arms and legs to provide the leverage to start the push.

- A handle would ideally be waist high for ease of pushing
- If it is necessary to pull, avoid twisting the lower back
- Sometimes, for very large loads, turning around and using the back to push against

an object allows the legs to provide maximum force while protecting the low back from strain or twisting.

The opposite of twisting is pivoting. Pivoting means moving the shoulders, hips and feet with the load in front at all times. The lower back is not designed to torque or repetitive twisting. Whether using a shovel or moving material or products, always avoid twisting the back. Practicing these techniques, both at work and at home, will go a long way to help prevent back injury and protect the structures in the low back.

IMPLEMENTATION: This ergonomics approaches has been implemented in a local Ceramic factory and found that their employee turnover has been reduced to 20 percent and productivity has been increased to 10 percent. Although the company has to spend some money for the implementation of the ergonomics approach but this cost is very small compared to their benefit.

CONCLUSION:

Occupational ergonomics is a part of industrial medicine, and is essentially applied to reduce work injuries and discomfort. The discipline deals with the body size of the workers, strength and stress while at work. Recent studies have suggested that many of the occupational diseases are connected to poor design of tools, machines and workplace. To prevent unnecessary error and overt and cumulative injuries, ergonomics has an essential role to play in increasing work efficiency and productivity by making the tool or machine fit the users and the worker's capability.

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Experimental Analysis on the Heat Transfer Performance of an Ammonia-charged Pulsating Heat Pipe

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An experimental analysis on the heat transfer performance of an ammonia-charged pulsating heat pipe (PHP) system is presented here. The experimental apparatus consists of a 8.382m long 3mm inner diameter closed loop aluminium pipe meandering back and forth into an electrically heated block of aluminium. The other end of the PHPs is cooled with air by natural convection. Heat transfer characteristics of PHPs are determined experimentally, based on the principle of phase change of the working fluid. Response curves in terms of temperature and heat transfer rate are obtained for different inclinations and liquid charge fill ratios. The experiment is conducted at constant heat input. The overall heat transfer coefficient of the system is determined to show the heat removing capability of the PHPs. The results show that, the performance of the heat pipe varies substantially for different inclinations and different liquid charge fill ratios.

Key words: Pulsating heat pipes, heat transfer coefficient, heat transfer rate.

1. INTRODUCTION

A heat pipe is a heat transfer device that employs both conduction and phase transition to efficiently manage the transfer of heat between two solid surfaces. It generally uses the gravitational force as the driving force for the flow of the working fluid. Pulsating Heat Pipe (PHP) is a special kind of heat pipe where slug-plug motion of the working fluid plays the most important role not the gravitational force. It is considered as being a potentially useful option in the thermal management and control of electrical and electronic devices [1]. Mainly, PHPs consist of a capillary tube meandered in several curves to form parallel passages. The vapor plugs generated by the evaporation of the working fluid push the liquid slugs toward the condensation section and this motion causes flow pulsations that guide the operation of the device [2]. There are several applications of PHPs, from electronics and structural thermal control to microgravity thermal control. Due to simple construction, light weight and low cost, PHPs have gained attention to be used in space radiators, in order to give a more isothermal characteristic for this component. Integrating such a device is not a big problem and it could be easily used in many other applications.

A PHP has no moving parts, no wick structure and its construction is very simple. It possesses a

relatively long but small diameter pipe meandering in a serpentine fashion between a heat source and a heat sink. The pipe is sealed, evacuated and charged with a working fluid [3]. Considering the sections of a PHP, it consists of evaporation and condensation sections and an optional adiabatic section in-between. Like in other two-phase passive thermal control devices, heat is acquired from the source through the evaporation section and is transferred to the working fluid undergoing slug-plug pumping action. The fluid then flows through the adiabatic section towards the condensation section. Provided the diameter is small enough the fluid forms a system of discrete liquid plugs and vapor bubbles that move in a seemingly random fashion back and forth between the heat source and the heat sink. There are two types of PHPs, one is closed loop and other is open loop. In the open loop configuration, one end of the tube is pinched off and welded, while the other end may have a service valve for evacuation and charging. On the contrary, the closed loop configuration has both ends connected and the fluid is allowed to circulate. Figure 1 shows a typical arrangement of a closed loop PHP. The PHP operation has some unique characteristics and a very interesting thermal behavior. One peculiarity of PHP operation is that it exhibits thermo-hydrodynamic instabilities related to the plug-slug dynamics. The vapor plugs form and collapse in such a chaotic fashion that is

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difficult to model. During its operation, metastable conditions of the working fluid (at both liquid and vapor phases) are present [4-6]. The plug-slug flow is directly dependent on the thermal power delivered to the evaporation section, tilt angle and amount of non-condensable gases [7].

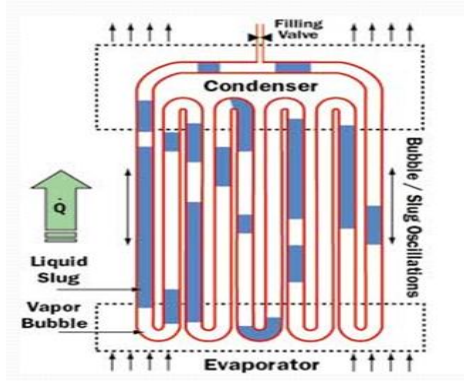


Fig. 1: Working principle of a closed loop PHP.

This paper presents the experimentally found thermal characteristics of an aluminum made pulsating heat pipe charged with ammonia. The experiments were done for different fill ratio of the working fluid (0.4, 0.6, and 0.8) and for different angular setting of the setup. The condenser section was cooled naturally by air and the evaporator section was heated electrically. Such results will be useful as ammonia is a known efficient heat transfer fluid and not much published results of its usage in a PHP are available. Aluminum was selected as heat pipe material because of its high heat transfers coefficient and flexibility to be meandered.

2. HEAT TRANSFER THEORY

The thermal circuit of the PHP is shown in figure 2. The heat transfer rate as well as the heat transfer coefficient between the working fluid (ammonia) and the inside wall of the PHP will vary as a function of position and time. At times there will be liquid, at other times vapor and yet at other times some two-phase combination of liquid and vapor in the same position. However, it is imagined that there is some average characteristic of heat transfer which is the same for the evaporator, the condenser and the rest portion of the PHP. Considering $h_{ci} = h_{ci} = h_{PHP}$, heat transfer coefficient can be defined by equation 1.

$$h_{PHP} = \frac{Q_{PHP}}{T_e - T_c} \left(\frac{1}{A_{ei}} + \frac{1}{A_{ci}} \right) \quad (1)$$

Where,

A_{ei} = Area of evaporating section of PHP = $\pi d_i L_e$

A_{ci} = Area of condensing section of PHP = $\pi d_i L_c$
And, Q_{PHP} is the heat transfer rate of the pulsating heat pipe which can be calculated by equation 2.

$$Q_{PHP} = Q_{elec} - Q_{Block} - Q_{ca} - Q_w \quad (2)$$

Q_{elec} = electric energy input = $\frac{V^2}{R}$

Q_{Block} = Heat absorbed by the block at unit time

Q_{ca} = Heat loss from the evaporator

Q_w = Heat transferred through the wall.

The heat transfer rate will depend on a number of independent variables; heat flux, liquid charge fill ratio, inclination angle and working fluid temperature as well as the liquid-vapor two-phase flow pattern.

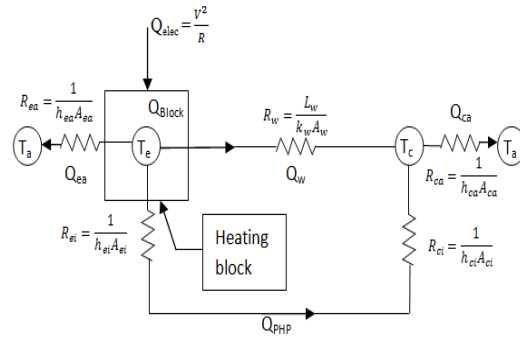


Fig. 2: Thermal circuit of the setup.

3. EXPERIMENTAL SETUP

To study the thermal characteristics of ammonia charged pulsating heat pipe, a setup was designed and fabricated. The experimental setup consists of an aluminum pipe, an aluminum block, thermocouples, selector switches, a pressure gauge and a wooden frame.

The aluminum pipe with outer diameter 4mm and inner diameter 3mm was bent and supplied with two charge/discharge valves to form a closed-loop. One end of the closed-loop is embedded in matching grooves in an aluminum block (350x210x35 mm³). To ensure good thermal conduction between the block and the pipe, the grooves were cut with precision milling machine. The block is supplied with a groove in which an electric heating wire insulated with ceramic beads is fixed. The condenser section was cooled with air by natural convection. The aluminum pipe and the block in evaporator and adiabatic sections are completely insulated with 20.0 mm thick foam rubber. The setup is mounted on a wooden stand in such a way that it can be tilted at any angle desired. The temperature of the block and the PHP is

measured by thermocouples; 7 in evaporator section, 2 in adiabatic section and 5 in condenser section (Fig. 3).

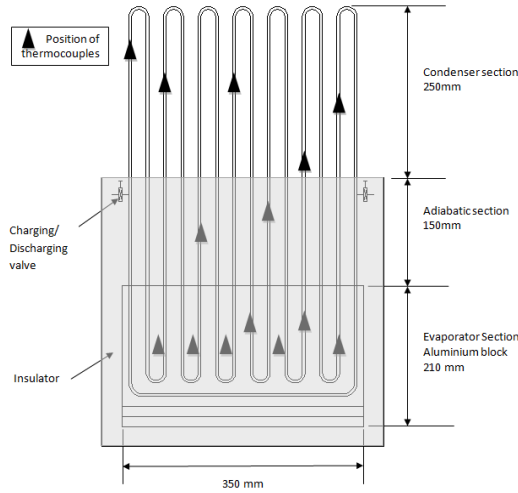


Fig. 3: Schematic diagram of the heat pipe system.

The important dimensions of the PHP set-up are given in table 1.

Table 1: Dimensions of the set-up

Total Length of pipe	L_{PHP}	8.382m
Evaporator Length	L_e	2.496m
Condenser Length	L_c	4.346m
Pipe Diameter (inner)	d_i	0.003m
Pipe Diameter (outer)	d_o	0.004m
Radius of each turn	R	0.013m
Length of block	L	0.35 m
Width of block	W	0.21 m
Thickness of block	B	0.035m
Mass of block	m	7.5 kg

4. TEST PROCEDURE

The PHP set-up is charged with a known volume of ammonia. After charging, the PHP is sealed and Alternating Current (AC) is supplied to the nichrome wire heater via a variac. The heat input is kept constant by providing a constant voltage by the variac. Wall temperatures of the PHP are recorded at an interval of 10 to 20 minutes for each heat input until steady values are attained. The entire procedure is repeated for different tilt angles of the set-up. Then the working fluid is discharged.

The procedure is repeated by charging the PHP at other fill ratio.

5. RESULTS & DISCUSSION

As heat load is applied to the evaporator section, the temperature of the evaporator rises and results in vaporization of the working fluid. This vaporization of the working fluid absorbs heat from the evaporator section. From equation 2, we get,

$$Q_{PHP} = Q_{elec} - Q_{Block} - Q_{ea} - Q_w \quad (2)$$

The heating value i.e. the electric energy input is determined from the voltage indicated by the variac and the resistance of the heating wire. The heat loss to the environment from the evaporator block Q_{ea} is determined by assuming a thermal circuit consisting of conduction from aluminum block to glass wool and then from glass wool to air and overall heat transfer coefficient for this circuit is $3.27 \text{ Wm}^{-1}\text{K}^{-1}$.

$$Q_{ea} = \text{Surface area} \times 3.27 \times (\bar{T}_e - T_a) = 0.61 \times (\bar{T}_e - T_a) \quad (3)$$

Heat absorbed by the block per unit time is calculated by equation 4, where the weight of aluminum block is 7.5 kg and the heat capacity of aluminum is $900 \text{ J/kg}\cdot\text{K}$.

$$Q_{Block} = \text{mass} \times \text{heat capacity} \times \frac{T_{en} - T_{e(n-1)}}{\Delta t \times 60} = 113 \times \frac{T_{en} - T_{e(n-1)}}{\Delta t} \quad (4)$$

The heat transferred though the wall of the PHP between the heating and cooling blocks was not experimentally determined. However, it is small and is calculated using simple theory as,

$$Q_w = k_w \frac{\pi \pi (d_o^2 - d_i^2) (\bar{T}_e - \bar{T}_c)}{4} \frac{L_e}{0.28} = 250 \frac{14 \times \pi (0.004^2 - 0.003^2) (\bar{T}_e - \bar{T}_c)}{4} = 0.0687 \times (\bar{T}_e - \bar{T}_c) \quad (5)$$

In this study, the heating value was kept same throughout the experiments; the variables were the fill ratio and inclination angle. These parameters have no direct relation with the performance which can be observed from the equations. So, experiments are obvious to find out the influence of these parameters on the performance of ammonia charged pulsating heat pipe.

The temperature of different sections was measured until steady state was obtained. Some sample temperature profiles with time are shown in Fig. 4, 5 and 6. In all these settings, heat source was at

lower position or leveled with the heat sink. From graphs it can be observed that for 0.4 fill ratio time needed to reach steady state is about 180 to 200 minutes (Fig. 4). For 0.6 fill ratio time required is little longer, about 200 to 230 minutes (Fig. 5). But for 0.8 fill ratio, it is even longer, more than 250 minutes (Fig. 6). For 0.4 and 0.6 fill ratio, the temperature profiles are almost identical for all angles. For 0.8 fill ratio when the setup is horizontal, the difference between evaporator and condenser temperatures is high and the condenser temperature stays almost constantly close to the atmospheric temperature (Fig. 6).

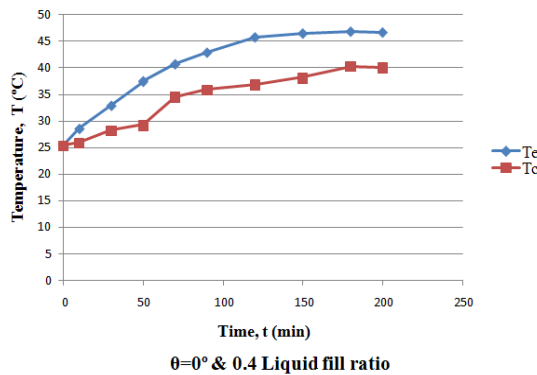


Fig. 4: Temperature vs. time for 0.4 fill ratio and vertical setup.

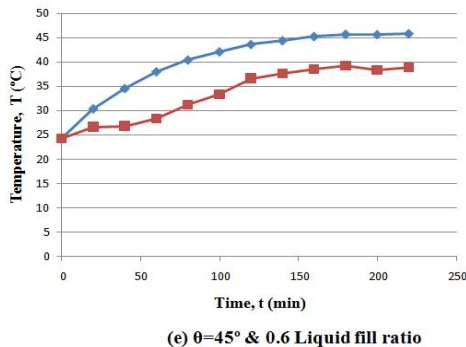


Fig. 5: Temperature vs. time for 0.6 fill ratio and setup at angle 45° with vertical.

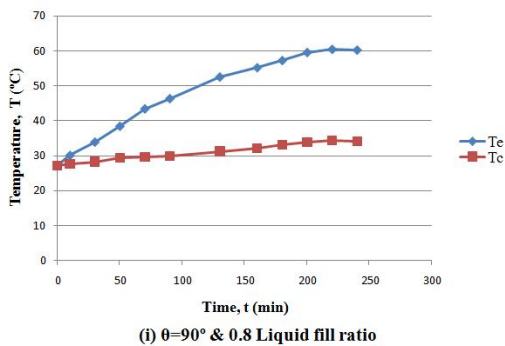


Fig. 6: Temperature vs. time for 0.8 fill ratio and setup at angle 90° with vertical.

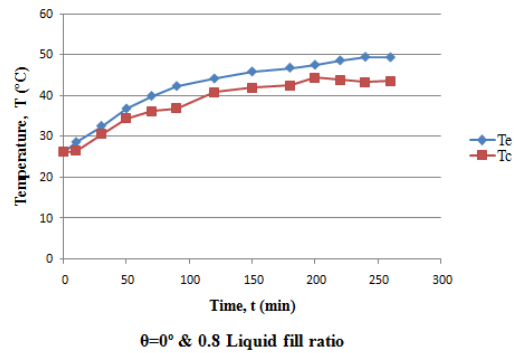


Fig. 7: Temperature vs. time for 0.8 fill ratio and vertical setup.

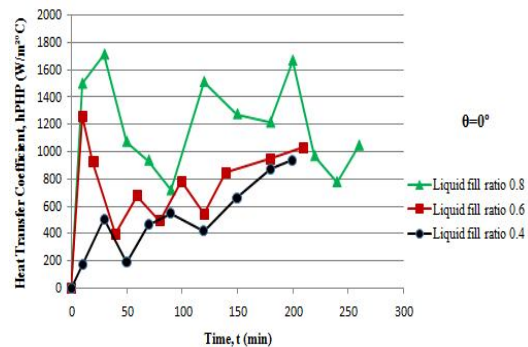


Fig. 8: Heat transfer coefficient vs. time for different fill ratio (0.4, 0.6 and 0.8) at vertical setup.

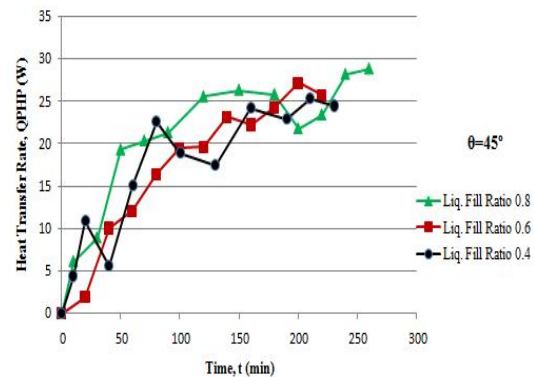


Fig. 9: Heat transfer rate vs. time for different fill ratio (0.4, 0.6 and 0.8) at 45° from vertical setup.

But for the same fill ratio when the setup is vertical the condenser temperature rises significantly closer to the evaporator temperature (Fig. 7).

Figures 8 and 9 show the heat transfer rates and heat transfer coefficients, respectively, of the PHP using ammonia as working fluid. For the inclination angle 0° to 45° from vertical 0.8 fill ratio seems to be the best fill ratio. Because the heat transfer rates and heat transfer coefficients are high for 0.8 fill ratio almost from the beginning throughout the

experiments. Though the heat transfer rate for 0.6 and 0.4 fill ratio approaches near to that of 0.8 fill ratio as steady state occurs, heat transfer coefficient of the system always show better result for 0.8 fill ratio. For any specific fill ratio heat transfer rate decreases as the setup angle is increased from 0° to 90° (Fig. 10). For the 90° vertical setup the efficiency of the system decreases for all fill ratios, but especially for 0.8 fill ratio it becomes very inefficient and shows chaotic behavior (Fig. 11)

The pressure is an important parameter for ammonia, as its pressure rises vigorously with temperature. The fill ratio affects the pressure significantly. For 0.4 fill ratio, the pressure remains lower than atmospheric pressure (Fig. 12) at the first hour of the experiments. It is because that at lower temperature for lower fill ratio there is not enough ammonia to be vaporized to take the pressure higher than atmospheric. So, some portion inside PHP remains vacuum. As the temperature

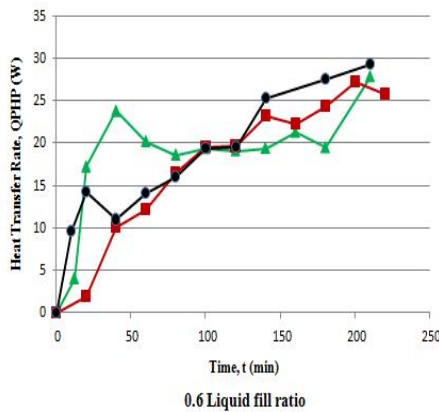


Fig. 10: Heat transfer rate vs. time for 0.6 fill ratio at different angles (0° , 45° , 90°) of setup.

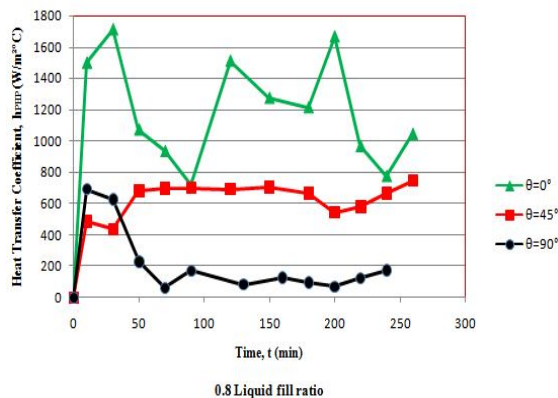


Fig. 11: Heat transfer coefficient vs. time for 0.8 fill ratio at different angles (0° , 45° , 90°) of setup.

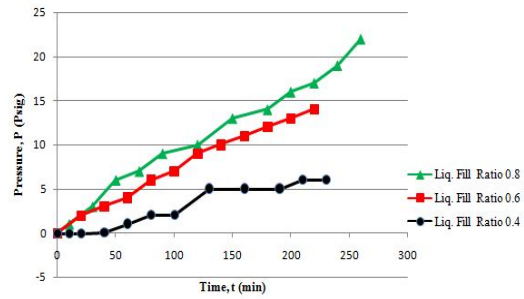


Fig. 12: Pressure vs. time for different fill ratio at angle 45° of setup.

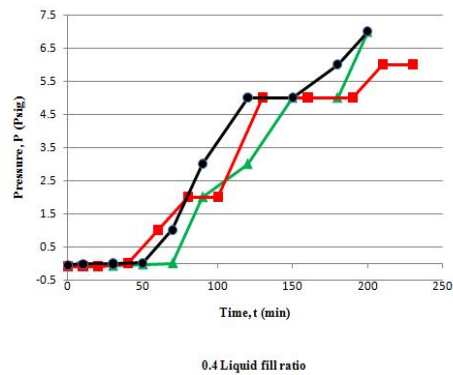


Fig. 13: Pressure vs. time for 0.4 fill ratio at different angles of setup.

increases the pressure increases and finally reaches up to 6 to 7 psi. For 0.6 fill ratio the pressure stays increases up to 24 psi. Inclination angle seems to have no influence on the performance of PHP (Fig. 13).

6. CONCLUSION

The following conclusions can be drawn from the experimental studies:

- Tilt Angle and fill ratio play significant role on the performance of PHP.
- The pressure of Ammonia-charged pulsating heat pipe increases vigorously with temperature. So sturdy and robust setup is to be ensured.
- For tilt angles between 0° to 45° from the vertical, higher fill ratio (0.8) shows better performance.
- For horizontal setup, lower fill ratio (0.4 or 0.6) is better.

NOMENCLATURE

A	area, m ²
d	diameter, m
h	heat transfer coefficient, W/m ² K
L	length, m
m	mass, kg
Q	heat transfer rate, W
R	thermal resistance, °C/W
T	temperature, °C
t	time, s
U	overall heat transfer coefficient, W/m ² K
B	thickness, m
Θ	angle, degree

SUBSCRIPT

c	condenser, cold
e	exit, environment, evaporator
a	ambient, adiabatic
ea	Evaporator to ambient

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FLEXIBLE WORKSTATION DESIGN

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ABSTRACT

A workstation is a place a worker occupies when performing a job. The work station may be occupied all the time or it may be one of several places where work is done. Some examples of workstation are work stands or work tables for computer operator, worktable for machine operation, assembly or inspection, control table where operator controls. A well designed workstation is important for preventing diseases related to poor working conditions, as well as for ensuring that work is productive. Every workstation should be designed with both the persons working and the task in mind so that work can be performed comfortably, smoothly and efficiently. Ergonomics is a multi-disciplinary science comprising subjects like anatomy, physiology, psychology, sociology, physics, engineering and medicine. The application of all these science is necessary in order to identify and optimize all the factors which may affect a person in his working environment. The modern science of ergonomics is concerned with relationships between man, machines and the environment which has created, and serves to make man-machine systems more efficient and safer. A poor environment can lead to many social problems. Up to the present, most ergonomists have been concerned more with industrial situations than with the office. Extended work with computers can lead to muscular fatigue and discomfort, usually in the back, arms, shoulders and neck. As well, if the computer is used for prolonged periods in awkward postures, there is a risk of musculoskeletal injury (MSI). This risk increases as the intensity of computer work increases recently there has been a significant increase in the number of injuries due to over-exertion and repetitive strain. In this paper an attempt has been made to give deep insight of the office environment ergonomics and workstation design applicable to flexible office work. The paper gives the readers a broad overview of the different aspects of Ergonomics issues applicable to office work and health and safety of working persons relating to work performed using a computer as a workstation.

Key words: Office, environment, workstation, human and design.

1. INTRODUCTION

Ergonomics can be defined as the application of knowledge of human's characteristics to the design of systems. Many companies have contested the established view of office design and office work since the beginning of the 1990's. Most of the offices nowadays are based on the concept of non-territorial or free address offices in which a given desk, office or workstation is intended to be used by different people at different times. It is important that the management has a clear understanding that when transforming the office to support flexible work practices the primary focus must be on people's needs and behavior rather than on actual interior design. Based on experience from research performed in the United States [1] and Sweden [2], some critical factors for success of the office design process have been identified. These include: A clear

identification of the project owner, projects that are productivity driven and not cost driven, identification and realization of benefits for the office staff, staff involvement in the process, all aspects of the project considered as a whole including the available space, interior design, information technology, organization, and working practices, good interior design and openness and flexibility to meet future requirements.

To succeed with an office design concept based on flexibility and openness requires a new and different way of looking at offices. The office must be regarded more as a tool, like any computer or telephone system, with the main purpose of supporting the business tasks. The organization of computer-based tasks has proven to have an essential impact on the comfort of the user. The environmental factors in the office

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environment also play an important role in ensuring comfort and efficiency in task performance. Reflections in video display terminal (VDT) screens, high indoor temperature, and disturbing noise levels are factors that could occur in cases of bad office planning. The negative impact of those factors must not be overlooked. Even though the computer hardware is designed according to the latest ergonomic findings, extensive keyboard input work could still cause muscular problem such as repetitive strain injury (RSI). Flexibility in work practices and work positions is essential to minimize health and safety risks.

The problem of more efficiency and fatigue also exist in the workstations of office i.e. the working environment of offices. If the workstations are properly designed, the persons working should be able to maintain a correct and comfortable body posture. Uncomfortable work posture can cause a variety of problems, such as back injury, circulatory problems in the legs. The main cause of these problems are poorly designed seating, standing for long periods, reaching too far, inadequate lighting forcing the workers to get too close to the work.

This paper presents a review of the effects of business process analysis approach to ergonomic aspects of office design and workstation design tools.

Extended work with computers can lead to muscular fatigue and discomfort, usually in the back, arms, shoulders and neck. As well, if the computer is used for prolonged periods in awkward postures, there is a risk of musculoskeletal injury (MSI). This risk increases as the intensity of computer work increases. Frequently, the source of muscular fatigue and discomfort is the operator's posture while working at the terminal, and this posture is due in turn to the layout of the computer workstation and the furniture provided. The specific tasks and the intensity of the work are also factors. Computer operators may experience visual as well as muscular fatigue and discomfort. Symptoms include eyestrain, burning eyes, blurred vision and headaches. The layout of the computer workstation can increase the visual demands on operators, as can lighting levels and glare.

2. FLEXIBLE OFFICE AND WORK PRACTICES

One of the most important factors when carrying out a flexible office designs or redesign project is the awareness that it is a project of changes that primarily affects staff and organization and only

secondarily a building project. One cannot easily transfer an existing office design from one organization to another. Instead every office must be created by and for its own staff organization. The business process analysis is therefore a fundamental element in the design of the flexible office. This emphasizes the need for a master plan – an office design process (ODP). This process could be described in several steps [3]. The staff members working in flexible and traditional office designs were asked to report the sensation of body strain. The “standard” report for people working in an office environment concerning the presence of body strain in neck and shoulders between 30 to 35 percent. In this case, the reported level in the traditional office design meets the expected value. The reported value from the flexible office design is much lower. There are no reports concerning strain in elbow, forearms, wrist, hands, or fingers from the personnel working in the flexible office design. One explanation is the increased flexibility in working positions that the furniture and work organization offer in this type of office. A flexible office design offers more than just a nice interior.

The changes in work organization/work behavior made possible by portable phones, client server computing, open plan office design, group work and telecommuting have made higher efficiency and better quality in office work possible [4]. Companies that have adopted this working style can present figures and facts that clearly demonstrate the advantages [5]. These include: More satisfied employees, decrease in sick leave time, decrease in staff turnover, up to 47 percent increase in working time availability, increase of net income (33 percent) and less costs for office space (50 percent). Five major activities, mainly stand out for bringing out the significant organization changes that result in such numbers: A strong management encouraged staff involvement in the change process, a clear setting of objectives, a business idea in line with the change process, taking advantage of the organizational force that comes with the enthusiastic people, a change in management style from control to support and coaching. There are some prerequisites for this transformation, with modern information technology playing a vital part. Central storage of all common information, digital communication between staff members, strict routines for computer usage and ways of cooperation is factors that must be considered.

The ideal workstation design

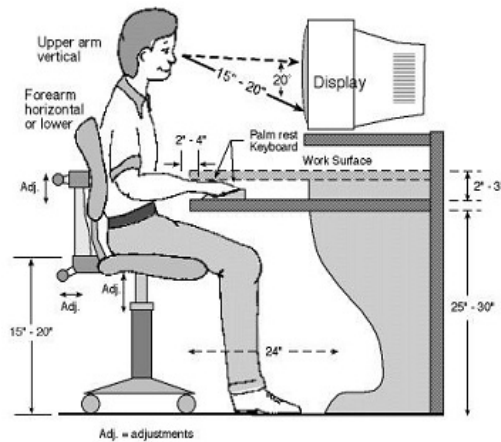


Fig. 1 Ideal workstation [20]

3. WORKSTATION DESIGN

There is no such thing as an “ergonomic working position”. Workplaces and work organizations that support flexibility also support good ergonomics. The ability to alter one’s position by sitting, standing, walking, and even lying down in a working situation is healthier than sitting continuously with 90 degree angles in knees and hips. Tables that are adjustable to meet working height of both sitting and standing positions; telephone and computer systems accessible all over the office; and comfortable, lie-down chairs in quiet areas are examples of designs that support good ergonomics [6,7]. Instead of referring to measurements regarding width and depth of tables and other office furniture, the basis for furniture requirements in this paper is the user and the user’s task to perform.

3.1 Working Surface

Working surface will then be defined as the width a user needs to accomplish a certain task. The width requirement is based on working on the task working with VDT (Visual Display Terminals) using a keyboard and an input mouse. It is important to have space available for the mouse/input device on both sides of the keyboard. The depth of the work surface will then be based on the required viewing distance in relation to the screen size. For displays based on the CRT technique there is a relationship between screen size and the depth of the housing. There is also a relationship between character size and the size of the screen. In both cases this means that for a bigger screen a greater depth is required.

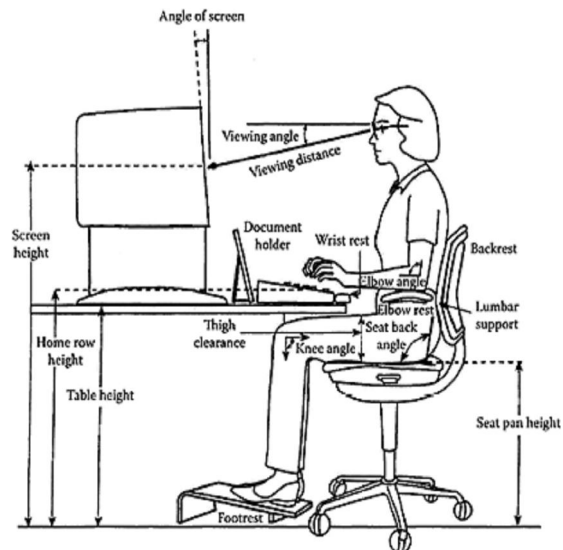


Fig. 2: VDT Workstation [8].

Basic ergonomics principles for workstation design are as follows:

Screen Height: The height between the floor and centre of screen.

Table Height: The vertical distance between the floor and table.

Viewing Angle: The center of the screen should be lower than the eye height, so as to obtain a viewing angle of about 25–35° below the horizontal. In particular, looking up with the head bent back is a common cause of strain and muscle fatigue in the neck. It prevent the muscle fatigue in the neck.

Thigh Clearance: A person sitting at a desk has limited space for the keyboard and the table top. Thigh clearance is the free space between seat and table board.

Angle of screen: The angle between the vertical line and screen of computer.

Elbow angle: The elbow angle should be 70-90. This makes quite a difference in design.

Seatback Angle: A seatback angle of greater than 110 reduces the pressure on the spine.

Footrest: A footrest can be helpful for short operators, so that they can support their feet.

Experience from flexible office environments and flexible workstation shows that some types of furniture are more suited types than others to encourage and facilitate flexible work practices [9]. Examples of such furniture follow-

(i) Balanced Tables: The balanced table is very appropriate for use as a worktable, since it can easily be adjusted to different heights.

To work well, balanced tables must be able to be adjusted; so that they balance the load placed on them. The desk surface can be designed so that

size and shape will specially accommodated the equipment and tasks to be performed.

(ii) Chairs: To meet the requirements of flexibility, one chair per person is not enough even though certain chair is fully adjustable regarding sitting height, width and so forth experience shows that people very seldom change the initial settings [10]. To offer each employee a set of different chairs that support differences in sitting style will contribute to increased health and safety.

Chairs should have the following features:

a. Seat height: Must adjust to allow the user to place the feet firmly on the floor or a supportive footrest; assuming an adjustable work surface height, an adjustment range of 380-520 mm (15 - 20.5") will allow 90% of potential users to find a comfortable sitting height while wearing shoes.

b. Seat pan depth: Must be such that the user can maintain contact with the backrest in the lumbar area and avoid increased pressure on the back of legs and behind the knees; seat pan depth should be less than 430 mm (17") and there should be space, about the width of a clenched fist, between the front of the seat pan and the back of the knees horizontal adjustment of the backrest is an excellent feature to permit changing the effective seat pan depth – a good range of seat pan depth is 380-430 mm (15 - 17") – a backrest like this will permit all but the shortest 5% of users to have adequate back support while seated.

c. Seat pan: Should have a "waterfall" or rounded front edge to minimize pressure on the back of the legs.

d. Backrest: Should provide good contact and support for the lumbar region of the user's back; the backrest should be vertically adjustable the backrest should have a height of 380-540 mm (15"-21") and a width of 350-480 mm (14" -19") the backrest tilt angle may be fixed, adjustable or spring-tensioned; if fixed, an angle of 103 +/-1 degrees is suitable; if adjustable, a range of 95-110 degrees is usually sufficient; the force of a spring-tensioned reclining backrest should be adjustable to suit the user's needs.

e. Adjustable armrests: Adjustable in both the horizontal and vertical planes which can provide light arm support are recommended for moderate and intensive computer users - armrests should not impede access to the work station or arm movement.

f. Five-pronged chair base with casters: For stability and easier mobility; the ability to swivel 360 degrees and move the chair around improves access to work materials, eases sitting down and standing up and reduces twisting stresses on the spine; appropriate casters for the surface (hard casters for soft floors or soft casters for hard floors).

g. Seat cushion: Should have minimal contouring to allow easy shifting of position and there should not be any local pressure points such as buttons or prominent seams.

4. WORKSTATION SUPPORTING FURNITURE

The rolling cabinet is appropriate to use when the work is characterized by flexibility and when the staff person does not have a fixed workstation. The surface area of the rolling cabinet is often used as an extension of existing table surfaces, which means that the "desk" height is controlled by the work height. This is naturally not good from an ergonomic point of view, and therefore the table surface of the cabinet should be introduced as an unloading area.

A. Display

The evolution of "office ergonomic" has been due largely to the rapid growth of information technology [11]. Factors concerning display ergonomics are related to the physical design of (VDT's) as well as user interface design aspects of the software. The software should be based upon usability factor. One of the main factors that affect performance and comfort is the image quality of monochrome as well as multicolor displays. Good image quality is a multi-factorial issue, dependent on character design, phosphorus quality (for CRT-based displays), and overall technical quality of the display.

Flat panel technology will enhance the possibilities to arrange work places using proper ergonomics. The easier positioning of the flat display gives more flexibility both regarding the use of the furniture and for the user.

The guidelines for use display unit in office environment:

- The work surface should be chosen to complement the task being performed and be able to accommodate the tools and space required.
- Moderate and intensive computer users should sit directly in front of the monitor and keyboard/mouse.
- Lateral viewing boundaries should not exceed 30 degrees either side of the body centre-line.
- The mouse or pointing device should be located next to the keyboard (as close as possible and at the same height) to minimize reach.
- The keyboard and mouse (or other pointing device) should be located at a height that allows the user's forearms, wrists and hands to be parallel to the floor (the surface of the keyboard should generally be lower than a typical writing surface in order to permit the best posture).

- Under desk adjustable height keyboard/mouse arms should be used to accommodate this need when the work surface height cannot be altered to accommodate this posture.
- An adjustment range of 600-730 mm (24-29") will allow most people to adopt a suitable arm posture for repetitive keying; if a single fixed surface is used, a work surface height of 720 mm (~28") is commonly recommended.
- Work surface height should provide adequate clearance for the operator's legs when seated in his or her most comfortable sitting position.
- Monitor viewing distance should be about arm's length away when seated comfortably in front of the keyboard.
- The computer screen should be positioned such that the top of the screen is about eye level or slightly lower (0 to 60 degrees below eye level is usually suggested).
- Individuals who wear bifocals and trifocals may need to place the monitor lower than this to maintain comfortable (neutral) neck posture.
- Frequently used items should be stored close to the user but should only be on the work surface if they are in constant use.
- Store heavy items close to minimize lifting, reaching, twisting or carrying.
- The screen height should be easily adjustable to accommodate gender height differences and the operator's personal preferences throughout the day. Further, the viewing height should allow the operator to view the monitor screen within an orthopedically correct "viewing cone" to minimize musculoskeletal stress disorders (MSD's).

B. Keyboard

Keyboard layout, key functionality and design are all essential factors that contribute to user productivity and comfort. Other factors such as thickness of the work surface supporting keyboard and overall layout of the workstations have implications on the comfort of the users. Low-profile keyboards with a proper tactile feedback are suitable for most users. However extensive keyboard work, (i.e. several hours per day) is not recommended due to the fact that even limited muscular stress could cause muscular problems if exaggerated. Keyboards should be placed at a height that allows the operator to operate the keyboard with the forearms level and hands sloping slightly downward. A negatively tilting keyboard, allowing the operator to "keep the wrinkles out of the top of the wrists" is ideal. Fore and aft positioning of the keyboard should be consistent with allowing the hands to move easily over the keyboard with forearms level and elbows

at the sides, maintaining a 90 ° - 120 ° angle between upper and lower arms.



Fig: 3 Keyboards [21]

C. Portable Computers

Since the keyboard and screen on a portable computer (also called a laptop computer) are attached, it is often difficult to position the computer to get a comfortable posture for both keyboarding and viewing. Either the keyboard is too high or the screen is too low. The importance of optimum posture increases as the duration and frequency of computer use increases. Awkward postures can be tolerated for short periods of time. Laptops are not ideal for extended periods of use; however, they are increasingly used in this manner. Laptop computers have several advantages for users in terms of being lightweight and highly portable, but these desirable design features present inherent ergonomic problems when moderate and intensive computer users use these devices extensively. Because the keyboard/pointer and the screen are attached, postural compromises are unavoidable. Short-term, infrequent use of laptops is not problematic but if a laptop is being used in one location for extended periods of time, then it is not the right tool for the job. If a laptop needs to be used in one location regularly for any length of time, a separate monitor or keyboard and mouse should be provided at that location. In addition, moderate and intensive laptop computer users need to be very aware of their keyboarding posture (avoid bending and resting wrists on the edge of the laptop, for example). Below are some good practices. For general use, place the laptop on a flat surface with the screen tilted back 110-150°. If desk use is extended some additional equipment should be used. As the keyboard and screen are attached it makes it difficult to optimally position the computer for suitable typing and viewing conditions. Ideally, a docking station or port replicate with a separate monitor, keyboard and mouse should be used. However, another option is to use a separate keyboard and mouse, then raise the laptop such that the screen is in an optimal position for viewing to avoid excessive neck bend (viewing angle of not more than 15° down). Bifocal users should take extra care to position the screen to allow viewing without awkward head positions. Take short "micro-breaks" frequently. Focus on a distant object for a few seconds. Avoid prolonged periods of use.

Optimize viewing conditions. Maintain a comfortable viewing distance (in the range of 40-74 cm). Font size can be adjusted to allow the laptop to be placed for both good viewing and a comfortable body position. Place laptop to minimize glare from lights and windows Adjust brightness and contrast to suit lighting conditions.

D. Keep Screen Clean

Have regular eye examinations and inform your eye care provider of your computer use. The Health and Safety Guide provided with the computer should be referenced.

E. Mouse and Other Input Devices

The WIMP-concept (Windows, Icon, Menus, and Pointing Device) is commonly used today. It is easier task to choose an object than to remember a certain action command- especially human computer communication tends to become more intense and time consuming. Ergonomic aspects of pointing devices (mouse, trackball, joystick, tablets) have been well studied. The most common input device, the mouse, could, in a bad workplace design, give the user muscular stress problems. This problem has been addressed in a number of technical studies as a substitute to using shortcut commands on the keyboard. Different input devices present different characteristics regarding speed, accuracy, and preference. The right approach is not to attempt to identify the best input device in general, but to classify input devices based on the task to be performed. Common activities are “choose objects, drag objects, change orientation of objects – rotate and data input.”



Fig: 4 Mouse [22].

Classification can also based on “learn-ability, effectiveness, speed, accuracy, attitude, benefits versus cost (in terms of fatigue, stress, frustration, discomfort and flexibility).”The usage of input devices can cause muscular stress in the hand/arm/shoulder regions. These effects are the combined results of the design of the input device, workstation layout task, and individual applications. Input devices such as computer mouse, trackballs and digitizing tablets are used to perform a variety of types of computer work ranging from word processing to computer aided design (CAD). There are a number of types and

styles of devices. For example, some mouse now has scroll buttons. Mouse settings can also be adjusted for left handed users and to change the speed and distance of mouse travel and clicking actions required. It is important that users and purchasers of computers are aware of the range of devices and settings available, to determine which are most appropriate for their application and use. Even with the appropriate device, poor positioning can lead to problems. Users may hold the arm they use to control the device in a fixed, raised or outstretched position. This results in static loading of the shoulder and in bent wrist postures that contribute to discomfort and risk of injury. A mouse or a tablet should be placed as close to the worker’s side as possible at a height that allows the upper arm to hang relaxed from the shoulder with a “neutral” wrist position, with the hand in line with forearm. This position causes the least physical stress. The mouse should be also placed so the cord and items on the desk do not limit movement. If a keyboard/mouse platform is used, take care that it allows the mouse to be placed as close to the keyboard as possible (at the same height and in the same plane), and that it provides a stable surface of sufficient size. At CAD and other workstations where work is done with one arm for long periods, the forearm should be supported by a desk surface to the side of the operator or by adjustable armrests on the desk or the chair. This support is necessary to reduce static loading. The mouse or other hand-held input device should not contribute to cramped hand postures. This may require consideration of different-sized devices for different hand sizes. The device should be shaped so as to minimize bent wrist postures, or, failing that, the forearm should be supported on a raised smooth surface to allow a comfortable wrist posture. The mouse buttons should be located so as to avoid awkward finger and hand postures. The activation force (the force needed to make a button click) should not be so great as to cause fatigue. But it should not be so little that buttons can be clicked inadvertently since users will then tend to hold their fingers up away from the buttons, causing static loading of the muscles. Users should be encouraged to hold the mouse in a relaxed way, not to grip it tightly, and to move it from the shoulder rather than just the wrist. This better distributes muscular demands and reduces wrist movements and static loading. Ergonomics studies [12] have also shown that anthropometric difference related to gender are factors relating to muscular stress. The conclusion is that it is not possible to choose “the right input device” without taking the context of use into consideration [13], [14].

5. OFFICE ENVIRONMENT ERGONOMICS

There is a continuous and dynamic interaction between people and their surroundings that produces physiological and psychological strain on the person. This can lead to discomfort, annoyance, subtle and direct affects on performance and productivity, affects on health and safety, and death. Discomfort in offices can be due to glare, noisy equipment, draughts, or smells. In the cold people experience frostbite and die from hypothermia. In the heat they collapse or die from heat stroke. People exposed to vibrating tools encompass damage to their hands. Performance can be dramatically affected by the loss of manual dexterity in the cold, noise interfering with speech communication or work time lost because the environment is unacceptable or distracting. Accidents can occur due to glare on displays, missed signals in a warm environment or disorientation due to exposure to extreme environment [15].

5.1. Office Lighting

Office lighting should meet a number of requirements to provide high-quality illumination. Low-quality lighting is tiring both physically and mentally. Even though inadequate lighting in most cases does not make vision impossible, the signals from the eyes to the brain can result in interpretation problems. Unsuitable lighting can lead to difficulty in concentration as well as in poor working performance. In addition it can also cause muscular strain as a result of the worker being forced to sit or stand in awkward positions. Lighting in offices must ensure sufficient high levels of illumination in requested areas, such as reading areas and computer operation areas. There must be no distracting reflections within the normal field of view, and specific requirements in respect to luminance levels should be met. Beside visual conditions, energy efficiency and environmental implications must be considered [16]. Visual conditions to be considered are: illumination, placement of accessories in relation to workstation, glare luminance and luminance distribution, contrast reduction, color rendering and color temperature, reflecting factors, flickering, installation and electric and magnetic fields. For energy efficiency, special high-frequency operation lights, installed wattage and the total use of energy are of interest. Research work has shown that an installed wattage level of as low as $< 10 \text{ W/m}^2$ still can maintain good ergonomics light quality.

Glare is caused by large differences in light levels within the visual field. The eyes try to adapt to these large differences and visual fatigue and discomfort may result. In addition, the computer operator may adopt a poor posture while trying to reduce the glare by changing his or her orientation to the screen. This may result in neck and back pain. There are three types of glare: direct, indirect and masking. Direct glare occurs when there are bright light sources directly in the operator's field of view. Windows are often a source of direct glare. Indirect glare occurs when light from windows or overhead lighting is reflected off shiny surfaces in the field of view, such as terminal screens, desks and other office equipment. Light from sources directly overhead causes masking glare on the screen, partly obscuring what the operator is trying to focus on. Ways of reducing both direct and indirect glare include the use of light-absorbing blinds or curtains. Every workstation should have a task light. Because harsh light spots increase eye strain and fatigue, the lamp needs to have an antiglare screen that does not impede the lamp's ability to deliver a broad area of uniform low glare light across the immediate work surface. The lamp should have an adjustable arm that permits both height and angle adjustments. Lamps can be purchased using halogen, fluorescent, or incandescent bulbs. In general, the halogen lamps allow the user to better focus the light's energy on the work, but the light is harsh and generates more heat. The fluorescent lamp offers the greatest potential for providing the necessary light. Special considerations for the workstations in a new office are that the workstations (desks with monitors) can be pointed in different directions within the same area, and that they can also be placed at different heights. This influences the choice of light fixtures. It can often be difficult to shade ordinary fluorescent lights with lighting turned down to avoid direct glare from occurring at any angle. In this environment it is therefore appropriate to have well-shaped fittings, either turned down with a deep-lying light source or a fitting with 100 percent upturned light. In a good light environment, a combination of these fitting types is recommended. It is also appropriate to use fixtures capable of high-frequency operation, so that light flickers do not arise.

5.2 Sound Level

Ambient sound levels should not be higher than 55 decibels (dBA). Sounds from conversation between colleagues and telephone conversations are the largest cause of disturbances in this type of environment, it is important in both the cases to apply a certain amount of telephone discipline.

Simultaneously, great efforts are made to create an interior design equipped with the prerequisites for a good sound environment. The recommended reverberation time for office space is 0.4 to 0.6 seconds, and one method to manage this is to create many surfaces using sound absorbent material [8].

Examples of this are textiles on the walls and the ceiling, perforated slabs as an esthetic element in the office environment, plant arrangements, and so forth. It is especially important to have curtains in front of glass walls, since glass surfaces have low sound absorbency. The sound of steps is another source of disturbance, and one should consider using floor material with a muffling effect in the passage areas. Another method that has been tried is to use “white noise”, that is, barely detectable music that reduces the worker’s comprehension of what others on the premises are discussing.

5.3 Climate

Temperature and humidity should be within comfortable ranges. A relative humidity level between 40% and 60% is generally desirable for most workers in office environments. Under no circumstances should the temperature and humidity be allowed to vary by an amount greater than 20% over a one hour time period. A positive aspect that has emerged is that large air volumes in these types of premises create the environment for a good indoor climate. A necessity, however, is that all heat-producing devices such as printers and copying machines are placed in their own location, which should be well ventilated so that the heat from these does not have a negative effect on the overall climate. This is also advantageous in noise suppression, since these devices are often very loud.

5.4 Office Layout

The premises that make up the flexible office environment should not be planned so that they become too large when connected. Experience points to a group size of 15 to 18 employees per workstation, area of approximately 200 to 250 m² (2.150 to 2.700 ft²) as being appropriate [5]. Within an area of this size one can still feel certain closeness and have a good general overview. It must be emphasized that several factors affect floor space accessibility per workstation or individual. Different businesses have different requirements, and other out-of-office activities affects this. An analysis of business processes should be the basis for the planning of floor space utilization, and therefore one generally cannot determine a specific number of square meters (feet) per person. The design of the workstation is

especially vital in a flexible office, where the adjustment of furniture to suit multiple users must be accomplished in a simple way. For instance, adjusting table heights must be extremely easy to accomplish.

5.5 Telephone Work

Increasingly, workers are required to use a keyboard while on the telephone. This often results in awkward head, neck and back postures with the receiver cradled between the shoulder and head to leave both hands free. Workers required to use a computer while on the telephone for long periods tend to experience discomfort, particularly in the head and back. In such cases, headsets should be used. Hands-free phones are also an option, where the office space and task are appropriate.

5.6 Personal

The office environment should be comfortable to the person utilizing the office. By comfortable, we mean mentally as well as physically. Pictures, plants, knick-knacks, etc., all have an important role to play in a proper work environment. An office worker’s potential to obtain an ergonomic injury is affected by their attitude toward their job and their surroundings [17]. Pictures reflect light. Watering plants near electrical outlets or devices is unsafe.

However, it is a good thing that needs to be managed with both individual and group safety as the ultimate arbitrator. Office workers should be encouraged to take rest / exercise / change of task breaks. A common recommendation is 2 to 3 minutes off every 30 minutes. Keep in mind that sitting in a chair is a repetitive task.



Fig. 5 Modern workstation designs [23].

6. STANDARDS AND GUIDELINES IN THE OFFICE ERGONOMICS DOMAIN

Standardization plays an important role in the field of ergonomics, as it is an important channel to bring knowledge of ergonomics and human factors to industry. There is a difference between technical standards that must deal with a dynamic technical development and ergonomic standards that are based on human abilities and limitations, factors that are more constant over time. Among standards regarding the aspects of ergonomics in an office environment, ISO 9241 and ANSI/HFS 100-1988 could be referred. Standards and guidelines are useful, but there are limitations. They are helpful in making designers and technicians aware of the ergonomic and human factors aspects of product design and in providing support in solving ergonomic requirements established in the process. While the workstations described above the recommended adjustable mounting hardware are designed to address the average range of workers, with some modification the suggested workstation designs can provide a satisfactory workspace environment for the 5% female to 95% male range of seated office workers. Addressing the average male to 95% male range of office workers who are typically 68.3" (173cm) to 72.8" (185cm) tall and who have 48.6" (123cm) to 52.1" (132cm) sitting eye heights [18]. Addressing the average Range of operator's workstation design provides an optimum ergonomic computer work environment for a minimum of 50% and perhaps up to 60% of all workers in a typical office at an extremely low cost [19]. Design a sit/stand workstation for employees who require this type of work environment. Anthropometric Data can be used; to design a sit/stand workstation to address the average range of female to male operators requires a vertical adjustment range of 20" (508mm). To address the 5% female to 95% range of operators requires a vertical adjustment range of 27.8" (706mm). However, standards and guidelines are by nature relatively limited and general. This gives a wide range for interpretation, and designers must use their own judgment, based on previous experience, when addressing ergonomic principles in a given design task [19].

7. CONCLUSIONS

Flexible office (i.e. offices where people, employees, and consultants work sporadically) and flexible workstation (a place a worker occupies when performing a job) will increase in number from the year 2020 onwards. Mobility of

the labor market, less rigid terms of employment, and work carried away from the office in different forms will create such demands for changed office design and changed working methods that the traditional office structure of today will no longer be able to compete. From an ergonomic point of view, this puts demands on development of new furnishing systems. The furniture produced in recent years and used in flexible office today is not sufficiently well developed for future needs, either in terms of function or quality. Future Systems illustrates a sit/stand workstation that can be designed as a free standing system or integrated into an office cubicle or other office or call center work environment. This system features a 20" (508 mm) vertical lift system which has the capacity to lift a work surface, monitor mount and keyboard mount designed as an integrated unit and can be dynamically adjusted to address the entire range of average sit/stand workers. Reductions in weight and size of computer display equipment, along with advances in lift technology will allow creation of optimized office computer work environments that are substantially lower in cost and easier to set up in the future. These advances will create a new era of office ergonomics that will provide significant health and cost benefits to computer users who work anywhere from homes, schools, and clinics to the largest of corporations (offices). The development of the flexible work and flexible workstation will be accentuated during the coming years and it is therefore of great importance that this line of development is allowed to take place based on ergonomic knowledge and principles.

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OPTIMIZATION OF SUPPLY CHAIN INVENTORY FROM CUSTOMER SERVICE LEVEL PERSPECTIVE

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This research aims to find out an optimal inventory policy for a multi echelon supply chain. Interactive multi-echelon inventory management model is a complex one that associates integration of the trading partners. This integration requires real time sharing of inventory related data so that replenishment policy can be set for all the echelons involved. This approach reduces the bullwhip effect along with minimize the total supply chain cost, through trade off between responsiveness and efficiency. Heuristics give a better result for this type of optimization problems. This paper tries to develop a generalized heuristics in order up to level for a DRC (Distributor, retailer and customer) network. A periodic review base stock policy is used in the development of the mathematical model. Heuristics applied on the inventory parameters for the generation of optimal solution sets. The set which meet target service level are selected as the optimal one and the associated cost for the set is tested against known one.

Key words: Multi echelon inventory, bullwhip effect, optimal inventory, order up to level, base stock policy.

1. INTRODUCTION

The control and maintenance of inventory is a problem common to all organizations in any sector of the economy. The problems of inventory do not confine themselves to profit making institutions but likewise are encountered by social and nonprofit institutions. Inventories are common to farms, manufacturers, wholesalers, retailers, hospitals, churches, prisons, zoos, universities, and national, state, and local governments. Indeed, inventories are also relevant to the family unit in relation to food, clothing, medicines, toiletries, and so forth.

1.1 Significance of the study

Inventory is very important because it helps the company respond quickly to customer demand, which is an important element of competitive strategy. It also represents one of the largest controllable resources in many companies.

Therefore, inventories of finished goods (that is, independent-demand inventories) of the correct items, within a reasonable distance of points of demand, play an important role in a company's ability to compete in a market for standardized

products. So we are going to conduct a thesis on inventory control of finished goods in a particular pharmaceutical industry with some objectives.

2. LITERATURE REVIEW

Inventory is a detailed list of those movable items which are necessary to manufacture a product and to maintain the equipment and machinery in good working order. The quantity and the value of every item is also mentioned in the list. [3]

Inventory is the stock of any item or resource used in an organization.

Inventory is actually money kept in the store room.

2.1 The purpose of inventory

In a just-in-time manufacturing environment, inventory is considered as waste. However, in environments where an organization suffers from poor cash flow or lacks strong control over (i) electronic information transfer among all departments and all significant suppliers, (ii) lead times, and (iii) quality of materials received, inventory plays important roles. Some of the more important reasons for obtaining and holding inventory are: [5]

- **Predictability:** In order to engage in capacity planning and production scheduling, we need to control how much raw material, parts, and subassemblies we process at a given time. Inventory buffers what we need from what we process.

- **Fluctuations in demand:** A supply of inventory on hand is protection: we don't always know how much we are likely to need at any given time, but we still need to satisfy customer or production demand on time. If we can see how customers are acting in the supply chain, surprises in fluctuation in demand are held to a minimum.

- **Unreliability of supply:** Inventory protects us from unreliable suppliers or when an item is scarce and it is difficult to ensure a steady supply. Whenever possible unreliable suppliers should be rehabilitated through discussions or they should be replaced. Rehabilitation can be accomplished through master purchase orders with timed product releases, price or term penalties for nonperformance, better verbal and electronic communications between the parties, etc. This will result in a lowering of your on-hand inventory needs.

- **Price protection:** Buying quantities of inventory at appropriate times helps avoid the impact of cost inflation. Note that contracting to assure a price does not require actually taking delivery at the time of purchase.

- **Quantity discounts:** Often bulk discounts are available if we buy in large rather than in small quantities.

- **Lower ordering costs:** If we buy a larger quantity of an item less frequently, the ordering costs are less than buying smaller quantities over and over again (The costs of holding the item for a longer period of time, however, will be greater). In order to hold down ordering costs and to lock in favorable pricing, many organizations issue blanket purchase orders coupled with periodic release and receiving dates of the SKUs called for. [5]

2.2 Functions of inventories

1. Separate different operations from one another and make them independent, so that each operation (starting from raw material to finished product) can be performed economically.
2. Maintain smooth and efficient production flow.
3. Purchase in desired quantities and thus nullify the effects of changes in prices or supply.
4. Keeps a process continuously operating.
5. Create motivational effect. A person tempted to purchase more if inventories are displayed in bulk. [3]

2.3 Types of inventory

Raw material inventories:

They include raw materials and semi finished products supplied from another firm and which are raw items for the present industry.

In-process inventories:

They are semi-finished goods at various stages of manufacturing cycle.

Finished inventories:

They are finished goods lying in stock room and waiting dispatch.

Indirect inventories:

They include lubricants and other items like spare parts needed for proper operation, repair and maintenance during manufacturing cycle.

2.4 Inventory cost

Holding cost:

This includes the cost for storages facilities, handling cost, insurance cost, breakage cost, depreciation cost, taxes and opportunity cost of capital. High holding costs tend to favor low inventory levels and frequent replenishment.

Set up cost:

To make each different product involves obtaining the necessary materials, arranging specific equipment setup, filling out the require papers, appropriately charging time and materials, and moving out the previous stock of material.

If there were no costs or loss of time in changing from one product to another, many small lots would be produced. This would reduce inventory levels, with a resulting savings in cost.

Ordering cost:

This cost refers to the managerial and clerical costs to prepare the purchase or production order. Ordering cost include all the details such as counting items and calculating item quantities.

Shortage cost:

When the stock of an item is depleted, an order for that item must either wait until the stock is replenished or be canceled. There is a trade-off between the carrying stocks to satisfy the demand and the costs resulting from stock out. This balance is sometimes difficult to obtain, because it may not be possible to estimate lost profits, the effect of lost customers, or lateness penalties. Frequently, the assumed storages cost is little more than a guess, although it is possible to specify a range of such cost. [4]

2.5 Inventory models

Inventory model determines when and how much inventory to carry.

Inventory model handles chiefly two decisions-

1. How much to order at a time;
2. When to order this quantity to minimize total cost;

Simple inventory models assume no delivery delay and that demand is known. [3]

There are two general types of inventory systems for independent demand:

- Fixed order quantity model (also called economic order quantity, EOQ, and Q model)
- Fixed time period models (also referred to variously as the periodic system, periodic review system, fixed order interval system and P model)

The basic distinction is that fixed order quantity models are “event triggered” and fixed time period models are “time triggered”.

The choice of system influenced by

- The fixed time period model has a large average inventory because it must also protect against stock out during the review period, T ; the fixed quantity model has no review period.
- The fixed order quantity model favours more expensive items because average inventory is lower.
- The fixed order quantity model is more appropriate for important items such as critical repair parts because there is closer monitoring and therefore quicker response to potential stockout.
- The fixed order quantity model requires more time to maintain because every addition or withdrawal is logged. [4]

2.6 Fixed-order quantity model with specific service level

A fixed-order quantity system perpetually monitors the inventory level and places a new order when stock reaches some level, R . The danger of stockout in this model occurs only during the lead time, between the time an order is placed and the time it is received.

The amount of safety stock depends on the service level desired. The quantity to be ordered, Q , is calculated in the usual way considering the demand, shortage cost, ordering cost and so forth. A fixed order quantity model can be used to compute Q . The reorder point is then set to cover the expected demand during the lead time plus a safety stock determined by the desired service level. Thus the key difference between a fixed-order quantity model, where demand is known and one where demand is uncertain is in computing the reorder point. The order quantity is the same in both cases. The uncertainty element is taken into account in the safety stock. The reorder point is ^[4]

$$R = \bar{d}L + z\sigma_L$$

z = number of standard deviation for a specific service level.

σ_L = standard deviation of usage during lead time.

$z\sigma_L$ = safety stock.

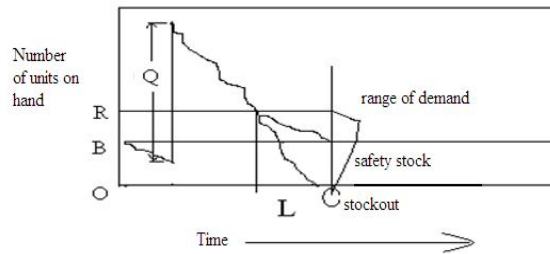


Fig 2.6: Fixed order quantity model [4]

R = Reorder point in units, B = Base stock level, Q = Quantity to be ordered, L = Lead time.

2.7 Fixed time period model with specified service level

In a fixed-time period system, reorders are placed at the time of review (T), and the safety stock that must be reordered is

$$\text{Safety stock} = z\sigma_{(T+L)}$$

Fig shows a fixed time period system with a review cycle of T and a constant lead time of L . In this case, demand is randomly distributed about a mean $\bar{d}$.

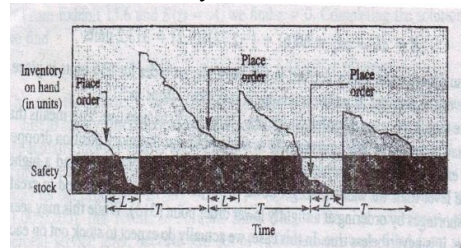


Fig 2.7: Fixed time period inventory model.

The quantity to order, q , is

$$q = \bar{d}(T+L) + z\sigma_{(T+L)} - I$$

Where,

$\bar{d}(T+L)$ = Avg. demand over the review period,

$z\sigma_{(T+L)}$ = Safety stock,

I = Inventory currently on hand (plus on order)

T = The number of days between reviews

L = Lead time in days (time between placing an order and receiving it)

$\bar{d}$ = Forecasted average daily demand

z = Number of standard deviations for a specified service level

$\sigma_{(T+L)}$ = Standard deviation of demand over the review and lead time

I = Current inventory level (includes items on order)

Note: the demand, lead time, review period, and so forth can be any time units such as days, weeks, or years so long as it is consistent throughout the equation.

In this model, demand () can be forecast and revised each review period if desired, or the yearly average may be used if appropriate. We assume that demand is normally distributed.

The value of z can be obtained by solving the following equation for $E(z)$ and reading the corresponding z value from table 1 appendix B: [4]

Where,

$E(z)$ = Expected number units short from a normalized table where $\sigma = 1$

P = Service level desired expressed as a fraction (e.g., satisfying 95% expressed as the fraction .95 of demand from items in stock)

D = Demand during the review period where d is daily demand and T is the number of days
 σ_D = Standard deviation over the review period and lead time. [4]

According to the nature of the selected case we are using fixed time period model with specified service level. Benefit is calculated by using single payment compound amount factor on capital involvement for inventory of finished goods.

OBJECTIVES

The study of inventory optimization in any supply chain is a must. The purpose of this paper is to find out an optimal ordering policy for a cost effective supply chain inventory system that will significantly minimize the total supply chain inventory cost with specific service level. Analytical techniques are used to obtain quantity of demand and safety stock at different stages.

The objectives of the thesis are as follows:

- To construct as echelon serial supply chain inventory model
- To find the appropriate safety stock in for each echelon at target service level.
- To find an appropriate order up to level with specific service level for each echelon.
- To obtain an optimal total cost of inventory for a cost effective supply chain.
- To verify the optimal order set against historical data.

3. METHODOLOGY

3.1. Model Construction

In our model, we consider one manufacturer, one distribution center and retailers shop of three categories (low volume retailers, medium volume retailers and high volume retailers).

We assumed that manufacturer can provide infinite products to the distribution center without any delay. So we identity order up to level and safety stock during lead time for distribution center and retailers stage. The construction of model given below:

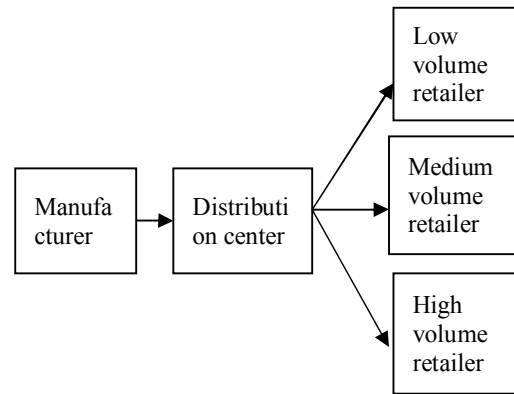


Fig. 3.1 Three echelon supply chain network.

3.2 Notations and Parameters

d_i = Monthly forecasted demand of i^{th} retailer
 L = replenishment Lead time in days
 n = desired average number of review intervals between consecutive replenishment.
 q_i = quantity to be ordered for i^{th} retailer.
 μ = average demand in a unit time interval
 σ = standard deviation of demand in a unit time interval
 $CV = \sigma / \mu$ = Coefficient of variation of demand in a unit time interval
 P_2 = desired value of filled = service level
 Q = Size of a replenishment
 τ = a random variable representing time from when the inventory position hits reorder point until the next review instant.
 $E(\tau)$ = the mean value of τ
 $\text{Var}(\tau)$ = the variance of τ
 I = Current inventory level (includes items on order)
 s = Order up to level
 x = total demand in $\tau + L$
 σ_x = the standard deviation of x
 $K[\]$ = safety factor
 C = average cost per unit purchased
 $H = h * C$ = Holding cost per year
 LVR = low volume retailer
 MVR = medium volume retailer
 HVR = high volume retailer

For retailer stage:

Reorder point at retailer =

$$E(\tau) + L + k \sqrt{[E(\tau) + L](CV)^2 + \text{Var}(\tau)} \cdot \sigma$$

Order up to level $S = s +$

$$n - E(\tau)$$

Quantity to be demand at retailer's stage, $Q_r = S - I$

Total OUL at retailer stage = OUL at LVR + OUL at MVR + OUL at HVR.

Annual cost of inventory = material cost + holding cost + ordering cost.

$$\text{Holding cost per year,} = \left[\sum_{j=1}^n h_{Rj} \times \sum_{j=1}^n q_{Rj} / 2 \right]$$

$$\text{Ordering cost per year,} = \sum_{j=1}^n (D_j / q_{Rj}) \times O_c$$

Annual inventory cost,

$$\sum_{j=1}^n C D_j + \left[\sum_{j=1}^n h_{Rj} \times \sum_{j=1}^n q_{Rj} / 2 \right] + \sum_{j=1}^n (D_j / q_{Rj}) \times O_c$$

Total Cost of Supply Chain Network

$$TC = D_c + \sum_{x=1}^3 R_x$$

Where, TC= Total cost.

D_c= cost of distribution center.

R_x= Cost of retailer shop.

Total supply network cost for service level 96%

4. DATA COLLECTION

4.1 Data Collection:

Data is collected from various retailer shops of cement sellers and distribution centre of specific cement manufacturing company at sylhet zone. These retailer shops are well known at the sylhet zone. We have collected data from 91 retailer shops and 1 distribution center. Data's are shows in appendix C.

4.2 Descriptive Analysis:

A number of variables have been included in the questionnaires in order to describe the sample characteristics. For retailer shop, we divided our data into three categories according to their demand volume.

4.3 Analysis of the Results

In this section, the study and analysis of the results are presented. The study has been conducted in various retailers and a distribution center of Lafarge Surma Cement Ltd. The objective of this case study has been to search for different aspects of inventory control, more specifically their current policy for inventory control of particular finished good, cement.

4.3.1 Inventory System of Retailer Shops:

The retailers shop focus on finish goods inventory. They forecast their demand from previous sales data. They don't follow any scientific method for controlling inventory.. They control inventory of

finished goods by setting target for a month's forecasted demand which is collected from their previous sale experience. For this cause, supply network can't optimize their inventory level and network carry large amount of inventory cost. At retailer level, we divide the retailer demand according to their demand volume. These are:

1. Low volume retailer shop $0 < x < 500$
2. Medium volume retailer shop $500 < x < 1000$
3. High volume retailer shop $x > 1000$

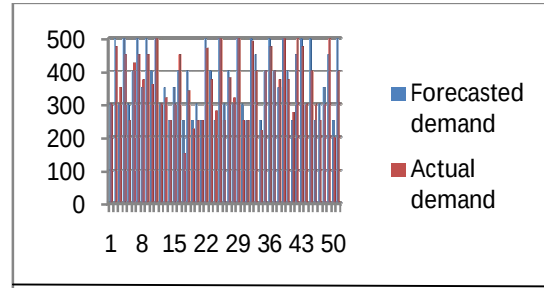


Fig.4.3.1. Actual demand versus forecasted demand at low volume retailers

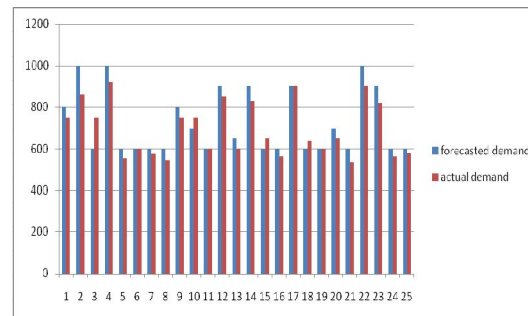


Fig.4.3.2. Actual demand versus forecasted demand at medium volume retailers

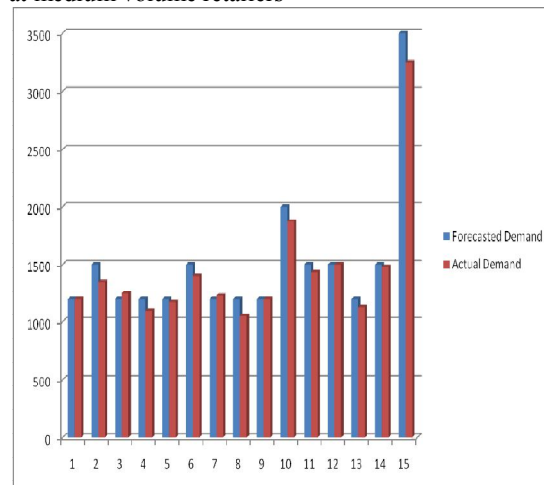


Fig.4.3.3 Actual demand versus forecasted demand at high volume retailers

4.3.2 Inventory System of Distribution Center:

At sylhet zone there is one distribution center for supercrete brand cement named Kibria Complex. These DC has a capacity of 80,000 bags of cement. This inventory is carried to fulfill the retailers demand.

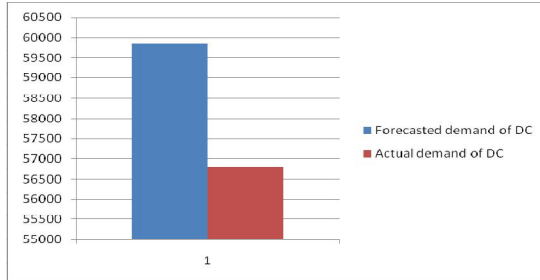


Fig.4.3.4 Forecasted demand vs. actual demand at DC

5. ANALYSIS

5.1 Assumptions:

- Demand for the product is constant and uniform throughout the month.
- The service level is constant (96%) for finished goods.
- Cost per unit of product is constant.
- Raw materials for the product are available for instant supply.
- All production related resources (e.g. equipment, machineries, labor etc.) are available for meeting the demand.
- Transportation facilities are available without any disturbance.

5.2 Calculation of Order Up to Level for Retailer

Calculation of low volume retailer data considering 96% service level.

$$P=0.96$$

$$n = 2$$

$$L=2$$

$$= 76$$

$$\mu=376$$

$$CV = \sigma / \mu = 96/376=0.255$$

From the fractional polynomial approximations in tables 8 and 9, $E(\tau)=0.54202$ and $Var(\tau)=0.0782$

From appendix A

$$\sigma / \mu = \sqrt{(0.54202+2)*(0.255)^2+0.0782}$$

$$=0.4935$$

$$G_u(k) = \frac{(1-P_2)n\mu}{\sigma_X}$$

$$= (1-.96)*2/0.4935$$

$$=0.162$$

$$K[12]=$$

$$s=\{$$

$$E(\tau) + L + k\sqrt{[E(\tau) + L](CV)^2 + Var(\tau)}$$

$$\} * \mu$$

$$=(0.54202+2-0.1325*0.4252)*376 \text{ bags}$$

Calculation of medium volume retailer considering 96% service level.

$$P=0.96$$

$$n = 2$$

$$L=2$$

$$= 76$$

$$\mu=376$$

$$CV = \sigma / \mu = 151/722=0.209$$

From the fractional polynomial approximations in tables 8 and 9, $E(\tau)=0.54202$ and $Var(\tau)=0.0782$

From appendix A

$$\sigma / \mu = \sqrt{(0.54202+2)*(0.209)^2+0.0782}$$

$$=0.4350$$

$$G_u(k) = \frac{(1-P_2)n\mu}{\sigma_X}$$

$$= (1-.96)*2/0.4350$$

$$=0.184$$

$$K[12]=$$

$$s=\{$$

$$E(\tau) + L + k\sqrt{[E(\tau) + L](CV)^2 + Var(\tau)}$$

$$\} * \mu$$

$$=$$

$$= \text{bags}$$

Calculation of high volume retailer considering 96% service level.

$$P=0.96$$

$$n = 2$$

$$L=2$$

$$= 76$$

$$\mu=376$$

$$CV = \sigma / \mu = 574/1507=0.380$$

From the fractional polynomial approximations in tables 8 and 9, $E(\tau)=0.54202$ and $Var(\tau)=0.0782$

From appendix A

$$\sigma / \mu = \sqrt{(0.54202+2)*(0.380)^2+0.0782}$$

$$=0.667$$

$$G_u(k) = \frac{(1-P_2)n\mu}{\sigma_X}$$

$$= (1-.96)*2/0.667$$

$$=0.119$$

$$K[12]=$$

$$s=\{$$

$$E(\tau) + L + k\sqrt{[E(\tau) + L](CV)^2 + \text{Var}(\tau)}$$

$$\} * \mu$$

$$=(0.54202+2-0.1325*4252)*376$$

$$= \text{bags}$$

T-1 order up to level for l of retailer with different lead time considering target service level

Number of period between replenishment n	Reorder point In bags	Order up to level at low volume retailer S= s+	Order up to level at low volume retailer S= s+	Order up to level at low volume retailer S= s+
		$n - E(\tau)$	$n - E(\tau)$	$n - E(\tau)$
2		417	962	1619
3		919	1961	3074
4		1429	2877	5272
5		1884	3689	6758

We found out average on hand inventory (I) for getting order quantity (q) from the 51 LVR, 25 MVR and 15HVR (total **91 retailers**)

Average on hand inventory for low volume retailer shop = 50

Average on hand inventory for medium volume retailer shop = 120

Average on hand inventory for high volume retailer shop = 180

Order quantity (in bags) q = Order up to level – Avg. on hand inventory (I)

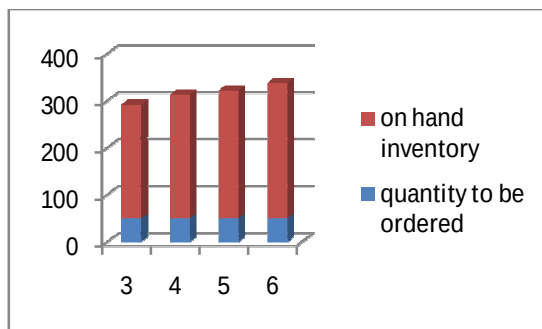


Fig.5.2.1 demand for LVR retailer

Calculation of Retailer Inventory Cost:

Total cost= material cost + ordering cost+ holding cost.

$$\sum_{j=1}^n CD_j + [\sum_{j=1}^n h_{Rj} \times \sum_{j=1}^n q_{Rj} / 2] + \sum_{j=1}^n h_R \times SS_{Rj} + \sum_{j=1}^n$$

Here, C=cost per unit

D= demand of jth retailer per year.

q= quantity to be ordered

S = ordering cost.

SS= safety stock.

Assume,

1track load =300 bags.

Cost per track= 240 tk

For lead time 3 days with service level 96%

Low volume retailer shop inventory cost:

Annual material cost= CD

$$=245*(12*376)$$

$$=1105440$$

Annual holding cost =

$$=(242/2+67)*24.5$$

$$=4606 \text{ TK}$$

Annual ordering cost,

$$\text{Number of order per year}=12*(376/242)$$

$$=19$$

$$\text{Truck load per order}= 242/350=.691=1$$

$$\text{Annual ordering cost}=1*19*240=4560$$

$$\text{Total cost} = 1105440+4606+4560= 1114606\text{tk}$$

Medium volume retailer shop cost:

Annul material cost=CD

$$=245*12*722=2,122,680\text{tk}$$

Annual holding cost =

$$= (405/2+92)*24.5$$

$$=7215 \text{ TK}$$

Annual ordering cost,

$$\text{No of order} =12*(722/405) =22$$

$$\text{Truck loaded per order}= 405/350$$

$$=1.16=2$$

$$\text{Annual ordering cost}= 2*22*240$$

$$=10,560 \text{ tk}$$

$$\text{Total cost} =2122680+7215+10560=2140455\text{tk}$$

High volume retailer shop cost:

$$\text{Annul material cost}= 245*12*1507=4430580\text{tk}$$

Annual holding cost =

$$=(1218/2+493)*24.5$$

$$=26999\text{TK}$$

Annual ordering cost,
 No of order = $12 \times (1507/1218) = 15$
 Truck loaded per order = $1218/350$
 $= 3.48 = 4$
 Annual ordering cost = $4 \times 15 \times 240$
 $= 14400$ tk
 Total Cost = $4430580 + 26999 + 14400 = 4471999$ TK

Total cost with 3 days lead time and target service at retailer stage
 $TC = 1114606 + 2140455 + 4471999 = 7727060$ TK

Total Cost of Supply Chain Network

$$TC = D_c + \sum_{x=1}^3 R_x$$

Where, TC = Total cost.
 D_c = cost of distribution center.
 R_x = Cost of retailer shop.

Total supply network cost for service level 96%
 $= (7727060 + 363580) = 8,090,640$ TK

Table 6 Total supply chain inventory cost with different lead and 96% service level

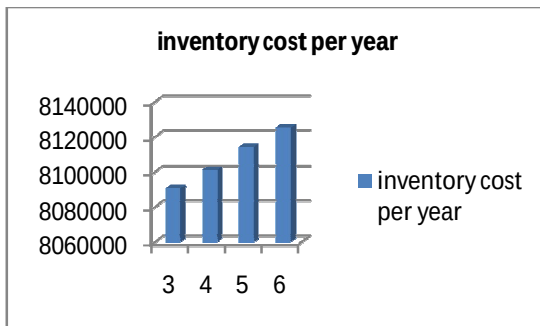


Fig.5.2.2 Total inventory cost per year with lead time considering target service level

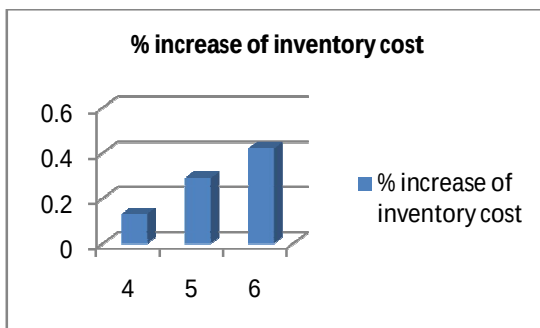


Fig16 change of inventory cost with lead time considering target service level

T -2 Lead time variation and total inventory cost

Number of period between replenishment , n	Inventory cost per year (taka)
2	7720896
3	7756844
4	7802462
5	7834986

6. RESULT, DISCUSSION AND CONCLUSION

6.1 Result:

From the 16, the change of lead time has a effect on changing the rate of inventory cost. If lead time is increase, the inventory holding cost is increase due to large amount of finished goods hold. Figure 16 shows, if lead time increase 1 days, inventory cost increase .13% due to increase of finish good. But if increase lead time from 4 to 5, then inventory cost increase 0.29%. The inventory cost increase sequentially due to holding and ordering cost if lead time is increase. Above the calculation shows inventory cost is optimum to meet the service level, when any chain keeps 4 days lead time.

6.2 Discussion

To optimize inventory at different stages of supply network, first needed coordination with all member of the network. Due to lack of coordination wrong information passes through the network, customer demand is fluctuated because of this wrong information. It s creates bullwhip effect that increase inventory level at supply network. For this reason supply network carry large amount of inventory cost. So, coordination is an important factor for inventory optimizing at supply chain net work. Another important factor is service level. If service level is low customers show dissatisfaction about product and chain can lost the sale of product. But if chain will carrying large amount of inventory cost due to maintain high level of service level then chain can successfully run. So it is necessary to built up a good relation between service level and inventory control

policy. In our thesis we built up a relation between service level and order up to level. It is shown how much of the finished product is needed for the target service level and what is the effect of lead time on inventory cost.

6.3 Limitations:

Due to lack of available resources especially the relevant information, the case study has not reached the perfection level that was expected. The demand distribution is found based on historical data, but no seasonal effect and other abnormal conditions were included. This type of analysis needs de-seasonalized demand data, but it was ignored. The other limitations are as follows:

- It was assumed that manufacturer has ample capacity but it is impossible.
- The manufacturer can instantly back up the distribution center, it is not possible.
- Back order cost is not calculated.

6.4 Scope of future work:

- This model will develop for distributor and multi retailer supply chain inventory optimization.
- This model can be generalized for any other supply chain network.

6.5 Conclusion

In this thesis, only inventory optimization was used as objective and it is proved that inventory level can be significantly minimized by setting up optimal levels at every stage and at the same time a higher level customer service can be maintained. The thesis identified order up to level and safety stock for each stage of network to optimize inventory of the whole chain. Service level is an important parameter for performance measure of any supply chain and it is proved that a high service level target can be ensured by setting appropriate inventory policy.

It is usually optimal for only a few stages to hold inventory and other stages operate as pull systems and hold very little inventory.

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Title: PROBLEMS AND PROSPECTS OF SPECIAL ECONOMIC ZONE IN SYLHET

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ABSTRACT: The present business world has become so much competitive as well as diversified due to huge globalization. In this context, the Special Economic Zone (SEZ) has got potentials as an important and the most appropriate way to improve the economic condition and develop the relationship between neighboring countries. For this reason, it becomes a time demand to carry on a research initiative in this regard. The core objectives of the study include identifying the prospects, possibilities and constraints within the region and also determining the investment and financial viability. Methodology applied for the study includes field survey, case studies, desk interview and reassert, personal interview of key information, focused group discussions, analysis of current scenario of local and industrial trends. The main prospects found are the abundance of huge idle money, availability of raw materials as well as large land areas in Sylhet. The main drawbacks are the lack of sufficient value-added **SEZ** services and infrastructure facilities, inefficient skill and technological inability. So the bottom line may be as -investment or attracting investors is one of the most competitive businesses in the world. Each and every country in the world is looking to attract investors to their shores. Besides foreign direct investment, the proposed Sylhet economic zone will bring in tens of millions of dollars in numerous investments.

Key words: *prospect, constraints, expatriate, investment, employment*

1. INTRODUCTION

It is said that Sylhet, the northeastern metropolitan city, is the 'London of Bangladesh' we know a huge amount of remittance flows in form non-resident Bangladeshis (NRB), whose origin is the greater Sylhet region. From most families, at

least one person lives in Europe, America or in the Middle East. It is natural that their relatives enjoy a better life. Though SEZs have become a buzzword among advocates of Bangladesh economic liberation in recent years, they are not entirely a new concept and are basically modeled on the export

processing zones (EPZ) that came up nearly five decades ago. The government is conducting a feasibility study on the establishment of a special economic zone in Sylhet, eying private capital for the set-up especially from the overseas Bangladeshi nationals. The government has selected Beani bazaar in Sylhet as the most suitable site for creating a special economic zone that could draw substantial private capital, especially from Bangladeshi expatriates. The pioneering SEZ in Sylhet area will be establish on 300 acres of land, which will be linked to international market. Officials at the board of investment (BoI) said that the Sylhet economic zone will be built on the basis of public-private partnership and the government wills development of such zones. It will create opportunities for local entrepreneurs and expatriate Bangladeshis, who have been sending a huge amount foreign Currencies.

2. OBJECTIVES

The study work of the seminar paper has been undertaken with the following objective views include identifying prospects and constraints within the region, availabilities of resources in this region, availabilities of external support required, investment and financial viability, Socio economic background of the region, location advantages regarding international business and other relevant aspects, problems existing in Sylhet about the SEZ, contrast between SEZ and EPZ(Export Processing Zone) and

prove the superiority of SEZ over our economy, some recommendations on how to solve the problems and improve the atmosphere for SEZ for a better and stabilized economy.

3. LITERATURE REVIEW

Bangladesh is developing country. One of the main goal of our government is poverty reduction by the meant of employment generation's achieve the national goal industrialization is one of the key factors. In order to establish economically prospective industries; the government of Bangladesh has a plan to set up **Special Economic Zone** (SEZ). The **SEZ**, the first of its kind in Bangladesh, will be modeled after similar "successful" zones located in China, Vietnam, South Korea, the United Arab Emirates and Jordan.

Bangladesh is expected to establish a **Special Economic Zone** (SEZ) to speed up local and foreign investments in the country. According to the Bangladesh's Board of Investment (BoI) country's former caretaker government approved principles for the creation of a **SEZ**. The office of the former chief advisor was scrutinized the final draft of a proposed "**Special Economic Zone Ordinance-2008**", under which a Special Economic Zone Authority would be established. In Bangladesh, the electronics industry hardly existed before the **SEZ** program was put in place—**SEZs** created

new job opportunities in this sector (Modal 2003).

The BoI official told the FE. Once developed, the proposed Sylhet **Special Economic Zone** will be the first of its kind in Bangladesh. The establishment of such new generation zones may also signal the country's radical shift toward modernizing its zone regime, now subsidized by the government, BoI officials say. Unlike the existing publicly owned and managed export processing zones (**EPZs**), an **SEZ** will be larger in scale and be linked to the domestic market. The Sylhet economic zone will be built on the basis of public-private partnership and the government will no longer finance the development costs of such zones, the officials added. In another development, the BoI is close to finalizing the Bangladesh Economic Zone Policy aiming to allow the establishment of economic zones, which are conceptually different from the traditional industrial zone.

4. METHODOLOGY

Methodology applied for the study includes field survey, case studies, desk interview and reassert, personal interview of key information, focused group discussions, analysis of current scenario of local and industrial trend as well as recent international trade related events and initiatives of SAARC, WTO, ASEAN, etc. SEZ Policy aiming to allow the establishment of economic zones, which are

conceptually different from the traditional industrial parks. As a result to do a research project in this specific sector is not only interesting but also complex and challenging.

The research is based on some documents and also some practical observations. Both primary and secondary data are used in this report. Since SEZ is at the developing phase in Sylhet, study has been performed on the SEZ in Sylhet to generate an idea about their present condition. Survey has also been conducted on the condition of SEZ. The main focus was on the understanding of basic difference between SEZ and EPZ.

5. KEY FINDINGS & ANALYSIS

5.1. FINDINGS OF KEY INFORMANTS INTERVIEWS (KII):

- Road and rail network is in excellent conditions and easy access to country's seaport with insignificant distance. Airport is having direct flight from abroad.
- People are ready to invest if there is **SEZ**. While cautioning about land ownership, people want easy investment to ensure the land ownership.
- Scope of regional integration with Northeast in trade and investment.
- Availability of huge idle money in the bank. And Abundance of natural resources in the region.

- A large number of NRS entrepreneurs living abroad who can be moralized for investment.
- Finally, most respondents emphasized on identification of real stakeholders and entrepreneurs who are capable, solvent and ready to take risk.

5.2. SWOT ANALYSIS

5.2.1. Strengths of such economic zone in Sylhet:

In response to the question on strength of a **special economic zone** in Sylhet, the respondents replied the followings:

- Road and rail infrastructure are in good condition.
- Abundance of idle money.
- Large land area available.
- Raw materials are available.

5.2.2. Weakness of such economic zone in Sylhet:

While inquiring about the weakness, the respondents replied the followings:

- High transportation cost from Sylhet to the principle seaport is a major weakness.
- Lack of urban facilities and amenities discourage official to work in Sylhet.
- Lack of skilled man power. People are having tendency to go abroad but not to work in industry.

5.2.3. Opportunity of such economic zone in Sylhet:

While inquiring about the opportunities, the respondents replied the followings:

- Growing consumers class in Sylhet and neighboring districts.
- Scope of enhancing production of agriculture and non-agriculture outputs.
- Presence of **SUST** and Scope of borrowing its “Research and development” facilities.

5.2.4. Threats for economic zone in Sylhet:

- Confining the **SEZ** only for **NRS** or local Sylheties.
- Lack of government political will and favorable policy to set-up **SEZ** in Sylhet.
- Lack of professional management.

5.3. The entrepreneur willingness to invest in SEZ

	percent
Yes	80%
No	20%
	100%

5.4. Reason behind supporting the

proposed SEZ: The study has revealed the reason supporting the **SEZ** as follows:

Reason	Count	Percent of responses
Industrial employment	218	18.00%
Economic development of the region	195	16.10%
Enhance local income level	161	13.30%
Development of infrastructure	135	11.10%
Greater investment in the region	111	9.20%
Development of linkage	107	8.80%
Skill Enhancement of local workforce	98	8.10%

Development of service industries	95	7.80%
Local Education development	93	7.7.%
Total responses	1213	100.00%

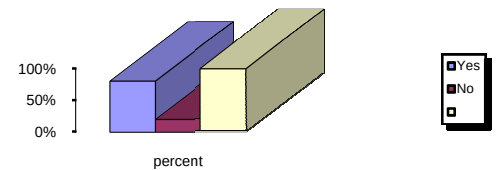


Figure: willingness to invest in SEZ

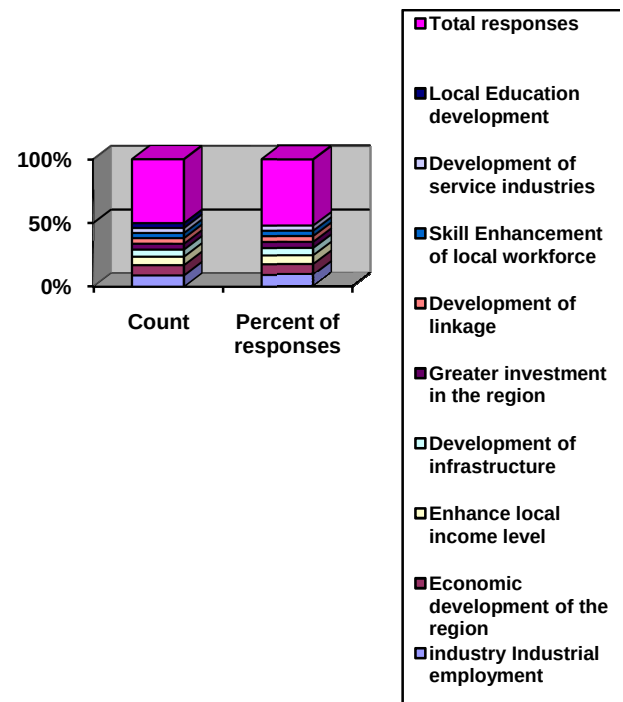


Figure: Percent of Reasons behind supporting SEZ

6. CONCLUSION

We can say that **SEZ** is a complete code of Business life. Here, all of the acceptable ways of business and other financial institutions are mention. These institutions are very much potential.

The main challenge of these industries is to maintain compliance with the **SEZ** principles. A major concern in this connection is the lack of enough trained manpower that has knowledge of **SEZ**. This problem can be solved establishing enough training centers about **SEZ** principles. The **SEZ** will be developed in such a way that it can really cater to the needs of investors. Otherwise, it is sure to face the same fate as **BSCIC**-built industrial estates, many of which are lying unutilized.

Investment or attracting investors is one of the most competitive businesses in the world. Each and every country in the world is looking to attract investors to their shores. It is no different for Sylhet and Bangladesh as it competes with the likes of India, Pakistan, Sri Lanka, Malaysia, Thailand, Vietnam and China. It is imperative for any investments to take place it is important that the right conditions are in place to attract potential investors. So, everyone encourages the Government of Bangladesh, the Sylhet Region and the Board of Investment to continue their work in enhancing Sylhet's infrastructure – roads, rail,

telecommunications and utilities for establishing **special economic zone** in Sylhet.

The upgrading of the airport is a positive step in the right direction. Infrastructure is the responsibility of government and is key to attracting new investors. Countries and regions that have accessible, fast and efficiency transport links will benefit in the long term of Special Economic Zone.

Finally, besides foreign direct investment, officials believe, the proposed Sylhet economic zone will bring in tens of millions of dollars in numerous investments, thereby generating substantial jobs and boosting the local economy.

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PRODUCTION SCHEDULING IN A GARMENTS MANUFACTURING COMPANY: A CASE STUDY

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Scheduling plays an important role in any manufacturing system. It is a core element of value-addition in chain of production system. Optimal Production Schedule plays an important role for minimizing lead time where penalty like as reduction of price, reduction of order quantity, sometimes rejection of whole lot occur for late deliveries. For this reason sometime products of garments' industries are sold in the local market in reduced price, hampering the export, which is a great economical loss of the company. To minimize the total completion time to make production schedule is proposed. Generally garments manufacturing faces a job shop scheduling problem however in reality for mass production this may turns into flow shop scheduling problem. In this study, production scheduling model based upon the Binary Integer Programming (BIP) technique is proposed to solve the flow shop scheduling problem where single operation is done by a single machine (SOSM). The BIP model is implemented by using software (Xpress-MP). This paper compares the results of the existing schedule of a typical Knitwear manufacturing Industry with a proposed schedule and it is found that the proposed schedule is better than the existing schedule.

Key words: Production Scheduling, BIP Model, SOSM, Garments

1. INTRODUCTION

The knitwear manufacturing industry is quite large and important sector in Bangladesh in terms of output, export and employment. The export items are shirt, trousers, jackets, T- shirt, sweaters and others. Uddin and Jahed (2007) informed that the knitwear manufacturing industry has been leading the Bangladesh economy since the early 1990s. Knitwear manufacturing industries are the country's biggest export making up about three quarters of total exports, and the industry is a symbol of the country's dynamism in the world economy. The industry is also the main non-farm formal sector creating employment opportunities for the poor. The greater part of the workforce is female; less educated, and has migrated from rural areas. The main characteristics of international business in this area is its tough competition among

several developing countries, such as China, India, Vietnam, Sri Lanka etc. Apart from this, free trade market opened up a new dimension for a search of other tools for getting upper edges over others. Logically, the main focus for such a search will be concentrated around the optimization of supply chain system.

In the apparel industry, a successful manufacturer must make efficient use of limited resources to meet dynamic customer demand as customer preference change on a seasonal or monthly basis. Production schedule is the key area to meet this demand.

According to Hasin et al (2005), [4] in the context of Bangladesh the garments industry apply a mix of two strategies: First, they try to apply Earliest Due Date (EDD) priority rule, and then they sometimes

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apply “Privileged or Priority Customer” concept. However this concept is old dated for the current competition in the market. Islam et al (2010) mentioned that in most cases the garments’ industries are doing their production schedule based on general knowledge without taking advantages of available modern techniques.

To develop this most export oriented field, an advanced scheduling technique, which may perform much better under this aspects, is needed. The general problems in the knitwear industry are considered and a study is carried out to propose a schedule to meet their challenges.

2. PROBLEM STATEMENT

Green Life Clothing Lt. is a typical knitwear manufacturing company. It is a renowned, well equipped and one of the most modern 100% export oriented Knit Garments project in Bangladesh. This Factory is BSCI approved factory and it is in a process of “WRAP” certificate. The factory is equipped with most modern machinery, having production capacity of 22,000 pieces Garments per day. This factory manufactures two types of cloth as basic T-shirt & Polo Shirt. Annual Production Capacity is 4.68 Million. Moreover, this factory is capable to manufacture T-Shirt, Polo Shirt, Tank Top, Singlet, Ladies Shorts, Pajama Set, Hooded Sweat Shirt, All Kind of Lingerie Items, Boxer Shorts, Trousers and all kinds of Knitted Children Wear (Moniruzzaman (2010)).

Various problems are an impartial phenomenon in the knitwear industry of Bangladesh. Like others, there are also some problems in the green life clothing limited even though they have highly positive response from the workers. Sewing section is a dominating one to control the efficiency of this factory but scheduling problem in this section is very visible. They meet their customers demand with very simple assembly line production. They have no specified time table for performing sewing operation. It creates bottle neck in this section because if an operation is completed to go next operation but find it busy. If they have a specified schedule to perform sewing operation, the production would not be delayed. It will be capable to earn time and can manufacture more quantities and capacity utilization will be higher.

The objectives of this study is to generate a schedule, for the sewing section of the mentioned factory, which will minimize the total completion time to make a T-Shirt in the sewing section and to

determine the starting and ending time of each operation.

3. MODEL FORMULATION

For definition purpose flow shop scheduling system is appropriate for manufacturing all types of T-shirt at their present system. To formulate this scheduling problem model Binary Integer Programming (BIP) is used. In this model assigning the machines is ignored but precedence relationship of operation of job is considered. This model contains of two parts like as objective function and system constraints.

Mathematical model is presented to minimize the total completion time in the single operation by a single machine (SOSM) scheduling.

The set of tasks = $\{1 \dots N\}$ where N is the fictitious end task.

Let, DUR_i be the duration of task i (the sewing time of a single part for making a T-shirt). To establish the precedence relationships between tasks, Precedence graph $G = (TASKS, ARCS)$ where $ARCS$ stands for the set of arcs (an arc (i, j) symbolizes that task i precedes task j) is used.

Variables are introduced as $START_i$ to represent the earliest start time of tasks i . The only constraint, that is used, is the precedence relationship. A task j may only start if all of its predecessors have finished, which translates into constraints. if there is an arc between i and j , then the completion time of i ($START_i + DUR_i$) must not be larger than the start time of j .

$ARCS: START_i + DUR_i \leq START_j$

The objective is to minimize the completion time to make a T-shirt that is the start time of the last, fictitious task N .

Objective Function: Minimize $START_N$

subject to

$ARCS: START_i + DUR_i \leq START_j$

$TASKS: START_i \geq 0$

3.1 Model Execution for Existing Schedule

The existing operations and their durations are provided in Table 1.

A computer program for the the existing schedule is written using the Binary Integer Programming technique. Xpress-MP student version software is used to run the program.

Table 1: Existing operations and their durations

Sl No.	Name of the Operations	Sewing time (Sec)
1	Shoulder Joining	15
2	Rib Tug	12
3	Neck Joining	17
4	Neck Piping	24
5	Size level attaching	18
6	Shoulder to Shoulder back Top stitching	18
7	Main Label	32
8	Sleeve Joining	36
9	Side joining	40
10	Body hem	20
11	Sleeve hem	20

The written computer program which is used is given here:

```

model "Scheduling to make a T-Shirt"
uses "mmxprs"
declarations
N = 12 ! Number of tasks in the project! (last =
fictitious end task)
TASKS=1..N
ARC: array(range,range) of real ! Matrix of the
adjacency graph
DUR: array(TASKS) of real ! Duration of tasks
start: array(TASKS) of mpvar ! Start times of the
tasks
end-declarations
initializations from 'existing.dat'
ARC: DUR
end-initializations
! Precedence relations between tasks
forall (i,j in TASKS | ARC(i,j)=1)
start(i) + DUR(i) <= start(j)

! Solve the first problem: minimize the total
duration
minimize(start(N))
end-model

```

After running the program it is found that the cycle time for existing system is 252 second.

3.2 Model Execution for Proposed Schedule

It is observed that some of the elements can be done in parallel without hampering the main production line. According to that observation the work elements are restructured. The operations times for each element are shown in table 2. The

operations times for the elements, which are done in parallel, are shown as 0.

Table 2: Proposed operations, their durations and their precedence relationship

Sl	Name of the Operations	Sewing time (Sec)	Predecessor
1	Shoulder Joining	15	None
2	Rib Tug	12	None
3	Neck Joining	17	1,2
4	Neck Piping	24	3
5	Size level attaching	0	None
6	Shoulder to Shoulder back Top stitching	18	4,5
7	Sleeve side stitching	32	None
8	Sleeve Joining	36	6,7
9	Main level attaching	0	None
10	Side joining	40	8,9
11	Body hem	20	10
12	Sleeve hem	20	11

A computer program for the the existing schedule is written using the Binary Integer Programming technique. Xpress-MP student version software is used to run the program. The written computer program which is used is given here:

```

model "To make a T-Shirt"
uses "mmxprs"
declarations
N = 13 ! Number of tasks in the project! (last =
fictitious end task)
TASKS=1..N
ARC: array(range,range) of real ! Matrix of the
adjacency graph
DUR: array(TASKS) of real ! Duration of tasks
start: array(TASKS) of mpvar ! Start times of the
tasks
end-declarations
initializations from 'proposed.dat'
ARC: DUR
end-initializations
! Precedence relations between tasks
forall (i,j in TASKS | ARC(i,j)=1) start(i) + DUR(i)
<= start(j)

```

```
! Solve the first problem: minimize the total
duration
minimize(start(N))
end-model
```

After running the program it is found that the cycle time for proposed system is 190 second.

4. RESULT

The completion time of the existing schedule based on the assignment of task is 252 second. where as the proposed schedule requires 190 second to complete the jobs. This result shows that the proper production schedule can save their time and can meet the demand relatively quickly.

5. CONCLUSION

Now a day, it is a great challenge for the knitwear manufacturing Industry of Bangladesh to deliver shipment to buyer on due date meeting varieties risks. As knitwear manufacturing Industry is mostly based on the human performance and little chance to develop the technical aspect. For this reason time is the major constraint to utilize the workforce with limited resource. This problem may be alleviated by using a better schedule. In this sense the Binary Integer Programming (BIP) model is noble idea and implementation of this model by using computer software is satisfactory. In this case study existing schedule is studied and a schedule is proposed. The essence of this study is recommended that this approach is working well for the Green Life Clothing Limited and should implement at their factory and may be suggested to other knitwear manufacturing industries of Bangladesh.

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Productivity improvement through cellular manufacturing in RMG: BANGLADESH PERSPECTIVE

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Shorter product life-cycles, unpredictable demand, and customized products have forced manufacturing firms to operate more efficiently and effectively in order to adapt to changing requirements. There are seven wastages in RMG industry. For removing seven wastages different lean tools are used. Cellular manufacturing which is considered as a lean tool is widely used in RMG. Cellular manufacturing, which incorporates the flexibility of job shops and the high production rate of flow lines, has been seen as a promising alternative for such cases. Here existing framework of traditional layout, different graphs of traditional layout & cellular layout is discussed & productivity can be improved by cellular manufacturing is also shown. For establishing cellular layout some recommendation also included.

Key words: seven wastages; cellular manufacturing; traditional layout; productivity improvement; value analysis.

1. INTRODUCTION

Lean Manufacturing is an operational strategy oriented toward achieving the shortest possible cycle time by eliminating waste. It is derived from the Toyota Production System and its key thrust is to increase the value-added work by eliminating waste and reducing incidental work. The technique often decreases the time between a customer order and shipment, and it is designed to radically improve profitability, customer satisfaction, throughput time, and employee morale. The benefits generally are lower costs, higher quality, and shorter lead times. The term "lean manufacturing" is coined to represent half the human effort in the company, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new

product in half the time. The characteristics of lean processes are: Single-piece production, Repetitive order characteristics, just-In-Time materials/pull scheduling, Short cycle times, Quick changeover, Continuous flow work cells, Collocated machines, equipment, tools and people, Compressed space, Multi-skilled employees, Flexible workforce, Empowered employees, High first-pass yields with major reductions in defects [ref: 1]

2. Literature Review

2.1 Overproduction: Production more than is needed, faster than needed or before needed. The results of overproduction are; Products being produced in excess of what's required, Products being made too early, Excess inventory carrying

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costs[Ref:2] Example: Units which were produced in anticipation of future demand are often scrapped due to configuration changes [ref.3]



2.2 Waiting: Idle time that occurs when codependent events are not fully synchronized. Also known as queuing, waiting refers to the periods of inactivity in a downstream process that occur because an upstream activity does not deliver on time. Idle downstream resources are then often used in activities that either don't add value or result in overproduction. [Ref: 2]



2.3 Transportation: This is unnecessary motion or movement of materials, such as work-in-process (WIP) is being transported from one operation to another. Ideally transport should be minimized for two reasons: It adds time to the process during which no value-added activity is being performed, handling damage could be incurred. [Ref: 2]



2.4 Extra Processing: This term refers to extra operations, such as rework, reprocessing, handling or storage that occurs because of defects, overproduction or excess inventory. [Ref: 2]
Example: Time spent manufacturing product features which are transparent to the customers or which the customer would be unwilling to pay for. [ref.3]



2.5 Inventory: This refers to inventory that is not directly required to fulfill current Customer orders. Inventory includes raw materials, work-in-process and finished goods. Inventory all requires additional handling and space. [Ref: 2] Examples: Large lot purchases of raw material which must be stored while production catches up. [ref.3]

2.6 Motion: This term refers to the extra steps taken by employees and equipment to accommodate inefficient process layout, defects, reprocessing, overproduction or excess inventory. Motion takes time and adds no value to the product or service. "To move and add value is called work. To move and not add value is called motion. Motion, then, means moving without working, moving and adding cost". [Ref: 2]

2.7 Defects These are products or services that do not conform to the specification or Customer's expectation, thus causing Customer dissatisfaction. [Ref:2]

3. LEAN MANUFACTURING TOOLS:

3.1 Continuous improvement:'5S' is the name of a workplace organization methodology that uses a list of five Japanese words which are sere, seiton, seiso, seiketsu and shitsuke.

Sorting (Seiri) Eliminate all unnecessary tools, parts, instructions. Go through all tools, materials, etc., in the plant and work area. Keep only essential items & eliminate what is not required, prioritise things as per requirements and keep them in approachable place & everything else is stored or discarded. [Ref.4]

Straightening (Seiton): There should be a place for everything and everything should be in its place. The place for each item should be clearly labeled or demarcated. [Ref.4]

Sweeping or Systematic Cleaning (Seiso): Keep the workplace tidy and organized. At the end of each shift, clean the work area and be sure everything is restored to its place.

Standardizing (Seiketsu): Work practices should be consistent and standardized. Everyone should know exactly what his or her responsibilities are for adhering to the first 3 S's. [Ref.4]

Sustaining the discipline Or Self Discipline (Shitsuke): Maintain and review standards. Once the previous 4 S's have been established, they become the new way to operate. Maintain focus on this new way and do not allow a gradual decline back to the old ways. While thinking **about the** new way, also be thinking about yet better ways. When an issue arises such as a suggested improvement, a new way of working, a new tool or

a new output requirement, review the first 4 S's and make changes as appropriate. [Ref.4]

3.2 Just-in-time (JIT): This is defined in the APICS dictionary as “a philosophy of manufacturing based on planned elimination of all waste and on continuous improvement of productivity”. It also has been described as an approach with the objective of producing the right part in the right place at the right time (in other words, “just in time”). Waste results from any activity that adds cost without adding value, such as the unnecessary moving of materials, the accumulation of excess inventory, or the use of faulty production methods that create products requiring subsequent rework.

3.3 Kanban Production Control System: A kanban or “pull” production control system uses simple, visual signals to control the movement of materials between work centers as well as the production of new materials to replenish those sent downstream to the next work center. Originally, the name kanban (translated as “signboard” or “visible record”) referred to a Japanese shop sign that communicated the type of product sold at the shop through the visual image on the sign (for example, using circles of various colors to indicate a shop that sells paint). As implemented in the Toyota Production System, a kanban is a card that is attached to a storage and transport container. It identifies the part number and container capacity, along with other information, and is used to provide an easily understood, visual signal that a specific activity is required. [ref.5]

3.4 Push vs pull: A kanban system is referred to as a pull-system, because the kanban is used to pull parts to the next production stage only when they are needed. In contrast, an MRP system (or any schedule-based system) is a push system, in which a detailed production schedule for each part is used to push parts to the next production stage when scheduled. Thus, in a pull system, material movement occurs only when the work station needing more material asks for it to be sent, while in a push system the station producing the material initiates its movement to the receiving station, assuming that it is needed because it was scheduled for production. The weakness of a push system (MRP) is that customer demand must be forecast and production lead times must be estimated. Bad guesses (forecasts or estimates) result in excess inventory and the longer the lead time, the more room for error. The weakness of a pull system (kanban) is that following the JIT production philosophy is essential, especially concerning the

elements of short setup times and small lot sizes, because each station in the process must be able to respond quickly to requests for more materials. [ref.5]

3.5 Design for manufacturability (DFM): DFM leads to low manufacturing cost without sacrificing product quality.

3.6 Cellular Manufacturing (CM): refers to a manufacturing system wherein the equipment and workstations are arranged in an efficient sequence that allows a continuous and smooth movement of inventories and materials to produce products from start to finish in a single process flow, while incurring minimal transport or waiting time, or any delay for that matter. [ref.8]

4. CELLULAR LAYOUT:

Productivity is improved by cellular manufacturing which is given below:

4.1. A cell consists of the people and the machines or workstations required for performing the steps in a process or process segment, with the machines arranged in the processing sequence.

4.2. Arranging people and equipment into cells helps companies achieve two important goals of lean manufacturing one-piece flow and high-variety production

One Piece Flow: One-piece flow is the state that exists when products move through a process one unit at a time, at a rate determined by the needs of the customer. The goals of one-piece flow are to make one part at a time all the time, without unplanned interruptions, and to achieve this without lengthy queue times.

High-Variety Production: Given the fact that customers expect variety and customization, as well as specific quantities delivered at a specific time, it is necessary to remain flexible enough to serve their needs. Cellular manufacturing offers companies the flexibility to give customers the variety they want. It does this by grouping similar products into families that can be processed on the same equipment in the same sequence. It also encourages companies to shorten the time required for changeover between products.

4.3. Converting a factory to cellular manufacturing means eliminating waste from processes as well as from operations.

4.4 Cellular manufacturing can help make your company more competitive by cutting out costly transport and delay, shortening the production lead time, saving factory space that can be used for other value-adding purposes, and promoting continuous improvement by forcing the company to address problems that block low-inventory production.

4.5 Cellular manufacturing helps employees by strengthening the company's competitiveness, which helps support job security. It also makes daily production work go smoother by removing the clutter of WIP inventory, reducing transport and handling, reducing the walking required and addressing causes of defects and machine problems

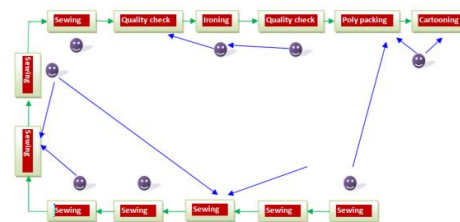
5. WHY CELLULAR MANUFACTURING IN RMG SECTOR OF BANGLADESH

Job shops are designed to achieve maximum flexibility such that a wide variety of products with small lot sizes can be manufactured. Products manufactured in job shops usually require different operations and have different operation sequences. Operating time for each operation could vary significantly. Therefore, to make processing more economical, parts are moved in batches. Each part in a batch must wait for the remaining parts in its batch to complete processing before it is moved to the next stage. This leads to longer production times, high levels of in-process inventory, high production costs and low production rates. [ref.11] In contrast to **job shop**, **cellular** manufacturing has U-shaped cell for which change over time is very easy according to product variety. For that reasons product variety can be meet very easily. Here teamwork is available and that's why if anyone are unable to fill his target another person help him to fill her/his target.

6.NECESSITY OF CELLULAR LAYOUT IN RMG SECTOR:

- 1. Reduce production wastages:** utilizing the different method for producing finished goods which reduces 7 wastages.
- 2. Establish strong layout:** This layout is made in such a way so that workstations are close to one another.
- 3. Appropriate controlling the line:** in this layout operators & machines are arranged in such a way that supervisor or line leader can easily control the line.
- 4. Direct impact of product quality in line:**

- 1.Every worker are trained to maintain quality for his own work , for that reasons they directly control & enhance the quality.
 - 2.Every worker are concerned by never take a alter from before worker , never produce alter, never give a alter to anyone. That's why there are no quality problem in line.
 - 3.Although some quality problems can arise ,then inform the line supervisor so that he take the action in such a way that never it happen.
- 5. Effective line balancing:**
- 1.The main vision of every worker is that maintaining quality, doing job in a short time & develop teamwork.
 - 2.In this layout working hour of every worker is utilized which is used to establish effective line balancing.



7. METHODOLOGY:

Material Flow: Cells are arranged in relation to each other so that material movement is minimized.

Capital Proximity: Large and/or expensive machines which cannot be easily relocated to cells that use them (Point-of- use).

Assembly Line: The layout of machines within each cell should resemble a small assembly line.

Mobility: Quick positional adjustments should be used to arrange/rearrange the machines within a cell

Layout Proximity: Sequential processes need to be placed side by side.

Unified Management Structure: The productive resources need to answer to the same voice.

Quality Checking: Quality must be checked in every work station which reduces wastes.

Skilled Operator: Skilled operator must be provided to make up the allowances time of other operator as an efficient manner.

Team Work: Team work must be provided for productivity improvement.

Information Shearing: Everyone should be informed about 7 wastes.

Training: Training facilities should be provided.

8.SUPPORTIVE SYSTEM FOR CELLULAR LAYOUT:

8.1.Develop production planning system.

8.2Establish industrial engineering / work study team.

- 8.3** Must be concern about lean culture
- 8.4** Every method must be standard
- 8.5** Appropriate PMTS must be introduced for conducting cellular layout
- 8.6** Different method of lean just like kanban , Supermarket, visual control must be introduced for maintaining a good communication among sewing, cutting & finishing department.
- 8.7** For maintaining quality right & effective method must be introduced.
- 8.8** For improve working environment 5s must be introduced
- 8.9** Enhancing team work
- 8.10** Member of different class of department must have a same goal.
- 8.11** Must avoid spreading scandal among worker & find out the problem & the solution
- 8.12** The member in cellular layout must have team working & leadership tendency.

9. BANGLADESH RMG SECTOR AND CELLULAR MANUFACTURING



9.1 Setup time is reduced. A manufacturing cell is designed to handle parts having similar shapes and relatively similar sizes. For this reason, many of the parts can employ the same or similar holding devices (fixtures). Generic fixtures for the part family can be developed so that time required for changing fixtures and tools is decreased.

9.2 Lot sizes are reduced. Once setup times are greatly reduced in CM, small lots are possible and economical. Small lots also smooth production flow.

9.3 Work-in-process (WIP) and finished goods inventories are reduced with smaller lot sizes and reduced setup times, the amount of WIP can be reduced. Askin and Standridge showed that the WIP can be reduced by 50% when the setup time is cut in half. In addition to reduced setup times and WIP inventory, finished goods inventory is reduced. Instead of make-to-stock systems with parts either being run at long, fixed intervals or random intervals, the parts can be produced either

just-in-time (JIT) in small lots or at fixed, short intervals.

9.4 Material handling costs and time are reduced. In CM, each part is processed completely within a single cell. Thus, part travel time and distance between cells is minimal.

9.5 A reduction in flow time is obtained. Reduced material handling time and reduced setup time greatly reduce flow time.

9.6 Tool requirements are reduced. Parts produced in a cell are of similar shape, size, and composition. Thus, they often have similar tooling requirements.

9.7 A reduction in space required Reductions in WIP, finished goods inventories, and lot sizes lead to less space required.

9.8 Throughput times are reduced. In a job shop, parts are transferred between machines in batches. However, in CM each part is transferred immediately to the next machine after it has been processed. Thus, the waiting time is reduced substantially.

9.9 Product quality is improved. Since parts travel from one station to another as single unit, they are completely processed in a small area. The feedback is immediate and the process can be stopped when things go wrong.

9.10 Better overall control of operations. In a job shop, parts may have to travel through the entire shop. Scheduling and material control are complicated. In CM, the manufacturing facility is broken down into manufacturing cells and each part travels with a single cell, resulting in easier scheduling and control.

9.11. Shorter production cycle times.[8]

9.12. Higher effective manufacturing capacity. [8]

9.13.Improved customer response time. [8]

9.14. Improved team work & communication

9.15. Changeover time is reduced

9.16. Reduced lead time : time required from input to finished good is reduced.

10. CURRENT SCENERY OF TRADITIONLA LAYOUT:



SMO	23
Helper	9
Workstation	32
Tack time	.18
Target pieces	3592
Efficiency	59%
Loss per worker	171.09(min)

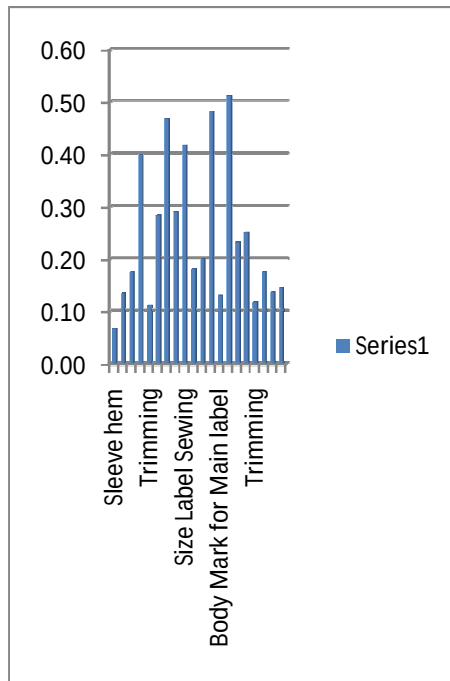


Fig: traditional layout [ref. 12]

11. PRODUCTIVITY IMPROVEMENT BY CELLULAR MANUFACTURING:

SMO	15
Helper	0
Workstation	15
Tack time	.34
Target pieces	1744
Efficiency	72%
Loss per worker	25.05(mins)

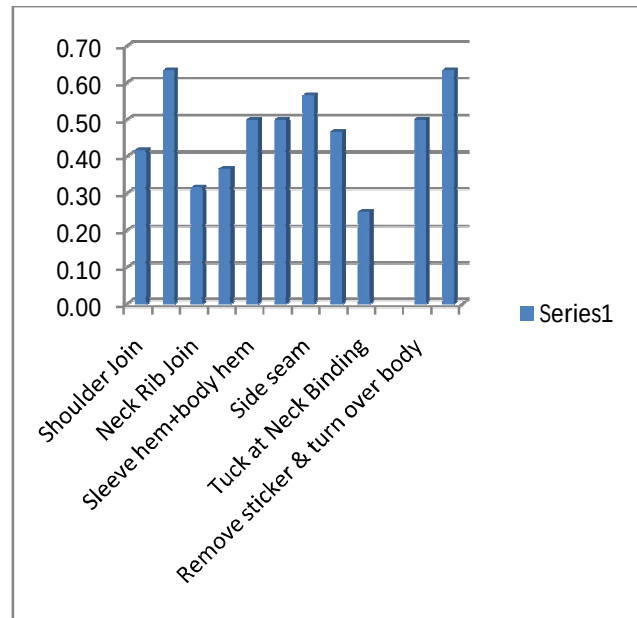


Fig: cellular layout [ref.12]

12. DATA ANALYSIS OR COMPARISON OF TRADITIONAL LAYOUT AND CELLULAR LAYOUT:

11. <http://scholar.lib.vt.edu/theses/available/etd-09132000-14380054/unrestricted/Etd.pdf>
12. interstoff apparels ltd

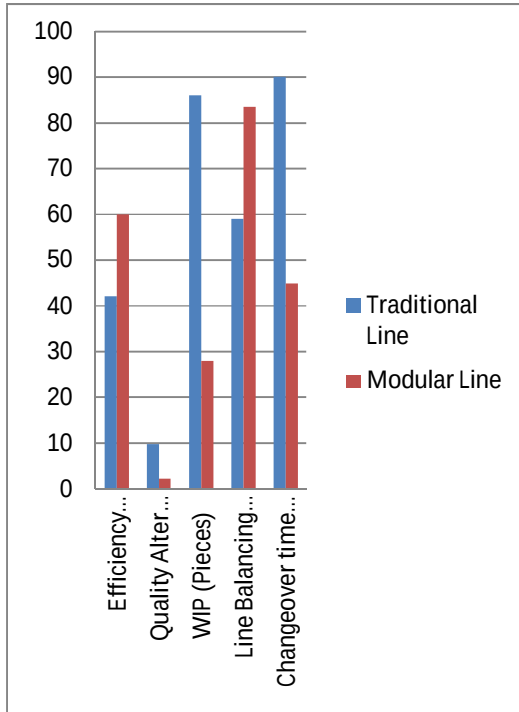


Fig: comparison [ref.12]

13. CONCLUSION :

From the above discussion we can say that cellular layout is very fruitful in competitive market. So for successful implementation of cellular layout company must concern different aspects of cellular layout.

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QFD APPROACH TO STUDY CUSTOMER REQUIREMENTS, CRITICAL SUPPLY CHAIN FACTORS AND A SYSTEM FOR SUPPLY CHAIN PERFORMANCE MEASURE

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In the increasingly competitive markets, effective management of supply chain is a very crucial factor for the better performance of the organization and realization of customer expectation. In the modern era, performance measure has significant role get competitive advantage. This dissertation explores and investigates how Garments Accessories Industries (GAI) use supplies chain management to gain competitive advantage and increase the supply chain factors performance in the customer point of view. This dissertation objective is to determine critical customer requirements and prioritize them to determine the success factors to improve performance. In this paper we also show a system of SCM performance evaluation using transformation matrix called QFD. This paper also shows how to improving customer satisfaction by QFD approach and identify performance gapes from the customer viewpoint in SCM. Actually this dissertation measures and evaluates supply chain performance of manufacturing industry. Findings can be used for selection of GAI supply chain strategies.

Key words: QFD, Supply chain, Performance measure, Critical supply chain factors, Performance gap

1. INTRODUCTION

The comprehension of business processes interactions along supply chain is an important factor to succeed in the fast changing and competitive business arena[21]. In the era of globalization of markets and business process outsourcing, many firms realize the importance of continuous monitoring of their supply chain's performance for its effectiveness and efficiency. It provides the management important feedback to monitor performance, reveal progress, diagnose problems and enhances transparency among the several tiers of the supply chain thus making a phenomenal contribution to decision making particularly in re-designing business goals and strategies and reengineering processes [6]. In this dissertation we show a system of performance evaluation using QFD SPECIALLY for the Garments Accessories industries in Bangladesh.

2. OBJECTIVES

Consolidating the concerns discussed in the previous

section, the objectives of the summarize-

- Determine the critical success factors in supply chain management that can provide competitive advantage.
- Identify supply chain factor performance as well as overall supply chain performance as service perceived by the firm's customers.
- To define a customer-based improvement strategy based on the critical elements identified by surveyed needs and wants of the customer's.

3. LITERATURE REVIEW

Effective supply chain management (SCM) is treated as a key to building a sustainable competitive edge through improved inter-firm and intra-firm relationships (Gunasekaran et al. 2001; Webster 2002). A magnitude of benefits has been attributed to SCM, including increased market share, reduced cost, and

enhanced customer relationship (Ferguson 2000). However, there is evidence to suggest this may be hyperbole rather than organizational reality (Thomas 1999). Additionally, an international study of modern manufacturing practices reported only a moderate perceived effectiveness of SCM (Clegg et al. 2002). Thus, it is critical to develop an effectual measurement system for supply chain performance since it can facilitate a deeper understanding of the supply chain and improve its overall performance (Chen and Paulraj 2004; Sharma and Bhagwat 2007)[13]. Following are some of the discussion about key terms of this dissertation

Critical factors: Critical factors are those few things that must go well to ensure success for a manager or organization, and therefore may represent those managerial or enterprise areas that must be given continual attention. CFs include issues vital to an organization's current operating activities and to its future success (Boynton and Zmud, 1984).

Performance gap: This is a gap between the perceived performance and the expected importance of a factor (in this dissertation it is a supply chain factor). The performance gap provides an indication as to whether executives and managers are successful in translating their vision to their employees and hence such perception may give an indication regarding the degree of employees' alignment with the organization's vision. If a factor is critical and has a negative value of factor alignment (perceived performance is less than the expectation), then the organization may have a potential problem with that factor. Information on factor alignment allows executives to develop a strategy to overcome the challenges associated with the gaps between importance and performance. (Martilla and James, 1977).

Quality Function Deployment (QFD): QFD is a comprehensive quality tool that can be used to uncover customers spoken and unspoken needs, and convert these needs to product or service design targets and processes (Akao, 1990).

Performance measurement in SCM: Performance measurement can provide important feedback information to enable managers to monitor performance, reveal progress, enhance motivation and communication and diagnose problems. In SCM, performance measurement can facilitate inter-understanding and integration among the supply chain members. It also provides insight to reveal the effectiveness of strategies and to identify success and potential opportunities. It makes an indispensable contribution to decision making in SCM, particularly in re-designing business goals and strategies and re-engineering processes. [11]

4. RESEARCH METHODOLOGY

A research methodology has been developed in this section to form and guide the research activity in a structured way in order to carry out the dissertation. The case study has been carried out on Garments Accessories industries (GAI) in Bangladesh. In this dissertation we considered the Garments industry or Garments buying house as a customer of GAI in Bangladesh. We construct our QFD table or house of Quality according to our desired goal of this dissertation.

4.1 The process to construct the QFD table

A QFD relationship table or house of quality was prepared based on the model from Akao, 1990. Refer to Figure -1, below, which shows the structure of the QFD table. [14]:

Step 1: Developing Customer needs 7 importance (refer to steps in Figure A6-1). The column on the left lists the 'WHATs' or customer needs, These customer needs were obtained from the sources of data mentioned earlier in this appendix. In preparing the customer's voice in the QFD table, it is important to distinguish between secondary and primary needs of the customer (Akao, 1990). In many case the customer's need is a secondary item, and the primary need has to be imputed. For example, Ease of Returns was a secondary need, while the Primary need was After Sales Support. Next to the WHAT's column, is the importance column. This state the importance of each customer need with a score of 1 to 5. The information is extracted from Table-1.

Step 2: Developing the How's: The row at the top of Table-1 shows the 'HOWs' or important supply chain factors that would meet customer needs. These factors are the top gaps in supply chain management, from Table -5.

Step 3: Interpretation of the information provided by the completed QFD table: The next step is to interpret the information in the QFD table. This is done by preparing a relationship matrix within the QFD table by identifying the performance gaps which are most crucial in meeting customer needs. The relationship matrix is prepared by indicating the strength of the relationship at each intersection of the customer needs and performance gaps. Refer to Table-1, below. The relationships are given based on the capability of each supply chain factor from the Literature Review and on this researcher's experience. The ratings are as follows: 1 -for very weak relationship, 2- for weak relationship, 3- for medium relationship, 4- for

strong relationship, 5- for extreme relationship, no relationship was given a rating of 0, and left blank. Indicated sign are shown figure by ل, م, ن, و. However, the relationship at each intersection point is insufficient to make a decision on good opportunities for the GAI. Also crucial is the importance score of each customer need. Hence, a weighted scoring for each gap comprising importance and relationship was required.

Step 4: Compute weighted score for each relationship: The weighted score for each relationship or cell is computed by multiplying the relationship score by the importance score. Refer to Figure

Step 5: Select important How's or critical supply chain factors: We identify critical supply chain factor by determining the absolute weight using following equation: $Absolute\ weight = \sum (Each\ customer\ need\ importance\ score \times relationship\ score\ at\ intersection)$. Highest value of absolute weight indicates as the most critical supply chain factor. Finally, the weighted scores are ranked, with the highest score being ranked as number 1, and so on. From the ranked list, it is possible to decide which supply chain factor, or critical gap, is most important to implement the completed QFD table, with the ranked critical supply chain gaps is shown in Table -5, below.

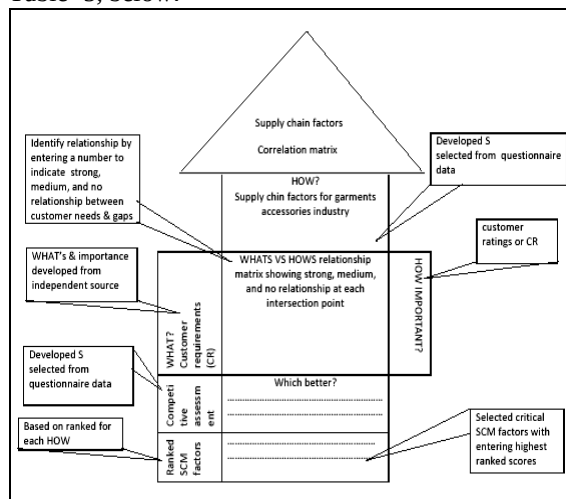


Fig. 1: Model for House of Quality specially developed for this study. Guidelines:[14],[12]

Step6: Develop house for the overall supply chain performance measure: Here we put value of importance and performance data collected from Garment accessories industry as studied firm. In the house importance for row for actual and performance for performance row.

Step 7: Determine the performance gap: we determine the gap by subtract the importance from performance and put this value into the table.

5. DATA COLLECTION & ANALYSIS:

Technique of Data collection: Data collection technique based on research attributes that will be measured and depend on the attributes characteristic. So that, there are some tools that can be used to collect data, e.g.:[4]

- **Focus Group Discussion:** This research used FGD as methodology to do analysis based on focus discussion from some point of view that do really understand about customer requirement toward successive supply chain factor selection to make the supply chain management more efficient and responsive for Garments accessories industries of Bangladesh.
- **Documentation:** This research needed document to get overall condition of supply chain management is it focus on externally or internally in the organization and the performance of the supply chain factors. And we also use this in the transformation matrix. Besides that, documentation is also in physical evidence of activity, such as observation picture, interview, and others that related to research.
- **Observation:** This research used observation to get data about field condition and to assess perception and behavior toward to make the supply chain more competitive than other by evaluation of supply chain performance in GAI Bangladesh.
- **Questionnaire:** This research used questionnaire to assess the requirement of Garments industry and buying house for Garments, performance evaluation for Garments accessories industries in Bangladesh, and make the relationship between supply chain factor and customer requirements.
- **Interview:** This research used interview to know the perception, conception, information, suggestion, and expectation about overall condition of supply chain management of GAI of Bangladesh and performance of this organization.

5.1 Analysis

In the section of data analysis for this research first we developed the matrix for determine the rank of supply factors using absolute weight which is shown in table 1. Our main analysis for this research is under the following fundamental section of SCM figure 2. We analyzed the data which area studied from focused (internal & external) to their supply chain.

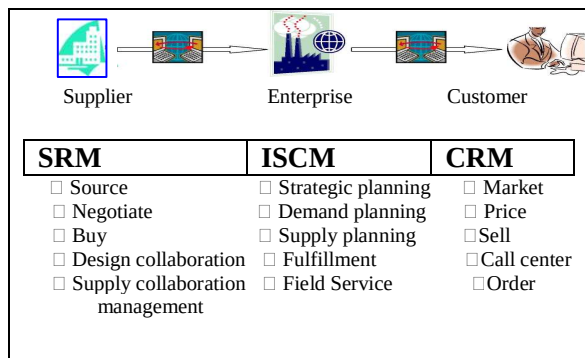


Fig. 2: Three fundamental section of supply chain management. *Guidelines* :[2][3].

We also analyzed the data with respect to style of supply chain focusing area this theory developed by S. Soim(2003). The term **Traditional ‘old style’ manufacturing company** is used to describe a company that focuses its supply chain management activity (that is, considers them more important) on manufacturing-type efforts (including quality), and other activity that occur prior to manufacturing such as supplier management, and procurement. This traditional manufacturing or internal focus is given priority by the company over supply chain activity that looks forward and allows closer connection with customers. Such a company can be termed as Traditional ‘old style’ manufacturing company or an internally focused company. [14]

The term **progressive manufacturing company** is used to describe a company that focuses its supply chain management activity (that is, considers them more important) on customer relationships type activity and information systems that connect with the customers (such as business to business Internet commerce). This external, or customer, focus is given priority by the company over supply chain efforts that look backward into the manufacturing process - these efforts can be construed as the company reaching out to connect and communicate better with customers. Such a company can be termed as a progressive manufacturing company or an externally focused company. [14]

5.2 Supply chain factors Performance:

Supply chain factor Performance for the studied firm ‘MA, RP, MO’ is calculated in terms of quantitative value by dividing the total expected (importance) SCM factors performance level to the total actual SCM factors performance level. Here we followed the following steps to calculate the overall supply chain performance. These steps have been adapted and modified from Arditi and Lee (2003)[17]. Expected (importance) SCM factors performance & actual SCM factors performance is identified from the questionnaires administered to the studied firm ‘MA,

RP, MO’ selected personnel those are related to the dissertation field we concern.

Actual SCM factors performance = final importance weight of each customer requirements X Σ relationship value between WHAT and HOW for the Supply chain factors X actual SCM factors Performance..... (1)

Expected (importance) SCM factors performance = final importance weight of each customer requirements X Σ relationship value between WHAT and HOW for the Supply chain factors X Expected (importance) SCM performance(2)

Total Actual SCM factors performance level = Σ Actual SCM factors performance..... (3)

Total Expected (importance) SCM factors performance = Σ Maximum service performance..... (4)

Supply chain factors Performance = Total Actual SCM factors performance level / Total Expected (importance) SCM factors performance..... (5)

Referring to Figure ‘MA’, ‘RP’ and ‘MO’ which has been adapted from the overall QFD matrix structure (Figure 1) and build three matrix indicated by table 2,3,4. and following steps provided by Arditi and Lee (2003), the Supply chain factors Performance can be calculated by using Equation (5):

Supply Chain Factors Performance of the firm, ‘MA’

= 6240.72 / 11233.32

= 0.555554

= 55.55 %.(calculated from table 2)

Supply Chain Factors Performance of the firm, ‘RP’

= 8673.99/ 10870.07

= 0.797970

= 79.79 %.(calculated from table 3)

Supply Chain Factors Performance of the firm ‘MO’

= 9462.28/ 11240

= 0.8418398

= 84.18 %.(calculated from table 4)

The result from the calculation shows the current quality service performance of the firm ‘MA’ is about 55.55%. ‘MA’ is performing lower than ‘RP’, but greatly lower than ‘MO’. Therefore, it is very critical for the firm ‘MA’ to further improve its Supply chain factors performance to higher level in order to ensure their customers are satisfied, thus provide long term sustainability and growth.

Table 1: QFD matrix for identify critical supply chain factors using absolute weight.

Legend		Relationship symbols:		Logistics management & execution		Procurement & Accounting		Inventory Management		Technology Management		Customer Relationship Management		Lean & Agile practice		Information & Communication Technology		Human Resource Management		Transportation																																																
		=1=(very low) =2=(low) =3=(medium) =4=(high) =5=(very high)																																																																		
Possible requirements	Customer requirement																																																																			
	Q1. Payment practice																																																																			
After sales service	Q2. top management support																																																																			
	Q3. Production capacity																																																																			
Product Quality	Q4. Reputation																																																																			
	Q5. Consistent image																																																																			
ICT	Q6. service warranty period																																																																			
	Q7. Return of unused product																																																																			
Reliable delivery	Q8. response to customer complaint																																																																			
	Q9. Product sample																																																																			
Risk & responsiveness	Q10. Appearance of the product																																																																			
	Q11. Testing of product material																																																																			
Resource price	Q12. trust and confidence																																																																			
	Q13. Product return process																																																																			
	Q14. Online representatives																																																																			
	Q15. Up to date information																																																																			
	Q16. Availability to its customers																																																																			
	Q17. consistency in performance																																																																			
	Q18. On-time delivery																																																																			
	Q19. customers' requirements																																																																			
	Q20. Willingness of Risk sharing																																																																			
	Q21. Safety in loading/unloading																																																																			
	Q22. Incentives																																																																			
	Q23. Competitive product price																																																																			
	Q24. Credit opportunity																																																																			
Absolute weight		56.45	97.85	60.81	29.33	59.51	31.79	50.02	92.69	67.46	21.85	25.47	154.1	113	23	78.38	26	46.05	18	59.95	5	113.9	2	141.1	10	91.95	14	69.75	4	117.6	25	47.74	37	20.95	29	39.12	22	54.62	15	68.25	13	71.96	35	23.2	34	23.56	38	15.57	12	73.69	32	28.17	21	55.44	8	94.23	27	45.16	28	39.73	40	8.13	3	140.3	41	00	39	12.21
Factors Rank		20	7	17	31	19	30	24	9	16	36	33	1	6	23	11	26	18	5	2	10	14	4	25	37	29	22	15	13	35	34	38	34	38	12	32	21	27	28	40	3	41	39																									
Category Rank		6					3					1					5					2					7					4																																				

Table 2: Supply Chain Factors Performance matrix for company, ‘MA’

[illegible]

Table 3: Supply Chain Factors Performance matrix for company, ‘RP’

SCM performance		performance		Risk & Responsiv		ICT		Product Quality		After sales service		Presales requirement		Relationship symbols:		Legend	
PERFORMANCE	IMPORTANCE	PERFORMANCE	IMPORTANCE	PERFORMANCE	IMPORTANCE	PERFORMANCE	IMPORTANCE	PERFORMANCE	IMPORTANCE	PERFORMANCE	IMPORTANCE	PERFORMANCE	IMPORTANCE	PERFORMANCE	IMPORTANCE	PERFORMANCE	IMPORTANCE
282.2	282.2	5	5														
391.4	489.2	5	4														
182.5	304	5	2														
88	146.7	5	3														
59.51	178.6	3	1														
63.98	95.3	3	2														
0	0	0	0														
463.5	463.5	5	5														
337.3	337.3	5	5														
21.85	21.85	1	1														
76.41	101.8	4	3														
616.4	770.5	5	4														
565	565	5	5														
217.88	272.4	5	4														
391.9	391.9	5	5														
230.3	230.3	5	5														
300	300	5	5														
341.7	455.6	4	3														
282.2	564.4	4	2														
183.9	459.8	5	2														
209.2	348.8	5	3														
352.8	588	5	3														
238.7	238.7	5	5														
83.8	104.8	5	4														
195.6	195.6	5	5														
163.9	273.1	5	3														
204.8	341.2	5	3														
0	215.8	3	0														
92.8	116	5	4														
70.5	70.5	3	3														
62.28	62.28	4	4														
221	368.5	5	3														
84.51	140.9	5	3														
110.9	277	5	2														
471.2	471.2	5	5														
225.8	225.8	5	5														
119.2	158.9	4	3														
40.65	40.65	5	5														
140.3	140.3	1	1														
00	00	5	4														
24.42	61.05	5	2														
8673	1087	SUM														8673	1087
99	0.07															99	0.07

Table 4: Supply Chain Factors Performance matrix of the company 'MO'

SCM performance	IMPORTANCE	performance	Relationship symbols:												Logistics management & execution
			Legend												
225.8	282.3	5	4											1. A centrally coordinated logistics function	
293.5	489.2	5	3											2. Provide on-time delivery to customers	
243.2	304.0	5	4											3. Provide logistics at lowest cost	
117.32	146.7	5	4											4. Design from customer's point view	
178.5	238	4	3											5. Information sharing with SC partners	
00	00	0	0											6. supplier involvement in design phase	
00	00	0	0											7. direct cash payment policy	
370.8	463.5	5	4											8. LC based payment policy	
202.4	269.9	4	3											9. Lead time based procurement	
109.3	109.3	5	5											10. Vendor managed inventory at	
127.4	127.4	5	5											11. Lowest inventory driven costs	
770.5	770.5	5	5											12. Effective use of CAD, CAE, & CAM	
339	565	5	3											13. Effective use of ERP systems	
272.4	272.4	5	5											14. Responsiveness to meet change - change	
184.2	230.3	5	4											15. Product customization to meet customer	
391.9	391.9	5	5											16. Outsourced product development	
239.8	299.8	5	4											17. Product design for recycling need	
341.7	569.5	5	3											18. Zero-defect manufacturing	
705.5	705.5	5	5											19. Total Quality Management (TQM)	
489.8	489.8	5	5											20. Statistical Quality Control (SQC)	
348.8	348.8	5	5											21. Monitor risk customer service level	
588	588	5	5											22. Acceptance of customer complaints	
238.7	238.7	5	5											23. A process to manage customer	
104.8	104.8	5	5											24. Multiple system to capture the customer	
117.4	195.6	5	3											25. Cycle times from supplier to customer	
273.1	273.1	5	5											26. Order fill rate to customer	
00	00	0	0											27. Practice on lean manufacturing	
369.8	369.8	5	5											28. Reconfigurable business process	
116	116	5	5											29. Responding to item variable	
117.8	117.8	5	5											30. Responding to demand variable	
31.14	46.8	3	2											31. E- procurement	
368.5	368.5	5	5											32. High Speed data communication	
140.9	140.9	5	5											33. Use of customize software for resource	
277.2	277.2	5	5											34. ECR system via electronic data	
282.7	282.7	3	3											35. Top management commitment	
90.32	135.4	3	2											36. Employees are empowered to make	
119.1	198.7	5	3											37. There is high employee morale	
00	00	0	0											38. designing effective conflict resolution	
24.4	40.7	5	3											39. Employees are trained in SC management	
280.6	701.5	5	2											40. effective method use of transportation	
00	00	0	0											41. IT based transportation route select	
9462.	112.40		SUM											IMPORTANT WEIGHT	
28															

Table 5: Competitive performance at each Garments accessories industry

SCM CATEGORIES	SCM factors	Company MA			Rank of categories	Company RP			Rank of categories	Company MO			Rank of categories
		importance	performance	gap		importance	performance	gap		importance	performance	gap	
Logistics management & execution	1. A centrally coordinated logistics function	3	2	1		5	5	0		5	4	1	
	2. Provide on-time delivery to customers	5	2	3		5	4	1		5	3	2	
	3. Provide logistics at lowest cost	5	3	2		2	5	3		5	4	1	
	4. Design from customers point view	1	1	0		3	5	2		5	4	1	
	5. Information sharing with SC partners	3	2	1		3	1	2		4	3	1	
	6. supplier involvement in design phase	2	1	1		3	2	1		0	0	0	
Procurement & Accounting	7. direct cash payment policy	5	1	4	1	0	0	0		0	0	0	2
	8. LC based payment policy	5	4	1		5	5	0		5	4	1	
	9. Lead time based procurement	5	3	2		5	5	0		4	3	2	
Inventory Management	10. Vendor managed inventory at production sites	1	1	0		1	1	0		5	5	0	
	11. Lowest inventory driven costs	5	3	2		4	3	1		5	3	2	
Technology Management	12. Effective use of CAD, CAE, & CAM Systems	5	5	0	2	5	4	1	2	5	5	0	4
	13. Effective use of MRP systems	3	2	1		5	5	0		5	3	2	
	14. Responsiveness to meet engg. change	5	3	2		5	4	1		5	5	0	
	15. Product customization to meet cstmr need	5	4	1		5	5	0		5	4	1	
	16. Outsourced product development	5	5	0		5	5	0		5	4	1	
	17. Product design for recycling need	3	3	0		5	4	1		5	3	2	
	18. Zero-defect manufacturing	5	1	4		3	2	1		5	5	0	
	19. Total Quality Management (TQM)	5	2	3		4	2	2		5	5	0	
	20. Statistical Quality Control(SQC)	5	3	2		5	3	2		5	5	0	
Customer Relationship Management	21. Monitoring customer service level	5	4	1	3	5	3	2	1	5	5	0	1
	22. Acceptance of customer complaints	5	4	1		5	5	0		5	5	0	
	23. A process to manage customer complaints	5	3	2		5	4	1		5	5	0	
	24. Multiple system to capture the customer	3	2	1		5	5	0		5	3	2	
	25. Cycle times from supplier to customer delivery	5	3	2		5	3	2		5	5	0	
	26. Order fill rate to customer	5	4	1		5	3	2		5	5	0	
	27. Practice on lean manufacturing	3	0	3		3	0	3		5	0	5	
Lean & Agile practice	28. Reconfigurable business process	4	3	1	5	5	4	1	3	5	5	0	
	29. Responding to item variable	5	5	0		3	3	0		5	5	0	
	30. Responding to demand variable	5	3	2		4	4	0		5	5	0	
	31. E- procurement	5	2	3		5	3	2		5	2	3	
Information & Communication Technology	32. high Speed data communication	5	3	2	4	5	3	2		5	5	0	3
	33. Use of customize software for resource planning	5	3	2		5	2	3		5	5	0	
	34. ECR system via electronic data interchange	4	3	1		5	5	0		5	5	0	
	35. Top management commitment	5	3	2		5	5	0		3	3	0	
Human Resource Management	36. Employees are empowered to make changes	2	1	1		4	3	1	4	5	2	3	5
	37. There is high employee morale	5	2	3		5	5	0		5	3	2	
	38. designing effective conflict resolution tech.	3	1	2		5	4	1		5	3	2	
	39. Employees are trained in SC management	3	1	2		0	0	0		5	0	5	
	40. effective method use of transportation	2	1	1		1	0	1		5	2	3	
Transportation	41. IT based transportation route select	3	1	2		5	2	3	5	5	0	5	

6. RESULTS AND DISCUSSION:

Now we can make decision and set up a comment under the three section of supply chain management and the definition of old style manufacturing company and progressive manufacturing company. Here we also discussed about focusing area external or internal.

6.1 Analysis and interpretation of SCM areas for company 'MA': This Company mainly gives priority on the procurement, accounting and the technology management over customer relationship management (CRM). It also give priority to ICT & agile practice over HRM. Its important ranking on categories is followings:

Procurement & Accounting-1, Technology Management-2, Customer Relationship Management-3, Information & Communication Technology-4, Lean & Agile practice-5.

It is possible to make some conclusions and observations about company 'MA's' behavior. Company 'MA' behaves like a *Traditional 'old style' manufacturing company* and its supply chain activity is internally focused. This company focused on the ISCM among the three section of SCM.

6.2 Analysis and interpretation of SCM areas for company 'RP': Here this company give highest priority on customer relationship management(CRM). It's important ranking on categories are followings:

Customer Relationship Management-1, Technology Management-2, Lean & Agile practice-3, Human Resource Management-4, Transportation-5.

It is possible to make some conclusions and observations about company 'RP's' behavior. Company 'RP' behaves like almost a *progressive manufacturing company* and its supply chain activity is externally focused. This company focused equally on the ISCM & CRM among the three section of SCM.

6.3 Analysis and interpretation of SCM areas for company 'MO': Here this company also gives highest priority on customer relationship management (CRM). It's important ranking on categories are followings:

Customer Relationship Management-1, Procurement & Accounting-2,, Information & Communication Technology-3, Technology Management-4, Human Resource Management-5.

It is possible to make some conclusions and observations about company 'MA's' behavior: Company 'MO' behaves like a *fully progressive manufacturing company* and its supply chain activity is externally focused. This company focused on the ISCM

among the three section of SCM. For this reason performance of SCM factors 84.18% for this company which is better than 'MA' & 'RP'. All of this three company have give more attention on the highest performance gap which value is 5 or more than 2.

6. Implications for practice: Based on the research findings, below is the summary of the suggestions to senior management at Garments accessories in Bangladesh on how they can enhance the efficiency and effectiveness of their supply chain management program:

- There is a need for better supply chain knowledge, as many employees may be unaware of their company's supply chain performance and its relationship to business performance.
- Management needs to select strategies that focus on supply chain management externally to achieve competitive advantage and business success.
- Management needs to analyze and understand their perceived critical gaps (and opportunities) in performance. After that they need to link these gaps to customer requirements using quality function deployment (QFD) methodology.

7. CONCLUSION

QFD is an effective technique that helps both manufacturing and non-manufacturing industries to improve their quality, overall supply chain performance, customer satisfaction, understanding the customers' needs, benchmarking against competitors, and clear vision of customer, market intangible requirements, and other quality and business characteristics by integrating the voice of customer with the firm's processes. The critical supply chain factors that need to be enhanced by the company according to their importance with respect to customer requirements which is found by absolute weight table. This study had achieved its aims to identify the critical supply chain factors and determine the overall supply chain factors performance of Garments accessories industry in Bangladesh using QFD technique.

It is recommended that future research should test this theory using a more quantitative research method for the purpose of statistical generalization. Future research can also try to understand if there are different behavior and characteristics of companies, such as traditional and progressive manufacturing companies. If the difference can be confirmed, it can lead to recommended strategies on how companies can improve performance. Most importantly, future research can try to understand if specific critical supply chain factors can contribute to competitive advantage and business success.

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REDESIGNING CYCLE RICKSHAW WHEEL TO MINIMIZE ACCIDENT PROBABILITY AND SEVERITY

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This paper reviews the possible problem areas of non-motorized means of travel in Rajshahi city, particularly cycle rickshaw, with respect to the view of rickshaw pullers and passengers; and severity analysis. Accidents are more frequent now a day mainly caused by lack of rickshaw pullers' adequate training and design of rear wheels; according to market analysis and reviews. Violent accidents are occurred while the rickshaws drive beside one another and it is observed that they made collisions and ultimately accident causes human injuries as well as cut off several spokes of the wheel. Additionally spokes are generally broken down frequently during riding on the rough roads. Redesigning of the wheel has been done on the basis of measured maximum load. The dimension of the new model was decided after studying the carried load of each spoke of the wheel. As five spokes were being used instead of forty two spokes, the reliability of the wheel is being increased considerably due to increased rigidity of the spokes. Hub was designed in such a manner that the extension portion of the wheel is no longer responsible to make frequent accidents. As a result of changing design the problems are being solved.

Key words: Redesign; Rickshaw; Accident Probability; Bearing life

1. INTRODUCTION

Cycle rickshaw is an important & major means of travel, particularly in small cities and amongst the urban areas (For short journey lengths) in Bangladesh. These are light weighted environment friendly vehicle. The people of certain class have these vehicles with affordable price as a principal income source. The mechanism of cycle rickshaw is served as a technical platform that encapsulates fundamental of problems in mechanics, vehicle dynamics, stability, motive power, etc. However in Bangladesh most rickshaws are assembled based on the general ideas without investigating the loads and the load bearing capacities. This causes frequent technical failure of rickshaws and due to lack of knowledge the rickshaw pullers are also involved in enhancing the accident probability. There are not many researches related to rickshaw. Chowdhury et al (1996), Vikhashu (2007) and

Nahar et al (2010) addressed some technical problems related to rickshaw. However those are not adequate. This paper examines the mechanics of the cycle rickshaw by considering the possible factors. Major problem area is identified as the wheel of the cycle rickshaw. All dimensions and specifications of new model are then developed with computation of mechanics.

2. PROBLEM SELECTION

2.1 Need Analysis

Market research is conducted to understand the present condition. To meet customer needs for the product survey is done. During the survey some basic questions (See Appendix A) are asked to the rickshaw pullers and as well as passengers. Based on the survey, problem related to wheels are identified as major problems and minor problems

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and shown in table 1. Customer needs and their priority are provided in table 2.

Table 1: Major (A) and Minor (B) problems

A	Rear Wheel Axle	rim	spoke	Seat	Chain-sprocket
B	Light	hood	Driver seat	packing	Foot rest

Table 2: Customer needs and their priority

Customer Needs	No. of Customer	Priority
Light Weight	11	3
Less Cost	16	1
High Endurance Limit	9	4
Long Life	13	2
Reliability	7	6
Aesthetic	5	7
Comfort	8	5

Through this analysis it is identified that the major problem area is wheel with hub, spoke and ball bearing.

2.2 Process Analysis

Another type of analysis is Cause Effect Diagram (CE Diagram) that depicts defects, errors, or problems which has been identified and begins to analyze potential causes of this undesirable effect. Among the types of CE diagram the followings are being used to identify the problem region with their respectable causes- (i) Cause Enumeration and (ii) Process Analysis.

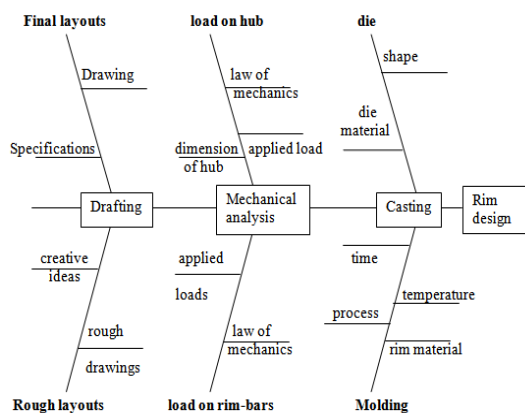


Fig. 1: Requirements for rim design

This diagram provides the information of the process of making the wheel from idea generation to final product development.

3. DESIGN ANALYSIS & SELECTION

To redesign the existing product, the cycle rickshaw wheel, for reducing accident severity & probability, the initial need is expressed in semantic language as a verbal request or requirement of the customers, in this case the rickshaw pullers & the passengers. Through graphical and analytical analyses; a physical model is being established. Some drawings are initially constructed considering possible problems & resolving techniques. Material selection is done on the basis of some design criteria such as yield strength, ultimate strength, elongation, density, modulus of elasticity, cost etc. Through mechanical analysis the design specifications are developed & correction over the layout is made.

Measurements for mechanical property analysis consist of different dimensions of lengths, weight of different parts and rickshaw self weight. Then the reaction/supporting loads at both rear and front wheels are determined according to the law of mechanics. By using the reaction loads at each of the rear wheel's the dimensions of the spokes are being calculated, i.e., the length and width of each spoke. Length of each spoke is found from the dimension of outer diameter of the hub. Outer diameter of the hub is determined by calculating the thickness of the hub according to the law of mechanics as the inner diameter is known from selected bearing's outer diameter.

3.1 Developing Ideas with Drawing

Initially several rough drawings are made to figure out the ideas of resolving problems of cycle rickshaw wheel.

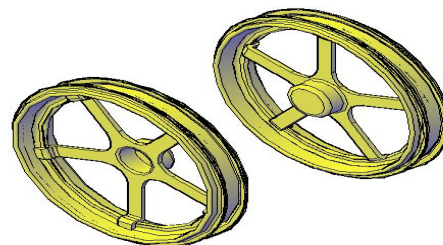


Fig. 2: Initial drawing of wheel

The drawing shown in fig. 2 is done by only considering the ideas of defined problems of extended portion of axle that causes the distortion of spokes of the wheels of other rickshaws. In that case the hub is designed in such a way (in fig. 2) that the axle extension is no longer visible. After that the spokes are replaced by five equally spaced spokes that are more reliable than spoke and are little subject to distortion.

But after developing this primary idea in the drawing the mechanical properties such as the material selection, static and dynamic load carrying capacities, bearing life etc. are being considered to compute the specifications of the spokes used in wheel and the hub's required dimensions as well. The calculations show that the hub is not properly designed shown in the fig. 2, because it uses only one bearing that reduces the bearing life much less than the existing one and also caused by the increased bending moment with spokes at one end of the hub and only one bearing at another end of the hub.

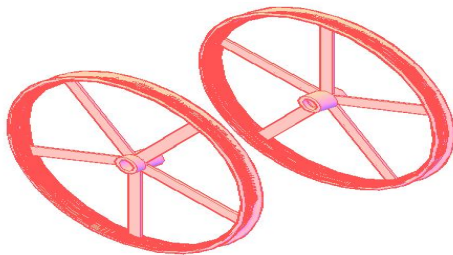


Fig. 3: Redesigned wheel

Redrawing of the wheel is prepared by taking into account the mechanics for rickshaw wheels and finalized the drawing with specifications to generate physical model of wheels at fig. 3. The specifications of the modified model are developed by calculating different force calculations according to the laws of mechanics. The area of each spoke is calculated for the selected material from load applied to each wheel. The outer diameter of the hub is determined by computing the thickness of the hub assuming the inner diameter as the outer of the bearings used with hub. By getting two of the bearings in the hub which retains the bearing life more than the existing one and the maximum bending moment for the eccentric placement of the spokes the thickness of the hub is being calculated.

3.2 Material Selection

After that the material selection is done considering some significant properties of different possible materials. Possible materials those are nearly suitable for the wheel manufacturing purpose are selected and then prioritized them according to the required material property for rim.

Priorities are given under score of 20 for each materials property. Over total priority of each material i.e. 200 score the % of priority is calculated. Amongst three competitive materials Aluminium Alloy with certain composition, which is conventionally used for rim manufacturing, is being selected in cycle rickshaw wheel manufacturing.

Properties of selected materials are provided in *Appendix B* in detail.

3.3 Mathematical Calculation

3.3.1 Design of Spoke

The testing result from universal testing machine for yield and failure of existing wheel shows that it can sustain about 14000 N loads. On behalf of this capacity the new design of wheel is made.

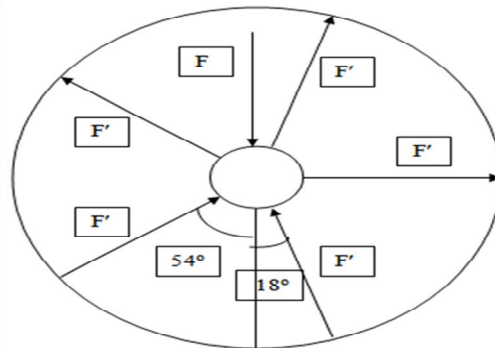


Fig. 4: Sketch of load on each spoke

The wheel is designed with five equally spaced spokes because more than five bars it causes reduction of cross-section area of each; thus the reliability of each spoke. And for less than that number the cross-section area is increased and thus the weight is also increased.

At equilibrium,

$$+ \uparrow \sum F_y = 0 \text{ so } F' = 3908.79 \text{ N}$$

Now,

$F' = \sigma A = \sigma b t$, thus $b t = 15.39 \text{ mm}^2$. Where, A =area of the wheel bar & $\sigma = 254 \text{ N/mm}^2$

If the breadth of each spoke, $b = 25.4 \text{ mm}$ than the thickness of each spoke, $t = 1.82 \text{ mm}$.

Having $FS = 3$ for mild shock of ductile material and with trial & error basis the breadth of each spoke is determined as, $b = 25.4 \text{ mm}$ and the thickness of each spoke, $t = 1.82 \text{ mm}$.

3.3.2 Hub Design

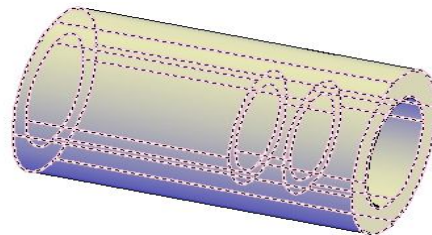


Fig. 5: Redesigned hub

As the bearing is of the same number 6204, the designed wheel's hub diameter (inner) is known. The designed wheel's hub diameter (inner) is known from bearing number. The minimum length of hub is determined by required spaces for two bearings, one nut and clearance between two bearings. To determine the thickness of hub it is required to calculate the forces on different point of the hub (Fig. 6), applied forces are F_1 and F_2 and supporting loads are R_1 and R_2 . Where the distances are $AB=0.014\text{m}$, $BC=0.007\text{m}$, $CD=0.027\text{m}$, $DE=0.007\text{m}$.

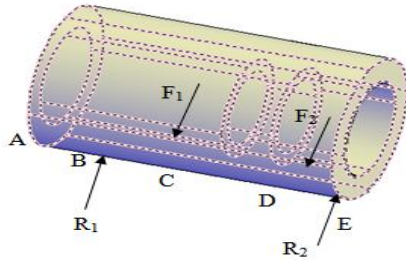


Fig. 6: Forces on hub

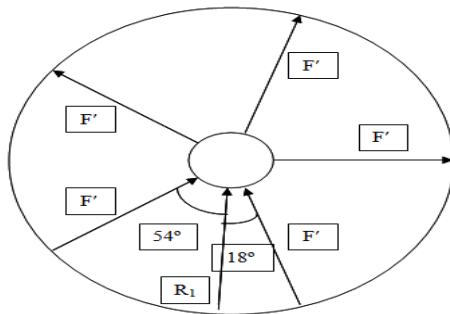


Fig. 7: Reaction forces on hub

By determining the value of R_1 from the figure of right most corner (Fig. 7), the unknown loads over the hub i.e F_1 & F_2 are calculated. Formulating with laws of mechanics, $R_1=6015\text{ N}$, $F_1=5503.7\text{N}$, $F_2=8694.29\text{N}$.

By using those values the thickness of hub is being determined with the established formula of maximum bending moment. In the Figure 8 the lower portion of the hub is considered as simply supported beam with breadth as same as the spokes breadth. Having maximum moment and with the known values of material strength and breadth the part thickness of the hub is being determined. The formula is- Maximum bending moment, $M= \sigma I /C= obh^2/6$. By putting the known values, the unknown value i.e thickness of the hub, h , is determined as 7.2mm .

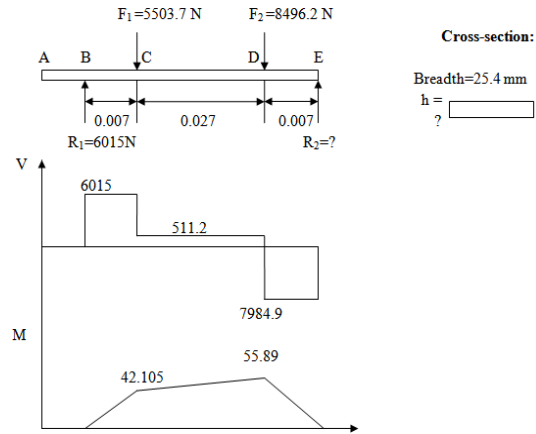


Fig. 8: Shear & Moment diagram for hub

3.3.3 Impact of the loads

Bearing life is calculated on basis of the loads that are practically applied to the wheel, that is, the load those are calculated in earlier section. In this case existing bearings of number 6204 ball bearing are used.

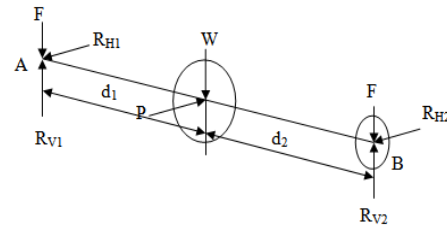


Fig. 9: Forces on Bearing

Where,

Applied forces on each wheel bearings,

$F=194.32\text{ kg}$

Sprocket weight, $W=0.5\text{ kg}$

Rickshaw puller's pulling force, $P=465\text{kg}$

Distances, $d_1=d_2=0.5715$

Vertical reaction forces on bearings are, R_{V1} & R_{V2}

Horizontal reaction forces on bearings are, R_{H1} & R_{H2}

According to law of mechanics, over vertical & horizontal forces we get $R_{V1}=194.32\text{ kg}$, $R_{V2}=194.57\text{ kg}$, $R_{H1}=232.5\text{ kg}$ & $R_{H2}=232.5\text{ kg}$. At point B of the Fig. 9 there are two bearings so that the forces on the bearing are needed to calculate with respect to practically applied load. Practically applied loads are computed for each bar i.e $F'=620.3\text{N}$ & spoke support $R_1=954.54\text{ N}$.

In the Fig. 10, $F=F_1+F_2$ and F_1 & F_2 are the loads applied through the bearings at point C and D. again from laws mechanics we get $F_1=948.555\text{N}$ & $F_1=955.780\text{N}$, where $F=194.32\text{ kg}$ is a calculated value of applied load on bearings.

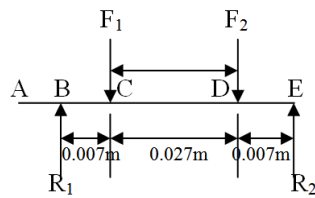


Fig. 10: Forces on Bearing

By using the forces on bearings the reaction forces of bearings are computed to determine the radial load of the bearings.

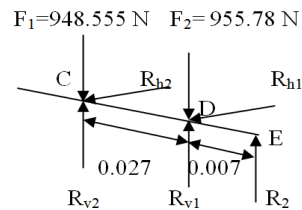


Fig. 11: Forces on Bearing

Here the calculated values are $R_{v1}=953.87\text{N}$, $R_{v2}=952.90\text{N}$, $R_{h1}=1689.05\text{N}$ & $R_{h2}=589.4\text{N}$.

Now, Reaction at bearing D,

$$R_d = \sqrt{(R_{h1}^2 + R_{v1}^2)} = 1788.93\text{N}$$

Reaction at bearing C, $R_c = \sqrt{(R_{h2}^2 + R_{v2}^2)} = 1120.45\text{N}$

Basic load rating for 6204 ball bearing,

$$C = 12700\text{N}, C_o = 6200\text{N}$$

With no axial thrust, $X=1$ & $Y=0$

$$\text{and } F_{rd} = F_{ad} = R_d = 1788.93\text{N}$$

The equivalent dynamic load,

$$P = XF_{rd} + YF_{ad} = 1788.93\text{N}$$

Bearing life at C,

$$L_d = (C/1.5P)^3 = 106.01 \text{ million rev}$$

$$\text{and } L_{hd} = L * 10^6 / 60 * 60 = 40.9 \text{ months}$$

With no axial thrust,

$$X=1 \text{ \& } Y=0, F_{rc} = F_{ac} = R_c = 1120.45\text{N}$$

The equivalent dynamic load,

$$P = XF_{rc} + YF_{ac} = 1120.45\text{N}$$

Bearing life at D, $L_c = (C/1.5P)^3 = 431.5 \text{ million rev}$

$$\text{and } L_{hc} = L * 10^6 / 60 * 60 = 166.6 \text{ months.}$$

The life of the bearings is 40.9 months and 166.6 months at points D and C respectively.

4. COST OF WHEEL

By considering monthly production 2400 Pcs, all fixed costs and variable costs per product is calculated, thus the total cost is calculated.

Total fixed cost of redesigned product: TK 4.587

Total variable cost: TK 380.66

Total cost of redesigned product: TK 385.24 per unit.

5. RESULTS

The redesigned wheel is shown in Fig. 3. Specifications of the wheel, hub, bearings are as: number of spokes, 5; thickness of each spoke, 1.82 mm; breadth of each spoke, 25.4 mm; rim is same as the existing one; hub diameter (inner) is same as 6204 ball bearing's outer diameter; hub thickness, 7.2 mm, the expected life of the bearings are 40.9 months and 166.6 months.

6. DISCUSSION AND CONCLUSION

Redesigned wheels are constructed at the university lab. It is tested for functionality. At the initial stage it is found that the wheels are performing well with comfort to the rickshaw puller. This hub design does not have any extended portion as the existing extension of rear axle. This will prevent the collision with the other rickshaws while overtaking each other. It is beyond this study to investigate the reliability, longevity, product life cycle and accident probability due to long cycle time or product life cycle. However it is believed that due considering the engineering design criteria, this redesigned wheel will serve the following purposes:

- Redesigned wheel will reduce the accident severity.
- This will minimize the problem of spoke distortion and axle position.
- Wheel longevity will be comparatively high.
- Wheel cost is reasonable.
- Outlook is good enough.

Overall it can be said that the redesigned wheel with accessories are good enough to prevent the accident severity and the maintenance cost will be reduced.

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Appendix A (Questionnaire)

To identify the problems related to cycle rickshaw, some basic questions were asked to the rickshaw puller, passengers and vendors. The questions are provided here.

1. What are the major problems that you face with your rickshaw?
2. How longer the rickshaw give service?
3. How much reliable it is?
4. What about the failure rate?
5. How much load you can carry?
6. Do you feel that the maintenance cost is ok with you?
7. Do you think rickshaw need improvement?
8. What parts should be modify and why?

Many other effective questions are done to clarify exact needs during market research.

APPENDIX B (Priority to Materials)

	Materials Property	Stainless steel	Given priority
1	Tensile strength, MPa	500	12
2	Yield strength, MPa	200	5
3	Endurance limit, GPa	280	14
4	Elongation, %	Not found	0
5	Modulus of elasticity, 200 GPa	200 GPa	15 GPa
6	Density, g/cc	7.5-8.5	12
7	Melting temp., °C	2500	5
8	Cost per lb	0.8-2.5	12
9	Hardness, BHN	52	2
10	Corrosion		10
	Total priority		101
	% over total priority		40.5
SI	Materials Property	Al Alloy (Conv.)	Given priority
1	Tensile strength, MPa	373	8
2	Yield strength, MPa	254	12
3	Endurance limit, GPa	200	10
4	Elongation, %	39.9%	5
5	Modulus of elasticity, 200 GPa	200 GPa	14 GPa
6	Density, g/cc	7-8	11
7	Melting temp., °C	550	14
8	Cost per lb	.2-.5	15
9	Hardness, BHN	150	16
10	Corrosion		7
	Total priority		111
	% over total priority		55.5
SI	Materials Property	Al Alloy	Given priority
1	Tensile strength, MPa	200	5
2	Yield strength, MPa	300	8
3	Endurance limit, GPa	100	7
4	Elongation, %	15-25%	8
5	Modulus of elasticity, 90 GPa	90 GPa	10 GPa
6	Density, g/cc	3	5
7	Melting temp., °C	700	10
8	Cost per lb	3-4	7
9	Hardness, BHN	52-100	12
10	Corrosion		14
	Total priority		86
	% over total priority		43

SOFTWARE BASED EVALUATION OF OVERALL LINE EFFECTIVENESS (OLE) OF A GARMENT'S INDUSTRY

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Abstract:

Competition is worldwide and markets are fast becoming price sensitive. These challenges are forcing companies to implement various productivity improvement efforts to meet the needs of ever changing market demand. The total productive maintenance (TPM) has provided quantitative metric overall equipment effectiveness (OEE) for measuring the productivity of individual production equipment. In future, an extremely important objective is to improve the performance of the whole process or line instead of concentrating only on a single machine. The traditional metrics like throughput and utilization rate measures, only the part of the performance of manufacturing equipment. They are not helpful in identifying the problems underlying improvements needed to increase productivity. In this paper, an attempt is made to use overall line effectiveness (OLE) as an index of performance evaluation in the production line of a garment's industry. Overall Line Effectiveness (OLE) is the common machinery and Process metrics utilized through a Lean manufacturing Initiative. $OLE = Availability \times Performance \times Quality$. A detailed methodology for determining the overall line availability, overall line performance and overall line quality is presented, and also OLE.

Development Platform: User Interface: Visual Studio (C#). Backend Database: SQL Server 2005

Key Words: Plan Production Time, Operating Time, Down Time, Availability, Performance, Quality.

INTRODUCTION:

Overall Line Effectiveness (OLE) is the common machinery and Process metrics utilized through a Lean manufacturing Initiative. OLE is a "best practices" way to monitor and improve the effectiveness of garment's industry. OLE is simple and practical. It takes the most common and important sources of manufacturing productivity loss, places them into three primary categories and distills them into metrics that provide an excellent gauge for measuring the position of the garments

industry- and how to improve! OLE is frequently used as a key metric in TPM (Total Productive Maintenance) and Lean Manufacturing programs and gives a consistent way to measure the effectiveness of TPM and other initiatives by providing an overall framework for measuring production efficiency. OLE is a tool that combines multiple manufacturing issues and data points to provide information about the process. It is an all-inclusive benchmarking tool that serves to gauge the various sub-components of the manufacturing process (i.e., availability, performance and quality)—and used to measure

actual improvements on 5S, WCM, Lean Manufacturing, TPM, Kaizen and Six Sigma. When using OLE with these management systems the benefits become tangible and noteworthy. After all factors are taken into account, the OLE result is converted in percentage. The results (in %), therefore, can be regarded as a preview of the existing production efficiency of a particular line, cell or machine. As we all know, manufactured goods are a result of a complex production process—and without the proper measuring tools and formula, expect your business to run blindly even in the light of day. Having the right metrics, OLE provides a window to analyze out-of-the-ordinary issues and gives an established framework for improving the whole manufacturing process. There are dozens of formulas, systems and metrics being used to improve the whole manufacturing process, but only OLE correctly reduces complex production problems into simple, easy-to-follow steps in handling data and information. The OLE tool helps to methodically improve the process using basic measurements. OLE is a very simple metric that immediately indicates the current status of a manufacturing process. Somehow it also becomes a multifaceted tool allowing understanding the effect of the various issues in the manufacturing process and how they affect the entire process. The biggest advantage of OLE is that it allows companies to have separate business functions by applying/using a single, easy-to-understand formula. OLE is by far the most effective benchmarking tool in making sound management decisions.

OBJECTIVES:

- To measure Overall Line Effectiveness (OLE) of a Garment's Industry
- To measure Overall Line Availability
- To measure Overall Line Performance
- To measure Overall Line Quality
- To identify bottleneck
- To store data for future use

RESEARCH BACKGROUND:

Software Based Evaluation of Overall Line Effectiveness (OLE) of a Garment's Industry has several advantages and overcome some traditional problems.

- Minimized calculating time
- Monitoring data any time
- Minimized human endeavor
- Real time production information visibility

Now a day's some software companies are making software on the basis of production information system and human resource information system etc. They make software according to companies demand. Although that software is very much strong in structure, that software is not cheapest and easier to maintain, so most of the garment industries are not capable to use this software. Basically the research of making this tool is come from current production information.

USEFUL FORMULAS:

OLE = Overall Line Availability x Overall Line Performance x Overall Line Quality

Overall Line Availability:

Overall Line Availability is a general term that is used to describe the amount of time over a specific period that the system resources are available in the wake of component failures in the system. Availability refers to the machine being available for production when scheduled (and only when scheduled). Overall Line Availability takes into account Down Time Loss, which includes any events that stop planned production for an appreciable length of time- the ratio of the actual production time to the planned production time. All planned stops and breakdowns will reduce the availability ratio, including set-up times, preventive maintenance, breakdowns and lack of operators, material shortages, and changeover time. While it may not be possible to eliminate changeover time, in most cases it can be reduced. The remaining available time is called Operating Time.

Overall Line Performance:

The performance measure identifies production lost when the machine is running at less than optimal speed, by comparing actual cycle times against the ideal. Overall Line Performance takes into account Speed Loss, which includes any factors that cause the process to operate at less than the maximum possible speed, when running. Loss of production due to underutilization of the machinery. In other words, losses are incurred when the equipment is not run with full speed. Examples include machine wear, substandard materials, misfeeds, and operator inefficiency. The remaining available time is called Net Operating Time. Short, unregistered, stops may affect the performance ratio as well.

Overall Line Quality:

Finally, quality takes account of the time wasted by producing something that does not meet quality standards (rejects and rework). The percentage of good pieces to total pieces made, becomes the quality measurement. The amount of the production that has to be discharged or scrapped. Quality takes into account Quality Loss, which accounts for produced pieces that do not meet quality standards, including pieces that require rework. The remaining time is called Fully Productive Time. Our goal is to maximize Fully Productive Time.

How do I calculate OLE for my entire industry?

Here are two reasonable options for calculating garment's industry OLE:

- Calculate OLE Using a Straight Average
- Calculate OLE Using a Weighted Average

Calculate garment's industry OLE Using a Straight Average:

The simplest method of calculating OLE scores of single line by averaging OEE of all machines in that line.

The simplest method of calculating OLE scores of a garment's industry by averaging OLE of all line in that industry.

If in a garment's industry there are 6 lines and every line has 70 machines then the calculation would be:

Overall Line Availability(OLA):

Overall Line Availability can be measured by straight average of the availability of all machines in that line.

$$OLA = (Availability_1 + Availability_2 + Availability_3 + \dots + Availability_{70}) / 70 * 100\%$$

Overall Line Performance(OLP):

Overall Line Performance can be measured by straight average of the performance of all machines in that line.

$$OLP = ((Performance_1 + Performance_2 + Performance_3 + \dots + Performance_{70}) / 70) * 100\%$$

Overall Line Quality(OLQ):

$$OLQ = (Good\ Pieces / Total\ Pieces) * 100\%$$

Overall Line Effectiveness (OLE):

$$OLE = (Overall\ Line\ Availability \times Overall\ Line\ Performance \times Overall\ Line\ Quality) * 100\%$$

Overall Line Effectiveness (OLE) for industry would be:

$$OLE = ((OLE_1 + OLE_2 + OLE_3 + OLE_4 + OLE_5 + OLE_6) / 6) * 100\%$$

Calculating Availability, Performance, and Quality for single machine:

The Formulas for single machine:

Availability:

Availability takes into account Down Time Loss, and is calculated as:

$$\text{Availability} = (\text{Operating Time} / \text{Planned Production Time}) * 100\%$$

Performance:

Performance takes into account Speed Loss, and is calculated as:

$$\text{Performance} = ((\text{Total Pieces} / \text{Operating Time}) / \text{Ideal Run Rate}) * 100\%$$

OEE Glossary:

Quality:

Quality takes into account **Quality Loss**, and is calculated as:

$$\text{Quality} = (\text{Good Pieces} / \text{Total Pieces}) * 100\%$$

Effectiveness of single machine would be:

Effectiveness takes into account all three Factors, and is calculated as:

$$\text{Effectiveness of single machine} = (\text{Availability} \times \text{Performance} \times \text{Quality}) * 100\%$$

Term	Definition	Implication
Actual Cycle Time	The actual time to produce one piece. In OEE, calculated as Operating Time divided by Total Pieces.	Used in calculating OEE Performance. A variation of the calculation uses Actual Run Rate instead.
Actual Run Rate	The actual rate of production, when it is running. In OEE, calculated as Total Pieces divided by Operating Time.	Used in calculating OEE Performance. A variation of the calculation uses Actual Cycle Time instead.
Adjustment Time	Productive time lost while tweaking equipment. See Setup and Adjustments.	Can be a significant loss factor, and in many factories is not directly measured.
Availability	One of the three OEE Factors. Takes into account Down Time Loss (events that stop planned production for an appreciable amount of time).	Must be measured in an OEE program, usually by recording the duration of Down Time Events.
Breakdowns	Lost time due to equipment failure. One of the Six Big Losses.	Contributes to OEE Down Time Loss (reduces OEE Availability).
Changeover Time	Lost time due to swapping of equipment, connections or materials. See Setup and Adjustments.	A prime candidate for improvement for most companies.
Cycle Time	The time to produce one piece.	Inverse of Run Rate.
Design Cycle Time	See Ideal Cycle Time.	See Ideal Cycle Time.
Down Time Loss	Production time lost to unplanned shutdowns.	One of the three OEE Losses (reduces OEE Availability). Major focus area for improvement.
Event	In OEE, a production loss which must be categorized.	OEE's purpose is to clarify the nature and effect of Events.
Fully Productive Time	Actual productive time after ALL losses are subtracted.	What OEE measures – the true bottom line of your facility's efficiency.

Good Pieces	Produced pieces that meet quality standards (without rework).	Used in calculating OEE Quality.
Ideal Cycle Time	Theoretical minimum time to produce one piece. The inverse of Ideal Run Rate.	Used in calculating OEE Performance. A variation of the calculation uses Ideal Run Rate instead.
Ideal Run Rate	Theoretical maximum production rate. The inverse of Ideal Cycle Time.	Used in calculating OEE Performance. A variation of the calculation uses Ideal Cycle Time instead.
Lean Manufacturing	Quality philosophy that strives to minimize consumption of resources that add no value to the finished product.	OEE can be a key tool and metric in Lean Manufacturing programs.
Nameplate Capacity	The design capacity of a machine or process.	Used to determine Ideal Cycle Time or Ideal Run Rate.
Net Operating Time	True productive time before product quality losses are subtracted.	Equipment time losses normally are much larger than defect losses.
OEE (Overall Equipment Effectiveness)	Framework for measuring the efficiency and effectiveness of a process, by breaking it down into three constituent components (the OEE Factors).	OEE helps you see and measure a problem so you can fix it, and provides a standardized method of benchmarking progress.
OEE Factors	The three constituent elements of OEE (Availability, Performance, and Quality).	Often it is more important to focus on the three OEE Factors than the consolidated OEE metric.
OEE Losses	The three types of productivity loss associated with the three OEE Factors (Down Time Loss, Speed Loss, and Quality Loss).	The goal is to relentlessly work towards eliminating OEE Losses.
Operating Time	Productive time available after Down Time Losses are subtracted.	Operating Time increases as Down Time Losses are reduced.
Performance	One of the three OEE Factors. Takes into account Speed Loss (factors that cause the process to operate at less than the maximum possible speed, when running).	Must be measured in an OEE program, usually by comparing Actual Cycle Time (or Actual Run Rate) to Ideal Cycle Time (or Ideal Run Rate).
Planned Production Time	Total time that equipment is expected to produce.	Benchmark that OEE is measured against.
Planned Shut Down	Deliberate unproductive time.	Excluded from OEE calculations.
Plant OEE	Consolidated OEE calculation as applied to an entire plant.	There are different methods of calculating Plant OEE. Pick the one that makes sense for your company.
Plant Operating Time	The time the factory is open and capable of equipment operation.	Planned Shut Down is subtracted from Plant Operating Time to reach the OEE start point – Planned Production Time.

Process	A sequence of activities that starts with some type of input (e.g. raw materials) and ends with some type of output (e.g. a product).	OEE can be used across a wide range of different processes, although it is most often associated with discrete manufacturing.
Production Rejects	Rejects produced during steady-state production. One of the Six Big Losses.	Contributes to OEE Quality Loss (reduces OEE Quality).
Quality	One of the three OEE Factors. Takes into account Quality Loss (parts which do not meet quality requirements).	Must be measured in an OEE program, usually by tracking Reject Pieces.
Quality Loss	Percentage of pieces which do not meet quality requirements.	One of the three OEE Losses (reduces OEE Quality). OEE views defects in terms of lost time.
Reduced Speed	Cycle where the process is truly running (as opposed to a Small Stop), but is slower than “expected”. One of the Six Big Losses.	Contributes to OEE Speed Loss (reduces OEE Performance).
Reject Pieces	Produced pieces that do not meet quality standards.	Used in calculating OEE Quality.
Rework Pieces	A subset of Reject Pieces, that can be reworked into Good Pieces.	OEE does not make a distinction between pieces that can be reworked and pieces that are scrapped.
Root Cause Analysis	A method of resolving a non-conformance, by tracing back from the end failure to its original (root) cause.	The basic tool for understanding and eliminating the sources of productivity losses.
Run Rate	The production rate when actually producing (running).	Inverse of Cycle Time.
Setup and Adjustments	Time lost configuring equipment. One of the Six Big Losses. See also Adjustment Time and Changeover Time.	Contributes to OEE Down Time Loss (reduces OEE Availability). Tracking Setup Time is critical to reducing this loss.
Six Big Losses	Six categories of productivity losses that are almost universally experienced in manufacturing: Breakdowns, Setup and Adjustments, Small Stops, Reduced Speed, Startup Rejects, and Production Rejects.	Drill down into the three OEE Factors, and you will reach the Six Big Losses. Measure your process with OEE, and improve your process by addressing the Six Big Losses.
Small Stop	A brief pause in production, but not long enough to be tracked as Down Time. One of the Six Big Losses.	Contributes to OEE Speed Loss (reduces OEE Performance).
SMED (Single Minute Exchange of Dies)	Program for reducing setup time. Named after the goal of reducing setup times to under ten minutes (representing time with one digit).	Often a part of programs to improve OEE Availability.
Speed Loss	Production time lost to equipment running below maximum rated speed.	One of the three OEE Losses (reduces OEE Performance). Usually the most difficult of the

		OEE Losses to analyze.
Startup Rejects	Rejects produced while equipment is adjusted for production. One of the Six Big Losses.	Contributes to OEE Quality Loss (reduces OEE Quality).
Takt Time	Production rate needed to meet customer demand.	Where sales and business planning meets the factory floor.
Theoretical Cycle Time	See Ideal Cycle Time.	See Ideal Cycle Time.
Total Pieces	Total of all produced pieces.	Used in calculating OEE Quality.
TPM (Total Productive Maintenance)	Maintenance system covering the life of all equipment: planning, manufacturing, maintenance and improving performance.	OEE is a metric for defining equipment effectiveness in a TPM program.
Visual OEE™	Plant floor real-time display of live OEE data for maximum team involvement.	Visual OEE™ displays make improvement everyone's job.
World Class OEE	90.0% Availability 95.0% Performance 99.9% Quality 85.0% OEE	A composite OEE number means very little without the total context.

WHY OLE?

OLE is used for

- Lean implementation
- Root Cause Analysis
- Motivation
- Identify bottle neck
- Real time production information
- Productivity improvement
- Measuring the efficiency of decision making units
- Optimized production technology(OPT)

Lean implementation:

It is important in a lean manufacturing implementation to use the correct tools at the right time. Many lean implementations have failed because organizations failed to grasp a deep understanding of all lean concepts.

OEE is a powerful lean manufacturing tool, especially when combined with other tools using an integrated approach.

Steps to achieve lean systems-

- Design a simple manufacturing system
- There is always room for improvement
- Continuously improve
- Measure (Overall Line Effectiveness (OLE) is a set of performance metrics that fit well in lean environment because it helps to identify the waste.)

Root Cause Analysis:

is applied starting with the most severe loss categories.

Cause & Effect Diagram-

The cause & effect diagram is the brainchild of Kaoru Ishikawa, who pioneered quality management. The cause and effect diagram is used to explore all the potential or real causes (or inputs) that result in a single effect (or output). Causes are arranged according to their level of importance or detail, resulting in a depiction of relationships and hierarchy of events. This can help you search for root causes, identify areas where there may be problems, and compare the relative importance of different causes.

The C&E diagram is also known as the fishbone diagram because it was drawn to resemble the skeleton of a fish, with the main causal categories drawn as "bones" attached to the spine of the fish, as shown below.

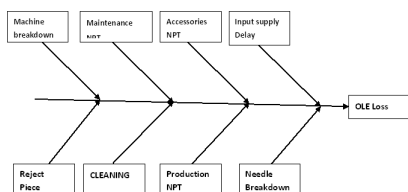


Figure: Cause & Effect Diagram

Real time production information:

Real-time data denotes information that is delivered immediately after collection. There is no delay in the timeliness of the information provided. Real-time data is often used for navigation or tracking the process. It helps management to monitor the effectiveness of the industry. It is easy to take immediate decision based on information. It is very easy to identify strength and weakness of the process.

Productivity Improvement:

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One of the major causes of company's decline is low productivity. Failure to meet targeted productivity can result to high costs per unit, hence higher prices, and services, not competitive enough on the market. Many businesses try very hard to remain competitive in the market. Therefore, it is important for businesses to implement strategies to make improvements in productivity levels. Businesses can make productivity improvement by improving OLE.

Optimized Production Technology (Opt):

An objective of OPT is to maximize utilization of the bottlenecks.....

The OPT principles

1. Balance flow not capacity
2.
3.
4.
5.
6. Bottleneck's govern both throughput and inventories
7.

Application of opt principals:

1. Identify bottlenecks
2.
3.

CONCLUSION:

The OLE solution gives us good intelligence about how many of each type of product we can put through this machine in a given timeframe. An overall OLE figure emerges when the three elements are multiplied together, and a world class OLE is generally accepted to be 85 percent. That doesn't sound too strenuous until we realize how the multiplier works. If all three elements were 90 percent, the overall OEE would be only 72.9 percent (90 percent of 90 percent of 90 percent). In practice the accepted world class standards are not uniform across the three factors, with world class availability being recognized as 90 percent, speed 95 percent and quality 99.5 percent to achieve an overall 85 percent. OEE provides data specifically about the manufacturing line, and as such is but a tool to identify the current state. Where overall line effectiveness really comes into its own is when

the results of OLE calculations are used to compare the performance of manufacturing lines, an assembly line involving a number of machines, or individual production shifts, as a part of a continuous improvement program. The first hand experience of companies that have implemented OLE technology solutions demonstrates its effectiveness.

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TENSILE AND ELECTRICAL PROPERTIES OF WOOD SAW DUST REINFORCED POLYMER MATRIX COMPOSITES

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Polymer matrix composites, reinforced with various types of fibers, are being widely used to reduce the overall weight of structures because of their good combination of various properties such as high strength to weight ratio, good fatigue properties, corrosion resistance, etc. However, most of the polymeric materials are not bio-degradable. As a result, demands of natural fiber reinforced composites are increasing day by day. Considering this, initiative was taken to develop wood saw dust reinforced polyester matrix composites with varying proportions (0, 5 and 10% by weight) and sizes (coarse and medium size particles) of wood saw dust. The developed composite samples were tested in Instron Universal Testing Machine to characterize their tensile behaviours and breakdown voltages were measured using 100 kV capacity high voltage testing machine. Experimental results showed a gradual decrease in tensile strengths with increase in both the fiber content and particle size. Similar to tensile strength, breakdown voltages were also found to decrease, however, the effect of fiber contents or particle sizes on breakdown voltages was not so pronounced.

Keywords: Polymer matrix composites, Wood saw dust, Reinforcement, Fiber size, Tensile properties, Breakdown voltage.

1. INTRODUCTION

Wood is a combination of cellulose fiber and lignin. The cellulose fiber provides strength and the lignin acts as glue that bonds and stabilizes the fiber. With the growing economic competition and the ecological pressure, the past decade has seen a renewed interest in developing more efficient reinforcements along with relatively lower overall production cost. Cellulose based fibers are relatively cheaper and can meet many requirements for making the products to be economical. They are made from recoverable resources and thus may add bio-degradability to plastics [1]. So, throughout the whole world, there is also a good potential for the use of natural fibers/particles as reinforcing fillers in polymeric materials. Short-fiber, i.e. wood saw dust reinforced polymeric composites have gained importance due to considerable processing advantages and improvement in certain mechanical properties. The utilization of ligno-cellulosic materials in the production of polymeric composites is attractive particularly because of low cost/high volume applications. Bio-degradable ligno-cellulosic fillers possess several advantages compared to inorganic fillers, such as lower density,

greater deformability, lower abrasiveness and cost [2-4]. The use of saw dust as a reinforcement for unsaturated polyester resins has been limited compared to mineral glass fibers or calcium carbonate. The main drawbacks of wood particles are their relative low degradation temperature and their hygroscopicities, which weaken their adhesion with hydrophobic polymers. However, wood fibers show very good mechanical properties such as tensile strength and Young's moduli [5]. To improve mechanical, thermal, electrical properties of saw dust reinforced polymer matrices, soft wood and hard wood fiber can be used.

Because of various attractive properties, polymer composites filled with natural ligno-cellulosic fibers have attracted the attention of many researchers and technologists [6-9]. As a result, both polymer matrices and natural filler systems have been widely investigated [10]. As a matter of fact, Oksman and Lindberg [11] as well as the team of Liao [12] studied the mechanical behaviours of composites based on polyethylene and wood flour samples [11,12]. On the other hand, Zaini *et al.* [13] and Kaci *et al.* [14,15] investigated the mechanical behaviours of polypropylene/wood flour composites. Some authors examined also the

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mechanical behaviours of various polymer based flour reinforced composites [16]. The electrical properties of this type of composites with chemically treated wood flour have been investigated by the team of Mansour [17].

Improvement in mechanical, electrical and thermal properties have resulted interest in wood saw dust polymer matrix composite materials in many industrial applications, including light weight, high strength parts for the automotive and aerospace industries, containers, sporting goods, thermal and electrical insulators, switch board and circuit board. Many studies have been published concerning the properties and processing conditions of various thermoplastics with wood fibers/particles, but there is not much literature available on the reinforcing of thermosetting polymers with those fillers. These fillers might reduce the tendency of the resin to crack during cure and reduce resin shrinkage [18]. The current study deals with the evaluation of the mechanical and electrical properties of composite materials of unsaturated polyester filled with wood saw dusts.

2. EXPERIMENTAL

2.1 Materials

The matrix was polyester resin and the reinforced materials were wood saw dusts obtained from sawing of three types of trees available in Bangladesh (Kerosin, Garjon and Gamari). The proportions of saw dust in test samples were 0%, 5% and 10% by weight. In order to know the effects of particle sizes on various properties of the developed composites, saw dusts of medium (250 to 500 μm) and coarse (above 500 μm) particle sizes were selected for this research work. The initiator was methyl ethyl keton peroxide, which was taken 1.5% by weight with respect to the total weight of the mixture. Before adding saw dust in to the liquid polyester, they were dried at 100°C in an oven for 2 hours. The apparent density (D_A) and true density (D_T) of various wood raw dusts are presented in Table 1.

Table1. Densities of the wood saw dusts.

Types of Wood	$D_A(\text{g/cc})$	$D_T(\text{g/cc})$
Kerosin	0.40	1.33
Gamari	0.35	0.86
Garjon	0.70	1.34
Polyester	-	1.40

2.2 Compounding and Moulding

The composite mixtures of polyester with sawdust (without chemical treatment) were prepared directly in a beaker (volume capacity 250 cm^3) for about 5 minutes. The compositions of the composite mixtures are given in Table 2. Before casting of the composite mixtures into moulds, vacuum-degassing was carried out to remove bubbles or any sort of dissolved gases inside the mixtures for 12 minutes. After vacuum-degassing peroxide (hardener) was mixed with the polyester-saw dust mixture. At last stage, the mixture was taken for degassing for another 2 minutes. The paste was filled in a metal mold (50 mm diameter and about 3 mm thickness) for electrical breakdown voltage test. In another batch, mixtures prepared following the above mentioned procedure were filled in a mould of dimensions 115 mm length, 10 mm width and 7 mm thickness for making tensile test specimens. Each sample was cured at room temperature for 24 hours.

Table 2. Compositions of polyester-wood saw dust composites.

Sample Code	Matrix	Filler (Wood saw dust)	Filler (wt%)
P(0)	Polyester	Nil (virgin polyester)	0
GMM	Polyester	Gamari medium	5 & 10
GMC	Polyester	Gamari coarse	5 & 10
GRM	Polyester	Garjon medium	5 & 10
GRC	Polyester	Garjon coarse	5 & 10
KRM	Polyester	Kerosin medium	5 & 10
KRC	Polyester	Kerosin coarse	5 & 10

2.3 Electrical Properties

Breakdown voltages were measured using 100 kV capacity high voltage testing machine to characterize their insulation behaviours. The size of the specimen was 50 mm diameter and 3 mm thickness.

2.4 Mechanical Properties

Three samples of each group were used to determine tensile properties. The tensile test was performed in Instron Universal Testing Machine to characterize their tensile behaviours at a cross-head speed of 2 mm/min according to ASTM D3039 standard (rectangular specimens). The tensile load, stress and modulus were computed from the stress-strain curves of the composites. The size of the specimen was 114×10×6 mm.

3. RESULTS AND DISCUSSION

3.1 Macrostructures

The macrostructures of the as-cast samples of polymer matrix composites containing various types of fillers (Gamari, Garjon and Kerosin saw dusts) are shown in Fig. 1. In these macrographs, dispersions of particles inside the matrix are clearly visible.

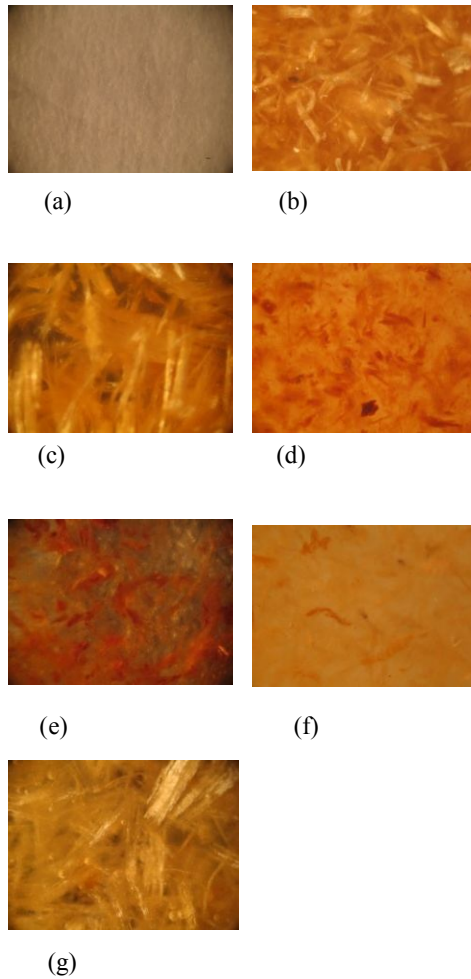


Fig. 1. Macrographs of cast samples (a) P(0), (b) GMM, (c) GMC, (d) GRM, (e) GRC, (f) KRM and (g) KRC.

3.2 Electrical Test

The breakdown voltages for polyester reinforced with different concentrations of untreated wood saw dusts were measured at a fixed frequency (50 Hz) in high voltage testing machine (100 kv). The effects of proportions of wood saw dusts on breakdown voltages of the composites are illustrated graphically in Figs. 2 & 3. From these

figures, it is clear that a gradual decrease in breakdown voltage is resulted with increase in both the fiber content and particle size of the wood saw dusts used. The reason of deterioration in breakdown voltages of the wood saw dust reinforced polyester based composites is that wood saw dust exhibits polar nature, whereas the nature of the polyester is non-polar [19]. So, in polyester-saw dust composites, adhesion between the two materials is expected to be rather poor. Besides this, the breakdown voltage of wood is significantly lower than that of polyester. Increase in the fiber contents also decreases matrix material in the composites. So, the breakdown voltage also decreases for all wood saw dust reinforced composites.

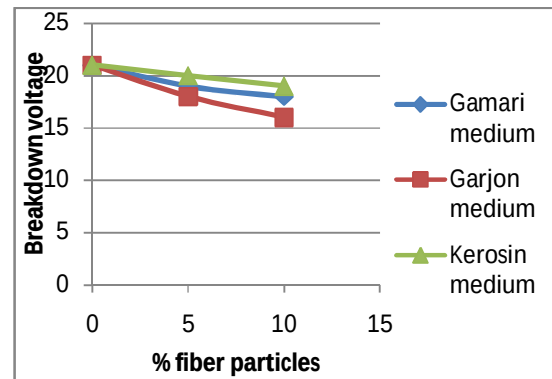


Fig. 2. Breakdown voltage (kV) versus %fiber curves of medium saw dust reinforced composites.

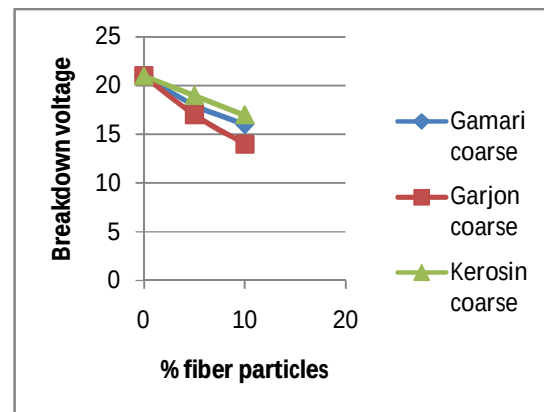


Fig. 3. Breakdown voltage (kV) versus %fiber curves of coarse saw dust reinforced composites.

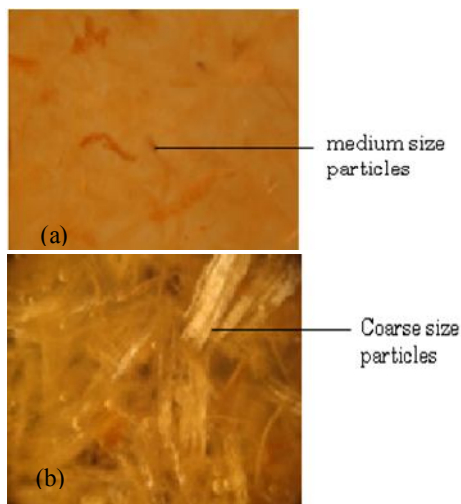


Fig. 4. Micrographs showing (a) medium and (b) coarse grain saw dust reinforced composites. Note: Coarse saw dusts caused poor dispersion.

From Figs. 2 & 3, it is seen that the effect of particle size on breakdown voltage of medium size (250 μm to 500 μm) saw dust reinforced composites are comparatively higher than that of coarse size saw dust (500 μm to above) reinforced composites. Because adhesion between medium size particles and polyester are better than that between coarse size particles and polyester, which is shown in Fig. 4. Woods were easily burned and created pores (marked by arrows) when they were tested. But this is not occurred when virgin polyester was tested is shown in Figs. 5 and 6.

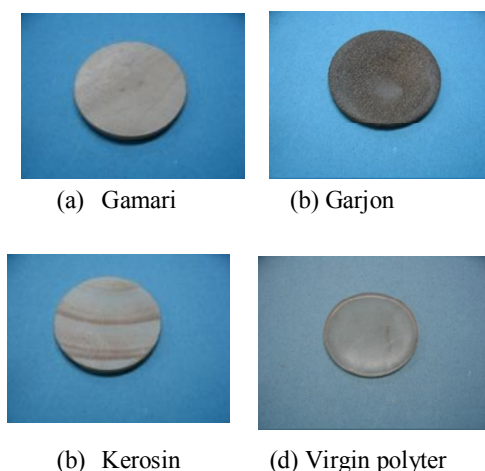


Fig. 5. Photographs showing different types of wood and virgin polyester before electrical test. Note: No porosity/crack is visible in wood/pure polyester samples

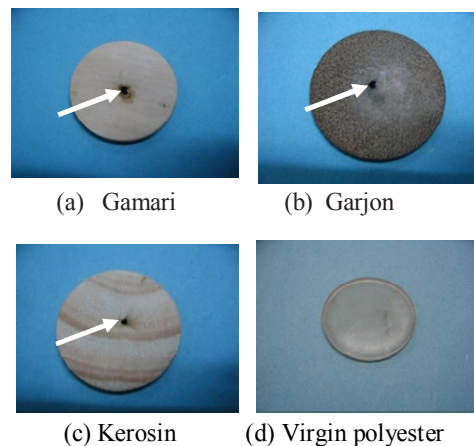


Fig. 6. Photographs showing different types of woods and virgin polyester after electrical test. Note: Pores are formed in the pure wood sample (marked by arrows, whereas polyester sample remained unaffected.

3.3 Tensile Test

The tensile strength vs. % of filler graphs are shown in the Figs. 7 & 8. It shows that the effect of proportion of the reinforcement particles, i.e. wood saw dusts on the load bearing capacity of the composites developed. From this tensile test results it is observed that there is a gradual decrease in tensile strengths with increase in both the fiber contents and particle size used for making the composites. Because, with increase in saw dust contents, mismatch areas between polyester matrix and reinforcing particles increased, which ultimately caused formation of early cracks with subsequent decrease in the maximum tensile load bearing capacity before failure. For the same reason, coarse particle reinforced composites were also showed inferior tensile strengths.

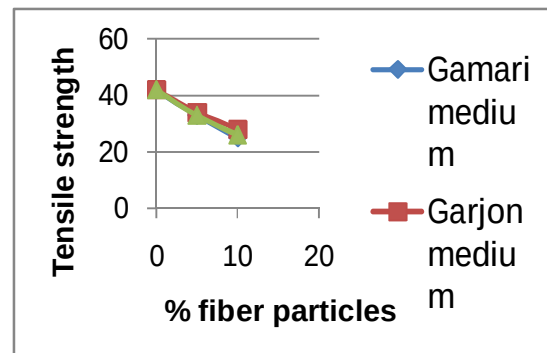


Fig. 7. Tensile strength (MPa) versus %fiber curves of medium size saw dust reinforced composites.

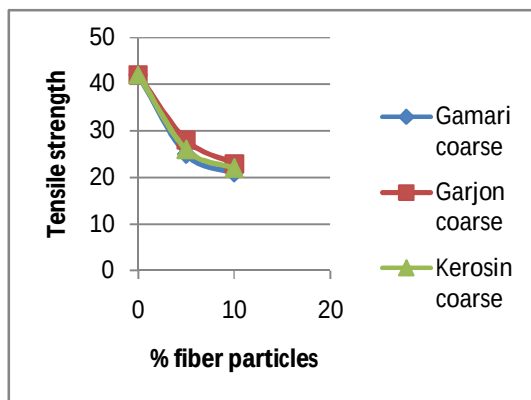


Fig. 8. Tensile strength (MPa) versus % fiber particles curves of coarse saw dust reinforced composites.

When more and more particle is added, resin particles are separated by the reinforced particles. Only reinforced particles cannot give enough strength. So, the strength of composites gradually decreases. From Figs. 7 & 8 it is seen that the tensile strength of medium size (250 μm to 500 μm) saw dust reinforced composites are comparatively higher than that of coarse size saw dust (500 μm to above) reinforced composites. Because, adhesion between medium size particles and polyester are better than that between coarse size particles and polyester is shown in Fig. 4. It is also seen that the density of the fiber content in composites has a very small effect on the tensile strength. Tensile strength depends on both reinforcement particle size and its percentage.

4. CONCLUSIONS

The experimental results lead to the following conclusions:

Addition of wood saw dust in polyester causes the tensile strength of the virgin polyester to decrease significantly. However, the electrical property, i.e. breakdown voltage of the virgin polyester is very similar to that of the 5% wood dust polyester composites. So, untreated 5% wood saw dust polyester composites can be used as an insulating material, i.e. switch board, circuit board, etc.

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THE TRENDS OF ENVIRONMENT FRIENDLY PRODUCT DESIGN IN BANGLADESH

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Environmental awareness continues to rise, and customers of all types are realizing the importance of eco-friendly products which are essential to protect our planet. Eco-designer creates designs that are demanded by markets. Green design rules are needed to support the implementation of environmental features in the practical design situation. Green design or Design for Environment (DfE) is a field of product design methodology that includes tools, methods and principles to help designers reduce environmental impact. The main objective of this work is to compile a set of DfE principles that are useful during the design process. Later the trends of environment friendly product and process design in Bangladesh are studied. Today, many industries in Bangladesh are aware of green design and implementing DfE principles. The present situations about the Green Design trends in some of the leading consumer goods manufacturers, Unilever Bangladesh, PRAN-RFL Group and Rahimafrooz were studied. Moreover the Government's recent initiatives concerning DfE are discussed in this article. This article may help the product designers a lot during eco-friendly design and to compare them with some market leaders. Though the list of compiled DfE principles is based on best practices, further work is needed to expand the list.

Key words: Green Design; Environment; Design Guidelines; DfE

1. INTRODUCTION

Environmental issues are becoming more and more important and Design for Environment (DfE) seems to be the most effective way of dealing with environmental concerns. *Design for environment (DfE) is defined as systematic consideration of design performance with respect to environmental, health, and safety objectives over the full product and process life cycle* (Ray and Guzzo 1993, Jeganova et al. 2004). Only in recent years, people have realized the importance of environmental protection. People are concerned about the context they are living in and the way people make use of resources. An important entrepreneurial challenge is to match products and services not only to the requirements of the market, but also to those of the environment. When products are being planned, the relevant ecological requirements and risks must be determined by considering both the needs of the

market and the technologies available. Key requirements at the product planning stage are energy and material efficiency, and the environmentally compatible disposal of individual components. During product design, environmental aspects are taken into account with respect to material preparation, manufacturing, installation, operation, maintenance and dismantling (Schindler Group 2002). While environmental considerations have always been part of the design process, environmental awareness continues to become a more pressing imperative.

1.1 Objectives

The main objective of this research is to review the literature related to Design for Environment and hence compile the DfE rules, so that Eco-designers can easily take advantage of getting DfE principles at a glance.

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A lot has been written about Design for Environment, but less has been said about how it should be implemented. This paper presents few case studies about how Design for Environment is currently being implemented. That is the next target of this research is to study and observe the present scenario of implementing DfE principles in some leading industries as well as during creating environmental laws in Bangladesh.

1.2 Literature Review

A great number of researches are being going on for compiling the product design guidelines for protecting the environment. A growing number of managers believe that there are tangible advantages to incorporating environmental concerns into product design decisions. The research of Murray (2005) is about the issue of industrialization and the environment and the role of product design in the supply of products which do not have a negative environmental impact, in their production, use or disposal.

Some studies are concerned about the trends of using DfE guidelines in different industries. One of these studies demonstrates the application of Eco-Design techniques in the re-design of a fish tank air compressor. This application aims the reduction of components, the minimization of raw materials and the manufacture processes and tends as main focus the minimization of environmental impact in the development of new products. This air compressor was awarded the first prize in the Product Project category in the ECODESIGN Award – FIESP/CIESP 2004 (Platcheck, 2008). Lenox, in his Doctoral thesis (Lenox et al. 1999) explores the efforts by four electronics firms to implement Design for Environment (DfE) practices within product development teams.

Many of the articles focus on the selection of raw materials which may be recyclable or collected from sustainable sources. In 2006 Medina discussed the role of eco-design tools in materials selection presenting some results of a six-month case study on Eco-design and Recycling Strategy. The different groups in charge of different automobile sectors worked together in simultaneous engineering at the design, prototyping and assembly line and achieved a recycling rate of 95% and incorporated over 18 Kg of recycled plastic (Medina, 2006).

Some research papers are based on life-cycle assessment of the product and concerned about the end-of-life strategies. Jeganova researched and proposed how to integrate Life Cycle Design in product design and development process at Alfa

Laval industry. The study investigated external and internal driving forces and implementation barriers around life cycle design at Alfa Laval (Jeganova et al. 2004). Rose, in his doctoral thesis (Rose, 2000) developed methodologies that aid in formulating the end-of-life strategies across a wide range of products. The analysis of current end-of-life practices identifies improvements to product design that reduce the impact of manufactured goods on the environment. The product end-of-life strategies include reuse, service, remanufacture and recycle. The research compares the strategies these companies have taken in implementing new environmental policies and to discover the most streamlined and cost-effective method for moving towards environmentally friendly product designs. On the other hand, reducing the quantity of waste for disposal and saving natural resources are main drivers for the introduction of the European Directive on waste electrical and electronic equipment (Walther et al. 2010). This policy focuses on an extension of the producer responsibility (EPR) to the end-of-life-phase of their products.

In a paper (Bras 1997), a number of options and environmental issues were illustrated which companies and organizations seeking to incorporate in product design. A brief overview and classification of a number of approaches for reducing the environmental impact has been given in this paper. In 1996 Kaila and Hyvarinen described the way of environmental issues that are being integrated into the product design of the Switching Platforms unit of Nokia Telecommunications. Switching Platforms is implementing Design for Environment by integrating environmental issues into its product design through influencing points found in the product process (Kaila and Hyvarinen, 1996).

Today, the world's community is very concerned about shearing of the knowledge on DfE. In 2009 Pitt and Lubben develops a framework for Education for Sustainable Development (ESD) that includes a 'concentric' view of Sustainable Development (SD). It is used to evaluate an intervention aimed at including sustainability, particularly the social dimension, in design tasks in the subject Design & Technology (D&T) in England and Wales, and in the Netherlands (Pitt and Lubben 2009).

Research of Jeswiet and Hauschild deals with three sections: Green House Gas emissions and environmental impacts, Design for Environment (DfE) and toxic substances to be avoided in design. All three parts must be addressed by the Eco-Designer in any design situation. Second and third

sections give the eco-designer rules, which can be applied in many design situations (Jeswiet and Hauschild, 2008).

Environmental awareness continues to rise among customers of all types. Consumer, SMB, and enterprise are realizing that the IT products they acquire and use on a daily basis need to be designed with a different set of criteria in mind. IT users expect reduced operating costs as well as more predictable disposal costs at the end of the product life cycle. Creative product design is the first step in a product life-cycle strategy with the goal of developing environmentally friendly products for customers of all types (Eastwood, 2007). To protect the environment researches are running not only for the sustainability but also for economies of redesign. With the rapid development of electronics and semiconductor technology, the life cycle of personal computers is getting shorter. To solve the problem, a study has been employed on economic benefit analysis of disassembling personal computers to reduce the cost of product upgrading and to help to protect environment and save resources (Tseng and Chen, 2004). At Dell, environmental opportunities and challenges are considered at every stage of the product life cycle from design and development, manufacturing and operations, to product use and recovery (Dell, 2010).

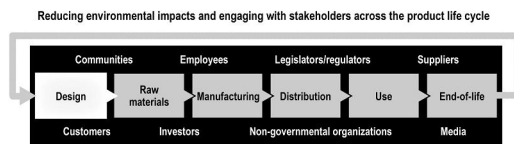


Fig. 1: Product life cycle (Source: Eastwood 2007, adapted from HP)

Not only product design but also all sectors of modern technology are going to be concerned about the environment. For example, Cools tried to express the method of shifting towards environment-friendly modes of transport. In the study, he adopted Q-methodology as the technique to segment people, and to ascertain which approaches and determinants matter to medium distance travel (Cools, 2009).

2. RESEARCH METHODS

When incorporating an environmental viewpoint into the design of materials and structures of a product, the entire context of the design process must be reconsidered in order to integrate environmental aspects into a set of other design aspects. This kind of process is known as

“Integrated Life Cycle Design” (Sarja et al. 1999). The eco-designer creates designs that are demanded by markets. A designer cannot control market forces but must be cognizant of them. To enable the designer to work with market demands, and translate them into product characteristics in an environmentally friendly way, DfE rules are needed to support the implementation of environmental features in the practical design situation.

In this paper different DfE guidelines have been compiled from many articles and internet websites, and summarized into seven basic principles. The last principle is totally a new concept in DfE which has been introduced based on the present scenario and requirement of environment awareness programs.

The case study of this research is based on observation of three leading industries in Bangladesh, how they are introducing the DfE principles in their production system. These are, PRAN-RFL Group, which is an agro based consumer goods manufacturer; Rahimafrooz, which is basically a wet battery manufacturer and Unilever Bangladesh, a world’s leading consumer goods manufacturer. Information has been collected from the internet websites and some med-level management personals of these manufacturers.

3. RESULTS & DISCUSSION

Different researchers provide DfE guidelines in different ways. But all of these guidelines can be classified into main seven principles which are summarized in table 1. Six of them are compiles from different articles (Telenko et al. 2008, Jeswiet and Hauschild 2008, Eastwood 2007) but the Principle G is a new concept in this area.

Table 1. The Seven DfE Principles

Principle A	Ensure sustainability of resources
Principle B	Ensure healthy inputs and outputs
Principle C	Ensure minimal use of resources in production and transportation phases
Principle D	Ensure minimal use of resources during use
Principle E	Ensure appropriate durability of the product and components
Principle F	Enable disassembly, separation, and purification
Principle G	Ensure appropriate training program for all stages of individuals in the value chain in order to enhance consciousness about environment

The Government of Bangladesh (GOB) is taking necessary initiatives to regulate the industries to follow the DfE principles by creating or modifying the environmental regulations. For example, recently the GOB banned Polyethylene shopping bags, Asbestos as building construction material, Two-stroke baby taxi etc. All of these are harmful to environment and violets DfE Principles A & B.

Next the authors describe what the industries in Bangladesh are doing for protecting environment. Rahimafrooz believes in promoting individual environmental responsibility through commitment to 3R (Reduce, Reuse, Recycle), a globally recognized concept and practice to address Environmental Issues. This ensures to follow DfE principles A, B, C and D. Every year, Rahimafrooz celebrates the International Environment Day with “RSF Poribesh Utshab”. In year 2010, Rural Services Foundation (RSF), a Social Development Initiative of Rahimafrooz, organised quiz competition covering 30 upazillas of Bangladesh and gave awards to 450 students. The quiz competition is aimed for candidates of SSC examination and the topics include climate change, renewable energy technology and 3R issues to promote greater environmental responsibility and to encourage the students to increase their knowledge on environment as well as to make them conscious about the climate change (Rahimafrooz, 2010). This program is the basic theme of DfE principle G.

PRAN-RFL Group was born in 1980 and over the years they diversified their activities. Today they are the largest processors of fruits & vegetables in Bangladesh. They encourage farmers and help them to grow quality crops with increased emphasis to source all their key agricultural raw materials sustainably and hence follow DfE principle A. The management is conscious about environment (PRAN-RFL, 2010).

2009 saw the launch of a new vision for Unilever, to double the size of the company while reducing overall impact on the environment. They are embarking on a long-term program of work with the suppliers, customers and other partners to realize this goal. From the year 1995 the company has significantly improved the eco-efficiency of its network of factories. In 2008 they developed a set of metrics for four priority environmental impact areas: greenhouse gas emissions, water, waste and sustainable sourcing. Their target is to source 100% raw material sustainably by year 2015. Some remarkable works can be listed as:

- 15% of palm oil now sourced sustainably via Green-Palm certificates

- 15% of the tea globally now sourced from Rainforest Alliance Certified farms
- Reduced environmental impacts of the manufacturing operations by 41% for CO₂ from energy, 65% for water use and 73% for total waste
- Lifebuoy promoted Global Hand-washing Day in 23 countries (Unilever, 2009)

Unilever observes the impacts of a product on environment in every stage of its lifecycle: in sourcing raw materials, packaging, manufacture, distribution, consumer use and disposal. Sustainability is now central to their business strategy. So it is clear that Unilever follows almost all of the DfE principles.

4. CONCLUSIONS

In general, environmental impact comes from excessive consumption of natural resources and emissions of pollutants to air, water, and land. If the DfE principles are followed properly in every stages of product life cycle then environmental impact will definitely become lesser. Then it would become a Green Product. From this study it is evident that just like other countries the leading industries in Bangladesh as well as GOB are very conscious about this fact.

All of the DfE principles may not be followed in a structured way but main principles like Principle A, B & G are strictly maintained during creating Government Regulations and Product Design in the manufacturing industries. It is expected that this trend will continue in following all of the DfE principles. In this article Design for Environment, for reducing environmental impacts, has been discussed, and a list to which a designer can refer has been included. It may help the related personals to make greater number of eco-friendly products. The eco-designer must be cognizant of all DfE principles.

DfE principles are still being discovered. Further work is needed to expand the list as new principles become available. Finally, the list of principles based on best practices but rigorous, quantitative validation of some of these principles is still lacking.

5. ACKNOWLEDGEMENT

The authors express their sincere gratitude to the Authority of Unilever Bangladesh, PRAN-RFL Group and Rahimafrooz who provided the necessary information and suggestions during the study.

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An Effective Bayesian Personalized E-mail Spam Filter Using Word Tokenization Method

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A personalized e-mail spam filter is designed and developed using word tokenization based on the Bayesian enumerated method. The spammacy or legitimacy of the incoming mails is calculated using pre-created spam and ham databases with respect to particular user domain. The filter is self-adapting by learning from new spam- or legitimate words of the incoming mail as well as with the outgoing e-mails. It is found that a well trained Bayesian spam filter is very effective and efficient with a minimum number of false positive and false negative in filtering the incoming e-mails.

Key words: Baye's theorem, legitimate mail, Internet, spam filters and token dictionary.

1. INTRODUCTION

Spam stands for short pointless annoying messages, although they may or may not be always short. Unsolicited bulk e-mail or unsolicited commercial e-mail is the practice of sending unwanted e-mail messages, frequently with commercial content, in large quantities to an indiscriminate set of recipients [1]. With the exponential growth of the Internet, it is harder to classify useful information from spam mail. The number of spam mails is increasing daily - studies shows that over 50% of all current e-mails are spam mail [2]. As spammers are becoming smarter and are constantly trying and updating themselves to outsmart conventional static methods such as keywords, blacklist, whitelist, collaboration filtering and so on. In the last few years, lot of research work has been carried out for the detection and filtering of e-mail spams [3]-[8]. Schneider [9], describe experiments with a Naïve Bayes text classifier in the context of anti-spam e-mail filtering using two models and found that multinomial model achieves higher accuracy than the multivariate Bernoulli model. Androutsopoulos *et al.* [10], developed a networked based Bayesian spam filter, which only considers the incoming mail

contents into consideration. These technologies are not obsolete but cannot be relied effectively to face the today's e-mail spam problem.

In this paper, we have presented Bayesian enumerated technique and developed a personalized e-mail filter considering both the incoming and outgoing e-mail contents which will overcome the limitations of the existing spam filtering techniques.

2. BAYE'S THEOREM AND ENUMERATION METHOD

Bayes' theorem relates the conditional and marginal probability distribution of random variables. It describes how to update or revise beliefs in light of new evidence a posteriori. The conditional and marginal probabilities of stochastic events A and B ,

$$P(A|B) = (B|A) * P(A)/P(B) \quad (1)$$

where, $P(A)$ is the priori probability or marginal probability of A , $P(A|B)$ is the conditional probability of A , given B . $P(B|A)$ is the conditional probability of B given A . $P(B)$ is the prior or marginal probability of B and acts as a normalizing condition.

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The Bayes' probability function operates on counts and frequencies rather than on probabilities. The most basic and intuitive method for computing $P(A|B)$ is the set enumeration method. Using this method, $P(A|B)$ can be computed by counting the number of times A and B occur together $\{A \& B\}$ and dividing by the number of times B occurs $\{B\}$

$$P(A|B) = \{A \& B\} / \{B\} \quad (2)$$

The enumeration method might still be regarded as the most basic and intuitive method for computing a conditional probability.

A. Bayesian Filter Design Principles

Using the set enumeration method as mentioned above, a Bayesian spam filter is designed which acts as personalized spam filter. By applying this method, we calculate how many times a specific word occurs in spam mails dividing by the total number of times overall (spam and ham mails) is the spamming probability of the regarding word. The same method is applied in defining the hamming (legal) probability of any specific word. In designing the spam filter we have considered the following points:

- To calculate spammacity or legitimacy of each word of the whole message.
- To learn from the all new incoming and valid outbound E-mails and thus constantly updates it.
- To make it sensitive to a user or particular domain of interest.

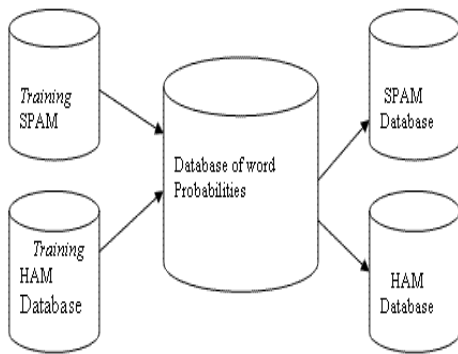


Fig. 1: The architecture of a personalized e-mail spam filter

Figure 1 shows the basic architecture of a personalized e-mail spam filter. To construct the Bayesian filter, first we have to create two databases with individual words and tokens gathered from two representative samples of spam e-mails (spam word list) and legitimate e-mails

(ham word list) the words occurring in the e-mail messages. The probability value designated to each word or token is commonly known as spammacity and ranges from 0.0 and 1.0.

If the total probability lies between 0.0 and 1.0 then the mail is defined as spam mail and if greater than 1.0, the mail is defined as ham (legal) mail. The range of values that determine the legitimacy and spammacity of the incoming mails is shown in Fig.2.

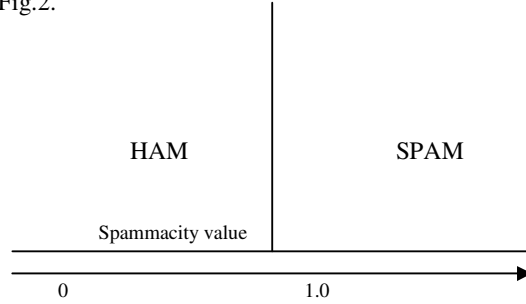


Fig. 2: Determination of legitimacy and spammacity

B. Database Design and Tokenization

The database schema of the proposed personalized spam filter is shown in Fig. 3. For each incoming mail, the associated words of each mail are stored in *in_mail* and *in_mail_wordlist* table respectively. Then the outgoing mail contents are also stored in the *out_mail* database and the outgoing mail contents is tokenized in *out_mail_wordlist* table. The calculation is processed in the *token_dic* table. The whitelist and blacklist filter maintained by *whtblcklst* table. Then *spam* table is used for storing all the spam words and *ham* is used for storing all the legitimate words previously found in the incoming and outgoing ma

Those words found in the spam table that is match is found between *token_dictionary* and spam table, their spammacity is calculated as follows:

$$P(spam) = \frac{\text{Previously how many times found in the spam mail (value of COUNT_SPAM)}}{\text{How many times found the word in the in_mail_wordlist}} \quad (3)$$

$$P(ham) = \frac{\text{Previously how many times found in the ham mail (value of COUNT_HAM)}}{\text{How many times found the word in the out_mail_wordlist}} \quad (4)$$

For the new words those will not be found in spam or ham table, their spammacity or legitimacy value will be zero. When all the words of the *token_dictionary* table probability calculation will be completed, then the final result will be as follows:

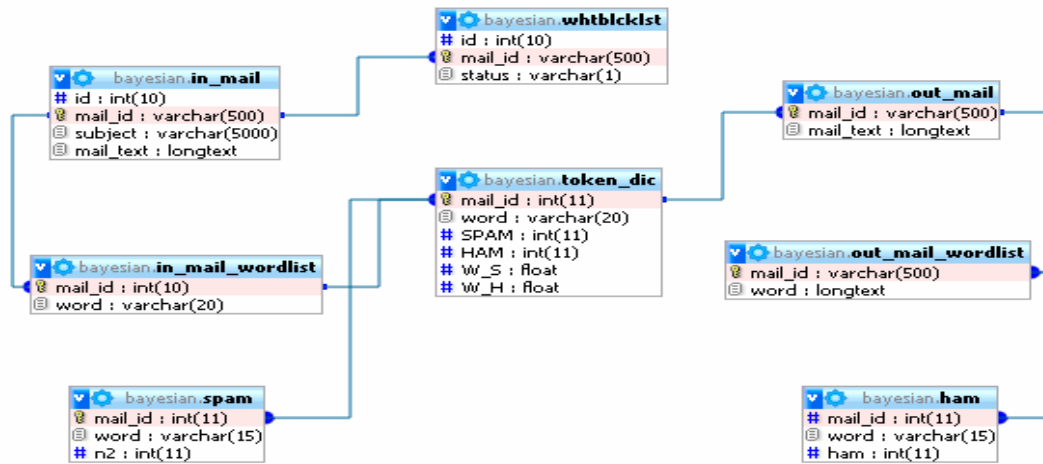


Fig. 3: The database schema of personalized spam filter

$$Final\ Result = \frac{\sum (P(spam))}{\sum (P(ham))} \quad (5)$$

If the *Final Result* > 1.0, the mail is more likely to be spam otherwise ham. After calculation, if the message is spam, for all the matched word as well as for new words of the *spam* table, *COUNT_SPAM* values will be increased by 1. Thus the spam table is updated with the words which mail was decided finally with spam mail.

C. Process Flowchart of the Filter

The Bayesian approach is a content-based personalized e-mail spam detection and filter. We already mentioned that after an initial learning process the filter will be able to distinguish between 'legal' and 'spam' mail respectively. The working process flowchart of the filter is depicted in Fig 4. When a new mail received, its address is verified from the stored whitelist and blacklist addresses. If it matches with the whitelist address, the spammacy of the mail will not be calculated. On the other hand, if the address matches with the blacklist, its spammacy also will not be calculated. If none of the above occurs, then the Bayesian filter will start its process to calculate its spammacy of each word of each incoming mail with associated learning and training process.

Finally the result of the overall spammacy calculated, if the spammacy value lies in the ranges 0.0 and 1.0, the incoming mail is legal and hence the white list will be updated with the new address. If ranges be greater than 1.0, it will be

regarded as spam mail and the blacklist will be updated with the new address.

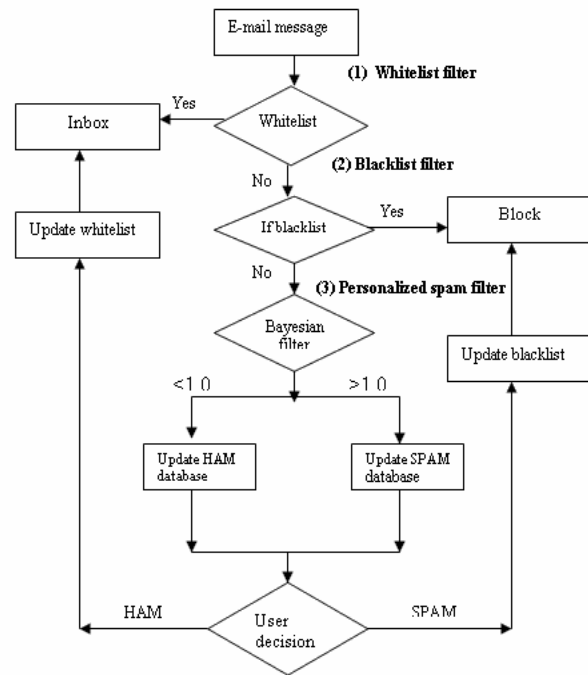


Fig.4: Process flowchart of the personalized Bayesian e-mail spam filter

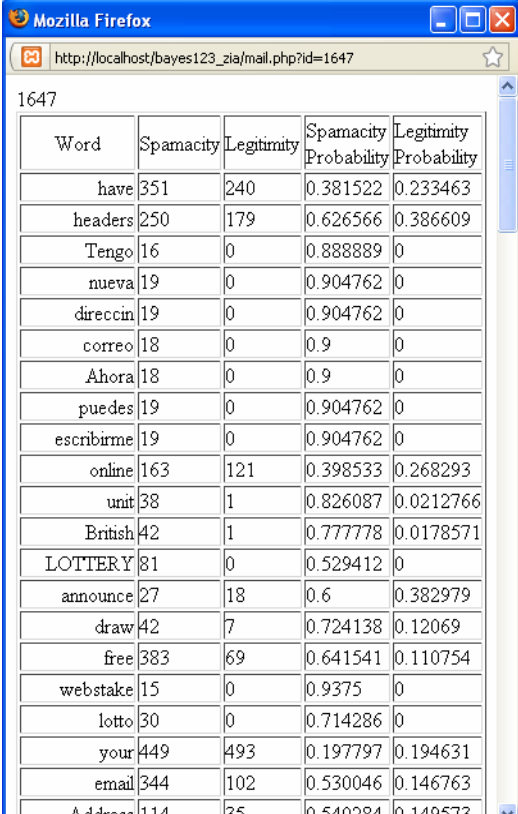
3. TRAINING AND TESTING OF BAYESIAN FILTER

There is a need for training to the developed Bayesian filter before using it. Training is important to prove the filters capability of spam detection. We have added the pre-classified e-mails to the input of the filter. During the testing

process the values of the tokens are changed time to time in the token dictionary of the filter in order to achieve higher accuracy. The filter uses the knowledge base from the training part to decide for every e-mail, whether it is spam or legitimate. It is worth to mention that the learning process does not stop after finishing training; it continues every time when the filter is used. Moreover, the filter gets more and personalized and related to our needs during usages.

Table 1: Number of e-mails set to the Bayesian filter

Test No.	Total number of e-mails
1	19 (3 non-spam + 16
2	18 (all spam)
3	32 (all spam)
4	25 (all spam)
5	20 (2 non-spam + 18
6	39 (4 non-spam + 35
7	56 (5 non-spam + 51
8	46 (3 non-spam + 43
9	106 (9 non-spam + 97
10	96 (6 non-spam + 90



The screenshot shows a web browser window with the address bar displaying 'http://localhost/bayes123_zia/mail.php?id=1647'. The main content area displays a table with the following data:

Word	Spamacity	Legitimity	Spamacity Probability	Legitimity Probability
have	351	240	0.381522	0.233463
headers	250	179	0.626566	0.386609
Tengo	16	0	0.888889	0
nueva	19	0	0.904762	0
direccin	19	0	0.904762	0
correo	18	0	0.9	0
Ahora	18	0	0.9	0
puedes	19	0	0.904762	0
escribirme	19	0	0.904762	0
online	163	121	0.398533	0.268293
unit	38	1	0.826087	0.0212766
British	42	1	0.777778	0.0178571
LOTTERY	81	0	0.529412	0
announce	27	18	0.6	0.382979
draw	42	7	0.724138	0.12069
free	383	69	0.641541	0.110754
webstake	15	0	0.9375	0
lotto	30	0	0.714286	0
your	449	493	0.197797	0.194631
email	344	102	0.530046	0.146763
Address	114	25	0.540284	0.140572

Fig.5: Spammacity and legitimacy calculations

Table 2: Number of spam detected by the Bayesian filter

sl	Total number of e-mails	Legitimate detected	Spam detected	White list	Black list
1	19 (3 non-spam + 16 spam)	17	2	0	0
2	18 (all spam)	12	4	0	0
3	32 (all spam)	20	9	0	0
4	25 (all spam)	9	16	1	1
5	20 (2 non-spam + 18 spam)	3	16	1	0
6	39 (4 non-spam + 35 spam)	7	30	2	3
7	56 (5 non-spam + 51 spam)	6	48	0	2
8	46 (3 non-spam + 43 spam)	3	41	2	0
9	106 (9 non-spam + 97 spam)	8	95	1	3
10	96 (6 non-spam + 90 spam)	5	89	1	1
To	457	90	350	8	9

The initial results indicated that filter is not very effective in blocking spam at the beginning of the testing process. The first test comprised 19 e-mails messages (3 non-spam and 16 spam) and it is evident that in this first trial the Bayesian filter detected only 2 spam message out 16 spam messages sent. This is due to the filter is not being trained fully trained. Table 2, demonstrates that as training progressed filter results improved significantly. False positive is defined as a non-

spam legitimate e-mail recognized as spam. False negative is defined as a spam e-mail recognized as non-spam e-mail

Figure 5 shows the snapshot of spammacity and legitimacy probability calculation window of a typical e-mail. As shown in the Fig. 5, the first column shows the word, the second row shows the spammacity meaning that previously how many times the word found in the mails those were spam mail, the third column shows legitimacy meaning

that previously how many times the word found in the mail those were legal mail with respect to this particular user or organization. With these two values, spammacy probability and legitimacy probability is calculated. Thus the summation of spammacy and legitimacy probability of all the tokens is taken and the final result is achieved. If the result is between 0.0 and 1.0 the messages is regarded as legal mail and if greater then 1.0, regarded as spam mail. Fig.6 shows the graphical representation of the testing result of the Bayesian filter.

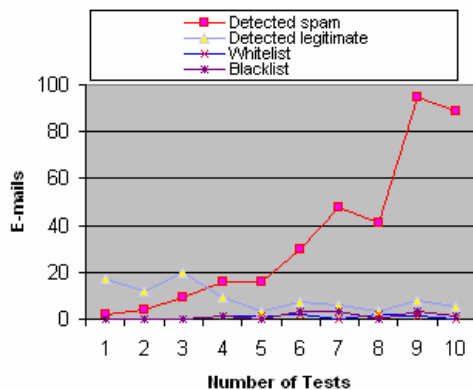


Fig. 6: Number of different types of e-mail detection by the Bayesian spam filter

4. CONCLUSION

Spam or unsolicited email has become a major problem for companies and especially for private users. The techniques currently used by most anti-spam software are static and it is often fairly easy to evade filters by changing the message a little and making the technique fool and failed. To effectively combat spam, we have developed a personalized adaptive spam e-mail filter by the use of Bayesian enumerated method as well as fast and accurate word tokenization process to overcome the limitations of existing spam detection techniques. The filter distinguishes between legal and illegal mails with respect to the particular users domain based on the spam and ham pre-created trained database. It has the capability to adapt and learn continuously by itself resulting very high spam detection rates and become more personalized day by day.

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AN EXPLORATORY STUDY OF VISION 2021: STATUS AND CHALLENGES

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The government has declared vision 2021 for establishing Bangladesh as a knowledge based developed country through the effective use of Information and Communication Technology. The government has already taken some proactive steps to fill up this target. The paper reviews some of the initiatives and achievements of Vision 2021 – a program to further a Digital Bangladesh. The paper then reviews and discusses some of the challenges and then provides some recommendations to further some of the Vision 2021 initiatives and then additional recommendations to strengthen the foundation and environment for Vision 2021 in Bangladesh.

Key words: Digital Bangladesh, E-governance, ICT, Vision 2021, Knowledge Base Society.

1. INTRODUCTION

The use of information and communication technology has been playing a vital role in the 21st century due to globalization. The democratic government has declared the “Vision 2021” termed as “Digital Bangladesh” which comprises ensuring people’s democracy and rights, transparency, accountability, establishing justice and ensuring delivery of government services in each door through maximum use of technology-with the ultimate goal to improve the daily lifestyle of general people. Government’s “Digital Bangladesh” includes all classes of people and does not discriminate people in terms of technology. Hence, government have emphasized on the four elements of “Digital Bangladesh Vision” which are human resource development, people involvement, civil services and use of information technology in business.

2. ELECTRONIC GOVERNMENT INITIATIVES

The Government has taken many initiatives for developing the country to make knowledge based society through information and communication Technology.

2.1 In Mobile Sector

Bill payment through mobile, port automation, e-centre, introducing e-governance (partially), establishing computer labs in 128 educational institutions, getting public examination results

through short message service (SMS) and introducing university admission process through SMS are some other significant moves taken by the government in its first year.

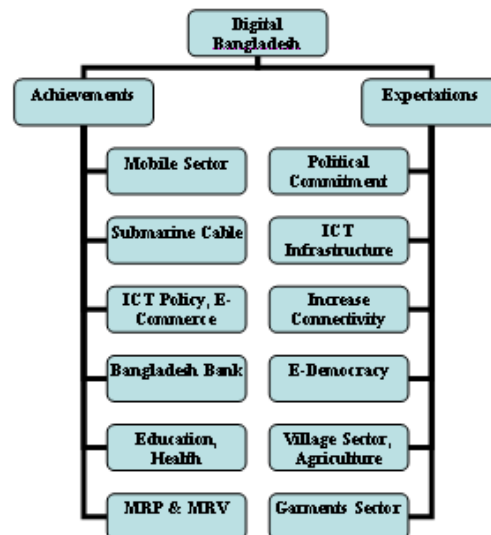


Fig. 1: Digital Bangladesh at a glance [Habib/Baizid © ACM 2010].

2.2 In Bangladesh Bank

Bangladesh Bank, being the monetary authority of the country, is at the forefront of government’s firm commitment to be digitized. They have already formulated a 5-year strategic plan for the financial sector based on advanced technological applications to deliver services with utmost efficiency. The ultimate goal is to make Bangladesh Bank a world class Central Bank with high

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applications of technologies. This should, in fact, transform itself into a paperless organization within this plan period [4].

Bangladesh Bank has achieved a historic milestone in trade and business arena, departing from conventional banking with the introduction of e-commerce recently; a giant stride towards digital Bangladesh. Banks have been allowed to make online money transactions; payment of utility bills through internet, transfer of funds (account to account), payments for trading goods and services, and facilitate online credit card payments in local currency. Indeed, the electronic payments will be considered as cash transactions, which will be regulated under the 'Anti-Money laundering Act' as well as other relevant rules and regulations. A national payment gateway, connecting all banks for inter-bank transactions (ebanking) is expected to be established soon. Electronic Fund Transfer will also be possible in near future [4].

Installation of 'Bangladesh Automated Clearing House (BACH)' is another remarkable event in the history of financial sector in Bangladesh; will ease the remittance channel and payment system, and therefore, bring dynamism in business activities. The system has been started in early November 2009 on experimental basis, participated by some well prepared banks; will be inaugurated formally soon. Applying sophisticated technological method, the system needs only images and corresponding information of the submitted cheque leaves instead of physical one; will send them to the BACPS (Bangladesh Automated Cheque Processing System) using a secured communication link. New cheques/clearing instruments (standardized) will contain Magnetic Ink Character Recognition (MICR) line that encompasses information regarding the amount, transaction code, clients account details, routing number (numeric code assigned to bank branches for easy identification of origin and destination of the instrument), cheque leaf's serial number and so on. The system will support both intra-regional and inter-regional clearings based on a centralized processing centre in Dhaka and designated clearing regions; conforms to the international best practices, cost effective solution for cheque processing [4].

Therefore, after getting customers' cheques for collection in the bank-branch, collecting banks will check the prima facie information of the submitted cheques, capture images and information, and send them to BACPS electronically. BACPS will then process and send the images and information to the paying banks for validation. Paying banks will examine the pertinent images and information, and send back to the BACPS for payment (further

examination if any inconsistency like fund insufficiency or mismatch of signature etc.) Then BACPS will accumulate all the information; workout a single net amount for each bank, and send back to the collecting banks. As such, cheque clearing time is expected to be turned down to a single day for countrywide payment. In other cases, this will be a matter of couple of hours only. Disaster centre for retrieving data [4].

2.3 In Submarine Cable

The government has already taken initiatives to connect Bangladesh with the second Submarine Cable Network to have secured connectivity with the information superhighway. The latest statistics (ITU 2007) revealed that internet penetration is only 0.3% in Bangladesh, whereas the rate is 7.3 and 5.3% respectively in India and Pakistan [4].

2.4 In E-commerce

BB has achieved a historic milestone in the trade and business arena, departing from conventional banking with the introduction of e-commerce recently; a giant stride towards digital Bangladesh. Banks have been allowed to make online money transactions, payment of utility bills through internet, transfer of funds (account to account), payments for trading goods and services, and facilitate online credit card payments in local currency.

2.5 In ICT policy

The government passed the national ICT policy with guidance from the access to information program of the Prime Minister's Office [6]. Under this policy, 306 work plans have been drawn up with a specific time frame. At the end of 2009, within the scope of this plan, the short-term projects were achieved. Among these projects, services like utility bill payment using mobile phone in Dhaka, Chittagong, Sylhet, Pabna, Cox's Bazar and the Hill Tracts, finding out the timetable, fare, seat availability of trains, and receiving advance warning of disasters via mobile phone are already available. DCs and upazila nirbahi officers have been trained and connected via laptops and internet. The government has taken initiatives to promote ICT among all spheres of people, including the hard-to-reach areas; tax and duty cut on computers, promoting ISP services etc.

2.6 In Education

In 2009 SSC and HSC results were made available via mobile and internet, and were also emailed to the educational institutions. The work for providing laptop and internet connectivity was started in various schools and colleges. Using the data from the education boards, Shahjalal University

completed its admission registration process via mobile phone-based applications. For the first time, results of medical college exams and primary exams were available through sms[6]. To make high speed internet more affordable for students of Shahjalal University and Dhaka University, special free wi-fi zones have been created. To ensure timely availability of textbooks to students, they have been published online. The science and ICT ministry has not only set up computer labs in 128 schools in 64 districts, but has also appointed IT professionals there.

2.7 In Health

The country's 800 health centres have been given internet and mobile connectivity. Several telemedicine centres have been built. Along with mobile health services by the private sector, upazila health complexes have started offering similar services. To ensure equal access to technology for all, the government is setting up community e-centres/ tele-centres all across the country -- there are more than 2,300 of them now. The Registrar of Joint Stock Companies and Firms has digitalised its registration process.

2.8 Machine Readable Passport

Prime Minister Sheikh Hasina on Wednesday (3rd June, 2010) launched the much - desired Machine Readable Passport (MRP) and Machine Readable Visa (MRV) taking the country a step forward towards Digital Bangladesh[2]. "From today we have entered into the digital era and the country's passport and visa system has been raised to international standard with the introduction of MRP and MRV," she said while inaugurating the MRP and MRV at the Osmani Memorial Hall here[2].

2.9 Others

Besides the government initiatives, various private initiatives have started to bloom as well. "Digital festivals" and "IT festivals" have been held in various parts of the country. Even as remote a place like Bagerhat organized a knowledge festival. BCS, Basis and Bangladesh Open Source Network took active part in these festivals, which have increased people's interest towards computers.

3. IDENTIFICATION OF CRITICAL FACTORS

Although there are many good initiatives like these, these are all right. Among the disappointments, the most important non-starter has been the automation process of Chittagong Custom House, even though the work had been completed and the finance

minister had inaugurated it. VoIP has not been properly liberalized and the long distance telecommunication policy has not been modified even after initiatives were taken to do so. Neither has the work been started for the backbone network of the secretariat. Work on the government's own network, "banglagov.net," has not resumed [6].

Experts say that government websites, launched 10 years ago as part of the e-governance initiative, were intended to make it easier for citizens to interact with public agencies. It meant no longer wait in queues in government offices to make complaints, pay bills or apply for special programmes. Instead, the websites are merely Windows dressing, say experts.

A 2010 United Nations survey showed Bangladesh had improved its e-government but still ranked 134 out of 184 countries. That was above Pakistan, but below the Maldives, Sri Lanka and India. The ranking was based on criteria such as the presence of web pages, information on public policy and whether citizens could give immediate feedback. Government officials admit their websites are unattractive, clunky and a flop among citizens. They blame the lack of techno-savvy people to look after the websites, which require at least half an hour a day to update and maintain. So the task falls to administrators who work on the home pages in addition to their official duties. The result is that many websites are lagging behind. When the nation was on a swine flu alert last August, a review showed the websites for the health ministry and other government offices carried nothing on the scare.

Even for more mundane matters--paying taxes or making an appointment to get a car fitness certificate--government websites fall far short, say experts. The portals for the 64 districts launched in January are not interactive, and mostly contain a collection of barebones information [8].

Many of the websites are also not available in Bangla, making them nearly useless to the bulk of the population. "The government needs to realize when they are providing content for the general people," said Jabbar, adding, "They need to do it in the language of the general people. They need to post contents for 150 million people, not just the five or six lakh who use Internet [8]".

But even the five or six lakh regular Internet surfers may find the cyber waves to be choppy. The website of the Ministry of Chittagong Hills Tracts Affairs, for one, has been dead for some time now [8].

Under the Ministry of Health there are medical universities, colleges and hospitals in big cities. In addition, there are a large number of rural hospitals/clinics/healthcare service centers at district, upazila, and thana levels. However, most of these hospitals and clinics are not well equipped and their services are not of desirable quality. The number of qualified doctors and nurses is much less than required. Nor do they have required type of diagnostic equipment and operating theatres. Reportedly, the available facilities and medicines are often misused.

4. WHAT TO DO?

4.1 The Political Commitment

All the political parties of Bangladesh must be committed to make a digital Bangladesh. Our government must take proactive steps to reach the technology to rural citizens so that the access of information might become very easier to the grass root levels citizens.

4.2 ICT infrastructure

A broadband infrastructure is needed with access for all Bangladeshis from their homes, work places, schools and tele-centres with Wimax and 3G network. We also need a digitally literate population and workforce, digital business development, and a legal framework that assures freedom of expression while protecting the rights of creators and innovators towards building an indigenous knowledge and technological base.

To make this infrastructure the Government has to take the following initiatives:

- The Govt. has to implement the TNT line up to each village so that ICT might reach at the door step of the villagers.
- The internet connectivity should be free so that the citizens can access easily and can understand its necessity first. After then the people can access it giving charge implemented by the Govt.

4.3 Increase Connectivity

Connectivity options to the rural areas can be improved, by using wireless access. A PC in Bangladesh costs around 12-15 months of average per-capita income as compared to China's 4 months and USA's 12 days. Hence, the govt. should

- Reduce the cost of taking PC.
- Reduce the tariff levels of ICT equipment and accessories to bring even a bigger population under Internet coverage.
- Connect the rural people by using wireless access.

4.4 Set up Talent Managerial

We must have the local experts to control the system of digital Bangladesh. To install the DB we need foreign help but to maintain its sustainability we must need local experts. So the Govt. must take initiative to promote of Science and Technology and management education. So,

- The Govt. must install a separate plan to produce sufficient number of scientists, computer and communication engineers, software engineers, technology management experts, etc.
- The Govt. needs to make a separate university for the fulfillment of such vision.

4.5 Health Sector

ICT can help bring medical expertise to Upazilla and District headquarters. Tele-medicine, for instance may link healthcare centers in remote locations, through satellites, with super specialty hospitals at major towns / cities. Thus it can bring connectivity between patients at remote end, with specialist doctors, for medical consultations and treatment.

By this way decisions can be implemented very quickly. This will ease out management problems. Because the entire information and data set will flow back and forth electronically they will be relatively more transparent and in turn the probability of indulgence in corruption will decrease.

- The Govt. should implement Video conference systems between doctors in major clinics.
- The Govt. should take initiatives to recruit doctors with TNT line through which from the remotest corner of the country the villagers can take serve through Massage or call.
- The Govt. should encourage other mobile companies so that they must implement it cheapest rate.

4.6 Private Sector

To make Digital Bangladesh the Govt. have to develop the private sector for efficiency and reduction of corruption and citizen harassment, in areas such as railway ticketing, tracking of Hajis etc. Services such as utility billing should be outsourced to the private sector. The ICT sector has to be utilized for efficiency in domestic organizations, particularly the government, which will ultimately lead to better services for citizens. Private companies and NGOs can partner, in order to enhance awareness and utilization of ICT at the grass-roots level. For instance, NGO's can work to bring elementary computer literacy to the people of rural Bangladesh. They can make arrangements so

that IT professionals and educators visit rural schools and help students get familiar with technology.

4.7 Village Sector

The villages are situated at a long distance from the digital society; scholars, professors, face book users. There are about 80% of citizens live in village where students are not well dress up, have no money to take Tiffin, the teachers are often bare footed is a elderly bearded wearing a purple and white hat, have a stick to manage his students. In many villages there exists no electricity, no clean drinking water, and no computer in school. So to make digital Bangladesh we must develop the rural people of Bangladesh.

- For the developing the village sectors through ICT the Govt. have to reach the electricity as well as the internet connection by reaching the TNT line to all the villages of Bangladesh.
- The schools, Hospitals and Union board must be brought under the internet connections.
- The villagers should have the opportunity to communicate with the Govt. electronically.

4.8 The Garments Factories

About 79.1% income of export has come from readymade garments in 2008-2009 amounted 67257.1 core taka [12]. To make digital Bangladesh we must digitize the garments factories for the connection with government digitally. By this way the Govt. can take care of the garments factories which will be the best source of revenue. The Govt. must take necessary steps to implement the followings

- Every Garments factory must have a website where there will have the list of all employees with their status and salaries.
- There will have a linkage between the Govt. and the Garments factories through which the Govt. can monitor these factories.
- The Govt. can make pressure to the Authorities of the Garments factories so that the living standard of the employees of garments factories must increase by increasing their salary and other facilities.

4.9 Agriculture Sector

Since more than half of our population is employed in agriculture; our planner should put ICT to good use in agriculture. For example, India has led the use of remote sensing satellite information for locating irrigation projects. The Internet has been effectively used in some of the villages to ensure effective dissemination of agricultural commodity price information.

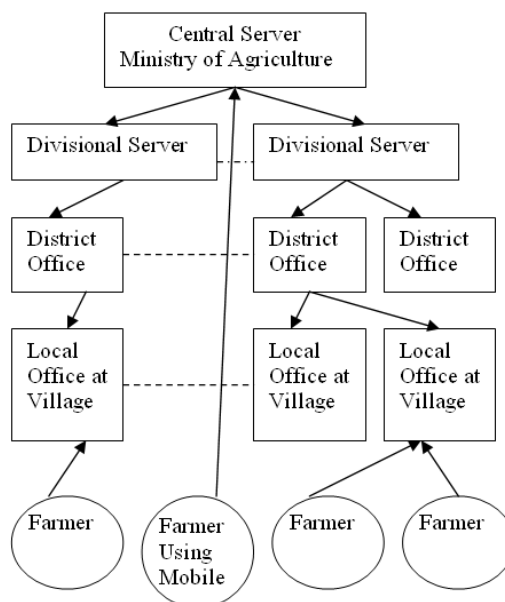


Fig 2: E-Agriculture [Habib/Mustafij © ACM 2009]

The above solution is proposed by [1] named 'E-Agriculture' to show how a farmer will be benefited from digital Bangladesh.

4.10 E-Democracy

The Prime Minister's Office (PMO) should introduce video conferencing in the administration level so that the prime minister can talk to officials at district and upazila levels through it. The mass people must have opportunity to share views with the government officials' electronically.

4.11 Greener Bangladesh

To make DB, Bangladesh should turn into a greener country which will change our climate into a better position. So engineers should play their role for a greener energy based digital Bangladesh.

- To make green Bangladesh quickly, the Govt. can make awareness of the green environment through TV and teleconferencing in such a way that if we transfer the country into a greener country through tree plantation then the country will be save from natural calamities quickly.
- The Govt. can encourage all the mobile companies for marking the people to be aware of green environment through SMS.

4.12 Paperless Office

All the offices government and private should be paperless. The offices should be automated through network. The officers should use digital signature.

4.13 Inter Departmental Cooperation

There must be a sense of balanced cooperation among the departments of the government as an example, the procedure to convey a passport to a citizen is done with the cooperation of passport office and the police department [1]. If the relationship between both departments is cordial and mutually beneficial in their interactions, providing service to the stakeholders will become smooth.

4.14 Others

The Govt. should promote IT systems in all government offices, trade and business to alleviate poverty, create more jobs and eradicate corruption. The government should keep in mind at least the following considerations.

- Priority should be given to automating government services that benefit a large section of the population, such as land record digitization.
- Development of web, radio and TV content that is comprehensible by large sections of the population should be emphasized and encouraged.
- Special incentives should be given to the private sector and NGOs to develop ICT-based services specifically targeted towards the under-served.

5. RECOMMENDATIONS

Latest statistics reveal that Bangladesh faces a power deficit of up to 2000 MW against a demand of 5000 MW daily. It may be noted that for proper ICT development an uninterrupted power supply is a must.

From different sources, it has been learnt that, English literacy rate in Bangladesh is less than one percent. There is a strong correlation between English literacy and ICT development in the present context of globalization. In the arena of ICT English has become the Lingua-Franca. Hence, English literacy is a must for our ICT development.

For making a digital Bangladesh by 2021, the government must address the above stated issues effectively and efficiently in transparent manners. In many cases we need to reformulate our national policy (e.g. education policy, ICT policy) in accordance with the Millennium Development Goals. In reformulating the ICT policy, we will need to take a pragmatic and visionary approach so that it can curb the prevailing digital gap in the society. Moreover, the journey towards a digital Bangladesh needs the incorporation of the technologically solvent innovative younger

generation. If the leaders of our country objectively guide this generation, they can do wonder for the nation. After all, the young generation always looks forward and they can help bring about positive changes in the society.

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COST BENEFIT ORIENTED ANALYSIS FOR DESIGNING OPTIMUM QUALITY ASSURANCE PRACTICES

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ABSTRACT: Quality assurance is a planned and systematic pattern of all actions necessary to provide confidence that an item or product conforms to established technical requirements. In a competitive market, quality assurance is essential to reduce unwanted cost of rework. Reducing cost by detecting and preventing defects at earlier stages of Software development phases, Software Companies can maximize benefits in different stages of software development life-cycle. This paper focuses on detection and prevention of defects at earlier stages of software development and designing optimum quality assurance practices to make tradeoff between the quality and the cost. Resource wastage and rework in software production can be visible and analyzed thus organization can reach the objective of the best balance between software quality vs cost and maximize net benefit.

Key words: Software quality assurance, Defect Prevention, Process Improvement, Gross Benefit, Net Benefit

1.0 INTRODUCTION

To get the real scenario about the software quality assurance [21] practices we visited some software outsourcing company in Bangladesh. These companies are offshore software development and information and communication technology (ICT) consulting firm which develops software product, provides application and web development/solutions and performs IT consultancy in various fields for many businesses in Europe and other parts of the world. These companies define itself by emphasizing central focus on providing best services to valued customers. They offer efficient solutions to valued customers by integrating solutions into their businesses' strategy, practices and tools. Their main focus is to help customers add value to their businesses through the services provided by them. They believe in mutually beneficial long term partnership with their customers and they significantly invest their resources on learning & implementing new technologies in the most innovative manner to enhance performance, promote efficiency and finally, add tangible values to the businesses of our customers.

The focal point of all services provided by these software companies is customer satisfaction and the foundation is quality assurance [21] policy. They believe and practices in creating long term mutually beneficial relationship with customers by

establishing close partnership at both technical as well as management level and by understanding the customers' business focus, values, practices, and processes. Their quality assurance policy ensures that all deliverables are provided on time, kept within scopes, delivered with quality as agreed upon by both customers and the outsourcing companies; and thus ensuring value addition to the business of our customers. Since they have the vision "Value Added Off-shore Services" is to add measurable business value for their customers in addition to integrating technology to Off-shore Software Development, they should emphasis on improving research methodology to ensure software quality.

1.1 PURPOSE

The purpose of this document is adhering to defect detection and defect prevention techniques to enhance quality of the product. Pro-active Defect Prevention (DP) is to create an environment for controlling defects and reduce cost. Defects that can be captured with the ratio of inspection and testing are only 80%. Cost required for rework is found to be more expensive than the cost incurred in adhering to DP strategies. The focal point of quality cost investment is to invest in right DP activities rather than investing in rework which is seen as an outcome of un-captured defects

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1.2 SCOPE

This document describes an analysis based on data obtained from leading software companies of varying software production competence. Defect prevention (DP) is a process of identifying defects, their root causes and corrective and preventive measures taken to prevent them from recurring in future. Identified defects are classified at two different points in time 1) time when the defect was first detected and 2) time when defect got fixed. If a defect dwells for a longer time in the product, it is more expensive to fix it. Therefore, it is necessary to reduce defect injection and boost defect removal efficiency. The cost of rework for 1% of defect when identified at the customer's site is 10 times the cost required for fixing the same defect when identified in-house. As a matter-of fact, companies adapting to DP strategies over a period of time, quality of the product is enhanced while the cost of quality is reduced. This document covers all of the activities and support required to reduce cost and reduce rework from the software requirements analysis phase through completion of the system test phase of the software life-cycle.

2.0 Methodology of data gathering and analysis

2.1 Characteristics of Software Quality

Software has both external and internal quality characteristics. External characteristics are characteristics that a user of the software product is aware of including,

- Correctness- The degree to which a system is free from faults in its specification, design, and implementation.
- Usability - The ease with which users can learn and use a system.
- Efficiency - Minimal use of system resources, including memory and execution time.
- Reliability - The ability of a system to perform its required functions under stated conditions whenever required—having a long mean time between failures.
- Integrity - The degree to which a system prevents unauthorized or improper access to its programs and its data. The idea of integrity includes restricting unauthorized user accesses as well as ensuring that data is accessed properly—that is, that tables with parallel data are modified in parallel that date fields contain only valid dates, and so on.
- Adaptability - The extent to which a system can be used, without modification, in applications or environments other than

those for which it was specifically designed.

- Accuracy - The degree to which a system, as built, is free from error, especially with respect to quantitative outputs. Accuracy differs from correctness; it is a determination of how well a system does the job it's built for rather than whether it was built correctly.
- Robustness - The degree to which a system continues to function in the presence of invalid inputs or stressful environmental conditions. Some of these characteristics overlap, but all have different shades of meaning that are applicable more in some cases, less in others.

External characteristics of quality are the only kind of software characteristics that users care about. Users care about whether the software is easy to use, not about whether it's easy for us to modify. They care about whether the software works correctly, not about whether the code is readable or well structured.

Programmers care about the internal characteristics of the software as well as the external ones, and it focuses on the internal quality characteristics. They include

- Maintainability - The ease with which we can modify a software system to change or add capabilities, improves performance, or correct defects.
- Flexibility - The extent to which we can modify a system for uses or environments other than those for which it were specifically designed.
- Reusability - The extent to which and the ease with which we can use parts of a system in other systems.
- Readability - The ease with which we can read and understand the source code of a system, especially at the detailed-statement level.
- Testability - The degree to which we can unit-test and system-test a system; the degree to which we can verify that the system meets its requirements.
- Understandability - The ease with which we can comprehend a system at both the system-organizational and detailed-statement levels.

The difference between internal and external characteristics isn't completely clear-cut because at some level internal characteristics affect external ones. Software that isn't internally understandable or maintainable impairs our ability to correct defects, which in turn affects the external characteristics of correctness and reliability. Software that isn't flexible can't be enhanced in

response to user requests, which in turn affects the external characteristic of usability. The point is that some quality characteristics are emphasized to make life easier for the user and some are emphasized to make life easier for the programmer. The following chart shows only typical relationship

among the quality characteristics. On any given project, two characteristics might have a relationship that's different from their typical relationship.

How focusing on the factor below affects the factor to the right	Correctness	Usability	Efficiency	Reliability	Integrity	Adaptability	Accuracy	Robustness
Correctness	↑		↑	↑			↑	↓
Usability		↑				↑	↑	
Efficiency	↓		↑	↓	↓	↓	↓	↓
Reliability	↑	↑		↑	↑		↑	↓
Integrity			↓	↑	↑			
Adaptability					↓	↑		↑
Accuracy	↑		↓	↑		↓	↑	↓
Robustness	↓	↑	↓	↓	↓	↑	↓	↑

Helps it ↑

Hurts it ↓

2.2 Finding a Defect

Debugging consists of finding the defect and fixing it. Finding the defect (and understanding it) is usually 90 percent of the work. Debugging by thinking about the problem is much more effective and interesting than debugging with an eye of newt.

2.3 The Scientific Method of Debugging

Here are the steps we go through when we use the scientific method:

- i. Gather data through repeatable experiments.
- ii. Form a hypothesis that accounts for the relevant data.
- iii. Design an experiment to prove or disprove the hypothesis.
- iv. Prove or disprove the hypothesis.
- v. Repeat as needed.

This process has many parallels in debugging. Here's an effective approach for finding a defect:

- i. Stabilize the error.
- ii. Locate the source of the error (the "fault").
 - a. Gather the data that produces the defect.
 - b. Analyze the data that has been gathered and form a hypothesis about the defect.
 - c. Determine how to prove or disprove the hypothesis, either by testing the program or by examining code.
 - d. Prove or disprove the hypothesis using the procedure identified in ii(c).
- iii. Fix the defect.
- iv. Test the fix.
- v. Look for similar errors.

2.4 BENEFITS OF EARLY DETECTION AND PREVENTION

Table 2.4: Cost of Defects/ Price of quality

Phase	Relative Cost to Correct defect
Definition	\$1
High-Level Design	\$2
Low-Level Design	\$5
Code	\$10
Unit Test	\$15
Integration Test	\$22
System Test	\$50
Post-Delivery	\$100+

3.0 Analysis of Action, Description and Responsibility

As special technical skills are needed, such as those of database administrators, quality assurance [21] specialists, human factors specialists, and technical writers, it becomes more and more important to plan organization structures carefully. Indeed, among the hallmarks of the larger leading-edge corporations are measurement specialists and measurement organizations. One of the useful by-products of measurement is the ability to judge the relative effectiveness of organization structures such as hierarchical vs. matrix management for software projects and centralization vs. decentralization for the software function overall. Here too, measurement can lead to progress and the lack of measurement can lead to expensive mistakes.

Table 3.1: Overview of Software Estimation Steps

Action	Description	Responsibility	Output Summary
Step 1: Gather and Analyze Software Functional & Programmatic Requirements	Analyze and refine software requirements, software architecture, and programmatic constraints.	Software manager, system engineers, and cognizant engineers.	- Identified constraints - Methods used to refine requirements - Resulting requirements ☐ Resulting architecture hierarchy
Step 2: Define the Work Elements and Procurements project.	Define software work elements and procurements for specific	Software manager, system engineers, and cognizant engineers.	☐ Project-Specific product based software WBS ☐ Procurements ☐ Risk List
Step 3: Estimate Software Size	Estimate size of software in logical Source Lines of Code (SLOC).	Software manager, cognizant engineers.	☐ Methods used for size estimation ☐ Lower level and total software size estimates in logical SLOC
Step 4: Estimate Software Effort Software manager, cognizant	Convert software size estimate in SLOC to software development effort. Use software development effort to derive effort for all work elements.	engineers, and software estimators.	☐ Methods used to estimate effort for all work elements ☐ Lower level and Total Software Development Effort in work-months (WM) ☐ Total Software Effort for all work elements of the project WBS in work-months ☐ Major assumptions used in effort estimates
Step 5: Schedule the effort	Determine length of time needed to complete the software effort. Establish time periods of work elements of the software project WBS and milestones.	Software manager, cognizant engineers, and software estimators.	☐ Schedule for all work elements of project's software WBS ☐ Milestones and review dates ☐ Revised estimates and assumptions made
Step 6: Calculate the Cost	Estimate the total cost of the software project.	Software manager, cognizant engineers, and software estimators.	☐ Methods used to estimate the cost ☐ Cost of procurements ☐ Itemization of cost elements in dollars across all work elements ☐ Total cost estimate in dollars
Step 7: Determine the Impact of Risks	Identify software project risks, estimate their impact, and revise estimates.	Software manager, cognizant engineers, and software estimators	☐ Detailed Risk List ☐ Methods used in risk estimation ☐ Revised size, effort, and cost estimates
Step 8: Validate and Reconcile the Estimate Via Models and Analogy	Develop alternate effort, schedule, and cost estimates to validate original estimates and to improve accuracy.	Software manager, cognizant engineers, and software estimators.	☐ Methods used to validate estimates ☐ Validated and revised size, effort, schedule, and cost estimates.

Step 9: Reconcile Estimates, Budget, and Schedule	Review above size, effort, schedule, and cost estimates and compare with project budget and schedule. Resolve inconsistencies.	Software manager, software engineers, software estimators, and sponsors.	☐ Revised size, effort, schedule, risk and cost estimates ☐ Methods used to revise estimates ☐ Revised functionality ☐ Updated WBS ☐ Revised risk assessment
Step 10: Review and Approve the Estimates	Review and approve software size effort, schedule, and cost Estimates	The above personnel, software engineer with experience on similar project, line and project management.	☐ Problems found with reconciled estimates ☐ Reviewed, revised, and approved size, effort, schedule, and cost estimates ☐ Work agreement(s), if necessary
Step 11: Track, Report, and Maintain the Estimates	Compare estimates with actual data. Track estimate accuracy. Report and maintain size, effort, schedule, and cost estimates at each major milestone.	Software manager, software engineers and software estimators	☐ Evaluation of comparisons of actual and estimated data ☐ Updated software size, effort, schedule, risk and cost estimates ☐ Archived software data

4.1 OBSERVATIONS ON THE OUTPUT OF ANALYSIS

Table 4.1: Current Capability Assessment about REQUIREMENTS

Objective	Policy	Procedures Practices & Sequence	Standard DOC	Cost	Help Objective
To cover functional and non-functional requirement, security requirements, interface requirements, user specific requirements, and system requirement of the project.	capabilities to deliver products, projects and services of an outstanding quality Quality requirements Testability Implement ability Integrity Maintainability Functional Requirements General Information - Concise, Complete and Consistent	- Existing Business process. - Modification Requirement of Existing Business Process - Functional and non functional requirements - System requirements - Existing Hardware & Software - Security Requirements - Expandability / Portability - Usability - Efficiency/Performance, Acceptance Criteria Review Checklist.	SRS Compliance Document Content General Information - Concise, Complete and Consistent Integrity Maintainability Performance Usability & User Training Portability Quality	\$2000	- Review information system procedures - Assure internal reviews to eliminate ambiguities and uncertainties -Assure internal reviews to define requirements in terms of their testability

Table 4.2: Current Capability Assessment about DESIGN

Objective	Policy	Procedures Practices & Sequence	Standard DOC	Cost	Help Objective
The Design considerations must cover any assumptions or dependencies which need to be addressed or resolved before attempting to devise a complete design Solution.	Architectural Design Detailed Design User interface design	Project Schedule Design Document Review Checklist Meeting Minutes Data Dictionary Entity Relationship Diagram User Interface	Design Document Review Check List Configuration Plan Configuration Control. Architectural/Logical phase of Designing	\$2000	-Promote peer inspections of new/modified design components for new releases -Assure proposed design changes are approved

Table 4.3: Current Capability Assessment about CODING

Objective	Policy	Procedures Practices & Sequence	Standard DOC	Cost	Help Objective
Coding procedure will maintain for both new project and enhancement of existence software project/module	Company Code Convention. Source Code tagging Configuration Management Plan. Review Meeting	Review the details design plan, identify legacy/external resources consider development and language/tools/technology selected for coding before start the actual coding phase by a review meeting. maintain the Project Schedule accordingly	The default java & Microsoft coding convention is used computing and software infrastructure	\$10000	-Review code against coding standards (source lines of code, complexity)
		code review meeting Minutes of the review is prepared and kept in the Project File. Approval for commencing Testing Phase is given.			

Table 4.4: Current Capability Assessment about TESTING

Objective	Policy	Procedures Practices & Sequence	Standard DOC	Cost	Help Objective
To ensure that the development is complete as per the Requirement of the Client for both new software project and for the maintained software project.	Purpose and Scope: Methodology Risk Analysis Configuration Plan Test Plan Progress Monitoring Project Schedule Deliverables Team Structure	Test Planning is done during the Analysis Phase and is stated in the Project plan. Unit testing System acceptance security test & other tests Test Plan. Test Schedule Test Specifications	Functional Tests Boundary Tests, Performance Tests	\$4000	-Participate in dry runs to assure real-time performance -Monitor actual timing results during stand-alone, integration and system level testing

Table 4.5: Current Defect Detection Assessments

Defect		Case Analysis												Cost of Defect Fixation	Migration Cost	Cost of Prevention
Entry	Detection	Requirement			Design			Coding			Testing					
		Policy	Procedure	Standard	Policy	Procedure	Standards	Policy	Procedure	Standard	Policy	Procedure	Standard			
Ambiguity	Standards	feedback from customers, staff, project reviews	Performance causal analysis and prioritize root causes	Integrity Maintainability Performance Usability & User Training Portability Quality	buffering and blocking	Records are labeled, indexed and filed	annotation standards DB design, use case design	Update coding standards for imports, naming, and user interface	Arrange code reading sessions.	Programming language standard	Verification and validation	Ensure effective implementation of QMS internal email system, intranet, daily scrum meeting, recording and circulation of management review meeting	Test plan	\$2500	\$2500	\$2000
Redundant data	Redundant Code Logic												Test report			

5.0 Suggestions for improving better balance between quality and cost based on analysis

In the previous tables we have certainly observed that prevention of defects and detection of early defects is the major requirement to improve software quality. If the error is detected at later stages the cost is also increasing proportionally in order to fixing the bugs. Even the quality decreases if the errors are detected at later stages because fixing a bug at later stages may add another bug and cause system malfunctioning. Based on the scenario we shall propose for improving better balance between quality and cost based on analysis are as follows:

Table 5.1: Proposed Capability Assessment about REQUIREMENTS

Objective	Policy	Procedures Practices & Sequence	Standard DOC	Cost	Help Objective
Gathering/eliciting/ascertaining/uncovering requirements Analyzing (and perhaps modeling and/or refining) those requirements for consistency, completeness, appropriateness, and so on Determining what subset of those requirements should actually be addressed given the constraining budgets and schedules Documenting the selected requirements Verifying that the specified requirements conform to all the quality standards Managing changes to requirements	formal specification techniques defensive design Promote informal communication among teams	Focus on interfaces between the software and the system in analyzing the problem domain Identify critical hazards early in the requirement analysis.	Function Identification Function Organization Function Specification Functional Requirements Documentation Requirements Performance Requirements Security Requirements Interface Requirements Portability Requirements Resource Requirements Maintainability Requirements Acceptance-Testing Requirements	\$1500	-Assure use of the requirements volatility metrics . Maintain system requirements . Assure functional baseline

Table 5.2: Proposed Capability Assessment about DESIGN

Objective	Policy	Procedures Practices & Sequence	Standard DOC	Cost	Help Objective
Design consists of multiple views (both static and dynamic) A design is evaluated against goals (requirements), often using standard properties(e.g., coupling and cohesion)	Hierarchical decomposition Top-down design Object-oriented design Functional design	Project Schedule Design Document Review Checklist Meeting Minutes Data Dictionary Entity Relationship Diagram User Interface	Data Flow Diagrams Transformation Schema Structured English Decision Tables State-Transition Diagrams Transition Tables Precondition-Post conditions	\$1500	-Participate in formal customer design reviews with the customer . Assure allocated baseline . Assure that test procedures cover all testable requirements

Table 5.3: Proposed Capability Assessment about CODING

Objective	Policy	Procedures Practices & Sequence	Standard DOC	Cost	Help Objective
Formatting, Layout and Style Defensive Programming Managing Construction	Commenting Format of Control Structures Compound Statements switch/case Statement	naming convention must be followed performing activities and their sequence to comply policies	The default java & Microsoft coding convention is used computing and software infrastructure Source code for functions should	\$8500	-Assure internal SCM for problem control and corrective action logs -Assure version control of
	Entry Condition Loops vs. Exit Condition Loop Functions		generally not exceed 50 lines of code. Functions shall begin on a new page.		development software prior to integration

Table 5.4 Proposed Capability Assessments about TESTING

Objective	Policy	Procedures Practices & Sequence	Standard DOC	Cost	Help Objective
The goal testing for software is to quickly find the defects in requirements and code and get the software running as an integrated component of the enterprise financial system as well as provide guidance for the people testing the software.	Purpose and Scope Methodology Risk Analysis Configuration Plan Test Plan Progress Monitoring Project Schedule Deliverables Team Structure Testing of individual program components; Defect testing	Test Planning is done during the Analysis Phase and is stated in the Project plan. Unit testing System acceptance security test & other tests Test Plan. Test Schedule Test Specifications	Acceptance testing Alpha test Beta test Installation testing Testing process goals Validation testing System testing Component testing Comparison testing Compatibility testing End-to-end testing Risk analysis testing Regression testing Compliance testing	\$3000	-Assure adequate regression testing as necessary -Assure adequate description exists of the released software version

Table 5.5: Quality and Cost Benefit Based Analysis of proposed capability:

Defect Entry		Case Analysis												Cost of Defect Fixation	Migration Cost	Cost of Prevention
Detection		Requirement			Design			Coding			Testing					
		Policy	Procedure	Standard	Policy	Procedure	Standards	Policy	Procedure	Standard	Policy	Procedure	Standard			
Logic Standards, Redundant code	Training on Database structure	Pareto analysis	Do a requirement walkthrough	Business process.	Define the rules and procedures for realizing an architecture in a completed system	Review the status and benefits of DP at end of next iteration	functional Database design	Traceability	use of global versus local variables, prohibiting the sharing of temporary intermediate storage between procedures, use of copy mem	logical flow	Validation testing	minimum testing and test case documentation required documenting of test cases, expected results, and test data, methods for running tests, methods for documenting actual results, methods for correcting errors and re-running test cases.	Test plan	\$500	\$500	\$1000
User Interface	object model	Implement solutions	Improve the communication and Coordination	Modification of Process -			Evaluate the architecture as implemented	Follow the exception handling			Defect testing		Test report			
Architecture	Perform causal analysis and prioritize root cause	Review the status and benefits of DP at end of next iteration	Should be examine concurrency problem or time	Functional and non functional requirements - System							Unit testing		Test result			
Information duplicacy																
concurrency problem	Identify and develop solutions															

6.0 Recommendation to improve

6.1 Improve project SQA processes

The SQA activity for process improvement requires:

- I) Understanding project and SQA processes
- II) Determining where inefficiencies or defects occur (root causes of defects)
- III) Recommending changes to project processes to improve efficiency or reduce defects
- IV) Recommending improvements to eliminate the root causes of defects
- V) Recommending training courses for the project team

The purpose of this activity is for SQA to review existing project and SQA processes and report on efficiencies and areas for improvement and identify processes that need to be defined. To improve project SQA processes, SQA needs to review and audit both project processes and SQA processes. This will ensure that project processes and project SQA processes are

consistent and compatible with one another. Process improvement may result in changes to the policy, processes, and/or procedures.

6.2 Measurements for Defect Analysis

In some sense the goal of all methodologies and guidelines is to prevent defects. For example, a design methodology gives a set of guidelines that if used will give a good design. In other words, the design methodology aims to prevent the designer from introducing design defects by guiding him along a path that produces good and correct designs.

However, by defect prevention (DP) we mean learning from actual defect data from a project with the goal of developing specific plans to prevent defects from occurring in the future. As the main goal of DP is reduction in defect injection and consequent reduction in rework effort, it is best if suitable measurements are made such that impact of DP can be quantitatively evaluated. That is, a project employing DP should be able to see the impact of DP in the injection rate and on the rework effort on the project. For both of these proper metrics have to be collected. Furthermore, suitable data needs to be collected to facilitate the root cause analysis for DP.

The measurements needed for evaluating the effectiveness are defects and effort. For defects,

data on all the defects found and their types is needed.

This data is easily available if projects follow the practice of defect logging, as is the case in most mature organizations. To facilitate defect analysis, for each defect, its categorization in a fixed set of categories should also be recorded. A classification like the one proposed by the IEEE standards [23], or by the orthogonal-defect classification scheme [22] can be used.

Frequently, organizations log information like detection stage, injection stage, etc to facilitate different types of analyses. Details about the different parameters recorded during defect logging are given in [9]. For understanding the impact of DP on rework, the effort spent on the project needs to be recorded with suitable granularity such that rework effort can be determined. Specifically, for each quality control activity, the rework effort should not be clubbed together with the activity effort but must be recorded separately. Effort logging generally requires that each member of the project team record the effort spent on different tasks in the project in some effort monitoring system. Frequently, different codes are used for different categories of tasks and for most of the major tasks the effort is divided into three separate categories – activity, review, and rework. With this type of categorization, rework effort for each phase can be determined. Details about the system and codes used for effort reporting are given in [9].

These measurements about defects and effort are sufficient to do defect analysis and prevention, as well as quantify the impact of DP. Note that DP can be done, and its impact on the defect injection rate can be determined, even if the effort data is not available. However, without the effort data, the impact of DP on rework cannot be determined.

7.0 Cost benefit analysis

Cost_c of Practicing Current Process

Cost_{im} of Practicing improved Process

$$\begin{aligned}\text{Cost increase} &= \text{Cost}_{im} - \text{Cost}_c \\ &= \$1000 - \$1500 \\ &= \$500\end{aligned}$$

$$\begin{aligned}\text{Gross Benefit} &= [\text{CDF}_c - \text{CDF}_{im} + \text{MC}_c - \text{MC}_{im} + \text{CP}_{im} - \text{CP}_c] \\ &= \$2500 - \$500 + \$2500 - \$500 + \$1000 - \$2000 \\ &= \$3000\end{aligned}$$

$$\begin{aligned}\text{Net Benefit} &= \text{Gross Benefit} - \text{Cost}_{im} - \text{Cost}_c \\ &= \$3000 - \$500 - \$1500 \\ &= \$1000\end{aligned}$$

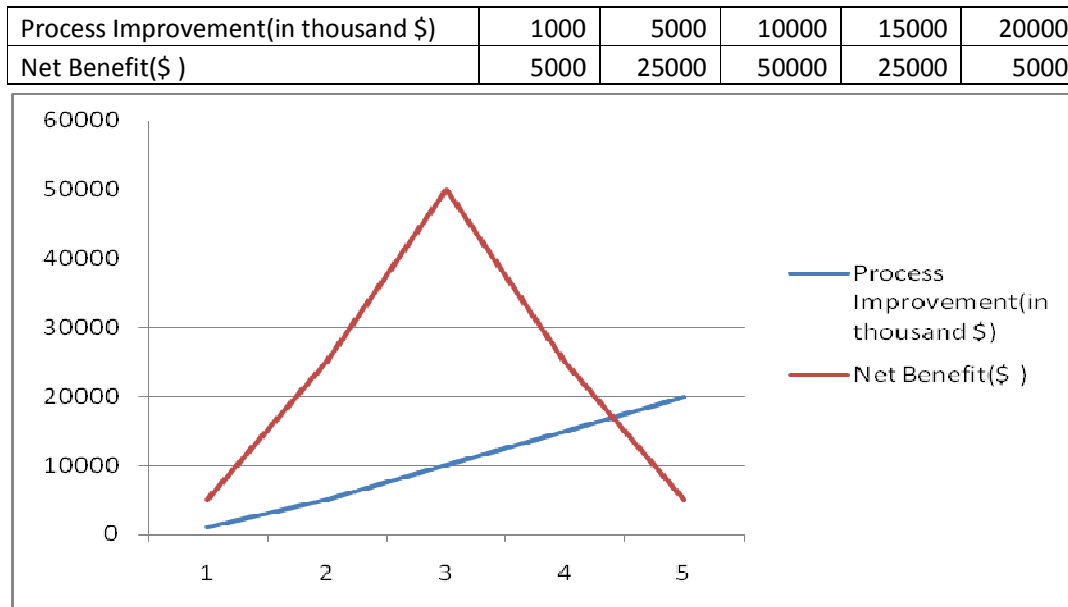


Figure 7.0: Net Benefit vs Process Improvement Graph

8. Conclusion and recommendations

Defect prevention can improve both quality and productivity. If the number of defects injected reduces, then the quality improves as the number of residual defects in the delivered software reduces. Furthermore, if we inject fewer defects, fewer defects need to be removed at earlier stage, leading to a reduction in the effort required to remove defects. The subjectivity of Net benefits vs process improvement graph measures the visibility on defection and prevention of defects at earlier stages. Optimum Software quality assurance practices and reduce rework for cost benefit oriented analysis can be visible and analyzed thus organization can reach the objective of the best balance for improving quality product and cost reduction process.

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DEVELOPMENT OF A VOICE CONTROLLED ROBOTIC ARM

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This paper describes a robotic arm with 5 degrees-of-freedom (DOF) which is controlled by human voice and has been developed in the Mechatronics Laboratory, CUET. This robotic arm is interfaced with a PC by serial communication (RS-232). Users' voice command is captured by a microphone, and this voice is processed by software which is made by Microsoft visual studio. Then the specific signal (obtained by signal processing) is sent to control unit. The main control unit that is used in the robotic arm is a microcontroller whose model no. is PIC18f452. Then Control unit drives the actuators, (Hitec HS-422, HS-81) according to the signal or signals to give required motion of the robotic arm. At present the robotic arm can perform a set action like pick & pull, gripping, holding & releasing, and some other extra function like dance-like movement, and can turn according to the voice commands.

Key words: Speech recognition; Artificial Neural Networks; PWM; Serial communication; Microcontroller interfacing; SAPI.

1. INTRODUCTION

Nowadays industries, service centers(Hospital), shopping centers, and house hold works are fully dependent on robotics & automation. For example, in a surgery, there are very few people besides the surgeon who actually contribute to the surgery. Most of the other people are there just to hand different tools and instruments to the surgeon, who is the one who actually does the surgery. Or, take the example of a mechanic. A mechanic almost always encounters situations in which he is forced to use a helper or assistant to do different things like holding two pieces of a machine together while welding, etc. It is thus seen that extra workforce is required, workforce that could otherwise be set to do other tasks. This is where the voice controlled robotic arm comes in. A robotic arm that is voice controlled enables the user to have more control over whatever task he is doing and also eliminates the need of unnecessary workforce. Also, the amount of stability and precision offered by the robot will be an added advantage over human assistants.

That is why, we think about a robot which will be controlled by human voice command that is versatile and can be used in a variety of different atmospheres and scenarios. We have successfully

completed the first step in achieving our goal. That is, our robot can now listen to vocal commands given to it and respond accordingly. The final plan involves the robot understanding common phrases from natural speech and acquiring the ability to work seamlessly and in perfect coordination with a person.

2. THE ROBOTIC ARM

To investigate the feasibility of a robot that operates on the basis of natural speech processing, we built a robotic arm that responds to basic commands given to it.

2.1 Working

A microphone receives the voice commands and feeds them to the computer. The SAPI¹ engine detects the commands given and matches the commands with the dictionary created before. Once the commands are decoded, the necessary coordinates are fed to the function that calculates the angles required at each joint by the inverse kinematics mode of mechanics. These angles are then converted to the corresponding on-times required for the Pulse Width Modulation (PWM) for the servos. This information is then fed to the microcontroller via the USART mode of communication. The microcontroller used is an 8-

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1. Speech Application Programming Interface (by Microsoft)

bit microcontroller, PIC16F852 from the microchip family.

The microcontroller then sends the required pulses to the servos attached to the each of the joints of the robot.

2.2 Flow of Control

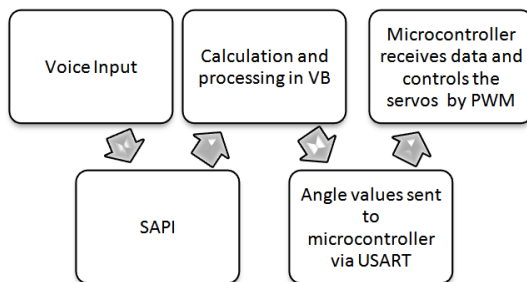


Fig. 1: Flow of control

2.3 Arm Overview

The robotic arm we used in this exploratory research is a small hobbyist device called the Lynx 6 by Lynxmotion. The arm has a total of five degrees of freedom (DOF): shoulder rotation, shoulder bend, elbow bend, wrist rotate, and wrist bend. A simple 2-prong gripper at the end of the arm is used to hold small objects. Figure 5 demonstrates these controllable features. Although the arm has no feedback or sensors, it is still sufficient as a prototype arm for use in this proof of concept exploration.

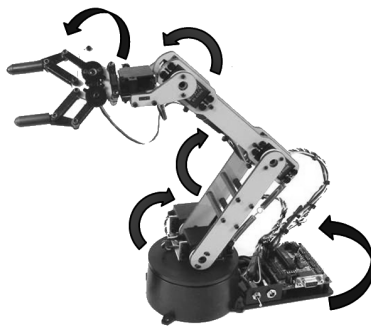


Fig. 2: Lynxmotion Lynx 6

The circuit board provided along with the package was replaced by one that we designed specifically for our purpose.

2.4 Speech Recognition

The Speech Application Programming Interface or SAPI is an API developed by Microsoft to allow the use of speech recognition and speech synthesis

within Windows applications. The SAPI engine is incorporated as a part of the Visual basic program, developed by us, which is responsible for decoding the vocal commands and sending the coordinates to the microcontroller. The SAPI engine is also responsible for the computer responding by means of speech. The version used in our research is SAPI4.0 which has features that include Voice Command, Voice Dictation, Direct Speech Recognition, Direct Text To Speech etc.

2.5 Artificial Neural Network

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. Artificial neural networks are made up of interconnecting artificial neurons (programming constructs that mimic the properties of biological neurons). Artificial neural networks may either be used to gain an understanding of biological neural networks, or for solving artificial intelligence problems without necessarily creating a model of a real biological system. The real, biological nervous system is highly complex and includes some features that may seem superfluous based on an understanding of artificial networks.

Every neural network possesses knowledge which is contained in the values of the connections weights. Modifying the knowledge stored in the network as a function of experience implies a learning rule for changing the values of the weights.

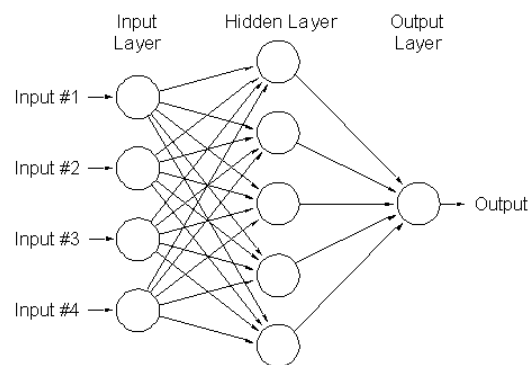


Fig. 3: Artificial Neural Network

Information is stored in the weight matrix W of a neural network. Learning is the determination of the weights. Following the way learning is performed, we can distinguish two major categories of neural networks:

Fixed networks in which the weights cannot be changed. In such networks, the weights are fixed a priori according to the problem to solve.

Adaptive networks which are able to change their weights.

All learning methods used for adaptive neural networks can be classified into two major categories:

Supervised learning which incorporates an external teacher, so that each output unit is told what its desired response to input signals ought to be. During the learning process global information may be required. Paradigms of supervised learning include error-correction learning, reinforcement learning and stochastic learning.

Unsupervised learning uses no external teacher and is based upon only local information. It is also referred to as self-organization, in the sense that it self-organizes data presented to the network and detects their emergent collective properties. Paradigms of unsupervised learning are Hebbian learning and competitive learning.

The SAPI engine uses the adaptive ANN of the first type i.e. Supervised Neural Learning. The computer uses the engine to collect a large amount of speech data from the user and trains itself to recognize the sounds that it receives and interpret the words correctly. The training generates a dictionary of words and phrases that are continually updated with more training. Once ample training is given to the SAPI engine, it is then able to recognize the words or commands given to it easily. After training the engine, we then wrote a program in Microsoft Visual Basic that uses this engine to communicate with the user. At present, our program can recognize around 100 different commands and respond vocally as well as do the work it was designed to do, i.e. control the robotic arm.

2.6 Serial Communication

We chose serial communication (RS-232) to interface our robotic arm with the computer. Serial communication was chosen because most of the computers have the necessary hardware and also because, it can be used over long distances without much loss in signal strength.

Serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus. **RS-232** (Recommended Standard 232) is a standard for serial binary single-ended data and control signals

connecting between a *DTE* (Data Terminal Equipment) and a *DCE* (Data Circuit-terminating Equipment). It is commonly used in computer serial ports. The standard defines the electrical characteristics and timing of signals, the meaning of signals, and the physical size and pin out of connectors. The signals of RS-232 serial are not suitable for use in TTL(**Transistor–transistor logic**) compatible digital logic circuits. So, **MAX232** integrated circuit is used to convert signals of **RS-232** to make suitable signals for use in TTL(**Transistor–transistor logic**) compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. It is helpful to understand what occurs to the voltage levels. When a MAX232 IC receives a TTL level to convert, it changes a TTL Logic 0 to between +3 and +15 V, and changes TTL Logic 1 to between -3 to -15 V, and vice versa for converting from RS232 to TTL. RS-232 Voltage Levels are given below:

Table1: Voltage levels

RS232 Line Type & Logic Level	RS232 Voltage	TTL Voltage to/from MAX232
Data Transmission (Rx/Tx) Logic 0	+3 V to +15 V	0V
Data Transmission (Rx/Tx) Logic 1	-3 V to -15 V	5V
Control Signals (RTS/CTS/DTR/DSR) Logic 0	-3 V to -15 V	5V
Control Signals (RTS/CTS/DTR/DSR) Logic 1	+3 V to +15 V	0V

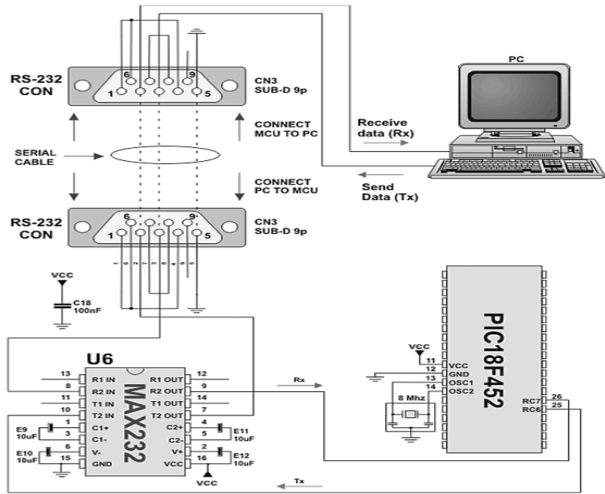


Fig. 4: Serial Communication(PC- microcontroller)

2.7 Pulse-Width Modulation

Pulse-width modulation (PWM) is a commonly used technique for controlling power to inertial electrical devices, made practical by modern electronic power switches. We used PWM to control Servo motor (HS-422 & HS81). PWM, as the name suggests, is a method of controlling devices by varying the length of the pulse in a given time period.

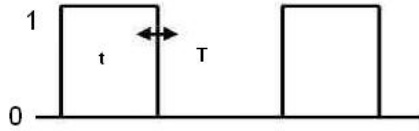


Fig. 5: Duty cycle

Duty Cycle describes the proportion of 'on' time to the regular interval or 'period' of time; a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully on.

$$\text{Duty Cycle, } D = \frac{t}{T}$$

Where,

t = on state or high state

T = the period of the function.

We chose the servos because they have the control circuits built in, and they have the highest torque to weight ratio and also because they can be precisely controlled by PWM. On the other hand, stepper motors and DC motors were both out of question due to weight constraints.

In Servo Motor Control, the time period of oscillation is 20ms. And the on-time varies from 1ms for 0 degrees to 2ms for 180 degrees.

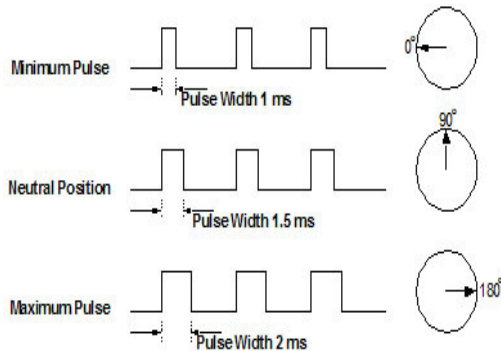


Fig. 6: Servomotor control PWM diagram

2.8 Inverse Kinematics

The kinematics solution of any robot manipulator consists of two sub problems, forward and inverse kinematics. Forward kinematics determines where the robot's manipulator hand will be if all joints are

known whereas inverse kinematics is used to find out where each joint variable must be if the desired position and orientation of end-effector is pre-determined.

The kinematics that we applied in this research was Inverse Kinematics. As shown in the diagram, the x and y coordinates of the end effector on the plane along a specified angle of the base is known. The angles at each joint are then calculated based on the equations derived by IK method.

2.8.1 Geometric Solution for IK Equations of the Arm

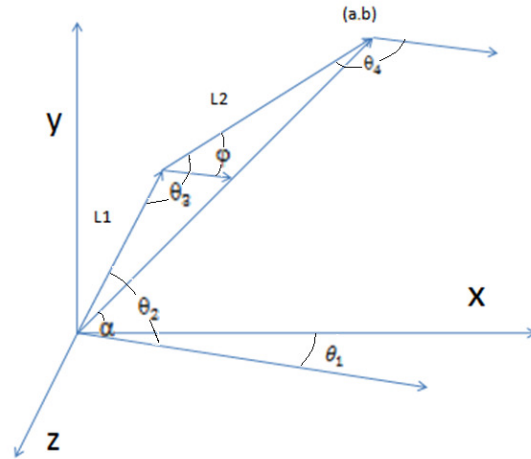


Fig. 7: Geometric Solution for IK equations

Let the coordinates of the end effector be (a,b, θ_1) where a,b are the coordinates of the effector in the plane which is offset at an angle of θ_1 from the xy plane.

From the figure,

$$a = l_1 \cos \theta_2 + l_2 \cos \phi$$

$$b = l_1 \sin \theta_2 + l_2 \sin \phi$$

Rearranging, we get,

$$\cos(\theta_2 - \phi) = \frac{a^2 + b^2 - (l_1^2 + l_2^2)}{2l_1 l_2}$$

Taking $\gamma = \theta_2 - \phi$, we get,

$$\gamma = \arccos \left(\frac{a^2 + b^2 - (l_1^2 + l_2^2)}{2l_1 l_2} \right)$$

Taking,

$$\alpha = \arctan \left(\frac{b}{a} \right)$$

Now applying sine rule for the triangle OAB, we get,

$$\frac{\sin(\theta_2 - \alpha)}{l_2} = \frac{\sin(\alpha - \varphi)}{l_1} = \frac{\sin(\theta_3)}{\sqrt{a^2 + b^2}}$$

Solving we get the values of θ_2 , θ_3 and θ_4 as,

$$\theta_2 = \alpha + \arcsin\left(\frac{l_2 \sin \gamma}{\sqrt{a^2 + b^2}}\right)$$

$$\theta_3 = \pi - \gamma$$

$$\theta_4 = \pi + \arcsin\left(\frac{l_1 \sin \gamma}{\sqrt{a^2 + b^2}}\right) - \alpha$$

3. CONCLUSIONS

The robotic arm was tested with different users and with sufficient training was able to respond to commands with an accuracy of almost 90 percent. Based on our study, we were able to conclude that it is possible to create robots for industrial applications that could interact with humans verbally and also help users to do their required tasks quickly and efficiently. At present our robotic Arm can perform gripping, holding & releasing object and dancing according to user voice command. It can also perform the conversation with users. This robotic can be developed without PC interfacing by using DSP(digital signal processing) module or HM-2007 & SPO-256 IC's.

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DISPERSION AND DISPERSION SLOPE COMPENSATION USING LINEARLY CHIRPED APODIZED FIBER BRAGG GRATING

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In this paper, we have proposed an analytical model to compensate both dispersion and dispersion slope in an optical transmission system using linearly chirped apodized fiber Bragg grating (FBG). We have developed an analytical formulation to calculate the value of linearly decreasing grating period and demonstrated an accurate selection of the apodization strength factor of *Sinc* apodization profiles of linearly chirped FBG based dispersion compensation. It is found that a proper choice of the apodization strength factor results in minimum deviation of the dispersion from the required level and maximum reflection bandwidth. Thus using a linear chirped *Sinc* apodized FBG can compensate dispersion and dispersion slope simultaneously.

Key words: Fiber Bragg Grating, *Sinc* apodization, strength factor, dispersion slope

1. INTRODUCTION

With the rapid increase of information industry in the world, high speed and big capacity communication networks become more and more insistent. Optical fiber communication system has this speed and capacity. But dispersion becomes the major obstacle for up-gradation to this system. Dispersion slope is particularly troublesome when increasing the system's bit rate. Fiber Bragg grating (FBG) is proving compensation to the dispersion and dispersion slope in this regard. Dispersion is the time domain spreading or broadening of the transmission signal light pulses as they travel through the fiber. The optical pulse is made of more than one component. Each component travels at slightly difference speed. Therefore different components will arrive at receiver at different times. This result of the spreading of the output pulse is called chromatic dispersion [1]. The use of higher bit rates for single channel propagation is of interest in WDM systems. The dispersion slope is particularly troublesome when increasing the bit rate of the system.

FBG is proving to be one of the most important developments in the field of the optical fiber technology especially because of the absence of nonlinear effects [2]. In recent years, many research and development projects focused on the study of FBG and these are used in optical communication

links in different applications such as all-optical routers, selective filters, gain equalizers, sensors and dispersion compensators [3-4]. Some previous work on grating demonstrated that the apodization sharpness parameter plays a more important role in the behavior of the mean dispersion than the type of apodization profile itself [5]. But various apodization profiles can be used in order to make the reflection spectrum more smooth and linearized the dispersion characteristics [6-7].

Recently phase-samples FBGs have been proposed for compensating the dispersion by chirping both the grating period and sampling period [8-9]. Simultaneous dispersion and slope compensation has been done by using phase only sampled FBG [10-11]. Works on apodized FBG carried out when operated in transmission [12-13]. Tunable dispersion compensation using a chirped apodized FBG in transmission was demonstrated both experimentally and numerically in [14]. In our previous paper [15] we have shown the chromatic dispersion compensation by using linearly chirped apodized FBG.

In this research an analytical model was developed to compensate the dispersion and dispersion slope simultaneously in an optical transmission system using linearly apodized fiber FBG.

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2. SYSTEM MODEL

In order to evaluate the effects of our proposed FBG, we have considered the system as shown in Fig. 1. The input pulses are launched to a link of standard single mode fiber. The output broadened pulses are then fed to a linearly chirped apodized grating through the optical circulator to get the recompressed pulse. This component extracts the restored pulse and that is reflected by the grating

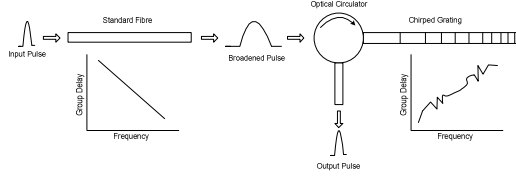


Fig. 1: System model of dispersion compensation

3. THEORETICAL ANALYSIS

The apodized and linearly chirped FBG structure with a refractive index modulation along the propagation direction of the core is given by

$$n(z) = n_{eff} \left\{ 1 + \Delta n(z) \left\{ m + \cos \left[\frac{2\pi}{\Lambda_B} + \phi(z) \right] \right\} \right\}; \quad -\frac{L_g}{2} \leq z \leq \frac{L_g}{2} \quad (1)$$

The equation is defined in the z axis from $-L_g/2$ to $L_g/2$, where L_g is the whole length of the fiber Bragg grating.

where
$$\Delta n(z) = \frac{\Delta n T(z)}{n_{eff}} \quad (2)$$

is the refraction index modulation depth and $T(z)$ is the apodization profile/function.

where
$$T(z) = \sin^A \left[\frac{1}{2} \left(\left(\frac{2z}{L_g} \right)^B \right) \right] \quad (3)$$

Λ_B is reference Bragg grating period at the center of the structure. The parameter m is the fabrication process penalty as a dc index change. For linearly chirped gratings, the chirp can be defined through the parameter F (chirp factor) which determines the variation in the phase term is expressed as $\phi(z) =$ grating phase,

$$\phi(z) = \frac{Fz^2}{2L_g^2} \quad (4)$$

The parameter take are $A=1$, $B=2$ The main spectral functions under the study is the reflection

coefficient, $r=|\rho|^2$ where ρ is the reflectivity coefficient [2] and given by

$$r(z) = \frac{\sinh^2(\gamma(z)L)}{\cosh^2(\gamma(z)L) - \frac{\hat{\sigma}(z)^2}{\kappa(z)^2}} \quad (5)$$

where $(\gamma(z) = \sqrt{(\kappa(z)^2 - \hat{\sigma}(z)^2)})$ and the coupling coefficient $\kappa(z)$ is related to the amplitude of the envelope function of the induced changes by

$$\kappa(z) = \frac{\pi}{\lambda_B(z)} \frac{\Delta n}{n_{eff}} T(z) \quad (6)$$

As λ_B is the Bragg wavelength, if we vary grating period linearly then λ_B will also vary as well as κ will also varies linearly with grating period. And general 'dc' self coupling coefficient define as

$$\hat{\sigma}(z) = \delta(z) + \sigma - \frac{1}{2} F(z) \quad (7)$$

where, δ is detuning parameter and σ is dc coupling coefficient, which is independent on z.

The delay time τ_p for light reflected off of a grating is

$$\tau_p = \frac{d\theta_p}{d\omega} = -\frac{\lambda^2}{2\pi c} \frac{d\theta_p}{d\lambda} \quad (8)$$

Thus we find the delay time τ_p as shown in the equation (18)

$$\tau_p(z) = \frac{\hat{\sigma}(z)^3 n_{eff}}{\left\{ \hat{\sigma}(z)^2 + \gamma(z)^2 \coth(\gamma(z)L_g)^2 \right\} \sqrt{\gamma(z)c}} \times \left(\frac{\coth(\gamma(z)L_g)}{\hat{\sigma}(z)} - \gamma(z) \hat{\sigma}(z)^{-3/2} \coth(\gamma(z)L_g) \right) - \frac{\gamma(z)L_g \csc h^2(\gamma(z)L_g)}{\hat{\sigma}(z)} \quad (9)$$

Second order dispersion is calculated as equation (19)

$$d_p = \frac{d\tau_p}{d\lambda} = -\frac{2\pi c}{\lambda^2} \frac{d^2\theta_p}{d\omega^2} \quad (10)$$

Third order or dispersion slope is calculated as rate of change of d_p with respect to $d\lambda$. That is

$$\frac{dd_p}{d\lambda} = \frac{d}{d\lambda} \left(\frac{d\tau_p}{d\lambda} \right) \quad (11)$$

4. RESULTS AND DISCUSSION

To design a linearly chirped apodized FBG we vary grating period Λ linearly. As shown in our previous work [15]. We divided grating length L_g into many small segments. We have design a linearly negatively chirped fiber brag grating structure by

using geometric series. As we varied grating period Λ_B linearly then the Bragg wavelength λ_B also varied, as shown in Fig. 2, where different wavelength is reflected from different length of grating period.

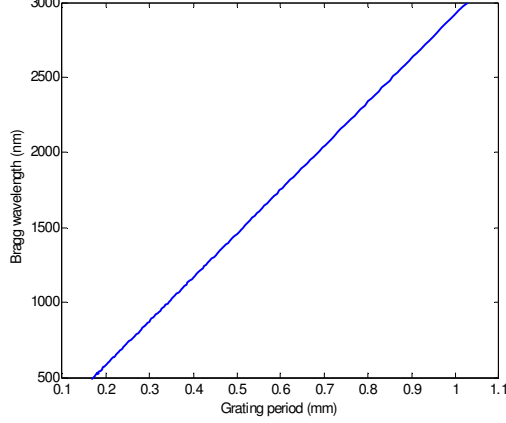


Fig.2: Linearly chirped grating period (with 200segment, length of 1st period is 1.6 mm, and linearly decrease by a factor of 0.99 mm) versus Bragg wavelength

The Fig. 3 shows the plot of grating length L_g against the apodization factor strength a_{eff} . Since grating length L_g is a major constraint in terms of mask length availability and exposure times. We got the maximum value of grating length is 10cm for the a_{eff} grater than 0.6.

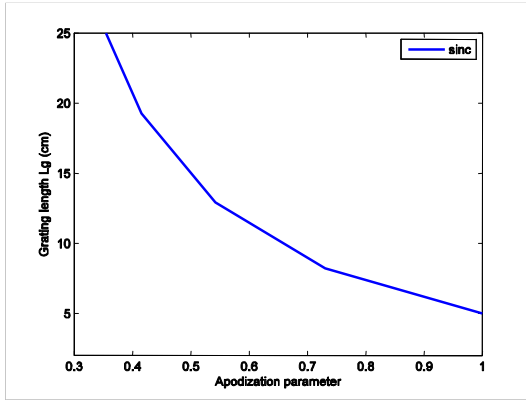


Fig. 3: Time trend of temperature data

The second order dispersion d_p (in ps/nm) is the rate of change of delay with respect to wavelength. Third-order dispersion compensation refers to the compensation over several WDM channels of both the second order $\left(d_p = \frac{d\tau_p}{d\lambda}\right)$ and third-order $\left(\frac{dd_p}{d\lambda}\right)$ dispersion effects. For such an operation, the compensator is required to have a different dispersion value for each of the channels.

We have calculated the rate of change of delay (express in ps/nm) numerically by using Centred Finite Divided Difference formula. We found that d_p changes linearly for all reflected wavelengths as shown in Fig. 4 (c).

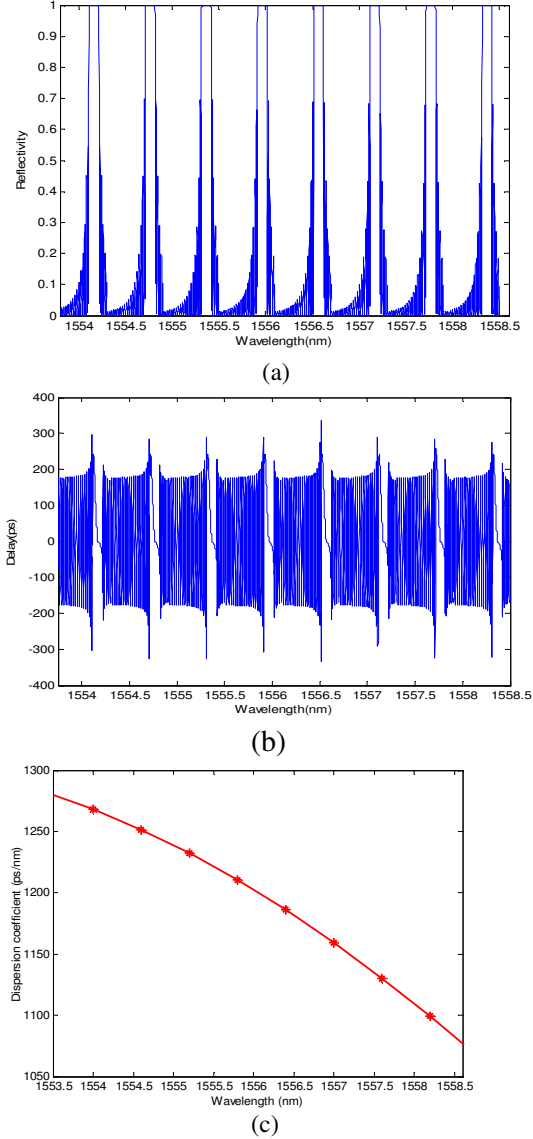


Fig. 4: (a) Reflectivity and (b) Delay spectra of an 8-channel WDM system by using proposed dispersion compensation grating. The bullet in the graph (c) gives the dispersion values obtained.

In Fig. 4 (a) and (b) graphs shows the plot of reflectivity and delay versus wavelength of an 8-channel WDM system, and the third one graph (c) shows the plot of dispersion coefficient versus wavelength for an 8-channel WDM system. We found that dispersion is linearly decreasing for every channel, so as the dispersion slope decreasing. We can say that apodized grating with

a chirped in the grating period can compensate the both second and third order dispersion.

The Fig. 5 shows the plot of pulse regeneration we obtain from linearly chirped FBG. If the initial pulse width is 100 ps (solid curve). The pulse is broadened to 190 ps (dashed dot curve) after it propagates over fiber length $L_f=100\text{km}$, FBG then recompressed the pulse (dashed curve) about the same as input pulse.

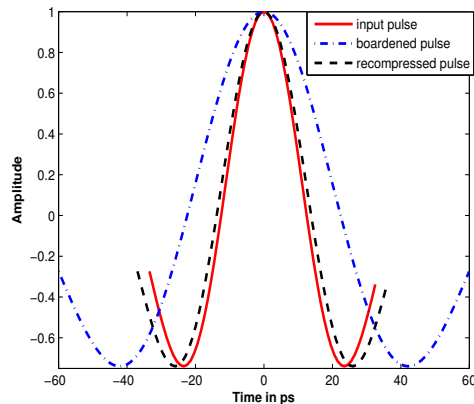


Fig. 5: Pulse regeneration with linearly chirped FBG having input pulse width=100ps

7. CONCLUSION

Dispersion compensation management plays a critical role in the overall performance of an optical transmission system. We have developed the analytical formulation that can effectively compensate the both second and third order chromatic dispersion. In summary, we have demonstrated that by using linearly chirped *Sinc* apodized FBG of apodization strength factor in the ranges of 0.7 - 0.8 can compensate both second and third order dispersion for a 8-channel WDM system.

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INTRODUCING GREEN ICT FOR DIGITAL BANGLADESH

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Green computing or green ICT refers to environmentally sustainable computing or ICT. It is the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment [1]. This paper shows some green initiatives towards digital Bangladesh and also shows some challenges towards green DB.

Key words: Green ICT, Green Computing, Digital Bangladesh, Environmentally Sustainable Computing, Energy Saving ICT.

1. INTRODUCTION

Information and communication technology (ICT) drives the technological and economic advancement of the developed as well as emerging economies. The government of Bangladesh wants to make Bangladesh fully digitized by 2021 through application of third generation ICT. Energy crisis is a burning issue for most of the countries in the world including Bangladesh. ICT systems consume significant amount of energy so energy saving ICT systems should be introduced. Environmental impact should have to be considered, while deploying ICT towards Digital Bangladesh. Introducing green ICT policies in the ICT sector and creating awareness among ICT professionals and government about energy consumption and subsequent carbon dioxide emissions from commercial ICT equipment will help reducing emission impact from ICT and will booster Bangladesh to be a Green Digital Bangladesh.

1.1 Digital Bangladesh

The concept of Digital Bangladesh should be termed as a “knowledge-based society,” in which creation and exchange of “knowledge” becomes an increasingly key factor of production, and in the process reducing the relative importance of traditional factors of production such as land, labor and capital. Information and communication technologies (ICTs) are a critical component for building this knowledge-society. So, Digital

Bangladesh, in that sense, is the crucial platform, the enabler for such a vision.

1.2 Green ICT

Green ICT is defined as ICT, which as a result of usage, produce comparatively low levels of carbon emissions while having the potential to exponentially reduce emissions in other areas by catalyzing technological, institutional and behavioral change, while bringing forth socio-economic benefits.

1.3 Why Green ICT for DB

ICT has a significant and emerging impact on carbon emissions and climate change. Use of ICT in Bangladesh is increasing day by day. Bangladesh is a remarkable buyer of ICT equipments and its ICT sector fully dependent on the import of ICT equipments. Not only new equipments but also huge volume of used ICT hardware equipments are imported every year which might cause a threat for Bangladesh to be a dumping station of e-waste. So, it is the responsibility of the Bangladesh Government how ICT could be used to attain environmental sustainability, limiting power consumption and protecting Bangladesh against the dumping station of e-waste. Following an effective Green ICT strategy will improve organizational efficiency in lowering energy costs, reducing carbon emissions and enhanced services.

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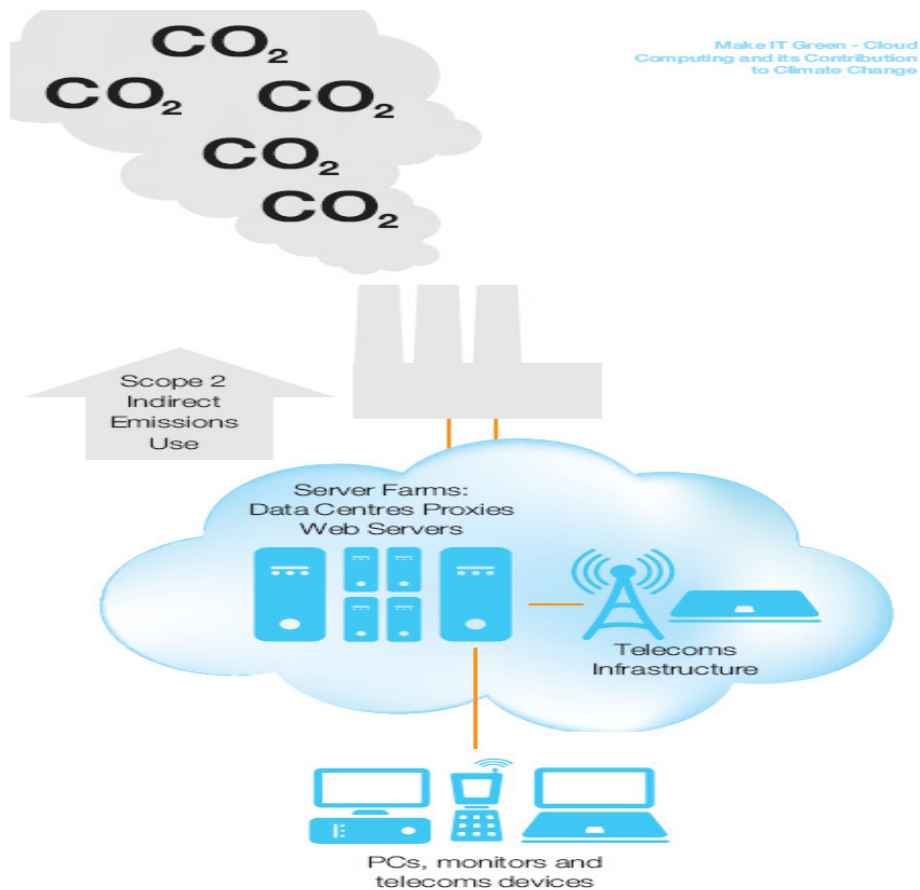


Fig. 1: CO₂ emissions by ICT equipments [2]

1.3.1 How big is the carbon footprint of the ICT sector?

On a global scale, some analyst reports have calculated that ICT represents 2 percent to 2.5 percent of the total global carbon emissions, which is equivalent to the global aviation industry. [3]

In 2008, The Climate Group and the Global e-Sustainability Initiative (GeSI) issued SMART 2020: enabling the low carbon economy in the information age. The study highlighted the significant and rapidly growing footprint of the ICT industry and predicted that because of the rapid economic expansion in places like India and China, among other causes, demand for ICT services will quadruple by 2020 [2].

SMART 2020 also found that:

- PC ownership will quadruple between 2007 and 2020 to 4 billion devices, and emissions will double over the same period, with laptops

overtaking desktops as the main source of global ICT emissions (22%).

- Mobile phone ownership will almost double to nearly 5 billion accounts by 2020, but emissions will only grow by 4%. Broadband uptake will treble to almost 900 million accounts over the same period, with emissions doubling over the entire telecoms infrastructure.

The Smart 2020 study also made a compelling case for ICT's significant potential to deliver climate and energy solutions, estimating that ICT technologies could cut 7.8 GtCO₂ of global greenhouse gas emissions by 2020, a 15% reduction over business-as-usual projections. The study posits that innovations from the ICT sector - when combined with increased use of renewable energy - can put the world on a more sustainable path and help keep global temperature increase below the 2°C threshold scientists say is needed to hold off the worst effects of climate change.

	Emissions 2007 (MtCO ₂ e)	Percentage 2007	Emissions 2020 (MtCO ₂ e)	Percentage 2020
World	830	100%	1430	100%
Server farms/Data Centres	116	14%	257	18%
Telecoms Infrastructure and devices	307	37%	358	25%
PCs and peripherals	407	49%	815	57%

MtCO₂e = Metric Tonne Carbon Dioxide Equivalent
GtCO₂e = Gigatonne Carbon Dioxide Equivalent

Fig. 2: CO₂ emissions throughout the world [2].

2. INITIATIVES

Bangladesh is one of the most severely affected countries of the world due to climate change and global warming effects. Bangladesh Government is concerned with these issues. Green energy program already introduced in Bangladesh to find a sustainable solution. Private and public both sector have taken some initiatives to implement energy saving ICTs.

- Leading mobile phone operator Grameenphone (GP) installed 14 renewable energy solutions at base stations, including a windmill, in 2008. GP is set to supply solar generated power in bulk to 140 of its sites that are currently run by diesel generators by the yearend. The generators consume nearly 1.15 million litres of diesel a year -- an amount enough to irrigate nearly 13.77 acres of land overall. The diesel consumed by GP accounts for 3,062 tonnes of carbon omissions a year. Currently, the telecom operator has 7,500 sites with 12,000 base stations [4].
- Clean Development Mechanism (CDM) projects being implemented in Bangladesh by the Ministry of Environment and Forest with support from the UNDP.
- In public procurement energy saving ICT equipments are being encouraged.
- Bangladesh power development board encouraging green power energy by implementing a new strategy: when a consumer apply for getting a new power supply it is required to implement own financed solar power to an extent to get it.
- Solar power system has been installed at the Prime Minister's Office (PMO) of Bangladesh in a move to encourage green energy expansion. The move followed a government decision for establishing solar power units in all public and semi-government offices to promote expansion of renewable energy from the sun, wind, biomass, and biogas — with an aim to meet 5 percent of the country's total power demand by 2015, and 10 percent by 2020 [5].
- Bangladesh's central bank has switched over to solar-powered lighting, in a move to encourage green energy.
- The government also focused on use of energy saving light bulbs. The power division of Bangladesh government has been implementing the free distribution of Compact Flurescent Lamp (CFL) to save power consumption. The bulbs are also durable and environment friendly as those emit a very low carbon to atmosphere.
- Government encouraging the use of Compressed Natural Gas (CNG) driven public transport to minimize CO₂ emission.

3. NEEDS

It is impossible to conceive digital Bangladesh without “Energy”. Energy crisis is one of the major issues for Bangladesh. Government of Bangladesh is working towards achieving “Power i.e. Electricity for All” by the year 2020. Densely populated country like Bangladesh can only sustain and progress if only latest energy saving technologies can be used efficiently.

The main challenge to using solar energy is in running the air-conditioners that are used to remove the heat generated by electric equipment. As air conditioners consume more power, replacing the air conditioners with direct-current fans that can save a huge amount of power.

ICT professionals can play a vital role to introduce green energy saving technologies towards digital Bangladesh. To support Green ICT campaign here are a few best practices.

- a) Data center optimisation: Effective optimisation and utilisation of servers is important because of the level of energy used to power and cool them. Increased utilisation can lead to server rationalisation saving energy and cutting carbon [6].
- b) Server Virtualisation: using virtualisation technology to reduce the number of servers in use [6].
- c) Desktop Virtualisation: Implement desktop virtualisation using ultra-small, secure clients on the desktop and linking the thin clients to their own virtual desktop machines residing on servers. With desktop environment consolidated within the data centre, firms can deliver secure, isolated desktops that consume less energy [6].
- d) Recycling: Break down computers into components and components into raw materials for reuse.
- e) Deploying innovative information technology solutions, such as Cisco’s SmartGrid, Energywise, and TelePresence.
- f) Moving to blade servers that use less power and require much less cooling.
- g) Configuring power management settings on new computers to reduce power consumption e.g. put PCs into low power modes after specified periods of inactivity.
- h) Turning off PC overnight, at weekends and during holiday periods.
- i) Switched off printers and other peripheral equipment after use.
- j) Refrain from printing emails whenever possible
- k) Removing active screen savers.
- l) Double-sided printing is a simple way to conserve thousands of pages of paper.

- m) Using gray scale to reduce the amount of maintenance and transport required and electricity, paper and toner used.
- n) Versatile multifunction devices can streamline workflows, boosting efficiency.
- o) Encouraging network printer instead of one desk one printer approach.
- p) Using software to run multiple operating systems on one device rather than using a separate device for each OS
- q) Reducing travel requirements through the use of video-conferencing.
- r) Flexible/mobile working.
- s) Reducing waste.
- t) Encouraging paper less office.

4. RECOMMENDATIONS

Government has a significant role to play in introducing green ICT towards digital Bangladesh. Government should:

- a) Introduce environmental concern in the national ICT policy including GHG emissions reduction.
- b) Make political commitment and national consensus to effectively encounter the energy challenges.
- c) Increase awareness of the importance of green ICT.
- d) Introduce new public procurement rules and regulations to purchase energy saving and eco-design ICT equipments eliminating hazardous goods.
- e) Encourage green ICT procurement by the public and private sector.
- f) Create a Green ICT Stimulus Package that can assist departments to hire expert advice to address and enable its key recommendations to ensure and accelerate delivery of Green ICT in Government.
- g) Positively setup examples of green ICT initiatives it has successfully implemented and clarify what energy as well as CO₂ savings were achieved.
- h) Support ICT Managers enabling them to create and better measure consistent green ICT strategies including measuring carbon and being responsible for energy bills.
- i) Impose high tax on importing energy inefficient equipments or anyway discourage energy inefficient ICTs.
- j) Discourage import of used ICT hardware that may prevent Bangladesh from e-waste dumping.
- k) Support green ICT pilot projects.
- l) Provide incentives to encourage private sectors to introduce or invent green technologies.
- m) Introduce provision for CO₂ emission audit.

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MATHEMATICAL MODELING OF BLOOD FLOW

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This paper presents a new mathematical model of the blood flow and the blood pressure. The main fluid component of the cardiovascular system is the blood which flows through the different blood vessels in the body. Although blood is the non-Newtonian fluid, in many cases it behaves like a Newtonian fluid which is governed by the Navier–Stokes equations. With the help of continuity equation and the Navier–Stokes equations, a simple differential equation was derived under some assumption which is called as the master equation. Then by applying the logical assumption on this master equation, the general mathematical model of the normal blood flow was developed. Then this model was extended for normal blood pressure using the Poiseuille's equation. At the end of this study, some analysis had been performed to determine the validity of the proposed model. The analysis showed that the model can satisfy both the different properties of blood flow and blood pressure.

Key words: mathematical model; cardiovascular system, non-newtonian fluid; differential equation; blood pressure; Navier–Stokes equation; continuity equation; Poiseuille's equation

1. INTRODUCTION

A mathematical model uses mathematical language to describe a system in the real world. The process of developing a mathematical model is termed as mathematical modeling or modeling. Cardiovascular system is the blood distribution network in the body. The cardiovascular system in the body consists of three components: blood, heart and blood vessels. When blood flows through the vessels, pressure is detected on the wall which is termed as the blood pressure. Blood pressure depends mainly on flow rate and size of the vessels and on the pressure gradient. There are three major types of blood vessels: arteries, capillaries and veins [1]. Arteries are large blood vessels that carry blood away from the heart to all regions of the body [1]. The arterioles further divide into smaller vessels called capillaries. Capillaries are the anatomic units that connect the arterial and venous circulatory system. The veins form a low-pressure collecting system to return the oxygen-poor blood to the heart [1]. In this analysis, all the vessels are assumed to be same in nature excluding their size, length and cross-sectional area.

Many studies have been published in this field. There is an important literature on the functional imaging and modeling of the heart [2] - [4]. Some studies have been performed on the measurement of

electrical activity, deformation, flows, fiber orientation [5]–[10], and on the modeling of the electrical and mechanical activity of the heart [11]–[13]. This study gives the mathematical modeling of the blood flow and also represents some simulation results based on the developed model.

To develop the model of the blood flow and blood pressure, some assumptions have been considered. These include that the blood vessels are the cylindrical, deformable components with circular cross-sections. They change their size as the blood flows through it. The blood is considered to be the Newtonian fluid which is governed by the Navier–Stokes equation and by the continuity equation. Although the blood needs the help of the lungs for the supply of oxygen, its properties remain unchanged by the addition of that oxygen. Another assumption is required and that is the blood has both the radial and axial flow in only one direction i.e. z-direction in a three dimensional system. So, the other two components (x-direction and y-direction) are vanished.

2. MATHEMATICAL MODELING

2.1 Developing the master equation

The velocity components in the x, y, and z directions are typically named u, v, and w

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respectively. Let ρ be the density of blood, P be the blood pressure and μ is the kinematic viscosity of blood. Then neglecting the orientation of gravity inside the body, the Navier-Stokes equation in the Cartesian co-ordinates is given by the following equations:

$$\rho \left(\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z} \right) = -\frac{\partial P}{\partial x} + \mu \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} \right) \quad (1)$$

$$\rho \left(\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z} \right) = -\frac{\partial P}{\partial y} + \mu \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2} \right) \quad (2)$$

$$\rho \left(\frac{\partial w}{\partial t} + u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z} \right) = -\frac{\partial P}{\partial z} + \mu \left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2} \right) \quad (3)$$

With the assumption of no tangential velocity and no x and y components of velocity, a change of variables on the Cartesian equations will yield the following system of equation in the cylindrical co-ordinate system [14]:

$$\frac{\partial w}{\partial t} + f \frac{\partial w}{\partial r} + w \frac{\partial w}{\partial z} = -\frac{1}{\rho} \frac{\partial P}{\partial z} + \mu \left(\frac{\partial^2 w}{\partial r^2} + \frac{1}{r} \frac{\partial w}{\partial r} + \frac{\partial^2 w}{\partial z^2} \right) \quad (4)$$

$$\frac{\partial f}{\partial t} + f \frac{\partial f}{\partial r} + w \frac{\partial f}{\partial z} = -\frac{1}{\rho} \frac{\partial P}{\partial r} + \mu \left(\frac{\partial^2 f}{\partial r^2} + \frac{1}{r} \frac{\partial f}{\partial r} + \frac{\partial^2 f}{\partial z^2} + \frac{f}{r^2} \right) \quad (5)$$

$$\frac{1}{r} \frac{\partial}{\partial r} (rf) + \frac{\partial w}{\partial z} = 0 \quad (6)$$

where $f(r, z, t)$ be the radial flow component, $w(r, z, t)$ be the axial flow component in z -direction.

And the continuity equation reads:

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho w)}{\partial z} = 0 \quad (7)$$

Now, define a new variable γ as $\gamma = \frac{r}{R(z, t)}$, Error! Bookmark not defined. where $R(z, t)$ is the radius of the blood vessels, obviously the cylindrical coordinate (r, z, t) is now replaced by coordinate (γ, z, t)

Again, the velocity profile in the axial direction, $w(\eta, z, t)$, is assumed to have the expression in the polynomial form:[15]

$$w(\gamma, z, t) = \sum_{k=1}^N q_k (\gamma^{2k} - 1) \quad (8)$$

where, $q(z, t)$ is a another variable which to be determined later. For simplification let, $N=1$. Then

$$w(\gamma, z, t) = q(z, t)(\gamma^2 - 1) \quad (9)$$

And the velocity profile in the radial direction, $w(\eta, z, t)$, is assumed to have the expression in the polynomial form: [15]

$$f(\gamma, z, t) = \frac{\partial R}{\partial z} \gamma f + \frac{\partial R}{\partial t} \gamma - \frac{\partial R}{\partial t} \frac{\gamma}{N} \sum_{k=1}^N \frac{1}{k} (\gamma^{2k} - 1) \quad (10)$$

Again for simplification let $N=1$,

$$f(\gamma, z, t) = \frac{\partial R}{\partial z} \gamma f + \frac{\partial R}{\partial t} \gamma - \frac{\partial R}{\partial t} \gamma (\gamma^2 - 1) \quad (11)$$

Using the help of equations of axial and radial velocity profile, radial coordinate and the continuity equation, the Navier – Stokes equations get the forms as below to determine the variable $q(z, t)$ and $R(z, t)$:

$$\frac{\partial q}{\partial t} - \frac{4q}{R} \frac{\partial R}{\partial t} - \frac{2q^2}{R} \frac{\partial R}{\partial z} + \frac{4\mu}{R^2} q + \frac{1}{\rho} \frac{\partial P}{\partial z} = 0 \quad (12)$$

$$2R \frac{\partial R}{\partial t} + \frac{R^2}{2} \frac{\partial q}{\partial z} + q \frac{\partial R}{\partial z} = 0 \quad (13)$$

Now, let to introduce the desired variable, the cross-sectional area of the blood vessel as

$$S = \pi R^2 \quad (14)$$

where R is the radius of the blood vessels.

And blood flow rate is given as the surface integral of w and $\partial \gamma$ [16]. Thus

$$Q = \iint w \partial \gamma = \frac{1}{2} q \pi R^2 \quad (15)$$

From (14) and (15) $\frac{\partial q}{\partial t}, \frac{\partial q}{\partial z}, \frac{\partial R}{\partial t}$ and $\frac{\partial R}{\partial z}$ can be found.

After inserting the value of $\frac{\partial q}{\partial t}$, $\frac{\partial q}{\partial z}$, $\frac{\partial R}{\partial t}$ and $\frac{\partial R}{\partial z}$ in (12) and (13), another two differential equations are obtained as:

$$\frac{\partial Q}{\partial t} + \frac{3Q}{S} \frac{\partial Q}{\partial z} - \frac{2Q^2}{S^2} \frac{\partial S}{\partial z} + \frac{4\pi\mu}{S} Q + \frac{S}{2\rho} \frac{\partial P}{\partial z} = 0 \quad (16)$$

$$\frac{\partial S}{\partial t} + \frac{\partial Q}{\partial z} = 0 \quad (17)$$

After combining (16) and (17) a simple differential equation is obtained as follows:

$$\frac{\partial Q}{\partial t} - \frac{3Q}{S} \frac{\partial S}{\partial t} - \frac{2Q^2}{S^2} \frac{\partial S}{\partial z} + \frac{4\pi\mu}{S} Q + \frac{S}{2\rho} \frac{\partial P}{\partial z} = 0 \quad (18)$$

Equation (18) is now called as the 'master equation'. The model of the blood flow rate and blood pressure can be now got by applying some assumptions on this master equation which is performed in the next sections.

2.2 Modeling of the Blood Flow Rate

To develop the model of the blood flow it is assumed that the cross-section area of the blood vessel remains unchanged with time and it is also assumed to be constant over distance and the pressure gradient is assumed to be constant over the distance.

Applying these assumptions on (18), the master equation reduces to:

$$\frac{\partial Q}{\partial t} + \frac{4\pi\mu}{S} Q + \frac{S}{2\rho} \frac{\partial P}{\partial z} = 0 \quad (19)$$

This is the one dimensional mathematical model of the blood flow rate. The required boundary condition and the values of the other parameters to solve this equation can be obtained from the past works in this field. Such as:

Pressure gradient, $\frac{\partial P}{\partial z} = 100$ to 40 mmHg [16]

Initial value of $Q = 1$ to 5.4 liter/minute [17]

Kinematic viscosity of blood, $\mu = 0.035$ cm²/s [18]

Density of blood, $\rho = 1.043$ to 1.057 g/cm³ [18]

2.3 Modeling of the Blood pressure

To develop the mathematical model of the blood pressure Poiseuille's equation is considered. Poiseuille's equation determines the relation between blood flow rate and the pressure which is given as:

$$Q = \frac{\pi R^4}{8L\mu} P \quad (20)$$

where, L is the length and R is the radius of vessel.

After inserting (20) into (19), the new equations are obtained as follows:

$$\frac{\pi R^4}{8L\mu} \frac{dP}{dt} + \frac{4\pi\mu}{S} \frac{\pi R^4}{8L\mu} P + \frac{S}{2\rho} \frac{\partial P}{\partial z} = 0 \quad (21)$$

$$\frac{dP}{dt} + \frac{4\mu}{R^2} P + \frac{4L\mu}{\rho R^2} \frac{\partial P}{\partial z} = 0 \quad (22)$$

Equation (22) is the mathematical model of the blood pressure in the body. The required boundary condition and the values of the other parameters to solve this equation can be obtained from the past works in this field. Such as:

Pressure gradient, $\frac{\partial P}{\partial z} = 100$ to 40 mmHg [16]

Kinematic viscosity of blood, $\mu = 0.035$ cm²/s [18]

Density of blood, $\rho = 1.043$ to 1.057 g/cm³ [18]

L varies for arteries, capillaries and veins, i.e. L is different for different types of blood vessels.

3. RESULTS

In this section of this paper, some analysis has been performed to verify the validity of the proposed model.

3.1 Analysis of Blood Flow Rate

The equation of the mathematical model of blood flow rate can be solved using the MATLAB function 'dsolve'. Fig. 1 represents this solution for different cross-sectional area. The significance of this plot is that the blood flow rate increases with the cross-sectional area. This result supports fig. 2 which is derived from the Poiseuille's equation.

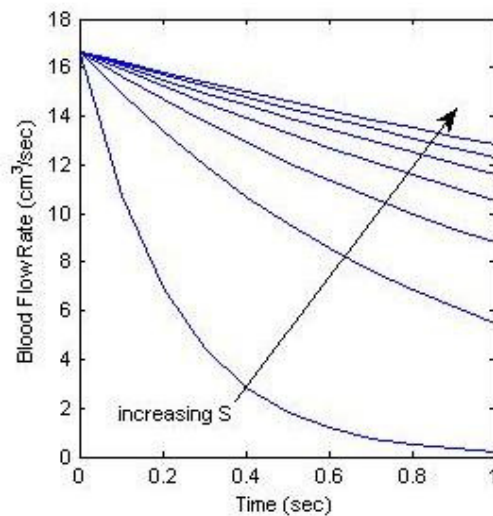


Fig. 1. Blood flow rate for different cross-sectional area (from 0.1 to 2 cm²)

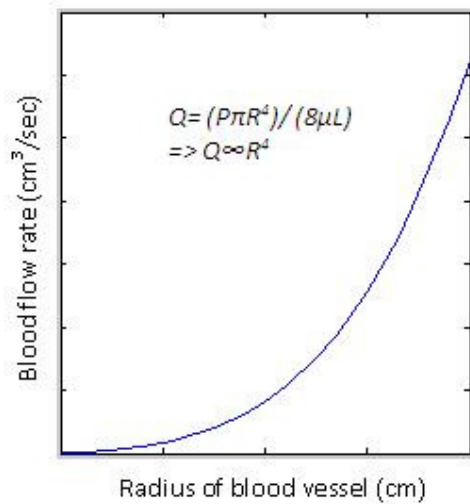


Fig. 2. Variation of blood flow rate with vessel radius using Poisuelli's equation

In fig. 3, the solution is plotted for various pressure gradients. Accordingly, pressure is higher at the beginning than at the end of vessel, establishing a pressure gradient. The greater the pressure gradient forcing bloods through a vessel, the greater the rate of flow through the vessel [19]. Fig. 3 also shows that for a given pressure gradient, the blood flow rate decreases with time and as the pressure gradient increases the blood flow rate also increases.

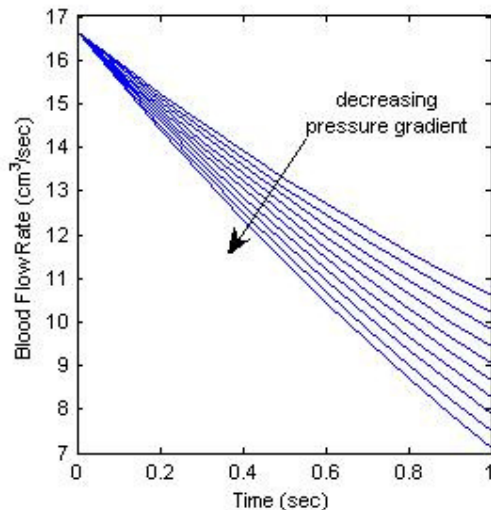


Fig. 3. Blood flow rate for different pressure gradients (from 40 to 100mmHg)

3.2 Analysis of Blood Pressure

The equation of the mathematical model of blood pressure can be solved using the MATLAB function 'dsolve'. Fig. 4 represents this solution for different cross-sectional area. The significance of

this plot is that the blood pressure decreases with the cross-sectional area. This result supports fig. 5 which is derived from the Poisuelli's equation.

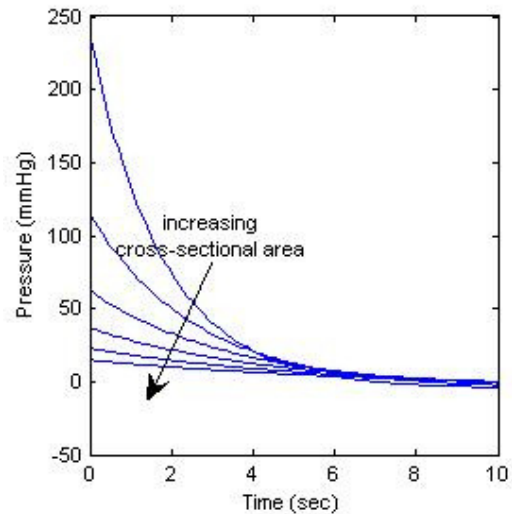


Fig. 4. Blood pressure for different cross-sectional area of vessels

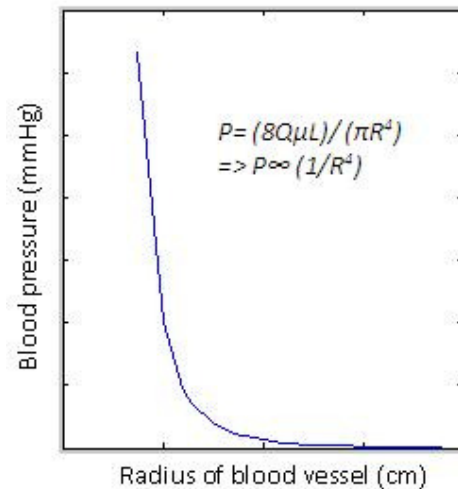


Fig. 5. Variation of blood pressure with vessel radius using Poisuelli's equation

In fig. 6, the solution is plotted for various length of the blood vessel. This analysis indicates the increment of blood pressure with the increment of length of the blood vessels. Higher pressure at the beginning and lower pressure at the end and the difference between this two highly varies with length of the blood vessels. This result supports fig. 7 which is derived from the Poisuelli's equation.

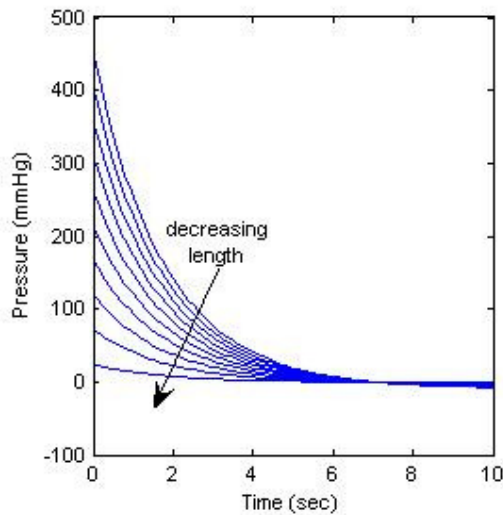


Fig. 6. Blood pressure for different length of vessels

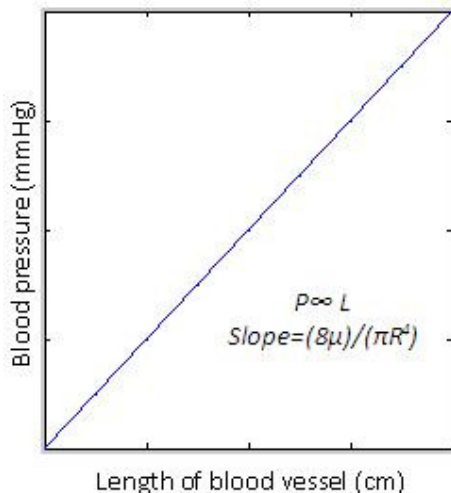


Fig. 7. Variation of blood pressure with vessel length using Poiseuille's equation

Systolic (maximum) blood pressure in the normal adult is in the range of 95 to 140 mm Hg, with 120 mm Hg being average. These figures are subject to much variation with age, climate, eating habits, and other factors. Normal diastolic blood pressure (lowest pressure between beats) ranges from 60 to 90 mm Hg, 80 mm Hg being about average. This pressure is usually measured in the brachial artery in the arm [20]. Fig. 4 and fig. 6 show that the blood pressure ranges support the normal values for the artery in the arm with corresponding cross-sectional area and length.

4. CONCLUSIONS

The design of computational models of human organs is a new research field which opens new possibilities for medical image analysis and therapy simulation [21]. The goal of this paper was to represent a mathematical model of the blood flow. A limited number of internal parameters were considered in developing the model. So, possible improvements of the study would include the integration of more anatomical structure (valve, exact size of the heart chambers), more realistic model and a more complex constitutive law. However, the objective of this research was not to build the more complex and faithful heart model ever. Instead, we want to adapt the complexity of the model but can show the sensitivity of the change in cross-sectional area, pressure gradient and length of blood vessel on the blood flow rate and on the blood pressure.

Although a large numbers of assumptions have been considered, the model can be treated as a valid one, because, this model is able to show that the blood flow rate is influenced by the change of cross-sectional area and the pressure gradient. The model can also show that the blood pressure is influenced by both of the cross-sectional area and the length of the blood vessel.

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MATHEMATICAL MODELING OF EYE MOVEMENT

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This paper presents a model of the eye movement. Using the natural process of seeing any object by the eye, a simple block diagram was considered. From this block diagram the mathematical model of eye movement was developed. The developed model was then converted into state equations which were used to draw the signal flow diagram. This diagram was simulated using simulink of MATLAB. An electrical circuit of the model was developed using the signal flow diagram. Finally, the condition of the stability of the model and the steady state error were determined from the different simulations. The model can describe the normal operation of the eye and can also describe the eye diseases like hypermetropia and myopia. This model also suggests the cure of hypermetropia and myopia.

Key words: state equation; signal flow diagram; simulink; MATLAB; stability; steady state error

1. INTRODUCTION

A mathematical model uses mathematical language to describe a system in the real world. The process of developing a mathematical model is termed as mathematical modeling or modeling [1]. It is often difficult to identify the appropriate level of modeling for a particular problem [2]. A crucial part of the modeling process is the evaluation of whether a proposed mathematical model describes a system accurately or not. When we face any problems with any real world task, then we convert the task into mathematical model, apply assumption if required, solve this and interpret for real world to see whether the developed model is correct for the system or not.

Eye is one the most important organs of the body. The human eye is an organ which reacts to light for several purposes. The visual system in the brain is too slow to process information if the images are slipping across the retina at more than a few degrees per second [3]. Thus, for humans to be able to see while moving, the brain must compensate for the motion of the head by turning the eyes. Another complication for vision in frontal-eyed animals is the development of a small area of the retina with a very high visual acuity. This area is called the fovea, and covers about 2 degrees of visual angle in people. To get a clear view of the world, the brain must turn the eyes so that the image of the object of regard falls on the fovea. Eye movements are thus

very important for visual perception, and any failure to make them correctly can lead to serious visual disabilities. Some works on human-machine interaction [4] - [8] and eye position [9] - [10] have been published. This study represents the model of eye and eye movement.

2. MATHEMATICAL MODELING

A model for eye movement consists of the closed-loop system shown in fig. 1, where an object's position is the input and the eye position is the output. As the brain detects any object, the brain sends signals to the muscles that move the eye. These signals consist of the difference between the object's position and the position and rate information from the eye sent by the muscles spindles. In these process two types of delays should be considered: delay due the signal processing in the brain and the propagation delay of the signals through the nervous system [11].

Each eye has six muscles that control its movements: the lateral rectus, the medial rectus, the inferior rectus, the superior rectus, the inferior oblique, and the superior oblique. When the muscles exert different tensions, a torque is exerted on the globe that causes it to turn, in almost pure rotation, with only about one millimeter of translation. Thus, the eye can be considered as undergoing rotations about a single point in the center of the eye.

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Muscle spindles are sensory receptors within the belly of a muscle, which primarily detect changes in the length of this muscle. They convey length information to the central nervous system via sensory neurons. This information can be processed by the brain to determine the position of body parts. The responses of muscle spindles to changes in length also play an important role in regulating the contraction of muscles, by activating motoneurons via the stretch reflex to resist muscle stretch.

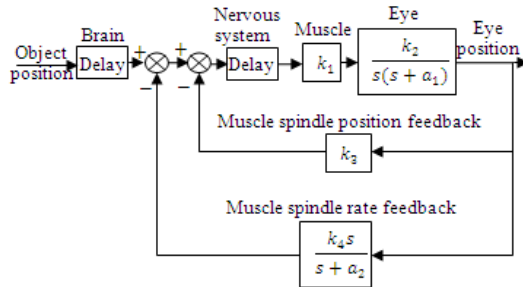


Fig. 1. Block diagram of eye movement

Let, $r(t)$ represents the object position, $y(t)$ represents the eye position, k_1 , k_2 , k_3 and k_4 are the gain constants, a_1 and a_2 determine the time constant of eye and muscle spindle respectively.

Using the block reduction techniques, the above figure is converted to its simplest form which results the determination of the transfer function as follows:

$$\frac{Y(s)}{R(s)} = \frac{k_1 k_2 (s + a_2)}{s^3 + (a_1 + a_2)s^2 + (a_1 a_2 + k_1 k_2 k_3)s + k_1 k_2 k_3 a_2 + k_1 k_2 k_4} \quad (1)$$

Taking cross multiplication

$$[s^3 + (a_1 + a_2)s^2 + (a_1 a_2 + k_1 k_2 k_3)s + k_1 k_2 k_3 a_2 + k_1 k_2 k_4]Y(s) = [k_1 k_2 s + k_1 k_2 a_2]R(s) \quad (2)$$

Let,

$$A = a_1 + a_2 \quad (3a)$$

$$B = a_1 a_2 + k_1 k_2 k_3 \quad (3b)$$

$$C = k_1 k_2 k_3 a_2 + k_1 k_2 k_4 \quad (3c)$$

$$D = k_1 k_2, E = k_1 k_2 a_2 \quad (3d)$$

Thus,

$$[s^3 + (a_1 + a_2)s^2 + (a_1 a_2 + k_1 k_2 k_3)s + k_1 k_2 k_3 a_2 + k_1 k_2 k_4]Y(s) = [k_1 k_2 s + k_1 k_2 a_2]R(s) \quad (4)$$

Or

$$s^3 Y(s) + A s^2 Y(s) + B s Y(s) + C Y(s) = D s R(s) + E R(s)$$

Applying inverse Laplace Transformation assuming zero initial condition to the above equation

$$\frac{d^3 y(t)}{dt^3} + A \frac{d^2 y(t)}{dt^2} + B \frac{dy(t)}{dt} + C y(t) = D \frac{dr(t)}{dt} + E r(t) \quad (5)$$

This differential equation represents the mathematical model of the eye movement.

3. STATE SPACE REPRESENTATION

Separating the transfer function of the system into two cascaded blocks, the system looks like as shown in fig. 2.

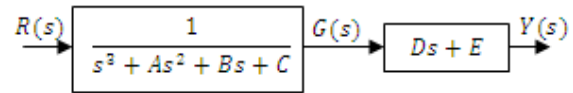


Fig. 2. Simplified transfer function

For first block, the corresponding differential equation

$$\ddot{g} + A\dot{g} + Bg + Cg = r \quad (6)$$

Choosing the state variables as successive derivatives

$$x_1 = g \quad (7a)$$

$$x_2 = \dot{g} \quad (7b)$$

$$x_3 = \ddot{g} \quad (7c)$$

Differentiating both sides and equating equivalent values, the state equations are obtained. Since the output is $g = x_1$, the combined state and output equations are:

$$\dot{x}_1 = x_2 \quad (8a)$$

$$\dot{x}_2 = x_3 \quad (8b)$$

$$\dot{x}_3 = -C x_1 - B x_2 - A x_3 + r \quad (8c)$$

In vector-matrix form,

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -C & -B & -A \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} r \quad (9)$$

From second block of fig. 2,

$$Y(s) = (Ds + E)G(s) \quad (10)$$

Taking inverse Laplace Transform with zero initial condition,

$$y = D\dot{x}_1 + Ex_1 \quad (11)$$

$$\text{But, } \dot{x}_1 = x_2$$

$$y = Dx_2 + Ex_1 \quad (12)$$

Thus the second block of figure.2b collects the states and generates the output equations as shown below:

$$y = [E \quad D] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad (13)$$

Using eq.9 and eq.13, the signal flow diagram [12] is constructed and is shown in fig. 3.

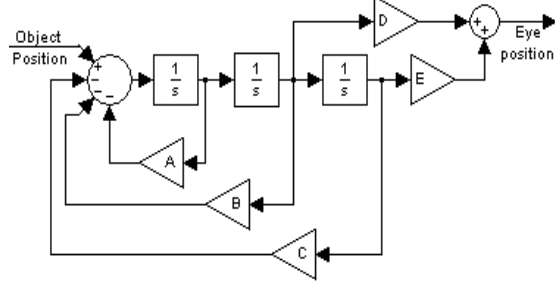


Fig. 3. Signal flow diagram

4. ELECTRICAL EQUIVALENT CIRCUITS

The signal flow diagram in fig. 3 can be replaced by electrical circuit components: integrators, inverting amplifiers and summing amplifiers [13]. The electrical circuit realization of the eye movement is given in fig. 4. The integrator consists of an op-amp, resistor and capacitor; an amplifier consists of an op-amp and resistors. In the figure below:

$$\frac{R_5}{R_8} = A, \quad \frac{R_5}{R_7} = B,$$

$$\frac{R_5}{R_6} = C, \quad \frac{R_5}{R_9} = 1$$

$$R_1C_1 = R_2C_2 = R_3C_3 = 1$$

$$\frac{R_{14}}{R_{12}} = D, \quad \frac{R_{14}}{R_{13}} = E,$$

$$\frac{R_{10}}{R_{11}} = 1$$

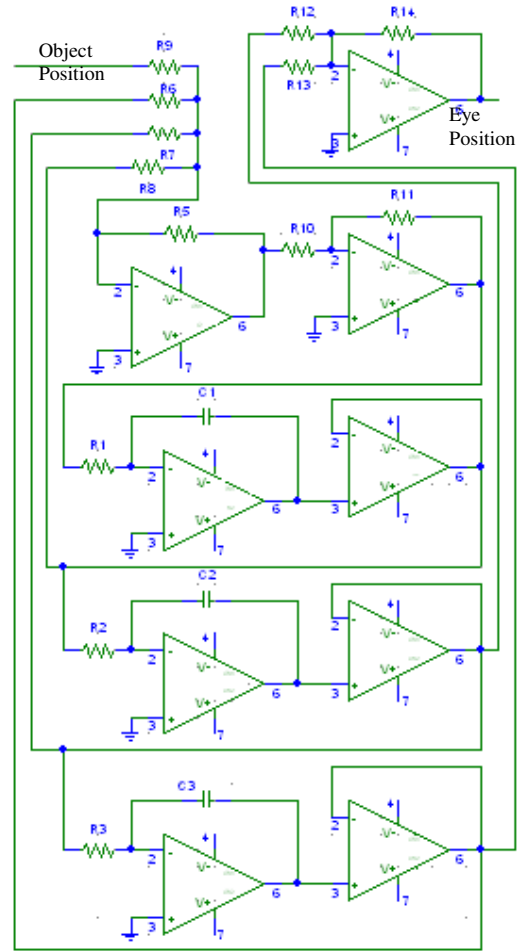


Fig. 4. Electronic equivalent circuit

5. STABILITY OF MODEL

A system is said to be stable if there is no poles in the right half plane in s-domain. Recalling the transfer function, the Routh-Hurwitz table is created using the denominator of the transfer function.

$$\text{Denominator, } D(s) = s^3 + As^2 + Bs + C$$

Table 1. Stability test of the model

s^3	1	B
s^2	A	C
s^1	$\frac{AB - C}{A}$	0
s^0	C	0

According to Routh-Hurwitz criteria for stability, each term of the second column must have same sign to ensure all the poles in the left half side of

the s-plane. The following conditions must be satisfied to ensure the stability of the system.

1. Condition 1:
 $A > 0$
 $Or, a_1 + a_2 > 0$
2. Condition 2:
 $(AB - C)/A > 0$
 $Or, AB - C > 0$
 $Or, AB > C$
 $Or, B > C/A$
 $Or, a_1 a_2 + k_1 k_2 k_3 > \frac{k_1 k_2 k_3 a_2 + k_1 k_2 k_4}{a_1 + a_2}$
 $Or, a_1 a_2 > \frac{k_1 k_2 k_3 a_2 + k_1 k_2 k_4}{a_1 + a_2} - k_1 k_2 k_3$
 $Or, a_1 a_2 > \frac{k_1 k_2 k_4 - k_1 k_2 k_3 a_1}{a_1 + a_2}$
 $Or, a_1 a_2 > \frac{k_1 k_2 (k_4 - k_3 a_1)}{a_1 + a_2}$
 $Or, k_1 k_2 < \frac{a_1 a_2 (a_1 + a_2)}{(k_4 - k_3 a_1)}$
3. Condition 3:
 $C > 0$
 $Or, k_1 k_2 k_3 a_2 + k_1 k_2 k_4 > 0$
 $Or, a_2 > -k_4/k_3$

To make the model stable all of the three conditions described above must be satisfied.

6. RESULTS

Fig. 5 and fig. 6 show the eye response to an object position. The object position or the input is considered as the unit step function in fig. 5 and the sine wave in fig. 6. The figures show that the eye can detect the position of the object after a certain time. This certain time includes the rise time resulted from delay of signal processing in the brain, propagation delay in the nervous system and from time constant determining factor of the eye.

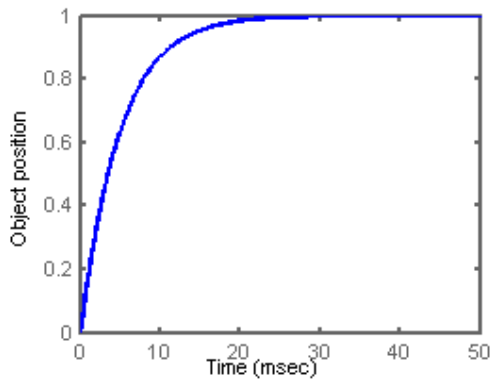


Fig. 5. Normal eye response to unit step function

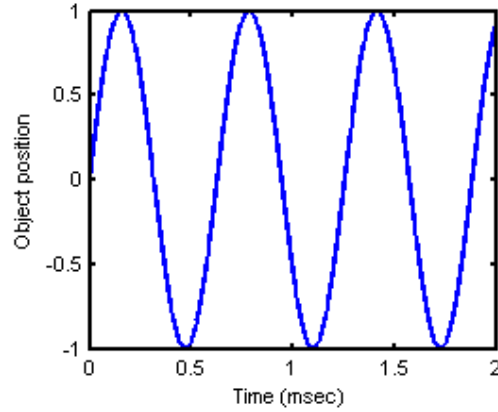


Fig. 6. Normal eye response to sine wave

If the eye suffers from diseases, the object position is not detected accurately. Eye disease means the changes of the different parameters in the model. When it occurs, the model suffers from instability and the eye cannot detect the actual position of the object which is described below.

Fig. 7 shows that when the eye suffers from myopia then there is a steady state error. This error means that the eye cannot reach to the actual object position. Myopia occurs due to increment of convex power of the eye which is determined by the decrement of gain constant of the muscle spindle. As the muscle spindle works as the negative feedback network, an increment means the decrement of power and vice versa.

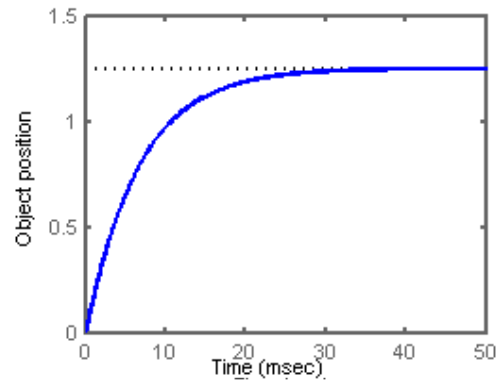


Fig. 7. Response of eye suffering from myopia

As myopia occurs due the increment of convex power of the eye, it is required to reduce the convex power of eye to get removed from this eye disease. A concave lens is used to reduce the power. In the model, the value of gain constants is increased so that the effect reduces by the negative feedback. Fig. 8 shows the response of the eye suffering from

myopia with a concave lens of suitable power. This response is same as normal eye response.

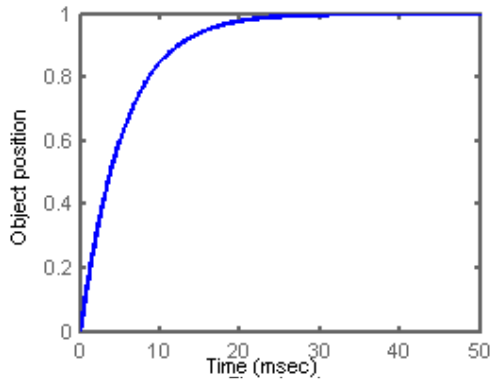


Fig. 8. Response of eye suffering from myopia with suitable concave lens

Fig. 9 shows that when the eye suffers from hypermetropia then there is a steady state error. This error means that the eye cannot reach to the actual object position. Hypermetropia occurs due to decrement of convex power of the eye which is determined by the increment of gain constant of the muscle spindle. As the muscle spindle works as the negative feedback network, an increment means the decrement of power and vice versa.

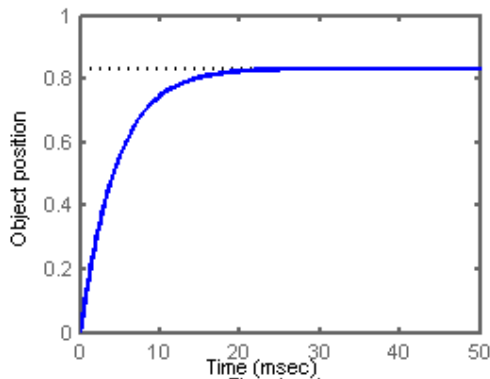


Fig. 9. Response of eye suffering from hypermetropia

As hypermetropia occurs due the decrement of convex power of the eye, it is required to increase the convex power of eye to get removed from this eye disease. A convex lens is used to increase the power. In the model, the value of gain constants is decreased so that the effect increases by the negative feedback. Fig. 10 shows the response of the eye suffering from hypermetropia with a convex lens of suitable power. This response is same as normal eye response.

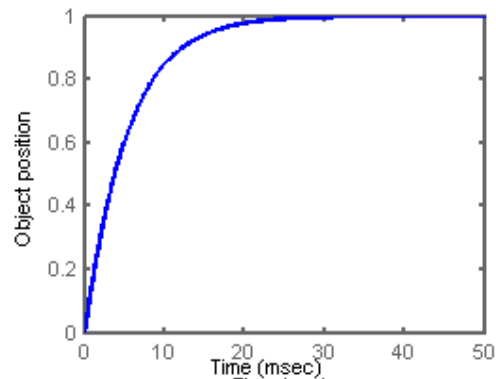


Fig. 10. Response of eye suffering from hypermetropia with suitable convex lens

Muscle and eye gain constants determine the rise time to detect the object position. The rise time increases as the gain constants decrease. It is due to aging effect, when the power of the eye muscle reduces. Rise time increases means it will take more time to detect the position of the object fully. Fig. 11 shows the variation of rise time for various gain constants.

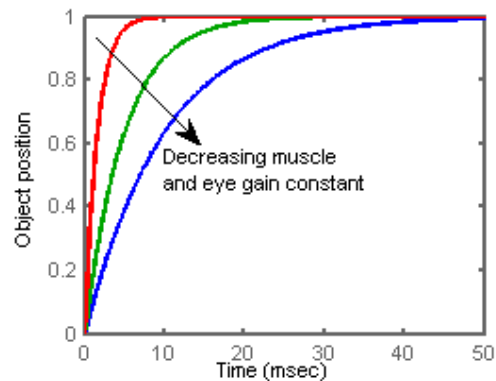


Fig. 11. Eye response to various gain constants

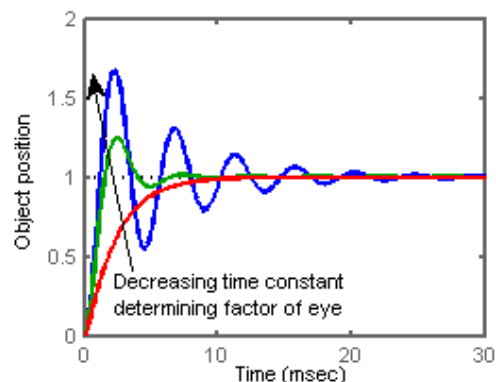


Fig. 12. Eye response to various time constant determining factor of eye

Time constant determining factor of eye affects both the rise time and clearness of the object

detection. As the factor decreases, rise time increases but clearness of the object reduces. This phenomenon is described in fig.12.

Time constant determining factor of muscle spindle affects the initial clearness of the object detection but does not affect the rise time. A change in this factor can lead a normal eye, eye with myopia and eye with hypermetropia as described in fig.13. Hypermetropia is significant than that of the myopia.

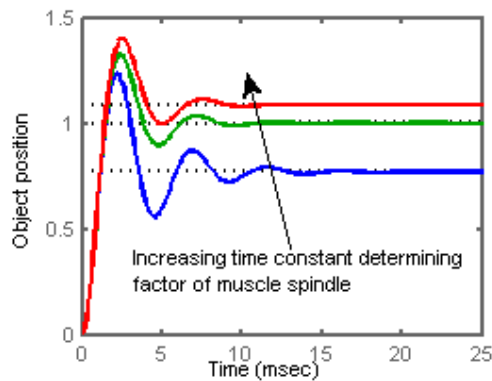


Fig. 13. Eye response to various time constant determining factor of muscle spindle

7. CONCLUSIONS

The goal of this paper is to represent a model of the eye movement. The mathematical model is presented in two forms: differential equation form and space state representation. This model is replaced by electronic circuits to develop an electrical model of eye movement.

A limited number of internal parameters are considered in developing the model. So, possible improvements of the study would include the integration of more sophisticated, more realistic model and a more complex constitutive law. Although some assumptions have been considered, the model can be treated as a valid one, because, this model is able to show the normal eye response to an object position, can describe the aging effect on eye. The model can also show the diseases of eye and the treatment of those diseases using convex or concave lens with suitable power.

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METHODOLOGY FOR COST EFFECTIVE WEB TESTING FOR ECOMMERCE WEB APPLICATIONS

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ABSTRACT: In the emerging global economy, electronic commerce (e-commerce) has increasingly become an indispensable component of business strategy and a strong catalyst for economic development. The World Wide Web has grown at an extravagant rate as a medium for promoting and marketing products and services. A web application is referred to as a system which consisted of many different functional modules. From the user point of view quality of services, predictable response services, response time, availability, reliability is the key factor to compete with others. Poor quality implies that the customer will not visit the site and the company loose business. The issues that affect the quality are broken links, broken images, broken pages, error messages, server faults etc. Software testing is primary way to improve software reliability and assuring software quality. This research generates methodology to improve quality of services for web based software applications

Key words: Web Application, Web Testing Methodology, Performance Testing, Website Design

1. INTRODUCTION

Internet and the web based applications are emerging and the WEB application creates a paradigm in the field of Ecommerce. And it is consisted of many autonomous and heterogeneous frameworks. As they are different in the modality, performance, functionality, usage and service, and the system is usually dominate in the market. Website is a combination of different hypermedia. Server Side Scripting Language and Client Side Scripting language make the web dynamic. There are several aspects to evaluate a website and its rank. The popularity depends on the contents and the way it designed and maintained. As a result, it is more difficult to carry out the development and maintenance for web site than the desktop based software.

As an important method to ensure the quality of Ecommerce web site, the testing obtains more and more attentions from researchers and users, and many important researching methods. Testing aims at finding errors in the tested object and giving confidence in its correct behavior by executing the hypermedia and its objects with selected objects. However, web applications raise important and challenging test issues that cannot be solved directly by existing methodology unlike desktop software's. The presentation details of the web, such as size, position and color of page elements,

although they are also of importance to the business factor.

2. RELATED WORK

The testing process for traditional software is generally consisted of different steps: firstly determine the testing objects and targets, such as the required testing coverage ratio; next, generate the testing input, and this input is generated by the specification and structure of the software; then produce the expected output results; subsequently, execute the test cases and validate output; This series of steps and flows are suitable for the general software testing, and the differences, which can directly influence the ultimate testing effect.

At present, the research on how to carry out the analysis and comparison of Web application testing results is not prevalent, for the current Web application testing is short of necessary criterion and strict process, and the testing for Web applications and the testing results judgment are often executed by testers manually. In order to be suitable for the specialties of numerous contents and heavy tasks of Web application testing, and further improve the testing precision and efficiency, researchers have done a lot in such aspects as assistant tool development and testing automation. Correspondingly, the automatic analysis and comparison are still needed for the testing results.

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However, there are many difficulties in the automatic analysis and comparison of the testing results, and the main reasons are: many Web pages are dynamically generated, so it is difficult to gain the determined expected results before executing testing; the outputs of Web applications are graphic interfaces, and the comparing method for graphics is scanning and comparing each pixel in turn, but due to the influences of client environments to the displaying of Web application, such as the system resolution, browser type and version, this method is very numerous and fallible, thus it is necessary to separate the data and displaying so as to compare the related contents directly.

In order to evaluate the quality of Web application and the efficiency of testing process, the quantitative analysis and metrics to the testing results are still needed so as to obtain some evaluating indexes and form the criterion. Then we can measure and evaluate a lot of testing results for Web applications and give the guidelines to the development of Web applications. In the existed research work, P.Warren [10,11] mainly focused on the Website evolution and Web application maintenance, and they pointed out that all kinds of problems occurred in the Website development, usage and maintenance are caused by disobey the rules of software engineering, and they put forward the metrics to indicate the evolvement of Websites; Devanshu Dhyani presented the origins, measurement functions, formulations and comparisons of well-known Web metrics for quantifying Web graph properties, Web page significance, Web page similarity, search and retrieval, usage characterization and information theoretic properties [9]. However, there are short of the related metrics criterions and indexes to the testing, so it is difficult to directly evaluate the testing effect.

After we obtain the Web application indexes by the metrics in multiple aspects, the modification and maintenance to the Web application are needed due to the testing results, so as to eliminate the influences caused by the faults in the system, satisfy all kinds of actual demands of users, improve the system quality actual demands of users, improve the system quality and the degree of users' satisfactions. We can use the control theory [8] and the feedback mechanism, and feed back the related testing information into the Web applications themselves, thus we can know the existed problems in Web applications and the difficulties of their modifications and improvements, then we can guide the development and evolvement of Web applications directly and exactly especially in the aspects of system reliability, usability and safety.

3. WEB TEST MODEL

As more and more services and information are made available over the Internet and intranets, Web applications have become extraordinarily complex. As time progresses the volume of information and web contents increase and update. Although traditional software testing is time consuming and difficult to maintain. Therefore new approach and new methodology is required for quality improvement.

Faults are obtained through a process similar to one defined and used in previous research in testing techniques [2,3,4] whereby faults are inserted, which are as realistic as possible and based on user experience. The following fault types are considered:

- Web page faults: This includes addition, deletion, or modification of name-value pairs.
- HTML faults: This includes HTML tag opening and closing error.
- Database query faults: This includes modification of a query expression, which may possibly affect the type of operation.

4. Reason for WEB Site Evaluation

Once the web application is set up, the challenge is to have users access the site and behave like typical users of this type of e-commerce site. And also continue the performance for the user and provide speed for simultaneous business transaction.

The repercussions of having a poorly operating website are staggering, and even affect the brick and mortar stores that the websites are enabling online. A recent study showed that when errors are found on an e-commerce website, 28% of the people stopped shopping at the site, 23% stopped buying from the site, and 6% of the people were so upset, that they stopped buying at brick and mortar store. One can only deduce that the customers feel that if the company cannot provide a quality website, then they may not be able to sell a quality product from their stores.

Table 1: Effects of poorly operating websites

Effects of poorly operating Websites	Percentage
People stopped shopping at the site	28%
Stopped buying from the site	23%
of the people were so upset	6%

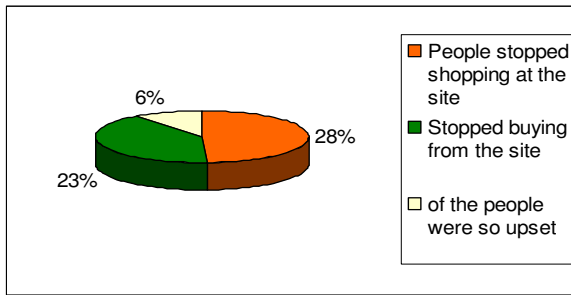


Figure 1: Effects of poorly operating websites [chart based]

5. Cost-Effective Methodology

Like any complex piece of software there is no single, all inclusive quality measure that fully characterizes a WebSite (by which we mean any web browser enabled application).

The process of website designing can be divided into different stages. The stages are Information Gathering, Apply methods, Website evaluation, Result Analysis.

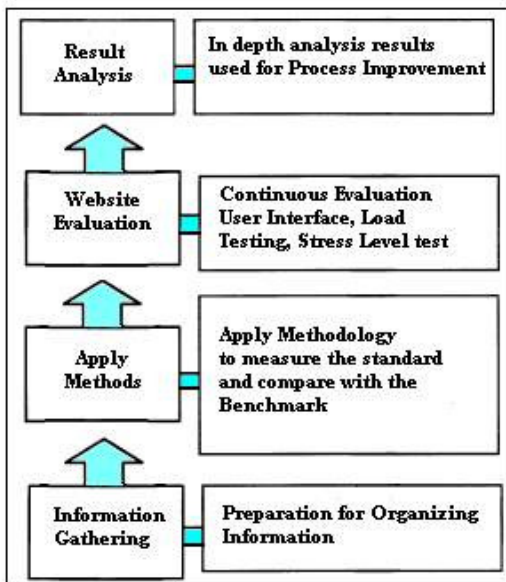


Figure 2: Web Evaluation Procedures

5.1 Dimensions of Quality:

There are many dimensions of quality; each measure will be appropriate to a particular WebSite in varying degrees. Here are some common measures:

- **Timeliness:** WebSites change often and rapidly. How much has a WebSite changed since the last upgrade? How do we highlight the parts that have changed?
- **Structural Quality:** How well do all of the parts of the WebSite hold together? Are all links inside and outside the WebSite working? Do all of the images work? Are there parts of the WebSite that are not connected?
- **Content:** Does the content of critical pages match what is supposed to be there? Do key phrases exist continually in highly-changeable pages? Do critical pages maintain quality content from version to version? What about dynamically generated HTML (DHTML) pages
- **Accuracy and Consistency:** Are today's copies of the pages downloaded the same as yesterdays? Close enough? Is the data presented to the user accurate enough? How do you know?
- **Response Time and Latency:** Does the WebSite server respond to a browser request within certain performance parameters? In an e-commerce context, how is the end-to-end response time after a SUBMIT? Are there parts of a site that are so slow the user discontinues working?
- **Performance:** Is the Browser --> Web --> webSite --> Web --> Browser connection quick enough? How does the performance vary by time of day, by load and usage? Is performance adequate for e-commerce applications? Taking 10 minutes -- or maybe even only 1 minute -- to respond to an e-commerce purchase may be unacceptable!

5.2 Impact of Quality.

Quality remains in the mind of the WebSite user. A poor quality WebSite, one with many broken pages and faulty images, with Cgi-Bin error messages, etc., may cost a lot in poor customer relations, lost corporate image, and even in lost sales revenue. Very complex, disorganized WebSites can sometimes overload the user.

The combination of WebSite complexity and low quality is potentially lethal to Company goals. Unhappy users will quickly depart for a different site; and, they probably won't leave with a good impression.

Some access to information from the database may be appropriate, depending on the application, but this is typically found by other means.

- **Navigation.** Users move to and from pages, click on links, click on images (thumbnails), etc. Navigation in a WebSite is often complex and has to be quick and error free.
- **Object Mode.** The display you see changes dynamically; the only constants are the "objects" that make up the display. These aren't real objects in the OO sense; but they have to be treated that way. So, the quality test tools have to be able to handle URL links, forms, tables, anchors, buttons of all types in an "object like" manner so that validations are independent of representation.
- **Server Response.** How fast the WebSite host responds influences whether a user (i.e. someone on the browser) moves on or gives up. Obviously, InterNet loading affects this too, but this factor is often outside the Webmaster's control at least in terms of how the WebSite is written. Instead, it seems to be more an issue of server hardware capacity and throughput. Yet, if a WebSite becomes very popular -- this can happen overnight! Loading and tuning are real issues that often are imposed -- perhaps not fairly -- on the WebMaster.

5.3 Interaction & Feedback.

For passive, content-only sites the only real quality issue is availability. For a WebSite that interacts with the user, the big factor is how fast and how reliable that interaction is.

5.4 Concurrent Users.

Do multiple users interact on a WebSite? Can they get in each others' way? While WebSites often resemble client/server structures, with multiple users at multiple locations a WebSite can be much different, and much more complex, than complex

5.5 Performance Testing Illustration.

To illustrate how the cost effective methodology measures timing we have built a set some measurement that have these features:

- **Top 20 Web Portals.** We selected 20 commonly available WebSites on which to measure response times.
- **User Recording.** We recorded one user's excursion through these suites and saved that keysave file (playback script).
- **User Recording.** We played back the scripts on a 56 kbps modem so that we had a realistic comparison of how long it would take to make this very-full visit to our selected 20 portals.
- **P4 Timings.** We measured the elapsed time it took for this script to execute at various times during the day. The results from one typical day's executions showed a playback time range of from 457 secs. to 758 secs (i.e. from -19% of the average to +36% of the average playback time).
- **Second Layer Added.** We added to the base script a set of links to each page referenced on the same set of 20 WebSites. This yielded the P4+ suite that visit some 1573 separate pages, or around 78 per WebSite. The testsuite takes around 20,764 secs (~5 Hrs 45 mins) to execute, or an average of 1038 secs per WebSite.
- **Lessons Learned.** It is relatively easy to configure a sophisticated test script that visits many links in a realistic way, and provides realistic user-perceived timing data.

Table 2: Cost-effective Testing Result

Dimension of Quality	Ebay.com	Hutbazar.com
Timeliness	2009-2010	2007-2008
Structural Quality	41 links	2 links
Content	11 img/ 1 Form /5 Jscript	32 img/ 1 Form /1 Jscript
Accuracy and Consistency	Dynamic	same as yesterday
	13 KB /115 ResT /	11KB / 211 ResT /
Response time and Latency	Down 180 ms	Down 561ms
	150 KB / 54 ResT /	15 KB / 189 ResT /
Performance	Down 328 ms	Down 374 ms

6. COST EFFECTIVE WEB TESTING EVALUATION MODEL

To find out the result about different criteria we need to visit different web based testing site. Since we need to find out the values against the criteria from different ecommerce validation testing site which is time consuming and not cost effective. Thus we can develop tool which can generate unified testing result and moderate the content.

The URL-Driven Methodology is a novel use of Data-Driven Methodologies for Web-based testing. A URL specifies the protocol that is used in accessing the resources that includes a Web server's domain name and the specific file name. Every part of the domain name indicates where you want to go, what type of data you are requesting, and where

you can find the information within the server site that you want.

URLs are most frequently used in Web pages. However, other types of URLs are: Web addresses, E-mail addresses, FTP hosts, Newsgroup addresses, Telnet hosts, Finger hosts, Gopher addresses, Wais hosts and Query URLs.

It will cause a long time to finish testing when we have hundreds or thousands of URLs to be checked. However, the URL-Driven Testing Methodologies help us to build a friendly, cost-effective, and maintainable system. We can use a common or selected web browser and a well-designed data matrix. The user can easily navigate through directories of pre-defined test cases, configure the test system, execute tests and view detailed test results.

The Following result produces by an online web testing site

Host name	File name	Mime type	File size	Status code	Response time, ms	Download time, ms	Last modified
www.ebay.com		text/html	35 Kb	200	311	989	
include.ebaystatic.com	GH-RA_ReskinEbay_e67311252544_en_US.css	text/css	13 Kb	200	115	180	5/21/2010
include.ebaystatic.com	CCHP_HomepageV4_SLDR_e66911242611_en_US.css	text/css	14 Kb	200	114	211	5/20/2010
include.ebaystatic.com	SYS-RA_vjo_e67311309442_1_en_US.js	application/x-javascript	150 Kb	200	54	328	6/2/2010
include.ebaystatic.com	GH-RA_ReskinEbay_e67311309442_1_en_US.js	application/x-javascript	116 Kb	200	54	283	6/2/2010
p.ebaystatic.com	logoEbay_x45.gif	image/gif	1 Kb	200	57	86	

7. Expected Outcome

Web-based analysis and test tools have been also developed that model the underlying structure for web applications. White box testing approach build system models from inspection of code, identify test requirements from those models, and require extensive human participation in the generation of test cases to fulfill those requirements. These approaches focus on the internal structural aspect and involve in the details of a web application.

Develop a prototype tool allowing users to run the test cases to test the functionality, security and find faults in the web application. The test cases should

specify the input conditions and expected output of each test as specified. It should be generated to be extensible and allow enhancements to be made for more complex and customizable tests. Load test the newly generated test cases to test the performance of the web application and generate a test report.

The system to be developed will need a web application used by many that resembles as closely as possible to those found in the real world. An open source web application will be used to capture relevant user sessions to generate a test suite.

7. CONCLUSIONS

The cost effective testing methodology for web application can improve the performance testing of web application. The approach is based on formal specification of the web applications functionality, security and performance. The results of an evaluation indicate that effectiveness of these approaches is better than conventional techniques and reduces required tester intervention.

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MICROWAVE ANALYSIS OF A MEMS SWITCH

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Micro electro mechanical systems (MEMS) have experienced an explosive growth over the past few years driven mainly by its physical properties and its promising technological applications in many different fields, particularly in space and RF systems. MEMS technology exhibits greater advantages over the existing semiconductor switches. In this paper, Radio Frequency (RF) performances of a two hot arms actuator MEMS switch have been investigated. The switch is designed and simulated using CST Microwave Studio. To get different parameters of transmission line, AWR Microwave Office has been used. The simulated results show that the designed MEMS switch performed well at high frequency. At OFF state the return loss S_{11} drops nearly to zero dB and the isolation S_{21} become lower than -50 dB at 1 GHz and -35 dB at 10 GHz which indicates the high isolation. At ON state position the simulation exhibits very low insertion loss, $S_{21} < -0.16$ dB at 10 GHz and return loss $S_{11} < -19$ dB at 10 GHz. Even at more high frequency insertion loss is very low as $S_{21} < -0.22$ dB and return loss $S_{11} < -18$ dB at 39.5 GHz.

Key words: MEMS, RF, Actuators, Insertion loss, Isolation

1. INTRODUCTION

MEMS technology has exhibited numerous advantageous properties that helped this technology to compete in the microelectronics market. MEMS technology allows miniaturizing the device while performance also boost up. Personal communication devices with miniaturized high frequency and high integration have been possible with the advent of fabrication technology which is using MEMS technology to fabricate the integrated RF circuits. MEMS (Micro-Electro-Mechanical Systems) is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through microfabrication technology.

RF switches are the most common and basic circuit elements. Current solid-state RF technologies (PIN diode- and FET- based) are utilized for their high switching speeds, commercial availability, low cost, and ruggedness [1]. This technology reached its maturity in areas such as device design, fabrication, packaging, applications/system insertion and, consequently, high reliability and well-characterized performance. Some parameters, such as isolation, insertion loss, and power handling, can be adjusted via device design to suit

many application needs. In spite of this great design flexibility, there are two major bottlenecks with solid-state switches: breakdown of linearity and frequency bandwidth upper limits, and the degradation of insertion loss and isolation at signal frequencies above 1-2 GHz. The advantage of low insertion loss, high isolation, extremely high linearity together with the potential for high reliability, low power consumption, low mass and long lifetime operation, make RF MEMS switches a promising solution to existing low-power RF technology limitations [2]. Various researches have been done on MEMS switches including metal-to-metal contact switch [3, 4], capacitive contact shunt switch [5], Ti/Gold switch [6, 7], push-pull series switch [8, 9] and DC-contact switch [10] - [13]. Nowadays, more MEMS switch, capacitors, inductors are reported to be integrated to make various RF devices. Devices such as phase array phase shifter, switching and reconfigurable networks and low power oscillator and varactors are actively pursued and manufactured for wireless communication industries [14, 15].

In this research, a MEMS switch had been developed for Radio Frequency (RF) application. The switch contains two hot arm actuators and was designed and simulated using CST Microwave Studio.

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2. DESIGN METHOD AND ANALYSIS

The NB Technology Company at Hamburg in Germany proposed a mechanical MEMS switch. Fig. 1 shows the design sequences of two hot arms

actuator MEMS switch which was developed. The purpose of this study is to analyze microwave performance of this switch.

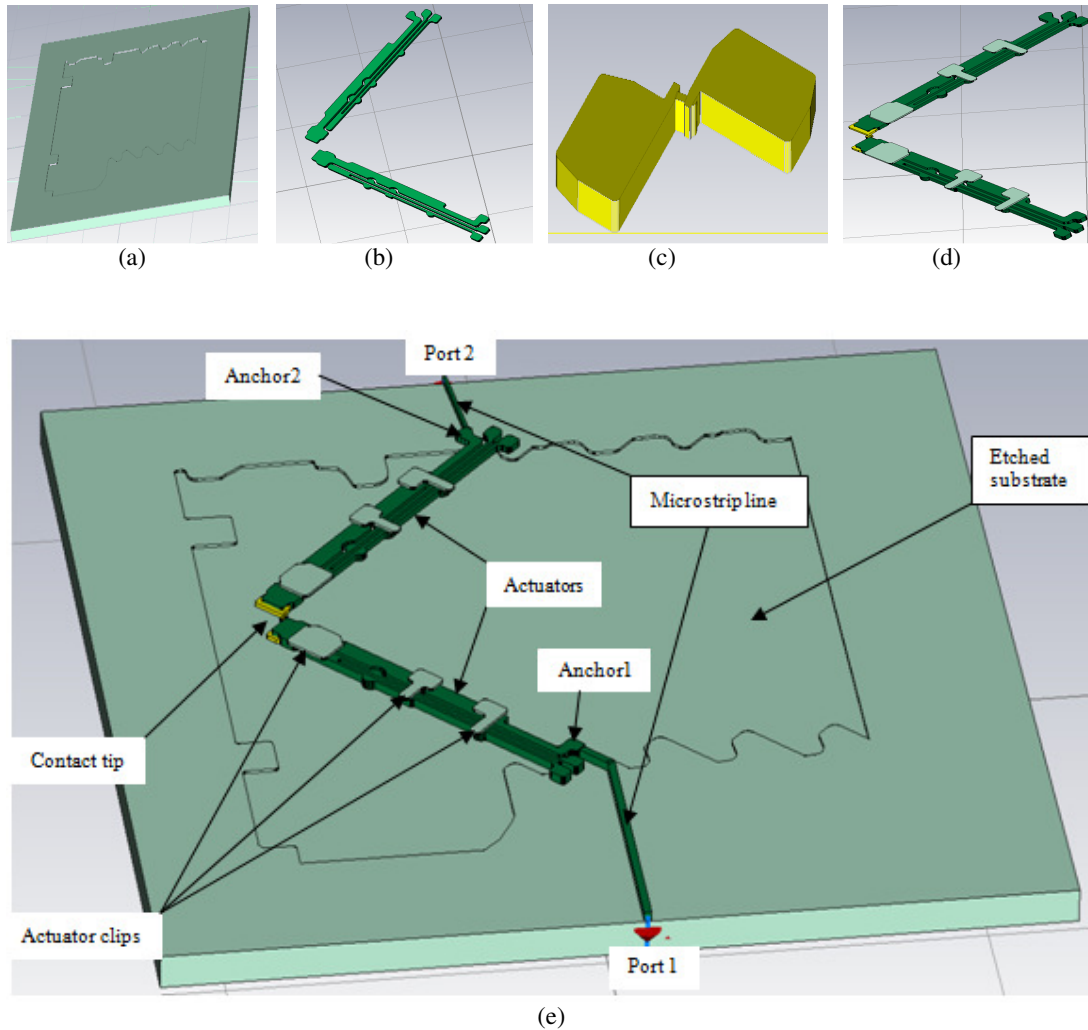


Fig. 1 Design of the switch (a) substrate with etching (b) actuators (c) contact tip (d) clip for actuators (e) complete switch

Substrate is made of quartz material with height of $50\text{ }\mu\text{m}$. An etching process has been performed on the quartz substrate to make a specific shape on the substrate and to create an air gap between the actuators and substrate material as shown in fig.1 (a). The two hot arms actuators are made by nickel with surface micromachining technology. The width and height of the actuator is $50\text{ }\mu\text{m}$ and $13\text{ }\mu\text{m}$ respectively as shown in fig.1 (b). To connect the actuators end, two contact tips have been made of gold as shown in fig.1 (c) and attached them with the end of each actuator. To avoid contact between

etched substrate and actuators, three clips are made of SU8 material as shown in fig.1 (d). Finally two microstrip lines have been created on the substrate to make input and output port as shown in fig.1(e).

The microwave signal travels from port 1 to port 2 through the microstrip lines and actuators. The equivalent electrical circuit of this transmission line is given in fig.2. When voltage is applied, the two actuators are connected with each other and the signal transmitted from port 1 to port 2 forming a complete transmission line. In this case the total

transmission line length $L=1.44\text{mm}$. The characteristics impedance of the line Z_0 has been calculated using AWR Microwave Office. For the physical characteristics of the transmission line of Length, $L=1.44\text{ mm}$, Width, $W = 50\text{ }\mu\text{m}$, Height, $H=50\text{ }\mu\text{m}$ and Thickness, $T=13\text{ }\mu\text{m}$, characteristics impedance of the transmission line $Z_0=70.05\Omega$, Electrical Length $\beta l=0.4947\text{rad}$ have been calculated at 10 GHz. $B=0.12776\text{mm}^{-1}$ thus $l=3.89\text{mm}$.

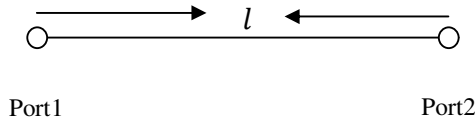


Fig.2 Equivalent circuit upon voltage applied

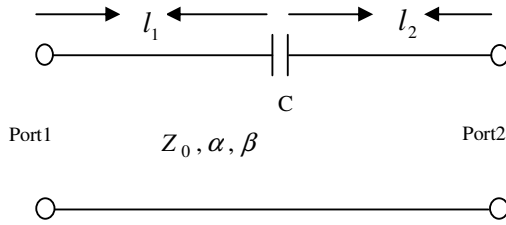


Fig.3 Equivalent circuit upon voltage turned off

When there is no voltage applied to the actuators, the transmission line is not connected as two actuators are separated by a distance of 0.003976 mm . An equivalent circuit is shown in fig.3 of this situation. In this case if a signal excited at port 1, it will try to travel from port 1 to port 2, but when as the actuators are disconnected the signal travels back from the end of the actuator with port 1. As two actuators are separated by some distance, there will be a capacitive effect between the two actuators. This capacitance $C=0.000076\text{pF}$. The impedance due to this capacitance is $-j209414\text{ ohm}$. From the AWR Microwave Office, the electrical length is calculated as 0.24736 rad . Therefore $l_1 = l_2 = l_c = 1.93\text{mm}$.

3. RESULTS

Fig.4 shows the simulated scattering parameters S_{11} and S_{21} when the MEMS switch is in OFF state. As shown, the return loss S_{11} drops nearly to zero for the signal transmission was interrupted. On

the other hand, the isolation S_{21} become lower than -50 dB at 1 GHz and -35 dB at 10 GHz which indicates the high isolation created by the gap between two actuators.

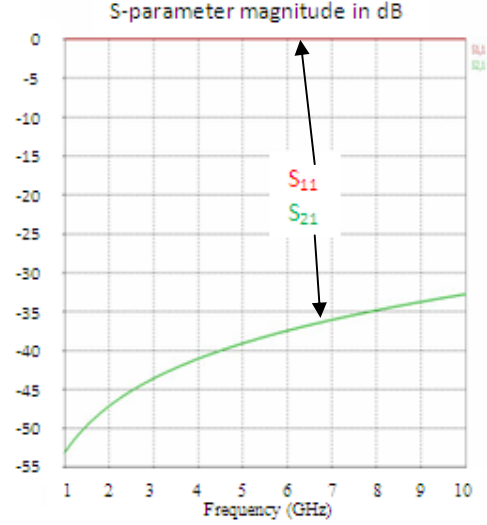


Fig.4 S-parameters with switch is in OFF state

Fig.5 shows the simulated scattering parameters S_{11} and S_{22} when the MEMS switch is in ON state. When MEMS actuator is connected means the switch is in ON state the signal transmitted from port 1 to port 2. At ON state position the simulation exhibits very low insertion loss, $S_{21} < -0.16\text{ dB}$ at 10 GHz and return loss $S_{11} < -19\text{ dB}$ at 10 GHz .

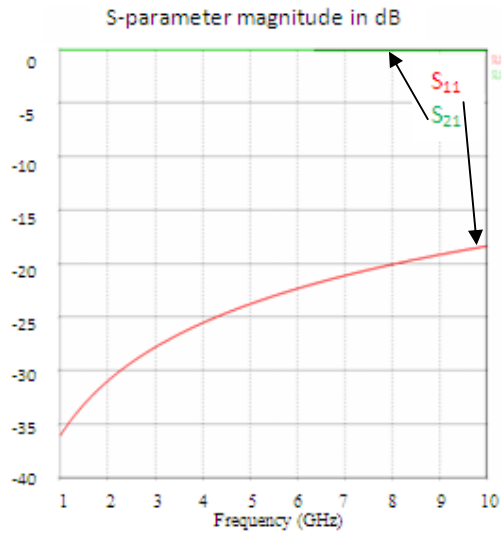


Fig.5 S-parameters with switch is in ON state

At higher frequencies the switch exhibits also good performance as shown in fig.6 when the actuators are connected upon voltage applied, the simulation shows us that the insertion loss is very low as $S_{21} < -0.22$ dB and return loss $S_{11} < -18$ dB at 39.5 GHz.

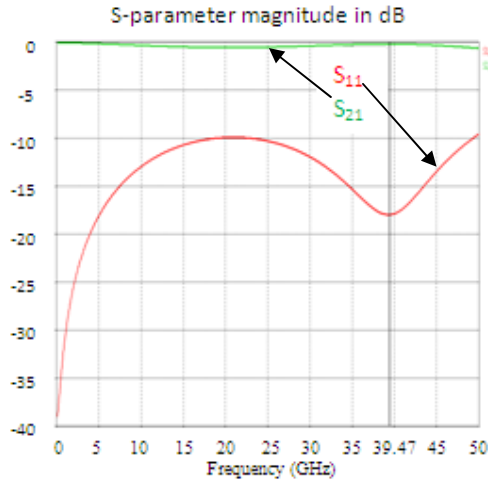


Fig.6 S-parameters at higher frequencies

From the fig.7 we can notice that in frequency range of 0 to 20 GHz, the scattering parameters S_{21} decays as the frequency increased. This is because the impedance of the transmission line also increased with frequency. On the other hand in the frequency range of 20 GHz to 40 GHz, the scattering parameter S_{21} rise up. This may happen due to the structure of the transmission line and can be explained as filtering effect. In this range of frequencies the impedance of the transmission line has matched due to the shape of the transmission line. Fig.8 shows an example of this effect.

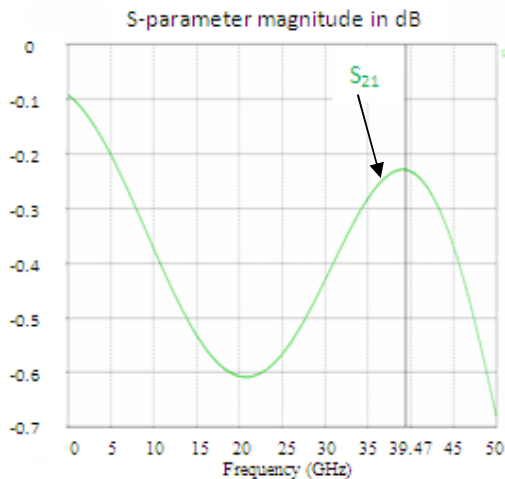


Fig.7 S-parameters S_{21} at higher frequency

In fig.8 (a) a microwave filter has been considered to understand the situation of fig.7. The microstrip line designed here has two different widths as shown. When a signal excited at input port, a portion of the signal will travel through the line and a portion will be reflected back because of the different width of the structure exhibits different impedance of the transmission line. From fig.8 (b), we can see that the structure filtered out some frequencies and allow some specific range of frequencies.

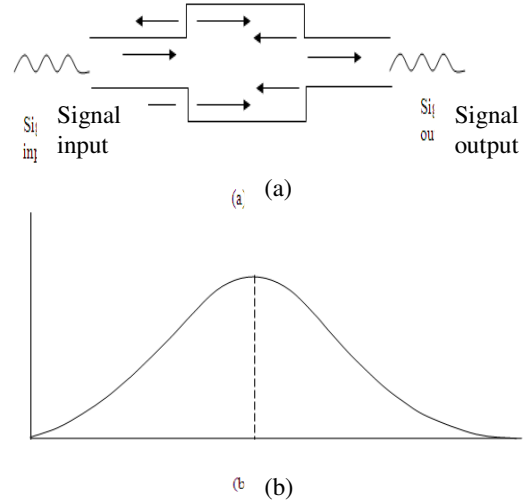


Fig.8 (a) A microwave filter (b) filtered output

The same phenomenon has caused to the MEMS switch designed here. Since the actuators are made of different width and different material, the impedance throughout the transmission line is not equal and mismatches of the impedances causes different values of scattering parameters at different frequencies.

4. CONCLUSIONS

High frequency performance analysis of a two hot arms thermal actuator has been attempted in this paper. The 3D design of the structure is designed and simulated using CST Microwave Studio. RF analysis of this MEMS switch has shown that at low frequency the isolation is very high as -50 dB at 1 GHz and at higher frequency the isolation is also quite high as achieved -35 dB at 10 GHz. ON state simulation results revealed that very low insertion loss is achieved ($S_{21} < 0.16$ dB) and the return loss $S_{11} < -19$ dB at 10 GHz. Even at more high frequencies (40 GHz) the performances of this switch is reasonably remarkable. The S-parameters simulation shows that a low insertion loss $S_{21} <$

0.22 dB and low return loss $S_{11} < -18$ dB have been achieved at 39.5 GHz.

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PACKING NON-IDENTICAL CIRCLES IN A SMALLEST CIRCULAR CONTAINER BY MODIFIED MONOTONIC BASIN HOPPING HEURISTIC APPROACH

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Packing problems have mathematical as well as practical application point of interest. Monotonic Basin Hopping (MBH) heuristic approaches are successfully implemented for solving equal circles problems. For the presence of combinatorial part, unequal radii, simple extension of MBH approach is not the appropriate way to co-opt the problem of packing non-identical circles within a smallest circular container. Here, we present a modified Monotonic Basin Hopping heuristic approach to solve the problem. As well as some new perturbation moves are proposed which are suitable for the case of unequal circles packing problems.. Several improvements with respect to the best results reported in the literature have been detected.

Key words: Circle Packing, Monotonic Basin Hopping, Multistart.

1. INTRODUCTION

The packing problem have a spectrum of application including production and packing for the textile, apparel, naval, automobile, aerospace and food industries, news paper, web pages design, in particular, to problems related to cutting and packing [Dyckhoff, 1990]. They are bottleneck problems in Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) where design's plans are to be generated for industrial plants, electronic modules, nuclear and thermal plants, etc [Hifi M. and R. Hallah, 2009]. In particular, we consider in this paper, the Non-Identical Circle Packing in a Circular Container (NICPCC) problems. The NICPCC problems can be described as follows:

Problem: To find the minimum circular container radius D_n which contains N non-identical and non-overlapping circles with given radii. Mathematically,

$$\min r \quad (1)$$

Subject to

$$x_i^2 + y_i^2 - r^2 + 2rr_i \leq r_i^2; \quad i \in I \quad (2)$$

$$(x_i - x_j)^2 + (y_i - y_j)^2 \geq (r_i + r_j)^2; \quad i, j \in I, i < j \quad (3)$$

$$\max(r_i) < r \quad (4)$$

Though there is a long history of solving packing problems in literature, problems of non-identical circles in a minimized circle have received very little attention. Very few papers addressing the problem of packing non-identical paper; but most of them considered non-circular container like square container, rectangular container [Dyckhoff, 1990]. Stoyan and Yaskov [Stoyan and Yaskov, (1998)] developed a mathematical model for packing different radii circles into a minimal length strip. Hifi and M'Hallah [Hifi and M'Hallah, 2008] proposed adaptive and restarting techniques based approach for circular packing problems. Addis et. al [Addis et. al, 2008a] proposed a heuristic approach to solve unequal circle packing problems. Addis et al. [Addis et. al, 2008] investigated the problem of packing equal circles in the unit square and proposed a quite successful method (MBH) for the problem. Jamali et al. [Jamali et al., 2009] also used MBH approach to solve identical circles in a circular container rather than square container. Finally, a survey about this problem can be found in [Szabó et al., 2005], and a recent book has been dedicated to the subject [Szabó et al., 2007]. In comparison with the best known problem of placing identical circles in a smallest container, here the fact that each disk has a different radius generates new difficulties and challenges. In fact, while the problem with identical radii can be

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considered as a pure continuous optimization problem, here the fact that each circle has a different radius adds some sort of a combinatorial structure over the original one. This is an extremely challenging global optimization test problem. Hence researchers are searching for the efficient heuristic approximation algorithms to solve the problems. Here we proposed a modified Monotonic Basin Hopping (MBH), which is denoted as sequential Insertion Based MBH approach to solve the non-identical circles packing problems.

2. PROPOSED MODIFIED MONOTONIC BASIN HOPPING ALGORITHM

In order to deal with the case of non-identical circles one may think to extend the approaches employed for the case of equal circles with a slight variant in the perturbation moves: for instance, for the Full Jerk (FJ) perturbation strategy the coordinates of each circle i are displaced by a uniform random perturbation within the interval $[-\Delta_{ri}, \Delta_{ri}]$, where r_i denotes the radius of circle i (for Random Perturbation Jerk (RPJ) and Fixed Perturbation Jerk (FPJ) the displacement is restricted to a subset of circles) [Hifi and M'Hallah, 2008]. But, as we will see through some experiments, this simple extension is not the best way to tackle the problem. Indeed, the case of non-identical circles has some peculiarities which have to be taken into account. The combinatorial side of this problem, represented by the different radii of the circles, can (and actually should) be exploited in some ways. In particular, we will propose a three phase modified MBH approach where the algorithm optimize a fraction of relatively larger circles, and then insert one or a part of the remaining smaller circles sequentially and simultaneously optimize them.

The procedure consists of three main steps:

- (a) apply the Removal Strategy to remove “small” circles;
- (b) apply MBH on the remaining subset of larger circles;
- (c) apply Insertion Rule for sequentially inserting the missing circles.

In what follows we define this approach as Sequential Insertion Based MBH (SIB-MBH). Besides all components of the MBH approach, there are two further components in this new approach namely (i) Removal Strategy (RemS) and (ii) Insertion Rule (IR). Before giving a formal description of SIB-MBH, we describe these below.

(i) Removal Strategy (RemS): It is observed from the experiments that small circles are sometimes relatively easily inserted in holes of optimized configurations for some subset of the larger circles

without having to enlarge the container or with just a small enlargement. According to our Removal Strategy, circles are indexed in decreasing order with respect to their radius. Then, a fraction of “small” circles is removed.

Of course, we need to define what a “small” circle is. We define a circle i

as a small circle if its radius is at least four times smaller than the largest one,

i.e., circle i is small if

$$r_i \leq \frac{1}{4} \max_{j=1,2,\dots,n} r_j$$

(5)

Let us denote the set of initially removed circles as S_R ; then

$$S_R = \left\{ i, : r_i \leq \frac{1}{4} \max_{j=1,2,\dots,n} r_j \right\} \quad (6)$$

This strategy strongly simplifies some instances of the problem through a considerable reduction of the search space during the first phase where some circles are removed.

(ii) Insertion Rule (IR):

In the insertion process of a given circle c_s in S_R , first the algorithm creates a regular grid of points over a square region containing the circular container. The step of the square grid is half of the inserted circle's radius. The edge length of the square region is the sum of the diameter of the container and the radius of the circle to be inserted, so that the circular container, which is optimized previously by the reduced circles, is fully enclosed within the square (both have the origin as their common center). Next, the algorithm searches for “free” spaces where to insert circle c_s . Given a point (x_i, y_i) over the grid, we declare the space around it as free, if its distance from the other circles' centers is at least equal to r_s , the radius of the circle to be inserted. In other words, if we place circle c_s with center in point x_i, y_i over the grid, the other circles' centers are not in the interior of such circle. Note that at least one free space certainly exists. Indeed, according to the above definitions, all the corners of the square certainly correspond to free spaces. It is worthwhile to note that the definition of “free” space does not mean that the space is large enough to contain circle c_s with no overlap with the other circles: a partial overlap is permitted and, actually, if the circle to be inserted is small compared to other circles, then even full overlapping may occur during the insertion process.

It may also happen that the new circle is not fully (or even not at all) contained in the circular container. In spite of this partial or full overlap with other circles and of the possibility of crossing the border of the circular container, a local search procedure started at the new configuration with the

added circle is able to adjust it in such a way that no overlap occurs without enlarging the radius of the circular container or with an as small as possible enlargement of such radius.

Once we have defined the insertion procedure, we are ready to give a formal description of the whole algorithm:

Sequential Insertion Based MBH :

Step 1(RemS): remove the set S_R of all the “small” circles

Step 2(MBH): Apply MBH on the reduced problem.

Let X be the outcome of MBH

While $S_R = \emptyset$

Let $s \in \arg\max\{r_i : i \in S_R\}$

Set $X = I_R(X, s)$

Set $S_R = S_R \setminus \{s\}$

EndWhile

Return X

In the above algorithm MBH can be easily substituted by any other algorithm returning a

configuration in the reduced space.

3. COMPUTATIONAL EXPERIMENT AND DISCUSSION

In this section we will perform some experiments to investigate different issues. In particular we will study:

- The performance of the proposed perturbations;
- The performance of the Sequential Insertion Based MBH (SIB-MBH) approach;

The test instances which will be considered are those reported in [Hifi and M'Hallah, 2008]. These are 18 test instances for the case of unequal circles. The characteristics of each test are indicated in Table 1. In such table column Test n. denotes the identifier of the instance; column n denotes the number of circles of the instance; column Radii denotes the different radii of the circles in the instance; column BestKnown denotes the best known value in the literature for the instance.

Table 1. Test set with unequal circles

Test n.	n	Radii	BestKnown
1	6	$r_{1-3} = 10, r_{4-6} = 4.826$	21.5480
2	9	$r_{1-4} = 1, r_{5-9} = 0.41415$	2.4142
3	9	$r_{1-3} = 10, r_{4-9} = 3.533$	21.5470
4	12	$r_{1-3} = 10, r_{4-9} = 3.533, r_{10-12} = 2.3$	21.5470
5	13	$r_{1-3} = 10, r_{4-6} = 4.826, r_{7-12} = 2.371, r_{13} = 1.547$	21.5470
6	19	$r_{1-3} = 10, r_{4-6} = 4.826, r_{7-12} = 2.371, r_{13} = 1.547, r_{14-19} = 1.345$	21.5470
7	19	$r_{1-3} = 10, r_{4-9} = 3.533, r_{10-12} = 2.3, r_{13-18} = 1.8, r_{19} = 1.547$	21.5470
8	22	$r_{1-3} = 10, r_{4-6} = 4.826, r_{7-12} = 2.371, r_{13} = 1.547, r_{14-19} = 1.345, r_{20-22} = 1.161,$	21.5470
9	25	$r_{1-3} = 10, r_{4-9} = 3.533, r_{10-12} = 2.3, r_{13-18} = 1.8, r_{19} = 1.547, r_{20-25} = 1.08$	21.5470
10	28	$r_{1-3} = 10, r_{4-6} = 4.826, r_{7-12} = 2.371, r_{13} = 1.547, r_{14-19} = 1.345, r_{20-22} = 1.161, r_{23-28} = 0.9$	21.5470
11	10	$r_1 = 50, r_2 = 40, r_{3-5} = 30, r_6 = 21, r_7 = 20, r_8 = 15, r_9 = 12, r_{10} = 10$	99.8850
12	11	$r_{1-2} = 25, r_{3-4} = 20, r_5 = 15, r_6 = 14, r_7 = 12, r_8 = 11, r_9 = 10.5, r_{10} = 10, r_{11} = 8.4$	60.8900
13	14	$r_1 = 40, r_2 = 38, r_3 = 37, r_4 = 36, r_5 = 35, r_6 = 31, r_7 = 27, r_8 = 23, r_9 = 19, r_{10} = 17, r_{11} = 16, r_{12} = 15, r_{13} = 14, r_{14} = 11$	114.9800
14	17	$r_1 = 25, r_2 = 20, r_{3-4} = 15, r_{5-7} = 10, r_{8-17} = 5$	49.6837
15	12	$r_{1-3} = 100, r_{4-6} = 48.26, r_{7-12} = 23.72$	215.4700
16	15	$r_1 = 1, r_{i+1} = r_i + 1, i = 1, \dots, 14$	39.3700
17	17	$r_{1-4} = 100, r_{5-9} = 41.415, r_{10-17} = 20$	241.4214
18	162	$r_{1-3} = 1.8, r_4 = 1.75, r_{5-16} = 1.3, r_{17-25} = 1.05, r_{26-40} = 0.9, r_{41-71} = 0.8, r_{72} = 0.75, r_{73-83} = 0.7, r_{84-137} = 0.65, r_{138-162} = 0.55$	11.7300

3.1 Experiments with different perturbation moves and with the sequential insertion strategy

Table 2. The Impact of Removal Strategy in SIB-MBH approach

Test n.	n	Reduced circles
1	6	6
2	9	9
3	9	9
4	12	9
5	13	6
6	19	6
7	19	9
8	22	6
9	25	9
10	28	6
11	10	8
12	11	11
13	14	14
14	17	7
15	12	6
16	15	12
17	17	9
18	162	162

The different perturbation moves which will be tested are the Full Jerk (FJ) one [Jamali et al., 2009] (with perturbation range $\Delta i = 0.8r_i$ for the coordinates of the i -th circle), the Random Jump (RJ) perturbation move (with a number of randomly selected circles, on which the perturbation is carried on, equal to $\lceil n/20 + 1 \rceil$, and the Radius Based Random Swap (RBRS) one (with $\lceil n/20 + 1 \rceil$, randomly selected pairs of circles on which the perturbation is carried on). Experiments are performed both with the standard MBH approach and with the moderate MBH i.e. the SIB-MBH approach. In all cases we set $\text{MaxNonImp} = 200$. The number of runs is $R = 50$ for all tests except for the highly computationally demanding Test n. 18 for which we reduced the number of runs to $R = 6$.

For what concerns SIB-MBH, we report in Table 2 for each test instance the total number n of circles for the instance and the reduced number of circles after removal of the “small” circles. We observe from the table that for some test instances like, e.g., n. 6-10 a large number of “small” circles is removed. For some other instances a small number of circles is removed (like, e.g., instances n. 4 and 11). Finally, for the test instances n. 1, 2, 3, 12, 13 and 18 there is no “small” circle and, consequently, the MBH and SIB-MBH approach are equivalent ones.

Table 3. The performance of MBH approaches with different perturbation moves. Note that in this table OurBestResults is denoted as OBRs.

Test n.	OBRs	No. of success (Result) of MBH approach			No. of success (Result) of SIB-MBH approach		
		FJ	RJ	RBRS	FJ	RJ	RBRS
1	21.5480	50	15	50	50	15	50
2	2.4142	12	15	37	12	15	37
3	21.5470	14	10	40	14	10	40
4	21.5470	8	1	19	14	10	40
5	21.5480	3	0	5	3	2	9
6	21.5470	0	0	0	19	14	50
7	21.5470	0	0	0	14	10	40
8	21.5480	0	0	0	20	16	50
9	21.5470	0	0	0	14	15	38
10	21.5470	0	0	0	20	15	24
11	99.8850	0	0	12	0	0	50
12	60.7099	0	0	12 (60.7099)	0	0	12 (60.7099)
13	113.5552 (♠)	10 (114.0814)	0	6 (113.5846)	10 (114.0814)	0	6 (113.5846)
14	49.1873	1 (49.31945)	10 (49.6498)	1 (49.2470)	6 (49.1873)	100 (49.1873)	50 (49.1873)
15	215.4700	5	0	7	31	16	50
16	38.8380	1 (38.9189)	10 (39.2962)	1 38.8380	0	3 (39.3534)	5 (38.8380)
17	241.4214	0	0	7	7	8	28
18	11.5119 (♣)	1 (11.5336)	5 (11.6599)	1 (11.5422)	1 (11.5336)	5 (11.6599)	1 (11.5422)
Failure	0	8	11	5	3	3	0
Success	18	10	7	13	15	15	18
Imp.	5	4	3	5	3	3	5

The results are reported in Table 3. Column Test n. denotes the identifier of the test instance as indicated in Table 1. Column OBRs (OurBestResult) denotes the best results we could obtain during all our experiments. Note that in all cases a value (in the Column OBRs) at least as good as the BestKnown one in the literature as reported in Table 1, is reached and that values in **boldface** indicate better results compared to the BestKnown ones. The next following three columns report the number of successes on each instance for each of the three perturbation moves tested (FJ, RJ, RBRs) with MBH approach. The last three columns report the number of successes on each instance for each of the three perturbation moves tested (FJ, RJ, RBRs) with SIB-MBH, i.e. with the use of the sequential insertion strategy. It is worthwhile to explain here what do we mean by number of successes? When the number of successes is equal to 0, this means that the approach was unable to reach the best known result in the literature. For all the instances for which the best result obtained by an approach was at least as good as the best known one in the literature, the number of successes is the number of runs where the best result has been obtained. In the latter case, when a result better than the best known one in the literature could be obtained, we also report within parenthesis such result. We also remark here that for Test n.13, we have obtained the best result – **113.5552*** by the 500 runs of SIB-MBH(RBRs) approach 2, while for Test n.18 we have obtained the best result– **11.5119*** by the SIB-PBH(FJ) approach discussed later on.

In the table the row named Failure reports the total number of instances where the approach was unable to reach the best known result in the literature (or, equivalently, the number of instances for which the number of successes is equal to 0). Similarly, row Success reports the total number of instances where the approach was able to obtain a solution at least as good as the best known one. Row Imp. reports the total number of instances for which the approach was able to obtain an improved solution and, finally, row **B. Imp.** indicates the total number of instances for which the approach was able to obtain an improved solution which is also the overall best among all those obtained in the different experiments. Now we briefly discuss the results reported in Table 3. At first we consider the performance of the different perturbations moves within the standard MBH approach, i.e. MBH without sequential insertion strategy. We observe that the MBH(RBRs) approach was able to obtain success in 13 instances out of 18; in five instances it was able to improve the available BestKnownResult value and in three cases the improvement is a best one. Unfortunately, there are also five failures. Note that enlarging the number of

runs only partially helps. Indeed, when we extended the number of runs to $R = 500$, we could get at least one success for all the instances but still two failures, namely for the two tests n. 9 and 10. The situation is even worse for the MBH(FJ) and MBH(RJ) approaches, for which the number of failures is clearly higher compared to that of the MBH (RBRs) approach; moreover, though there are some improvements in both the approaches, none of them has a best improvement.

Table 4. The total elapsed CPU times of the experiments for SIB-MBH(RBRs) approach

Test n.	Elapsed time (sec)
1	39
2	75
3	104
4	440
5	35806
6	17607
7	3778
8	11768
9	63890
10	52967
11	213
12	264
13	468
14	4975
15	813
16	249
17	3130
18	407137

Things get definitely better when we consider the performance of the different perturbations moves in the SIB-MBH approach. The SIB-MBH(RBRs) approach has no failure, five improvements and three best improvements; both SIBMBH (FJ) and SIB-MBH(RJ) approaches, though inferior with respect to SIB-MBH (RBRs), have only three failures but one best improvement. If we focus our attention on the comparison between MBH(RSBS) and SIB-MBH(RSBS), we can remark that the five failures in MBH(RSBS) occur with instances n. 6-10, for which the SIB-MBH(RSBS) approach first removes a relatively large number of (“small”) circles. Once such circles are removed, the problems get quite easy ones and the following sequential insertion can always be carried on relatively easily without having to enlarge the radius of the circular container (i.e., all the missing circles can be inserted in the “holes” of the container).

The total elapsed CPU times of the experiments for SIB-MBH(RBRs) approach is shown in the table 4.

Note that all the tests have been performed on a Pentium IV 2.4 GHz with 1GB RAM.

4. CONCLUDING REMARKS

For the presents of combinatorial nature, in presents of unequal radii, we have proposed two new perturbation moves name Random Jump (RJ) and Radius based Random Swap (RBRS) for solving NICPCC problems. Experimentally it is shown that RBRS is more efficient in non-identical circle packing problem. We also proposed another variant of MBH approach – Sequential Insertion Based MBH (SIB-MBH) approach which is only suitable for unequal circle packing problems. By experimentation we saw that SIB-MBH is more efficient than MBH approach for non-identical circle packing problems. We have also investigated the efficiency of the proposed algorithm for solving packing non-identical circles in minimum circular and have compared with available ones. Below we point out the main achievements regarding packing problems:

- Proposed a variant of MBH approach -- SIB-MBH approach for NICPCC. The use of the sequential strategy clearly enhances the performance of all the approaches, independently from the perturbation move employed (for a given perturbation move the performance with the sequential strategy is almost always better than the one without);
- Proposed two perturbation techniques for unequal circle packing problems. The RBRS move is a clear winner with respect to the FJ and RJ moves with a lower number of failures, a higher number of improvements and best improvements, and with a number of successes almost always larger than those obtained with the other moves. The only exception is represented by instance n.18. The peculiarities of this instance and a possible explanation for the worse behavior of RBRS, with respect to FJ on it, will be discussed later on.
- Radius Based Random Swap (RBRS) perturbation based SIB-MBH/PBH approach seems the most robust one in NICPCC.
- Obtained many improved solutions compared to the available literature

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PATTERN OPTIMIZATION OF A LINEAR DIPOLE ANTENNA THROUGH IMPROVING DIRECTIVITY AND REDUCING SIDE LOBES

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This paper deals with a keen analysis of antenna measurement and propagation of information through air media. Antennas have practical uses for the transmission and reception of radio frequency signals (radio, TV, etc.). In air, those signals travel very quickly and with a very low transmission power. The signals are absorbed when moving through more conducting materials, such as concrete walls, rock, etc. When encountering an interface, the waves are partially reflected and partially transmitted through. Antenna radiates energy in all direction in free space where some energy radiated in a preferred direction and if the amount of directed energy is high then it would be said a better and efficient energy transmission. In this research we have developed a new scheme by which an antenna's performance can be improved to an acceptable level and we have considered linear dipole antenna as reference model. The proposed scheme is developed in three steps – firstly we have set the best dipole arrangement by varying the elevation angles above the horizon and adjusted the feed point impedance, then an optimization technique is applied to achieve the low outer as well as low inner side-lobe levels and finally shielding mechanism (reducing surface resistance) have been deployed. The main goal of this research is to improve the gain of the reference antenna and reduce noise to a sustainable level and ultimately preferable effectiveness and greater efficiency have been achieved.

Key words: Directivity; Dipole; Side lobe; Pattern synthesis and surface resistance.

1. INTRODUCTION

Generally, an antenna is a transducer designed to transmit or receive electromagnetic waves that converts electromagnetic waves into electrical current and vice versa in the process of transmission and reception^{[1][2]}. Physically, an antenna is an arrangement of conductors that generate a radiating electromagnetic field in response to an applied alternating voltage and the associated alternating electric current, or can be placed in an electromagnetic field so that the field will induce an alternating current in the antenna and a voltage between its terminals. All antennas radiate some energy in all directions in free space but careful construction results in substantial transmission of energy in a preferred direction and negligible energy radiated in other directions. By adding additional elements and carefully arranging their length, spacing and orientation, an antenna

with desired directional properties can be created^{[2][11]}. Several critical parameters affect an antenna's performance that can be adjusted during the design process. These are resonant frequency, impedance, gain, aperture or radiation pattern, polarization, efficiency and bandwidth. Transmit antennas may also have a maximum power rating, and receive antennas differ in their noise rejection properties. All of these parameters can be measured through various means. In this paper we tried to present a new scheme to improve the effectiveness and performance of the antenna by improving the directivity and reducing side lobes. Directivity is the measure of the power density in the direction of its strongest emission, related to the power density radiated by an ideal isotropic radiator antenna radiating the same amount of total power and side lobe is the pattern distortion of the signal during beam steering. If the directivity is improved and the side lobes are reduced than desired transmission

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and reception can be achieved. This paper shows how directivity can be improved and a pattern synthesis method has developed to reduce side lobes.

2. DIRECTIVITY AND GAIN

In electromagnetic, directivity is a figure of merit for an antenna^[8]. It measures the power density an actual antenna radiates in the direction of its strongest emission, relative to the power density radiated by an ideal isotropic radiator antenna radiating the same amount of total power. Mathematically, the directivity is defined as the maximum of the directive gain^[10]:

$$D = \max \left(\frac{\text{Radiated power density } (\theta, \varphi)}{\text{Total radiated power} / 4\pi} \right) \text{ equ}^n \quad (1)$$

where

- θ and φ are the standard spherical coordinates angles
- Radiated power density is the power per unit solid angle such that
- Radiated power density =
$$\int_{\varphi=0}^{\varphi=2\pi} \left(\int_{\theta=0}^{\theta=\pi} \text{Radiated power density } (\varphi, \theta) \sin \theta d\theta \right) d\varphi$$
- 4π is the total solid angle for a sphere (also the surface area of a unit sphere, similar to 2π being the total angle for a circle and the perimeter of a unit circle).
- The denominator, Total radiated power/ 4π , represents the average radiated power density

The directivity is rarely expressed as a unitless number. Usually, the directivity is expressed in dBi, so that

$$D_{dBi} = 10 \log_{10} \left[\max \left(\frac{\text{Radiated power density } (\theta, \varphi)}{\text{Total radiated power} / 4\pi} \right) \right] \text{ equ}^n \quad (2)$$

The reason the units are dBi (decibel relative to an isotropic radiator) is that for an isotropic radiator, the radiated power density is a constant, and therefore equals the average radiated power density (the denominator). This isotropic radiator is not directive at all but has nevertheless a directivity strict sensor equal to 1^{[9][10]}. This can be misleading and is much better described in dBi.

$$D_{\text{isotropic radiator}} = 1 \text{ unitless} = 0 \text{ db} \quad \text{equ}^n \quad (3)$$

The word directivity is also sometimes used as a synonym for directive gain. This usage is readily understood, as the direction will be specified, or directional dependence implied. Later editions of the IEEE Dictionary specifically endorse this usage; nevertheless it has yet to be universally adopted. The peak directivity of an actual antenna can vary

from 1.76 dB for a short dipole, to as much as 50 dB for a large dish antenna^[3].

Again gain as a parameter measures the directionality of a given antenna^[9]. An antenna with a low gain emits radiation in all directions equally, whereas a high-gain antenna will preferentially radiate in particular directions. Specifically, the Gain, Directive gain or Power gain of an antenna is defined as the ratio of the intensity (power per unit surface) radiated by the antenna in a given direction at an arbitrary distance divided by the intensity radiated at the same distance by a hypothetical isotropic antenna.

$$G = \frac{(p/s)_{ant}}{(p/s)_{iso}} \quad \text{equ}^n \quad (4)$$

3. PATTERN OPTIMIZATION

In the field of antenna pattern synthesis, the side-lobe level of an array radiation pattern can be reduced by appropriately changing inter-element spacing, namely, by applying a non-uniformly spaced array^{[4][5][6]} and directivity can be improved by shielding. The desired low side-lobe level can be achieved by optimizing the amplitudes and phases of excited array elements with uniform spacing. However, this method degrades total radiation power efficiency due to amplitude tapering. The non-uniform linear array can reduce inner side-lobes, whereas it may increase outer side-lobe levels^[4]. To overcome this problem, an optimization technique is adopted to reduce both the inner side-lobes and the unwanted outer side-lobes simultaneously. In this pattern synthesis method both the inner side-lobes and the outer side-lobes are reduced to a sustainable level and at the same time directivity of the antenna also degrades. To overcome this problem and to improve the directivity best dipole setup and a shielding mechanism are also developed in this work. The research procedure of the optimal gain and reduced side lobes of a linear dipole antenna are described in three steps as follows,

Step 1: Best dipole arrangement by varying the elevation angles above the horizon and adjusting feed point impedance.

Step 2: Optimization technique is applied to achieve the low outer side-lobe levels as well as low inner side-lobe levels.

Step 3: Shielding mechanism (reducing surface resistance).

4. DIPOLE SETUP AT AN EXACT ELEVATION

Generally a linear dipole antenna in free space exhibits a feed impedance of 72Ω and has a

doughnut shaped radiation pattern. But, as the dipole is brought close to the earth, the radiation pattern changes and the feed point impedance also changes. Careful selection of position and setting up a dipole above the ground can make its impedance exactly match the impedance of the feed line used that help to improve the directivity of the antenna. In this part we have developed a better possible setup of wavelengths above a standard earth ground model through which significant amount of side lobes are reduced and a directed vertical lobe is gained.

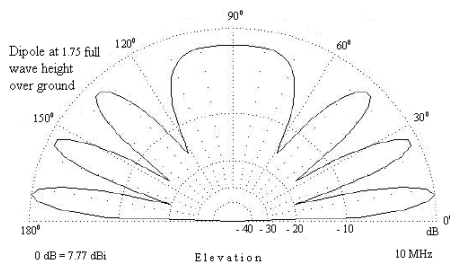


Fig. 1: Dipole at 1.75 wavelengths elevation.

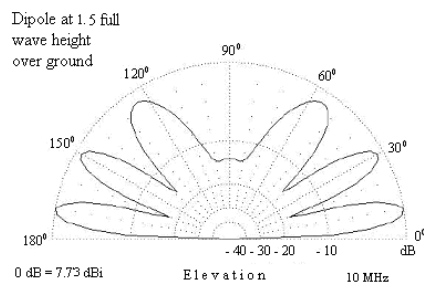


Fig. 2: Dipole at 1.5 wavelengths elevation.

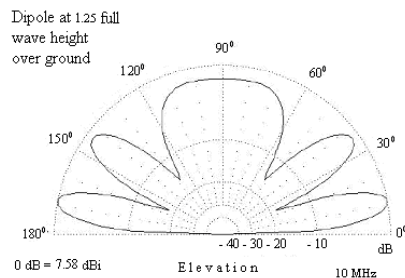


Fig. 3: Dipole at 1.25 wavelengths elevation.

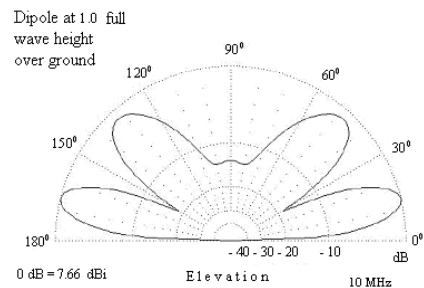


Fig. 4: Dipole at 1.0 wavelength elevation.

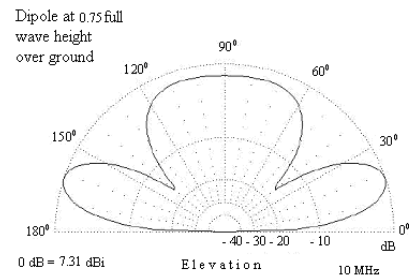


Fig. 5: Dipole at 0.75 wavelength elevation.

All the figures showing a sequence to the patterns and that is if the antenna get lower, the lobes move higher, combine and disappear. The energy being directed at the horizon, the peak of the pattern is elevated at about a 30° angle (actually 28°). Thus, for a quite broad range of elevation angles and for a correspondingly broad expanse of geographical area covered by the signal reflected off the ionosphere, there is substantial signal strength. If lowering the dipole continues, familiar raising and combining of the lobes will continue until at 0.25 wavelengths and will produce a single broad peak, aimed straight up. Moreover, below a certain critical frequency (which depends on the density of the ionization in the ionosphere), a signal directed straight upward will be reflected back down into an area near the transmitter. This can allow communications within a 100-200 mile radius of the transmitter – the area normally skipped over by signals transmitted from the dipole at lower radiation angles (generated by higher positions above ground). Fig. 5 shows that this pattern has both the low-angle lobes and a broad vertical lobe. The vertical lobe is about 2 dB below the low-angle lobes and has an almost insignificant difference in signal strength. This section shows that dipole at 0.75 wavelength height over ground is the best of all possible setups and this setup has been selected for the next procedure of this research.

5. LINEAR ANTENNA PATTERN SYNTHESIS

This section presents a pattern synthesis method of non-uniform linear antennas for simultaneous reduction of the side-lobe level and pattern distortion during beam steering. To achieve these two requirements, the positions of linear array elements are adjusted using the Gauss-Newton method. It is shown that the proposed method can significantly reduce pattern distortion as well as the side lobe level of a linear dipole antenna.

For an odd number of elements, if isotropic array elements are uniformly distributed along the x axis and are assumed to be symmetric about the array

center, the radiation field pattern over the set of angles $\theta_1, \theta_2, \theta_3 \dots \theta_L$ can be described as follows:

$$p(\theta_i) = \frac{1}{N} \sum_{n=0}^{N-1} \exp[jkdx(\sin \theta_i - \sin \theta_o)]$$

$$= \frac{2}{N} \sum_{n=1}^M \cos[kdx(\sin \theta_i - \sin \theta_o)] + \frac{1}{N}$$

equⁿ (5)

where N is the number of element antennas, k is free space propagation constant, dx is the inter-element spacing, θ_o is the maximum radiation angle, and M is given by $(N-1)/2$.

Then, the normalized pattern of the non-uniform linear antenna is given by

$$p_{nu}(\theta_i) = \frac{2}{N} \sum_{n=1}^M \cos[k(n + e_n)dx(\sin \theta_i - \sin \theta_o)] + \frac{1}{N}$$

equⁿ (6)

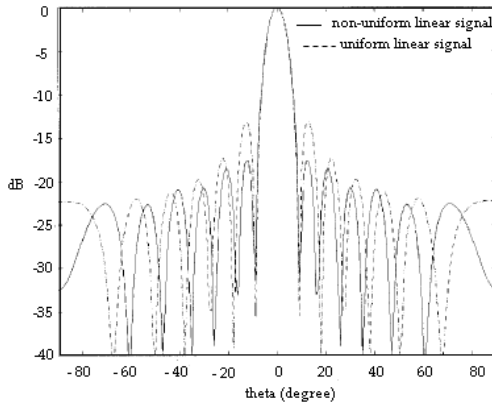


Fig. 6: Radiation pattern of non-uniform linear antenna using the Fourier-transform-based formula; the maximum radiation angle is 0°

Thus the procedure for the pattern synthesis of the NULA using the proposed algorithm is summarized as follows.

$$e_n^o = \frac{N}{\pi} \int_0^\pi n(p(u) - p_{nu}(u)) S_a(n \cdot u) du \quad \text{equ}^n (7)$$

$n = 1, 2, 3, \dots, M.$

$$\text{Where } S_a(n \cdot u) = \frac{\sin(n \cdot u)}{(n \cdot u)}$$

Iterate the following relative error (RE),

$$RE = \frac{1}{2N} \sum_{i=1}^L |p_{nu}^{k+1}(\theta_i) - p_{nu}^k(\theta_i)|^2 < \gamma \quad \text{equ}^n (8)$$

Fig. 6 shows the comparison of array pattern shape of a 13-element uniform linear antenna (ULA) of isotropic elements spaced every half-wavelength with the non-uniform linear antenna (NULA) on the basis of Fourier-transform. In comparison with the ULA, an amount of about 5-dB reduction of the first side-lobe level is achieved with the NULA. However, when the main beam of NULA is steered to 30° , some large outer side-lobes higher than the first side-lobe are observed within the visible

region, as shown in Fig. 7. Furthermore, their levels in the vicinity of an angle of -60° are also higher than the first side-lobe level of the ULA.

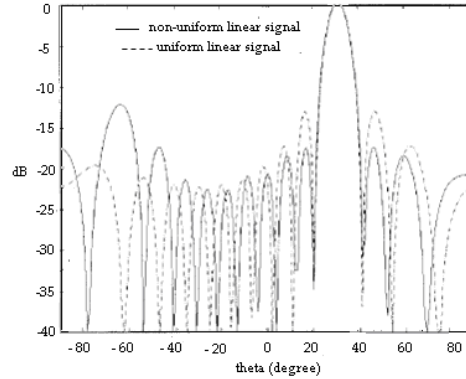


Fig. 7: Comparison of the two radiation patterns with uniform or non-uniform spacing when the maximum radiation angle is steered to 30°

In order to reduce the undesirable side-lobe levels above, we now apply the algorithm to pattern synthesis of the NULA with beam steering. For the pattern synthesis algorithm, we have set the iteration gain to $\eta = 1.5 \exp(-9 \cdot \frac{k}{40})$, the maximum

allowable error, γ to 10^{-4} and δ^2 to 0.001 respectively. The resulting radiation pattern is shown in Fig. 8.

- Case 1 : NULA pattern via the formula on the basis of the Fourier transform method.
- Case 2 : NULA pattern via the proposed Gauss-Newton method.

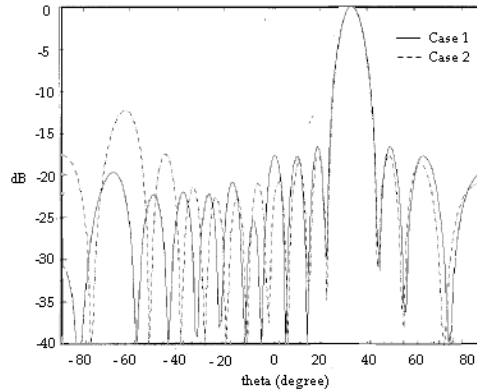


Fig. 8: Improvement of the non-uniform radiation pattern in Fig. 7 using the optimization method

As shown in fig. 8, the proposed algorithm causes the undesirable large side-lobes near -60° to be significantly reduced to smaller levels than the first side-lobe level of Case 1.

Again we have considered an equally excited 15-elements and 17-elements linear array with the same uniform spacing and scanning angle, as in the previous one. Using the pattern synthesis algorithm, the optimized positions of the NULA are given in Table 1.

Table 1: Position of the optimized non-uniform antenna elements

Element	Non-uniform pattern	Uniform pattern
13	1.182 λ	2.0 λ
15	2.941 λ	3.0 λ
17	4.066 λ	4.0 λ

6. COVER SHIELDING TO INCREASE ANTENNA DIRECTIVITY

Very thin conducting layer has a much higher resistivity than a bulk layer because of electron scattering from the layer surface. If the layer thickness is very large compared to the electron mean-free-path, the resistivity is expected to be nearly the same as that of a bulk conducting material. In the far field, high attenuation occurs in a structure made of material having high conductivity and low permeability. In this paper, we have used the intrinsic properties of a two-dimensional copper lattice material to design a cover antenna so that an optimal amount of radiation is attenuated by the antenna and to achieve this we have matched a lower resistance of the antenna surface. Mathematically,

$$R = \frac{\text{specific resistivity} \times \text{length}}{\text{thickness} \times \text{width}} = \frac{\rho l}{tw} \quad \text{equ}^n (9)$$

When the length and width are chosen to have equal magnitude then the equation becomes,

$$R_s = \frac{\rho_f}{t} = \frac{1}{t\sigma_f} \quad \Omega/\text{square} \quad \text{equ}^n (10)$$

where ρ is the resistivity, t is the thickness of the cover shield, σ_f is the conductivity of the shielding material and can be denoted as,

$$\sigma_f = \frac{3t\sigma}{4p} \left[\ln\left(\frac{p}{t}\right) + 0.4228 \right] \quad \text{for } t \ll p \quad \text{equ}^n (11)$$

Where σ is the conductivity of the bulk material and p is the electron mean-free-path.

Hence the attenuation becomes,
Attenuation = Absorption loss (A) + Reflection loss (R) + Correction term (C) $\text{equ}^n (12)$

Absorption loss:

$$A = 20 \log_{10} e^{\alpha l} = 20(\alpha l) \log_{10} e \\ = 20 \log e t \sqrt{\pi f \mu \sigma_f} \quad \text{equ}^n (13)$$

Reflection loss:

$$R = -20 \log \left[\frac{2|\eta_f|}{|\eta_a + \eta_f|} \times \frac{2|\eta_s|}{|\eta_s + \eta_f|} \times \frac{2|\eta_a|}{|\eta_a + \eta_s|} \right] \\ = 29 + 10 \log \left(\frac{\sigma_f}{\mu f} \right) \text{ dB} \quad \text{equ}^n (14)$$

where η_f = intrinsic impedance of the copper

η_s = intrinsic impedance of the antenna material

η_a = intrinsic impedance of the free space

Correction term:

$$C = 20 \log \left[1 - \rho 10^{-\frac{A}{10}} (\cos \theta - j \sin \theta) \right] \\ = 11 + 20 \log \left[t \sqrt{f \mu \sigma_f} \right] \quad \text{equ}^n (15)$$

So the Eq. (12) becomes as follows,
Attenuation,

$$A = 20 \log e t \sqrt{\pi f \mu \sigma_f} + 29 + 10 \log \left(\frac{\sigma_f}{\mu f} \right) + 11 + 20 \log \left[t \sqrt{f \mu \sigma_f} \right] \\ = 40 - 20 \log R_s \quad \text{equ}^n (16)$$

This leads to the gain of the copper shielded dipole antenna,

$$G_f = \left(\frac{P}{S} \right)_{ant} = \frac{120}{AR_s} \quad \text{equ}^n (17)$$

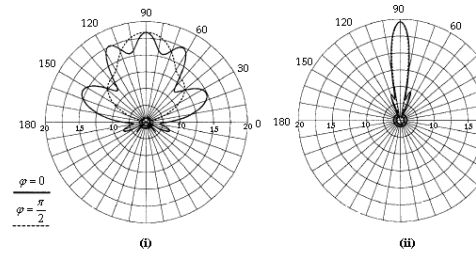


Fig. 9: Comparison of the directivity of the (i) antenna without shielding (ii) antenna with a 2-D copper shielding. The cover has increased the directivity from 8 to 12.5 dB

The actual value of the linear dipole resistance is about 73.1296 Ω and in most cases the gain of a dipole antenna is 2.15 dBi. By using the copper shield (thick layer) the surface resistance can be

reduced up to $10\ \Omega$ that results a gain of 10.80 dBi. The fig. 9 shows the comparison of the directivity between the general dipole antenna and copper shielded dipole antenna (proposed model).

7. CONCLUSION

For antennas used as receivers, side lobes make the antenna more vulnerable to noise from nuisance signals coming far away from the transmit source and transmit antennas communicating classified information, side lobes represent security vulnerability, as an unintended receiver may pick up the classified communication. For these reasons reduced side lobes and improved directive gain are essential for efficient data transmission and reception. In this research we tried to pick up the best positioning of the antenna's placement for getting effective function. At the same time we have used a pattern synthesis method and at last we have used shielding mechanism over the reference model and finally we have got a maximum gain of $8 - 12.5$ db which is an improved model upon the previous existing models. In the shielding mechanism we have used copper material (thick layer) due to some limitations. If anyone uses better material other than copper, he/she may get better performance. Our next research leads to the three dimensional thick layer (better than copper) shielding over the proposed model.

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A Review of the Numerical Solutions of Dimensionless Radial Flow Diffusivity Equation Using Laplace Transforms

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Solutions of the radial flow diffusivity equation are essential in computation of fluid flow through porous media. Based on Darcy's law, this paper re-produced an unsteady state flow equation and a set of data is generated through the solution of the equation for unsteady state flow of slightly compressible fluid $\frac{\partial^2 P_D}{\partial r_D^2} + \frac{1}{r_D} \frac{\partial P_D}{\partial r_D} = \frac{\partial P_D}{\partial t_D}$ two sets of solutions of this equation are redeveloped for the constant terminal pressure case and the constant terminal rate case. Here the diffusivity equation is re-produced based on some assumptions and its solutions for both cases according to A.F. Van Everdingen and W. Hurst solutions. Most of the information is obtained with the help of the Laplace transformations, complex inversion formula, modified Bessel function which proved to be extremely helpful for analyzing the problem encountered in fluid flow. With the help of Laplace transformations, some original developments were obtained which could not have been easily foreseen by the earlier methods. Some curves are developed from this solution and the dimensionless values are reproduced from the curve. The final solution of diffusivity equation is handy for water influx calculation which is essential for reservoir simulation and well test analysis.

Keywords: Darcy's law, Diffusivity equation, Laplace transforms, Dimensionless numbers, Water influx

1. INTRODUCTION:

Fluid flow through porous media covers an important part in Petroleum Engineering. This phenomenon is based on diffusivity equation which is a highly nonlinear partial differential equation. Nonlinearity of this equation arises due to pressure dependency of fluids properties. Generally this equation is formulated for slightly compressibility fluids for fluid flow calculation. On the other hand from the operating point of view this equation is solved for constant terminal rate and constant pressure cases.

This paper represents the review of numerical solution of the dimensionless radial flow diffusivity equation from Darcy's law and numerical calculation of the unsteady state flow which is used to calculate the fluid flow through porous media generally water influx modal. The study is limited to conditions where the flow of fluid obeys the diffusivity equation. Multi-phase fluid flow has not been considered. This paper exposes the sequential description of some steps.

At first there is a discussion of Darcy's law, then diffusivity equation for slightly compressible fluid, dimensionless analysis of the diffusivity equation, solution of the diffusivity equation using Laplace transformation, numerical value of the dimensionless diffusivity equation and the representation of curve which is used to reproduce the dimensionless water influx value and used to calculate water influx model which is essential for reservoir simulation and wall test analysis.

This approach is useful academically, for it is relatively easy to do, and it also is useful to give insight into the nature of aquifer flow. For these reasons it will be discussed here in some detail. Unfortunately, it is "not" very useful for real reservoir problems, for typically we cannot define the inner boundary condition for the oil reservoir/aquifer system in any meaningful way.

This work is applicable to the flow of fluids to a well whenever the flow conditions are such the diffusivity equation is obeyed.

2. OBJECTIVES OF THIS STUDY:

- Reproduces the dimensionless water influx value and dimensionless pressure value.
- Understanding the Bessel function term which is used into the solution of the radial flow diffusivity equation.
- Clearly understanding reservoir estimation model.
- Easily calculation nonsteady state flow equations.

3. PROCEDURE:

Some basic terms are used to solve the dimensionless radial flow diffusivity equation and some assumptions are considered to calculate the dimensionless water influx value and dimensionless pressure value. This basic terms definition and assumptions are given below

3.1 Definitions of the Various Terms:

3.1.1 Boundary condition: The location of the interior and exterior boundaries and the specification of pressure and/or flow at these boundaries at a given instant of time.

3.1.2 Boundary variation: The changes in the boundary conditions of a reservoir system undergoing exploitation.

3.1.3 Continuous succession of steady state: A method of solving flow problems in a reservoir system that suffers boundary variations but fulfills instantaneous steady state conditions. The history of such a system is divided into an appropriate number of stages, each of which is treated by steady state analysis.

3.1.4 Darcy's law: The Darcy' law which is defined by the following relation

$$Q = A \frac{k(h_1 - h_2)}{L}$$

3.1.5 Dimensionless pressure: The dimensionless pressure ratio defined by the following relation

$$p_D = \frac{0.007082kh(p_i - p)}{qB\mu}$$

3.1.6 Dimensionless radius: The dimensionless radius ratio defined by the following relation

$$r_D = \frac{r}{r_w}$$

3.1.7 Dimensionless time: The dimensionless time ratio defined by the following relation

$$t_D = \frac{0.0002637kt}{\phi\mu c_t r_w^2}$$

3.1.8 Fluid influx terms: Terms that appears in the Hurst Van Everdingen equation which treats the pressure case. Such a term, denoted by $q_D(t_D)$, is a dimensionless , numerical quantity representing the total volume of fluid per unit thickness that passes the interior boundary of a reservoir system over the time span $t=t_M-t_i$, which is caused by a unit pressure drop at this boundary at time t .

3.1.9 Infinite reservoir system: A reservoir system analyzed over a period of time during which the presence of an exterior boundary is not felt.

3.1.10 Non steady state flow: In reservoir systems undergoing exploitation, fluid flow that is characterized predominates by time variations and necessitates the formal introduction of time as an explicit variable in the basic flow equation.

3.1.11 Pressure case: In the analysis of a reservoir system the situation that presumes knowledge of the pressure history and predicts the cumulative fluid influx.

3.1.12 Radial reservoir system: A system defined by two concentric circular cylinders, which serve as boundaries, over which pressure and flow are specified according to prescribed conditions and whose physical propertied of interest vary only with the distance r from the axis of symmetry.

3.1.13 Rate case: In the analysis of a reservoir system the situation that presumes knowledge of the production or fluid-influx rate history and predicts the cumulative pressure drop for a reservoir at its interior boundary.

3.2 Assumption:

- Uniform pressure p_i throughout the reservoir before production.
- Constant rate production q from a single well of a radius r_w centered in a cylindrical reservoir.
- No flow across the reservoir outer boundary at reservoir r_e .
- Homogeneous and isotropic porous medium of uniform thickness.
- Pressure independent rock and fluid properties.
- Small pressure gradients.
- Radial flow.
- All flow through reservoir systems is assumed macroscopically laminar and thus governed by Darcy's law.
- The effects of gravity on the fluid flow are neglected totally

3.3 Darcy's Law:

It is believed Petroleum Engineering starts from Darcy's law. So, Darcy's is a hallowed name in this discipline. Darcy's law is a relationship that explains fluid flow in porous media, such as often seen in geological formulations. According to Darcy's law, fluid velocity or flow rate is directly proportional to the hydraulic conductivity, inversely proportional to the length of the flow path, directly proportional to the energy loss in terms of head loss. Which is state that

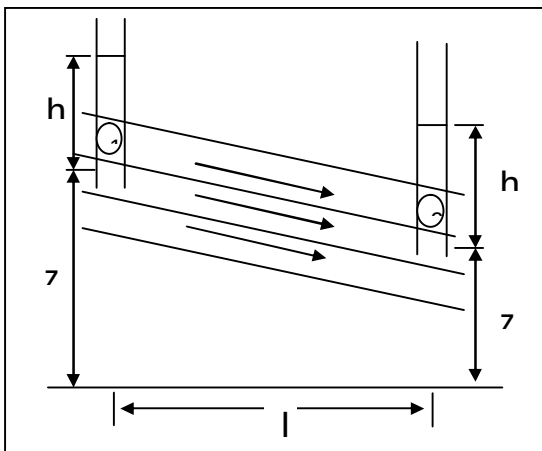


Figure 01: Show the vertical cross section of groundwater flow with linear parallel stream line.

Darcy's law is a relationship that explains fluid flow in porous media, such as often seen in geological formulations. The basic formula to calculate the flow rate Q is

$Q = \frac{A \cdot k \cdot \Delta p}{\mu \cdot L}$
 A is the cross sectional area. Finally, Darcy's law provides the concept of absolute permeability which is a rock property and driving force (gradient of fluid potential or pressure gradient) essential to move fluid from one place to another.

3.4 Basic Theory of the Diffusivity Equation:

3.4.1 Diffusivity equation for flow of slightly compressible fluids:

Considering this Figure

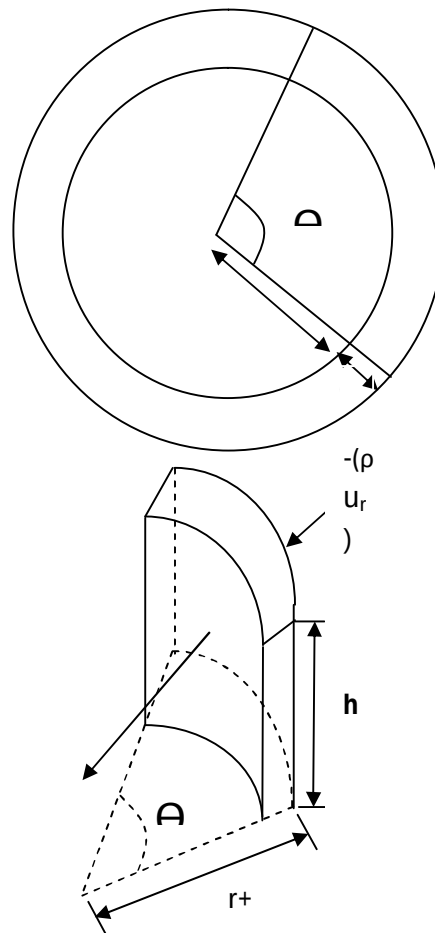


Figure 02: Control volume radial coordinate system.

We assume that this element is a porous media fixed in space and that flow is radial in the $-r$ direction. Assuming that the net generation of matter is zero. We can write a mass balance on the element as

$$W_{in} - W_{out} = q_m \quad (3.4.1.1)$$

We solve this equation according to the Fig.02, we get

$$\frac{1}{r} \left(\frac{\partial(r\rho u_r)}{\partial r} \right) = - \left[\frac{\partial(\rho\phi)}{\partial t} \right] \quad (3.4.1.2)$$

This equation is called the continuity equation.

An equation of motion or flux law relates velocity and pressure gradient within the control volume. Liquid flow generally is modeled by Darcy's law, which state that velocity is proportional to the negative of the gradient of the potential.

In radial co-ordinates, with flow in the radial direction only

$$u_r = -0.0002637 \frac{k\rho}{\mu} \frac{\partial\phi}{\partial r} \quad (3.4.1.3)$$

Total compressibility of the rock and fluid

$$c_t = c + c_f \quad (3.4.1.4)$$

Combination the above equation we can solved

$$\frac{\partial^2 p}{\partial r^2} + \frac{1}{r} \frac{\partial p}{\partial r} = \frac{\phi\mu c_t}{0.0002637k} \frac{\partial p}{\partial t} \quad (3.4.1.5)$$

This equation is called the diffusivity equation for liquid flow. The term $\frac{0.0002637k}{\phi\mu c_t}$ is called the hydrolic diffusivity.

3.4.2 Dimensionless form of the diffusivity equation:

From the diffusivity equation and considering some boundary condition, the diffusivity equation is converted to dimensionless diffusivity equation for solving any fluids flow in the porous media.

The initial condition is

$$p(r, t = 0) = 0 \quad (3.4.2.1)$$

The inner boundary condition (constant rate production) $r=r_w, t>0$ is

$$q = \frac{0.007082kh}{B\mu} \left(r \frac{\partial p}{\partial r} \right)_{r=r_w} \quad (3.4.2.2)$$

The outer boundary condition, $r=r_e, t>0$; is

$$q=0,$$

$$\left(\frac{\partial p}{\partial r} \right)_{r=r_w} = 0 \quad (3.4.2.3)$$

Using the dimensionless terms i.e. dimensionless radius, dimensionless time, dimensionless pressure ratio, we can get the dimensionless form of the diffusivity equation

$$\frac{\partial^2 p_D}{\partial r_D^2} + \frac{1}{r_D} \frac{\partial p_D}{\partial r_D} = \frac{\partial p_D}{\partial t_D} \quad (3.4.2.4)$$

And the initial condition is

$$p_D(r_D, t_D = 0) = 0 \quad (3.4.2.5)$$

The inner boundary and outer boundary conditions are

$$\left(\frac{\partial p_D}{\partial r_D} \right)_{r_D=1} = -1 \quad (3.4.2.6)$$

And

$$\left(\frac{\partial p_D}{\partial r_D} \right)_{r_D=r_{eD}} = 0 \quad (3.4.2.7)$$

Respectively.

3.4.3 Laplace transforms formulation:

Dimensionless diffusivity equation is the second order partial differential equation so this equation is easily calculated by the Laplace transforms for two independent variables (dimensionless radius and dimensionless time).

Taking the Laplace transform of Eq. (3.4.2.4) gives,

$$\frac{1}{r_D} \frac{\partial}{\partial r_D} \left(r_D \frac{\partial \bar{p}_D}{\partial r_D} \right) = s \bar{p}_D - p_D(t_D = 0) \quad (3.4.3.1)$$

$$\left[\mathcal{L} \left\{ \frac{\partial p_D}{\partial r_D} \right\} = \frac{\partial \bar{p}_D}{\partial r_D} \text{ and } \mathcal{L} \left\{ \frac{\partial p_D}{\partial t_D} \right\} = s \bar{p}_D - p_D(t_D = 0) \right]$$

At initial condition,

$$\text{or, } p_D(t_D = 0) = 0 \quad (3.4.3.2)$$

So the Eq. (3.4.3.1) is

$$\frac{1}{r_D} \frac{\partial}{\partial r_D} \left(r_D \frac{\partial \bar{p}_D}{\partial r_D} \right) = s \bar{p}_D \quad (3.4.3.3)$$

Taking the Laplace transform of the inner boundary condition gives

$$\left(\frac{\partial \bar{p}_D}{\partial r_D} \right)_{r_D=1} = -\frac{1}{s} \quad (3.4.3.4)$$

Taking the Laplace transform of the outer boundary condition gives

$$\bar{p}_D(r_D \rightarrow 0, s) = 0 \quad (3.4.3.5)$$

Multiply r_D^2 by both sides

$$\frac{1}{r_D} r_D^2 \frac{\partial}{\partial r_D} \left(r_D \frac{\partial \bar{p}_D}{\partial r_D} \right) = s r_D^2 \bar{p}_D$$

$$\text{or, } r_D \frac{\partial}{\partial r_D} \left(r_D \frac{\partial \bar{p}_D}{\partial r_D} \right) = s r_D^2 \bar{p}_D \quad (3.4.3.6)$$

We define a variable of substitution, z , as

$$z = \sqrt{s} r_D \quad \text{or, } r_D = \frac{z}{\sqrt{s}}; \quad \frac{\partial z}{\partial r_D} = \sqrt{s}$$

Put the substituted value into the upper equation

$$\frac{z}{\sqrt{s}} \frac{\partial}{\partial z} \frac{\partial z}{\partial r_D} \left(\frac{z}{\sqrt{s}} \frac{\partial \bar{p}_D}{\partial z} \frac{\partial z}{\partial r_D} \right) = z^2 \bar{p}_D$$

$$\text{or, } z \frac{\partial}{\partial z} \left(z \frac{\partial \bar{p}_D}{\partial z} \right) = z^2 \bar{p}_D$$

$$\text{or, } z^2 \frac{\partial^2 \bar{p}_D}{\partial r_D^2} + z \frac{\partial \bar{p}_D}{\partial r_D} = z^2 \frac{\partial \bar{p}_D}{\partial t_D} \quad (3.4.3.7)$$

The general equation of the Bessel function is

$$z^2 \frac{\partial^2 y}{\partial z^2} + z \frac{\partial y}{\partial z} = (z^2 + v^2) y \quad (3.4.3.8)$$

The general solution of Eq. (3.4.3.8) is given by

$$y = A I_v(z) + B K_v(z)$$

Where I_v and K_v are the modified Bessel function of the first & second kinds, respectively, there “ v ” is the order & “ z ” is the argument. Compare the Eq. (3.4.3.7) & (3.4.3.8), let $v=0$;

$$\bar{p}_D(z) = A I_0(z) + B K_0(z) \quad (3.4.3.9)$$

3.4.4 Constant terminal rate case:

The boundary conditions for the constant rate case in an infinite medium are that (1) the pressure drop $p_D(r_D, t_D = 0) = 0$ initially at every point in the formation (2) at the radius of the field $r_D = 1$ we have $\left(\frac{\partial p_D}{\partial r_D} \right)_{r_D=1} = -1$

The general solution of Eq.(3.4.3.9) is given by $\bar{p}_D(r_D, s) = A I_0(\sqrt{s} r_D) + B K_0(\sqrt{s} r_D)$ (3.4.4.1)

Now considering the boundary condition we can determine the constant value of A and B and put this value into equation we can get

$$\bar{p}_D(r_D, s) = \frac{k_0(\sqrt{s} r_D)}{s \sqrt{s} k_1(\sqrt{s})} \quad (3.4.4.2)$$

The term $\frac{k_0(\sqrt{s} r_D)}{s \sqrt{s} k_1(\sqrt{s})}$ cannot be inverted directly, now the residue methods are applied from complex variable.

3.4.5 The complex inversion formula:

Complex inversion formula is used for transfer general Bessel function from modified Bessel function.

$p_D(s) = \mathcal{L}\{p_D(t_D)\}$, then $\mathcal{L}^{-1}\{p_D(s)\}$ is given by

$$p_D(t_D) = \frac{1}{2\pi i} \int_{\gamma-i\infty}^{\gamma+i\infty} e^{st} p_D(s) ds \quad (3.4.5.1)$$

This result is called the complex inversion integral or formula is also known as Bromwich's integral formula. The result provides a direct means for obtaining the inverse Laplace transform of a given function $P(s)$.

The integration in Eq.(3.4.5.1) is to be performed along a line $s = \tilde{a}$ in the complex plane where $S=x+iy$. The real number $\tilde{a}$ is chosen so that $S = \tilde{a}$ lines to the right of all the singularities. To develop the explicit solution for the constant terminal rate case, it is necessary to invert the Laplace transforms equation (3.4.4.2) by the complex inversion formula. The path of integration for this transform is described by the cut along the negative real axis Fig.03 which

gives the single value function on each side of the cut.

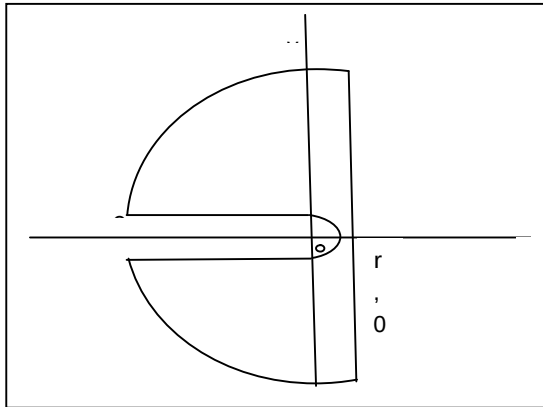


Figure-03: Contour integration in establishing the constant terminal rate case for infinite extent.

That is to say that path AB which is equal to the path AD & CB both of which are described by a semi-circle of radius infinity. Since its integration is zero in the second & third quadrant, this leaves the integration along path DO & OC equal to AB.

Modification of both Bromwich's contour in case of Branch point

Where $\bar{p}$ is the transform $\bar{p}$, where this report is concerned with pressure drops, the above can be written as

The integration on the upper portion of the cut can be obtained by making $\bar{p} = \bar{p} e^{i\theta}$, which yields equation (3.4.5.7)

Modified Bessel functions of the first and second kind of arguments $\sqrt{r}$ can be expressed by the regular Bessel functions as complex values as follows

Where, the imaginary term has been dropped.

Likewise, the integration along the under portion of the negative real "cut" is expressed by and

The integration along paths DO & OC is the sum of the relation Eq.(3.4.5.7) & Eq.(3.4.5.8)

Initially that is at time zero at Eq.(3.4.5.9)

This is the explicit solution of constant terminal rate for an infinite medium.

To determined the cumulative pressure drop for a unit rate of production at the wellbore or field radius The Eq. (3.4.5.8) changes to

For regular Bessel function

$$J_0(u)Y_1(u) - Y_0(u)J_1(u) = -\frac{2}{\pi u}$$

So the Eq. (3.4.5.9) is changed to

$$p_D(t_D) = \frac{4}{\pi^2} \int_0^\infty \frac{(1 - e^{-u^2 t_D}) du}{u^3 (J_1^2(u) + Y_1^2(u))} \quad (3.4.5.10)$$

3.4.6 Constant terminal pressure case:

As already shown, the transform of the pressure drop in an infinite medium

$$\bar{p}_D(s) = B k_0(\sqrt{s}) \quad \text{Or, } B = \frac{1}{s k_0(\sqrt{s})}$$

$$\bar{p}_D(r_D, s) = \frac{k_0(\sqrt{s} r_D)}{s k_0(\sqrt{s})} \quad (3.4.6.1)$$

Considering Fig.03, we can get the path line pressure drop

$$\begin{aligned} & p_D(r_D, t_{D1}) - p_D(r_D, t_{D2}) \\ &= \frac{2}{\pi} \int_0^\infty \frac{(e^{-u^2 t_{D1}} - e^{-u^2 t_{D2}}) (J_0(ur_D)Y_0(u) - Y_0(ur_D)J_0(u)) du}{u^2 (J_0^2(u) + Y_0^2(u))} \end{aligned} \quad (3.4.6.2)$$

If we are interested in the cumulative fluid influx at the field radius $r_D = 1$, then the relationship is

$$Q_D(t_D) = \int_0^{t_D} \left(\frac{\partial p_D}{\partial r_D} \right)_{r_D=1} \partial t_D \quad (3.4.6.3)$$

The determination of the transform of the gradient of the pressure drop at the field's edge is as follows—

$$\left(\frac{\partial \bar{p}_D(s, r_D)}{\partial r_D} \right)_{r_D=1} = -\frac{k_1(\sqrt{s})}{\sqrt{s} k_0(\sqrt{s})} \quad (3.4.6.4)$$

Since the pressure drop $p_D(r_D, t_D)$ corresponds to the difference between the initial & actual pressure is given by

$$\left(\frac{\partial \bar{p}_D}{\partial r_D} \right)_{r_D=1} = - \left(\frac{\partial \bar{p}_D(s, r_D)}{\partial r_D} \right)_{r_D=1}$$

$$\text{or, } \left(\frac{\partial \bar{p}_D}{\partial r_D} \right)_{r_D=1} = \frac{k_1(\sqrt{s})}{\sqrt{s} k_0(\sqrt{s})} \quad (3.4.6.5)$$

Taking the Laplace transforms in Eq.(3.4.6.3)

$$\mathcal{L}\{Q_D(t_D)\} = \mathcal{L}\left\{ \int_0^{t_D} \left(\frac{\partial p_D}{\partial r_D} \right)_{r_D=1} \partial t_D \right\}$$

$$\text{or, } Q_D(s) = \left(\frac{\partial \bar{p}_D}{\partial r_D} \right)_{r_D=1} \frac{1}{s}$$

$$\text{or } Q_D(s) = \frac{k_1(\sqrt{s})}{\sqrt{s} k_0(\sqrt{s})} \frac{1}{s} \quad (3.4.6.7)$$

The application of the Mellin's inversion formula the above equation follows the path

$$Q_D(t_D) = \frac{4}{\pi^2} \int_0^\infty \frac{(1 - e^{-u^2 t_D}) du}{u^3 (J_0^2(u) + Y_0^2(u))} \quad (3.4.6.8)$$

4. COMPUTATION OF $Q_D(t_D)$ AND $P_D(t_D)$

From Chatas A.T (1953), A practical treatment of nonsteady state flow problems in reservoir systems, he expressed an infinite series of exponentials and Bessel function in terms of dimensionless pressure evaluated as a function of dimensionless radius and dimensionless time.

Some important characteristics of this tabulation include the following.

1. When $t_D < 0.1$, $p_D(t_D)$ can be approximated by the relation

$$p_D(t_D) = \frac{2\sqrt{t_D}}{\sqrt{\pi}} \quad (4.1)$$

2. For $t_D > 100$; $p_D(t_D)$ can be extended by use of the equation

$$p_D(t_D) = .5(\log t_D + .80907) \quad (4.2)$$

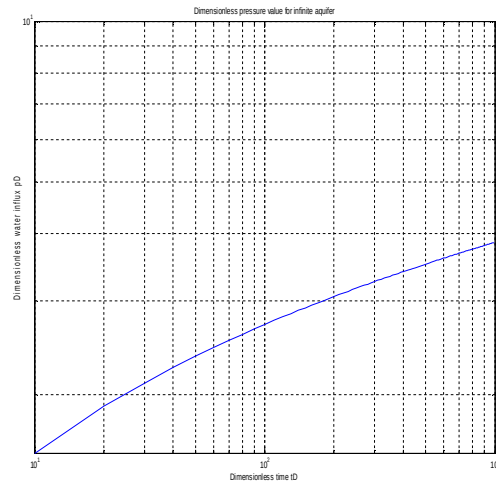


Figure 04: Dimensionless pressure value for infinite reservoir in several of dimensionless time.

Computation of $Q_D(t_D)$, some important characteristics of this tabulation include the following for infinite reservoir

1. When $t_D < 0.1$, $Q_D(t_D)$ can be approximated by the relation $Q_D(t_D) = \frac{2\sqrt{t_D}}{\sqrt{\pi}}$ (4.3)

2. For $t_D > 200$; $Q_D(t_D)$ can be extended by use of the equation

$$Q_D(t_D) = \frac{-4.29881 + 2.02566 t_D}{\log t_D} \quad (4.4)$$

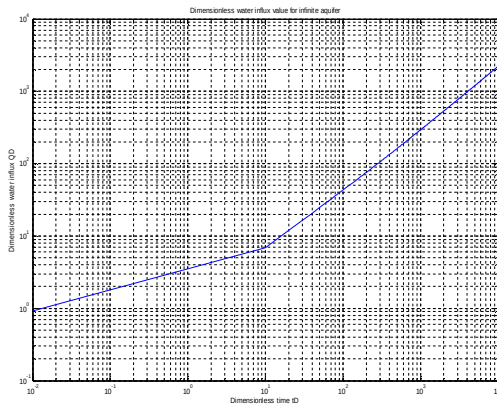


Figure05: Dimensionless water influx value for infinite reservoir in small value of dimensionless time.

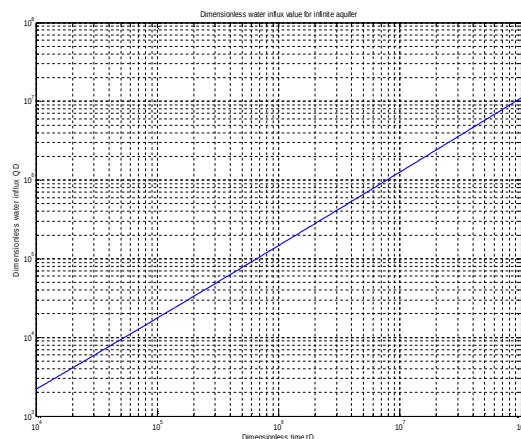


Figure 06: Dimensionless water influx value for infinite reservoir in large value of dimensionless time.

5.DISCUSSION AND CONCLUSION:

To determine the fluid flow rate in any reservoir, some conditions are applied and which is very important. This paper shows that solutions of differential equation describing flow in a petroleum reservoir for given initial and boundary condition can be expressed compactly using dimensionless variables and parameters.

This solution of the diffusivity equation, models radial flow of a slightly compressible liquid in a homogeneous reservoir of uniform thickness reservoir at uniform pressure (p_i) before production and no flow boundary and production at constant rate q from the single well at radius r_w .

Two sets of solutions of diffusivity equation are developed namely for "the constant terminal pressure case" and "the constant terminal rate case". In the constant terminal pressure case, the pressure at the terminal boundary is lowered by unity at zero time, kept constant and the cumulative amount of fluid flowing across the boundary is computed as a function of time. In the constant terminal rate case, a unit rate of production is made to flow across the terminal boundary and the ensuring pressure drop is computed as a function of time.

Some curves can be employed to reproduce the effect of any pressure or rate history encounter in practice.

This paper is useful to understand the Darcy's law, how diffusivity equation is developed from the Darcy's law, and the development of the dimensionless variable from the diffusivity equation and finally the numerical solution of the diffusivity equation using Laplace transform. The final solution of diffusivity equation is handy for dimensionless water influx calculation well test analysis.

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AN OVERVIEW OF GEOLOGY, HYDROGEOLOGY, AND OPEN PIT MINING PERSPECTIVE OF THE PHULBARI GONDWANA COAL DEPOSIT, NW BANGLADESH

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The Phulbari coal deposit is one of the largest coal reserves in NW Bangladesh. The country requires exploring this resource to overcome the present energy crisis. Two types of mining methods-open-pit and underground, might be considered for the exploration of coal worldwide. However, depths of the coal seam, geological, and hydrogeological circumstances of the Phulbari area vigorously disfavor open-pit mining. In this article, geology and hydrogeology of the area have been reviewed first, and then Boundary Element Method (BEM) numerical modeling has been applied to recognize *in situ* stress state around the proposed open pit mine of the Phulbari coal deposit. The modeling result reveals that the tensional rock failure state would be created around the proposed open-pit excavation. The major focus of the article is to explain the geological and hydrogeological problems linked to the *in situ* stress state of the surroundings open-pit dimension and how long distance the groundwater table would be affected because of the mine dewatering.

Key words: Coal, Geology, Hydrogeology, and Mining

1. INTRODUCTION

Bangladesh needs coal as a major alternative energy source to overcome the present critical situation in the power sector. The Phulbari coal basin in northwestern Bangladesh has over 572 Mt of bituminous ranks of coal. The geographical location of the basin is shown in Fig.1. The existence of the Phulbari basin was first discovered by the Geological Survey of Bangladesh (GSB) to investigate a negative gravity anomaly identified by geophysical exploration for oil and gas, confirmed the existence of a sequence of Gondwana coal-bearing sediments. In 1992, GSB established a negative gravity anomaly map and it was assumed that about 13 Gondwana coal-bearing basins remains in the NW Bangladesh^[1].

Australia-based Broken Hill Proprietary (BHP) worked in Bangladesh for about eight years, spent millions of dollars on the geological and geophysical exploration and discovered a large-

scale coal deposit at the Phulbari area in 1997. Because of location of coal at a deeper depth, BHP realized that open-pit mining at a depth of more than 130m would be inconceivable at the Phulbari basin. Considering the unconsolidated overburden and thick unconfined aquifer, open-pit mining was problematic even at a depth of 130m. Finally, BHP decided not to proceed open-pit mining due to environmental reasons and for geological, hydrogeological, and economic reasons^[2].

The Government of Bangladesh signed a contract with BHP through an open tender. While BHP determined not to continue for open-pit mining, at that juncture, Asia Energy, a UK-based company without any mining experiences elsewhere made contract with BHP in 1998^[3]. Asia Energy took license of the Phulbari basin from BHP and was planning to submit an underground mining proposal to the government. However, instead of submitting an underground mining

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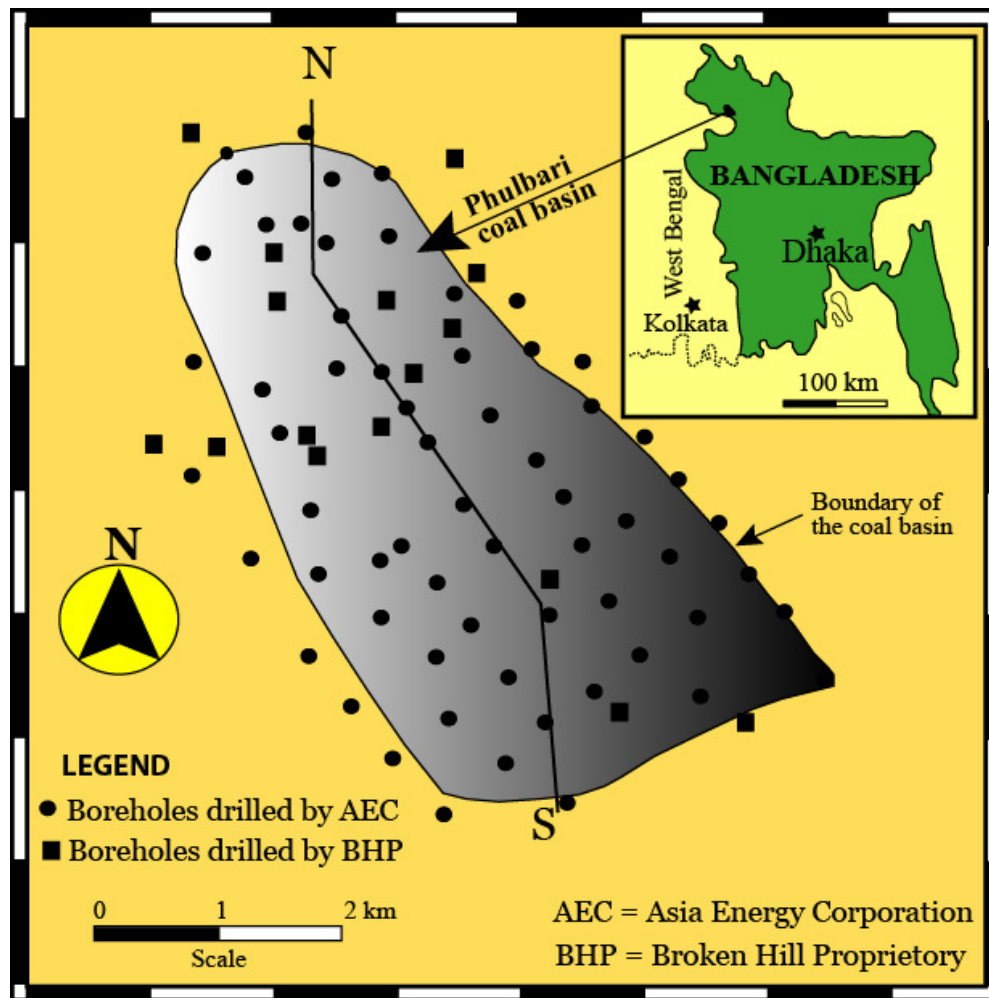


Fig.1. Location of the Phulbari coal basin in NW Bangladesh (modified after GHD Pty.Ltd, Australia⁴)

proposal, Asia Energy is now trying to overlook the devastating consequence of open-pit mining ^[2].

Regarding the aforesaid state of situations, the Government of Bangladesh is concerned to get a decision for the selection of mining method, i.e. either open-pit mining or underground mining. Before selection of a mining method the technical information- such as, geology, coal distributions and hydrogeology of the basin are earnestly required. However, necessary data concerning geology and hydrogeology of the Phulbari basin are not available to the scientific community of the country and abroad. The two major objectives of the present article are- (i) to provide an overview of the geological setting and hydrogeological conditions of the area associated with open-pit mining outlook, and (ii) safety measures of the regional groundwater table regarding the mining method selection of the Phulbari coal deposit. Safety measures of the regional hydrogeology have been focused on the basis of BEM numerical simulation.

2. GEOLOGY OF THE DEPOSIT

The Phulbari Coal Basin is located in the Dinajpur Shield of Bangladesh and is surrounded by Himalayan Foredeep to the north, the Shillong Shield/Platform to the east, and the Indian Peninsular Shield to the west. The Garo-Rajmahal gap lies between the exposed Peninsular Shield and the Shillong Shield ^[1].

The geology and structure of the Phulbari coal deposit were illustrated by GHD of Australia ^[4]. According to the geological data of the basin, the sedimentary strata of the deposit are nearly 350 m thick. In general, the area is characterized by the horizontal occurrence of the sedimentary rocks with large-scale tectonic disturbances. The Phulbari basin preserved in two faults controlled basins surrounded by Archaean basement at shallow depth. BHP drilling recognized two giant faults having vertical displacement about 150m. From a cross-section (N-S) of the basin, as prepared by GHD, it is observed that one fault is located toward the south of the basin and another to the central part ^[4].

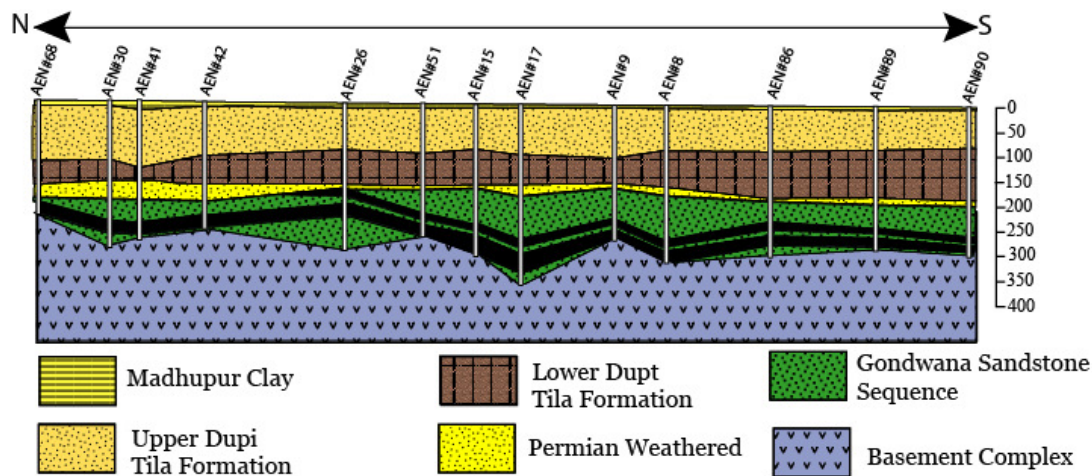


Fig.2. Stratigraphic cross-section (see location of boreholes in Fig.1) of the Phulbari coal basin (modified after GHD Pty.Ltd, Australia⁴)

The geological features of the rock mass structure suggest that there are large-scale tectonic forces in the area of the Phulbari coal deposit. Existence of two major faults reveals the basin is a part of the tectonically high-disturbed zone within the continental Indian plate, where convergence and subduction of Indian plate is continuing beneath the Eurasia plate at 55 mm per year. It means there are numerous faults, fractures, joints, and fissures within the Phulbari basin [6]. The stratigraphic sequence (Figs.2,3) of the Phulbari coal deposit is identical to that of the Barapukuria basin and it is divided into four formations on the basis of age and lithology:

- Madhupur clay from the recent Holocene era,
- A water-bearing Dupi Tila aquifer of Late Miocene-Middle Pliocene age,
- Permian coal-bearing Gondwana Group rock sequences, and
- Pre-Cambrian Archean basement [4,7, 8, 9].

The sedimentary stratum contains the Madhupur Clay, Upper Dupi Tila (UDT), Lower Dupi Tila (LDT), Gondwana coal-bearing rock series. About 3m thick Madhupur Clay Formation composed of clay, mostly silty. The Tertiary sediments occur in two distinct sequences- the UDT and LDT. The UDT Formation is almost 80m thick, which is an unconfined mega-aquifer that extends entire northern districts of the country. The host rocks are sand- unconsolidated to partly consolidated, medium to coarse-grained, occasionally gravelly with bands of silt. The Lower Dupi Tila Formation, approximately 30m thick, consists of sandstone, silt and white clay.

The Permian-Carboniferous coal-bearing sequence is subdivided into three unit- an upper unit of mudstone and sandstone; a middle unit represented by a carbonaceous mudstone and well developed coal sequence and a lower unit consisting of quartz rich sandstones and interbedded carbonaceous mudstone, siltstone and

sandstone. Total coal sequence thickness is up to 45m with one or more partings up to 5.5m thick identified. The depths of the two proposed mineable coal seams of the Phulbari basin range between 120m-350m [4, 7, 8, 9].

3. HYDROGEOLOGY

Belonging to the same geological belt, the hydrogeological characteristics of the Phulbari basin would be identical to that of Barapukuria basin. The both upper and lower seams of the Phulbari basin lie beneath an unconfined aquifer. In the Barapukuria, there is a proven potential for groundwater flow from the Upper Dupi Tila into the Gondwana sandstones. All Gondwana sandstones are typically jointed, although the joints are frequently mineralised or infilled which reduces the secondary permeability of the aquifer. The Dupi Tila deposits are comprised of poorly consolidated to unconsolidated sands with high permeability ranging from 4.81 mD to 558 mD [1, 7, 8, 9].

Permeability within the Gondwana is considerably less (3.67 mD to 75 mD) than that of the overlying Dupi Tila aquifer. The upper coal seams have permeability between 9.8 mD and 137.8 mD because these seams are comparatively soft and, to a varying extent, are in hydraulic continuity with the Upper Dupi Tila aquifer. In the Dupi Tila aquifer, the estimated hydraulic continuity results range from 160–260 m/d for the entire thickness of about 110m Estimated hydraulic conductivity for the Gondwana aquifer is 31 m/d for the entire thickness of about 100 m. The permeability value of the Lower Dupi Tila aquiclude is about 0.15 mD [1, 7, 8, 9].

4. OPEN-PIT MINING OUTLOOK

Four important factors that have major impacts on the mining method selection include- (i) physical and mechanical characteristics of the overburden

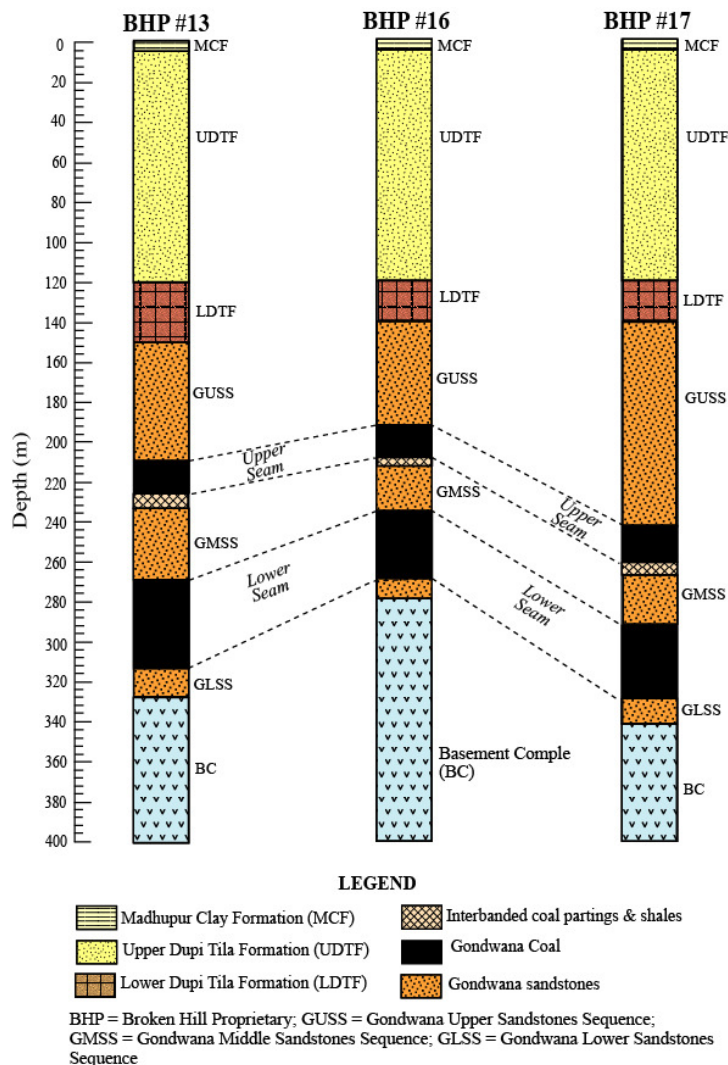


Fig.3. Upper and lower coal seams (see location of boreholes in Fig.1) of the Phulbari coal basin (modified after GHD Pty.Ltd, Australia⁴).

rock of the deposits, (ii) technical factors, (iii) economic factors, and (iv) productivity factors^[10]. Usually, an open-pit mining is considered for large tonnage, high rates of production while overburden rock is thin, not greater than 120m. On the contrary, underground mining is beneficial while the coal deposit is deep, greater than 120m; ore body is steep and grade is high enough to cover costs^[11]. Asia Energy Corporation (AEC) is committed to open-pit mining in the Phulbari coal basin based on the economic and productivity factors.

5. SIMULATION RESULTS

Boundary Element Method (BEM) numerical simulation of the Phulbari proposed (Fig.4) open-pit mine has been carried out to assess tensional strength factor within the surrounding rock sequences. The two-dimensional BEM model covers a length of the pit ground line of about 4 km, length of the pit bottom is about 2.5 km, and a

depth of it is about 400 m (Fig.5a). The simulation result reveals that high tensional failure within rock strata would be extended upto 27 km towards the both sides from the center of the open pit. The lateral and vertical tensional effect within the strata would be around 54 km, and 1.25 km, respectively.

6. DISCUSSION

Two types of mining methods- open-pit and underground, have been practiced for a long time worldwide. The depth of coal deposits beneath the surface and nature of the overburden determine the mining method employed. The seam thickness and continuity influence the specific mining practices as well as the resource recovery attainable for a given deposit. The open-pit mining method is usually selected based on the geology, hydrogeology, depth of overburden of coal, and topographic locations of the basin. Most of the open-pit coalmines in Australia, for example, Surat Basin, Galilee Basin,

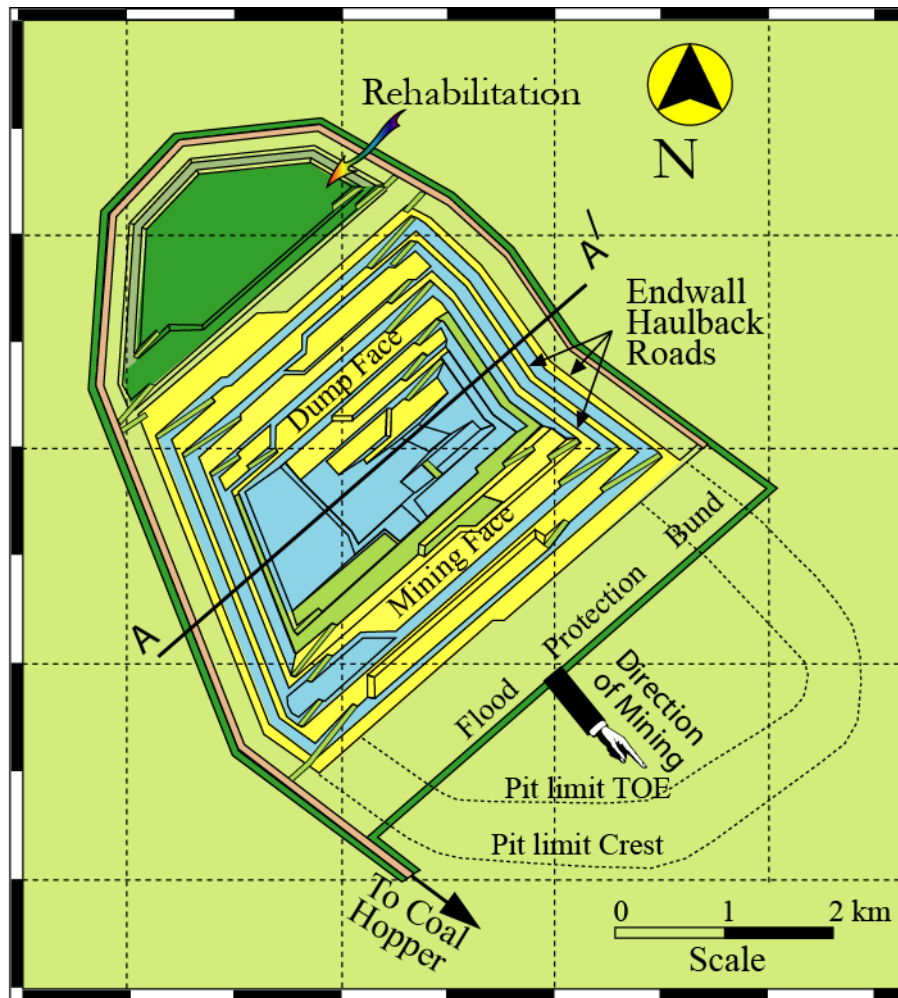


Fig.4. Design of the proposed open pit coal mine of the Phulbari coal basin, NW Bangladesh (modified after AEC ^[5]). Note that the coal basin is located under a town with many densely populated villages around the town. Line AA' shows the position, along which BEM simulation (Fig.5) has been considered.

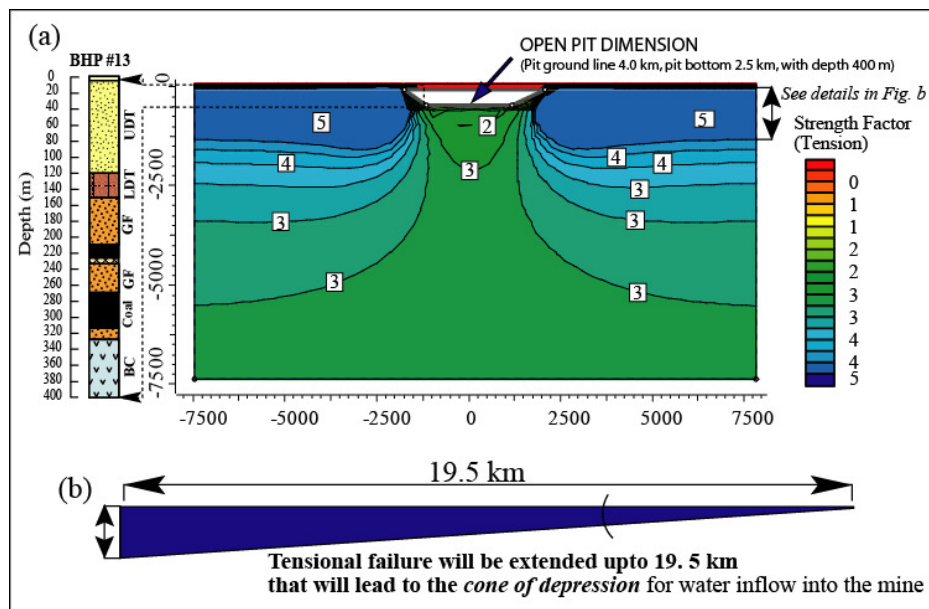


Fig.5. Distribution contours of tensional strength factor within the UDT, LDT, and Gondwana rock sequences.



Fig. 6. Aerial photograph of an open-pit mining in a hilly region of Australia

Washpool open-pit coal project, the Red Hill open-pit coal project, the Burton, Ellensfield and Wallanbah open-pits, etc, are found in and around the hilly regions (for example, Fig.6) and the depths of these open-pit mines in that area are shallower than 120m^[11].

The first problem for open-pit mining in the Phulbari basin is connected to the depth of coal seams that lie beneath an unconsolidated overburden associated with unconfined regional aquifer, the Upper Dupi Tila Formation. The depth of coal seams of the basin ranges from 150 to 350m. The deeper depth (greater than 120m) relevant dilemma for open pit mining in the Phulbari basin was first detected by BHP in 1997. The company recognized very high water inflow within the overburden Dupi Tila aquifer which is connected to the coal-bearing Gondwana Group rock sequences by different faults and joints. BHP's target was to have coal seams under a depth of maximum 100m below the surface. However, the company could not find a shallow coal deposit around 100m depth. After the pre-feasibility study, BHP abandoned the open pit mine project in the Phulbari coal basin because the company did not want to create another environmental disaster as they have bitter experience in Papua New Guinea^[6].

The second problem is associated with regional hydrogeology of the area. From the BEM numerical simulation result (Fig.5) it is revealed that the safety of the regional groundwater table would be damaged because of high tensional factor within the rock strata up to about 27 radius from center of the

pit. Extensive tensional failure into the rock strata up to 54 km would create numerous fractures and tensional shear stress that will enhance porosity and permeability. In a rational sense, when a mine dewatering is continued, groundwater is released continuously from geological formations and the water level doesn't rebound. Recovery of surroundings water level due to continuous dewatering from an open pit mine is impossible. The present study clarify that the *cone of depression* (Fig. 5b) will be extended up to 54 km and local tube-wells, shallow machines, and deep tube-wells will not get groundwater for agriculture and domestic purposes within a radial distance up to 27 km from the center of the mine^[10].

7. CONCLUSIONS

The disagreement for open-pit mining of the Phulbari deposit hinges upon only coal recovery rate (over 90%). The ultimate goals of a mining method selection are to- (i) maximize company profit, (ii) maximize recovery rate of the mineral resources, and (iii) provide a safe environment by selecting the method with the least problems among the feasible alternatives. From the reviews, it seems that AEC interest was only the first two factors; apart from the technical, physical, and mechanical properties of the overburden rock stratum. Therefore, expert's opinions regarding mining geologists and engineers are disparate from that of AEC's information. However, the present study illustrates a serious technical issue regarding

geological and regional hydrogeological aspects of the northwest Bangladesh.

ACKNOWLEDGEMENTS

The basic geological data, (Fig.1,2,3) and open pit mine sketch (Fig.4) outlook, published in this article has been extracted from the technical report of Australia-based GHD Pty. Ltd, and AEC's presentation that were available to their websites (2005-2009). Authors have also taken assist from the important articles of the daily newspaper that were written by different scholars of the concerning fields.

The authors are also grateful to **Dr. Md. Khalequzzman**, Professor of Lock Haven University, USA; Professor **Dr. Badrul Imam**, Department of Geology, D.U; **Md. Nazrul Islam**, Ex. Geological Consultant of BHP's Bangladesh Coal Project; and **Engr. A.K.M. Samsuddin** for their scholarly achievements in **the Daily Star**. Thanks to **Mr. Nurul Kabir**, the Editor in chief of **the Daily NEW AGE** who published some important articles of Dr. M.R. Islam.

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COAL BED METHANE (CBM) PROJECT, HOW FAR TO MINIMIZE THE ENERGY CRISIS OF BANGLADESH

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At North West of Bangladesh there are five major Gondwana coal fields of Permian age contains 4744 million tons of coal (Barapukuria, Phulbari, Khalaspir, Dighipara, Jamalganj). The depths of coal seams below surface lie in range 118-118m including 29 coal seams in average thickness range of 38.4-64m. These coals are high to medium volatile bituminous with high FC including a little sulphur 0.54-0.77%. Porosity and permeability is respectively 1.6-3.2% and 9.80-137.8mD, including temperature gradient 32-36°C/km. These characteristics show how prospective the CBM project could be in Bangladesh. Gondwana coal consists of 90% methane, calorific value of 10450-11876 Btu/lb and average estimate in-situ CBM resource is 9.56m³/ton. Through the empirical formula given by Meinser and Kim (direct method) CBM reserve is estimated. Bangladesh requires 5000MW of electricity but generating only 3200MW. Coal provides 40% of total electricity produced in the world. So, CBM project can minimize this energy crisis of Bangladesh within half time required for mining. Large amount of water will be produced due to production of CBM which contains high amount of total dissolved solids (TDS) can cause salinity problems of soil, decrease the ground water level as well as affect the environment. Proper treatment and management of process can ensure the safety and risk.

Key words: Coal, CBM extraction, Estimation, Energy, Environment

1. INTRODUCTION:

Bangladesh is a developing country. As a developing country, we are facing many problems. Moreover, we have very limited natural resources like gas, coal, crude oil, limestone, pit etc. Like the whole world, Bangladesh is also facing energy problem due to the lack of gas and other natural resources. But electricity is the key ingredient of socio-economic development of the country. Adequate and reliable supply of electricity is an important pre-requisite for attracting both domestic and foreign investment. The Government has given top priority to the development of the sector and has set the goal of providing electricity to all citizens by 2020.

Reliable supply of electricity is a pre-condition for poverty reduction and economic development. In Bangladesh, 47% of total populations have access to electricity but reliable and quality power is still a faraway. To alleviate poverty in the face of resource limitations and high population density, Bangladesh requires an economic growth rate of more than 7% p. a. In order to achieve this growth rate, electricity growth needs to be achieved by 10%. By best utilizing the natural, human and

agricultural resources the desired pace of GDP growth could be attained by increasing electricity generation at much higher rate, which is the key target for development.

2. BANGLADESH POWER SECTOR:

In FY 2009-10 total generation capacity was 5,823 MW (up to May'10) including 3226 MW in public sector and 2045 Megawatt in private sector.

Table 1: overview of Bangladesh power sector

No.	Items	2009-2010
1.	Installed Capacity, MW	5,823
2.	Generation Capacity	5,271
3.	Maximum Generation	4,606
4.	Net Generation, MKWh	26,533
5.	Transmission line, km	8,391
6.	Number of consumers	12 million
7.	No. of village electrified	53,281
8.	Per capita generation	220
9.	Access to electricity	47%

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2.1 Present Generation Capacity:

Presently total generation capacity is 5,271 MW. Of this capacity 3,226 MW is from public sector and 2045 MW is from the private sector, which is 62% and 38% respectively of the total generation capacity.

Considering 10 - 15 % Maintenance and Forced Outage, Available Generation Capacity is in the range of 4500 – 4800 MW without fuel constraint. After Considering 10 - 15 % Maintenance and Forced Outage, Available Generation Capacity is in the range of 3400-3900 MW in those plants where gas is used as fuel.

2.2 Future Rolling Plans:

Power is the pre condition for social and economic development. But currently consumers cannot be provided with uninterrupted and quality power supply due to inadequate generation compared to the national demand. To resolve the present shortfall and to meet the increasing demand for electricity, the government has taken an initiative to increase generation (installed) capacity to 13735 MW by 2015. For this reason installation of new power plants and the maintenance of the old power plants has been given highest priority.

2.3 Worldwide Electricity Generation:

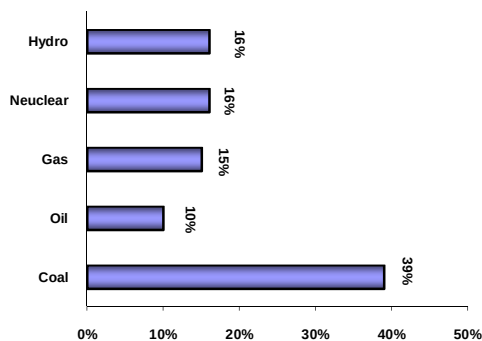


Figure 1: Worldwide Electricity Generation, coal is used to produce 39% of electricity worldwide

2.4 Electricity Generation in Bangladesh:

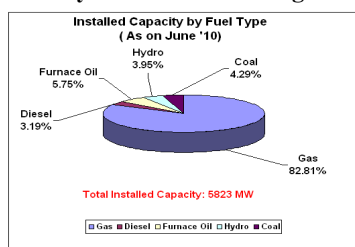


Figure 2: Electricity Generation in Bangladesh

Coal is used to produce 4.29% of electricity in Bangladesh; where, natural gas is used to produce 82.21%, furnace oil 5.75%, hydro 3.95%, diesel 3.19% of electricity in Bangladesh.

3. GAS SECTOR SENARIO IN BANGLADESH:

Total recoverable gas: 21 TCF (Proven and probable)

Reserve remaining: 13 TCF (more 2 TCF gas have been discovered now)

National demand of natural gas: 2200 MMCFD

Production capacity: 1880 MMCFD

Power sector requirement: 921 MMCFD

Power sector gets: 800 MMCFD

3.1 Sector wise use of Gas in Bangladesh:

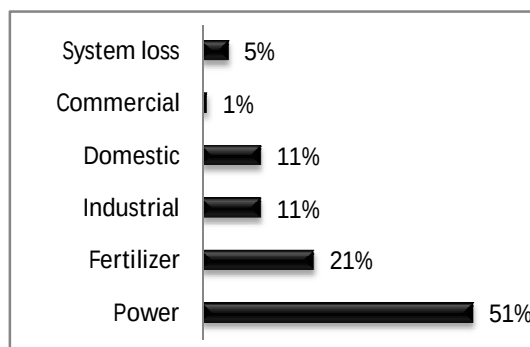


Figure 3: Sector wise use of Natural gas in Bangladesh

3.2 Next 50 Years Sector wise and Total Gas Demands:

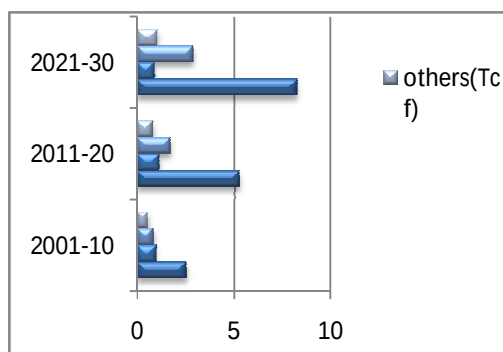


Figure 4: Sector wise and total gas demand projections for 50 years by Petrobangla

3.3 Supportive Fuel For Energy Sector:

Natural gas several uses like in domestic or industrial purpose. We have shown a data how the need of natural gas will rise in many sectors. Bangladesh is facing a critical energy shortage and, while requiring an estimated 5823 MW of electricity, is currently having a generation capacity of 4500-4800 MW. And from them, 3400-3900 MW produced from those plants where natural gas is used as fuel. According to the vision 2021 plan of present government, within 2015, there will be a generation addition of 9426 MW, from where 5182 MW will come from those plants where natural gas is used as fuel. Natural gas used only 15% to produce electricity worldwide, but in our country this is about 82.81%. Due to the high necessity of natural gas, it is very tough to depend very much on natural gas to produce electricity.

Unit Conversion Factors:

Gas volume: 1 Tcf = 28.3286 Gm³

Energy: 1 Kcal = 4186.75 j

Energy Equivalence:

1 Mt coal = 0.6967 Gm³ gas

1 Gm³ gas = 1.4354 Mt Coal

Daily requirement of Natural gas in the power sector = 921 MMCFD

So, requirement of Natural gas to produce **1 MW of electricity = 0.2095 MMCFD**

Now, according to the present demand of Bangladesh, 1 Tcf gas can be used to produce 3500 MW power per day for approximately for 4 years.

4. COAL AND COAL BED METHANE (CBM):

Coal is a sedimentary rock and basically lithified plant material. Bangladeshi coal is Pre-main in age and occurs within fault bounded Gondwana basins. Coal quality is high to medium volatile bituminous with high fixed carbon provides high calorific value. At North West of Bangladesh there are five major Gondwana coal fields contains 4744 million tons of coal (Barapukuria, Phulbari, Khalaspir, Dighipara, Jamalganj). The depths of coal seams below surface lie in range 118-1178m including 29 coal seams in average thickness range of 38.4-64m. These coals are high to medium volatile bituminous with high FC, including very little Sulphur 0.54-0.77%. Gondwana coal consists of 90% methane, 10% Carbon dioxide, Nitrogen, calorific value of 10450-11876 Btu/lb and average. All the data related with the coal fields are given below in the Table 5:

Table 2: Description of five major coal fields of Bangladesh:

	Discover (year)	Depth (meter)	No of coal seam	Average thickness of coal seams (meter)	Reserve (mt)
Jamalganj	1962	640-1158	7	64	2513
Barapukuria	1985	118-506	6	51	377
Khalaspir	1989	257-451	8	42.3	828
Dighipara	1995	250	7	42	600
Phulbari	1998	152-246	1	38	426
Total	-	-	29	-	4744

(Table continued)

Coal Quality	High to medium volatile bituminous	High to medium volatile bituminous	High to medium volatile bituminous	High to medium volatile bituminous	High to medium volatile bituminous	High to medium volatile bituminous	Coal Quality
Ash Content %	24.2	16.2	21.8	-	15	-	Ash Content %
Fixed Carbon %	36.7	46.2	54.1	-	-	-	Fixed Carbon %
Volatile Matter %	36.9	27.6	22.86	-	-	-	Volatile Matter %
Sulphur %	0.55	0.57	0.77	<1	<1	-	Sulphur %
Calorific Value (Btu/lb)	11876	10450	11264	-	-	-	Calorific Value (Btu/lb)
Moisture Content %	3.58		1.28			-	Moisture Content %

For CBM project six geological characteristics to be considered:

1. depth and thickness of coal seam
2. rank of the coal
3. fractures in the coal seam
4. porosity and permeability
5. hydrodynamic properties
6. geothermal gradient

Bangladesh is highly prospective for CBM project because it has satisfactory values of terms required, the minimum standard values and Bangladesh coal fields are compared below:

Table 3: Comparison of minimum standard values for CBM and Bangladesh coal fields

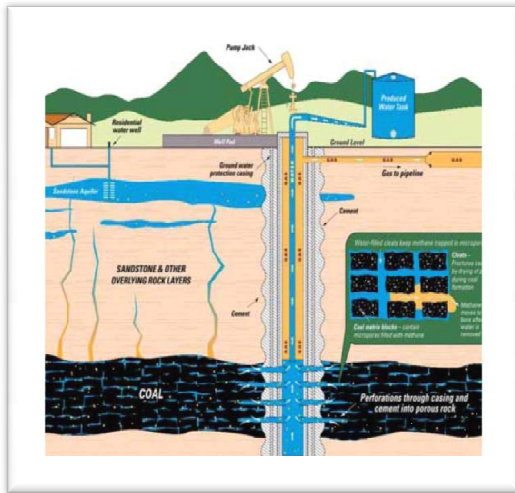
	Minimum Standard	Bangladesh Coal Fields (average)
Depth	300 meter	283-590 meter
Thickness of coal seam	20 meter	38.4-64 meter
Rank of coal	High volatile bituminous	High to medium volatile bituminous
Porosity	> 1.6%	1.6-3.2%
Permeability	5 Md	9.8-137.8 Md
Temperature	<40°C	32-36°C
CBM content	70 ft ³ /ton	200-400 ft ³ /ton

This chart is announcing the high possibility of CBM project in Bangladesh. There are 6.5-12.68 m³/ton of gas content at Barapukuria, Gondwana coal contains 90% methane and 10 % carbon dioxide, nitrogen, carbon monoxide, ethane etc. So, we can say how prospective is CBM for Bangladesh.

4.1 CBM Extraction-Basic Principal:

The methane is absorbed into the solid coal matrix and is released when the coal seam is depressurized. To economically retrieve reserves of methane, wells are drilled into the coal seam, the seam is dewatered and then the methane is extracted from the seam, compressed and piped to market. The goal is to decrease the water pressure by pumping water from the well. The decrease in pressure allows methane to desorb from the coal and flow as a gas up the well to the surface.

While dewatering is occurring, the operator should make sure that the pump jack is not running too long. If the water level is pumped too low, this will



allow the gas to travel up the tubing into the water line, causing the well to become "gassy". The main
Figure 5: A typical CBM well

objective is not to put the gas in the water line, but to allow it to flow up the backside of the well (casing) and into the pipeline, where it can be transported to the compressor station and delivered to the customer for sales. Once the gas goes up the tubing, it is usually recovered in a water-gas separator at the surface. However, pumping water and gas is inefficient and can cause pump wear and breakdown.

Most gas in coal is stored on the internal surfaces of organic matter. Because of its large internal surface area, coal stores 6 to 7 times more gas than the equivalent rock volume of a conventional gas reservoir. Gas content generally increases with coal rank, with depth of burial of the coal bed, and with reservoir pressure. Fractures, or cleats, that permeate coal beds are usually filled with water; the deeper the coal bed, the less water is present, but the more saline it becomes. In order for gas to be released from the coal, its partial pressure must be reduced, and this is accomplished by removing water from the coal bed. Large amounts of water, sometimes saline, are produced from coal bed methane wells, especially in the early stages of production. While economic quantities of methane can be produced, water disposal options that are environmentally acceptable and yet economically feasible, are a concern. Water may be discharged on the surface if it is relatively fresh, but often it is injected into rock at a depth where the quality of the injected water is less than that of the host rock. Another alternative, not yet attempted, is to evaporate the water and collect the potentially saleable solid residues; this scheme might be feasible in regions having high evaporation rates.

5. MEASURING GAS CONTENT:

Coal bed gas content measurements are commonly used in mine safety as well as coal bed methane resource assessment and recovery applications. Gas content determination techniques generally fall into two categories: (1) direct methods which actually measure the volume of gas released from a coal sample sealed into a desorption canister and (2) indirect methods based on empirical correlations, or laboratory derived sorption isotherm gas storage capacity data.

The total gas content by the in direct methods is based on the empirical formula given by Meinsner and Kim. The quantity of gas is determined by Meinsner and Kim formula with using the moisture content, volatile content, volume of gas adsorbed on wet coal, fixed carbon, thickness of coal and temperature.

Meinsner (1984) observed that the amount of methane gas (V_{CH_4}) is related to volatile matter (daf)

$$V_{CH_4} = -325.6 \times \log (V.M/37.8)$$

Estimation of in-situ gas content of the coal will be evaluated by using Kim's (Kim 1977) equation

$$V = (100 - M - A) / 100 \times [V_w / V_d] [K(P)N - (b \times T)]$$

Where, V = Volume of methane gas adsorbed (cc/g), M = Moisture content (%), A = Ash content (%), b = Adsorption constant due to temperature change (cc/g/°C), N = Composition of coal (for most bituminous coals, $F.C$ = Fixed carbon (%), VM = Volatile matter (%), V_w = Volume of gas adsorbed on wet coal (cc/g), V_d = Volume of gas adsorbed on dry coal (cc/g), T = Temperature at given depth, T_o = Ground temperature, h = Depth (m). The values of K and N depend on the rank of the coal and can be expressed in terms of ratio of fixed carbon (FC) to Volatile matter (VM).

$$V_w / V_d = 1 / (0.25 \times M + 1)$$

$$K = 0.8 (F.C / V.M) + 5.6$$

$$N = (0.39 - 0.013 \times K)$$

$$T = \text{Geothermal Gradient} \times (h / 100) + T_o$$

Using the formula we get **total CBM potential 0.8-1.0 TCF in Bangladesh**. So, according to the previous estimation, we can say that, using only CBM, Bangladesh can fulfill the present demand in power sector of 921 MMCFD approximately for 4 years. But, if we use natural gas also with CBM, then we can use this CBM for more than 12 years.

6. ENVIRONMENTAL CONCERN FOR CBM:

The environmental impacts of CBM development are considered by various governmental bodies during the permitting process and operation, which provide opportunities for public comment and intervention. Operators are required to obtain building permits for roads, pipelines and structures, obtain wastewater (produced water) discharge permits, and prepare Environmental Impact Statements. As with other natural resource utilization activities, the application and effectiveness of environmental laws, regulation, and enforcement vary with location. Violations of applicable laws and regulations are addressed through regulatory bodies and criminal and civil judicial proceedings.

CBM wells are connected by a network of roads, pipelines, and compressor stations. These structures can compromise the scenic quality of the landscape, fragment wildlife habitat, and displace local wildlife populations. Over time, wells may be spaced more closely in order to extract the remaining methane. Additionally, the produced water may contain undesirable concentrations of dissolved substances. Water withdrawal may depress aquifers over a large area and affect groundwater flows.

Large amount of water will be produced due to production of CBM which contains high amount of total dissolved solids (TDS) can cause salinity problems of soil, decrease the ground water level as well as affect the environment. Proper treatment and management of process can ensure the safety.

7. CONCLUSION:

The purpose of this review is not to laud the benefits of coal operation, but to raise awareness of CBM extraction approaches, which will provide an alternative energy for the power sector of Bangladesh.

An electricity supply of around 5,271 MW is currently required to meet the needs of the people of Bangladesh, yet only 4,600-4,800 MW is being produced. Most of the electricity supply is generated by power plants fueled by natural gas and the reserves of our country's natural gas are finite. If the present-day natural gas consumption rate were to increase at a rate of 10% per year, the proven and recoverable gas reserves (a maximum of about 340 Gm³), would be exhausted by 2019.

No direct laboratory measurements have yet been made of the CBM gas content of coal samples from any of the Bangladesh coal basins. In the absence

of such measurements, the current best estimate of the gas content of the coals is provided by the predictions of gas concentration based on the known characteristics of coal. These prediction suggest Bangladesh has a CBM resource of 0.8 Tcf to 1 Tcf.

To limit the available options to mining only would fail to maximize the resource recovery. It would also, almost certainly, maximize the social and environmental costs of energy provision.

Bangladesh has a limited reserve of gas. If we use natural gas as fuel for generating power in most of the power plants then we will be in a great scarcity by 2019. So, this is the time to use the alternative energy as fuel to generated power.

Given the close proximity of all the basins, we can say that, the coal fields of Bangladesh are highly prospective for CBM project because it has satisfactory values of terms required. CBM provide an energy return that is less than that provided by coal itself, were it to be mined.

To release the dependence on the natural gas on the power sector, alternative fuel has to be used. CBM is one of the alternative fuels that can be use in the power plants as fuel to minimize the power crisis of Bangladesh.

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COMMONLY USED RESERVE ESTIMATION METHODOLOGY FOR GAS RESERVOIRS

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Reserve estimation is very crucial in order to gain the confidence on profitable extraction of gas from a gas reservoir. Because the degree of uncertainty is inherent in the assessment, the reserves are 'estimated' rather than 'measured'. It is a dynamic process; reserves are updated and likely to change as more data are available in the course of the development of a gas field. After discovery, during initial delineation, volumetric method can be used. When adequate production data are available, material balance can be used to estimate the reserve. As depletion proceeds decline curve analysis can be used to determine the remanent amount of reserve. During the whole process recovery factor plays a vital part as it determines the percentage of the gas can be extracted from the gas initially in place.

Keywords: reserve definition, volumetric method, material balance method, decline curve analysis.

1. INTRODUCTION

Natural gas is the naturally occurring hydrocarbon gas predominantly composed of methane. It is found in underground traps formed by structural and stratigraphic features called as reservoir. The prospect of accumulation of natural gas depends on coexistence of several factors in the subsurface which includes a) source rock, b) reservoir rock, c) trap, d) seal or cap rock etc. Once a reservoir is discovered, it is necessary to estimate the reserve of it. Reserve is the quantity of gas that is recoverable from the underground gas deposits. In many places natural gas and crude oil are found coexisting because their origin and accumulation processes are similar in many accounts. We shall discuss about the estimation process of dry gas reservoir as they are common in Bangladesh.

In 1986, the Society of Petroleum Engineers (SPE) adopted the following definition for reserves :

“Reserves are estimated volumes of crude oil, condensate, natural gas, natural gas liquids and associated marketable substances anticipated to be commercially recoverable and marketable from a given date forward, under existing economic conditions, by established operating practice, and under current government regulations.”

The process of estimating oil and gas reserves for a producing field continues throughout the life of the field. There is always uncertainty in making such estimates. The level of uncertainty is affected by the following factors:

- a) Reservoir type
- b) Source of reservoir energy,
- c) Quantity and quality of the geological, engineering, and geophysical data,
- d) Assumptions adopted when making the estimate,
- e) Available technology, and
- f) Experience and knowledge of the evaluator.

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Due to the degree of uncertainty is inherent in the assessment, the gas reserves are ‘estimated’ rather than ‘measured’. Reserves are defined in different categories on the basis of uncertainty such as:

- Proved Reserve: up to 10% uncertainty
- Probable Reserve: 10 to 50% uncertainty.
- Possible Reserve: uncertainty level is as high as 90% .

2. ESTIMATION METHODS

Different methods can be used to estimate the reserve depending on the maturity of the reservoir. The commonly used methods are:

- Volumetric Method: at early stages.
- Material Balance Method: when production data is available.
- Decline Curve Analysis: when the reservoir reaches decline mode.

2.1 Volumetric Method

In the early stages of development, reserves estimates are restricted to the volumetric calculations. The volumetric method entails determining the physical size of the reservoir, the pore volume within the rock matrix, and the fluid content within the void space. This provides an estimate of the hydrocarbons-in-place, from which ultimate recovery can be estimated by using an appropriate recovery factor.

For a gas reservoir:

$$GIIP = \frac{7758 V_R \phi (1 - S_{wi})}{B_{gi}} \times R.F \quad \dots\dots(1)$$

Where:

$GIIP$ = Gas initially in place (SCF)

V_R = Reservoir volume (acre-ft)

ϕ = Porosity (fraction)

S_{wi} = Interstitial water saturation (fraction)

B_{gi} = Initial gas formation volume factor (res bbl/SCF)

$R.F$ = Recovery factor (fraction)

2.1.1 Volume: The reservoir volume is obtained from geologic and fluid pressure analysis data. The geologist provides contour maps of the top and base of the reservoir, as shown in Figure: 1.

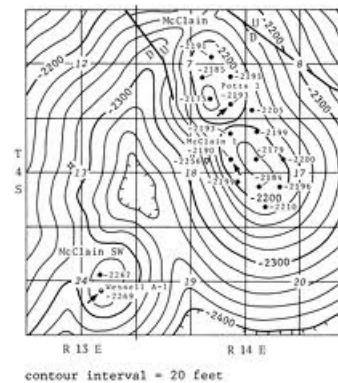


Figure 1: Contour Map

Such maps have contour lines drawn for every 20 feet, or so, the elevation can be determined by determining the gas water contact (GOC).

2.1.2 Porosity, ϕ : Effective porosity of a sample is defined as the following ratio:

$$\text{Effective Porosity} = \frac{\text{Interconnected pore volume}}{\text{Bulk volume}}$$

Effective porosity of the reservoir rock can be determined from study of core analysis. The porosity of clean sandstones may be calculated from electric logs.

2.1.3 Interstitial water saturation, S_{wi} : Water saturation is defined as the following ratio:

$$\text{Water saturation} = \frac{\text{Volume of water present in pore spaces}}{\text{Volume of total pore spaces}}$$

Interstitial or connate water saturation may be determined from electric logging information or by laboratory determinations run on cores by restored state, evaporation mercury injection, or centrifuge methods.

2.1.4 Formation volume factor , B_g : Gas formation volume factor is the ratio of volume of gas at the reservoir condition to that of gas at the standard condition. Mathematically:

$$B_{gi} = \frac{V_{\text{reservoir condition}}}{V_{\text{base condition}}} = \frac{p_b}{5.615} \frac{T_i}{p_i} \frac{Z_i}{T_b} \frac{Z_b}{Z_i} \dots\dots\dots(2)$$

Where:

B_{gi} = Initial gas formation volume factor (res bbl/SCF)

p_b = Base pressure (psia)

p_i = Initial reservoir pressure (psia)

T_b = Temperature at base conditions ($^{\circ}$ R)

T_i = Temperature at initial conditions ($^{\circ}$ R)

Z_b = Gas deviation factor at base conditions

Z_i = Gas deviation factor at initial reservoir conditions.

2.1.5 Recovery factor (R.F) : Recovery factor is a number between zero and unity representing the fraction of recoverable oil. It depends on the following factors:

- Current economic circumstances.
- Environmental and ecological considerations.
- Governmental regulations as well as politics.
- Physics of the reservoir-fluid system.

Finally, GIIP can be obtained by using all the parameters in the initial equation. Thus we obtain the estimated reserve of the gas reservoir.

2.2 Material Balance Method

Material balance methods provide a simple, but effective alternative to volumetric methods for estimating not only original gas in place, but also gas reserve at any stage of reservoir depletion. Material balance equation is simply a statement of conservation of mass, or

(Original hydrocarbon mass)–(Produced hydrocarbon mass)=(Remaining hydrocarbon mass)

The general material balance equation reduces to the conventional gas material balance equation as :

$$G \left[B_g - B_{gi} \left\{ 1 - \frac{(c_w S_{wi} + c_f)(p_i - p)}{1 - S_{wi}} \right\} \right] + 5.615 W_e = \bar{G}_p B_g + 5.615 \bar{W}_p B_w \dots\dots\dots(3)$$

Where:

$\bar{G}_p$ = Gas equivalent of the gas and liquid hydrocarbons produced on the surface

$\bar{W}_p$ = Free water from the reservoir

S_{wi} = the initial water saturation

C_w = Compressibility of water (psi^{-1})

P_i = Original mean pressure

P = pressure after producing G_p amount of gas.

G = Original standard cubic feet in free gas zone

B_{gi} = Original gas volume facto

W_e = Cumulative reservoir barrels of water influx into the volume

B_w = Formation volume factor of water

B_g = Formation volume factor of the evolved solution gas.

W_p = Cumulative barrels of water produced

G_p = Cumulative SCF of gas produced

2.2.1 Without Water Influx : If there is no external energy from other sources, such as aquifer is applied, the reservoir is considered as completely enclosed. If $W_p = 0$; $W_e = 0$ and $HCPV = \text{constant}$, then the equation (3) reduces to:

$$\frac{p}{Z} = \left[\frac{p_i}{Z_i} - \frac{p_i}{Z_i} \frac{G_p}{G} \right] \dots\dots(4)$$

This equation is applicable for:

- Constant reservoir temperature
- No phase change in the reservoir
- No water influx
- No rock compaction
- No connate water expansion.

From equation (4) a plot of p/Z vs. G_p can be found.

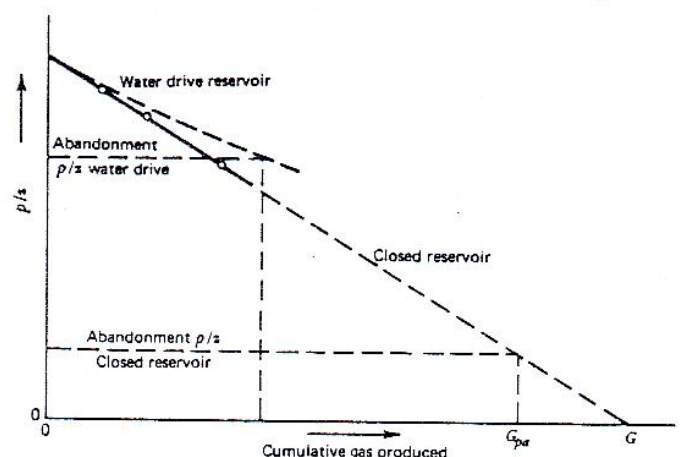


Figure 2: p/z vs G_p curve

2.2.2 With water influx

If there is a water drive in the reservoir, then the pore volume is reduced by the amount equal to the volume of encroaching water. Now, considering water influx, equation (3) becomes:

$$GB_{gi} = (G - G_p)B_g + W_e - W_pB_w \dots(5)$$

Now, using production data we can use equation (4) or (5) to determine the amount of gas remaining $(G - G_p)$ in the reservoir.

2.3 Decline Curve Analysis

The production rate of wells, or groups of wells, generally declines with time. An empirical formula can sometimes be found that fits the observed data so well that it seems rather safe to use the formula to estimate future relationships.

In most case the production will decline at a decreasing rate, that is, dq/dt will decrease with time. The figure below shows an identical curve. The $t = 0$ point can be chosen arbitrarily. q is the gas production rate and t is time. The area under the curve between the times t_1 and t_2 is a measure of the cumulative production during this time period since

$$G_p = \int_{t_1}^{t_2} q \, dt \dots\dots(6)$$

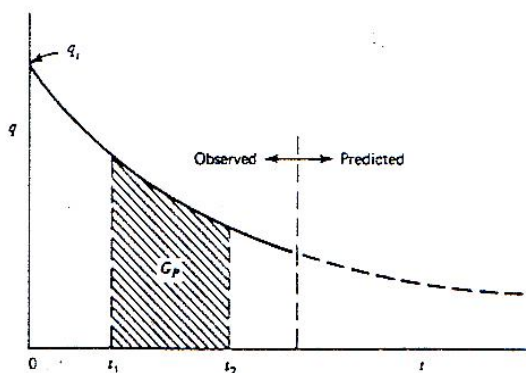


Figure 3: production rate vs time

There are three commonly recognized types of decline curves. Each of these has a separate mathematical form that is related to the second factor, which characterizes a decline curve, that is, the curvature. These types are referred to as:

1. Constant-percentage or exponential decline.
2. Hyperbolic decline.
3. Harmonic decline.

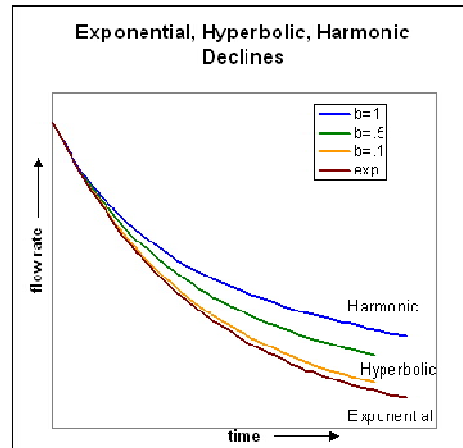


Figure 4 Exponential, Hyperbolic and Harmonic Decline Curve

2.3.1 Exponential Decline:

In the exponential decline, the well's production data plots as a straight line on a semilog paper. The equation of the straight line on the semilog paper is given by:

$$q = q_i e^{-Dt} \dots\dots(7)$$

Where:

q = well's production rate at time t , SCF/day
 q_i = well's production rate at time 0, SCF/day
 D = nominal exponential decline rate, 1/day
 t = time, day

2.3.2 Hyperbolic Decline:

Alternatively, if the well's production data plotted on a semilog paper concaves upward, then it is modeled with a hyperbolic decline. The equation of the hyperbolic decline is given by:

$$q = q_i (1 + bDt)^{-1/b} \dots\dots(8)$$

Where:

q = well's production rate at time t , SCF/day
 q_i = well's production rate at time 0, SCF/day

D_i = initial nominal exponential decline rate (t = 0), 1/day
 b = hyperbolic exponent
 t = time, day

2.3.3 Harmonic Decline :

A special case of the hyperbolic decline is known as “*harmonic decline*”, where b is taken to be equal to 1.

$$q = q_i (1 + D_i t)^{-1} \dots \dots \dots (9)$$

Where:

q = well's production rate at time t, SCF/day
 q_i = well's production rate at time 0, SCF/day
 D_i = initial nominal exponential decline rate (t = 0), 1/day
 b = hyperbolic exponent=1
 t = time, day

Decline curve relationships are empirical, and rely on uniform, lengthy production periods. Decline curves are the most common means of forecasting production. They have many advantages such as:

- a) Data is easy to obtain,
- b) They are easy to plot,
- c) They yield results on a time basis, and
- d) They are easy to analyze

3. CONCLUSION

Reserve estimation is very important for a reserve to make decisions. Estimation provides the confidence about economical feasibility to produce from a reservoir; whether it is cost worthy or not. Here only a few common methods for dry gas reservoirs are discussed. Other methods like analogy, reservoir simulation are also used to estimate the reserve. Wet gas reservoirs and oil reservoirs can also be estimated by modified version of above methods. It should be noted that the total amount reserve may vary with respect to time due to accumulation or migration of gas. So reserve estimation should be done in a regular basis to have clear idea on current reserve.

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Comparable Analysis of Engineering Properties between Crushed Hardrock dust of Maddhyapara Granite Mine, Dinajpur and Natural Sand

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This paper reports the experimental study undertaken to investigate some engineering properties of crushed hardrock dust of Maddhyapara Granite Mine (MGM), Dinajpur and natural sand. Engineering properties of these two materials have been compared to draw a conclusion for whether crushed hardrock dust can be used as an alternative of sand in construction work. The properties that were determined are fineness modulus, bulk Specific gravity, apparent specific gravity, absorption capacity, unit weight, percentage of voids and relative density. Results obtained indicate that all these properties have higher values for crushed hardrock dust of MGM than for natural sand. This has the effect of making the crushed hardrock dust relatively stronger fine aggregate than natural sand.

Key words: Crushed hardrock dust; Sand; Engineering Properties

1. INTRODUCTION

Aggregates occupy 65 to 80% of the total volume of concrete and affect the fresh and hardened properties of concrete. In this paper, the focus will be placed on the characteristics of fine aggregate. Out of the total composition of aggregate, the fine aggregate consumes around 20 to 30% of the volume [2, 3]. Due to increase of construction activity, natural sand is becoming difficult to get and costly. The shortage of the resources of natural sand has opened the possibility for the use of quarry dust. Quarry dusts are by-product produced as a result of the aggregate crushing and production process. The utilization of by-products obtained as waste materials will be pronounced advantageous in the aspects of reduction in environmental load and waste management cost, reduction concrete production cost and enhancement in some properties of concrete.

Crushed hardrock dust is produced from the production and crushing processes during quarrying activities in Maddhyapara Granite Mine. The handling and disposal of these crushed hardrock are some of the major problems facing the Mine. Now crushed hardrock dust is being used as fly ash in cement industry. But this does not consume

sufficient amount of crushed hardrock dust produced in the mine. No research has been conducted to study the engineering properties of these crushed hardrock dust and the suitability of those properties to enable the crushed hardrock dust to be utilized in concrete mixes. The present study is an experimental study which attempts to investigate some engineering properties of crushed hardrock dust of MGM and natural sand and compare the properties of these two materials. Finally, a comparison between the crushed hardrock dust and natural sand will help out to draw a piece of advice for whether crushed hardrock dust can be used as an alternative of sand.

2. OBJECTIVES

The objectives of the study are to determine some engineering properties of crushed hardrock dust of MGM and natural sand and to discuss the suitability of these crushed hardrock dust as alternative material for sand in construction work.

3. METHODOLOGY

The properties of crushed hardrock dust and natural sand that were determined for this study are fineness modulus, bulk Specific gravity, apparent

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specific gravity, absorption capacity, unit weight, percentage of voids and relative density.

3.1 Fineness Modulus

Fineness modulus was determined based on ASTM C 33 [4].

3.2 Bulk Specific Gravity

The Bulk Specific Gravity (BSG) was obtained based on the ASTM C 128 [4]. The principle by which this parameter is determined is the following. The material is placed in an oven for 24 hours at 100⁰ C to drive off all absorbed moisture and then cooled to room temperature. The weight of the oven-dry material is measured. The material is then submerged in water for 24 hours and then taken to a Saturated Surface Dry (SSD) condition. At this point the weight of a picnometer filled with water should be known and a known weight of the material in SSD condition should then be placed in the picnometer. The weight of the picnometer with the SSD material and the water should be recorded in order to obtain the value of the volume of water displaced by the SSD material. The weight of the material in SSD condition divided by the volume of water that the SSD material displaces is the BSG in the SSD basis and the weight of the material in dry condition divided by the volume of water that the material displaces is the BSG in the oven-dry (O-D) basis.

3.3 Apparent Specific Gravity

The measurement of the Apparent Specific Gravity (ASG) is same as that of BSG except the weight of the picnometer with the oven-dry material and the water should be recorded in order to obtain the value of the volume of water displaced by the oven-dry material. The weight of the material in oven-dry condition divided by the volume of water that the oven-dry material displaces is the ASG.

3.4 Absorption Capacity

The absorption capacity (AC) of the material is obtained from a sample in SSD condition. When the material is in SSD condition a known weight of the sample is placed in the oven for 24 hours at 100⁰C. The weight difference as a percentage of the dry material is the absorption capacity.

3.5 Unit Weight

The test is performed in a container of known volume. The container is filled with oven-dried aggregates, in three layers of equal volume. Each layer is rodded 25 times and the top layer is then leveled off. The weight of the container plus its contents and the mass of the container alone were measured. The weight of the dry material divided by the volume of the container is known as the unit

weight on a dry basis. The bulk density on a SSD basis is calculated taking into account the absorption capacity of the material as described by ASTM C 128.

3.6 Percentage of Voids

The percentage of voids in the aggregate was determined from the unit weight and bulk specific gravity (oven-dry basis) using the formula,
$$\% \text{ voids} = 100[(S*W)-M]/(S*W)$$

Where,

M = unit weight of the aggregate

S = bulk specific gravity (oven-dry basis)

W = unit weight of water

4. RESULTS AND DISCUSSION

4.1 Gradation and Sieve analysis

The aggregate gradation plays an important role on the fresh concrete properties. The sieve analysis of an aggregate gives a percentage of the material passing through an opening of a certain size. A representative sample tested will give the characteristics of the total amount of the aggregate to be used.

From the sieve analysis of the fine aggregate a characteristic curve for the material and a number, known as the fineness modulus, will be obtained as described by ASTM C-33. The gradation curve will show the tendency of the material to be fine, coarse or deficient in a certain particle sizes [3]. The fineness modulus is a number represented by the sum of the cumulative percentages retained on the ASTM standard sieves number 4, 8, 16, 30, 50 and 100. It is important to mention that the fineness modulus is not unique to a single gradation curve, i.e., the same fineness modulus could be obtained from different gradations. The fineness modulus by itself does not represent a gradation but its value can be used for the concrete mix design as stated in the ACI procedure. In figure 1, the gradations of the natural Sand and crushed hardrock dust of MGM are shown.

The natural Sand remains below the coarse limit before the sieve number 100. From sieve number 100 to sieve number 50 it remains in the middle of the fine and coarse limits established by ASTM. After sieve number 50 the natural Sand moves towards the finer limit and then crosses the finer limit established by ASTM. After sieve number 30 it remains above the finer limit.

The crushed hardrock dust of MGM remains above the finer limit from sieve number 200 to sieve number 50. After sieve number 50 it remains close to the coarse limit established by ASTM. However

after the sieve number 8 it moves towards the finer limit.

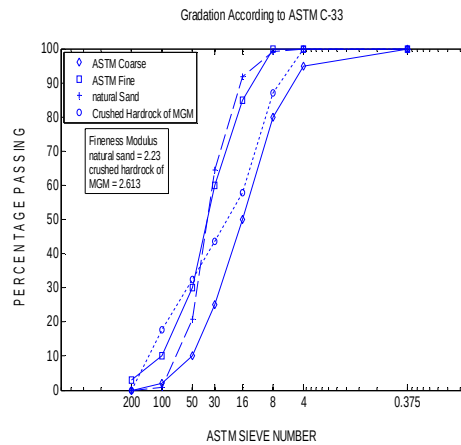


Fig. 1: Gradations of natural sand and crushed hardrock dust of MGM according to ASTM C-33

The amount of fines, percentage passing the #200 sieve, for both of the materials is 0 percent. ASTM recommends the amount passing the #200 sieve for a concrete pavement application should be between 1 and 3% as long as the material does not contain organic or deleterious impurities. Concrete mixes containing greater than 3% passing the #200 have exhibited diminished wearing resistance. It is important to mention that ASTM only gives recommendations and the gradations should fit the purpose of the project for which they will be used.

The Fineness Modulus (FM) of the crushed hardrock dust of MGM is higher than that of the natural Sand. So the crushed hardrock dust of MGM is coarser than natural Sand.

4.2 Bulk Specific Gravity, Apparent Specific Gravity, Absorption Capacity, Unit weight, Percentage of voids and Relative density

Aggregate generally contain pore, both permeable and impermeable, for which specific gravity has to be carefully defined. With this specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required in calculating the compacting factor in connection with the workability measurements.

Bulk specific gravity is defined as the ratio of the weight of the aggregate (oven-dry or saturated surface dry) to the weight of water occupying a volume equal to that of the solid excluding the

impermeable pores. This is used for 1) calculation of the volume occupied by the aggregate in various mixtures containing aggregate on an absolute volume basis, 2) the computation of voids in aggregate and 3) the determination of moisture in aggregate.

Apparent specific gravity is the ratio of the weight of the aggregate dried at oven at 100 to 110°C (212 to 230°F) for 24 hours to the weight of water occupying a volume equal to that of the solid including the impermeable pores. This pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles that is accessible to water.

Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition. For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture can be determined by deducting the absorption from the total moisture content. The absorption capacity is also used to make moisture corrections in order to maintain a consistent water/cement ratio between concrete mixes.

Bulk specific gravity, apparent specific gravity, absorption capacity, unit weight, percentage of voids and relative density of crushed hardrock dust of MGM and natural sand are shown in table 1.

Table 1. Some engineering properties of crushed hardrock dust of MGM and natural sand

Properties	Crushed hardrock dust of MGM	Natural sand
BSG (SSD Basis)	3.05	2.56
BSG (O-D Basis)	3.04	2.5
ASG	3.08	2.67
AC (%)	2.96	2.56
Unit Weight (KN/m ³)	16.26	15.38
Relative Density (%)	50.29	34.81
% Voids	45.38	37.15

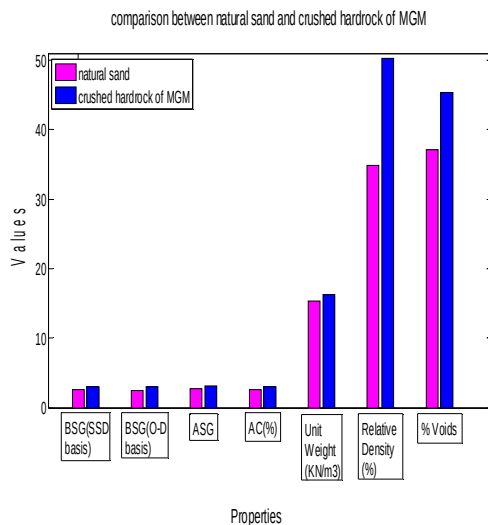


Fig. 2: Comparison of some engineering properties between crushed hardrock dust of MGM and natural sand

When compared to the natural sand, the crushed hardrock dust used in this study exhibited higher bulk specific gravity, higher apparent specific gravity and also higher absorption capacity. It can be mentioned that there are no direct relationship between these properties and the strength and durability of concrete, but they might have minimal effects to the bond strength between cement paste and aggregate.

The crushed hardrock dust of MGM has higher value for unit weight, relative density and percentage voids than the natural Sand. It is noticeable that both unit weight and percentage of voids of the crushed hardrock dust are larger than those of the Sand. Since the void content of the crushed hardrock dust of MGM is higher, there is a need for more paste to fill the voids.

There is a noticeable difference between the particle shape and the surface characteristics of the crushed hardrock dust of MGM and natural sand. The sand particles are more rounded and smooth which is why the void content was measured lower than the crushed hardrock dust. The crushed hardrock dust has a more angular shape and micro roughness is revealed on the surface of the particles.

The increased angularity and void content will also increase the water demand for a mix to obtain the same lump, but the mechanical properties of the material do not seem to be effected [1].

5. CONCLUSIONS

Based on the results and discussion mentioned above, the following conclusion can be derived:

The crushed hardrock dust of MGM is a relatively stronger fine aggregate when compared to the natural sand used in this study. Consequently, crushed hardrock dust if used as fine aggregate in concrete will increase strength of concrete. Thus, crushed hardrock dust of MGM can be used as alternative of sand in concrete.

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**ENGINEERING CLASSIFICATION OF SHARI GHAT RIVER BED SAND AND
PROSPECT OF IT'S UTILIZATION IN DIFFERENT CONSTRUCTION SECTORS**

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ABSTRACT

Sand is a natural resource can be used as an engineering material which plays an important role in engineering constructions. Generally sand is used as a fine aggregate in mortar, plaster, concrete and finishing works. It also used for filling under floor, basements. Sand should be pure silica (SiO_2), but all types of sand are not suitable for such work. From this point of view, the present study assesses some engineering properties for understanding their suitability for construction works. The properties such as Fineness Modulus (FM), Specific Gravity, Silt & Clay content and Compressive Strength have been estimated in laboratory and the results revealed that the sand is best for mortar and concrete work and suitable for plastering and finishing work. Results also suggest that this sand can be used for filling up the roads and brick soling gap area.

Keywords: River Bed Sand, Fineness Modulus (FM), Specific Gravity, Compressive Strength, Utilization.

1. INTRODUCTION

Sand deposits are located mostly in the Sylhet area in Bangladesh. The studied area belonging to the Jaintapur Thana in Sylhet district that about 45 km NNE direction of Sylhet town and is also about 189 km NNE of Dhaka. Shari river is located about 7 km from Jaintapur Thana parishad in the east direction.

In the Shari river bed, vast amount of Sands will be deposited. This type of sands will be used in different construction sectors without any assessment.

This studies aim that, proper utilization of sands in different construction sectors.

Natural sand is available from local river beds or pits. An examination should be made on the fineness of the available sands. Based on this fineness, it should be considered to be used for the different sectors of construction. Sand is a loose, fragmented, naturally occurring material

consisting of very small particles (fine to medium sized particles between 2 mm & 0.06 mm) of decomposed rocks, corals, or shells. In concreting work it is usually termed as fine aggregate.

Sand is form of silica (SiO_2) and may be of argillaceous, siliceous or calcareous according to its composition. Sand is usually obtained from pits, shores, river beds, & seas. It mainly three kinds of sands in use: Pit Sand, River bed Sand & Sea Sand. Sand should be of pure Silica (SiO_2). It should free from clay, silt, organic matter, shells & salts. Very good variety of sand is available in the districts of Dhaka, Mymensingh, Sylhet.

Sand is available here and there, but all sand is not suitable for every sand related work. In this study, it is aimed that which sand are suitable for which purpose. It is preferable that sand should be washed before use in all engineering construction.

2. METHODS

In order to conduct this study steps like field observation, sample collection, analysis and laboratory test etc measures are considered. Methods for this investigation are composed of the following activities:

2.1 Sample Collection

Sample was collected from Shari Ghat river of Jaintapur. Disturbed samples are taken from river bed. After collecting the sample we perform various tests. For performing test, samples should have normal condition. As samples are collected the source, so it was not ready for test. At first it dried in room temperature for one week.

Fineness Modulus (FM) gets from an equation,

$$FM = \frac{[\text{Cumulative \% retained on standard ASTM sieves No. 4, 8, 16, 30, 50, 100}]}{100}$$

b) Specific Gravity of Sand

Specific gravity of the sand is defined as the ratio of the mass of a given volume of sands to the mass of an equal volume of water at 4°C. The specific gravity of sand is 2.65 – 2.68. The

Calculate the specific gravity of the sands using the following formula;

$$\text{Specific gravity of sand, } G_s = \frac{G_T * W_O}{W_O - (W_B - W_A)}$$

c) Compressive Strength Test

Two types of test specimens are used in our country. This test methods covers determination of the compressive strength of Portland cement mortars, using 50 mm cube specimens. For making mortar sample same ratios are maintain for all type of sand particles and the ratios are water: cement: sand = 0.485: 1: 2.75 as a standard value but sometimes additional amount of water was applied to make the paste workable, shown in figure 2.3.

2.2 Laboratory Test

a) Sieve Analysis of Sand

Sieve analysis is one of the oldest methods of size analysis and is accomplished by passing a known weight of sample material successively through fine sieve to determine the percentage weight in each size fraction (shown in figure 2.1)

This test was performed to determine the percentage of different grain sizes within sands. Fineness Modulus (FM) is factor which is computed using the sieve analysis results. Lower FM indicates fine particle and Higher FM indicates coarse size particle

specific gravity is generally two types. Determine the specific gravity by Pycnometer method, shown in figure 2.2 Specific gravity depends on temperature so it has to be measured.

Where,

W_O = Mass of dry sample (sand) (gm)

W_A = Mass of empty clean pycnometer+ water (gm),

W_B = Mass of empty clean pycnometer+dry sand+ water (gm),

G_T = Specific gravity of water at temperature $T^\circ\text{C}$,

Temperature, $T^\circ\text{C} = 28$

The mortar sample is prepared following the standard procedure and released from the mould. It is placed at a bucket for curing then after the specific duration the mortar is taken out from the bucket and waited for half an hour for removing water and tested by the compression testing machine, shown in figure 3.4. The obtained result is analyzed and then discussion is prepared depending on the result obtained and field observant

3. RESULTS AND DISCUSSION

3.1 Fineness Modulus of Shari Ghat River Bed Sand

Fineness Modulus of **fine** aggregate is given tabulated form

Table 3.1: Fineness Modulus of *fine* aggregate

Sieve size	Standard Opening (mm)	Material retained (gm)	Percent of material retained (%)	Cumulative Percent Retained (%)	Percent finer	Fineness Modulus (FM)
No.4	4.75	0	0.0	0.0	100.0	1.28
No.8	2.36	1	0.1	0.1	99.9	
No.16	1.18	10	1.0	1.1	98.9	
No.30	0.60	38	3.8	4.9	95.1	
No.50	0.30	191	19.1	24.0	76.0	
No.100	0.15	743	74.3	98.3	1.7	
No.200	0.075	12	1.2	99.5	0.5	
Pan		5	0.5	100.0	0.0	
Total		1000				

Fineness Modulus (FM); $FM = \frac{0+1+1.1+4.9+24+98.3}{100} = 1.28$

From percent finer (%) and sieve size can draw particle size distribution curve or gradation curve of fine sand, shown in figure 3.1

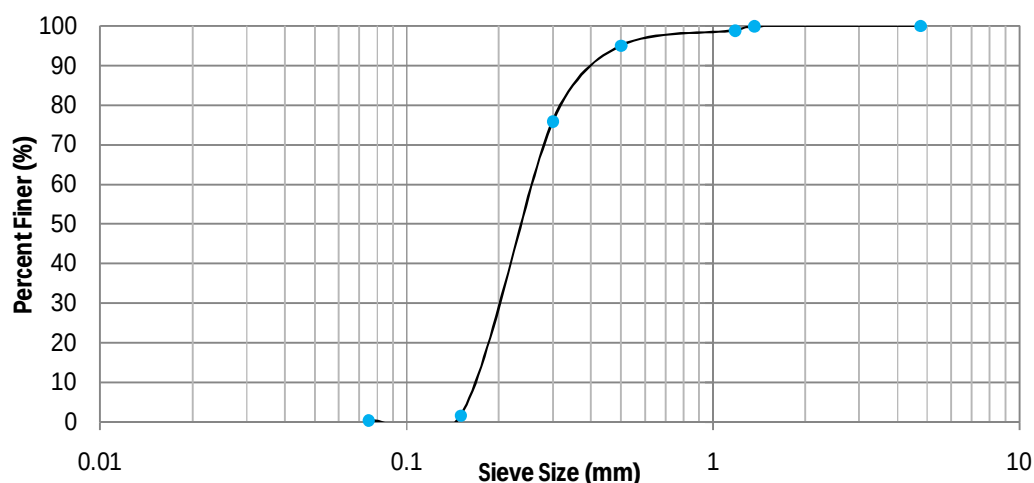


Figure 3.1: Gradation Curve of Shari Ghat River Sand (*Fine*)

Fineness Modulus of *medium* aggregate is given tabulated form

Table 3.2: Fineness Modulus of *medium* aggregate

Sieve size	Standard Opening (mm)	Material retained (gm)	Percent of material retained (%)	Cumulative Percent Retained (%)	Percent finer	Fineness Modulus (FM)
No.4	4.75	11	1.1	1.1	98.9	2.94
No.8	2.36	31	3.1	4.2	95.8	
No.16	1.18	284	28.4	32.6	67.4	
No.30	0.60	354	35.4	68.0	32.0	
No.50	0.30	205	20.5	88.5	11.5	
No.100	0.15	111	11.1	99.6	0.4	
No.200	0.075	3	0.3	99.9	0.1	
Pan		1	0.1	100.0	0.0	
Total		1000				

$$\text{Fineness Modulus (FM); FM} = \frac{1.1+4.2+32.6+68+88.5+99.6}{100} = 2.94$$

From percent finer (%) and sieve size can draw particle size distribution curve or gradation curve of medium sand, shown in figure 3.2

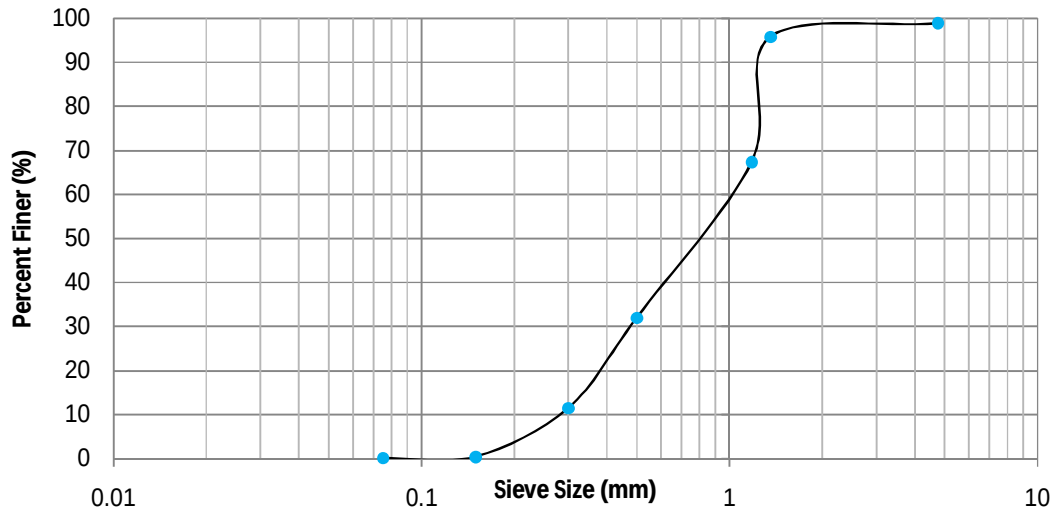


Figure 3.2: Gradation Curve of Shari Ghat River Sand (*Medium*)

From the experiment, Fineness Modulus of fine aggregate is **1.28** and Fineness Modulus of medium aggregate is **2.94**. The Fineness Modulus (FM) range (1.24 – 2.94) of shari Ghat river bed sand is nearly similar to the FM range (2.0 – 2.6)

of other area's sand of Sylhet. The Fineness Modulus (FM) range of shari Ghat river bed sand compared with the different area in Bangladesh as tabulated form in *table 3.3*

From the Gradation Curve, it is observed that this sand is not well graded and there is a gap grade between #4 to #100 sieve. In this sand all particle are similar size.

Table 3.3: Compare of Fineness Modulus

Location of Availability	F.M. (Range)
Sylhet area	2.0 – 2.6
Dhaka area	1.2 – 1.6
Comilla area	1.3 – 1.5
Mymensingh area	1.5 – 1.8
Khulna area	1.2 – 1.5
Bogra area	1.3 – 1.4
Shari Ghat River	1.24 – 2.94

3.2 Specific Gravity of Sand

Specific Gravity of Fine aggregate

$$G_s = \frac{G_T * W_o}{W_o - (W_B - W_A)} = 2.84$$

Specific gravity of **Fine** sand at 28°C is tabulated bellow:

Table 3.4: Specific gravity of **Fine** sand

Observation No	W_p (gm)	W_o (gm)	W_{ps} (gm)	W_A (gm)	W_B (gm)	G_T (gm)	G_s (gm)	Average Value of G_s
1	274	10	284	1265	1271.5	0.9963	2.84	2.88
2	274	10	284	1265	1272	0.9963	3.32	
3	274	10	284	1265	1271	0.9963	2.49	

Specific Gravity of **medium** aggregate,

$$\frac{W_p}{W_o} = 2.49$$

Specific gravity of **Medium** sand at 28°C is tabulated bellow:

Table 3.5: Specific gravity of **Medium** sand

Observation No	W_p (gm)	W_o (gm)	W_{ps} (gm)	W_A (gm)	W_B (gm)	G_T (gm)	G_s (gm)	Average Value of G_s
1	274	10	284	1265	1271	0.9963	2.49	2.51
2	274	10	284	1265	1270.5	0.9963	2.21	
3	274	10	284	1265	1271.5	0.9963	2.84	

The Specific gravity of Fine sand is 2.88 and Specific gravity of Medium sand is 2.51. The Specific gravity of sand decreasing from fine to

medium aggregate. The average specific gravity of Shari Ghat river bed sand is 2.695

3.3 Compressive Strength of Sand-Cement Mortar

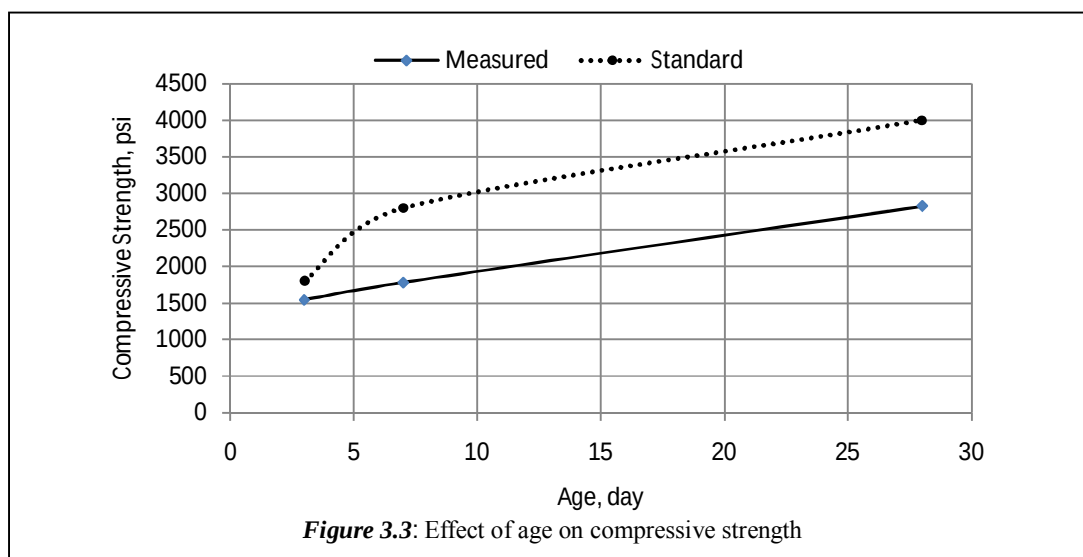
The compressive strength of mortar with increasing curing period is tabulated bellow:

Table 3.6: Compressive Strength of Sand-Cement Mortar

Age (days)	Specimen No.	Specimen area (mm ²)	Compressive Strength (MPa)	Average Value (MPa)
3	1	50 × 50	10.74	10.65
	2	50 × 50	11.18	
	3	50 × 50	10.03	
7	1	50 × 50	12.70	12.28
	2	50 × 50	11.98	
	3	50 × 50	12.18	
28	1	50 × 50	19.42	19.48
	2	50 × 50	21.10	
	3	50 × 50	17.93	

The Experimental compressive strength compared with the standard requirement of minimum compressive strength. The effect of age on compressive strength of sand is shown in figure 3.3 It is shown that, the experimental

compressive strength of sand is substantial deviated from the standard value. This deviation takes place due to impurities of sand, lack of lab facilities, experimental error, Instrumental error and effect of Portland cement and so on.



3.3 Utilization Prospect

This studies aim that, proper utilization of sands in different construction sectors. Sand size between 4.75mm and 0.15mm is called as fine aggregate. It is used for making concrete, mortar and plaster. It is also used for filling under floor, basements. It is also better to use for fill up the roads and brick soling gap area. Natural sand is available from local river beds or pits. An examination should be made on the fineness of

the available sands. Based on this fineness, it should be considered to be used for the different sectors of construction such as plastering and finishing works, Mortar, Concrete & Filling sand. River bed Sand generally contains earthly impurities like gravels, pebbles etc. These impurities should be screened and washed before the sand is used.

4. CONCLUSIONS

It is necessary to use perfect sand for any purpose with due properties. From the study it is evident that fine to medium sand found in Shari Ghat river bed, which is good for plastering and finishing work. It is most suitable for fill up the roads and brick soling gap area. It is also better to use for Mortar and Concrete work. For

stabilization purpose cement can be used as stabilizing agent. For economical purposes the percentage of cement should be used as much strength as required for construction. The compressive strength increases with the curing period.

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FLOWING GAS MATERIAL BALANCE: A CASE STUDY OF TITAS GAS FIELD

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ABSTRACT

Reserve estimation is the most common and important task in evaluating an oil or gas field. Among several methods of reserve estimation, a most recent method namely Flowing Material Balance (FMB) is quick and easy to use in determining the original gas-in-place (OGIP). Traditional material balance plot for gas pools requires fully built-up reservoir pressures, obtained by shutting in the wells. Titas gas field is so far the largest gas field of Bangladesh. It is important to estimate its reserve precisely. Among all other Petrobangla operated fields, Titas gas field lacks of shut-in pressure data records time to time. The estimates obtained in this paper are quite reasonable compared with other estimates done for this field, and hence proving the reliability of FMB analysis as a quick estimating tool.

Key words: Flowing Material Balance, Titas gas field, reserve estimation, original gas-in-place, well interference.

1. INTRODUCTION

The determination of gas reserves is a fundamental calculation in reservoir engineering. Because it is important for the development of a production strategy, design of facilities, contracts and valuation of the reserves. Classically, reserves are estimated in three ways: volumetric, material balance and production decline. It is always commendable to do the estimation with as less data as possible. For traditional material balance, the well would be shut-in at several points along its producing life and let the pressure in the reservoir to stabilize. Then the average reservoir pressure is obtained for each point from a properly conducted buildup test and interpretation. The duration of the shut-in is often not long enough to directly measure current average reservoir pressure. As a result, problems with testing and interpretation comprise some of the key causes of erratic pressure data often observed in traditional material balance plots. But in FMB there is no need to shutting in the well. Also it requires less data to accomplish the estimation than traditional analysis. In this paper FMB is used to estimate reserves of Titas gas field, Bangladesh.

Titas gas field in Brahmanbaria district was discovered in 1962 by Pakistan Shell Oil Company (PSOC) by the exploratory well Titas-1. The gas field is operated by Bangladesh Gas Field Company limited. Following the drilling of three more wells, it

was put into production in 1968. Titas field comprises three major reservoir sands namely: A, B and C. Three wells are producing from the B and C Sands and the rest in A Sands. At present, 15 wells are producing an average rate of about 396MMscf/d. The major objectives of this paper are to determine original gas-in-place (OGIP) of Titas gas field and to verify the strength of Flowing Gas Material Balance as a reserve estimation tool.

2. METHODS

2.1. Flowing Material Balance

The Flowing Material Balance (FMB) uses the concept of stabilized or "pseudo-steady-state" flow to evaluate total in-place fluid volumes. In a conventional material-balance calculation, reservoir pressure is measured or extrapolated based on stabilized shut-in pressures at the well. In a flowing situation, the average reservoir pressure clearly cannot be measured. However, in a stabilized flow situation, there is very close connectivity between well flowing pressures (which can be measured) and the average reservoir pressure. Fig. 1 shows how these pressures are related.

The figure illustrates that the pressure drop measured at the wellbore while the well is flowing at a constant rate is the same as the pressure drop that would be observed anywhere in the reservoir,

including the location which represents average reservoir pressure. This is true only if pseudo-steady-state conditions are present (all boundaries have been reached).

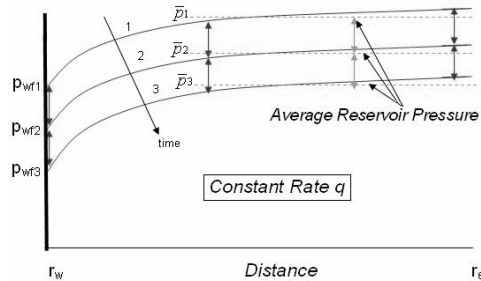


Fig. 1: Pseudo-steady state condition showing constant pressure drop. (After L. Matter and R. McNeil)

2.1.1. Constant Rate Flowing P/Z Plot for Gas:

The p/z plot is a very useful tool for estimating Original Gas in Place of gas reservoirs. The conventional p/z plot uses the extrapolated straight-line trend of measured shut-in pressures (for gas reservoirs) to predict OGIP. The same can be done with flowing pressures, provided that the pseudo-steady-state assumption is valid (i.e., constant rate boundary-dominated flow). Fig. 2 shows how this is done.

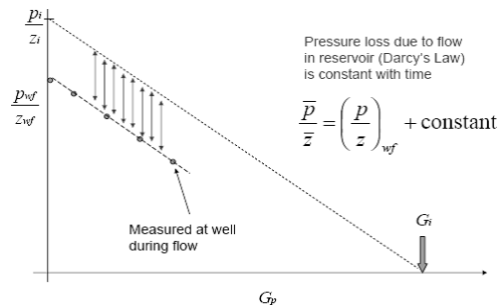


Fig. 2: The Flowing P/Z Plot-Constant Rate Production. (After L. Matter and R. McNeil)

The above analysis is (Fig. 2) created by plotting measured flowing pressures (as p/z points) on a graph vs. produced gas. The slope of the resulting line of best fit should be the same as the slope of the conventional p/z line. Thus, the existing line needs only to be "shifted" upwards so that it falls through the initial p/z point. The equation that describes this graphical procedure is as follows:

(1)

Where,

= gas pseudo-pressure (which can be converted to p/z)

p_{wf} = Pseudo gas bottom hole pressure
 q = Gas flow rate

(2)

Where,

T = Formation temperature
 k = Formation Permeability
 h = Net thickness
 r_e = Reservoir radius
 r_{wa} = Adjusted wellbore radius

represents the pressure loss due to the steady-state inflow of gas, and is assumed to be constant over time. The above definition applies to a vertical well in the center of a circular reservoir.

Thus, for a constant rate system, equation (1) suggests a constant difference between average reservoir p/z and flowing p/z.

2.1.2. Variable Rate Flowing P/Z Plot:

Unfortunately most gas wells do not have extended periods of constant rate production. It is for general gas production (variable rate/variable pressure) profiles that we require a reliable flowing p/z plot. This can be accomplished with only a slight modification to the constant rate flowing p/z analysis.

For a variable rate system, equation (1) clearly shows that the difference between reservoir p/z and flowing p/z is not constant, but a function of flow rate. Since the flow rate is known, we need only to determine the value of b_{pss} , using some independent method. Note that the value of b_{pss} did not have to be explicitly determined for the constant rate case because the total value of " $q b_{pss}$ " (the product of flow rate and b_{pss}) is determined graphically.

One way to obtain a reliable estimate of b_{pss} is to plot the production and flowing pressure data in the following manner (Fig. 3).

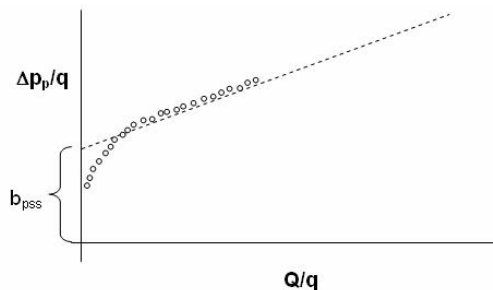


Fig. 3: b_{pss} estimation for variable plot.

The straight-line portion of this graph represents boundary dominated flow, and the y-intercept is b_{pss} . This value of b_{pss} may then be used in equation (1) to calculate the average reservoir pressure. Note that the value of b_{pss} is always subject to interpretation as it depends on proper identification of the stabilized (straight-line) section of the above graph.

2.1.3. Modified Agarwal-Gardner Analysis: An alternative to the flowing p/z plot is the Normalized Rate/Normalized Cumulative analysis. The normalized rate approach applies to both oil and gas reservoirs, and works for constant or variable rate systems. Its advantage is its flexibility and ease of use. Its primary drawback is that the resulting analysis plot is not as intuitive as that of the flowing p/z.

The procedure is similar to the pseudo-steady-state approach, but involves plotting the inverse of the pseudo-steady-state equation, so that a declining trend is produced.

The equation developed for gas is,

$$\frac{p}{p_i} = 1 - \frac{C}{p_i} \left(\frac{p_i - p}{p_i} \right) \quad (3)$$

2.1.4. Calculation of Abandonment Pressure:

From the bottomhole flowing pressure at the projected abandonment conditions the abandonment pressure (average reservoir pressure) is calculated as follows:

$$p_a = p_i - \frac{C}{p_i} (p_i - p_a) \quad (4)$$

Where, C = Units conversion constant (1.417e6 for field units)

3. RESULTS AND DISCUSSION

3.1. Single-well Analysis

In this paper FMB analysis for individual wells is done first to show the results would appear if the interference of other wells is not considered. The production data upto May, 2007 is used for the analysis. The pressure data available is the flowing well head pressure which is converted to flowing bottomhole pressure using Gray correlation with appropriate wellbore data. In the analysis it is assumed that the flow is constant rate boundary-dominated. The estimates are shown in Table.1 and some selected corresponding plots are shown in Fig. 4 and Fig. 5.

The plots show the interference of other wells in the well being examined. The lower portion of the data points do not follow the straight line trend showing that the effect of other wells in the vicinity of the well being considered. Thus, the interference effect felt for another producing well should be considered to avoid overestimation or underestimation of OGIP from material balance methods.

The analysis shows that the total reserve at Titas A Sand is 17.08 Tcf and ultimate recovery is 11.96 Tcf for a recovery factor of 70%. The result seems to be overpredictive because the straight lines drawn in Fig. 4 and Fig. 5 to find OGIP have to be forced to follow the initial trend of the data points.

Table. 1: OGIP from single-well analysis.

Well No.	OGIP (Bscf)	Recovery Factor %	Expected Ultimate Recovery (EUR), (Bscf)
Titas-1	4484.16	70	3138.912
Titas-2	2776.48	70	1943.536
Titas-3	1511.92	70	1058.344
Titas-4	1432.43	70	1002.701
Titas-5	1553.04	70	1087.128
Titas-6	989.13	70	692.391
Titas-7	988.72	70	692.104
Titas-11	1326.37	70	928.459
Titas-12	416.22	70	291.354
Titas-13	592.31	70	414.617
Titas-14	511.44	70	358.008
Titas-15	235.52	70	164.864
Titas-16	264.82	70	185.374
Total	17082.56		11957.79

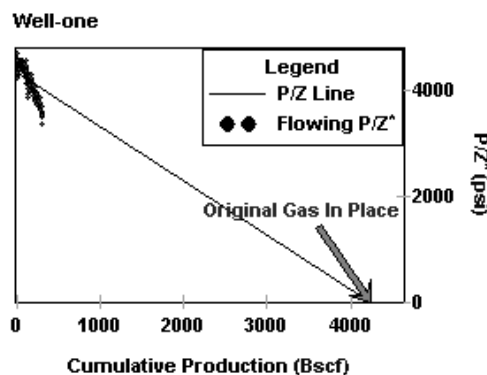


Fig. 4: OGIP of Titas-1 (single well analysis).

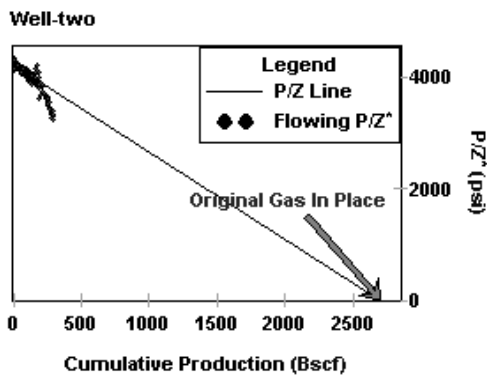


Fig. 5: OGIP of Titas-2 (single well analysis).

3.2. Multi-well Analysis

Multi-well FMB analysis is done to consider the interference of all wells to the older one. As Titas-1 & Titas-2 both started production at about same time these wells are considered for multi-well analysis. The estimates are shown in Table. 2 and the corresponding plots are shown in Fig. 6 and Fig. 7

Beside the calculation by graphical FMB, Modified Agarwal-Gardner analysis is also used to estimate OGIP. The plots shows quite scattered data points as stated as its primary drawback, but it still can be used with a best fit line through the data points. Both methods give same result.

In this paper the abandonment average pressure is also predicted assuming the abandonment flow rate of 1 MMscfd. The result is included in Table. 2.

For analysis with Titas-1 the OGIP is 8.22 Tcf and Ultimate Recovery is 5.76 Tcf for a Recovery Factor of 70%. From analysis of Titas-2 the OGIP is 12.9 Tcf and Ultimate Recovery is 9.05 Tcf for a Recovery Factor of 70%.

Table-2: OGIP from multi-well analysis.

Well No.	OGIP (Bscf)	Expected Ultimate Recovery (EUR), (Bscf)	Abandonment Pressure, P_{ab} (Psia)
Titas-1	8223.27	5756.29	864.4
Titas-2	12922.2	9045.567	840.5

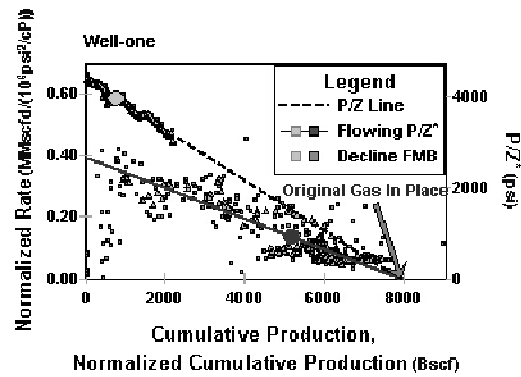


Fig. 6: OGIP from Titas-1 (multi-well analysis).

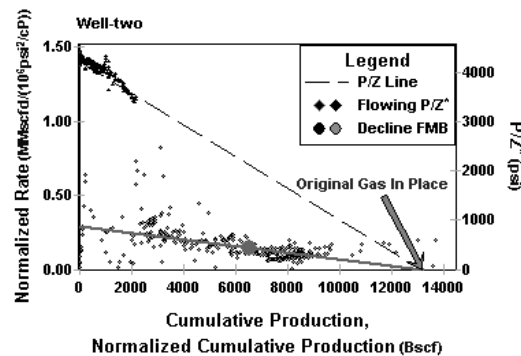


Fig. 7: OGIP from Titas-2 (multi-well analysis).

The results obtained from above analysis shows quite reasonable estimate of gas reserves at Titas Gas Field. Different estimates obtained from multi-well analysis (OGIP- 8.22 Tcf from Titas-1 and 12.9 Tcf from Titas-2) are due to the difference in pressure decline trend of different wells (Titas-1 & Titas-2). This is due to the heterogeneity of reservoir which indicates that a rigorous analysis should be done at Titas Gas Field to find actual reserve and ultimate recovery.

The single-well analysis shows quite erroneous result (17.08 Tcf) with respect to other estimates. The discrepancy arises due to the interference of wells in pressure decline trend.

4. CONCLUSION

In normal condition, production wells are not shut down usually. This constraints leads to a problem of accumulating sufficient representative shut-in pressure data calculate OGIP by traditional material balance method. The flowing material balance method presented in this paper is quite reasonable to use in such condition. However, this paper do not deny the importance of regular updating of the reserve estimation using different methods such as-

traditional material balance, type curve analysis and reservoir simulation in accordance with the added information gathered from various aspects of geophysical, geological and production phenomena. But FMB for both single-well and multiple well analyses can be helpful whenever the production data is insufficient to perform other methods with better accuracy.

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FORMATION WATER RESISTIVITY PREDICTION OF TITAS GAS FIELD USING SELF-POTENTIAL LOG DATA, BANGLADESH

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The Titas gas field is the biggest gas field in Bangladesh which lies in the south central part of the Surma Basin. This paper shows how to predict the formation water resistivity from Self-Potential (SP) wireline log data. The formation water resistivity is the most important rock fluid properties for saturation (water or hydrocarbon) estimation, Petrophysical analysis and Formation evaluation in the Petroleum field. The geothermal gradient is 0.937 °F per 100 feet following surface temperature at 77 °F. The average formation temperature is 159.18 °F of A2 gas sand based on log data. The average formation water resistivity is 0.1174 ohm-meter of A2 gas sand based on SP log which implies formation water resistivity value is a slight lesser than the value estimated made by Reservoir Management Project-2 of Petrobangla (2009). This estimated result is reliable for calculating water or hydrocarbon saturation and formation evaluation for A₂ gas sand of Titas gas field.

Key Words: Titas Gas Field; Geothermal Gradient; Formation Temperature; Self-Potential Log; Formation Water Resistivity.

1. INTRODUCTION

The Titas gas field is situated in Brahmanbaria district in the vicinity of Brahmanbaria town about 4 km north of Brahmanbaria town and 96 km ENE of Dhaka which is belonging to the south central part of the Surma Basin, and on the western margin of the Tripura high^[8].

Formation water, sometimes called connate water is the water, uncontaminated by drilling mud that saturates the porous formation rock. The resistivity of this formation water (R_w) is important parameters since it is required for the calculation of saturation (water or hydrocarbon) from basic resistivity logs. There are several sources for formation water resistivity information which includes SP curve, chemical analysis, water catalogs, various resistivity-porosity computations and cross plots^[9].

Interkomp Kanata Management (IKM)^[4] studied about Geological, Geophysical and Petrophysical Analysis of the Titas Gas Field in December, 1991 based on combined evidence of seismic

data, well data and log data. Petrobangla also studied about Petrophysical analysis of Titas gas field based on Petro Log software in 2009, Bangladesh^[7].

2. OBJECTIVES

The objectives of the present study are to predict the formation water resistivity with self-potential (SP) log from field.

3. GEOLOGICAL STRUCTURE

The Titas Field is an elongate asymmetrical anticline with a simple four ways dip closure. The structural trend main axis lies S-N, with a broader northern nose and steeper eastern flank. The structure lies on the western margin of the Chittagong-Tripura folded belt in the south central part of the Surma Basin. The maximum flank dip to the east is 12° and that to the west is 6°. The dip is much gentler in the north-south direction at 3° and indicates stronger compression and uplift. The structure was first mapped by Shell in 1960

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with a single fold seismic grid. No faults were observed from the 2D seismic data over the Titas gas field and its vicinity^[8]. The major gas sand of A-group is A2 sand (Figure-1).

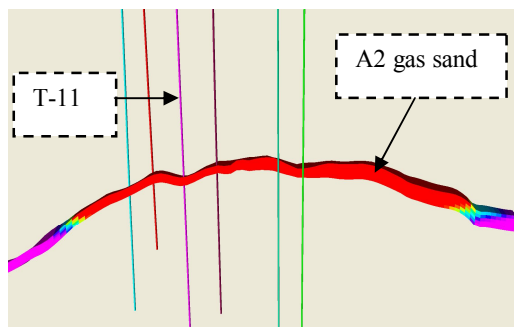


Fig. 1: Cross-sectional view of A2 gas sand (S-N direction) (Source: Reservoir and Data Management Division, Petrobangla).

4. MATERIALS AND METHODOLOGY

The Methodology includes both manual interpretation of the available log data and formula following standard rules and practices used in the oil and gas industry of the world.

There are 16 wells drilled so far in Titas structure but this study selected only one well namely Titas-11 (Fig. 1) because of the availability of all necessary data for calculating formation water resistivity of this field. The available data are Caliper Log, Gamma Ray, SP log, Compensated Neutron and Density logs, Sonic Log and Resistivity Logs.

4.1 Data Quality and Modification

The quality of log data of studied well is good but some of the paper prints are difficult to understand. In well number 11, Caliper log shows borehole caving and washout is absence within sand zone. Mud-cake is so small which is negligible to count at the following depths: 8710-8784 feet and 8792-8904 feet. No environmental corrections have been applied in the value of Gamma Ray and SP logs.

4.2 Geothermal Gradient

Geothermal gradient has been calculated as the following equation^[6]:

$G_g = \left[\frac{(BHT - T_s)}{TD} \right] \times 100$ where BHT is the Bottom Hole Temperature in degree Fahrenheit, T_s is the Surface (ambient) Temperature in degree Fahrenheit and TD is the Total Depth in feet.

4.3 Formation Temperature

Formation Temperature (T_f) has been estimated as the following equation^[11]: $T_f = [T_s + (Gg/100)]$.

4.4 Formation Water Resistivity

Formation water resistivity (R_w) has been calculated using SP log as the following steps^[12]:

Step-1: Estimation of formation temperature (T_f),
Step-2: Converting from Pseudo-Self Potential (PSS) to Static Self Potential (SSP) using SP correction factor,
Step-3: Estimation of R_{weq}/R_{mfeq} from Schlumberger nomograph chart SP-1,
Step-4: Determination of equivalent formation water resistivity (R_{mfeq}) from nomograph,
Step-4: Estimation of R_{weq} from nomograph and
Step-5: Correcting from R_{weq} to R_w at formation temperature from (Schlumberger) chart SP-2.

5. RESULTS OF ANALYZED DATA AND DISCUSSIONS

Petrophysical zonation has been used based on the log responses especially on Gamma Ray log response throughout the A₂ gas sand. Shale and sand zone have been identified with respect to Gamma Ray response and SP shale baseline (well no. 11) from 9300 feet to 9530 feet which indicates SP value is 0 mV. High GR response and positive deflection of SP log from shale base line indicates the shale or clay zone. Also, Low GR response and negative deflection of SP log from shale base line indicates the clean sand and/shale sand zone. The Top and Base of the A₂ gas sand are 8698 ft and 8904 ft respectively at measured depth. The surface temperature (T_s) has been used 77 °F. The Bottom Hole Temperature (BHT) and Total Depth (TD) have been used 77 degree Fahrenheit and 10456 feet, respectively from log header. Geothermal gradient of the studied well is determined and shown in Table-1. From the analysis it is found that well no.11 shows the geothermal gradient of 0.937 °F/100 feet. The formation temperature ranges from 158.58 to 160.05 °F. The equivalent formation water resistivity (R_{weq}) estimated from Schlumberger nomograph chart^[10] SP-1 (Fig.2). Then, formation water resistivity (R_w) calculated from chart SP-2 at formation temperature ranges from 0.09 to 0.118 ohm-m. The average formation water resistivity is 0.1174 ohm-m. A detailed result shows in Table-2.

Table-1: Geothermal gradient and formation temperature of A₂ gas sand.

A2 sand sub-zone	Depth Interval (feet)	Average formation depth, feet	Formation temperature (Tf) °F
1	8698-8710	8704	158.58
2	8710-8732	8721	158.74
3	8732-8784	8758	159.09
4	8792-8800	8796	159.44
5	8818-8904	8861	160.05

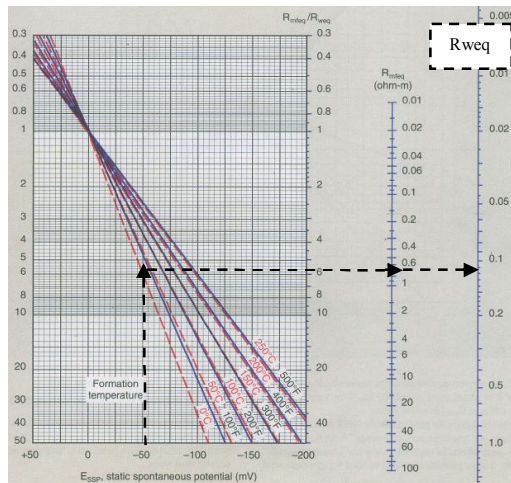


Fig. 2: R_{weq} determination from SSP (mV) (Schlumberger well service chart, 1998)

Table-2: Formation water resistivity (R_w) prediction from SP log at formation temperature.

Sand sub-zone	PSP (mV)	SSP (mV)	Formation resistivity (ohm-m) from nomograph SP-1 and SP-2.		
			R _{mfe} /R _{weq}	R _{weq}	R _w
1	-38	-57	4.9	0.098	0.113
2	-34	-51	4.2	0.084	0.095
3	-39	-58.5	5.1	0.100	0.118
4	-35	-52.5	4.3	0.090	0.111
5	-45	-67.5	6.4	0.132	0.150

Formation water resistivity varies with respect to Self-Potential log responses and formation temperature. In order to convert PSP to SSP, a correction factor 1.5 has been used which values may be changed with respect to invasion diameter and true resistivity correction for sub-zones of A₂ gas sand.

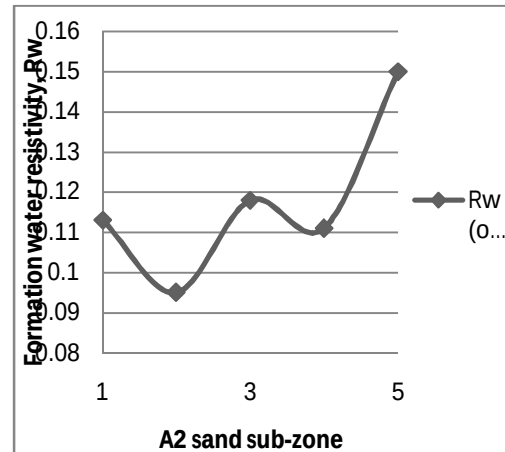


Fig.3: R_w versus A₂ sand sub zones.

By SP method, based on SP responses, the calculated R_w is slightly lower than the Inverse Archie's method (R_{wa})^[5] and estimation made by Reservoir Management Project-2, Petrobangla (2009a)^[7].

6. CONCLUSIONS

The estimated geothermal gradient can be used to calculate the formation temperature at any sub-surface depth in this field. The predicted R_w value is reliable for calculating water or hydrocarbon saturation and formation evaluation for A₂ gas sand of Titas gas field.

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MODELING AND ANALYSING PRESSURE BUILDUP DATA OF KAILASTILLA GAS FIELD (WELL NO. KTL-01 AND KTL-02)

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ABSTRACT

The vertical model simulates the pressure response in a vertical well within a rectangular shaped reservoir with homogeneous characteristics. The main objectives of this work were to estimate the reservoir parameters and construct a classical configuration for a dynamic reservoir system by history matching with a vertical model. For this study a homogeneous, single phase, rectangular shaped gas reservoir with vertical well is selected. At first the pressure transient data is analyzed and reservoir parameters-permeability, skin factor, average pressure, wellbore storage coefficient, reservoir drainage extent are estimated. To estimate these parameters, the deliverability test and buildup test (MBH) are used based on pressure transient data and production data. Then, the estimated parameters are matched by vertical modeling. Finally, type curves are used to validate these parameters.

Key words: Pressure transient test, Vertical modeling, Type curve, Skin factor and wellbore storage, Reservoir configuration.

1. INTRODUCTION

Modeling is the process of history matching pressure transient data based on a mathematical model. In order to optimize a development strategy for an oil or gas field, it is assumed a reservoir model is capable of predicting the dynamic behavior of the field in terms of production rate and fluid recovery. Such a model is constructed using geological, geophysical and well data. The necessary parameters are obtained from direct measurements (cores, cuttings, formation fluid samples, etc.) and from interpreted data (surface seismic, well logs, well tests, PVT analysis, etc.). While seismic data and well logs provide a static description of the reservoir, only well test data reflects information on dynamic reservoir response.

The well test data is therefore a key element in the reservoir model construction.

Interpretation of these data leads to individual "models" (what the geophysicist, the petro-physicist and well analyst think the reservoir looks like). A brief understanding of the fundamental aspects of well test analysis is necessary in order to incorporate dynamic well test data into the reservoir model and it is the job of the reservoir engineer to incorporate these individual models into a cohesive reservoir model. In the initial phase of well tests, pressure measurements are dominated by wellbore storage effects.

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In this paper, a simple model is developed that can explain the measured well test data. The model gives a rather simplified and idealistic view of the reservoir, characterized by:

- Isotropic and homogenous reservoir volume,
- Constant porosity, - absolute permeability, - viscosity and - reservoir height (reservoir thickness)
- Test production with relative small pressure gradients
- Horizontal radial flow paths (no cross flow) and
- Constant flow rate
- Darcy flow

Even though these items place tight restrictions on the reservoir itself, some important information can be extracted from the models, explaining reservoir behavior on basis of the well test data.

There are many different models available to match the data depending on the situation. Thus, it is important to analyze the pressure transient data before modeling because it forces the analyst to think about the probable reservoir configurations and provides good estimates of reservoir parameters. Models are not unique (different model types can match the same set of data) and, as a result, it is essential that the choice of model type occur after the analysis step. The values of parameter obtained during the analysis step provide a good starting point for an appropriately chosen model type. Parameters can then be optimized by automatic parameter estimation (APE). Before using the APE method, irrelevant data should be removed from the data set to for efficient matching.

2. OBJECTIVES OF THE STUDY

The objectives of this study are to analyze the well test data available for well KTL-01 and, KTL-02, to estimate the following parameters and finally these estimated parameters are matched by vertical modeling.

- The formation permeability
- The skin effect
- Average reservoir pressure
- Wellbore storage effects

- Reservoir areal extents

3. METHODOLOGIES AND STUDY PROCEDURES

There are several methods may be used to estimate these parameters. The pressure build-up test, type curve analysis, Dietz_MBH method and vertical modeling are used to complete this study. Permeability and skin due to damage are estimated by build-up test of radial analysis by developing semi log and derivative type curves. These values of parameters are used as input parameters for Dietz_MBH method. After entering these parameters into “FEKETE software” the Dietz_MBH method gives the output values of reservoir areal extents and these areal extents again used as input parameters for Dietz_MBH method and finally the average reservoir pressure is estimated. The estimated parameters are used as input parameters for vertical modeling. Vertical model gives the output of all parameters on the basis of extrapolated pressure those are found by conventional analysis with dimensionless wellbore storage coefficient.

4. RESULTS AND DISCUSSIONS

From Table 1 and Table 2, it is obtained that the total skin effect ($\bar{S}$) are negative for both well KTL-01 and well KTL-02. But it is tough to conclude that the wells are stimulated as all the skin components have not been analyzed here.

The average reservoir pressure, P_{avg} (3499.3psia) from Dietz_MBH analysis for KTL-01 in Table-1 is closer to initial reservoir pressure indicates the test duration was small. But in case of KTL-02, the average reservoir pressure is greater than the initial reservoir pressure. This may be the error at the time of data recording. The areal extents indicate the reservoir is rectangular which is consistent with assumption. The results are tabulated here from pressure semi log plots, pressure derivative type curve and dimensionless type curve. The resultant values of a specific parameter obtained from all analysis methods are same. For this reason, the

specific method has not mentioned in table containing results.

Extrapolated pressures were found $P^* = 3503.8$ psia for KTL-01 and $P^* = 3223.8$ psia for KTL-02 against the actual shut in pressure 3499.29 psia and 3222.37 psia respectively.

Though, all the estimated parameters are well matched with actual reservoir pressures but the quality of vertical model prediction deviates. It occurs very often as all of the models are developed theoretically. Therefore, it is better to avoid vertical model to predict the reservoir parameters. Other perturbing influences that may cause measured pressure data to deviate significantly from the basic theory include well stimulation, formation damage, perforations, fractures and a host of other formation and fluid heterogeneities. Another reason is that, some PVT properties were assumed here due to the lacking of available PVT data.

Table-1: Comparison between conventional analysis parameters and vertical model analysis parameters of KTL-01

Parameters	Analysis Value	Model value	Remarks
K(md)	46.0842	129.480	Average permeability
Kh(md.ft)	2995.47	8416.22	Total permeability-thickness product
S^-	-5.557	Not found	Total Skin
S_d	Not found	-2.300	Skin due to damage
P^* (psia)	3503.8	3505.3	Extrapolated pressure
$P_{(avg.)}$ (psia)	3499.3	3505.2	Average reservoir pressure
$P_{(syn)}$ (psia)	3658.7	3516	Synthetic pressure
X_e (ft)	12736.735	10630.012	Reservoir length
Y_e (ft)	2188.818	38220.643	Reservoir width
X_w (ft)	6368.367	5710.068	Well location in X-direction
Y_w (ft)	1094.409	119.477	Well location in Y-direction

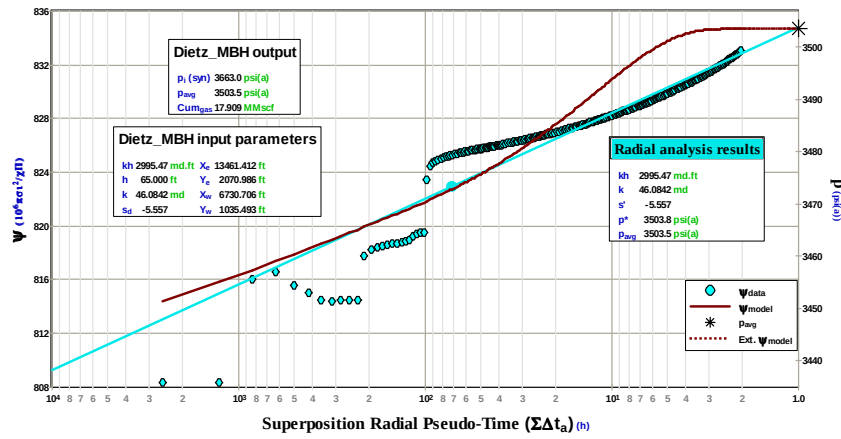


Figure-1:Dietz_MBH Semi log plot of radial flow analysis for KTL-01

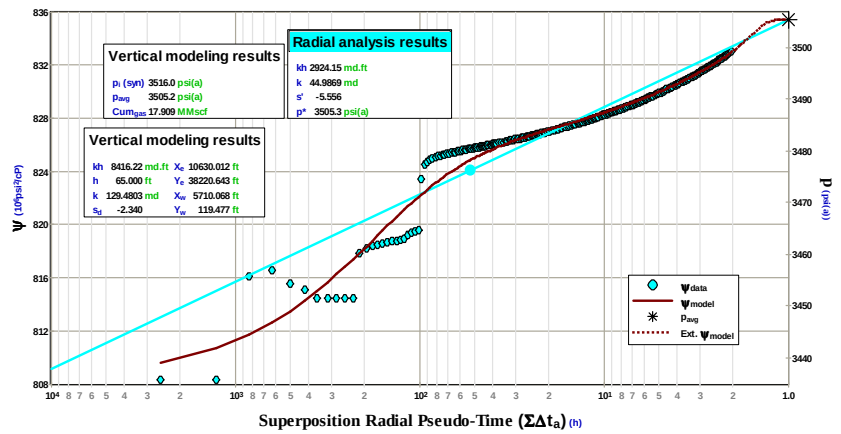


Figure-2: Semi log plot showing pressure buildup test results comparison of diagnostic analysis and vertical model analysis for KTL-01

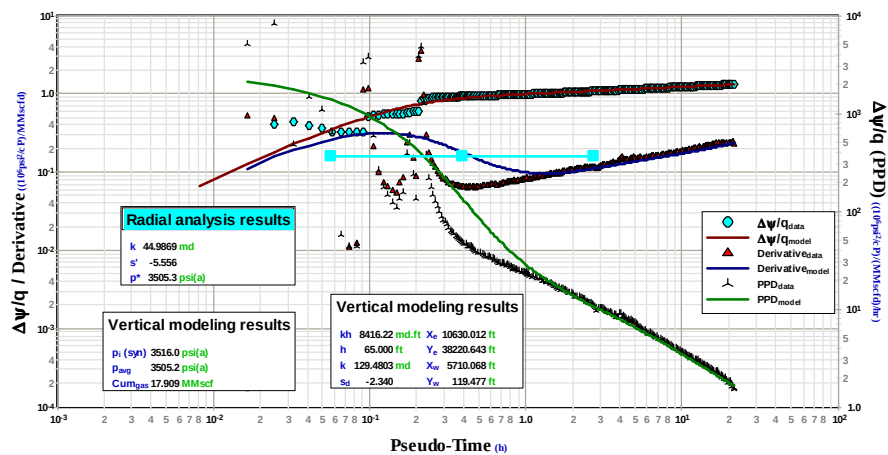


Figure-3: Type curve plot showing pressure buildup test results comparison of diagnostic analysis and vertical model analysis for KTL-01

Table-2: Comparison between conventional analysis parameters and vertical model analysis parameters of KTL-02

Parameters	Analysis Value	Model value
K(md)	699.098	899.7578
Kh(md.ft)	27963.92	35990.31
S ⁻	-0.332	Not found
S _d	Not found	0.294
P* (psia)	3223.8	3225.2
P _(avg.) (psia)	3222.4	3219.3
P _(syn) (psia)	3373.7	3340.5
X _e (ft)	14032.289	6866.983
Y _e (ft)	1986.792	5046.971
X _w (ft)	7016.135	90.492
Y _w (ft)	993.366	4148.806

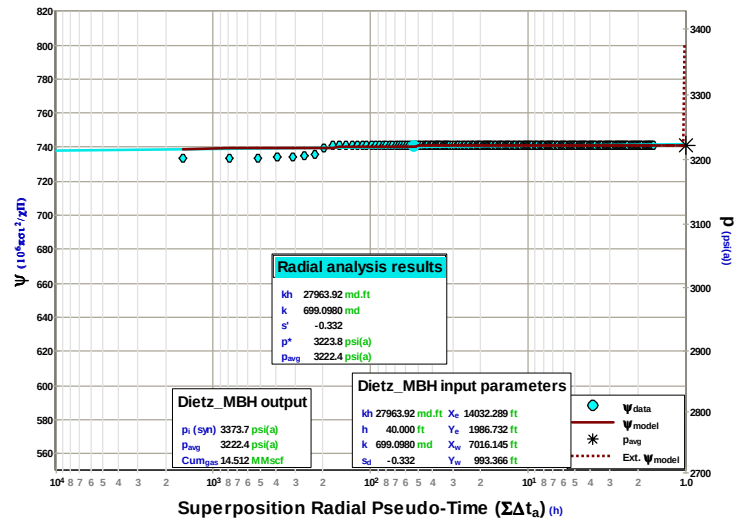


Figure-4: Dietz_MBH Semi log plot of radial flow analysis for KTL-02

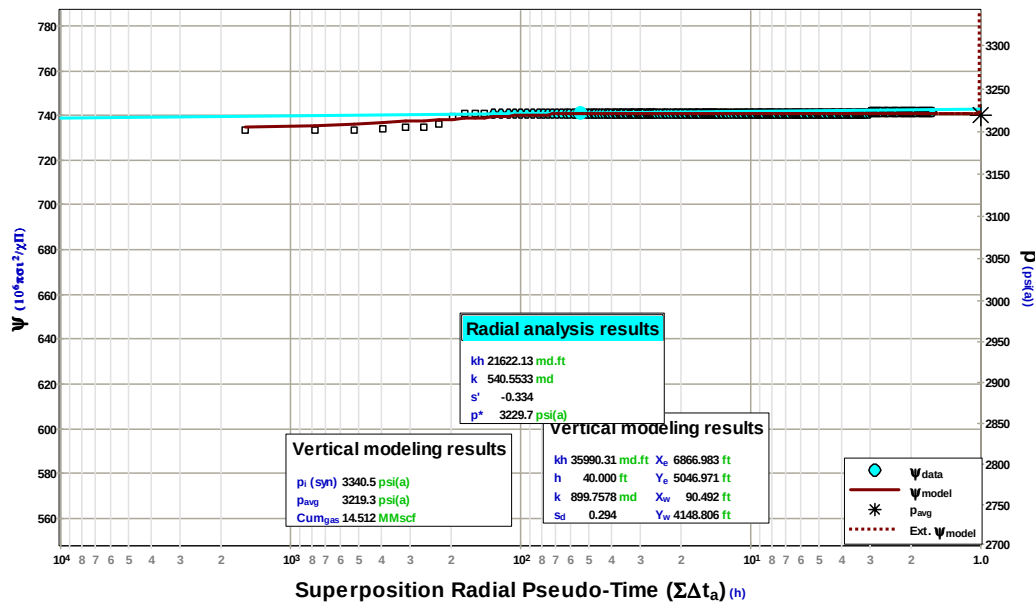


Figure-5: Semi log plot showing pressure buildup test results comparison of diagnostic analysis and vertical model analysis for KTL-01

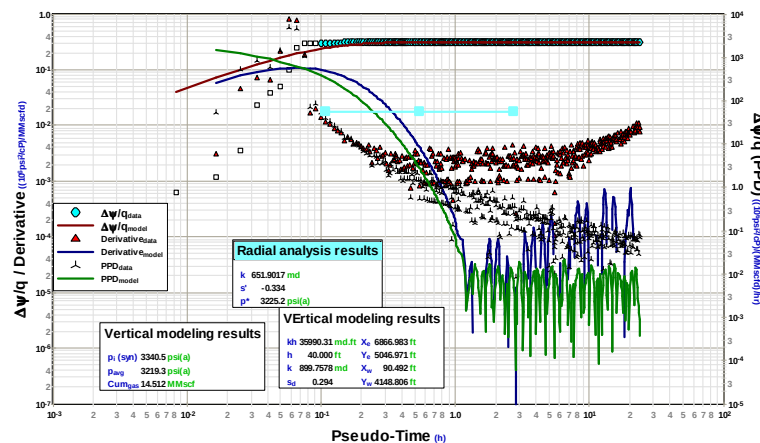


Figure-6: Type curve plot showing pressure buildup test results comparison of diagnostic analysis and vertical model analysis for KTL-01

5. CONCLUSION

Finally it is concluded that modeling is not a good tool for estimating or predicting the reservoir parameters for a practical field.

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Modern Approach to Estimation of Gas Reserve with Dynamic Reservoir Simulation.

- A Case Study of Narshingdi Gas Field.

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Gas is the most valuable natural resource all over the world as well as in Bangladesh too. Estimating and updating the gas reserve helps the planners for drawing mid-term and long-term development plan from field development level to national level. So estimating correct reserve has become vital issue now days in terms of energy demand and economics.

This paper presents the study of reserve estimation of Narshingdi Gas Field. In this paper Dynamic Reservoir Simulation model developed by Petrel 2005 has been used to perform a history match “pressure and production” using Eclipse-100 for reserve estimation. So the result of this study is expected to provide Gas Initially in Place (GIIP) in Narshingdi Gas Field.

Because of data limitations, efforts were taken to use SWHP (Shut in Well Head Pressure) and FWHP (Flowing Well Head Pressure) data for reserve estimation analysis of this field. Some variables like permeability, fluid contact, well productivity index, pore volume, initial pressure have been adjusted to obtain a good match to the observed well and reservoir behaviour. Simultaneously some forecast scenarios have also been evaluated. Since there is no strong aquifer pressure support in the producing gas zone, so gas production continues from the reservoir due to pressure depletion which may limit the future gas recoverable volume.

Key words: Gas Reserve Estimation, History Match, Forecasting, Sensitivity Analysis

Introduction:

Simulation is the way to describe quantitatively the flow of multiple phases (typically, oil, water, and gas) through porous media in a reservoir having a production schedule determined not only by the properties of the reservoir but also by the market demand, investment strategy which involves the performance predictions in intermediate and long term planning and government regulations.

Two commercial accumulations of gas sands have been discovered which are of different depositional

environment. The drilled section penetrated these two main gas sands and other four thin gas bearing sands of minor interest. Two major sands are 9.5m and 14m thick. Thickness of minor sands ranges from 0.6m to over 7m. Production is continuing only from lower gas sand and there is no production from upper gas sand yet. In Narshingdi Gas Field (lower gas sand) there are two wells named NAR-1 and NAR-2. NAR-1 was drilled to a total depth of 3450 meter in 1990 and production through this well commenced on 25th July 1996. Second well NAR-2 was drilled in the crest following new depth contour map in October 2006 and started

production on 18th February 2007. This well was drilled successfully to a depth of 3285m. Up to February 2008 the total gas production is approximately 82 Bcf (53% of GIIP).^{1, 2, 3}

In different time different companies and organizations updated reserve figure and those figures were mainly based on volumetric calculation and material balance analysis. Highly developed simulator tool ECLIPSE-100 which provides realistic and detailed reservoir behavior, is used to find out the gas reserve by performing history match “pressure and production”.

Methodology:

A reservoir model is a geometric model which contains a detailed description of geological properties and the dynamics of complex multiphase flow in a porous media. The reservoir model tries to describe the different static properties in all regions, along with the dynamic variables, i.e. saturations and pressures. The model needs to be discretized to

use in simulations. The common approach is therefore to model the reservoir with spatial blocks, as a discretization in space. The blocks are known as grid blocks. Appropriate static and dynamic parameters are assigned to each grid block.

The geological model had been built by using Petrel™-2005. The static model grid has dimension of 101×149×29 representing four sand layers of the field. It has been discretized into 328 x 328 ft grid blocks. For simulating of gas-water system the model grid layering was designed with average thickness of 10 ft, so up scaling is unnecessary in this case. Both middle gas sand-1 and middle gas sand-2 have no commercial value, so both of them are kept inactive. And this reduces the total number of active grid blocks to 66,966. The model has a minimum water saturation of 0.35 based on the initial water saturation distribution.⁴

Table-01: Properties of model layers.

Sand layers	Simulation layers	Porosity (%)	Permeability Distribution, md	Status
Upper gas sand	1-4	0.15-0.22	77	Active
Middle gas sand-1	5-15	-	-	Inactive
Middle gas sand-2	16-24	-	-	Inactive
Lower gas sand	25-29	0.07-0.22	1-100	Active

During DST 3 and extended production test-1, two sets of experimental gas compositional data were found from the lower gas sand. From these two sets of tests, data from extended production test-1 is considered to be more representative of the reservoir fluid due to long duration of flow period. Long duration draw down periods provides more accurate estimate of gas-liquid ratio. So PVT properties are based on gas composition from production test-1 (NAR-1) in Lower Gas sand.

Initial condition:

From pressure temperature phase diagram (Fig: 01) types of reservoir can be defined by the location of the initial reservoir temperature and pressure.³

Here the initial condition of the reservoir is as follows-

The initial reservoir temperature =205.8 °F=370K

Initial pressure of upper gas sand=4054 psia=279.5 bar

Initial pressure of lower gas sand=4274 psia=294.7 bar

Phase Plot: Sample ZI

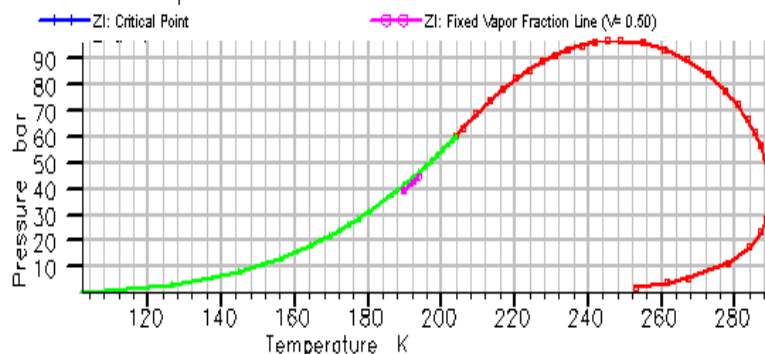


Fig. 1: Pressure temperature phase diagram of reservoir fluid.

The fluid left in the reservoir during production remains at 205.8 °F, so it will remain in the gas phase as the pressure declines. Liquid is condensed from the well effluent at temperature lower than 100° F and pressure in the range of 1100 psia. So it can be said that the reservoir fluid of the Narshingdi Gas Field is non-retrograde at reservoir temperature and can be defined as lean gas since no condensate is formed in the reservoir during the life of production. The Narshingdi fluid contains over 97% methane and ethane, a larger percentage of C7+ and significant amount of recoverable C5+ liquids. The condensate is highly viscous. The specific gravity of the reservoir fluid is 0.6 and condensate-gas-ratio (CGR) is about 2.24 bbl/MMscf.³

Gas Properties:

The gas properties were analyzed at the reservoir temperature of 205.8 °F and pressure range of 15 – 5000 psia. The specific gravity of the gas is 0.60. There is an assumption for rock compressibility and the value is $C_f = 3 \times 10^{-6} \text{ psia}^{-1}$.

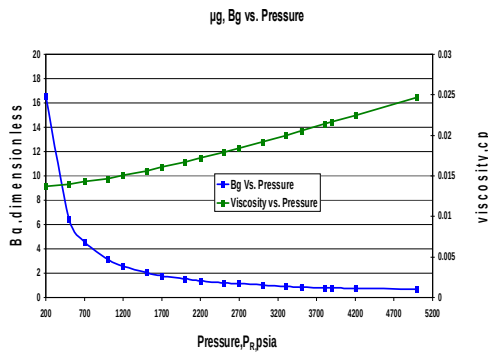


Fig. 2: Properties of Gas in the lower gas sand

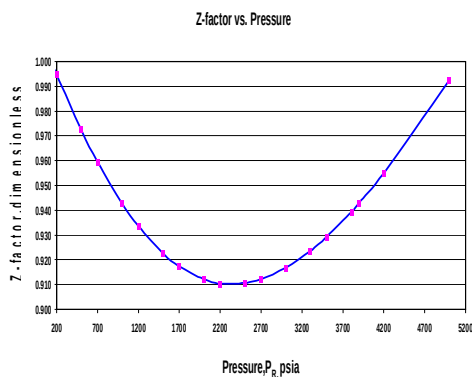


Fig. 3: Properties of Gas in the lower gas sand

Relative Permeability:

Brooks-Corey's equations for two-phase flow have been used to generate relative permeability curves for the simulation. Here some assumptions are made to have value of pore size distribution index both for gas and water. It is assumed that the fluid flow is neither segregated nor evenly distributed and this gives Corey exponents- 4 for water and 2 for gas to calculate relative permeability. Minimum water saturation is selected as the endpoint in the model.

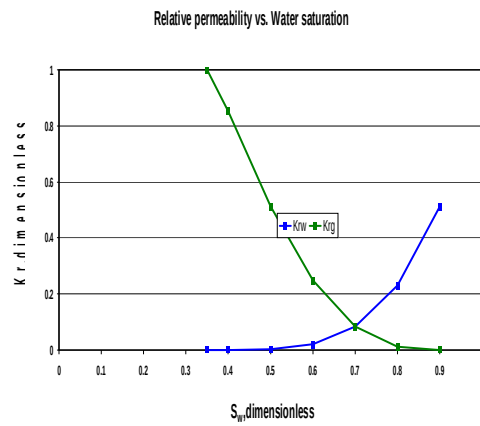


Fig. 4: gas water relative permeability curves.

Well performance curve:

To calculate well head pressure for history match and production forecast vertical lift performance (VFP) curve has been generated by using another commercial software IPM for two wells NAR-1 and NAR-2 having tubing size of 3.5 inch and 4.5 inch respectively. Through a series of graphical modules, control and data panels, it allows to study all aspects of pressure traverse calculations along wells. To calculate the pressure traverse, Beggs and Brill flow correlations has been chosen because it performs well in gas and gas condensate well.

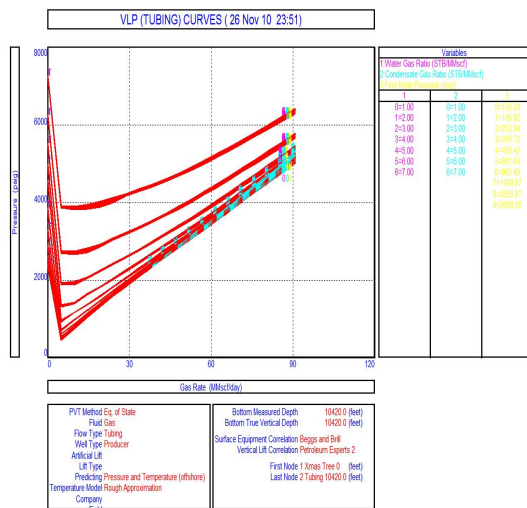


Fig. 5: Vertical lift performance curve for NAR-1

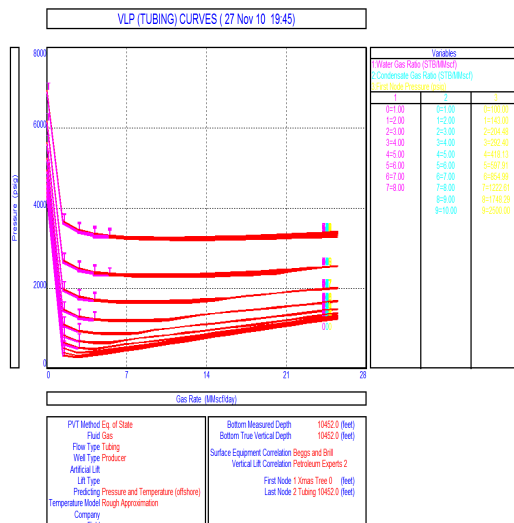


Fig. 6: Vertical lift performance curve for NAR-2

History match:

In this section the simulation model has been applied to match production and pressure data from wells of the volumetric reservoir to confirm the initial reservoir conditions and obtain an acceptable match of the observed reservoir behavior. There is a limitation of having shut-in BHP measurements in the field and no flowing BHP data but historical flowing THP is available for the two wells. That's why in this article efforts are put on matching THP rather than BHP. For this purpose, some of the process parameters called history match variables are modified and the calculation repeated.

History Match Variables:

The following listed variables have been manually adjusted to obtain a good match to the observed well and reservoir behavior.

- Permeability-** in case of NAR-1, there is a good match between calculated and observed production rates (gas and water) but in case of NAR-2 the situation is not very good. It is observed that values of permeability in grid cells near the well bore of NAR-2 were low. So it was necessary to adjust the permeability (increased by up to a factor of 1000) to have improved match of gas and water production rate.
- Fluid contact-** There is no available pressure data for either the upper or lower gas sand to provide information about initial reservoir conditions. From NAR-1 log data, the lower gas sand has a touchy contact with shale and shows no indication of a gas water contact (GWC), but there is a gas-down-to (GDT) at 10376 ft and from NAR-2 log data, GWC at 10531ft Sub Sea. So, there remains uncertainty over the fluid contact in the lower gas sand.

Here both wells (NAR-1 and NAR-2) are controlled on the gas rate and the matches in case of production rate, THP are quite good. A summary of all history match changes have been introduced to the simulation model and a set of graphs comparing model results with measured data are presented below.

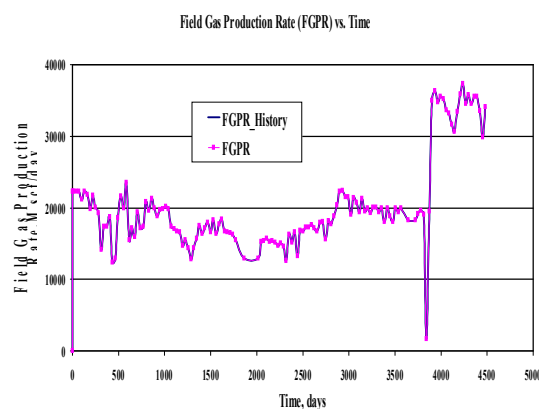


Fig. 7: Field gas production rate history match

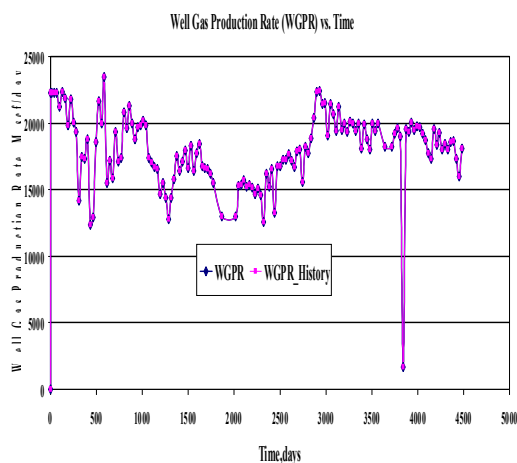


Fig. 8: Well gas production rate history match for well NAR-1

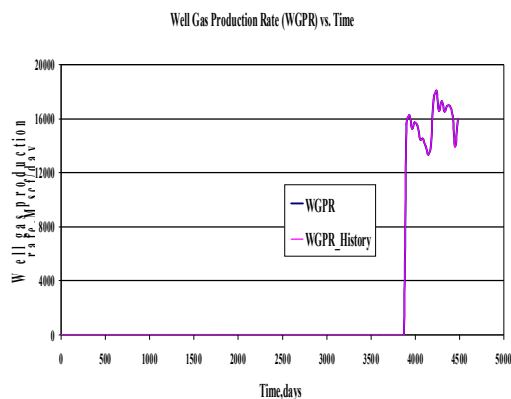


Fig. 9: Well gas production rate history match for well NAR-2

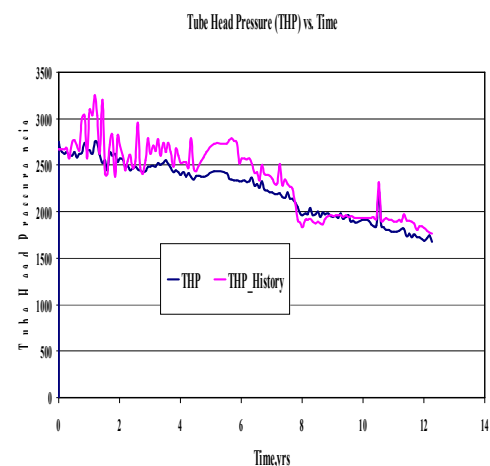


Fig. 10: Tubing head pressure history match for NAR-1

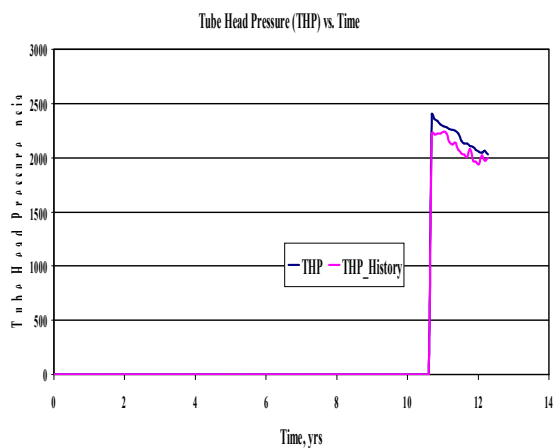


Fig. 11: Tubing head pressure history match for NAR-2

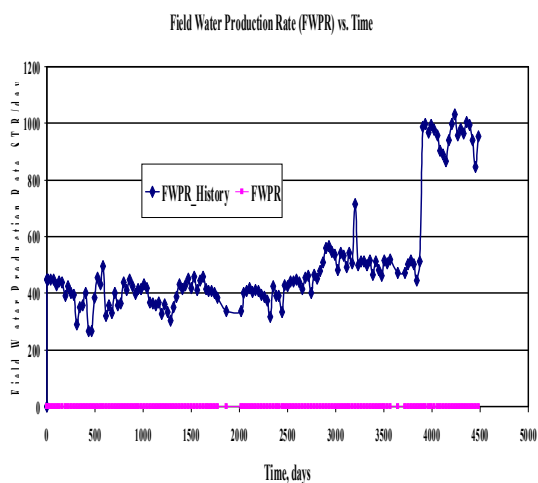


Fig. 12: Field water production rate history match

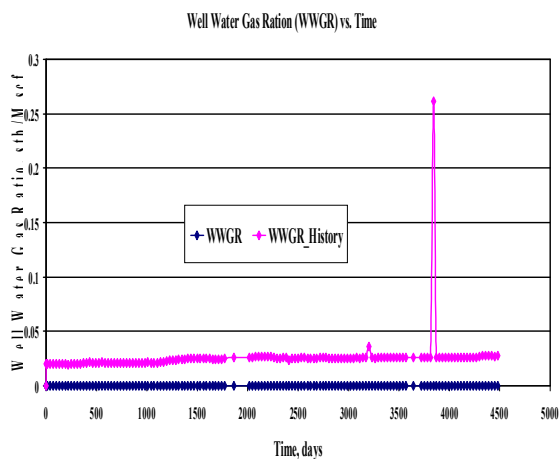


Fig. 13: Well water gas ratio history match for NAR-1

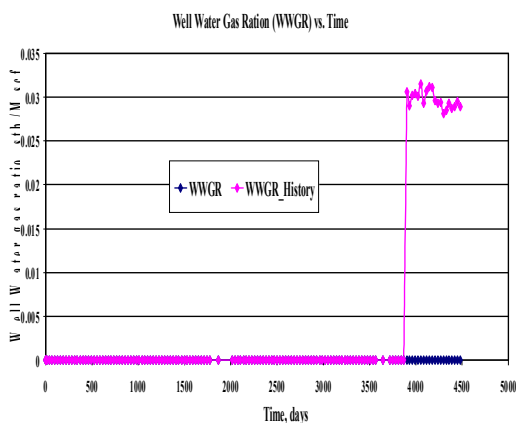


Fig. 14: Well water gas ratio history match for NAR-2

Sensitivity analysis 1

Fluid Contact: The gas-down-to at 10376 ft Sub Sea seen in well NAR-1 is used as the fluid contact of the lower gas sand. This is investigated to observe the impact on initial gas volume and reservoir behavior.

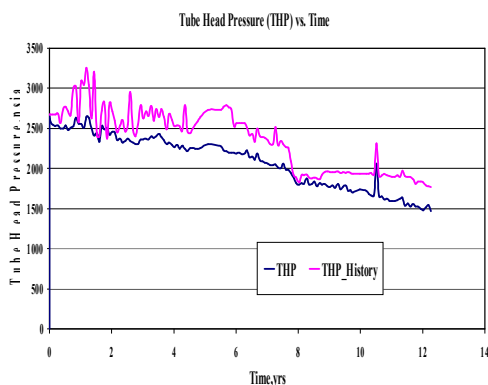


Fig. 15: NAR-1 THP history matches sensitivity

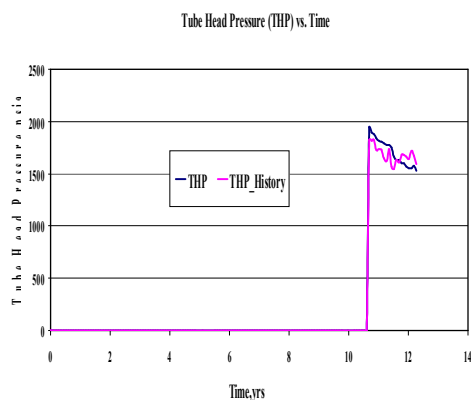


Fig. 16: NAR-2 THP history matches sensitivity case-1

There is a poor match to the pressure history of the two wells because part of their perforations fall below the contact. The poor match to the reservoir behavior show that the gas-down-to seen in well NAR-1 is deeper than the value interpreted from log.

Sensitivity analysis 2:

Aquifer pressure support: A numerical aquifer is modeled by a one-dimensional row of cells. A set of cells in the simulation grid is nominated to represent the aquifer, which then connect to specified faces of the reservoir. The properties of the aquifer grid blocks (length, cross-sectional area, porosity, permeability, initial pressure, depth) declared explicitly but PVT and saturation table numbers are based on the reservoir properties. This is to investigate the possibility of a weak pressure support.

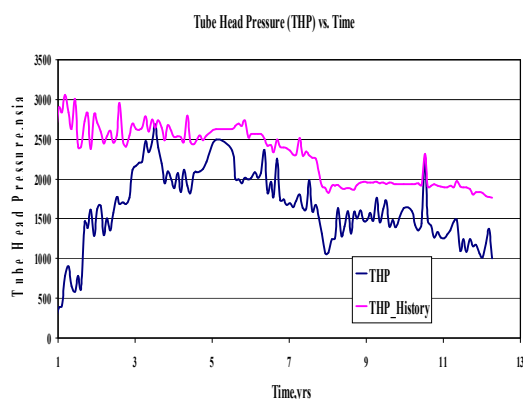


Fig. 17: NAR-1 THP history matches sensitivity case-2

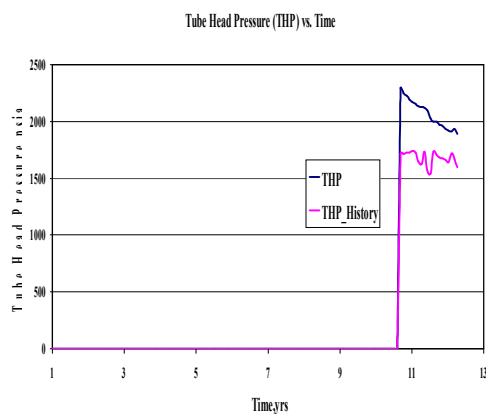


Fig. 18: NAR-2 THP history matches sensitivity case-2

The influx from the aquifer attached to the simulation model is weak relative to the field production history. With this weak aquifer pressure support, a poor history match is obtained to THP in both wells. The results of this sensitivity case confirm that there is no aquifer pressure support to the lower gas sand.

Interpreting the plot of cumulative gas produced against P/Z presented in Figure below, it can be seen that as a reservoir undergoing depletion with no aquifer support and this is to be consistent with the production data.

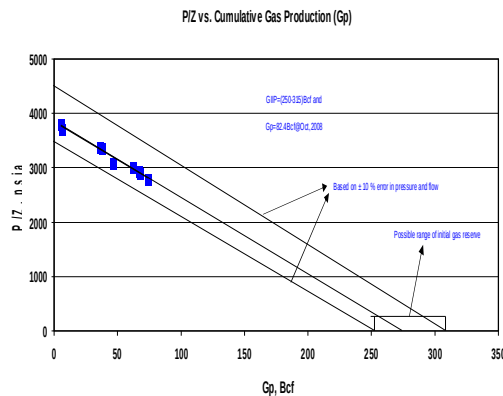


Fig. 19: P/Z plot for lower gas sand

Performance Projections:

Sets of sensitivity prediction simulation runs have been performed using the history-matched model. All the forecast sensitivity cases are set up to run till December 2032 with the current well production capacity (NAR-1 – 20MMscf/D, NAR-2 – 15 MMscf/D). For this the plateau rates and following two constraints were used to shut well production when violated.

- Economic rates – NAR-1: 3 MMscf/day and NAR-2: 4 MMscf/day.
- Wellhead flowing pressure requirement – 1000 psia.

Forecast case 1: do-nothing scenario that involves predicting future production with the existing wells until the economic rates of the wells are reached.

Forecast case 2: additional Horizontal well in the middle high permeability zone.

Forecast case 3: additional horizontal well across all layers scheduled to start production from January 2013.

The following figures present the production profile of the forecast case-1. Production from the field is controlled by declining reservoir pressure. The well NAR-2 has low bottomhole pressure, so due to this

the production from this well is limited and ended before the well NAR-1.

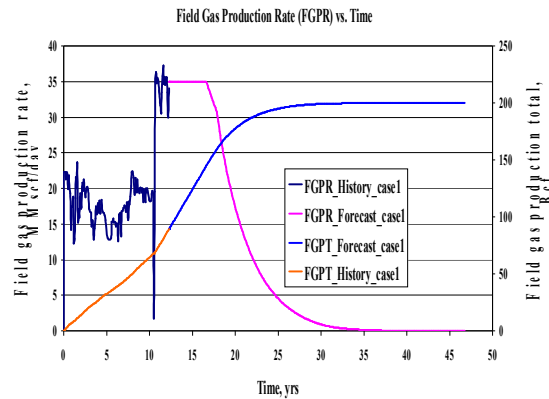


Fig. 20: Production profile for case-1

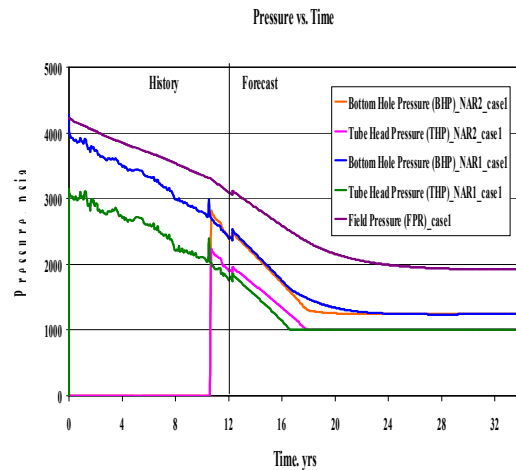


Fig. 21: Simulated reservoir pressure behavior for case-1

The following figures present the comparison among three cases. The additional horizontal well has some effect on the field gas rate production for some time but that would not last for longer time. As the reservoir pressure declining, so the additional well has low pressure support and production from this well is interfering with the production from other two wells NAR-1 and NAR-2.

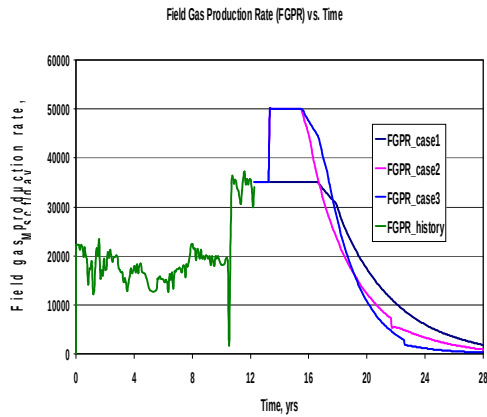


Fig. 22: Field gas production rate-impact of additional well

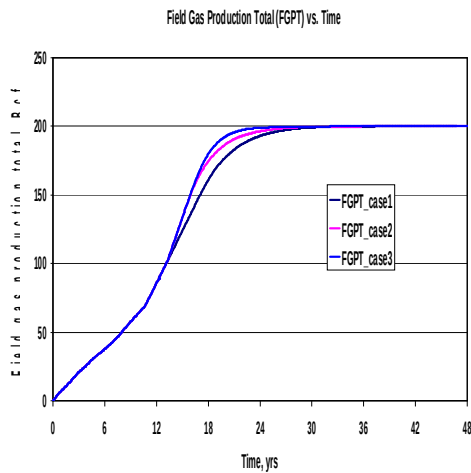


Fig. 23: Field gas production total-impact of additional well

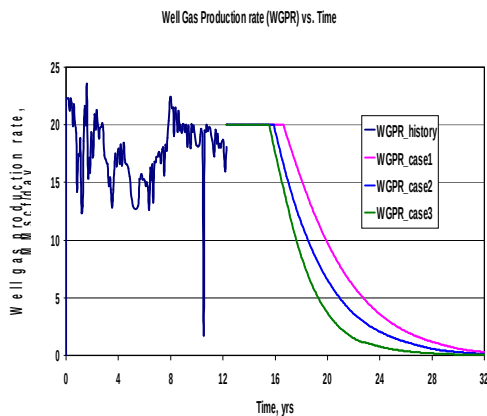


Fig. 24: Impact of additional well on well gas production rate for NAR-1

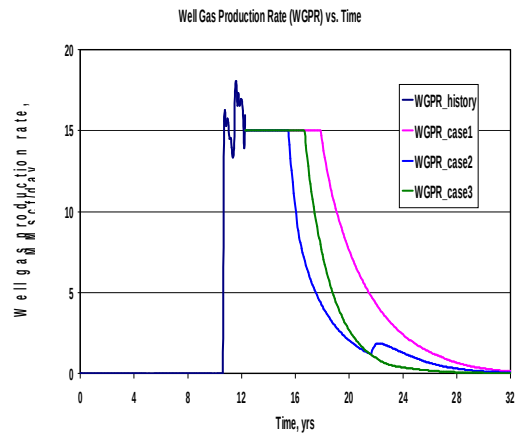


Fig. 25: Impact of additional well on well gas production rate for NAR-2

Conclusions:

The GIIP estimated for the lower gas sand from material balance analysis also agrees with the history-matched model. According to simulation model the total gas reserve is about 364.51 Bcf, where upper and lower gas sand contains 83.852 Bcf and 284.662 Bcf respectively. Between these two gas sands (upper and lower gas sands), only the lower gas sand has been developed. So no material balance calculation is performed for upper gas sand. The material balance analysis gives the possible range of GIIP for the lower gas sand 250-315 Bcf.

From NAR-1 log data the fluid contact in the lower gas sand is to be 10376 ft. Good production and pressure history match is found by manipulating the contact based on information provided by PetroBangla about NAR-2.

From production history no aquifer pressure support is found in the lower gas sand. However there is some uncertainty due to inadequate pressure data. A simulation sensitivity analysis confirms that there is no aquifer pressure support. Production is continuing because of pressure depletion.

From the lower gas sand, future recoverable volume will increase by 118 Bcf at the end of field life which gives the total recoverable volume 200 of Bcf based on the do nothing scenario (i.e. 70% recovery factor).

The impact of drilling one horizontal well across all layers is that it will not accelerate the recovery. The total recoverable volume will be 195 Bcf (i.e. 68%). In this case reservoir pressure depletion will be more than do nothing scenario and makes field life shorter.

Again the horizontal well across maximum permeable zone through one layer does not seem very economic considering case 1. 197 Bcf gas could be produced giving 69% recovery. In case of individual well gas production rate, case-1 showed the better result rather than other two cases and it gives the plateau rate for longer time.

Recommendations:

- The production companies need to adopt an integrated program of testing and pressure surveys. This will help to build a reliable production database and updating of reserves.
- Additional seismic survey over the structure is required
- There are some uncertainties in fluid contact (lower gas sand). So the interpretation of both NAR-1 and NAR-2 well log data is necessary to resolve this. In that case there may be a need to run a new log in the wells to find out the fluid contact.
- All the analysis done in this article does not include economic analysis. So, for field development economic analysis for each of the forecast case is urgent. By doing this the optimum condition could be determined.
- More forecast cases like maintaining THP by including compressor, additional vertical well in more permeable zone etc could be set up for further analysis to choose the optimum option.

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Nomenclature:

FBH	Flowing bottom hole pressure
FGPT	Field gas production total
FTHP	Flowing tubing head pressure
GDT	Gas Down To
GIIP	Gas Initially in Place
GPR	Gas production rate
GPRH	Gas production rate history
GWC	Gas water contact
Kr	Relative permeability
Krg	Relative permeability of gas
Kw	Relative permeability of water
MMscf/day	Millions of standard cubic feet/day
FPR	Average reservoir pressure
THP	Tubing head pressure
THPH	Tubing pressure history
WBHPH	Well bottom- hole pressure
WGRH	Water-gas-ratio history
WGPR	Well gas production rate
WGPRH	Well gas production rate history
WWGR	Well water-gas-ratio
WWGRH	Well water-gas-ratio history
SIWHP	Shut in well head pressure

Natural Gas Pipe Line Design from Ashugonj Valve Station#3 to Zia Fertilizer Company Limited and in an Arbitrary Power Plant

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Abstract

This paper presents a details feasibility study on road selection, design and construction of a natural gas pipeline from Ashugonj valve station 3 to Zia Fertilizer Company Limited (ZFCL). In addition, it conducts feasibility study of a new pipeline to an arbitrary power plant of 1000 mw capacity .5 km away from ZFCL. The proposed pipeline should contain the transmission capacity of 1500 MMSCFD of NG as the energy consumption is augmenting rapidly. It considers pipeline facility exist along the road to minimize the construction cost, it appears that there are some pipeline facility existed along the proposed road from Ashugonj VS 3 to ZFCL. Therefore, the main concern of the study is to develop .5 km pipeline to the power plant. To examine the technical and economical legitimacy of the study, a financial study for the next 20 years has been performed. In addition, a comprehensive sensitivity analysis has been performed to check the reliability of the projects. The above study demonstrates that the project is technically and economically feasible and should be implemented to keep pace with energy demand in future.

Introduction

There is 3.5 km pipeline with 10 inches diameter from Ashugonj VS#3 to Zia Fertilizer Company. After the scrutinizing, the overall energy scenery of Bangladesh in the next 20 years there would be needed the

1000 MW power plant the surrounding of Ashugonj. In that cases

- Will the existence pipeline keep pace with the demand rising?
- If not what will be recommended pipeline design and base of what?

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According to the given data of TGTDCCL the gas flow through the pipeline per day $Q=175$ MMSCFD, if we consider the 30% more (as pipeline thumb rule) with this flow it will be approximately 230MMSCFD.

If we set up 1000MW power plant half kilometer away from Ashugonj ZFCL its consumed gas per day will be 850 MMSCFD approximately (reference of 728 MW power plant of Ashugonj) and if we deigned pipeline based on for the next 20 years including 30 % more as pipeline thumb rule, the ultimate gas required per day is 1100 MMSCFD.

In this circumstance it is well realized that the existing pipeline will not sustain with demand rising. $230 \leq Q < 1100$

Basically, we can be solved this problem in two ways comparing between two methods we will choose one which will give us less cost estimation delivering good one.

The two methods are:

- Series pipeline
- Parallel pipeline

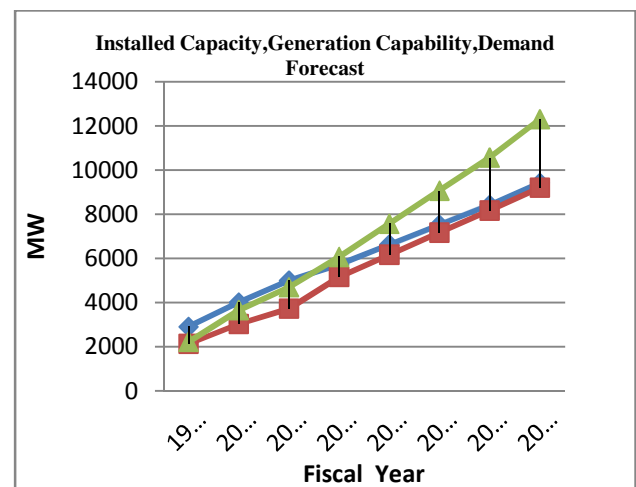
Methodology:

Review of the present demand of power scenario of Bangladesh, Review of the forecasted demand of power production, supply, Designing a pipeline for

transmission of natural gas to that area, Financial analysis will be done of the proposed pipeline project.

Analysis Bangladesh Power Development Board (BPDB) Annual report 2008-2009.

[5.] We can forecast the near future installed capacity, generation capability, and demand augmentation



The average demand growth of electricity has been about 10% per year at current tariffs. That means 500 MW of new generation capacity must be added every year just to satisfy demand growth [6].

Design Calcualtion:

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For transporting a given quantity of gas at a given pressure drop, length is proportional to diameter raised to the power 16/3.

$$\begin{aligned} L_A &= L_B \left(\frac{D_A}{D_B} \right)^{\frac{16}{3}} \\ &= L_B \left(\frac{10}{D_B} \right)^{\frac{16}{3}} \end{aligned}$$

The series line shown has a total equivalent length of,

$$\begin{aligned} L_{AEQ} &= L_A + L_B \\ &= L_A + L_B \left(\frac{10}{D_B} \right)^{\frac{16}{3}} \\ &= L - L_B + L_B \left(\frac{10}{D_B} \right)^{\frac{16}{3}} \end{aligned}$$

The modified panhandle (panhandle B) equation –Horizontal flow,

$$Q = 737 \left(\frac{T_b}{T_b} \right)^2 \left[\frac{P_1^2 - P_2^2}{\bar{T} L Z Y_g^{.961}} \right]^{.510} D^{2.530}$$

Combining the equivalent length equation and modified panhandle equation for horizontal flow and putting necessary data we get the following equation,

$$L_B = \frac{2.173665}{1 - \left(\frac{10}{D_B} \right)^{\frac{16}{3}}}$$

Putting different value of D_B in this equation we get the following table,

Table: Pipeline diameter in respect of length

$D_B(\text{inches})$	$L_B(\text{miles})$
11	5.4544
12	3.4955
13	2.8857
14	2.6068
15	2.4561
16	2.3665
17	2.3099
18	2.2724
19	2.2468
20	2.2288
21	2.2159
22	2.2065
23	2.1995
24	2.1941
25	2.1901
26	2.1870
27	2.1845
28	2.1826
29	2.1810
30	2.1798
31	2.1788
32	2.1780
33	2.1773
34	2.1768

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The series pipeline will not suitable with our proposed pipeline demand. because as for example if choose to series 2.1941 miles of pipeline with a diameter 24 inches the rest of pipeline will be 1.3059 which is existing 10 inches diameter pipe that will not sustain to deliver the whole demand. Therefore, we are going to looping pipeline design.

$$Y = \frac{1 - \frac{q_0^2}{q}}{1 - \frac{1}{(1+w)^2}}$$

When, Y= 100% we get $D_B = 19.16$ inches

When, Y=98% we get $D_B = 30$ inches diameter pipe, we will use this 30 inches in our proposed pipeline.

To calculate pipe wall thickness, following formula is used.

$$t = DP / 2YFLJT$$

t = Pipe wall thickness in mm

P= Design Pressure in Psig=960 psig

D= Outside diameter of pipe in inch=30in

Y= Minimum Yield Strength in Psig=60,000 psig (Assume API 5LX 60 Grade Steel Pipe)

F= Design Factor= 0.8

L= Location Factor, it depends on the route of the pipeline. For the cross country pipeline this factor to 0.6

T= Temperature Derating factor= 1 for temperature up to 250⁰ F

J= Joint Factor, J=1

Therefore using equation 3.6 we get, t=12.7 mm

Assume, corrosion allowance for steel pipe = 2 mm

Hence Pipe wall thickness = (12.7+2) mm= 14.7 mm

Compare this calculated pipe wall thickness to API 5L line Chart we get wall thickness from API chart = 12.7 mm [2].

Cost Estimation:

Once a project is found technically sound, the next step is to check its soundness from financial standpoint. Financial analysis of development project deals with review of profitability analysis, efficiency analysis effectiveness analysis, cost effectiveness analysis and sustainability analysis. One important aspect of financial appraisal is to ensure that there is a financial plan that will make funds available to implement the project on schedule. (Financial analysis 2000-2001, planning dept. of titas T & D Co. ltd.) [3]

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NPV= 32789.589

BCR= 877.469

IRR= 35%

From table 2.

Note:

1. Land acquisition and requisition cost have been calculated in the basis of actual cost of Nalka-Bogra project and the quality of land has been fixed as bare minimum base on the Natural Gas Safety rule 1991 amended on 2003
2. Land development cost has been prepared in the basis of public Works Department (PWD) standard and rate as on 2004
3. Accommodation area and Estimated cost for civil construction works have been prepared on the basis of Public Works Department (PWD) standard and rate as on 2004
4. Cost of machinery and equipment has been calculated on the basis of proportionate value of actual cost of being implemented Nalka-bogra, Ashuganf-Monohordi project
5. LC= Local Price, FC= Foreign Price, Conversion rate 1 US\$=70.02Tk. [8]

Conclusion

The objectives of this project were to design a new pipeline altering the existing one in order to provide gas flow at the design pressure and volume. Presently only maximum 225 MMSCFD gas can be supplied through the existing pipeline, which

is also reducing day by day with the increasing of gas demand along the pipeline Route. After completing the proposed pipe line it could be supplied around 1100 MMSCFD gas per day. Presently supply is Just meet the present demand. To meet the future increasing demand it needs to increase Supply rationally. The total cost of the project is 342.287 lakh taka .Different technical evaluations such as NPV, BCR, IRR and EIA are formulated to analyze the profitability

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Table – 2: Calculation of Financial Value of NPV, BCR, IRR

Year	Investment cost(million taka)	Operating cost(million taka)	Total cost(million taka)	Total revenue(million taka)	Net income(million taka)	Discount factor 15%	Discounted total cost(million taka)	Discounted total revenue(m illion taka)
2010	34.2287		34.2287		(34.2287)	1.00	34.2287	-
1		.51343	.51343	1455	1454.48	.870	.4466	1265
2		.51343	.51343	3147	3146.49	.756	.3881	2379
3		.51343	.51343	3467	3466.49	.658	.3378	2281
4		.51343	.51343	3823	3822.49	.572	.2937	2186
5		.51343	.51343	4215	4214.49	.497	.2552	2094
6		.51343	.51343	4648	4647.49	.432	.2218	2007
7		.51343	.51343	5124	5123.49	.376	.1930	1926
8		.51343	.51343	5649	5648.49	.327	.1679	1847
9		.51343	.51343	6228	6227.49	.284	.1458	1768
10		.51343	.51343	6867	6866.49	.247	.1268	1696
11		.51343	.51343	7572	7571.49	.215	.1103	1627
12		.51343	.51343	8348	8347.49	.187	.0960	1561
13		.51343	.51343	9203	9202.49	.163	.0837	1500
14		.51343	.51343	10148	10147.49	.141	.0724	1430
15		.51343	.51343	11186	11185.49	.123	.0632	1196
16		.51343	.51343	12334	12333.49	.107	.0549	1319
17		.51343	.51343	13598	13597.49	.093	.0477	1264
18		.51343	.51343	14993	14992.49	.081	.0416	1214
19		.51343	.51343	16526	16525.49	.070	.0359	1156
2030		.51343	.51343	18223	18222.49	.061	.0313	1111
Total =34.2287							37.411	32827

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NUMERICAL INVESTIGATION OF PARTICLE PROPERTIES ON COAL GASIFICATION UNDER CO₂ ATMOSPHERE

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To achieve efficient energy from coal gasification using CO₂ recycling and to reduce CO₂ emission as well, oxy-combustion of coal becomes attracting interest worldwide. A 3D numerical simulation for coal gasification is carried out to investigate the effect of particle properties on coal gasification under CO₂ atmosphere. Reaction rate equation of n-th order type with the Random Pore Model is applied to the char gasification reaction. The presence of a much greater CO₂ concentration than in a conventional air-fired reactor causes significant differences in gas physical properties, such as temperature, and in solid particle properties, such as temperature, density and burnout. The effects of CO₂/O₂ mixture on combustion characteristics during pulverized coal combustion are investigated. The CO₂ gasification rate increases with increasing the CO₂ partial pressure in CO₂/O₂ mixtures. The particle temperature and residence time for coal are examined with various mixtures of CO₂/O₂. Influence of inlet particle size is also studied and the results are presented in this paper.

Key words: Oxy-combustion; coal gasification; CO₂ emission; reaction rate

1. INTRODUCTION

Coal gasification is a process in which coal is partially oxidized to form mainly the following combustible gases: carbon monoxide, hydrogen and methane. The noncombustible products carbon dioxide and water are also formed. During the early 19th century, almost all fuel gas was produced by coal gasification. During the 1940's, natural gas became a cheaper alternative to gases derived from coal gasification. However, interest in coal gasification is renewed due to recent increases in natural gas prices and decreases in natural gas supply. A number of research programs are now under way all over the world to test and develop efficient and economical production of high heating value gas from coal.

Coal is a major source of energy, accounting for 27% of the world energy supplies and 35% of the world electricity generation (Williams et al., 2002 and Alam et al., 2010). It is predicted that coal will continue to play an important role in meeting the world's increasing energy demands in the foreseeable future. However, the use of coal faces several challenges. The major one is the considerable emission of CO₂ which leads to climate change and air pollution. Carbon dioxide is

believed to be a "greenhouse gas" which can lead to global warming (Bachu and Adams, 2003).

Oxy-fuel combustion is recognized as a promising technology for pulverized coal-fired power plants to control CO₂ emissions. In this process coal is burned in a mixture of oxygen and recycled flue gas (principally CO₂). This produces an exhaust gas with a high concentration of CO₂ ready for sequestration (Changdong and Yi, 2008). Pilot-scale experiments demonstrate that oxy-fuel combustion can offer additional benefits of substantially reducing NO_x, SO₂, and Hg emissions (Croiset et al., 2000, Croiset et al., 2001). Therefore, it motivates numerous studies that cover many scientific and engineering fundamental issues on the application of this technology. The dry flue gas of oxyfuel combustion consists of mainly CO₂ and minor amount of O₂, N₂, and SO₂, while that of air-fired combustion contains a great amount of N₂ as well as CO₂, O₂, and SO₂. Such changes imply that the gas environment experienced by pulverized coal particles is significantly different. These differences is found to have impacts on combustion processes (Tan et al., 2005, Liu et al., 2005, Murphy and Shaddix, 2006, Molina and Shaddix, 2007) including devolatilization and ignition, combustion characteristics, char reaction, and

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pollutant formation. The findings provide us in-depth understandings of the phenomena and fundamentals for further research and development of this technology. The combustion of coal in the CO_2/O_2 atmosphere result in a much higher CO_2 concentration in flue gas than in conventional coal combustion (using air as an oxidant), which can greatly reduce the cost of CO_2 capture. In our previous paper (Alam et al., 2010b), we studied that a high molar ratio of CO_2 to O_2 is suitable for achieving more syngas for pulverized coal combustion. However, this increase in CO_2 concentration will produce different gas environment and the particle will show different behavior during pulverized coal combustion. Therefore, to investigate the combustion behavior, it is also necessary to study the gas environment and the particle behaviors during coal combustion process under CO_2 atmosphere. The authors concern on char- O_2 and char- CO_2 reaction in oxy-fuel combustion process of pulverized coal. In this study, combustion characteristics of pulverized coal in various ratios of CO_2/O_2 mixtures are investigated. The objectives of the present work are to numerically investigate the coal combustion behaviors under various ratios of CO_2/O_2 mixtures. The numerical results are used to investigate the particle properties and to study the char/ CO_2/O_2 reactions. The present paper is also examined the effect of inlet particle size on particle behaviors showed during CO_2/O_2 combustion of pulverized coal.

2. EXPERIMENTAL METHODS

The experiment, explained by Schaffel et al., 2009, were carried out by the International Flame Research Foundation (IFRF) and shown in Fig. 1.

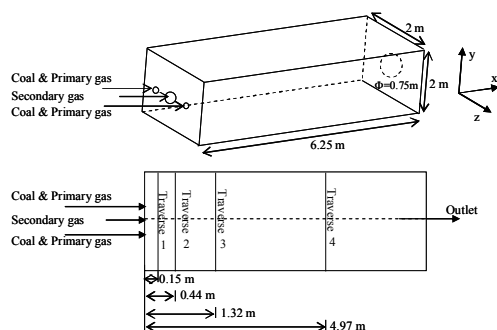


Fig. 1: Reactor geometry and the location of the data measurement

The burner consisted of a central 125 mm diameter pipe supplying the oxidizer and two 27.3 mm coal injectors (pipes) which were located 280 mm away

from the burner center, as shown in Fig. 1. A constant wall temperature at 1500K was maintained for the reactor. The measurements were taken at several traverses (Fig. 1) in a horizontal plane cutting through the burner centerline. Detailed description of these measurements can be found in Weber et al., 2005. The experimental conditions are summarized in Tables 1 and 2.

Table 1. Experimental conditions (Schaffel et al., 2009)

	Flow rate (kg/s)	Temperature (K)
Coal	66	-
Primary gas	130	313
Secondary gas	675	1623

Table 2. Inlet composition for primary and secondary gas

Primary gas	$\text{O}_2=23, \text{N}_2=77$
Secondary gas	$\text{O}_2=22, \text{H}_2\text{O}=9.5, \text{CO}_2=12.5, \text{N}_2=56$

3. NUMERICAL METHODS

Three-dimensional simulations of a quarter of the furnace are performed under steady-state conditions. The coal combustion is modeled including pyrolysis, volatile combustion, and char burnout. All the gas phase reactions are calculated using global mechanisms. The interaction between chemistry and turbulence is modeled using the Eddy Dissipation model. Turbulence is calculated using the standard $k-\epsilon$ model whilst radiative heats transfer by P1 radiation method. The governing equations are discretized by the first-order upwind scheme. The pressure-velocity coupling was also corrected by using the SIMPLE scheme. The Venezuelan bituminous Guasare coal (Schaffel et al., 2009) is used to conduct the simulation. The proximate and ultimate analyses of Guasare coal are given in Table 3.

Table 3. Proximate and ultimate analysis of bituminous coal (Guasare)

Proximate analysis (wt %)		Ultimate analysis (wt % d.a.f)	
Moisture	2.9	C	81.6
Volatile matter	37.1	H	5.5
Fixed carbon	56.7	O	10.7
Ash	3.3	N	1.5
LCV(MJ/kg)		31.74	

A quarter of the furnace is performed due to symmetry under steady-state conditions and 44,824 tetrahedral cells are used with the cell size around 2 mm.

4. MATHEMATICAL METHODS

The following general basic Equations (1) – (3) for fluid flow are considered to calculate the pulverized coal combustion modeling.

Mass Conservation Equation:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{v}) = S_m \quad (1)$$

Momentum Conservation Equation:

$$\frac{\partial}{\partial t} (\rho E) + \nabla \cdot (\vec{v} (\rho E + p)) = -\nabla \cdot \left(\sum_j h_j J_j \right) + S_h \quad (2)$$

Energy Conservation Equation:

$$\frac{\partial}{\partial t} (\rho \vec{v}) + \nabla \cdot (\rho \vec{v} \vec{v}) = -\nabla p + \nabla \cdot (\vec{\tau}) + \rho \vec{g} + \vec{F} \quad (3)$$

The k - ε model (Launder and Spalding, 1974) with the following model constants: $C_{1\varepsilon}=1.44$, $C_{2\varepsilon}=1.92$, $C_\mu=0.09$, $\sigma_k=1.0$, $\sigma_\varepsilon=1.3$ are used for the flow predictions. The turbulence kinetic energy, k , and its rate of dissipation, ε , are obtained from the following two transport equations:

$$\begin{aligned} \frac{\partial}{\partial t} (\rho k) + \frac{\partial}{\partial x_i} (\rho k u_i) &= \frac{\partial}{\partial x_j} \left[\left(\mu + \frac{\mu_t}{\sigma_k} \right) \frac{\partial k}{\partial x_j} \right] \\ &+ G_k + G_b - \rho \varepsilon - Y_M + S_k \end{aligned} \quad (4)$$

$$\begin{aligned} \frac{\partial}{\partial t} (\rho \varepsilon) + \frac{\partial}{\partial x_i} (\rho \varepsilon u_i) &= \frac{\partial}{\partial x_j} \left[\left(\mu + \frac{\mu_t}{\sigma_\varepsilon} \right) \frac{\partial \varepsilon}{\partial x_j} \right] \\ &+ C_{1\varepsilon} \frac{\varepsilon}{k} (G_k + C_{3\varepsilon} G_b) - C_{2\varepsilon} \rho \frac{\varepsilon^2}{k} + S_\varepsilon \end{aligned} \quad (5)$$

The spherical harmonics (P1) model is used to calculate the radiation. The radiative transfer equation, Eq. 6 describes the transport of radiative intensity through a medium.

$$\begin{aligned} \frac{dI(\vec{r}, \vec{s})}{ds} + (a + \sigma_s) I(\vec{r}, \vec{s}) &= a n^2 \frac{T^4}{\pi} + \\ \frac{\sigma_s}{4\pi} \int_0^{4\pi} I(\vec{r}, \vec{s}') \Phi(\vec{s}, \vec{s}') d\Omega' \end{aligned} \quad (6)$$

where $a + \sigma_s$ is the optical thickness or opacity of the medium.

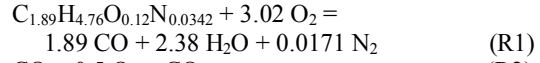
The P1 method permits the total radiative intensity over all solid angles, G , to be written as a Helmholtz Eq. 8;

$$G = \int_{4\pi} I d\Omega \quad (7)$$

$$\nabla \cdot \left(\frac{1}{3(k_a + \sigma_s)} \nabla G \right) - k_a G + 4k_a \sigma T^4 = 0 \quad (8)$$

This enables the incident radiation to be solved as a scalar quantity within CFD codes.

Combustions of the volatiles are simplistically represented by two overall reactions:



A turbulence chemistry interaction model, based on the work of Magnussen and Hjertager, 1976, called the Eddy Dissipation model employs for this simulation. The net reaction rate is taken as the minimum of these two Equations 11 and 12.

$$R_{i,r} = v'_{i,r} M_{w,i} A \rho \frac{\varepsilon}{k} \min \left(\frac{Y_R}{v'_{R,r} M_{w,R}} \right) \quad (9)$$

$$R_{i,r} = v'_{i,r} M_{w,i} A B \rho \frac{\varepsilon}{k} \frac{\sum_P Y_P}{\sum_j v'_{j,r} M_{w,j}} \quad (10)$$

where A and B are two model empirical constants equal to 4 and 0.5, respectively.

In discrete phase modeling, coal particles of known size distributions and properties are injected into the combustion chamber and tracked in a Lagrangian fashion throughout the computational domain. The trajectory of a discrete phase particle is computed by integrating the forces acting on the particle.

$$\frac{du}{dt} = F_D(u - u_p) + \frac{g_z(\rho_p - \rho)}{\rho_p} + F_x \quad (11)$$

where F_x is an additional acceleration (force/unit particle mass) term, $F_D(u - u_p)$ is the drag force per unit particle mass and

$$F_D = \frac{18\mu}{\rho_p d_p^2} \frac{C_D R_e}{24} \quad (12)$$

Here, u is the fluid phase velocity, u_p is the particle velocity, μ is the molecular viscosity of the fluid, ρ is the fluid density, ρ_p is the density of the particle, and d_p is the particle diameter. R_e is the relative Reynolds number, which is defined as

$$R_e = \frac{\rho d_p |u_p - u|}{\mu} \quad (13)$$

The devolatilization law is applied to a combusting particle when the temperature of the particle reaches the vaporization temperature. The constant rate devolatilization law indicates that volatiles are released at a constant rate with the following Eq. 16;

$$-\frac{1}{f_{v,0}(1 - f_{w,0})m_{p,0}} \frac{dm_p}{dt} = A_0 \quad (14)$$

For heterogeneous surface reactions, the following reactions (Watanabe and Otaka, 2006) are assumed to occur inside the gasifier during coal combustion.





The rate equation for char suggested by Kajitani et al., 2002 is based on the Random Pore Model and is used to conduct the simulation. The reaction rate is expressed as follows:

$$dx/dt = k_p (1-x) \sqrt{1-\psi_i} \ln(1-x) \quad (15)$$

where x indicates a conversion ratio of char and ψ_i is a dimensionless parameter indicating the initial pore structure. k_p is the reaction constant that follows the Arrhenius equation.

$$k_p = A_{O_i} P_{A_i}^n \exp\left(\frac{-E_i}{RT_p}\right) \quad (16)$$

5. RESULTS AND DISCUSSION

Fig. 2 shows the comparisons of outlet species concentration and outlet temperature between experiment and simulation. For species O_2 , H_2O , CO_2 and N_2 , the comparisons are plotted in terms of outlet composition (wt %), and the outlet temperature is scaled in Kelvin (right scale in the Fig. 2). This comparison shows that computation and the experiment (Schaffel et al., 2009) are in a good agreement.

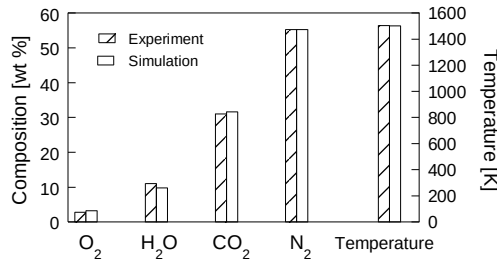


Fig. 2: Comparison of calculated outlet species composition and temperature with experimental (Schaffel et al., 2009)

In our previous study (Alam et al., 2010b), the temperature profiles, and the concentrations profiles for oxygen, carbon dioxide and carbon monoxide along the measurement traverses (From the centerline 0.15m, 0.44m, 1.32m and 4.97m for the Traverse 1, 2, 3 and 4, respectively, in Fig. 1) are compared with experimental (Schaffel et al., 2009). These comparisons confirm the validity of the current model.

5.1 Gas temperature profile

The Fig. 3 shows the gas temperature profiles at CO_2 to O_2 molar ratio of 3.3, 4.67 and 7.0 keeping constant CO_2 inlet mole composition. It is found that the temperature decreases with increasing the ratio of CO_2 to O_2 . It confirms the occurrence of char- CO_2 reaction (R4) at higher CO_2/O_2 ratio. Because of the endothermic behavior of char- CO_2

reaction the temperature of the gas environment decreases. The rate of char reaction with CO_2 and O_2 are discussed in section 5.2.

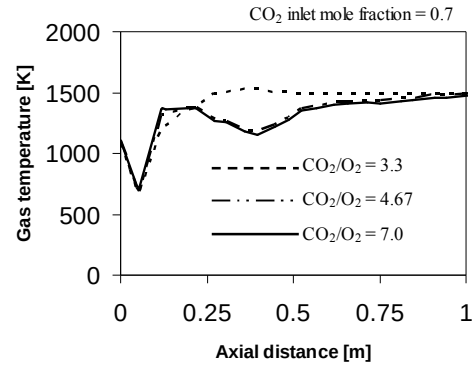


Fig. 3: Temperature profile along axial distance for various CO_2/O_2 ratios (at constant CO_2 inlet molar fraction)

5.2 Particle rate of reaction

The rate of char reaction with CO_2 and O_2 are investigated with various CO_2/O_2 ratios. At lower value of CO_2/O_2 ratio, the char- O_2 reaction (R3) rate becomes dominant than char- CO_2 reaction rate. But, the char- O_2 reaction rate becomes negligible compared to char- CO_2 reaction rate if the CO_2/O_2 ratio increases. In Fig. 4, the rates of char reaction with CO_2 and O_2 are shown for two CO_2/O_2 ratios of 3.3 and 7.0. It is clear that char- O_2 reaction and char- CO_2 reaction rate are dominant at lower and higher CO_2/O_2 ratio, respectively.

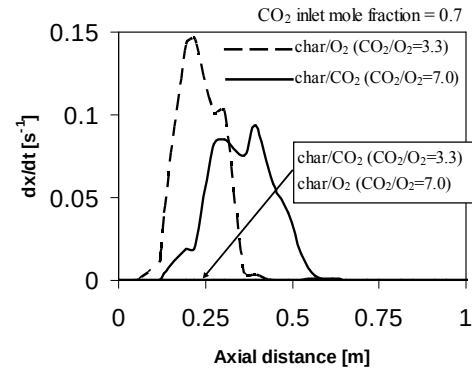


Fig. 4: Char rate of reaction profile along axial distance for various CO_2/O_2 ratios (at constant CO_2 inlet molar fraction)

5.3 Particle temperature

The changes of particle temperature with residence time for various CO_2/O_2 ratios at constant CO_2 inlet molar fraction are shown in Fig. 5. It is found that high CO_2/O_2 ratio produces lower particle temperature. The particle residence time also

reduces with higher concentration of CO_2 . This reduction in residence time is due to the occurrence of char- CO_2 reaction. The lower residence time may reduce the heat loss by particle radiation during coal combustion.

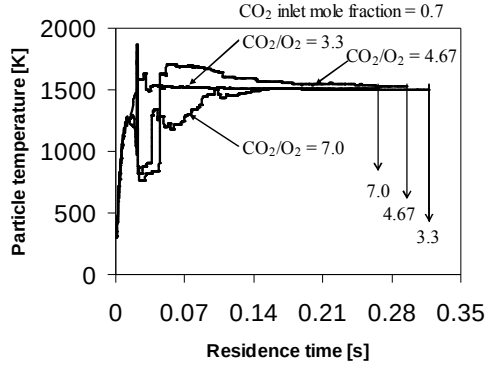


Fig. 5: Change of particle temperature with residence time for various CO_2/O_2 ratios (at constant CO_2 inlet molar fraction)

5.4 Effect of particle size

The effects of inlet particle size are carried out by simulating the coal gasification with four different particle sizes (20, 30, 100 and 150 μm). For a single particle, the calculated results are shown in Fig. 6 and Fig. 7. In the Fig. 6, it is seen that the particle shows much lower temperature if the inlet particle diameter is large. Therefore, to keep the high particle temperature, the particle size should be small. From the Fig. 6, it is also found that the residence time is also very high for large coal particle than that of smaller one. This indicates the rate of particle disappearance is faster for smaller size coal particle.

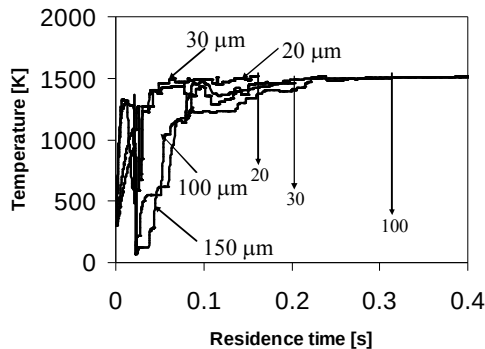


Fig. 6: Change of particle temperature with residence time for various inlet particle diameters

The particle density is also changed during the coal combustion and the corresponding changes with

particle residence time for different particle sizes are shown in Fig. 7. It is found that the large particle shows high density than the smaller size particle at same residence time. It is because of the rapid disappearance of coal particle for smaller size that is explained in previous paragraph.

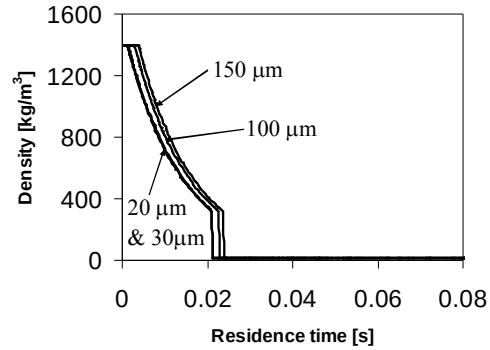


Fig. 7: Change of particle density with residence time for various inlet particle diameters

6. CONCLUSIONS

The numerical simulations for pulverized coal combustion are carried out under various CO_2/O_2 inlet molar ratios. The higher CO_2/O_2 ratio produces lower temperature for both gas phase and solid particle. But the rate of char- CO_2 reaction increases significantly with increasing CO_2/O_2 ratios. High CO_2/O_2 ratio also reduces the residence time for coal particle which are assumed to reduce the radiation heat loss during combustion. The particle size shows a significant role during pulverized coal combustion. Smaller size coal particle can perform higher temperature and shorter residence time in the reactor. It can minimize the gas and solid particle temperature not to become suddenly reduced under higher CO_2/O_2 ratio. For getting efficient coal combustion it is predicted that high CO_2/O_2 ratio with smaller coal particle would be preferable for pulverized coal combustion.

NOMENCLATURE

A	Area, m^2
A_0	Rate constant, s^{-1}
a	Absorption coefficient, m^{-1}
C_w	Swelling coefficient, dimensionless
d_p	Particle diameter, m
f_v	Particle's volatiles fraction, dimensionless
g	Gravitational acceleration, m/s^2
J	Mass flux, $\text{kg/m}^2\text{-s}$
I	Radiation intensity, $\text{W m}^{-2} \text{s}^{-1}$
k	Turbulent kinetic energy, m^2/s^2

m_p	Particle mass, kg
M_w	Molecular weight, kg/kgmol
p	Pressure, Pa
s	Path length, m
T	Temperature, K
t	Time, s
v	Velocity, m/s
Y	Mass fraction, dimensionless
ε	Turbulent dissipation rate, m^2/s^3
∂_s	Scattering coefficient, m^{-1}
∂	Stefan-Boltzmann constant, $\text{W}/\text{m}^2\text{-K}^4$
Φ	Phase function
Ω'	Solid angle, degree
μ	Dynamic viscosity, Pa-s
ρ	Density, kg/m^3
η_r	Effectiveness factor, dimensionless

ACKNOWLEDGMENTS

This research is partially supported by NEDO project under Innovative Zero-emission Coal Gasification Power Generation Project. The authors would also like to acknowledge the GCOE for providing research funding.

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PRESSURE DATA ANALYSIS AND RESERVOIR PARAMETER ESTIMATION OF KAILASTILLA GAS FIELD (WELL NO. KTL-01& KTL-02)

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ABSTRACT

The reservoir parameter estimation on the basis of pressure transient data and production data at the well is an essential part in the prediction of reservoir behavior. The estimation of these parameters in a dynamical system is referred to as parameter estimation, identification or inverse problem. In this paper the reservoir parameters-permeability, skin factor, average pressure, wellbore storage coefficient, reservoir drainage extent are estimated on the basis of pressure data observed at the wellbore and production data using build up test (MBH) and deliverability test methods. This paper represents the contribution in quantifying the effects of wellbore storage along with the skin intensity on deliverability from gas wells. Generalized charts for type curve studies on gas wells, based on pseudo-pressure and pressure squared concepts, along with wellbore storage, are presented with applications and support from field data.

Key words: Single phase gas reservoir, type curve analysis, pressure transient test, skin factor and wellbore storage, inflow performance curve.

1. INTRODUCTION

Gas well test analysis is a branch of petroleum engineering. Information derived from flow and pressure transient tests about in-situ reservoir conditions is important in many phases of petroleum engineering. The reservoir engineer must have sufficient information about the reservoir/well conditions and characteristics to adequately analyze reservoir performance and forecast future production under various modes of operation. Pressures are most valuable and useful data in reservoir engineering. Directly or indirectly, they enter into all phases of reservoir engineering calculations. Therefore accurate determination of reservoir parameters is very important. In general, gas well test analysis is conducted to meet the following objectives:

- Formation permeability
- Average reservoir pressure
- Connected reservoir pore volume
- Degree of formation damage or stimulation
- Distance to a fault if present
- Fracture length
- Fracture conductivity
- Wellbore storage coefficient
- Detection of reservoir heterogeneities such as fractures, layering and mobility changes
- Reservoir areal extent
- To estimate skin factor or drilling and completion related damage

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2. METHODOLOGIES AND OBJECTIVES

2.1 OBJECTIVES

The objectives of this study are to analyze the well test data available for well KTL-01 and KTL-02 to estimate the following parameters and finally these estimated parameters are compared with the previous study was conducted by Al Mansoori Wireline Services.

- The formation permeability
- The skin effect
- Average reservoir pressure
- Wellbore storage coefficient
- Reservoir areal extents
- Productivity of the formation and deliverability of the wells
- The Absolute-Open-Flow-Potential (AOFP) of the wells

2.2 Data Collection and Processing

To accomplish this study all data are collected from “Sylhet Gas Fields Limited (SGFL)” through “Petrobangla” of Bangladesh.

The raw data file contains some pressure data recorded before and after the test period, when pressure gauges were running and pulling respectively. The pressure data recorded before and after test period create some problem during analysis. It is not possible to obtain the desired parameters until remove these extra pressures data. To avoid complication in test interpretation and to obtain better results these data are filtered in the following ways.

2.2.1 Data Removing

There are three methods used to filter data. Here two methods, grid method and plot method are used. In grid method, highlighted the last row of “data recorded before test”, clicked right button of mouse over the row number column and finally clicked “delete all rows before” from the pop-up menu to delete selected rows. In the same way, the data recorded after the test is removed.

In plot method, the specific point can be removed. In this study, the data outside the curve are removed by this method. Just, the specific data

point is selected and clicked on delete button on the same toolbar to remove the point.

2.2.2 Data Filtering

To filter the data logarithmic time steps (300 points per log cycle) for build-up periods and arithmetic time steps (0.25 hr per time step) for flow periods are used. Data are filtered for obtaining better results only.

The production data is entered manually into well testing software “FEKETE” after processing the pressure data. Finally, the PVT data and reservoir properties are entered. To estimate the desired parameters the semi log, log-log and derivative plots are used for pressure transient test and, AOF and IPR curves are created for flow-after-flow test. These plots are analyzed and desired parameters are obtained.

2.3 Methodologies

There are several methods may be used to estimate the reservoir parameters. The pressure build-up test, type curve analysis, Dietz_MBH method, and flow after flow test methods are used to complete this study. Permeability and skin due to damage are estimated by build-up test of radial analysis by developing semi log and derivative type curves. These values of parameters are used as input parameters for Dietz_MBH method. After entering these parameters into “FEKETE software” the Dietz_MBH method gives the output values of reservoir areal extents and these areal extents again used as input parameters for Dietz_MBH method and finally the average reservoir pressure is estimated. Finally, the absolute open flow potential (AOFP) is estimated by the flow after flow test. To conduct the flow after flow test the reservoir production rate and the pressure of sand face and well head are used. For this, inflow performance (IPR) and outflow performance (OPR) curves are created.

3 RESULTS AND DISCUSSIONS

3.1 Buildup Analysis

From Table-1 it is obtained that the total skin effect (S) are negative for both well KTL-01 and well KTL-02. But it is tough to conclude that the wells are stimulated as all the skin components have not been analyzed here.

The average reservoir pressure, P_{avg} (3499.3 psia) from Dietz_MBH analysis for KTL-01 in Table-1 is closer to initial reservoir pressure indicates that the reservoir is at its early stage of production. But in case of KTL-02 the average reservoir pressure is greater than the initial reservoir pressure. This may be the error at the time of data recording. The areal extents indicate the reservoir is rectangular in shape which is consistent with assumption. The results are tabulated here from pressure semi log plots, pressure derivative type curves and dimensionless type curves. The resultant values of a specific

parameter obtained from all analysis methods are same. For this reason, the specific method has not been mentioned in Table containing results.

The obtain results from this study are so much dissimilar with the results of Al Mansoori Wire lines Services model study though all the input parameters are near about same. The main reason of this dissimilarity is that, Al Mansoori Wire lines Services did not perform any diagnostic analysis. They found their results by model analysis only. It is also highly pointed out that, they mentioned in their report that their results were erroneous but they did not mention any reason of this erroneous results.

Table-1: Results and comparison of this study and Al Mansoori Wireline Services for well KTL-01 and KTL-02

Parameters	Analysis Value		Al Mansoori Wireline Services model value		Remarks
	Well KTL-01	Well KTL-02	Well KTL-01	Well KTL-02	
K(md)	46.0842	699.098	147	4700	Average permeability
Kh(md.ft)	2995.47	27963.92	9550	197000	Total permeability-thickness product
S^-	-5.557	-0.332	3	25	Total skin
S_d	Not found	Not found	Not available	Not available	Skin due to damage
P_i (psia)	3515	3221	3515	3221	Initial pressure
P^* (psia)	3503.8	3223.8	Not available	Not available	Extrapolated pressure
$P_{(avg.)}$ (psia)	3499.3	3222.4	Not available	Not available	Average reservoir pressure
$P_{(syn)}$ (psia)	3658.7	3373.7	Not available	Not available	Synthetic pressure
X_e (ft)	12736.735	14032.289	6000	4000	Reservoir length
Y_e (ft)	2188.818	1986.792	6000	4000	Reservoir width
X_w (ft)	6368.367	7016.135	300	Not available	Well location in X-direction
Y_w (ft)	1094.409	993.366	300	Not available	Well location in Y-direction

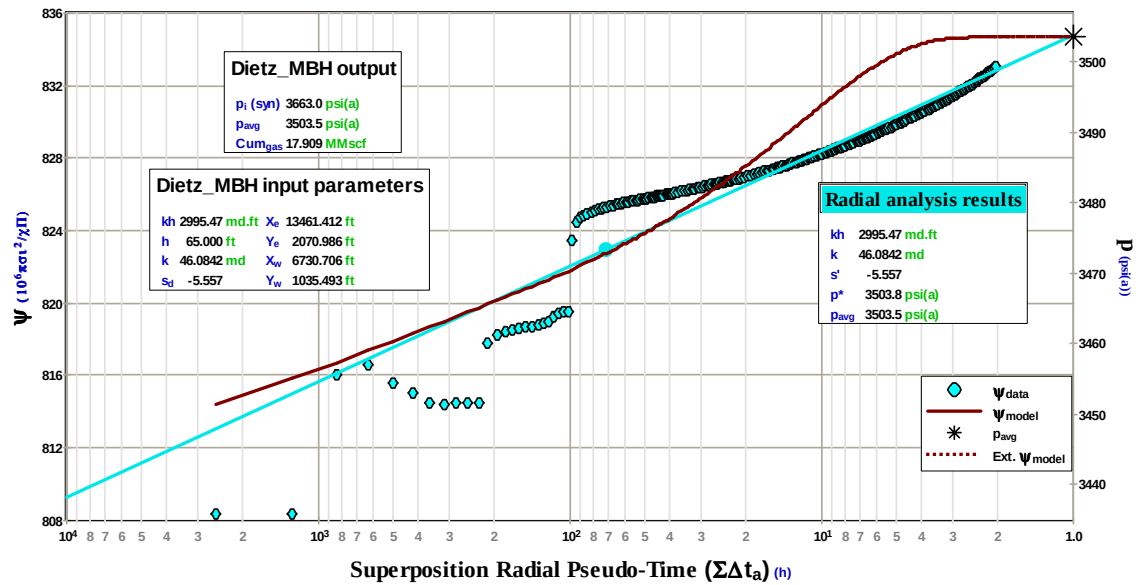


Figure-1: Semi log plots of radial analysis and Dietz_MBH model analysis for KTL-01

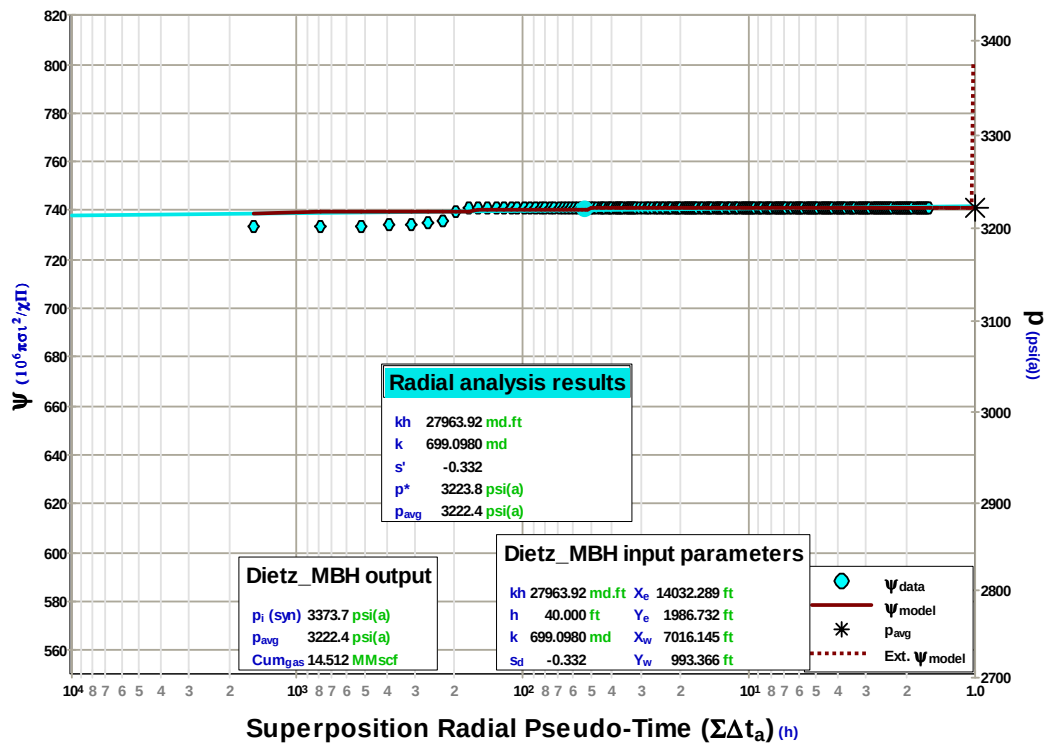


Figure-2: Semi log plots of radial analysis and Dietz_MBH model analysis for KTL-02

3.2 Flow-After-Flow Test Analysis

The obtained value of 'n' for KTL-01 from both pseudo-pressure method and pressure squared method in case of sand face flow and well head flow indicate the Darcy flow which are consistent with assumption of the empirical equation . On the other hand, the value of n for KTL-02 in case of sand face flow indicates the non-Darcy flow but in case well head flow it indicates a Darcy flow. This is because; it was not possible to record the production test appropriately for KTL-02 due to inactiveness of gas flow meter.

The flow-after-flow test analysis results obtained from this study are so much dissimilar with the results obtained from Al Mansoori Wire Lines Services. This may happen for several causes as, Al Mansoori Wire Lines Services was performed model analysis only which is theoretical, the obtained value of 'n' from their study is 1.15 for KTL-01 which should be in between 0.5 to 1.0.

Table-2: Deliverability test results for KTL-01 in terms of pressure squared

Parameter	Sand face value	Well head value
$P_{avg}(psia)$	3499.3	2860
AOF(mmscfd)	293.210	237.292
$C[(mmscfd/10^6)/(psi^2)^n]$	$8.50e^{02}$	$2.57e^{02}$
N	0.781	0.863

Table-3: Deliverability test results for KTL-02 in terms of pressure squared

Parameter	Sand face value	Well head value
$P_{avg}(psia)$	3222.4	2714.7
AOF(mmscfd)	531.567	216.251
$C[(mmscfd/10^6)/(psi^2)^n]$	$1.65e^{05}$	$2.93e^{01}$
n	0.5	1.0

Table-4: Comparison of sand face flow-after-flow test results in terms of Pseudo-pressure with Al Mansoori Wireline Services model results for KTL-01

Parameters	Analysis Value	Al Mansoori value
AOF (mmscfd)	336.961	852.2
$C [mmscfd/(10^6 psi^2/cp)^n]$	1.80	$4.86e^{01}$
n	0.778	1.15

Table-5: Comparison of sand face flow-after-flow test results in terms of Pseudo-pressure with Al Mansoori Wireline Services model for KTL-02

Parameters	Analysis Value	Al Mansoori value
AOF (mmscfd)	583.610	3575
$C [mmscfd/(10^6 psi^2/cp)^n]$	2.14^{01}	$7.99e^{05}$
n	0.5	0.638

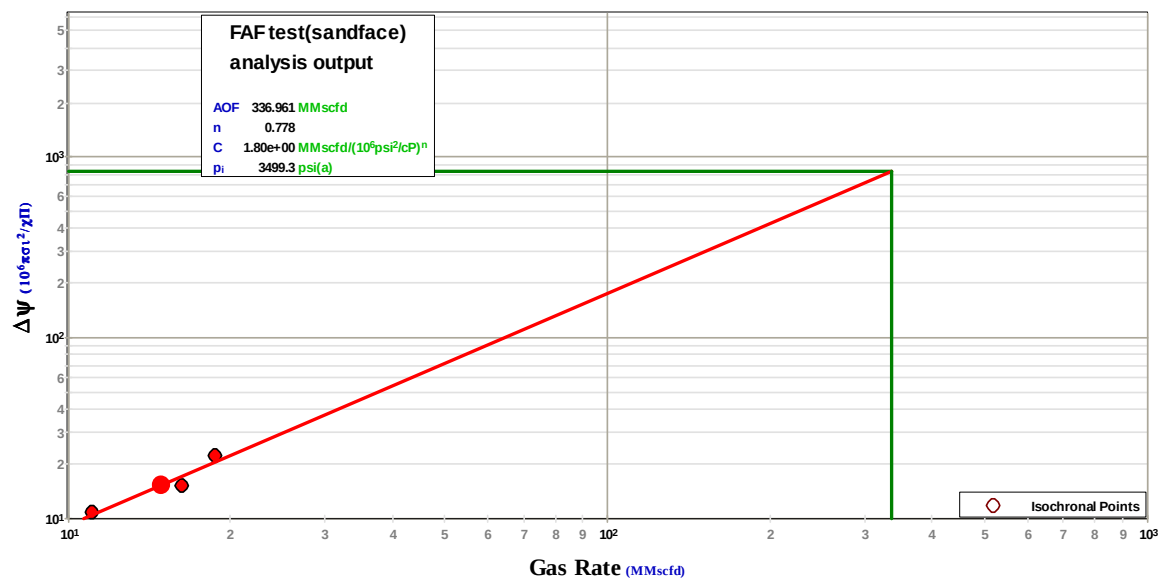


Figure-3: Sand face flow after flow test analysis curve in terms of Pseudo-pressure for KTL-01

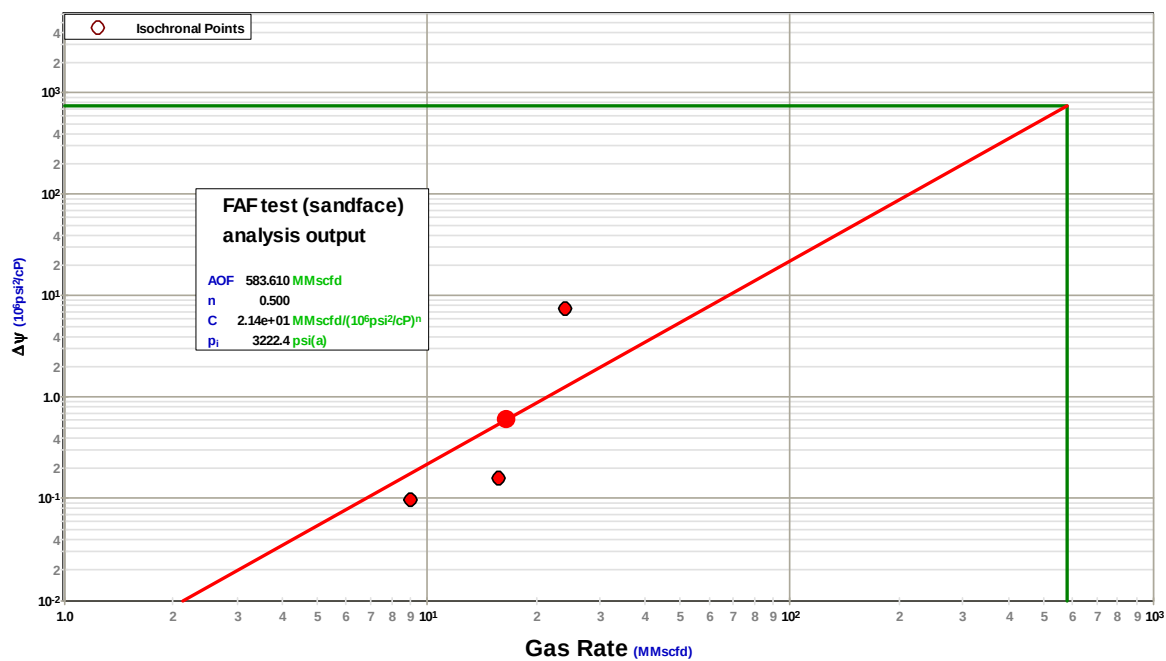


Figure-4: Sand face flow after flow test analysis in terms of Pseudo-pressure for KTL-02

CONCLUSION

In this study pressure buildup data and deliverability data are analyzed and different reservoir parameters are estimated. These parameters are compared with the previous study of Al Mansoori Wire Lines Services, which revealed better results of this study and fortified the robust analysis procedure.

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RESERVOIR CHARACTERIZATION USING GEOSTATISTICAL METHOD

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ABSTRACT

Reservoir characterization is the process of describing various reservoir characteristics with the exploitation of available data. Petroleum reservoirs are generally heterogeneous in nature. This heterogeneity is captured with different reservoir properties. Geostatistics is a statistical technique that accounts the spatial variation of these reservoir properties. This paper focuses on geostatistical approach to provide porosity distributions of the reservoir based on available porosity-permeability data at different well locations. Isotropic variogram models are applied first and then kriging technique to estimate spatial distribution of porosity. Cokriging technique is then applied to incorporate a second variable- the permeability and the result is the more robust estimation of the variable. The final porosity distribution is presented in a 2-D map. Finally, the cross validation is completed to assess the reliability of estimation.

Keywords: Reservoir characterization, Geostatistics, Variogram, Kriging, porosity-permeability.

1. INTRODUCTION

Reservoir characterization on the basis of available data is essential for proper reservoir management. Ideally, all the different sources of data should be incorporated for reservoir characterization for better description. In practice, however, several problems are associated with the utilization of all the data at a time. The problems include: all the data are not available at the same time, the quality of data collected from various sources may differ, information collected from different sources may not be measured at the same scale and data interpretation may be qualitative rather than quantitative. As a result of these limitations, the reservoir characterization is usually completed based on the part of the available data.

Another problem in reservoir characterization arises due to the spatial heterogeneity associated with a reservoir. The data dealt under this study such as permeability and porosity are macroscopic heterogeneities measured at a core level. Geostatistics is an excellent tool to capture reservoir heterogeneity and generate spatial distribution of reservoir properties for each virtual grid.

2. GEOSTATISTICS

The main reason of using Geostatistics for reservoir characterization is that, geostatistical procedures are versatile enough to apply in several purposes related to reservoir description. This includes- interpolation and extrapolation of the values at unsampled locations, providing the quantitative relationship describing the spatial variability of a reservoir property, providing different ways of defining uncertainties in estimated values at unsampled locations, incorporating other variables to estimate one variable. The relationships may include information concerning how neighboring values of the same variable are related to each other or information concerning what the chances are that two different variables are close to each other. This can not be done by conventional statistical methods such as inverse-distance-weight (IDW) or normal-distance-weight (NDW).

The basic principle of Geostatistics is that, in many natural phenomena, data values that are close together intrinsically have higher spatial correlation than points that have higher separation distance. Application of Geostatistics is a three-step procedure: 1) assumption of stationarity, 2) spatial

modeling of sample data (variogram analysis and modeling), and 3) estimation of a variable value at unsampled locations (kriging or cokriging).

3. METHODS

Before performing the modeling and estimation, data should be carefully analyzed to identify patterns within the known data to determine if points are uniform, random, isotropic or anisotropic, correlated or clustered. The data analysis is performed through the calculation of mean, variance, minimum, maximum, standard deviation, histograms, scatter plots, cross plots etc. The final analysis begins according to the knowledge of these summarized results.

3.1. Measures of spatial distribution

3.1.1. Variogram: The most common spatial distribution analysis is variogram analysis and modeling. Variogram is a prerequisite for estimation by kriging and cokriging. The variogram, $\gamma(h)$, is half the average squared difference between paired data values. Mathematically it is defined as

$$\gamma(h) = [1 / 2N(h)] \sum [x_i - x_{i+h}]^2 \quad (1)$$

where,

$\gamma(h)$ = Semivariance for interval distance class h ;

x_i = measured sample value at point i ;

x_{i+h} = measured sample value at point $i+h$; and

$N(h)$ = total number of sample couples for the lag interval h .

3.1.2. Isotropic variogram models: The variogram is a graph of semivariance vs. separation distance. Where autocorrelation is present, semivariance is lower at smaller separation distances (autocorrelation is greater). This typically yields a curve such as that described in Figure-1, which can be modeled using three terms – a nugget variance, a sill, and a range.

There are three most common types of isotropic models (Spherical, Exponential and Gaussian), each of which can be described based on three parameters:

Nugget Variance or C_0 – the y-intercept of the model; the nugget variance can never be greater than the sill.

Sill or C_0+C – the model asymptote; the sill can never be less than the nugget variance.

Range (A) – the separation distance over which spatial dependence is apparent. This is sometimes called Effective Range in order to distinguish range (A) from a model's range parameter (A_0). The Range A is calculated from A_0 as described later in the formulas for the different models.

The spherical isotropic model is a modified quadratic function for which at some distance A_0 pairs of points will no longer be autocorrelated and the semivariogram reaches an asymptote. The formula used for this model is:

$$\gamma(h) = C_0 + C [1.5(h / A_0) - 0.5(h / A_0)^3] \quad (2)$$

for $h \leq A_0$

$$\gamma(h) = C_0 + C \quad (3)$$

for $h > A_0$

In the case of the spherical model, the effective range $A = A_0$.

The exponential isotropic model is similar to the spherical in that it approaches the sill gradually, but different from the spherical in the rate at which the sill is approached and in the fact that the model and the sill never actually converge. The formula used for this model is:

$$\gamma(h) = C_0 + C[1 - \exp(-h / A_0)] \quad (4)$$

In the case of the exponential model, the effective range $A = 3A_0$.

The Gaussian or hyperbolic isotropic model is similar to the exponential model but assumes a gradual rise for the y-intercept. The formula used for this model is:

$$\gamma(h) = C_0 + C[1 - \exp(-h^2 / A_0^2)] \quad (5)$$

In the case of the Gaussian model, the effective range $A = 3^{0.5}A_0$. The sill never meets the asymptote in the Gaussian or exponential models.

3.2. Estimation techniques

3.2.2. Kriging: The Kriging technique uses a linear estimation procedure to estimate a value at unsampled locations. In principle, the technique assumes that the value at the unsampled location is estimated by

$$X^* (\vec{u}_0) = \sum_{i=0}^n \lambda_i X (\vec{u}_i) \quad (6)$$

Where,

$X^* (\vec{u}_0)$ = the estimated value at the unsampled location,

$X(\vec{u}_i)$ = the value at the neighboring location, $\vec{u}_i$,
 n = the total number of samples selected within a search neighborhood, and
 λ_i = the weight assigned to the neighboring value.

In other words, the estimated value is a weighted average of the neighboring values. All of the kriging algorithms use this basic equation with minor variations, depending on the particular application.

There are two common types of kriging procedures: simple kriging and ordinary kriging. Simple kriging requires knowledge of the mean, which may not be known in practice without prior assumptions. Therefore, this type of kriging procedure is not very popular. Simple kriging starts with the assumption that a value at an unsampled location can be estimated by

$$X^*(\vec{u}_0) = \lambda_0 + \sum_{i=1}^n \lambda_i X(\vec{u}_i) \quad (7)$$

Where, λ_0 is a constant.

Ordinary kriging is the most popular technique, which eliminates the need for knowledge of the mean value. It also is easier to adapt to local variations. It is the most widely applied kriging technique. The estimate is written as

$$X^*(\vec{u}_0) = \sum_{i=1}^n \lambda_i X(\vec{u}_i) \quad (12)$$

forcing λ_0 to be zero.

3.2.3. Cokriging: Cokriging is an interpolation technique that allows one to better estimate map values if the distribution of a secondary variate is known. The secondary variate (also called a covariate or Y) is sampled from the same locations as the primary variate X, and also from a number of additional locations. If the primary variate is difficult or expensive to measure, then cokriging can greatly improve interpolation estimates without having to more intensely sample the primary variate.

The cokriging estimate is based not only on distance to nearby sample locations for X and the variogram for X, but also distance to nearby sample locations for Y, the variogram for Y, and the cross-variogram for X x Y. This can provide a more robust estimate of X at unsampled locations if X and Y are sufficiently correlated.

Prior to cokriging one must a) define a covariate, b) perform semivariance analysis (including variogram modeling) for the primary variate X, for the covariate Y, and c) for the cross variate X x Y.

To estimate a value, $x^*(\vec{u}_0)$ at the unsampled location, $\vec{u}_0$ we can write the estimation equation as

$$X^*(\vec{u}_0) = \sum_{i=1}^n \lambda_{x_i}^* X(\vec{u}_{x_i}) + \sum_{k=1}^n \lambda_{y_k}^* Y(\vec{u}_{y_k}) \quad (15)$$

Where, λ_{x_i} is the weight assigned to the sample, $X(\vec{u}_{x_i})$, located at $\vec{u}_{x_i}$ and λ_{y_k} is the weight assigned to the sample, $Y(\vec{u}_{y_k})$, located at $\vec{u}_{y_k}$.

3.3. Cross validation

Cross validation involves the estimation of values at the sampled locations so that the estimation can be compared with the sampled values. The most common cross validation involves the “leaving one out” method. In this method, one sample point at a time is removed from the sample data, and using the remaining sample points, the value of the variable at the now “unsampled” location is estimated. The estimated value is then compared with observed value. The procedure is repeated at all sampled locations, to have an estimated value at every sampled location.

4. RESULTS AND DISCUSSIONS

4.1. Porosity prediction

To determine the spatial relationship of porosity values several variograms are calculated. Three variogram models (Spherical, Exponential and Gaussian) are analyzed to capture best continuity. Only spherical model is shown in Fig. 1.

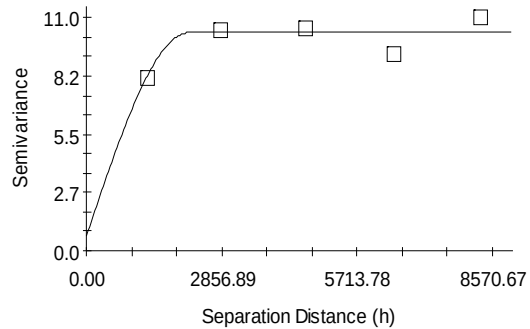


Fig. 1: Spherical isotropic variogram of porosity. (Nugget = 0.69, Sill = 10.29, range = 2170 meters).

The variogram properties are then used for ordinary kriging. The result shows how kriging produces a crude contour of actual data samples (Fig. 2). Near the well points and at small search neighborhoods, bull's eyes are apparent. The erroneous constant porosity region shows the lack of well control and effect of extrapolation. The standard deviation near the well points is around 0.7 and more than 3 where

estimation lacks of well control. Cross validation (Fig. 3) shows standard error of $\pm 69.8\%$, showing that the kriging estimation model is highly erroneous.

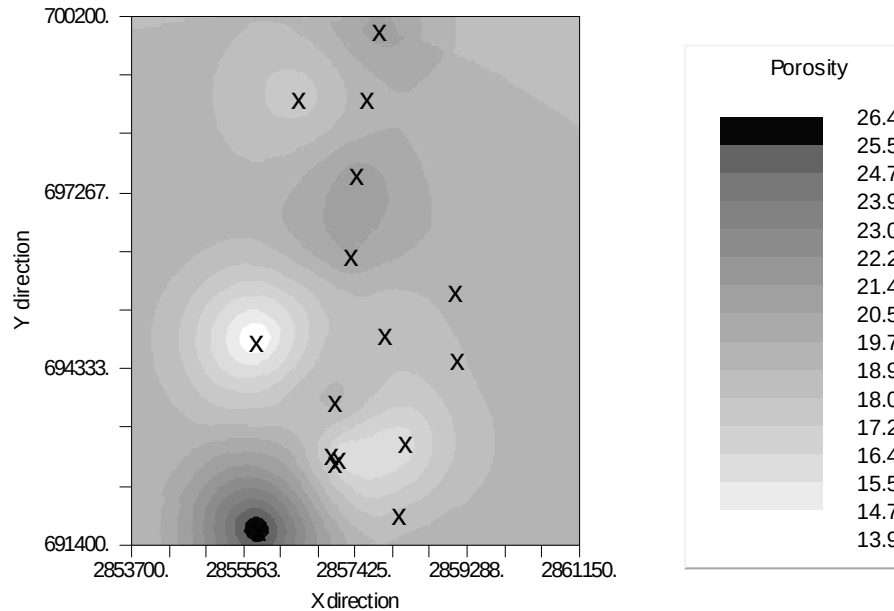


Fig. 2: Porosity distribution map resulted from ordinary kriging.

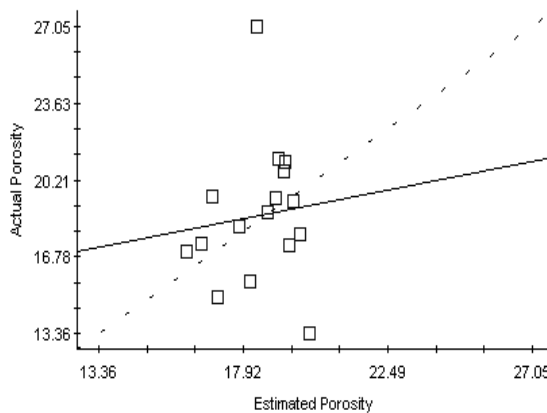


Fig. 3: Cross validation for ordinary kriging.

To minimize the estimation error, cokriging is performed incorporating a second variable (permeability) to establish the porosity distribution.

The process of estimation by cokriging is similar to kriging except it exploits a second variable and thus the variogram of permeability and a cross variogram of porosity-permeability have to be calculated. The variograms are shown in Fig. 4 and Fig. 5.

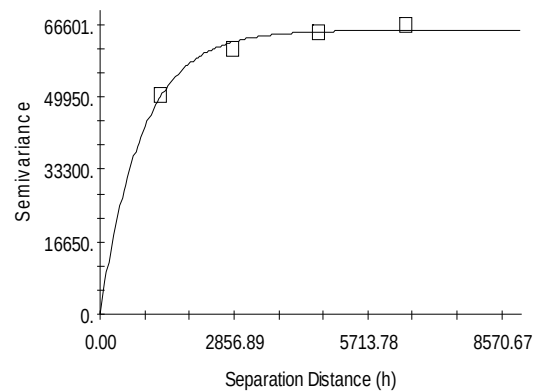
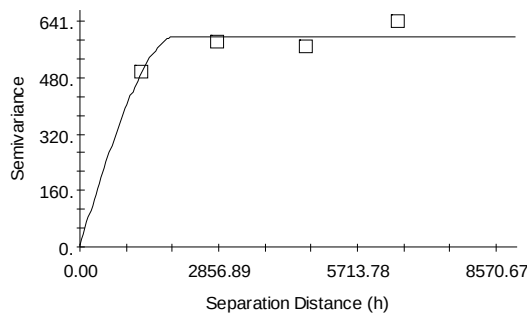


Fig. 4: Spherical isotropic variogram of permeability. (Nugget = 2700, Sill = 64080, range = 2180 meters).



The estimation map obtained from simple cokriging provides relatively better picture of porosity distribution (Fig. 8). Cross validation (Fig. 10) with a standard error of $\pm 7\%$ indicates a good estimation model.

However, in both cases bull's eyes and crude contouring around well points are apparent which is due to the lack of sufficient sample points and may be the aberration of stationarity at extreme values.

Fig. 5: Spherical isotropic cross variogram of porosity and permeability. (Nugget = 6, Sill = 597.7, range = 1990 meters).

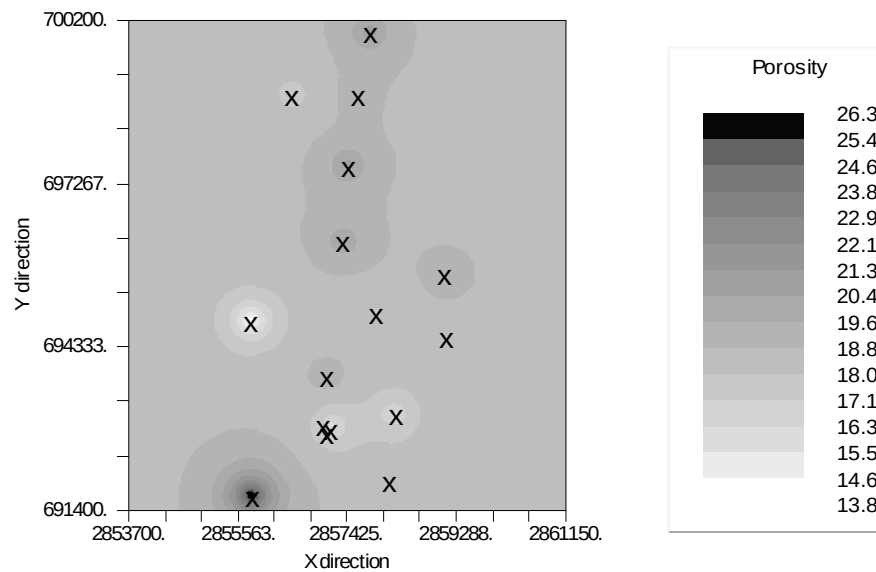


Fig. 6: Porosity distribution map resulted from simple cokriging.

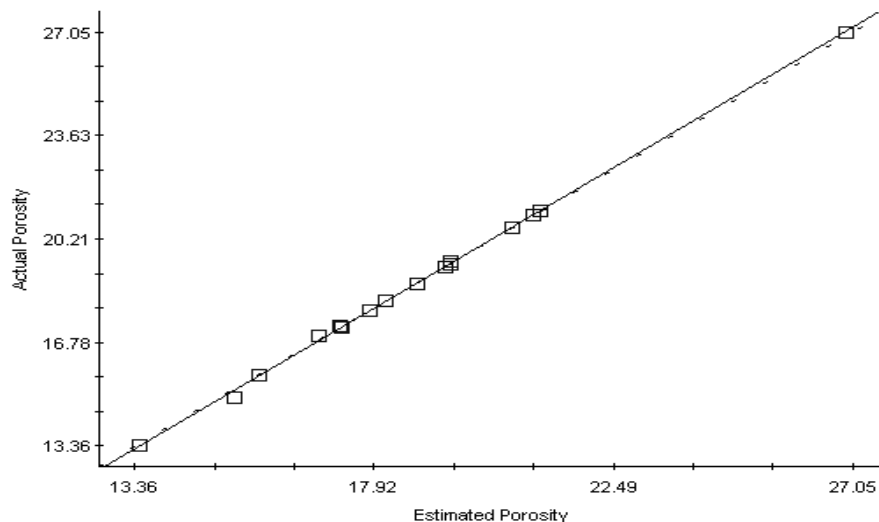


Fig. 7: Cross validation of simple cokriging estimate. (SE=0.007)

5. CONCLUSION

Characterizing a gas reservoir is a complex and costly procedure. Prediction of reservoir properties in different grids is essential for numerical reservoir simulation. Geostatistics provides good estimation techniques allowing the analysis of spatial distribution of values and error analysis. In this study, porosity distribution model predicted by cokriging gives good estimation as expected. However, the methods applied here could not produce a clear picture at a distance apart from the well points and the distinct zone may represent different zone of stationarity. The estimation model can be improved by incorporating other well points from future wells. Besides, the methods are versatile enough to estimate heterogeneous reservoir properties.

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Structural Analysis of Fenchugonj Gas Field

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ABSTRACT

The Fenchugonj structure is located in the southern part of the Surma Basin, Bangladesh. The paper presents an integrated interpretation of seismic data considering the available geologic information. Nine seismic sections of this area have been analyzed to interpret the subsurface geology, structure and stratigraphy. Based on the seismic sections and well data, two prominent reflecting horizons have been identified. The litho-stratigraphy of the Fenchugonj structure is prepared on the basis of well information. The lithological sequences encountered in the area ranging from Oligocene to Pliocene age. The gas bearing sands of the structure are within Lower Bokabil to Upper Bhuvan Formations of the Late Miocene age. The seismic study indicates that the Fenchugonj structure is a low hillock, high amplitude fold which is EW elongated anticline affected by a major reverse fault on the eastern flank. It is an asymmetrical anticline with the axis of steep north flank and gentle south flank.

Keyword: Fenchugonj structure, Seismic interpretation, Stratigraphy, Reverse fault.

1. INTRODUCTION

Bangladesh belongs to a young deltaic sedimentary basin named as the Bengal basin. The development of the Bengal Basin meets the geological requirements for the generation and accumulation of natural gas in the subsurface. Fenchugonj field is located near the western margin of the folded belt into the Bengal Basin which appeared as a reversely faulted anticline with a NNE-SSW trending axis. It is bounded by Longitude E $91^{\circ}53' - 92^{\circ}$ and Latitude N $24^{\circ}30' - 24^{\circ}37'$ and is 30 km long and 8 km wide. Fenchugonj structure is situated on the Sylhet trough, formed due to continuous uplift of Shillong Massif with simultaneous subsidence, is oval shaped and represents negative anomaly. It is sharply asymmetric with steep north flank and gentle south flank. Fenchugonj structure is consisting of alternate shale and sandstone in varying proportion. The eastern folded belt comprises sediments of Oligocene to Recent age. This field was discovered by Petrobangla in 1988 and it should be noted here that after discovering this field, no significant research have yet been performed on the Structural development of the area. Thus, the objective of this research is to reconstruct structural maps of the interfaces between formations, identifies channel, fault and other structure delegation at seismic lines

and finally interpret the analyzed results for understanding the Structural development of the area.

2. METHODOLOGY

Seismic prospecting is the best and most popular indirect method used for locating subsurface structures and stratigraphy that may contain hydrocarbons. The basic seismic method is consisting of data acquisition, processing and interpretation equipment which has three main components such as an input source, an array of detectors and a recording instrument. The type and relative size of the acoustic-impedance changes called the *Reflection coefficient* and the time taken from the initial bang to the recording of a reflection is called *Two-way time* (TWT). At the processing stage, basically five items of correction (such as Preprocess, Correction of amplitude, Correction of travel time, CDP stacking and Imaging) have done to get a clear image of the subsurface structure from the raw shot record. In each stage of processing, careful analysis of data and parameter tests are required to optimize the result. The actual requirements and equipment also needed to carry out a seismic interpretation.

In this paper, seismic reflection and well log data were mainly used which were obtained from Bangladesh Petroleum Exploration & Production Com-

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pany Limited (BAPEX) which has been interpreted to obtain information on the structure of the area. Nine 2-D seismic reflection sections of the study area have been analyzed. In order to interpret seismic sections, seismic marker horizons were selected and reflection times were picked to make the cross-sectional maps by developing time and depth structure maps.

3. RESULT & ANALYSIS OF INTERPRETATION

3.1 Interpretation of Seismic data

Seismic interpretation is the process of determining information about the subsurface of the earth from seismic data. There are two main approaches to the interpretation of seismic sections: *Structural analysis* which is the study of reflector geometry on the basis of reflection times, and *Stratigraphic analysis* which is the analysis of reflection sequences as the seismic expression of lithologically distinct depositional sequences. Structural interpretation is the first major step of geophysical interpretation and main application is in the search for structural traps containing hydrocarbon. During 1979 – 1981, Prakla Seismos carried out multifold seismic survey on behalf of BOGMC (then BAPEX, subsidiary of Petrobangla). The seismic data has 12 fold stacking, finite difference migrated sections, in which three (3) strike lines (such as: PKFG-2 EXT., PKFG-9 &

PKFG-8) and six (6) dip lines (such as: PKFG-1, PKFG-3, PKFG-4 EXT., PKFG-5, PKFG-6 & PKFG-7) were shot using in UP (Underground Point) location map of Fenchugonj structure. The quality of the seismic data used for this interpretation was fair to good.

A structure contour is an imaginary line connecting points of equal altitude on a single horizon. The closer the structure contours are to each other, the steeper is the dip. The slope is also the steeper (Billings, 2005). For structural interpretation, well #3 is considered, seismic line PKFG-4 is considered as the basis strike line at SP (Shot point) 214 m. show two gas horizons, which are named Upper and Lower gas sands respectively. All sections were interpreted manually by hand and prepared time & depth structure contour maps, where depth conversions by using T-Z (Time-Depth) curve, which are more authentic.

3.2 Cross-sectional map of Fenchugonj structure

Cross-sectional maps were constructed from depth contour maps, which graphically representation of structure. It is the easiest method for anyone to understand the ground structure and true subsurface geometry (Figures 1 & 2).

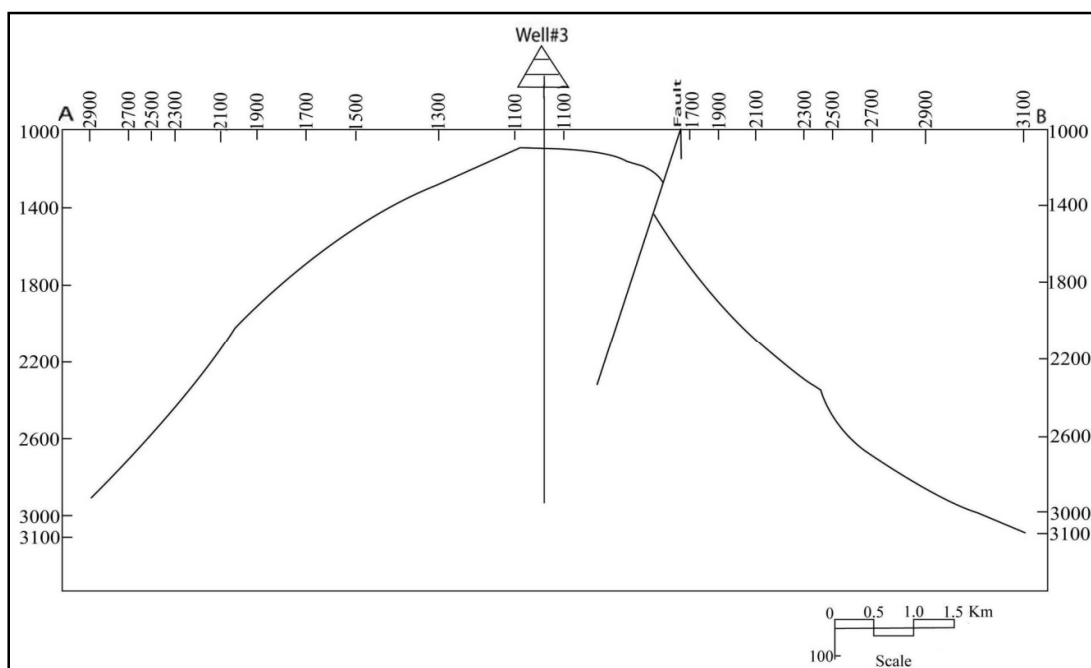


Fig. 1: Cross -sectional map for Upper Gas Sand

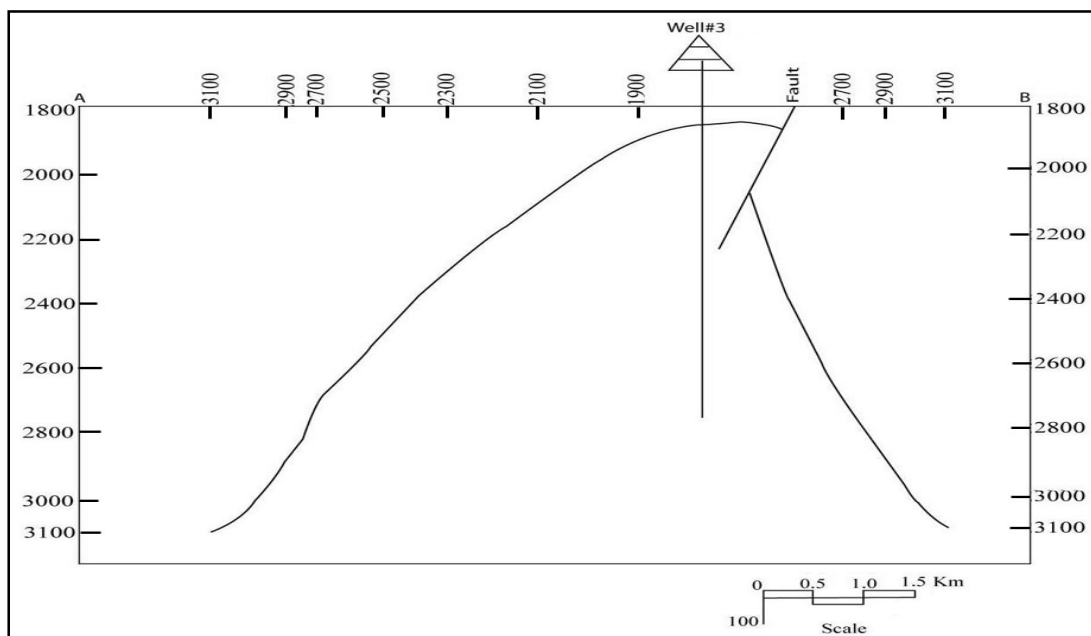


Fig. 2: Cross -sectional map for Lower Gas Sand

3.3 Structural Interpretation

The time contour map shows the structure having the NNE-SSW structural trends. The structural trend of this gas sand is marked in the contour map. The horizons in the seismic sections are interpreted and show that they are high amplitude folds with single fault. Especially, this fault is termed as anticlinal reverse fault.

Billings (2005) stated that reverse fault is genetic type of thrust fault and formed when dips more than 45° . They may develop in crystalline rocks or in sedimentary rocks before or after they are folded. Rocks are relatively brittle; a sharp break may develop on one side of an anticline, as a result of which the older rocks are thrust over the younger rocks. A thrust running parallel to the axis, partitions the anticline of the Fenchugonj area. The fault system in the area has been interpreted as an N-S oriented fault zone, which is compatible with regional fault trend and stress regime of the eastern folded belt of Bengal Basin. Its affects on the eastern part of the anticline are visible in all the dip lines, mainly in PKFG-1, PKFG-4 and PKFG-6. The fault planes of the area were correlated in a band type fashion and the displacement of fault is more prominent in the northern part than in the south, which indicates that in the northern part thrusting effect is high and towards the south thrusting is less. Moreover, from surface geological map, the amount of dips in the eastern flank varies

from 30° - 35° and in the western flank varies from 20° - 25° . From this point of view, genetically we can compare this fault with thrust fault and termed as reverse fault.

4. CONCLUSION

The Fenchugonj gas field comprises three wells. The Fenchugonj well #1 was drilled to evaluate dry well and well #3 was drilled to appraise and develop the well. The Fenchugonj well #2 was drilled to evaluate gas prospect, where two gas zones (UGS & LGS) were identified. Only Reverse faults can be clearly identified by structural interpretation. Channel and other features could not be identified due to limitation of field data. The structural configuration of the Fenchugonj anticline is smooth and uniform throughout the area. The contour shape is elongated in NNE-SSW direction. An EW oriented fault zone in the area has been interpreted, which is compatible with regional fault trend and stress regime of the Eastern fold belt of the Bengal Basin. Finite difference migrated seismic lines has good performance with low S/N ratios and is adaptable to horizontal velocity gradients. This is also relatively expensive and has difficulty with steep deep. The success of interpretation also will depend on the density of the seismic grid.

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The orientation of Dauki Fault: an approximation using the 2D finite element modeling

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The Dauki Fault is a major fault along the southern boundary of the Shillong Plateau. Its location may be a cause of the formation of destructive seismic hazard for the adjoining areas, including northeastern Bangladesh. In this study, we simulated the present-day stress distribution and the ongoing convergent-induced deformation within the study area using numerical simulation. This is an attempt to reveal the proper orientation of the Dauki Fault reflected in different models but maintaining realistic boundary conditions. The maximum compressive stresses which show the significant stress orientations helped us recreate the type of tectonic environment and the faulting patterns of the study area. The model predicts the compressive stress regime in the study area but excluded the uppermost-part of the Shillong Plateau, the Bengal Basin and Assam areas where extensional stress regimes are known to exist. These extensional stress regimes support the NE-SW normal faulting over the plateau area. Rock domain properties and Mohr-Coulomb's failure criterion were used to calculate failures in stress field. The failure elements within the model are comparable with the observed earthquake data that referred the Dauki fault as a north-dipping thrust fault.

Key words: Dauki Fault, Bengal Basin, tectonic stress, earthquake.

1. INTRODUCTION

The Dauki Fault runs from East to West of the Shillong Plateau and has a major role on the regional deformation of the adjoining areas. The fault may be a potential zone for future earthquake in Bangladesh (Islam et al., 2010a, b). The Dauki Fault separates the plateau by ~17 km thick Tertiary to recent thick sediments of the Bengal basin to the south (Uddin and Lundberg, 1998). However, the Shillong Plateau is characterized by seismically active and geologically complex region (Fig. 1). The surface of the 2-km-high plateau consists of Archaean rocks, and equivalent rocks lie 4±5 km below sea level to the north and south of the plateau (Evan, 1964, Bilham and England, 2001). Bilham and England (2001) suggested that the Assam earthquake was caused by the 'pop up' tectonics between the north dipping of the Dauki Fault and south dipping hidden in the Odham Fault, though the existence of the Oldham Fault is controversial and recent studies (Srinivasan, 2004; Das et al., 2005; Rajendran et al., 2004; Islam et al., 2010a) do not support the existence of the Oldham fault. Moreover, Rajendran et al. (2004) proposed that Brahmaputra fault (~20 km away from proposed

Oldham Fault) may be the northern boundary fault of the Shillong Plateau. On the contrary, Evans (1964) and Nandy (2001) argued that the Dauki Fault is nearer to a vertical or a south dipping strike slip/normal fault than to a north dipping thrust fault. However, Gravity data and earthquake focal mechanisms (Verma and Mukhopadhyay, 1977; Chen and Molnar, 1990; Mitra et al., 2005) support the existence of thrust or reverse faults beneath at the southern part of the Shillong Plateau (Oldham, 1899; Evan 1964; Hiller and Elahi, 1984; Johnson and Alam, 1991; Bilham and England, 2001; Srinivasan, 2005; Clark and Bilham, 2008).

Due to political boundary between Bangladesh and India, the Dauki Fault was ignored from tectonic synthesis. In fact, no detailed geophysical survey had been or yet to be conducted. Definitely, there are many unanswered questions regarding the Dauki Fault's dynamics including its orientation in the present time. However, there are few tectonics model proposed by several researchers (e.g., Bilham and England, 2001; Kayal et al., 2006, Clark and Bilham, 2008) regarding the evolution and deformation in the Shillong Plateau and its adjoining areas. Among these, Bilham and

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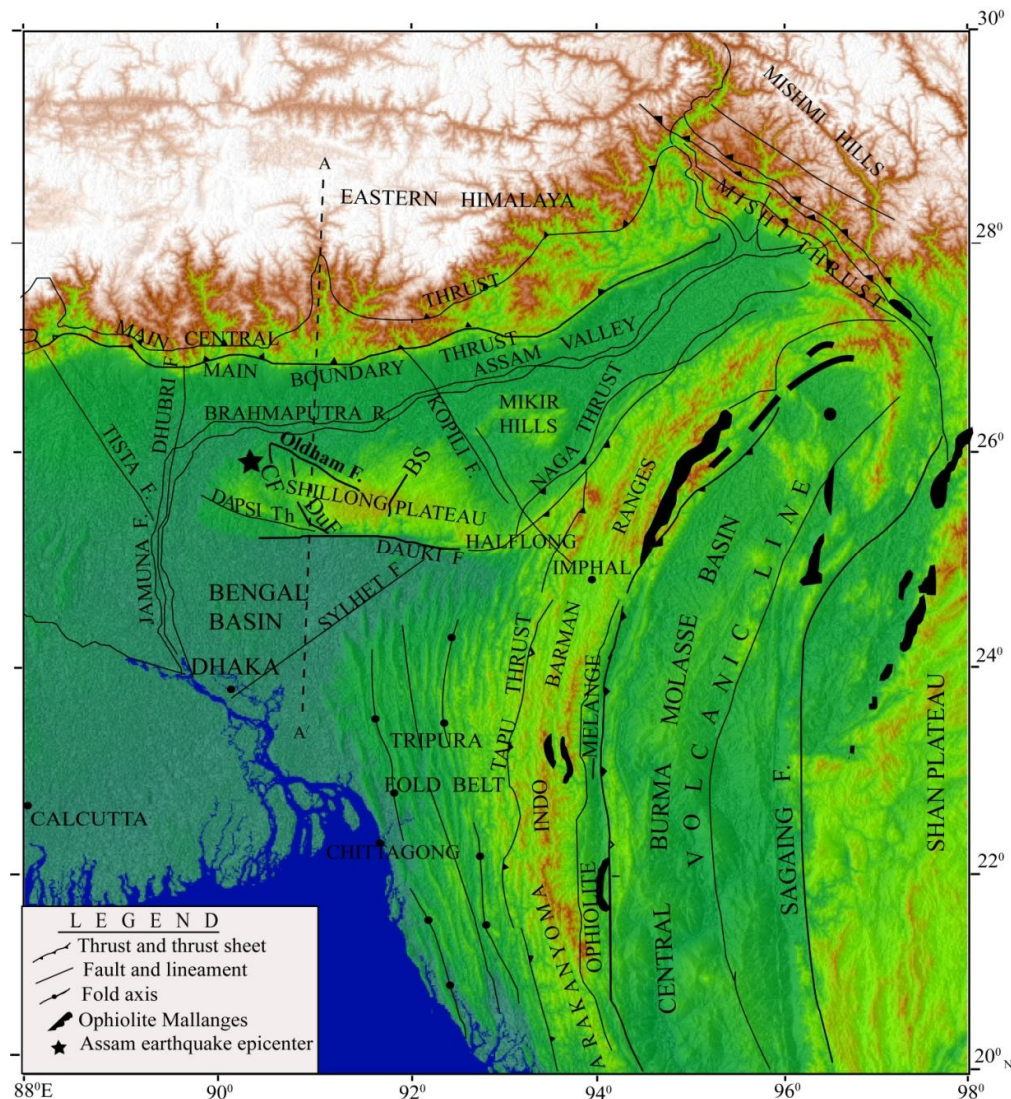


Fig. 1: Major tectonic features in the study region (modified after Bhattacharya et al., 2008). Line A-A' indicates the location of the cross-section used in this study. DuF=Dudhnoi Fault; CF=Chedrang Fault; BS=Barapani Shear Zone.

England's (2001) 'pop-up' model is mostly discussed and created a controversy on the tectonic study. In such circumstances, it is important to explain the realistic ongoing deformation in this study area with appropriate proxies (parameters). Therefore, this study aims to examine the contemporary stress field and ongoing deformation in the study area using finite element modeling. We proposed different orientations of the Dauki Fault on the basis of aforesaid discussion on its orientation. We further compare our model study with the regional tectonic stress, seismicity, earthquake focal mechanism solution and other geophysical studies for validation of our results.

2. GEOLOGY AND PLATE VELOCITY OF THE STUDY AREA

The Shillong Plateau is located between the arcs (Fig. 1) of the Himalaya to the North and Indo-Burmese to the East and is connected to the Himalayan fronts through faults and lineaments (Rajasekhar and Mishra, 2008). The E-W, N-S and NE-SW oriented major faults and lineaments (e.g., Dudhnoi Fault, Chedrang Fault, and Barapani Shear Zone) over the Shillong Plateau might be the result of plate tectonic forces in these directions. Evidently, the Dauki Fault and the Brahmaputra Fault are the southern and northern margin of the Shillong Plateau, which are oriented in E-W direction. In addition, the Dauki Fault

accommodates ~25% of the regional velocity of the Indian plate (Islam et al., 2010b).

The Shillong Plateau is at present behaving like a rigid body tied with the Indian shield at a velocity of 46.5 ± 1 mm/yr in a direction N 51° E (Jade et al., 2007). The preceding studies (e.g., Malaimani et

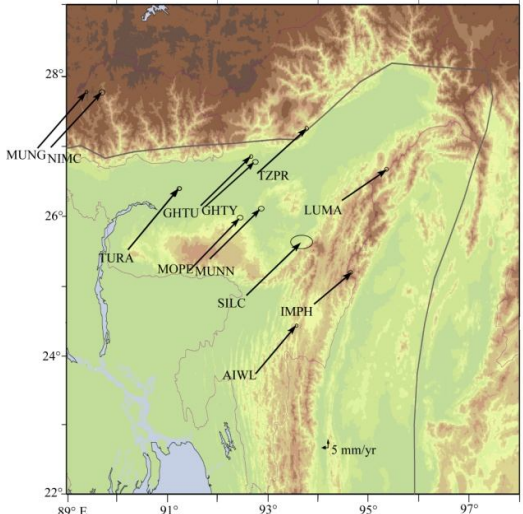


Fig. 2: GPS velocity of the study area (modified after Mukul et al., 2010). The GPS stations are GHTU=Guwahati University, TZPR=Tezpur, LUMA=Lumami, IMPH=Imphal, and AIWL=Aizawl, MUNG=Mungpu, NIMC=Nim, TURA=Tura, MOPE=Mopen MUNN=Mun, GHTY=Guwahati and SILC=Silchar.

al., 2000; Chen et al., 2000; Shen et al., 2000; Holt et al., 2000; Paul et al., 2001; Sella et al., 2002; Socquet et al., 2006) show that the velocity of Indian plate relative to Eurasia is between 34.8 to 43.7 mm/yr, slightly slower than the 45 mm/yr rate which has been observed using the NUVEL-1A modeling (De Mets et al., 1994). Furthermore, very recent studies (Angelier and Baruah, 2009; Mukul et al., 2010) confirm similar direction of Indian plate's motion (Fig. 2) which are opposite to the results of former studies.

3. MODELING

The stress field modeling of a particular area helped us understand the mechanism of earthquakes in that area. The present modeling is constrained by using the simple geometric cross-section (Fig. 3) that is used in Bilham and England (2001). Three geometric models with eleven rock layers have been constructed based on the different orientation of the Dauki Fault (Figs. 3a-c). The mesh of all three models is consisted of 1200 nodes and 2242 elements. The spatial distribution and orientation of the stress were obtained at each node of the mesh.

The boundary conditions that have been applied to the models are at 200-m convergent within the study area between the Indian and the Eurasian plates. In the models, horizontal displacement has been applied at the bottom side of the model, along the x-axis, running from right to left. However, vertical dimension are fixed and the displacement in the area gradually decreases from zero point towards left at rear nodal point. All nodal points at the right side of the model have equivalent vertical dimensions as with the left side, thus mirroring the displacement of the left side. We fixed rear nodal point at the bottom of the left side while a free slip boundary condition was used along left wall of the model such that left side is fixed in horizontal dimension and free along y-axis. All of the upper part of the model is kept free to move and was designed to represent the Earth's surface.

Table 1. Rock layer properties used in the plane strain models.

Layer	Density (kg/m ³)	Young's modulus (GPa)	Cohesion (MPa)	Internal friction angle (degrees)
1	3300	65	21	46
2	2900	60	18	45
3	2000	1	10	32
4	2000	1	10	32
5	2600	56	16	46
6	2450	50	15	44
7	2400	45	16	42
8	2800	55	18	45
9	2000	1	10	32
10	2850	48	15	45
11	2400	40	14	30

Poisson's ratio is 0.25.

References: Khan and Hoque, 2006; Rajeskhari and Mishra, 2008; Clark, 1966; Joshi and Hayashi, 2008a, b; Islam et al., 2010a, b and this study.

The rock layer properties manipulate the results of numerical simulation and the state of stress within the model as well. For Instance, we consider different rock parameters (density, Young's modulus of elasticity, Poisson's ratio, Cohesion and internal angle of friction) during simulation as listed in table 1. The density values are taken from Rajeskhari and Mishra (2007) and Khan and Hoque (2005). The value of Young's modulus of elasticity

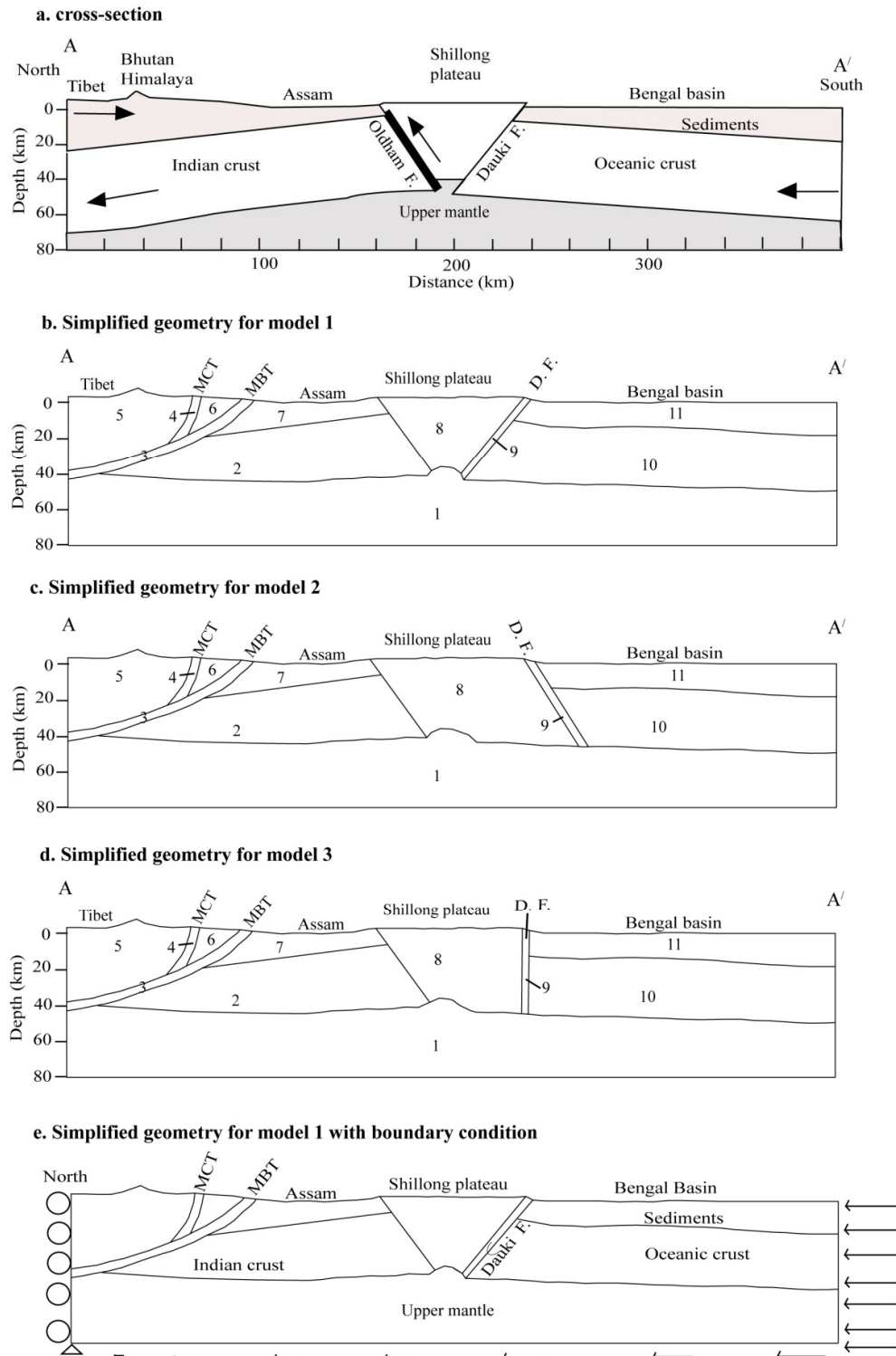


Fig. 3: a) North-south cross-section (A-A' shown in Fig. 1) from Tibet to the Bay of Bengal, showing schematic “pop-up” geometry of the Shillong Plateau (simplified from Bilham and England, 2001), b) simplified geometry of model 1, c) simplified geometry of model 2, d) simplified geometry of model 3, and e) boundary condition of the model. 1=Upper mantle, 2=Indian crust, 3=MBT, 4=MCT, 5=Upper Indian crust in Tibet, 6=Area between MBT and MCT, 7=Assam, 8=Shillong Plateau, 9=Dauki fault zone, 10=Upper part of the Bengal basin and 11=Lower part of the Bengal basin.

is designed by using equation 1 (Timosenko and Goodier, 1970; Hayashi, 2008),

$$E = \rho V_p^2 \frac{(1+\nu)(1-2\nu)}{(1-\nu)} \quad \text{-----(1)}$$

Where V_p is P- wave velocity, ν is Poisson's ratio and ρ is density of rock.

The values of V_p are based on the values from Mitra et al. (2005) and we used Poisson's ratio (ν) .25 in our simulation. The two other physical parameters, Cohesion and internal angle of friction were adapted from Clark (1966). The simulation of this study was performed using FE software package of Hayashi (2008).

4. RESULTS

Simulating the state of stress is one of the techniques that are helpful in understanding the proximities of the ongoing crustal deformation and neotectonics. The Dauki Fault is the prominent southern boundary fault of Shillong Plateau which

plays a significant role in the deformation patterns observed in the study area that control the contemporary stress field (Islam et al., 2010a). The simulated stress field, faulting pattern, predict the significant change under the applied convergent displacement within the model. The modeling results presented here are based on (i) stress distribution and (ii) the fault and failure element in the models.

4.1 Stress Distribution

Figures 4a-c represent the simulated principal stress distribution under 200-m convergent displacement for the model 1, 2, and 3. The maximum compressive stress (σ_1) and minimum compressive stress (σ_3) are aligned along vertical and horizontal in the Bengal Basin and Assam as observed in the models except for the region close to the faults. However, substantial stresses change within the deeper part of model near the Dauki Fault which may indicate function of weaker zone within the region. The fault region predicts that the orientation

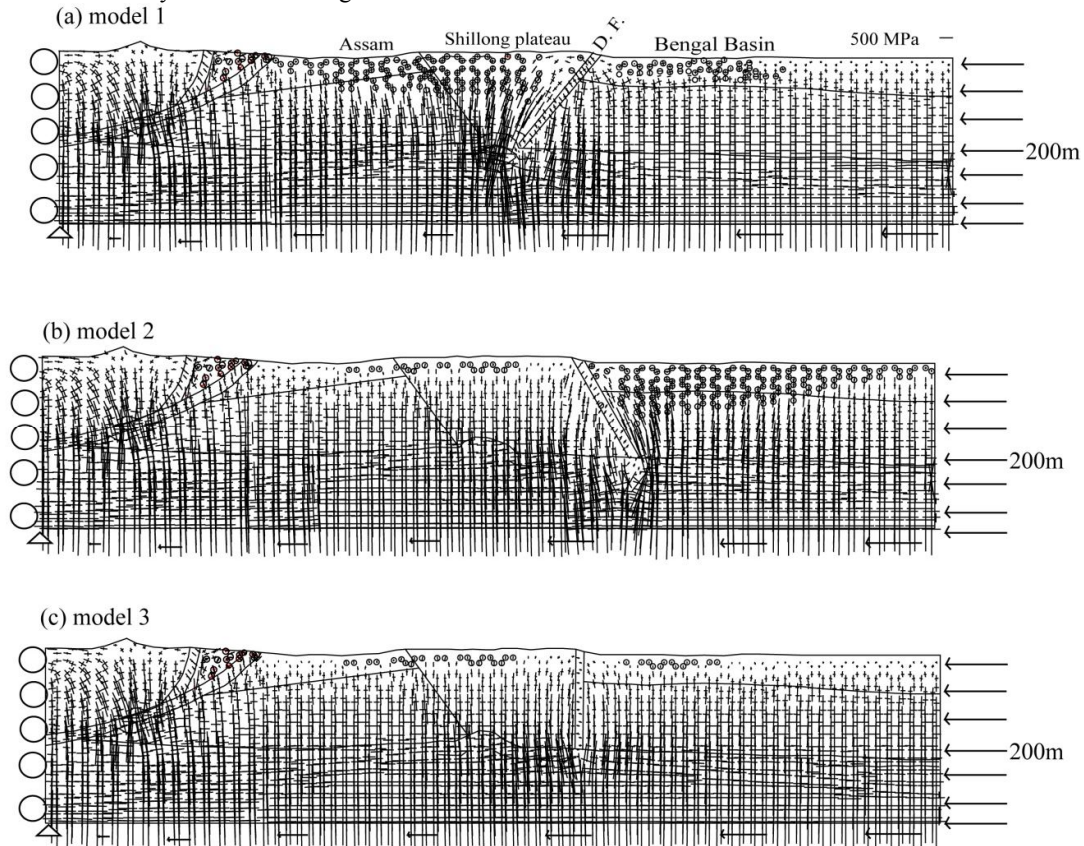


Fig. 4: Distribution of principal stresses for model 1 (a), and model 2 (b), model 3 (c), at 200-m of convergent displacement. The circle represents extensional stress.

of σ_1 is normal to the fault with small magnitude from the neighboring areas, which is sign of accommodation of the deformation velocity within it. A complex stress distribution exists beneath the Shillong Plateau in the model 1 (Fig. 4a). The upper part of the Shillong Plateau, the Assam valley, and the Bengal Basin predict the extensional stress regime, whereas deeper part predicts compressional regime. The extensional stress is mainly predominant in the Bengal Basin area for model 2 (Fig. 4b). However, some extensional stresses are to be predicted within the model 3 (Fig. 4c) for the shallow depth in the Bengal Basin, the Shillong Plateau and Assam valley.

5.2 Fault and failure elements in the models

Our simulated results predict the seismotectonic deformation and fault development within the study area as shown in the Figs. 5a-c. Each and every model shows the different pattern of faults development and deformation style. The Dauki Fault is predicted to be as the thrust fault with strike-slip component in model 1 (Fig. 5a). However, the model 2 (Fig. 5b) predicts the Dauki Fault as strike-slip fault. As a result, the significant failure elements have been predicted in the Bengal Basin, the Shillong Plateau, and the Assam valley within model 1 (Fig. 5a). The failures within the Dauki Fault zone are recommended to be related with compressional state. In spite of these, the upper part of all models is linked with extensional failures. Moreover, there are few failures predicted within the Bengal Basin, the Shillong Plateau, and Assam valley at shallow depth (<30 km).

5. DISCUSSION

5.1 Neotectonics stress field

The study area is very tectonically dynamic and connected with the compressional regime (Gowd et al., 1992). In the Bengal Basin, the orientation of maximum horizontal principal stress (σ_{Hmax}) in the sedimentary pile is NE-SW (Rajendran et al., 1992), but north-trending folds and thrusts in the eastern part of Bengal Basin is also a sign of E-W compression. The northeastern part of Assam is consistent with regional NE-SW stress orientation (Islam et al., 2010b), whereas other parts of this area has no constant direction of maximum principal stresses (Rajendran et al., 1992). However, one powerful earthquake event (December 1984), shook the Silchar town of southern Assam that created numerous ground cracks and these cracks are linked with NE-SW σ_{Hmax} (Gowd et al., 1992). Focal mechanism solution also indicates that the Shillong Plateau has been subjected to N-S, NW-SE and NE-SW

compression stresses (Verma, 1991; Angelier and Baruah, 20009). Islam et al. (2010b) predicted that the Sylhet trough, the Dauki Fault, southern part of the Shillong Plateau, and the eastern Bengal Basin have also similar direction (NE-SW) of σ_{Hmax} . However, this study predicts that the study area is under compressional stress regime, except for the shallow depth.

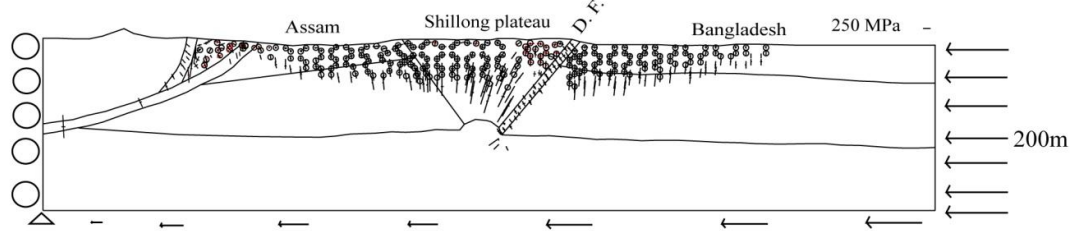
5.2 Seismicity and earthquake focal mechanism solution

The earthquake records revealed that the Shillong Plateau and its neighboring areas is typical laboratory of active tectonics with high seismic activity. The number of lineament structures is coupled in with this plateau. Dozens of large earthquakes are recorded in the Himalayan region with $M_s > 7$ in past 110 yrs and among those 1897 Assam earthquake's occurred around the SP (Sukhija et al., 1999).

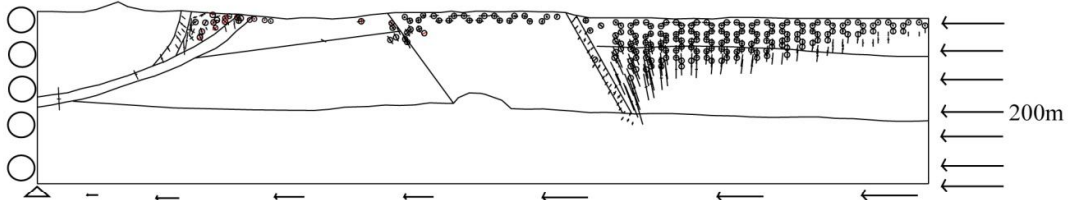
Rajendran et al., (2004) showed that most of the earthquakes occurred during 1986-1999 in the Shillong Plateau and the Brahmaputra valley with shallow (depth <30 km) epicenters. Besides, seismic events in the Bengal Basin are linked with strike-slip faulting at deep depth ~48-55 km (Kayal et al., 2006; Khan and Hoque, 2006) with low V_p (Bhattacharya et al., 2008). Moreover, Das et al. (1995) suggested that the area south of the Dauki Fault has high tectonic activity of shallow and deep-seated earthquakes in the past. Bhattacharya et al. (2008) reported a well-defined clustering of earthquake's epicenter in the Shillong Plateau with high V_p velocity, which may be a sign of active seismicity of the region. Our simulated failure elements under stress field explain the more realistic faulting pattern of the study area. These results predict a comparable failure location with observed data (Figs. 5d-e). Nonetheless, the best-fit model (Fig. 5a) does not reproduce the failure in the exact location of study area but it explains most of the area of model properly and realistically. Moreover, it is evident from simulation that the failures are restricted within shallow depth (especially < 30 km), and failure patterns also support the opinion's of Kayal et al. (2006) on depth of earthquake activities.

The earthquake focal mechanism solutions indicate that the Shillong-Mikir hills-Assam valley is mostly dominated by thrust faults with N-S compression (Chen and Molnar, 1990; Bhattacharya et al., 2008). Furthermore, the simulated results predicted compressional state of stress under imposed boundary condition (Fig. 4). Kayal et al. (2006) stated that the study area dominated by

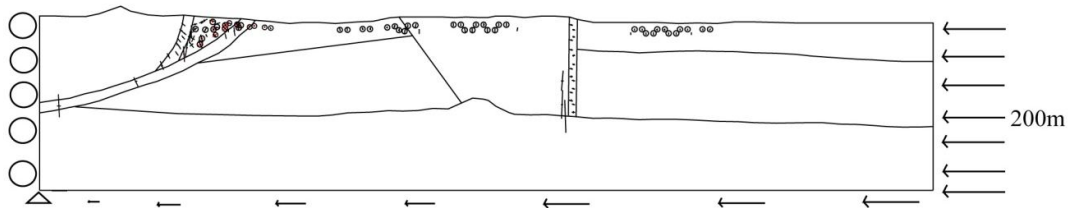
a. model 1



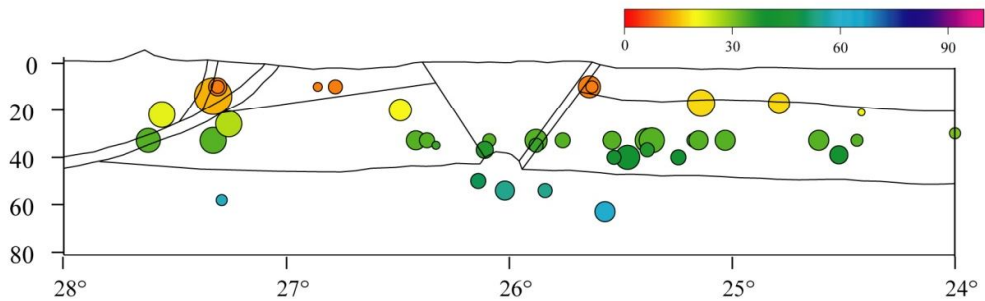
b. model 2



c. model 3



d. Epicenter distribution ($M_s > 5$)



e. Epicenter distribution (including micro-earthquake)

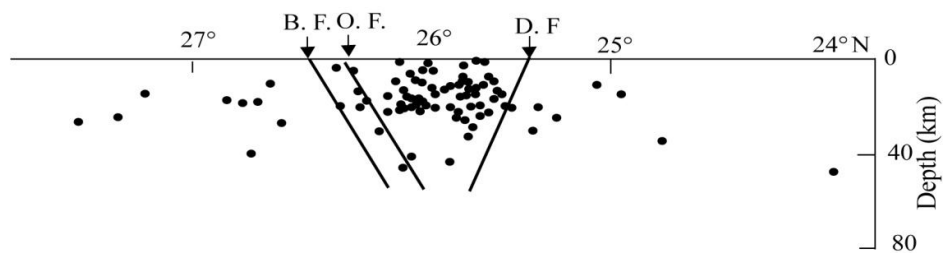


Fig. 5. Principal stress within failure elements for model 1 (a), model 2 (b), model 3 (c) at 200-m convergent displacement. The circle represents extensional stress. (d) Epicenter distribution downloaded from www.usgs.org, (e) Epicenter distribution taken from Fig. 4 of Nayak et al. (2008). BF=Brahmaputra Fault, OF=Oldham Fault.

by thrust/reverse faulting, as is normally found in the Dauki fault. In addition, Islam et al. (2010a, b) predicted that the Dauki Fault as thrust fault with strike-slip component is also supported by this present study. However, the best-fit model (model 1) predicts that the Dauki Fault is thrusting with strike-slip component (Fig. 4a).

5.3 Implication for the Dauki Fault's Orientation

Indeed, the Dauki Fault has a great role in the deformation of the Shillong Plateau and its surrounding (Islam et al. (2010a, b) areas. The fault's and its orientation is highly related with the deformation style observed in the region, as what has been found in the simulated results. Stress distribution, fault pattern, and failure elements depict distinct pattern with the Dauki Fault's orientation. The Dauki Fault with north-dipping orientation (model 1) predicts realistic failures within the model (Fig. 5a), which are comparable with the earthquake epicenters distribution (Fig. 5d). In contrast, models 1 and 2, where the Dauki Fault is south-dipping or vertical, (Fig. 5a and 5b) realistic failures cannot be predicted. The failures within these two models are mismatched with geophysical or geodetic observed data. However, the best fit model (model 1) does not reproduce proper location of failure as have seen in the observed data (Fig. 5d). This mismatching may be caused by some faults within the Shillong Plateau, Assam and the Bengal Basin which were not considered in this study.

6. CONCLUSIONS

The 2D finite element modeling is applied to explain the quantitative estimation of present-day stress field and describe deformation style within the study area. The results of simulation are found to be consistently similar with existing micro and macro seismic activity and active faulting. The comparison between the simulated results and the existing data indicates that our best-fit model (model 1) predicts more realistic contemporary stress field and faulting pattern of the study area. The modeling results predict that the Bengal Basin and Assam Valley is under compressional stress regime. While, the upper part of the Shillong Plateau shows extension stress regime, the deeper part indicates compressional stress regime. Our computed result also predicted that the Dauki fault is thrust fault with strike-slip component. The Shillong Plateau region shows the normal faults under extensional stress condition under regional NE-SW σ_{Hmax} . Accordingly, north-dipping orientation of the Dauki fault gives realistic failure

within the model that recommended its relative orientation. For confirming the actual orientation, geophysical and borehole data is needed to come into conclusion.

7. ACKNOWLEDGEMENTS

M. S. I. is grateful to the Ministry of Education, Culture, Sports, Science and Technology (Monbukagakusho) Japan for providing a scholarship to carry out this research. We thank Mamoru Nakamura at the University of the Ryukyus for his help during manuscript preparation.

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Underground or Open Pit Mining Method – an Unresolved Debate Delaying Coal Mining in Bangladesh

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ABSTRACT:

Bangladesh is blessed with coal-basins in the northwest and natural-gas fields are profuse in the eastern region. The current GDP growth of the country is proportionally related on its power generated from natural gas (82%), oil (9%), hydro (4%) and coal (5%) resources. The recoverable gas reserve (proven and probable) of discovered gas fields of the country is 20.63 TCF of which 7.42 TCF has been used so far leaving 13.21 TCF. Evidently, coal would be the only available alternative resource to meet the upcoming demand. Around 3 billion tones of high-grade coal were discovered at 5 coal-basins in northwest Bangladesh. Significant amount of coal mining has yet not been started, though first discovery of coal came in 1959. There are two coal mining methods: open pit and underground mining, are used in the world. Experts proposed both methods to extract the coal from Bangladesh-coal fields and also CBM (Coal Bed Methane) for deep 300-500m or more. Despite all well-meaning intentions, it appears that selection of mining method has been delaying the coal mining in Bangladesh. This critical review would provide rationales in favour of underground mining over open pit mining method in Bangladesh.

Keywords: Gondwana coal, Open pit mining, Underground mining, Northwest Bangladesh, Groundwater.

1. INTRODUCTION:

The peoples of Republic of Bangladesh emerged 1971 from Pakistan. The country covers an area of 1, 44,000 sq km of onshore and 63,000 sq km offshore. Bangladesh extents from 20°34'N to 20°38'N and 88°01'E to 92°41'E. It is a densely populated developing country situated in the south-east Asia in the world (1099.3 percent per sq km) (source-Wikipedia).

Bangladesh is undoubtedly heading towards a major energy crisis in the days to come. But with the reserve of coal, even if recovered even by open pit mining, will at best contribute a pond, if not a drop, in an ocean. So we must explore multiple options like undertaking massive search for oil, gas and coal, tapping wind energy in the

coastal belt, generating small-scale hydro-electricity in the hilly terrains, solar energy, and coal extraction by underground mining only from the known deposits.

The primary objectives of this over view is to provide the reader with a better understanding about the geological formation of the North-Western part of Bangladesh and different types of mining methods basically underground mining and open pit mining which is best applicable in Bangladesh. In finally in the discussion and conclusion emphasis is given which method is more applicable in Bangladesh.

2. GEOLOGICAL STRUCTURE OF BANGLADESH:

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2.1 Plate Tectonic Evolution of Bangladesh:

The Bengal basin has evolved from collision of Indian plate and the Asian plate. According to the plate tectonic theory, the north western part of Bangladesh (Bogra-Rangpur-Dinajpur area) was initially jointed along with Indian land mass with Antarctica, Australia and other forming a vast super continent named Gondwanaland far in the southern hemisphere. About 110 million year ago, during the cretaceous time, the Gondwanaland super continent began to breakup and Indian began drifting toward north. The Bengal basin was initiated during this time with the rifting of the Indian plate from Antarctica. Then Indian plate collided with Asian plate and formed the Himalayan Mountain. The remaining landmass of Bangladesh formed from the sediment that coming from Himalayan mountain. With the above outline the tectonic framework of Bangladesh may be broadly divide into two main units: (1) Stable platform in the northwest (2) Deep basin to the southeast and a third unit a narrow northeast, southwest trending zone called hinge zone separate to above two unit.

Stable Platform unit occupies Rajshahi-Bogra-Rangpur-Dinajpur area and is characterized by limited to moderate thickness of sedimentary rock above a Precambrian igneous and metamorphic basement. Based on the thickness stable platform divided into two parts: (a) Rangpur saddle in the north with thin to limited (130m to 1000m) sedimentary cover above the Precambrian basement and (b) Bogra shelf with moderate (1 to 6 km) sediment covers over the Precambrian basement. Deep (geosynclinals) Basin unit lies to the south and east of the stable platform and is characterized by huge thickness (maximum 22 km) of sedimentary rocks mostly sandstone and shale of Tertiary age. It occupies greater Dhaka-Faridpur-Noakhali-Sylhet-Comilla-Chittagong and Chittagong Hill tracts areas and Bay of Bengal. And a third unit is called Hinge Zone unit which is a 25 km wide northeast-southwest zone that separates Precambrian platform from Deep basin to the southeast. There are no surface expressions of this unit. From the tectonic evolution of Bengal

Basin and structural framework of Bangladesh we see that the coal layers are situated in the stable platform.

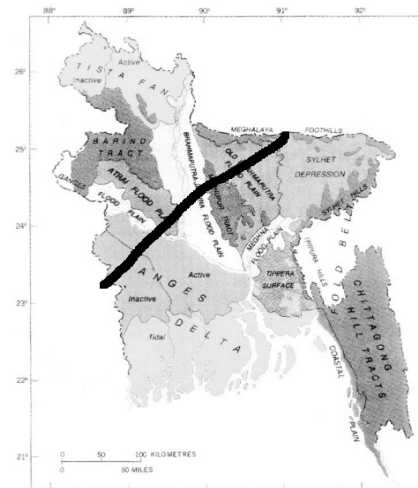


Figure 01: Geological map of Bangladesh.

2.2 Stratigraphy of the Bangladesh Coal Field:

Most of the coal fields are located in stable platforms in North-Western part of Bangladesh. The major coal fields are Jamalganj coal field, Barapukuria coal field, Phulbari coal field, Dighipara coal field, Khalashpir coal field. General Stratigraphy of the North-western part is given below:

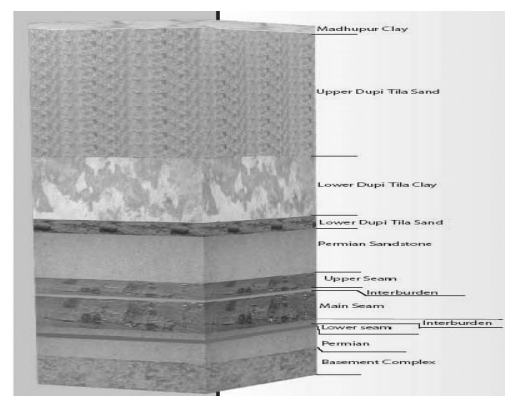


Figure 02: Stratigraphy of stable platform in Bangladesh

Table 01: Stratigraphy Succession of North Western in Bangladesh:

Period	Formation	Lithology	Hydrogeology
Recent to sub recent (Holocene)	Alluvium	Silty clay	
Pleistocene	Barind Clay	Clay and sandy clay	
Pliocene	Dupi Tila	Sandstone, loosely compact sandstone	Unconfined Aquifer
Upper Oligocene to Miocene	Jamalganj formation	Silty fine sand, clay, Shaly clay, sandstone, shaly coal	
Eocene	Kopili Shale Sylhet Limestone Tura sandstone	Sandstone, shale and small limestone	
Permian to Cretaceous	Shibganj Trapwash Rajmahal Trap Paharpur kuchma	Medium to very coarse grained off- white feld pathic sandstone frequently interbedded with conglomerate and coal layer with sandstone sequence	
Precambrian Crystalline Basement		Igneous and metamorphic rocks	

2.3 General Characters of Bangladesh Coal Fields:

- The coal found in NW Bangladesh is high volatile bituminous coal. The quality of the coal is very good.
- The coal is Permian in age and occurs within fault bounded Gondwana basins.
- The coal seams occur at depth range from 118m to 1000m. Thick to very thick multiple coal layers are found in the coal fields of Bangladesh.
- The coal deposits are covered unconformable at the top by 100m to 200m thick loose to poorly consolidated water bearing sand layer.
- The coal basins are bounded by major normal fault forming half graben.
- Bangladesh's coal is over 245-286 m.y. old.
- Coal was deposited in swampy environment.

3. FACTORS OF CONSIDERING THE SELECTION OF MINING METHODS:

- Depth of the seam
- Thickness of the seam
- Seam configuration (in terms of horizontal or vertical dimension)
- Lateral continuity of the seam
- The compositions of the overburden
- Overburden and seam hardness
- Proximity to surface water or an active ground water system
- Total deposit of coal
- Economical profitable

4. DIFFERENT MINING METHODS IN THE WORLD:

Coal is commercially won by either of two basic methods: surface mining or Underground mining. When an ore bed has been located relatively close to Earth's surface, it can be mined by surface

Table 02: the advantage and disadvantage of main two mining methods (open-pit mining and underground mining)

Item	Open pit mining	Underground mining
Development work	Minimum development work	Needed major development work
Overburden	Need to excavate large volume of overburden to extract coal.	Most excavation, apart from entry and tunneling, are made in saleable coal.
Surface area loss	Large area of land temporarily lost.	Only the area around pit-top is visibly disturbed.
Environmental effect	Noise and coal dust pollution in and around mining area.	No surface pollution; subsidence above workings may affect surface installation.
Mine safety	Greater safety, no danger of explosion or fire; however danger includes landslides on excavation or spoils pile.	Methane gas explosion, spontaneous combustion, roof collapse, water flooding pose danger to mine personnel.
Affect of climate	Mining is affected by rigorous climate condition like heavy rain or snow	Climate do not affect the mining
Depth of mining	Maximum depth of mining limited by cost of overburden removal	Can work coal to greater depth; overburden to coal ratio not critical
Machinery	Simple machinery needed	More complex machinery needed
Recovery of coal	Almost all in situ coal may be recovered.	Less than 60% of the in situ coal commonly recovered.
Water discharge cost	High discharge cost	Less discharge cost than open pit mining.

techniques. Surface mining can be subdivided into two large categories: open-pit mining and strip mining. Open-pit mining is used when an ore bed covers a very large area in both distance and depth. Mining begins when scrapers remove any non-ore material (called overburden) on top of the ore.



Figure 03: open pit coal mining.

When an ore bed covers a wide area but is not very deep, strip mining is used. It begins the same as open-pit mining, with scrapers and other machines removing any overburden. This step involves the removal of two long parallel rows of material. Coal is normally extracted by underground mining techniques when the depth

of the seam is greater than 300 feet. Other types of mining methods are proposed when depth is greater than 500m named CBM (coal bed methane).



Figure 04: Underground coal mining

5. PROBLEMS FACING IN UNDERGROUND AND OPEN PIT MINING METHODS:

5.1 Impact on Hydro-geological

Environment:

Potential and major groundwater reservoir of Bangladesh lies in its north-western region covering greater Dinajpur and Rangpur districts. The groundwater resource of this region is the main aquifer of Bangladesh which is about 80-120 meters thick in the Dupi Tila formation and situated at about 10-12 meters below the surface. Extraction of coal adopting open-pit mining method can be disastrous for the north-western region in particular and Bangladesh in general due to dewatering of arsenic contamination free source of drinking and irrigation groundwater from Dupi Tila formation from a depth of 250 to 300 meters. Dewatering in the open pit mining area may not only disturb but also damage the aquifer, making the area a desert like place. During monsoon, already mined out area will be filled up by rain water, which is required to be pumped out again. During rainy season mining will be difficult and may have to be postponed to facilitate pumping of water out of the mine. Thus 2-3 months in a year may be lost due to this. Thus uninterrupted supply of coal to the power station and other coal consumers may not be possible. There are lower Dupi Tila which is impermeable for that underground mining is suitable than open pit mining.

5.2 Subsidence/landslide

Subsidence in the context of underground mining is the lowering of the earth surface due to collapse of bed rock and unconsolidated material (sand, gravel, silt and clay) into mine area. This geological hazard is like an earthquake. The mine subsidence is controlled by many factors include mined out area, width of unsupported mine roof, thickness of overburden, competency (strength) of bed rock, hydrology and time. The area of mine subsidence increases proportionally with increasing width of unsupported roof rock. From the structural geology and Stratigraphy of Bangladesh, rock strength is high so the subsidence is low but Dupi Tila formation has high permeability and porosity so the quality of landslide high for the upper formation. In open pit there is landslide due to loose, incompact Dupi Tila formation.

5.3 High Geothermal Gradient:

The temperature rise will be caused by the heat dissipated from the human, and duct and pipe, the heat of blasting and etc. The temperature rise will worsen the underground environment, influence

seriously the workers health and the laborer productivity, and finally become heat harm. According to the supplementary geological survey report, the temperature at the zone of invariable temperature of the mine is about 25.50°C; the depth is about 30m; ground temperature gradient in average is 3.51°C/100m. According to above mentioned the comprehensive measured necessary for lowering the temperature should be taken. So for underground mining better ventilation system must be needed.

5.4 Air Pollution:

Coal mining operations are sources of air pollution in the form of coal or rock dust from the mine itself. Gaseous air pollutants may also be generated by the transport operations within the mine area. The production of electric power used for in-mine ventilation, conveying, digging, loading, transfer, and other operations can contribute to air pollution indirectly. For most underground mines ventilation rates range from 5 to 40 cubic feet per minute per ton of coal per day, this translates to 10,000 to 200,000 cubic feet per minute for an average mine. Underground mines will release coal dust particles from blasting or loading operations, as well as gases such as hydrogen sulfide, sulfur dioxide, methane, and other hydrocarbons, although in relatively low concentrations.

5.5 Gas Explosion:

Gas is one of the main disasters to coal mine. It has large harmfulness. It cannot only suffocate the people but also burn and explode easily, also break down the middle and small size facilities seriously and thus stop the production. In the view of the whole mine, the main place with the gas build up are: working and heading face so the working place of the shearer and the tunneling machine coal falling place by mining, goaf, air sealed zone, airless zone, air supply stopping zone and the corner zone with poor ventilation. The gas explosion is less in open pit mining but environmental impact is relatively high.

5.6 Particulate Emissions:

Particulate emissions in underground mining are relatively minimal, ranging from 0 to 0.0005

lb/ton of coal. The particulate concentrations in the ventilation exhaust gases can range from below 100 to more than 1,000 ft-Lg/m³ depending on the ventilation rate, the type of mining method and the moisture content of the coal. The particulate dust losses from surface mining are greater, 0.005 to 6.600 lbs/ton of coal mined, because of the open exposure to the atmosphere as compared to the confined tunnels in underground mines. The magnitude of these dust losses is largely dependent upon the surface mining method used as well as the local geography. Coal and soil dust losses are generally greater from area than from contour surface mining operations (0.04 to 0.05 vs. 0.005 to 0.007 lb/ton coal mined).

5.7 Solid Wastes:

Solid wastes are produced from both underground and surface mining operations in varying quantities. Wastes generated from underground mining are the waste rock from shaft tunneling, and refuse and coal fines removed during preparation. The solid wastes generated from surface mining include overburden from removal of the soil plus rock and impurities removed during preparation. The total solid wastes from underground mining are 0.06 to 0.10 lb/ton of coal when waste removal is not required and 2.0 to 80 lbs/ton of coal when required because of the need to remove impurities, refuse, and "gob". These materials can be used as backfill for the mine shafts once the mining operation is completed to minimize the need for surface disposal. Solid wastes generated from surface mining operations are generally much greater when uncontrolled because of the large overburden soil washout. When careful land reclamation is practiced, the amount of overburden waste is greatly reduced. Much of the solid waste materials from coal preparation and waste water treatment can also be backfilled in the mined-out pits following mining before the land is reclaimed.

6. UNDERGROUND OR OPEN PIT MINING METHOD WHICH IS PERFECT IN BANGLADESH

6.1 Views Favoring Underground Method in Bangladesh

The 100 to 200 meter thick unconsolidated and water bearing sandy layer (Dupi Tila formation) overlying the coal deposit is an active ground water aquifer. The amount of water that would be released in an open pit mining is not manageable and will create several problems. The monsoon

rain may make the water problem even worst. The presents of loose sandy water bearing aquifer above cold deposit is also responsible for large scale land sides in open pit mining. An open pit mining method would take up significant amount of agricultural land then underground mining method. For example an underground mine will take 0.96sq.km. of land where an open pit mine would require 16sq.km.of land The coal fields are located very depth, which is not very encouraging for an open pit mine.

6.2 Views Favoring Open Pit Mining Method in Bangladesh

The loose water bearing 100 to 200m thick Dupi Tila sand layer above the coal deposit renders the shaft sinking for underground mine very difficult under normal circumstances. A time consuming and expensive freezing technique is required for the above purpose. This increase the project cost to a significant amount. The average stripping ratio is nearly 6:1 in m³/ton (cubic meter of over burden per ton of coal). This ratio is suitable for open pit mining. The extraction ratio is very high in open pit mining. The open pit mining is very safety. In Bangladesh the coal is overlying by younger sediment. The Permian sand stone also moderately fractured and jointed. It has low strength so it could not able to sustain the overburden stress / pressure.

7.CONCLUSION AND DISCUSSION:

Bangladesh is facing a serious challenge in terms of meeting the demands in the energy sector. Bangladesh needs to build national capability, formulate legal and organizational frameworks and mine coal so that she can retain and use the entire quantity to meet domestic energy needs. Finally, in such a national capability-based coal mining, Bangladesh needs to use coal mining methods that best suits the socio-economic, cultural, geologic, and environmental settings.

The government may undertake a detail hydro-geological study on major and potential aquifer in the north-western region of Bangladesh in the light of Asia Energy's proposal for open-pit coal mining in Bangladesh coal fields. At the same time Asia Energy may give a second thought to their proposal and examine underground mining prospects in the Bangladesh coal fields. The most pressing issue is the method to be used for coal mining in Bangladesh. Based on publicly available information on socio-economic and environmental feasibility studies done on the possibility of open-pit coal mining in Phulbari and other coal fields in Bangladesh, it is safe to conclude that open-pit coal mining will cause

huge economic loss, social unrest, and environmental degradation of unprecedented nature. There are several other viable alternatives to open-pit coal mining that are being practiced in various countries in the world. Given the socio-economic, cultural, and environmental settings, Bangladesh should consider a combination of underground coal mining, extraction of coal bed methane (CBM), and underground coal gasification (UCG) projects.

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DESIGN AND SIMULATION OF FOUR BANDS MICROSTRIP PATCH ANTENNA ARRAY FOR MULTIBAND APPLICATIONS

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In this paper, a four band microstrip antenna with very straightforward configuration is proposed. This paper presents an array antenna which can be operated in four different bands. The designed array adopts four series feed rectangular microstrip patches having different sizes. The simulation has been performed by using SONNET version V12.56 simulator which is a commercially available antenna simulator. The intended antenna is designed by using Taconic TLY-5 dielectric substrate with permittivity, $\epsilon_r = 2.2$ and height, $h = 1.588$ mm. The size of the antenna is $83.5 \times 16.9 \times 1.602$ mm and four resonant frequencies are 7.6GHz, 8.0GHz, 9.3GHz and 10.1GHz. The result confirms satisfactory performance having maximum achievable directive gain of 15.16 dB and return loss of -23.67 dB. The main features of the presented antenna are simplicity and flexibility to be designed for any numbers of operating frequencies.

Key words: Microstrip Antenna; Rectangular Microstrip; Multiband Array Antenna; Series Feed Array

1. INTRODUCTION

With the rapid growth of the wireless communication system, the future technologies need a very small and multiband antenna. Nowadays, people demand multiband wireless phone supporting more than one network, having different frequencies and simultaneous transmission of audio, video and data. These services are possible with the help of microstrip antenna because of its broad band and multiband characteristics. The advantages of microstrip antenna makes them popular in many applications requiring a low profile antenna and this antenna is promising to be a good candidate for the future technology due to the flexibility of the structure as it can be easily incorporate into the communication equipments [1]. Many researchers have studied different structure and different techniques to increase the radiation efficiency and to have multiband in single element antenna by using double PIFA[1], U-slot [2] and other structures. In this paper, an investigation on the design of microstrip array antenna to control four bands by matching the impedance of successive elements and using the quarter wavelength transformer method [3] is made. This paper aims to decrease the size of

the antenna and at the same time to improve the radiation performance of the patch antenna in terms of directivity, maximum radiation, return loss and efficiency. As an advantage, the resonant frequency of this antenna can be easily controlled by either increasing or decreasing some parameters such as, width and length of each element. Here, the designed tetra band microstrip antenna supports four bands at 7.6GHz, 8GHz, 9.3GHz and, 10.1GHz. Furthermore, this antenna could be designed for any number of operating frequency at any range by varying some parameter and adding more elements. Another promising advantage of this antenna is very simple structure and compatibility of multiband applications.

2. ANTENNA CONFIGURATION AND DESIGN PROCEDURE

This antenna has a simple structure fed by 50Ω microstrip line. Fig. 1 demonstrates the dimensions of the proposed antenna used for theoretical and simulated study where the dimensions are in mm range. The dielectric material selected for the design is Taconic TLY-5 which has dielectric

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constant of 2.2 and the height of dielectric substrate of (h) = 1.588 mm. Generally the overall dimension of the antenna is 83.5 x 16.9 x 1.602 mm. Here, SONNET version V12.56 package is used to obtain the return loss and the radiation patterns.

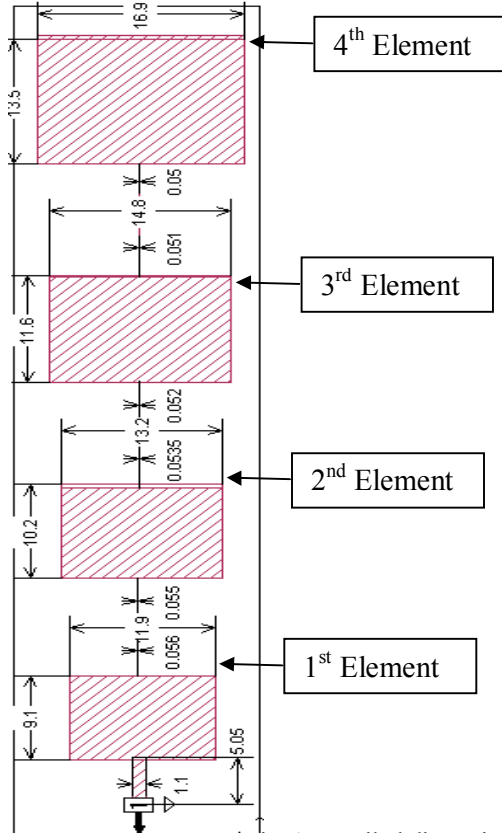


Fig. 1: Detailed dimensions of the proposed microstrip antenna

For an efficient radiation, practical width of the patch is [3]

$$w = \frac{1}{2 f_r \sqrt{\mu_0 \epsilon_0}} \times \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

and the length of the antenna is [3]

$$L = \frac{1}{2 f_r \sqrt{\epsilon_{eff}} \sqrt{\epsilon_0 \mu_0}} - 2 \Delta L \quad (2)$$

where,

$$\Delta L = 0.41 h \frac{\epsilon_{eff} + 0.3}{\epsilon_{eff} - 0.258} * \frac{(\frac{w}{h} + 0.264)}{(\frac{w}{h} + 0.8)} \quad (3)$$

and

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2 \sqrt{1 + 12 \frac{h}{w}}} \quad (4)$$

Where, λ is the wave length, f_r is the resonance frequency, L and W are the length and width of the patch element and ϵ_r is the dielectric constant. Here, the antenna seems to be a series feed array network [5]. But each element has designed for different operating frequency. In Fig. 1 the antenna has designed only for four bands. The 1st, 2nd, 3rd and 4th elements of the rectangular array antenna is the rectangular slot having the area of 11.9 x 9.1 mm, 13.2 x 10.2 mm, 14.8 x 11.6 mm and 16.9 x 13.5 mm operating at 10.1 GHz, 9.3 GHz, 8 GHz and 7.6 GHz frequency respectively. Although, each element covers specific operating frequency, because of their array network configuration the antenna provides efficient radiation performance in term of gain and directivity. In this array network configuration two successive patch elements are matched by using quarter wavelength transformer method where in case of selecting the length of the transformer the operating frequency of the patch element near by the source has been chosen [5].

3. ANTENNA SIMULATION AND RESULT

The return loss response of the proposed microstrip array antenna simulated in the SONNET version V12.56 is shown in Fig. 2, where the minimum return loss i.e. -23.67dB is found at 10.1 GHz operating frequency. The other three dip values of return losses are -14.0dB, -3.67dB and -4.0dB at 9.3GHz, 8GHz, and 7.6GHz frequencies respectively. This indicates that the proposed antenna has lower return loss at higher frequency than lower frequency. Therefore, the highest radiation efficiency is at 10.1GHz among the total frequency band. Again, the radiation patterns of this four band antenna for the four operating frequencies are shown in Fig. 3 using the same simulator. The directive gain for the antenna with the operating frequencies 7.6 GHz, 8 GHz, 9.3 GHz and 10.1 GHz have values 15.16dB, 15.15dB, 13.12dB and 12.15 dB respectively. Fig 3 illustrates that the antenna has higher directivity at lower frequencies than higher frequencies.

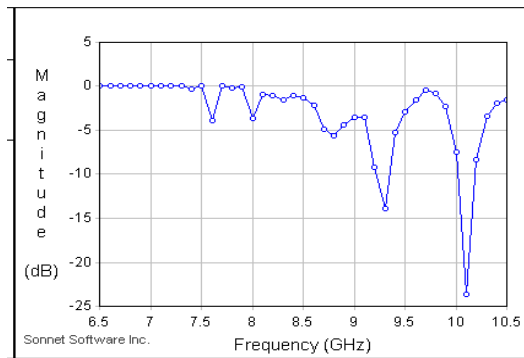


Fig. 2: Return loss response of the antenna array

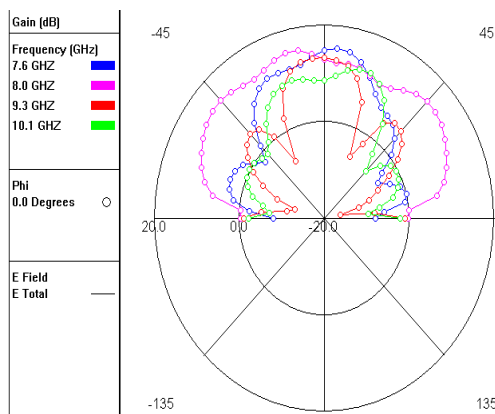


Fig. 3: Radiation pattern at 7.6 GHz, 8 GHz, 9.3 GHz and 10.1 GHz of the microstrip array antenna

For the convenience, the effect of the individual element on the overall performance and their comparison with the same sized single element microstrip patch antenna are summarized below. From the result shown in the following tables it can be concluded that the designed antenna outperform the conventional one with respect to the directive gain, return loss and radiation efficiency. It is also summarized that each element in array contributes better than the element as a single antenna.

Table 1. Comparison of the effect of the 1st element on array configuration and single element microstrip antenna

Antenna Type	Performance Parameter		
	Directive gain	HPBW	Return loss
1st element on array	12.15 dB	50°	-23.67 dB
Single element configuration	6.25 dB	130°	-8.4 dB

Table 2. Comparison of the effect of the 2nd element on array configuration and single element microstrip antenna

Antenna Type	Performance Parameter		
	Directive gain	HPBW	Return loss
2nd element on array	13.12 dB	36°	-13.84 dB
Single element configuration	6.38 dB	140°	-4.9 dB

Table 3. Comparison of the effect of the 3rd element on array configuration and single element microstrip antenna

Antenna Type	Performance Parameter		
	Directive gain	HPBW	Return loss
3rd element on array	15.15 dB	100°	-3.67 dB
Single element configuration	6.5 dB	130°	-2.7 dB

Table 4. Comparison of the effect of the 4th element on array configuration and single element microstrip antenna

Antenna Type	Performance Parameter		
	Directive gain	HPBW	Return loss
4th element on array	15.16 dB	76°	-3.88 dB
Single element configuration	6.6 dB	140.3°	Above 3 dB

4. CONCLUSION

The unique feature of this antenna is its simplicity to get improved performance for multiband applications. This paper presents a geometric configuration for a microstrip antenna array which provides a mean to get higher directive gain and maximum radiation efficiency than the conventional antenna structure using simple technique. Other benefits of this designed antenna are, it can be used as a single band as well as multiband and it would also be possible to design the antenna operating at any other system such as WLAN, WiMAX or other wireless system by changing the dimension of the patch elements. Here, the series fed array configuration has been investigated and in future the corporate-series feed

array configuration could be designed and simulated operating at multiple frequencies and having higher directive gain.

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FREE-SPACE OPTICAL COMMUNICATION SYSTEM UNDER STRONG TURBULENCE WITH Q-ARY PULSE-POSITION MODULATION

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Free-space optical communication is an attractive and cost-effective solution for high-rate image, voice, and data transmission. However, optical wave propagation through the air experiences fluctuation in amplitude and phase due to atmospheric turbulence. The use of multiple laser transmitters combined with multiple photo detectors has the potential for combating fading effects on turbulent optical channels. For strong turbulence gamma-gamma models are treated. In this paper, the modulation format is Q-ary PPM across lasers, with intensity modulation. Ideal photodetectors are assumed, with and without background radiation. The performance results are evaluated in terms of symbol error probability for several system parameters.

Keywords: free optics (FSO), multiple input/multiple output(MIMO) , pulse position modulation (PPM), probability of density function (PDF) , symbol error probability (SEP)

1. INTRODUCTION

Free-space optical (FSO) communication has received significant attention recently, as a possible alternative to solve the bottleneck connectivity problem, and as a supplement to more conventional RF/microwave links [1-6]. However, optical wave propagation through the air experiences fluctuation in amplitude and phase due to atmospheric turbulence. This intensity fluctuation, also known as scintillation is one of the most important factors that degrade the performance of an FSO communication link even under the clear sky condition. Two primary challenges are attached to free-space optical communication. First, the narrow beam-width implies the need for careful pointing, and perhaps a need for active pointing and tracking mechanisms to combat building sway, etc. Second, the need to combat link fading due to scattering and scintillation. To enable the transmission under the strong atmospheric turbulence the use of the multi-laser multi-detector (MLMD) concept has been reported in Ref. [4, 6]. Specifically, we envision separate lasers, assumed to be intensity-modulated only, together with photodetectors (PDs), assumed to be ideal noncoherent (direct-detection) receivers. The sources and detectors are physically situated so that the fading experienced between source-detector pairs is statistically independent, and thus, diversity benefits can accrue from the multiple-input multiple-

output (MIMO) channel. Obviously, the assumption of independence may not be valid, depending upon the spacing of the devices, and on the nature of the fading. For example, a cloud or fog bank that fills most of the link will obviously induce large fades on all source-detector pairs. Alternative means of operation in such environments must be considered.

In this paper, we propose an analytical approach to evaluate the performance under strong turbulence with Q-ary PPM. The proposed scheme allows aggregation of RF/microwave signals and a conversion to the optical domain in a very natural way and may be a good candidate for hybrid RF/microwave-FSO systems. The symbol error probability (SEP) are evaluated with and without fading in the presence of background radiation. The symbol error probability are determined assuming that p.i.n. photodiodes are used, and the channel is modeled using Gamma-Gamma distribution.

2. SYSTEM MODEL

Fig. 1 depicts a block diagram of the physical system under study. M laser sources, all pointed toward a distant array of N PDs, are intensity-modulated by an information source. The laser beam-widths are narrow, but sufficiently wide to illuminate the entire PD array. For example, if the half-power beam-width is 10 mrad, the half-power spot size at

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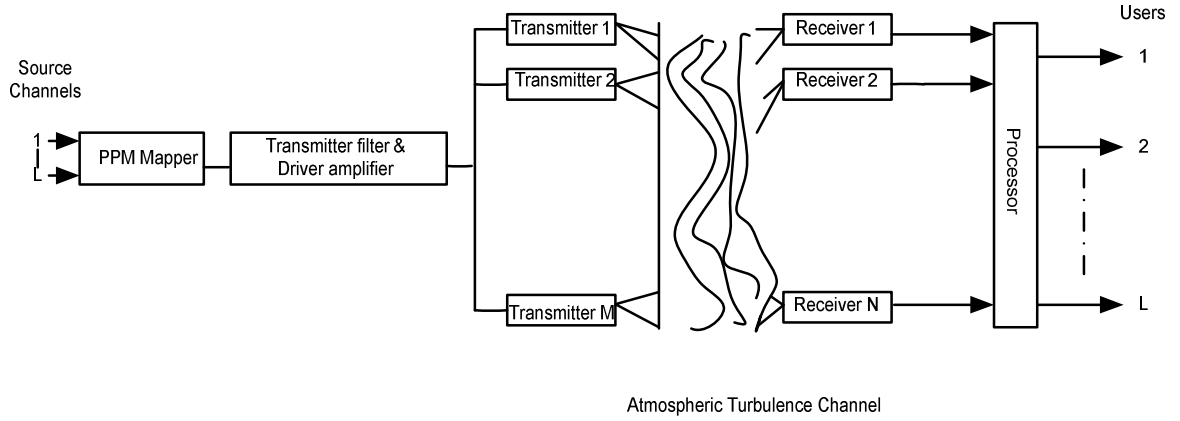


Fig. 1. Atmospheric optical MIMO system with Q-ary PPM

distance 1 km has diameter 10 m. The MN optical path pairs may experience fading, and we designate A_{nm} as the amplitude of the path gain (field strength multiplier) from m source to detector. A Q-ary PPM scheme transmits $L=\log_2 Q$ bits per symbol, providing high power efficiency. In the transmitter, the signals are described by the waveforms

$$\begin{aligned} s_0(t) &= A = \sqrt{2P}, \quad 0 \leq t \leq T_s/4 & \text{'00'} \\ s_1(t) &= A = \sqrt{2P}, \quad T_s/4 \leq t \leq T_s/2 & \text{'01'} \\ s_2(t) &= A = \sqrt{2P}, \quad T_s/2 \leq t \leq 3T_s/4 & \text{'10'} \\ s_3(t) &= A = \sqrt{2P}, \quad 3T_s/4 \leq t \leq T_s & \text{'11'} \end{aligned} \quad (1)$$

At the receiver the received signal $r(t)$ after optical/electrical conversion is:

$$r(t) = \eta h(t) I_0 + n(t) \quad (2)$$

where I_0 = the average transmitted light intensity and $I = h I_0$ = the corresponding received intensity in an ON PPM slot.

h = the channel fading coefficient

n = receiver noise.

The aggregate optical field is detected by each PD, assuming an ideal photon counting model with typical quantum efficiency. Also a single-channel link analysis is included to suggest typical link parameters. Though the transmission rate is rather flexible, we have in mind systems sending in the range of 100 Mb/s. Here we consider the chosen parameters rate 100 Mb/s, the expected number of detected photoelectrons per slot is on the order of 300 in either binary or quaternary PPM. Though this is more than adequate for the desired performance with the ideal photon-counting model, fading and other parameter choices could make this number much smaller. We next present specific details regarding the optical MIMO model.

3. CHANNEL MODELING

To characterize the FSO channel from a communication theory perspective, it is useful to give a statistical representation of the scintillation. The reliability of the communication link can be determined if we use a good probabilistic model for the turbulence. Several probability density functions (PDFs) have been proposed for the intensity variations at the receiver of an optical link. Al-Habash et al. [7] proposed a statistical model that factorizes the irradiance as the product of two independent random processes each with a Gamma PDF. The PDF of the intensity fluctuation is given by [7]

$$f(I) = \frac{2(\alpha\beta)^{(\alpha+\beta)/2}}{\Gamma(\alpha)\Gamma(\beta)} I^{(\alpha+\beta)-1} K_{(\alpha-\beta)}(2\sqrt{\alpha\beta}I), I > 0 \quad (3)$$

I is the signal intensity, $\Gamma(\cdot)$ is the gamma function, and $K_{\alpha\beta}$ is the modified Bessel function of the second kind and order α, β . α and β are PDF parameters describing the scintillation experienced by plane waves, and in the case of zero-inner scale are given by [7]

$$\alpha = \frac{1}{\exp\left[\frac{0.49\sigma_R^2}{(1+1.11\sigma_R^{12/5})^{7/6}}\right] - 1} \quad (4)$$

$$\beta = \frac{1}{\exp\left[\frac{0.51\sigma_R^2}{(1+0.69\sigma_R^{12/5})^{5/6}}\right] - 1} \quad (5)$$

where σ_R^2 is the Rytov variance given by [2]

$$\sigma_R^2 = 1.23 C_n^2 k^{7/6} L^{11/6} \quad (6)$$

$k = 2\pi/L$ (is the optical wave number, L is propagation distance, and $Cn2$ is the refractive index structure parameter, which we assume to be constant for horizontal paths.

4. THEORETICAL ANALYSIS

Symbol error probability (SEP) of the system

We consider four cases: with or without channel fading, and with or without background radiation.

Case:1 No Fading, No Background Radiation

First, consider the case of negligible background radiation and equal-gain links i.e. $\mathbf{A}_{nm}=1$ almost surely, $n=1, \dots, N$, $m=1, \dots, M$ with no loss of generality, assume that each laser sends energy in slot 1. The only possibility for decision error is that each detector registers zero counts in time slot 1, since the other slots register zero counts by assumption ($\lambda_b=0$). By the Poisson property and independence, we have SEP

$$P_s = \frac{Q-1}{Q} \left[e^{-\frac{M\eta\left(\frac{P_r}{M}\right)T_s}{hfQ}} \right]^N = \frac{Q-1}{Q} e^{-\frac{\eta E_s N}{hf}} \quad (7)$$

Case:2 Fading, No Background Radiation

First, we assume the channel gain of every laser-detector pair is fixed over a symbol duration. Letting a_{mn} denote the amplitude fading on the path from laser m to photodetector n , we define the channel gain matrix as $\mathbf{A}$ with element $[a_{nm}, n=1, \dots, N, m=1, \dots, M]$. The probability of symbol error conditioned on the fading variables is

$$P_s = \int P_{s|A} f(I) dI = \frac{Q-1}{Q} \left\{ \int e^{-\frac{a^2 \eta \left(\frac{E_s}{M}\right)}{hf}} f(I) dI \right\}^N \quad (8)$$

Case:3 No Fading, Background Radiation

At the receiver end, it received a matrix $\mathbf{Z}$ with elements $[Z_{nq}, n=1, \dots, N, q=1, \dots, Q]$. λ_b is the Poisson count random variable parameter due to the background radiation, and if slot q is an 'off' slot, $\mathbf{Z}_{nq}$ will be also a Poisson distributed random variable with parameter λ_b . The upper bound of error probability for this case

$$P_s \leq 1 - P[\text{all } Z_q < Z_1] = 1 - (P[Z_2 < Z_1])^{Q-1} \\ = 1 - \left[\sum_{i=1}^{\infty} \sum_{j=0}^{i-1} P(Z_1 = i, Z_2 = j) \right]^{Q-1} \quad (9)$$

In case there is no channel fading, the ML detector does not need to weight Z_{nq} . The ML detector just compares the sum of the photoelectrons counts of all N photodetector in every slots and chooses the largest w slots. Expanding the exponent with a Taylor series SEP can be given by,

$$P_s \cong \frac{w(Q-w)}{2} \exp\left(-\frac{\lambda_s^2}{4\lambda_b}\right) \quad (10)$$

Case:4 Fading background Radiation

For this most general case, the optimal detector is as described by the following equation. We propose instead a more realistic design of simply summing over the received PD counts for each time slot as was optimal for the cases presented above. Channel estimation at the receiver is thereby avoided in exchange for a small performance penalty.

$$P_{S/X} = 1 - \left[\sum_{i=1}^{\infty} \frac{(M(\lambda_s + \lambda_b))^i e^{-N(\lambda_s + \lambda_b)}}{i!} X \frac{(N\lambda_b)^j e^{-N\lambda_b}}{j!} \right]^{Q-1} \quad (11)$$

5. RESULTS AND DISCUSSION

Following the analytical approach presented in section IV, we evaluate the symbol error probability result of a MIMO FSO link with Q-ary PPM and direct detection scheme under strong turbulence condition.

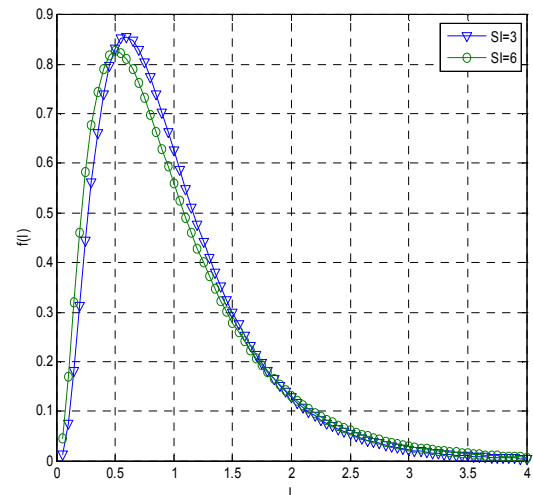


Fig2: Probability of Distribution Function for Gamma-Gamma.

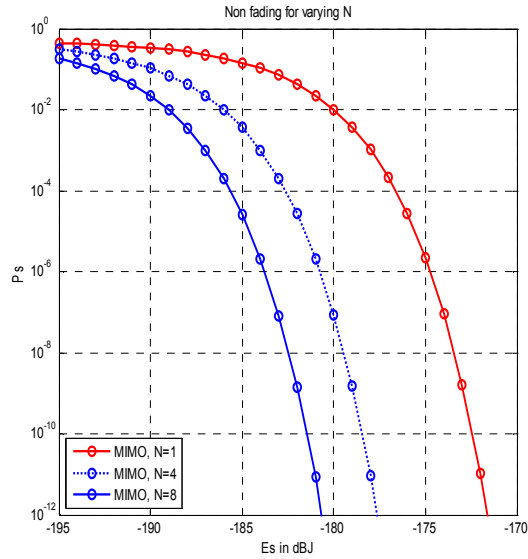


Fig3: SEP with varying N, for gamma-gamma non-fading with $S.I. = 3$, $Q = 2$. $M=1$ and no background noise

The simulations are performed using matlab, the influence of scintillation is modeled assuming a Gamma-Gamma distribution, and an ideal photon counting receiver is employed. The plots of the probability density function in Fig. 2 for gamma gamma cases with several typical values of scintillation index (S.I) and turbulence strength.

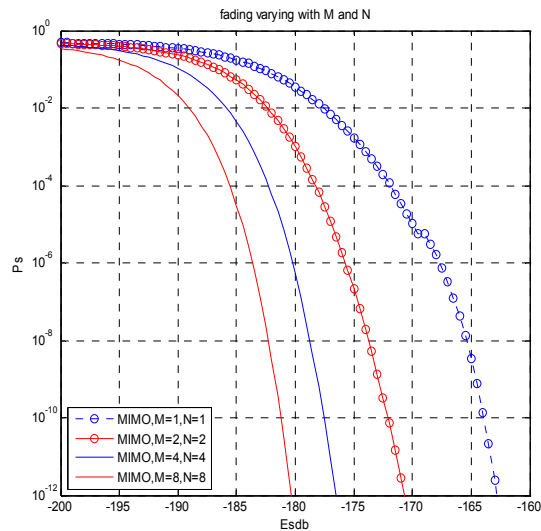


Fig. 4 :SEP with varying both M and N, for gamma-gamma fading with $S.I.=3$. $Q = 2$ and no background noise.

.In particular, notice the gamma-gamma model has a much higher density in the high amplitude region, leading to a more severe impact on system performance. Fig. 3 shows the SEP under strong turbulence for non faded system with Q-ary scheme. The SEP are shown in Fig. 4 for several combinations of transmitting and receiving antennas

under faded condition.. The symbol energy due to background light is set to -170 dBJ for both system. It is noticed that, SEP improves as the numbers of lasers and photodetectors are increased and in the presence of background light the SEP decreases as the order of the Q-ary PPM scheme increases.

6. CONCLUSIONS

We have analyzed an optical MIMO system employing QPPM across sources, together with direct detection. Gamma gamma model has been treated, assuming independent fading on source-detector pairs. The analysis shows the beneficial effects from a diversity standpoint of multiple sources and detectors, and transmit diversity is achieved here without additional special coding. Some aspects of the optical MIMO system here mimic those of the microwave MIMO systems. Full transmit diversity can be shown analytically for the no-background-noise case. Even for the case of normal background radiation, QPPM is still able to approach the performance of the unfaded case by increasing the number of transmitter. The proposed MIMO scheme provides excellent gains for different atmospheric turbulence conditions, ranging from the weak to the strong turbulence regimes.

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INTELLIGENT TRAFFIC CONTROL BY CCTV, PIC16F877A MICROCONTROLLER AND IR ROAD SENSOR

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In view of domestic traffic, the traffic flow has been increasing dramatically in recent years, whereas traffic control is deficient. This paper presents a design of intelligent traffic control which contains road sensor, emergency sound detector, traffic signal violation detector and live human-computer interaction. Road sensor will determine the traffic density and according to the traffic density the microcontroller will organize the signal light. Emergency sound detector can detect ambulance, fire brigade and other emergency car and the microcontroller will give precedence for this kind of emergency vehicles. The regulation violation detector can detect vehicle if they violate the traffic signal and take the picture of number-plate of violating vehicles. In any kind of unexpected situation the signal light can be controlled by the computer.

Key words: Road sensor; Infrared; Traffic Control; Microcontroller; intelligent

1. INTRODUCTION

Bottleneck of traditional traffic signal controller is not intelligent, and the mode of control is quite unitary. Obviously traditional traffic signal controller can not meet the complicated and diversified traffic control in modern city [1-5]. In the existing traffic control system of Bangladesh the traffic signals are repeated at certain time intervals, without taking into consideration the traffic load in the roads. It works at a constant time interval irrespective of the crowd density at any time [6]. So it is very common that a nearly empty road is enjoying the green signal while a more congested road is under the red signal. The proposed system has the capacity to realize the traffic load. Basically some road sensors count the vehicles in various roads. Here it is tried to minimize traffic jam by assigning slots of sensor to each road. Every crowded slot has a predefined time. In a easy way it can say that, the road sensors count vehicles in various roads and according to this count microcontroller determines which road has more vehicles and give more time for green signal in that road compare to other roads which have lesser vehicle. As more crowded road will find more time for green signal, a balance will be maintained among different roads and the traffic jam will be reduced. Traffic signal violation detector identifies vehicle which violate signal and

camera will take picture of number-plate from back sides of this car. Any time signal light can be controlled by computer command also. Thus it can intelligently accomplish human-computer interaction, control signal according to traffic density, detect vehicle if any one go against to signal.

2. MAIN PARTS OF THE SYSTEM

The main parts of the system are road sensors, emergency sound detectors, traffic signal violation detectors, cameras, processing unit and signal lights. From road sensors and sound detector processor (a microcontroller) takes input and according to input it controls the signal lights. Figure 1 signifies the block diagram of the system.

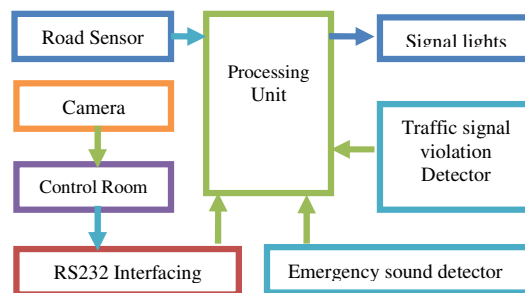


Fig. 1: Block Diagram

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Details of each block are given one by one below.

2.1 Processing Unit

Processing unit is the heart of this system. Here used a PIC16F877A microcontroller as processor. It is an 8bit microcontroller introduced by Microchip corporations [7-8]. Program for this microcontroller is written in Assembly language. For program editing, compiling and simulation, MPLAB IDE was used. The output of sensors is taken as input by microcontroller an according to this output delay for signal lights are calculated and implemented automatically according to program's instruction. A serial port programmer was used for program writing into microcontroller.

2.2 Road Sensor

Road sensor's has two parts, a light source and a receiver. An infrared generator acts as light source and photoresistor acts as receiver. When light (Infrared) from light source fall into receiver (photoresistor) the output of the sensor is zero as resistance of the photoresistor decreases. When no light in the receiver the resistance of it is high and for this output is high. Fig. 2 shows how it works.

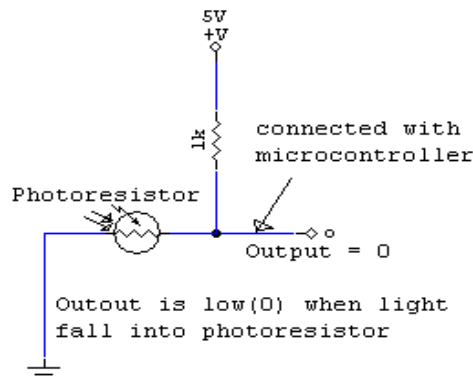


Fig. 2: How road sensors work

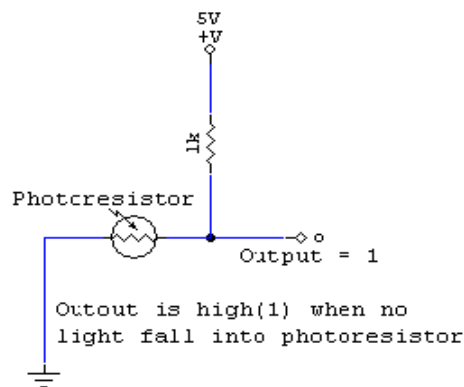


Fig. 2: How road sensors work

The sensors output is connected to the microcontroller and microcontroller gets this output as digital input (0 for low and 1 for high). Receiver is connected in series with a resistor and act as voltage divider. When resistance of photoresistor is low then ground will appear as output and when resistance of photoresistor is high then +v will appear as output.

The main work of road sensor is to count vehicle in various roads. Infrared sensor is used as road sensor. Infrared LEDs are placed at one side of the road. Another side contains infrared receivers. Infrared rays are focused to receiver from infrared LEDs. When there is no vehicle in the road infrared rays fall to the receivers and it shows low resistance. When the vehicles obstruct the light to fall receiver then it shows high resistance. A road is divided into several slots and every slot contains a set of sensors. A fixed time is predefined for every slot. According to the filled slot with vehicles the microcontroller calculates the duration of signaling time.

Let, the predefined time for a slot is a ,

Filled slots are n ,

So the duration of the green signal for this roads = $a*n$.

Consider a junction of four roads. Let, at a time 1 slot of first road's, 3 slots of second road's, 2 slots of 3rd road's and 4 slots of 4th road's is filled. Assume predefined time for each slot is $a=5$ second. As forth road has maximum number of filled slot (4 slot) compare to other in this junction, so the duration of green signal corresponding to forth road will be maximum ($4*5=20$ seconds). For first, second and third road green signal's duration will be 5, $3*5=15$ and $2*5=10$ respectively. So from here it is clear that a more congested road will get more time automatically by this system. It is frequently occurred in the existing traffic control system in Bangladesh that, a nearly empty road enjoys the green signal while a more congested road enjoys red signal. By this automatic traffic control system the problem will be minimized as well as reduced traffic jam.

2.3 Emergency sound detector

When ambulance, fire brigade, VIP cars are entered in a road, emergency sound detector of that road detects this and microcontroller takes this as an interrupt and turn on the green signal of the corresponding road. Microphone and band pass filter are used as sound detector. Figure 3 represents how emergency sound detector will work. Sound detector contains a MIC and a band pass filter which allows to pass emergency sound band such as 2 kHz - 3.5 kHz only. The signal from band pass

filters then sent to amplifier section for amplification. Microcontroller takes amplified output of amplifier as input and input is high only for frequency which will pass from band pass filter.

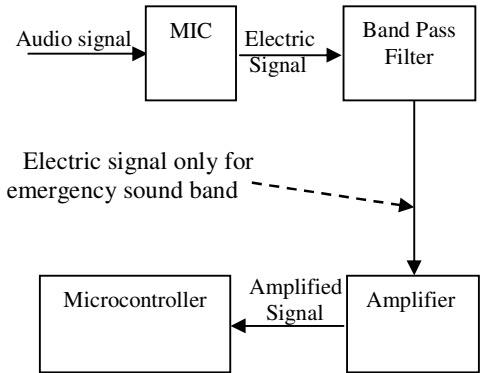


Fig. 3: How emergency sound detector works

Microphone (MIC) is used as transducer and convert audio signal into electrical signal. This electrical signal contains energy for all range of audio frequencies (Fig. 4a). But the system needs signal only for emergency vehicles, so it is then passed through a band pass filter which frequency band is for emergency sound range (such as 2KHz to 3.2 KHz). Now the output contains electric energy only for emergency sound band (Fig. 4b).

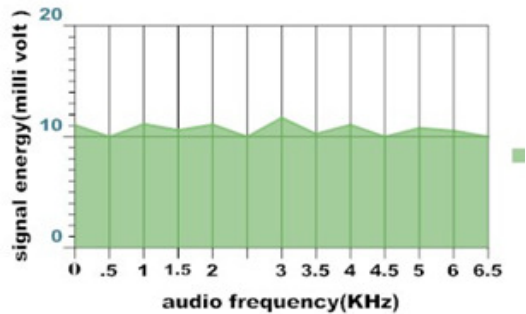


Fig. 4a: frequency response before filtering

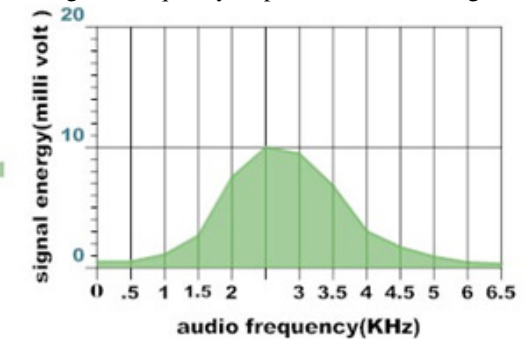


Fig. 4b: frequency response after filtering

The output energy is very low (at milli volt). So amplifier is used for amplification of signal. Figure 5 shows frequency response of amplified signal.

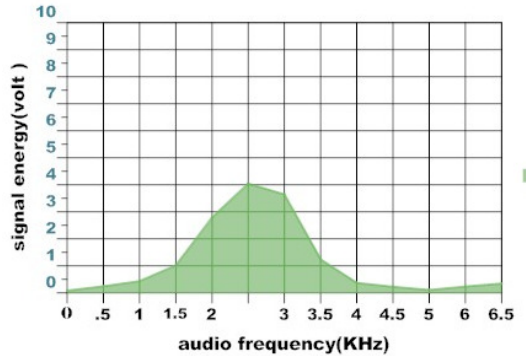


Fig. 5: Frequency response of amplifier's output

2.4 CCTV and PC Interfacing

With RS232 interfacing standard the system can communicate with computer. It is one kind of serial communication with computer. Serial terminal program is needed for user interfacing with pc. Windows default terminal program 'Hyper Terminal' can be used. CCTV camera is set in every traffic point. Several points can be control from a control room. The overall view of o point can be seen from the room and can send control instruction to the signal. All video will be saved into video server in the control room for future investigation. From the control room if it is seen that a traffic signal point should need more 40 second for green signal to pass vehicle because of an unexpected situation occurred. So it is very easy to do this job. Simply press 40 in Hyper Terminal input box and press enter. Microcontroller takes it as a serial interrupt and instantly implements this into corresponding signal. If more 20 seconds needed it is also possible in the same way.

2.5 Traffic signal violation detector

If any time a road is under red signal and then if any vehicle pass the last limit violation detector identify it and instantly camera take the picture of the number plate of that vehicle from its back side. Traffic rule violation detector contains sensor and camera. Sensor is like road sensor but it sets up at the starting of the road from junction. Figure 6 shows the setup of violation detector. When any vehicle crosses the last limit of road at the time of red signal, microcontroller gets an interrupt and instantly switched the camera to take picture. Camera is sat as this way that, it can take picture from the back side of the car which violates the rule. Getting the picture proper action could be taken against the violator.

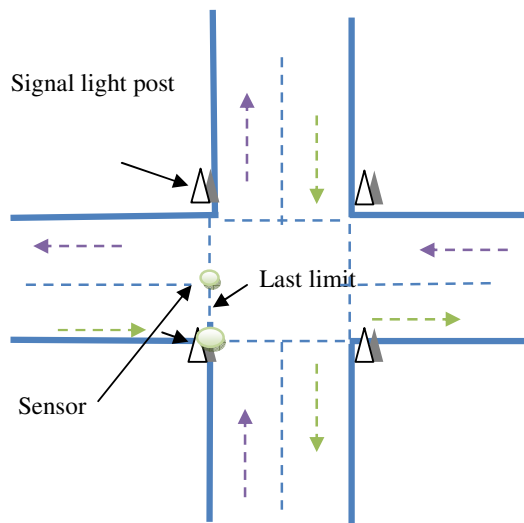


Fig. 6: Signal violation sensor setup in a 4 roads junction

3. CONCLUSIONS

The system represented here used very basic element. So implementing of this system will be cost efficient. The system can automatically control the traffic signal considering traffic density, can detect vehicle that disobey the traffic signal. The duration of a signal light can also be defined from a computer. The overall view of a traffic point can be viewed by CCTV cameras and any time the signal can be controlled by computer from a remote control room. The CCTV can also be used for security purpose. In case of violating traffic signal camera take the picture of number plate. By this necessary steps can take against violator. As it is automatic so people will keep alert and traffic discipline can be improved. By this intelligent system safety will improve and chances of accident will fall. Emergency vehicles will get automatic priority. The system will also improve the security of the traffic point as well as the road.

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INTERFERENCE REDUCTION AND CAPACITY ENHANCEMENT USING SMART ANTENNAS IN CDMA NETWORKS

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In this paper a high-resolution direction finding algorithm called ESPAR (electronically steerable parasitic array radiator) using MUSIC with periodic signals is employed on a smart antenna. The modified MUSIC algorithm is free from the negative influences of the mutual coupling among antenna elements. The simulation confirmed that a smart system has ability to distinguish between signals of interest and interference by directing beams in the directions of the desired signals and nulls in the directions of the interferences. Moreover, signal distortion problem of a CDMA system can be resolved with the help of a omnidirectional pattern of a circular array.

Key words: Smart antenna, CDMA, Direction of arrival estimation, Multiple signal classification.

1. INTRODUCTION

The limited capacity analog cellular AMPS (Automatic Mobile Phone System) is being replaced by more advanced digital cellular CDMA system in some parts of the USA. With the introduction of PCS frequencies, GSM and CDMA technologies are making giant strides in commercial wireless markets across the world [1]. In CDMA systems the frequency reuse factor is 1 which enables it to offer higher capacities and the capacity improvement by CDMA technology may be as high as 13 times that of TDMA. But in CDMA all subscribers use same frequency and this creates inter-cell & intra-cell co-channel interference. Thus the actual performance of a CDMA system is still interference limited and is affected by adverse channel conditions created by multipath propagation. It is obvious that the capacity of CDMA based wireless communication system can be improved by different interference reduction techniques and that can be achieved by using smart antennas such as switched beam smart antenna (SBSA) or adaptive array smart antenna [2]-[3]. Reactance loading of circular array for omnidirectional beamforming has been considered in [4]. In our analysis, we have shown that perfect

omnidirectional beam pattern can be obtained by Music algorithm and by varying reactance loading of a circular array designed for CDMA.

2. DIRECTION OF ARRIVAL ESTIMATION

Direction of arrival (DOA) estimation is a basic and important technique in array signal processing for wireless communication systems. In signal processing literature, direction of arrival denotes the direction from which usually a propagating wave arrives at a point, where usually a set of sensors are located. This set of sensors forms a sensor array [5].

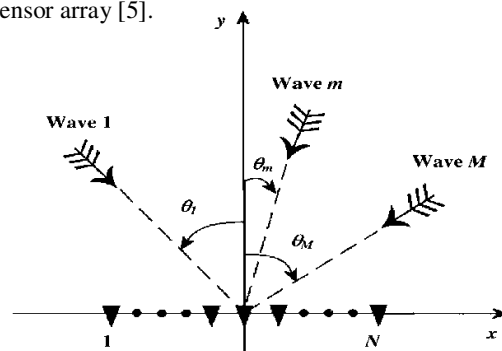


Fig. 1: Configuration of the smart antenna

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As shown in Fig.1 a uniform linear array composed of N elements with inter-element spacing d is considered. In this case, M Electromagnetic waves (which are supposed to be narrowband plane waves with central frequency ω) impinge on the array from directions $\theta_m, m = 1, \dots, M$. It is generally assumed that $M < N$, though there exist approaches that do not place this constraint. In practice, the estimation is made difficult by the fact that there are usually an unknown number of signals impinging on the array simultaneously, each from unknown directions and with unknown amplitudes. Also, the received signals are always corrupted by noise. Nevertheless, there are several methods to estimate the number of signals and their directions. In this paper, MUSIC algorithm is used to estimate the DOA of signals [6]-[8].

3. THE MUSIC ALGORITHM

MUSIC is an abbreviation for Multiple Signal Classification. The multiple signal classification (MUSIC) method is a simple and efficient eigen structure variant of DOA estimation methods. It is perhaps the most studied method in its class and has many variations. It is the most promising and a leading candidate for further study and actual hardware implementation. MUSIC algorithm is popular due to its generality. It is an algorithm used for frequency estimation and emitter location.

It is applicable to arrays of arbitrary but known configuration and response, and can be used to estimate multiple parameters per source (e.g., azimuth, elevation, range, polarization, etc.). However, this generality is accompanied with the expense that the array response must be known for all possible combinations of source parameters; i.e., the response must be either measured (*calibrated*) and stored, or one must be able to characterize it analytically (e.g., as in the case of root-MUSIC). In addition, MUSIC requires *a priori* knowledge of the second-order spatial statistics of the background noise and interference field. [9] – [11].

The signal and noise subspaces are first identified using eigen decomposition of the received signal covariance matrix. Then *MUSIC spatial spectrum* is computed, from which the DOAs are estimated. Inside the algorithm, we first define the general *array manifold* to be the set

$$A = \{a(\theta_i) : \theta_i \in \Theta\}$$

The structure of the exact covariance matrix with the spatial white noise assumption implies that its spectral decomposition can be expressed as [12]-[13]

$$R_{xx} = AU_{ss}A^H + \Omega^2 I = U_s \Lambda_s U_s^H + \Omega^2 U_n U_n^H$$

where, assuming $AU_{ss}A^H$ to be of full rank, the diagonal matrix Λ_s contains the L largest eigenvalues. Since the eigenvectors in U_n (the noise eigenvectors) are orthogonal to A , we have,

$$U_n^H a(\theta) = 0, \quad \theta \in \{\theta_1, \theta_2, \dots, \theta_L\}$$

Here, the eigen decomposition of R_{xx} will give the eigenvalues λ_n such that $\lambda_1 > \lambda_2 > \dots > \lambda_K > \lambda_{K+1} = \lambda_{K+2} = \dots = \lambda_N = \Omega_n^2$ and the corresponding eigenvectors $U_n \in C^N, n = 1, 2, \dots, N$, of R_{xx} .

To allow for unique DOA estimates, the array is usually assumed to be unambiguous, that is, any collection of M steering vectors corresponding to distinct DOAs η_k forms a linearly independent set $\{a(\eta_1), \dots, a(\eta_M)\}$, where $L < M$. If $a(\theta)$ satisfies these conditions and R_{xx} has full rank, then $AU_{ss}A^H$ is also of full rank. It then follows that $\theta_1, \dots, \theta_L$ are the only possible solutions to the relation in Eqn. (2), which could therefore be used to exactly locate the DOAs. In practice, an estimate $\hat{R}_{xx}$ of the covariance matrix is obtained and its eigenvectors are separated into the signal and noise eigenvectors. The orthogonal projector onto the noise subspace is estimated as

$$P^\perp_A = U_n^\perp U_n^H$$

The MUSIC spatial spectrum is then defined as

$$PL(\Theta) = [a^H(\Theta)a(\Theta)] / \{a^H(\Theta) P^\perp_A a(\Theta)\}$$

Although $P_L(\theta)$ is not a true spectrum in any sense (it is merely the distance between two subspaces), it exhibits peaks in the vicinity of the true DOAs. The performance improvement of the MUSIC estimator was so significant that it became an alternative to most existing methods. Thus, in contrast to the beam forming techniques, the MUSIC algorithm provides statistically consistent estimates. The DOA's of each of the incident signals can be estimated by plotting the spatial spectrum given by $P_L(\theta)$ [14] -[16].

4. SIMULATION RESULT

The following cases are considered for MATLAB simulation:-

The antenna generates a directional beam based on load reactances ($x_1, x_2, \dots, x_6$). The signal

impinging directions are set arbitrarily to 120° and 150° in the azimuth plane, respectively. As a result, all the spectra reach the peak values at the respective signal directions. Here, three different reactance load settings are studied to investigate their influence on the performance of the DOA estimation. The signal-to-noise ratio (SNR) is 30 dB for each individual signal source.

When we set equal load reactances to the elements of the circular array considered, the antenna exhibits a nearly omnidirectional beam pattern.

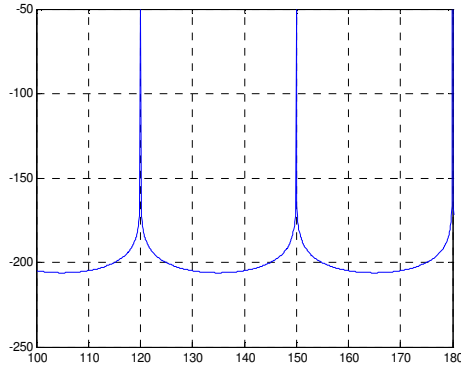


Fig. 2.1: MUSIC spectrum for SNR=30dB in the signal direction 120° and 150° in the azimuth plane.

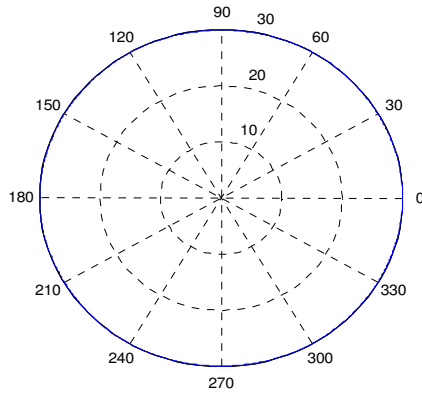


Fig. 2.2: Beam pattern in the azimuth plane for $x_1=30\Omega$, $x_2=30\Omega$, $x_3=30\Omega$, $x_4=30\Omega$, $x_5=30\Omega$ and $x_6=30\Omega$

After that, we took ordered but unequal load reactance and set $x_1 = 0\Omega$, $x_2 = 60\Omega$, $x_3 = 0\Omega$, $x_4 = 60\Omega$, $x_5 = 60\Omega$, and $x_6 = 60\Omega$. As a result, it slightly influence MUSIC spectrum and provide insufficient beam patterns for rotation.

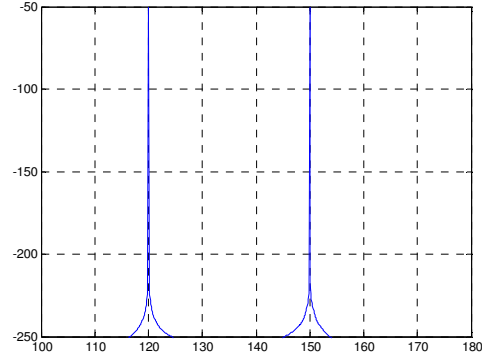


Fig. 2.3: MUSIC spectrum for SNR=30dB in the signal direction 120° and 150° in the azimuth plane.

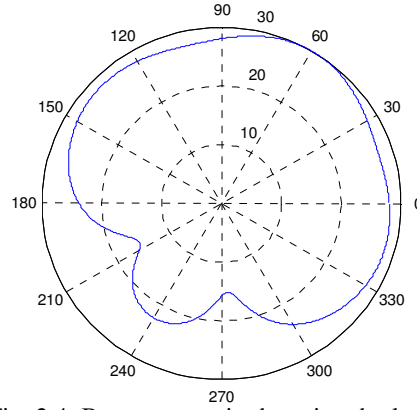


Fig. 2.4: Beam pattern in the azimuth plane for $x_1=0\Omega$, $x_2=60\Omega$, $x_3=0\Omega$, $x_4=60\Omega$, $x_5=60\Omega$ and $x_6=60\Omega$

Finally, we randomly set $x_1 = 0\Omega$, $x_2 = 30\Omega$, $x_3 = 60\Omega$, $x_4 = 90\Omega$, $x_5 = 120\Omega$, and $x_6 = 150\Omega$. It gives the directional information like an adaptive beam processor.

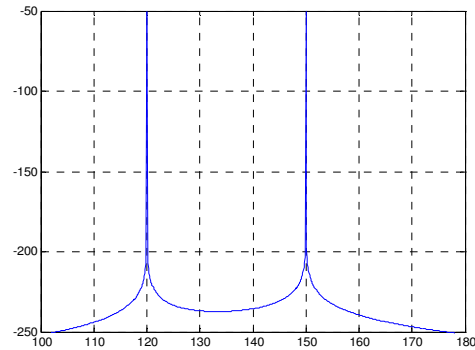


Fig. 2.5: MUSIC spectrum for SNR=30dB in the signal direction 120° and 150° in the azimuth plane.

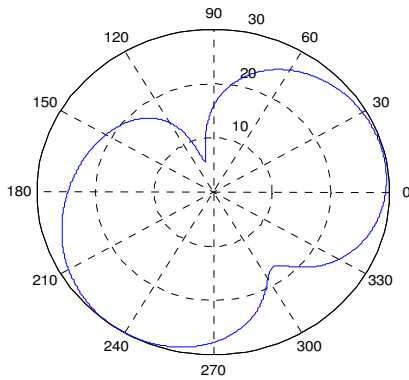


Fig. 2.6: Beam pattern in the azimuth plane for $x_1=0\Omega$, $x_2=30\Omega$, $x_3=60\Omega$, $x_4=90\Omega$, $x_5=120\Omega$ and $x_6=150\Omega$

7. CONCLUSIONS

From the above investigations, we can conclude that the manner of load settings for the elements of a circular smart array greatly influences the DOA estimation performances. The load setting that gives deep nulls in radiation patterns in certain directions should be avoided, because signals coming from that region could be received with low power levels, or even be nulled. Consequently, the information of signal in the null region cannot be extracted. Moreover, Signal distortion is prominent in multiple beam forming. This problem should be resolved for a CDMA system where binary pulses are extensively used. Omnidirectional pattern of a smart antenna system can resolve this problem. We have shown how an omnidirectional pattern can be obtained by a circular smart array of parasitic elements by parameter adjustment. For example, Fig-2.2 corresponding to 30Ω - 100Ω reactance loading for each element in a circular array gives omnidirectional pattern which can resolve the problems of signal distortion

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MULTIBAND STRIP ANTENNA FOR 2.3/2.5/5.5 GHZ WIMAX AND 2.4 GHZ WLAN OPERATIONS

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Abstract— This paper presents a multiband strip antenna for 2.3/2.5/5.5 GHz WiMAX and 2.4 GHz WLAN operations by means of numerical simulations. The dimension of the antenna is $39 \times 30 \text{ mm}^2$ and provides an impedance bandwidth of 300 MHz (2350-2650 MHz) and 130 MHz (5490-5620 MHz) at lower and upper frequency band respectively, which fully covers the 2.4, 2.5 and partially covers the 2.3, 5.5 GHz bands. The antenna contains very high peak gains of 8.25, 8.43, 8.46 and 6.43 dBi at 2.3, 2.4, 2.5 and 5.5 GHz band respectively with less than 0.2, 0.1, 0.3 and 1.5 dBi gain variations within the 10 dB return loss bandwidth. The VSWR of the antenna varies between 1.20~1.80 and 1.06~1.83 at the lower and upper resonant frequency bands respectively and the peak values of the return loss are -20.85 and -30.71 dB. The antenna has good omnidirectional radiation characteristics at E-plane and H-plane.

Key words: Strip Antenna; Multiband Antenna; Numerical Electromagnetic Code (NEC); WiMAX; WLAN

1. INTRODUCTION

At present the demand of wireless local area networks (WLANs) and worldwide interoperability for microwave access (WiMAX) are increasing numerously worldwide for commercial communication because WLAN provides high speed connectivity and easy access to networks without wiring and WiMAX can provide a long operating range with a high data rate for mobile broadband wireless access, faultless internet access for wireless users becomes more popular. Also in recent times the function of various portable devices is increasing, so the antenna designer's encountered difficulty in designing antennas that could provide multiband operations with high gain in each operating band. The fast growing WLAN protocols operating bands are IEEE 802.11 b/a/g at 2.4 GHz (2400–2484 MHz), 5.2 GHz (5150–5350 MHz) and 5.8 GHz (5725–5825 MHz), the operating bands of WiMAX is 2.5/3.5/5-GHz (2500–2690/3400–3600/5250–5850 MHz) bands (Pan et. al., 2007, Pazin et. al., 2008, Wu et. al., 2005, Su and Wong, 2006).

A dual wideband printed monopole antenna for WLAN/WiMAX applications (Pan et. al., 2007), a

multiband flat-plate Inverted-F antenna for Wi-Fi/WiMAX operation (Pazin et. al., 2008), a T-shaped monopole antenna with shorted L-shaped strip-sleeves for WLAN 2.4/5.8-GHz operation (Wu et. al., 2005), an internal PIFA's for UMTS/WLAN/WiMAX multi-network operation for a USB dongle (Su and Wong, 2006), a CPW-fed triangle-shaped monopole antenna for 2.4/5 GHz WLAN and 3.4 GHz WiMAX applications (Song, et. al., 2007), a capacitively fed hybrid monopole/slot chip antenna has been proposed for 2.5/3.5/5.5 GHz WiMAX operation in the mobile phone (Lai and Wong, 2008), a printed antenna with a quasi-self-complementary structure for 5.2/5.8 GHz WLAN operation (Wong, et. al., 2003), a compact monopole antenna has been proposed for dual ISM band (2.4 and 5.8 GHz) operation (Jung, et. al., 2009), a printed antenna which is working in 2.4 GHz bluetooth, 3.5 and 5.8 GHz WiMAX, 2.4–2.5 and 5.0–5.8 GHz Wi-Fi, 2.4–2.84 GHz, 5.15–5.35 and 5.72–5.83 GHz WLAN operation (Sun et. al., 2009), a broadband low-profile printed T-shaped monopole antenna for 5 GHz WLAN application (Su et. al., 2004) and a compact PIFA for bluetooth, S-DMB, WiBro, WiMAX and WLAN applications (Shin and Park, 2007) have been proposed.

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To provide the rising demand and cover up the widespread applications of WiMAX and WLAN an antenna with high gain, satisfactory bandwidth and less gain variation within the antenna bandwidth are desired. To meet up most of mentioned requirements, multiband strip antenna is one of the superior candidates within the micro-strip printed antennas.

2. ANTENNA DESIGN

In designing multiband strip antenna for WiMAX, and WLAN operation, we examine the possibility of increasing antenna gain and number of operating bands. Using MoM's in Numerical Electromagnetic Code (Burke, and Poggio, 1981), we conducted parameter studies to ascertain the effect of different loading on the antenna performance to find out the optimal design. In our analysis we assume the copper conductor and the antenna is assumed to feed by 50 Ω coaxial connector, with its central conductor connected to the feeding point and its outer conductor connected to the ground plane just across the feeding point. Fig. 1 represents the basic geometry of the IFA. Here one leg of IFA directly connected to the feeding and another leg spaced s from the ground plane. For the simulation we consider printed circuit board (PCB) with permittivity of $\epsilon_r = 2.2$ and substrate thickness of 1.58 mm. In the analysis the dimensions of the ground plane considered as 60 mm $\times$ 60 mm. Fig. 2 and 3 represents the loaded IFA, called the double branch inverted-F antenna (DBIFA) and triple branch inverted-F antenna (TBIFA) respectively. Fig. 4 represents the proposed strip antenna.

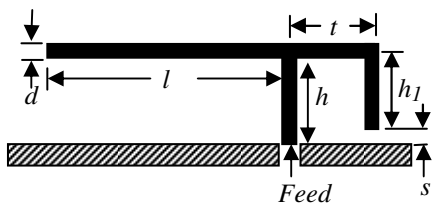


Fig. 1: Structure of inverted-F antenna (IFA)

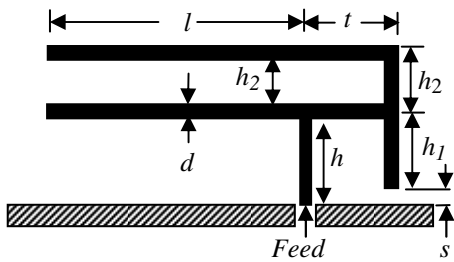


Fig. 2: Structure of double branch IFA (DBIFA)

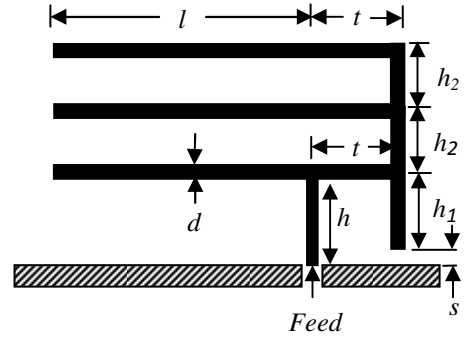


Fig. 3: Structure of triple branch IFA (TBIFA)

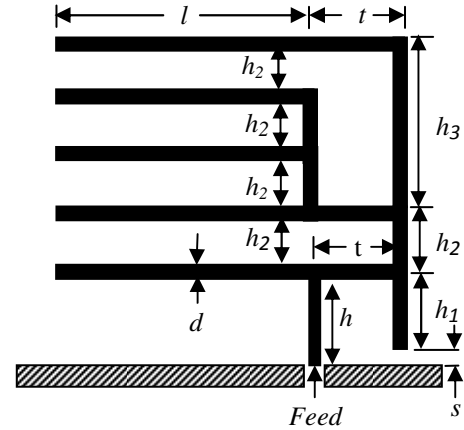


Fig. 4: Structure of proposed strip antenna

For IFA of Fig. 1, the resonant frequency related to d given as (Huynh, 2000)

$$f_1 = \frac{c}{4(l+t+h_1)} \quad (1)$$

Where c is the speed of light. The effective length of the current is $l+t+h_1+d$. Under this case the resonant condition can be expressed as

$$l+t+h_1+d = \frac{\lambda_0}{4} \quad (2)$$

The other resonant frequency that is a part of linear combination with the case $0 < d < (l+t)$ and is expressed as

$$f_2 = \frac{c}{4(l+t+h_1-d)} \quad (3)$$

The resonant frequency (f_r) is a linear combination of resonant frequency associated with the limiting case. For the antenna geometry of Fig. 1, f_r can be written from equation (1) and (2) as (Hirisawa and Haneishi, 1992)

$$f_r = r.f_1 + (1-r)f_2 \quad (4)$$

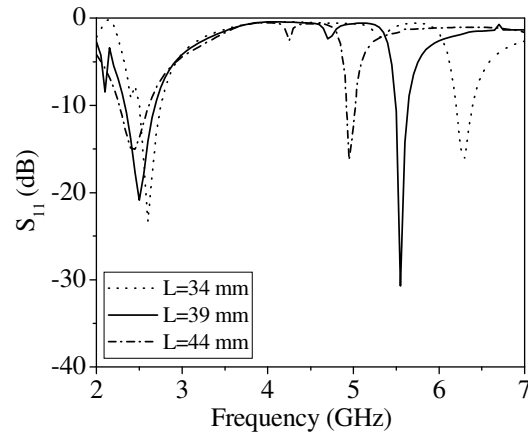
Where $r=d/(l+t)$. Fig. 5 shows the return loss variation with frequency of IFA, DBIFA, TBIFA

and strip antenna. It represent that the return loss of IFA is like dual band shape but both band stay above the required 10 dB level. As the performance of IFA is not satisfactory for the multiband operation then we apply a small suitable structured load on the horizontal branch of the IFA named double branch IFA (DBIFA) as shown in Fig. 2.

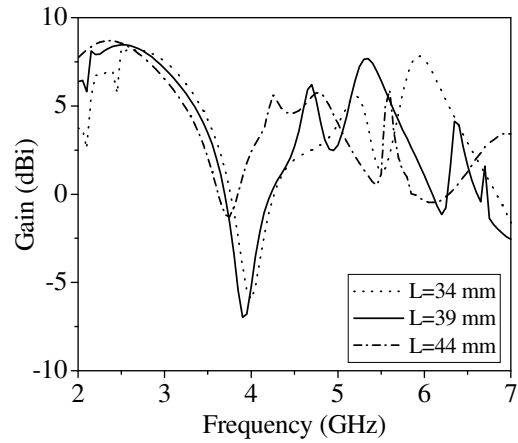
From Fig. 5 we observe that when we apply that load then the antenna performance improves significantly but the performance of the lower frequency band is not till satisfactory. So we further modify the applied load (as shown if Fig. 3) and observe that the antenna has achievable return loss characteristic for both operating band. We continue advanced analysis on the loaded IFA for achieving best performance from the antenna structure (shown in Fig. 4 called strip antenna). Fig. 6, 7 and 8 show the effects of L , h_2 and t on the performance of strip antenna (antenna structure of Fig. 4). Table 1 represents the optimized dimensions of the proposed antenna of Fig. 4.

Table 1. Dimension of the proposed antenna of Fig. 4

Antenna name	Antenna parameters	Values (mm)	Dimension (mm ²)
Strip antenna	l	33	39×30
	t	6	
	$L=l+t$	39	
	h_1	13.4	
	h_2	4	
	h_3	12	
	h	14	
	d	2	
	s	0.6	



(a)



(b)

Fig. 6: Variation of (a) return loss and (b) gain for different values of L of strip antenna

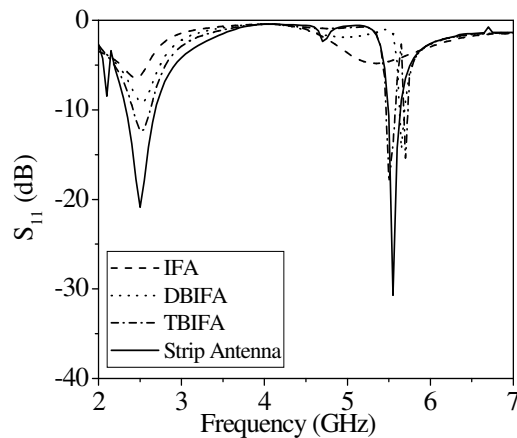
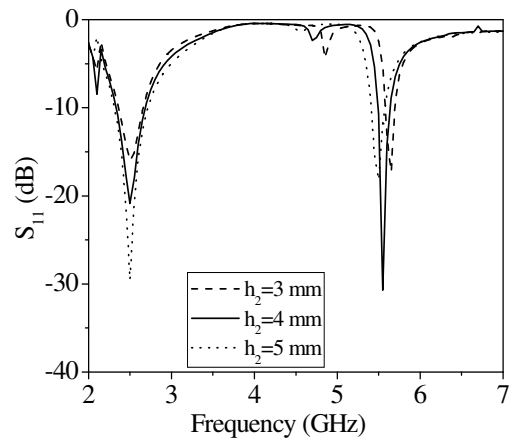


Fig. 5: Variations of return loss for different types of antennas



(a)

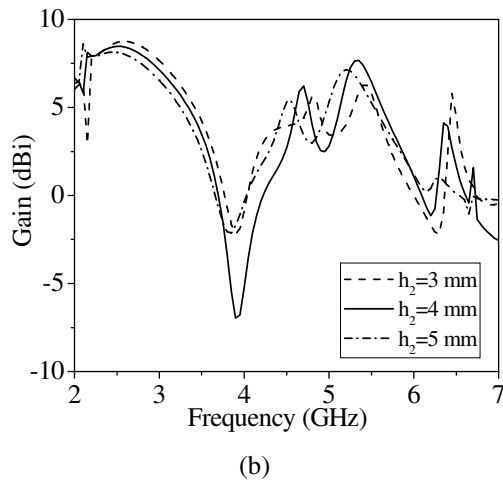


Fig. 7: Variation of (a) return loss and (b) gain for different values of d of strip antenna

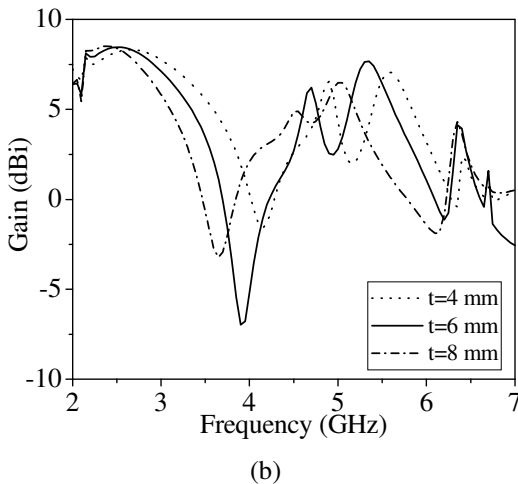
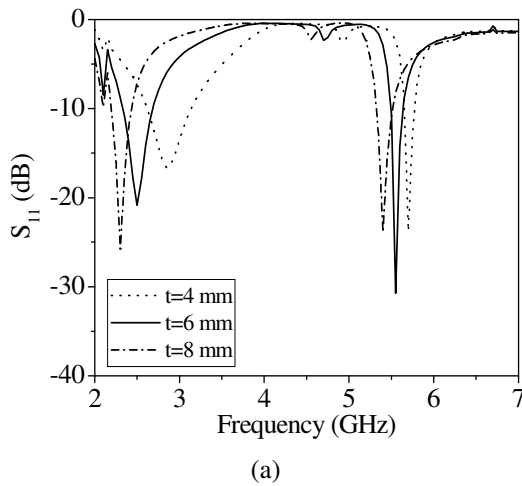


Fig. 8: Variation of (a) return loss and (b) gain for different values of t of strip antenna

3. SIMULATION RESULTS

The proposed antenna is constructed and numerically analyzed using MoM's. The numerical

results of the antenna are shown below. The proposed antenna have the return loss appreciable than the commonly required 10 dB level. Fig. 9 represents the voltage standing wave ratio (VSWR) variation and Fig. 10 represents the return loss variation of strip antenna with frequency. The strip antenna provides a large impedance bandwidth of 300 MHz (2350-2650 MHz) and 130 MHz (5490-5620 MHz) which fully covers the 2.4, 2.5 GHz and partially covers the 2.3 and 5.5 GHz bands. The values of the VSWR of the antenna vary between 1.20~1.80 and 1.06~1.83 at the lower and upper frequency bands respectively (shown in Fig. 9) and the peak values of the return loss are -20.85 and -30.71 dB at lower and upper frequency band respectively (as in Fig.10). Fig. 11 shows the peak gains of the proposed antenna. The peak gains of the antenna are 8.25, 8.43, 8.46 and 6.43 dBi at 2.3, 2.4, 2.5 and 5.5 GHz band respectively, with less than 0.2, 0.1, 0.3 and 1.5 dBi gain variations within the 10 dB return loss bandwidth. Fig.12 represents the impedance variation of frequency. From the simulated data, the proposed antenna is near about 50 Ω at operating frequency bands so extra impedance matching network is not essential for the operation of the antenna. Fig. 13 represents the antenna phase shift causes due to the impedance mismatch as a function of frequency. Also, from the simulation study, the antenna offers a phase shift of -14.484° , -18.743° , -7.066° and -25.277° at 2.3, 2.4, 2.5 and 5.5 GHz band respectively. So phase shift of strip antenna closer to 0° all over the antenna bandwidth. Fig. 14 and 15 show the normalized radiation patterns of strip antenna at 2.4 and 5.5 GHz bands respectively. Normalized radiation patterns for two resonant frequencies are shown as: total gain in H-plane (YZ/XZ plane) and E-plane (XY plane). The antenna's normalized total radiation in H and E-plane is almost omnidirectional at the 2.3/2.5/5.5 GHz WiMAX and 2.4 GHz WLAN operating frequency band.

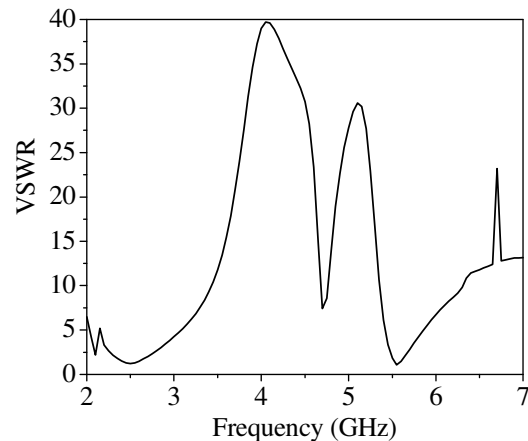


Fig. 9: VSWR variation of strip antenna with frequency

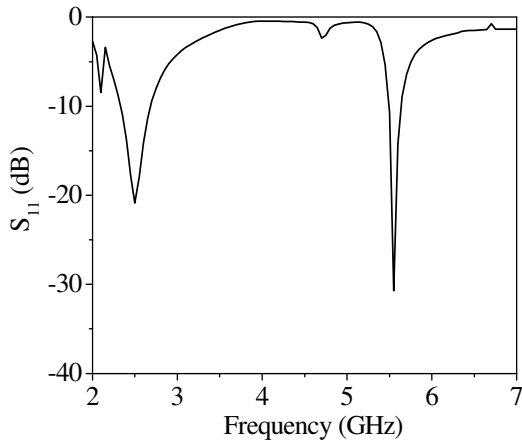


Fig. 10: Return loss variation of strip antenna with frequency

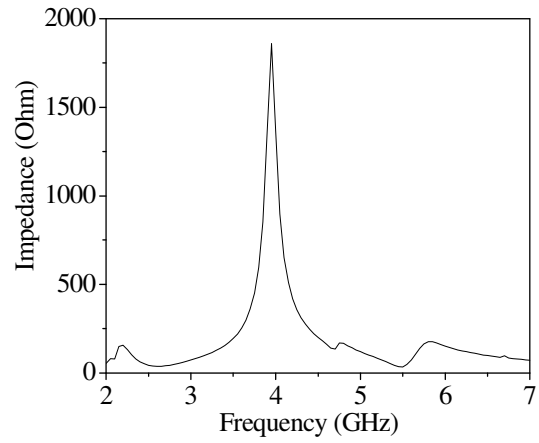


Fig. 12: Impedance variation of strip antenna with frequency

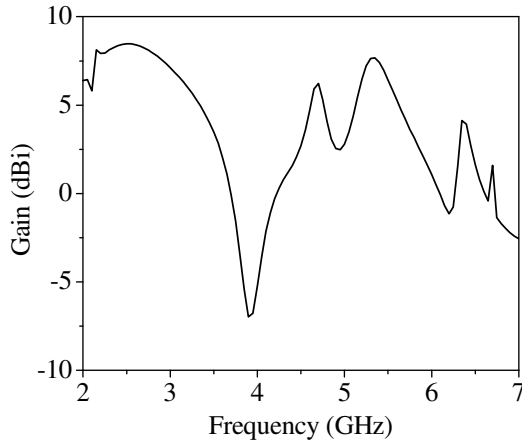


Fig. 11: Gain variation of strip antenna with frequency

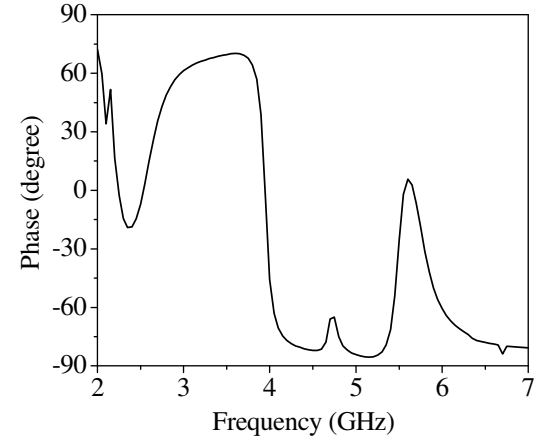


Fig. 13: Phase shift variation of strip antenna with frequency

Printed monopole antenna (Pan et. al., 2007), flat-plate Inverted-F antenna (Pazin et. al., 2008), T-shaped monopole antenna with shorted L-shaped strip-sleeves (Wu et. al., 2005), internal PIFA's (Su and Wong, 2006), CPW-fed triangle-shaped monopole antenna (Song, et. al., 2007), capacitively fed hybrid monopole/slot chip antenna (Lai and Wong, 2008), printed quasi-self-complementary antenna (Wong, et. al., 2003), compact monopole antenna (Jung, et. al., 2009), printed antenna (Sun et. al., 2009), low-profile printed T-shaped monopole antenna (Su et. al., 2004), compact PIFA antenna (Shin and Park, 2007), suffer from the gain limitations for required applications. But the gain of the proposed antenna is much better with stable gain variation within the antenna bandwidth than the antennas proposed earlier. In overall considerations, the performance of the proposed strip antenna is much better than all other antennas.

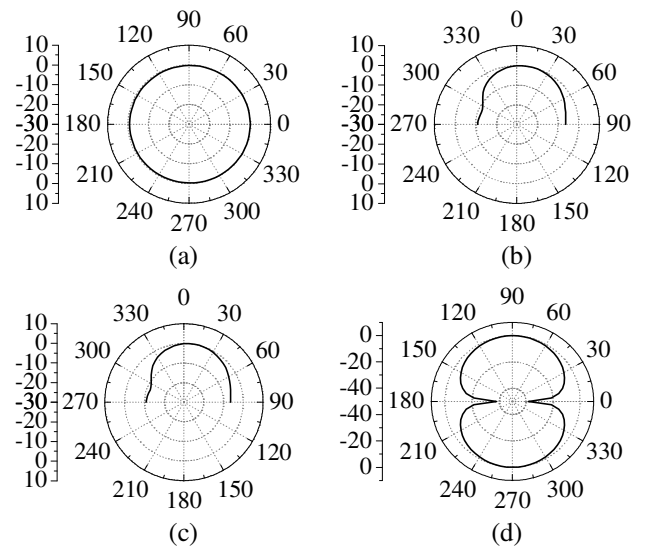


Fig. 14: Normalized radiation pattern (a) total gain in E-plane (b) total gain in H-plane, (c) vertical gain in H-plane and (d) horizontal gain in E-plane of strip antenna at 2.4 GHz

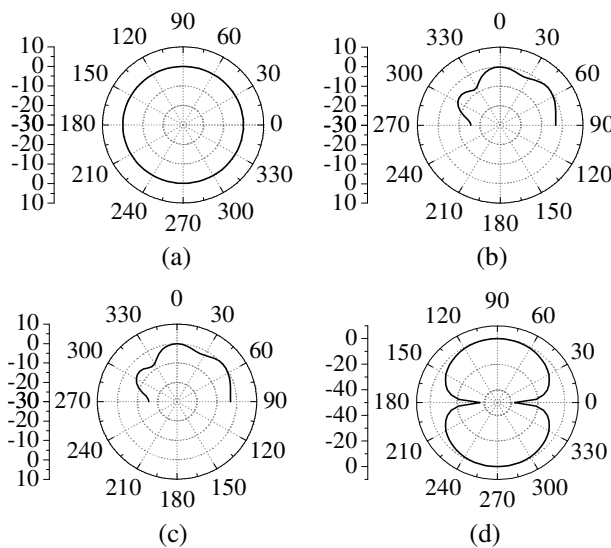


Fig. 15: Normalized radiation pattern (a) total gain in E-plane (b) total gain in H-plane, (c) vertical gain in H-plane and (d) horizontal gain in E-plane of strip antenna at 5.5 GHz

4. CONCLUSIONS

A multiband strip antenna has been proposed and investigated by means of numerical simulations using method of moments in NEC. The antenna occupies a very small area of $39 \times 30 \text{ mm}^2$ with bandwidths of 300 MHz (2350-2650 MHz) and 130 MHz (5490-5620 MHz) at lower and upper frequency band respectively. Moreover the gain of the antenna is very high and the gain variation of the antenna is very low at the operating bands. The simulated pattern, return loss and radiation characteristics indicates the suitability of the antenna for 2.3/2.5/5.5 GHz WiMAX and 2.4 GHz WLAN operations. As the antenna occupies small area, so it is promising to be embedded within the different portable devices employing WiMAX and WLAN applications.

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PERFORMANCE ANALYSIS OF WIFI NETWORK FOR INDOOR ENVIRONMENT

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This paper gives a picture of the performance of a WiFi network in Indoor Environment. To observe the performance, a WiFi network of 802.11b standard is established in an office. The performance analysis is conducted in terms of two parameters: Throughput and RSSI (Received Signal Strength Indicator). The analysis shows that for a coverage area of 20 meter radius the signal strength remains around 60%-70% and a power level is -25dB to -85 dB. Analysis also shows the pattern of change of the signal strength with in range of 8 feet to 35feet. A Maximum throughput of 7.9Mbps is observed where as the Upload data rate is 4.9Mbps and Download data rate is 143.2 kbps.

Keywords: Wireless Fidelity, RSSI, Throughput, Transfer Rate, SSID

1. INTRODUCTION

The term "Wi-Fi." is the short form of "wireless fidelity." All the modern devices increasingly come ready to work with Wi-Fi. (One example: By 2007, according to IDC Research of Framingham, Mass., 98% of all new notebook PCs will be sold with Wi-Fi capability) [1]. Wi-Fi refers to products certified to work with the high-tech industry's global standard for high-speed wireless networking. A person with a Wi-Fi enabled device such as a PC, cell phone or PDA can connect to the Internet when in proximity of an access point [2]. The region covered by one or several access points is called a hotspot. Hotspots can range from a single room to many square miles of overlapping hotspots. A huge number of the people of the world are now enjoying the service of the hotspots. But the problem is they are not actually happy with the speed they are getting. Actually it is not always possible to achieve the data speed guaranteed by the IEEE standards 802.11. In reality the speed is really different in most of the cases. In this paper we have tried to investigate the performance of a WiFi network in an official environment through the process of site

Survey. The survey is conducted with the help of two software WirelessMon and DuMeter.

2. PLAN FOR THE NETWORK

An experimental network is designed using a variety of antennas, antenna cables and connectors, a laptop computer (or PDA) with a wireless PC card, Wireless client pc, some site survey utility software such as "Wireless Mon" and "Du meter". Two personal computers of having following configuration are considered:

PC No: 1

Configuration:

System requirements: Windows XP
IP address: 192.168.2.115
AP configuration: Bel_WiFi
Adapter: Shiro WA54-U
Software: Wirelessmon and DU meter

PC No: 2

Configuration:

System requirements: Windows XP
IP address: 192.168.2.139
AP configuration: Bel_WiFi
Adapter: Belkin N Wireless Adapter
Software: Wirelessmon and DU meter

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3. PARAMETERS USED FOR PERFORMANCE MEASUREMENT

3.1. RSSI reading (Radio Signal Strength Indicator)

The received signal strength indicator (RSSI) is an optional 802.11 parameter with a value from 0 to 255. It is designed to be used by the hardware manufacturer as a relative measurement of the RF power that is received[3]. The RSSI is one of the indicators that are used by a wireless device to determine if another device is transmitting. Here we have used a simulation Software “WirelessMon” to get RSSI reading from AP to wireless adapter.

3.2 Throughput reading

The throughput is a measure of how efficiently a data communication takes place through a network. In this experiment we have used software called “DU METER” for the measurement of throughput.

4. EXPERIMENTAL RESULTS

In simulation part there are two steps which are as follows:

- ❖ Sending Data
- ❖ Receiving Data

4.1 RSSI reading while Sending Data

From figure we may see that the signal strength while transferring data through the access point. The signal strength and RSSI depends upon the coverage and the distance area from the Access point. While sending data through the network using the CISCO Router as the access point to a base station set or a Wifi network client pc. For this step we took the wireless client pc having the configuration of pc no 1 and got the following informations from the given figures:

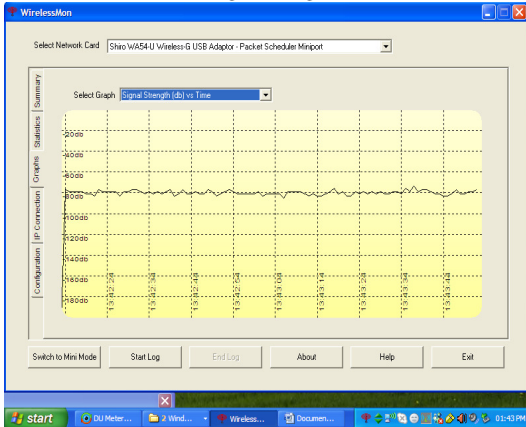


Fig 1. Signal Strength(In dB) Vs Time curve

From the figure[Fig 1.] we may observe that the signal strength lies between 60%-80% and the figure [Fig. 2] gives us a report on RSSI reading.

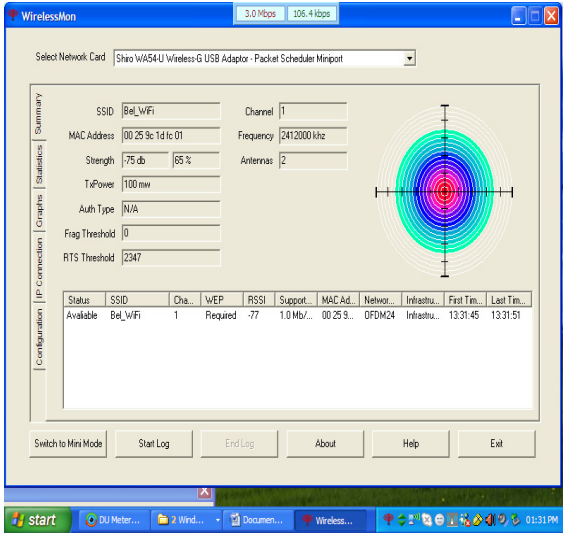


Fig 2. RSSI report for sending data

From figure [Fig. 2] it is observed that the signal strength is -75 dB and it is 65% for the distance of 20 feet between the client and access point. The distance between the two PCs is 25 feet.

4.2 RSSI Reading while receiving Data

In this experiment we have used the 2nd pc as the receiver and the measured the performance of the signal received by this pc.

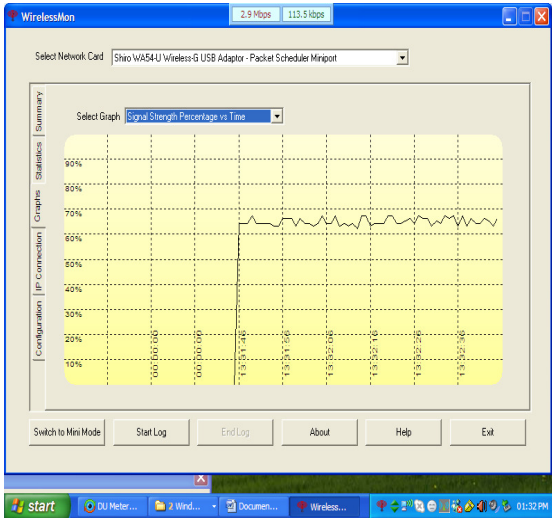


Fig 3. Signal Strength(%) Vs Time curve.

From figure [Fig. 4] it is observed that the strength of the signal lies between 60% to 80%. Figure [Fig. 5] provides a report on the RSSI level of the received data.

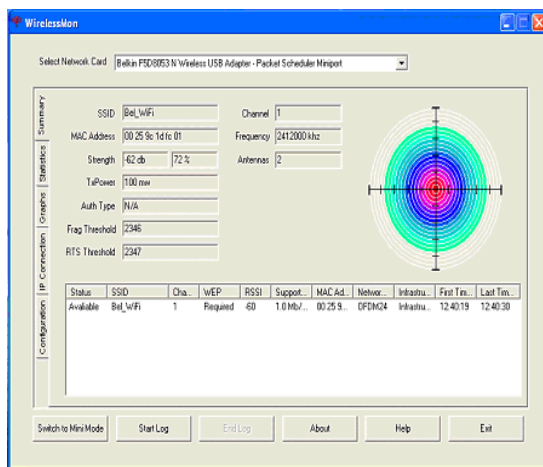


Fig 4. RSSI report for receiving data

The above figure [Fig. 5] shows the RSSI level of the received data is -77 db and in terms of percentage it is 65%.

4.3 ThroughPut reading while sending data

To take throughput reading a WiFi network named Bel_WiFi, with operating Frequency 2.4 GHz is selected and this network is designed using CISCO AP with wireless pc client with wireless adapter of Shiro WA54-U. Throughput reading is taken using FTP protocol. While sending data through the access point in 802.11b Mode we observed a Maximum throughput of 7.9Mbps [Fig. 5] at that time Upload data rate was 4.9Mbps and Download data rate was 143.2 kbps.

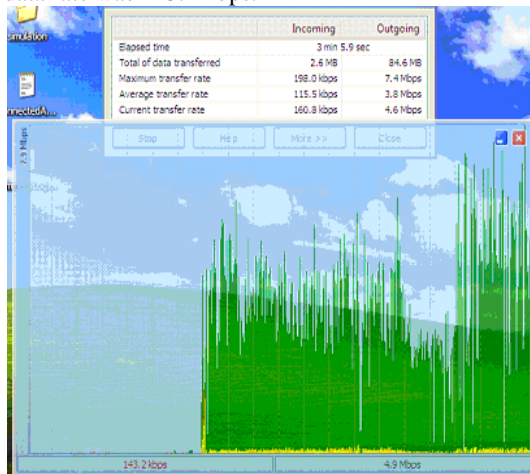


Fig. 5: Throughput performance for sending data

From the above figure we get the following data while transferring data through the network:

Transfer Rate	Incoming	Outgoing
Maximum Transfer rate	198.0 Kbps	7.9 Mbps
Average Transfer rate	115.5 Kbps	3.8 Mbps
Current Transfer rate	160.8 Kbps	4.9 Mbps

From the above figure we may see that during receiving data through a specific WiFi network named Bel_WiFi the signal strength is between 60%-70%.

4.4 Throughput Reading while receiving data

To take throughput reading of the received data same WiFi network named Bel_WiFi, with operating Frequency 2.4 GHz is used. In this experiment we used the wireless pc client having wireless adapter of **Belkin N Wireless Adapter**. The throughput performance is evaluated named "DU Meter". While receiving data through the access point's Band in 802.11b Mode named **Bel_WiFi** we got a Maximum throughput of 9.7Mbps [Fig. 6] at that time Upload data rate was 160.8Mbps and Download data rate was 4.2 Mbps.

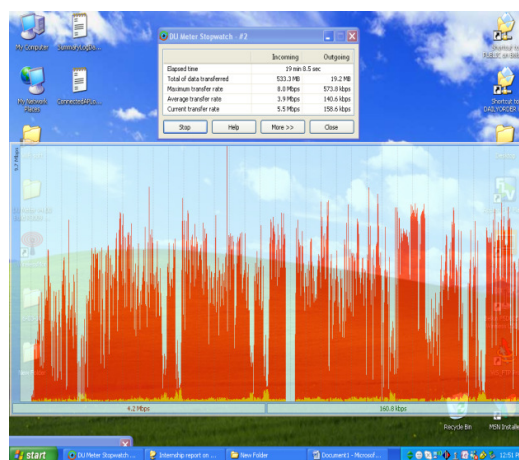


Fig. 6: Throughput performance for receiving data.

From the above figure we may see that the transfer rate during receiving data through a particular network which SSID is Bel_WiFi and the transfer rate during the elapsed time is as follows:

Transfer Rate	Incoming	Outgoing
Maximum Transfer rate	8.0 Mbps	573.8 Kbps
Average Transfer rate	3.9 Mbps	140.6 Kbps
Current Transfer rate	5.5 Mbps	158.6 Kbps

4.5 Overall Performance of the Network

The following table [Table: 1] provides the data of RSSI , Signal strength and throughput for all the clients of the network and the figure[Fig. 7] shows the overall performance of the network in terms of distance and signal strength.

Table 1: Data Sheet of performance of the network

PC(IP Address)	Distance From AP	RSSI	Signal Strength	Throughput
192.168.2.130	08ft	- 25 db	92%	9.7 Mbps
192.168.2.137	15ft	- 60db	72%	8.7 Mbps
192.168.2.115	20 ft	- 77db	65%	7.9 Mbps
192.168.2.135	35ft	- 82 db	43%	4.5 Mbps



Fig.7: Performance of the network in terms distance and signal strength.

5. CONCLUSIONS

A complete site survey for of a WiFi network is executed for indoor environment in this work. The performance analysis for the data sending shows that signal strength lies between 60%-80% and the maximum throughput is 7.9 Mbps. For data receiving signal strength lies between 60%-70% and the maximum throughput is 9.7 Mbps. It is also found that the strength of the signal gradually decreases with the distance which is not perfectly linear. All the performance found in the experiment doesn't match with the performance claimed by the IEEE standard which may be caused by various reasons and this is a scope for future investigation.

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PERFORMANCE OF MIMO-OFDM OVER FLAT FADING CHANNEL USING CONVOLUTION CODING

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Orthogonal frequency division multiplexing (OFDM) is a popular method for high data rate as well as high spectral efficiency. In multiple input multiple output (MIMO) system, deploying multiple antennas at both the transmitter and receiver achieve higher data rate without increasing transmission power or bandwidth. As a promising technology for future wireless communication, MIMO-OFDM has gained more and more wellbeing in recent years. In this paper, we have derived an analytical bit error rate (BER) expression in MIMO-OFDM system and the performance of convolution encoding and viterbi decoding are investigated through simulation. It is found that the theoretical and simulation result of convolution coding signal in terms of BER are better than without coding signal. The BER performance for convolution coding has been reduced about 3dB at BER of 10^{-2} than without coding system.

Keywords: Orthogonal frequency division multiplexing, single input single output, convolution coding, viterbi decoding, multiple input multiple output, bit error rate.

1. INTRODUCTION

In a conventional wireless communication system, there is only one antenna at both transmitter and receiver which is called the single input single output (SISO) antenna. Future wireless services demand much higher data rate transmission. In order to increase the capacity of the SISO systems to meet such demand, the bandwidth and transmission power have to be increased significantly. Fortunately, recent developments have shown that using multiple input multiple output (MIMO) systems increase the capacity in wireless communication substantially without increasing the transmission power and bandwidth [1, 2]. The MIMO systems offer very higher data rates in the same bandwidth as compared to the SISO systems. In the MIMO systems, multiple antenna elements are required at both transmitter and receiver.

OFDM is a multicarrier modulation technique which a single high rate data stream is divided into multiple low rate data streams and is modulated using subcarriers which are orthogonal to each other [3]. On each subcarrier channel, lower data rate brings longer symbol duration. The main advantage of the OFDM system is its ability to

convert a frequency selective fading channel into several flat fading channels. In frequency selective fading channels, wideband signals suffer inter symbol interference (ISI), but ISI is eliminated in OFDM because of its flat fading channel. At present OFDM is mainly used in digital audio broadcasting (DAB), digital video broadcasting (DVB), Wireless LAN and MAN such as IEEE802.11a, IEEE802.11g and IEEE802.16a, HIPERLAN/2 and other high speed data application for both wireless and wired communications.

To achieve satisfactory performance, coding is needed for wireless communication. Coding is a technique where redundancy is added to original bit sequence to increase the reliability of the communication [4]. Convolution code is one of the most widely used channel coding in practical communication systems. Convolution codes convert the entire data stream into one single codeword. It is a type of forward error correction (FEC) which its function is to improve the capacity of a channel by adding redundant information to the data being transmitted through the channel. Viterbi decoding is one of decoding algorithms used with convolution encoding. The other type is sequential decoding. Sequential decoding has the advantage

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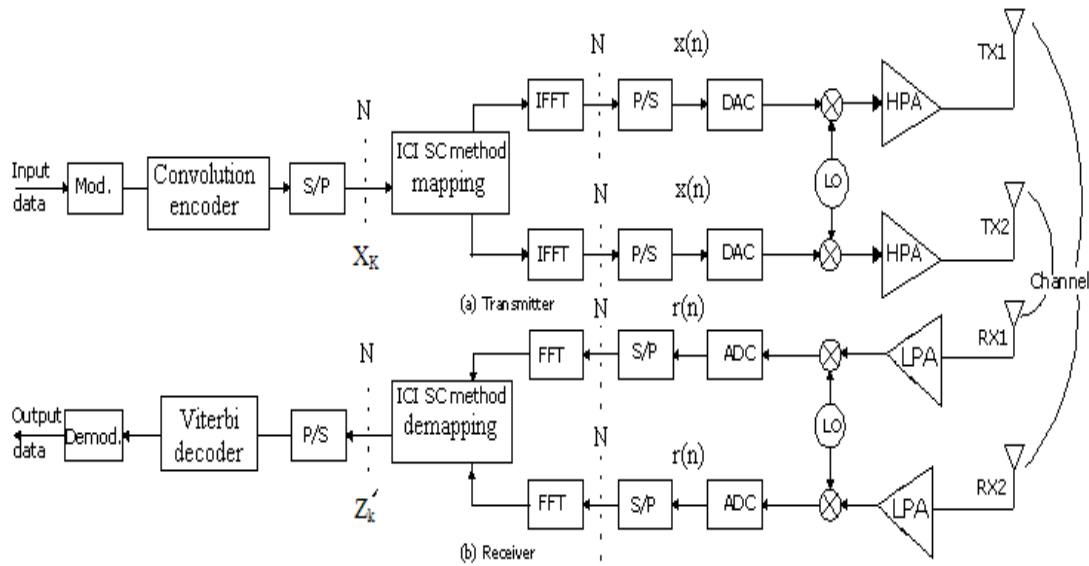


Fig. 1: Block diagram of MIMO-OFDM system model (a) Transmitter (b) Receiver

that it can perform very well with long constraint length convolution codes, but it has a variable decoding time. Viterbi decoding has the advantage that it has a fixed decoding time. It is well suited to hardware decoder implementation. But its computational requirements grow exponentially as a function of the constraint length. Viterbi decoding essentially performs the maximum likelihood decoding. It reduces the computational load by taking advantage of special structure in code trellis [5].

In this paper, we have established analytical BER of MIMO-OFDM systems in presence of frequency offset and phase noise. Convolution coding and without coding for QPSK scheme have been developed theoretically and simulated using MATLAB. We use convolution coding scheme at the transmitter and associated viterbi decoding scheme at the receiver. We evaluate the BER performance of our proposed scheme.

2. SYSTEM MODEL IN MIMO-OFDM

The block diagram of a typical discrete time baseband equivalent model of 2x2 MIMO-OFDM systems is shown in Fig. 1. As shown, Convolution encoder is placed at the first stage and then serial input bit encoded by using suitable modulation technique like (BPSK, QPSK or M-QAM). The N symbols are transferred by the serial to parallel converter (S/P), in this stage duration of input bits

is increased. After S/P converter, the same data symbols will be transmitted on the first and second antenna. Both antennas, the modulated symbols are serialized using a parallel-to-serial converter (P/S), then converted to analog via the digital to analog converter (DAC) and passing high power amplifier before being send to the channel. At the receiver side, the received symbols are passed low noise amplifier and converted from analog to digital using the analog to digital converter (ADC) and transferred by the S/P both antenna. The original signal can be recovered from the simple relation of

$Y_k = Y_k^1 + Y_k^2$. Here, Y_k^1 and Y_k^2 are the first antenna and second antenna k th subcarrier data. Then viterbi decoded in order to recover the transmitted data.

3. THEORETICAL ANALYSIS OF BER IN MIMO-OFDM

The complex baseband MIMO-OFDM signal after IFFT at the transmitter [6]:

$$x^t(n) = \sum_{k=0}^{N-1} X_k^t e^{j(\frac{2\pi}{N})kn} \quad \text{for } 0 \leq n \leq N-1$$

$$t = 1 \text{ or } 2 \quad (1)$$

Where, $j = \sqrt{-1}$, N is the total number of subcarriers, t means transmitter antenna number, X_k^t is data symbol for k th subcarrier.

Received signal is affected by phase noise and frequency offset. So, it can be expressed as,

$$r^\tau(n) = \left\{ \sum_{t=1}^2 [x^t(n) \otimes h^t(n) + w(n)] \right\} e^{j[2\pi \Delta f^\tau t + \phi^\tau(n)]} \quad \tau = 1 \text{ or } 2 \quad (2)$$

Where, Δf^τ and $\phi^\tau(n)$ are frequency offset and phase noise. τ means received antenna number. $x(n)$, $h(n)$, $w(n)$, $r(n)$ are transmitted signal, channel impulse response, complex Gaussian noise and received signal respectively.

Furthermore, the received signal after FFT can be expressed as,

$$\begin{aligned} Y_k^\tau &= \frac{1}{N} \sum_{n=0}^{N-1} r^\tau(n) e^{-j[\frac{2\pi}{N}]kn} \\ &= \frac{1}{N} \sum_{n=0}^{N-1} \sum_{t=1}^2 \sum_{l=0}^{N-1} X_l^t H_l^t e^{j[(\frac{2\pi}{N})(l-k+\varepsilon^\tau)n + \phi^\tau(n)]} + N_k \\ &= \sum_{t=1}^2 \sum_{l=0}^{N-1} X_l^t H_l^t Q_{l-k}^\tau + N_k \end{aligned} \quad (3)$$

Where, Y_k , X_l and H_l are the frequency domain expression of $r(n)$, $x(n)$, $h(n)$. N_k is the complex AWGN. Here, ε is the normalized frequency offset and is given by $\Delta f^\tau T$. Δf is the frequency difference between the transmitted and received carrier frequencies and T is the subcarrier symbol period.

Q_L^τ is defined as follows:

$$Q_L^\tau = \frac{1}{N} \sum_{n=0}^{N-1} e^{j[(\frac{2\pi}{N})(L+\varepsilon^\tau)n + \phi^\tau(n)]} \quad (4)$$

Using phase noise linear approximation method, suppose $\phi[n]$ is so small that $e^{j\phi[n]}$ can be approximated into $1 + j\phi[n]$. So, Q_L^τ can be defined as follows:

$$Q_L^\tau = \frac{1}{N} \sum_{n=0}^{N-1} e^{j[(\frac{2\pi}{N})(L+\varepsilon^\tau)n]} (1 + j\phi^\tau(n)) \quad (5)$$

Frequency offset and phase noise is analyzed independently and channels have similar flat frequency response in two paths such as $H_l^1 = H_l^2 = 1$. In this paper, all received signal

Y_k^τ equation after FFT. Transmitted signal is supposed to have zero mean and statistically independence.

In the MIMO-OFDM, both antennas transmit the same signal as the form of $X_l^1 = X_l^2 = X_k$ the k th subcarrier signal is expressed as,

$$\begin{aligned} Y_k^\tau &= \frac{1}{N} \sum_{n=0}^{N-1} r^\tau[n] e^{-j\frac{2\pi}{N}kn} \\ &= \sum_{t=1}^2 \sum_{l=0}^{N-1} X_l^t \cdot H_l^t \cdot Q_{l-k}^\tau + N_k \end{aligned} \quad (6)$$

The received signal at the receiver 1 (RX1) can be expressed as,

$$\begin{aligned} Y_k^1 &= \sum_{l=0}^{N-1} X_l^1 \cdot H_l^1 \cdot Q_{l-k}^1 + \sum_{l=0}^{N-1} X_l^2 \cdot H_l^2 \cdot Q_{l-k}^1 + N_{1k} \\ &= X_k \cdot H_k^1 \cdot Q_0^1 + \sum_{l=0, l \neq k}^{N-1} X_l^1 \cdot H_l^1 \cdot Q_{l-k}^1 + X_k \cdot H_k^2 \cdot Q_0^1 \\ &\quad + \sum_{l=0, l \neq k}^{N-1} X_l^2 \cdot H_l^2 \cdot Q_{l-k}^1 + N_{1k} \\ &= X_k \{H_k^1 \cdot Q_0^1 + H_k^2 \cdot Q_0^1\} \\ &\quad + \sum_{l=0, l \neq k}^{N-1} \{X_l^1 \cdot H_l^1 \cdot Q_{l-k}^1 + X_l^2 \cdot H_l^2 \cdot Q_{l-k}^1\} + N_{1k} \\ &= X_k + X_k \{H_k^1 \cdot Q_0^1 + H_k^2 \cdot Q_0^1 - 1\} \\ &\quad + \sum_{l=0, l \neq k}^{N-1} \{X_l^1 \cdot H_l^1 \cdot Q_{l-k}^1 + X_l^2 \cdot H_l^2 \cdot Q_{l-k}^1\} + N_{1k} \end{aligned} \quad (7)$$

Similarly, the received signal at the receiver 2 (RX2) can be expressed as,

$$\begin{aligned} Y_k^2 &= \sum_{l=0}^{N-1} X_l^1 \cdot H_l^1 \cdot Q_{l-k}^2 + \sum_{l=0}^{N-1} X_l^2 \cdot H_l^2 \cdot Q_{l-k}^2 + N_{2k} \\ &= X_k + X_k \{H_k^1 \cdot Q_0^2 + H_k^2 \cdot Q_0^2 - 1\} \\ &\quad + \sum_{l=0, l \neq k}^{N-1} \{X_l^1 \cdot H_l^1 \cdot Q_{l-k}^2 + X_l^2 \cdot H_l^2 \cdot Q_{l-k}^2\} + N_{2k} \end{aligned} \quad (8)$$

Final signal are achieved as follows,

$$\begin{aligned} Y_k &= Y_k^1 + Y_k^2 \\ &= 2X_k + X_k \{H_k^1 \cdot (Q_0^1 + Q_0^2) + H_k^2 \cdot (Q_0^1 + Q_0^2) - 2\} \\ &\quad + \sum_{l=0, l \neq k}^{N-1} \{X_l^1 \cdot H_l^1 \cdot Q_{l-k}^1 + X_l^1 \cdot H_l^1 \cdot Q_{l-k}^2\} \\ &\quad + \sum_{l=0, l \neq k}^{N-1} \{X_l^2 \cdot H_l^2 \cdot Q_{l-k}^1 + X_l^2 \cdot H_l^2 \cdot Q_{l-k}^2\} + N_k \end{aligned}$$

$$\begin{aligned}
&= 2X_k + 2X_k \{(Q_0^1 + Q_0^2) - 1\} \\
&+ \sum_{l=0, l \neq k}^{N-1} \{(X_l^1 + X_l^2) \cdot Q_{l-k}^1 + (X_l^1 + X_l^2) \cdot Q_{l-k}^2\} + N_k
\end{aligned} \quad (9)$$

In order to evaluate the statistical properties [7], assuming average channel gain

$$\begin{aligned}
E[|H_l^1|^2] &= E[|H_l^2|^2] = 1 \text{ and} \\
E[|X_l^1|^2] &= E[|X_l^2|^2] = |X|^2
\end{aligned} \quad (10)$$

$E[\cdot]$ denotes the expectation value.

The desired received signal power can be represented by

$$\begin{aligned}
\sigma_{DRS}^2 &= E[|X_k|^2] \cdot E[|H_k^1|^2] \cdot |Q_0^1|^2 \\
&+ E[|X_k|^2] \cdot E[|H_k^2|^2] \cdot |Q_0^2|^2 \\
&+ E[|X_k|^2] \cdot E[|H_k^1|^2] \cdot |Q_0^2|^2 \\
&+ E[|X_k|^2] \cdot E[|H_k^2|^2] \cdot |Q_0^1|^2 \\
&= 2\{|X|^2 \cdot |Q_0^1|^2 + |X|^2 \cdot |Q_0^2|^2\} \\
&= 2|X|^2 \{|Q_0^1|^2 + |Q_0^2|^2\}
\end{aligned} \quad (11)$$

Hence, the ICI power is

$$\begin{aligned}
\sigma_{ICI}^2 &= E[|I_{ICI}|^2] \\
&= \sum_{l=0, l \neq k}^{N-1} E[|X_l^1|^2] \cdot E[|H_l^1|^2] \cdot |Q_{l-k}^1|^2 \\
&+ \sum_{l=0, l \neq k}^{N-1} E[|X_l^2|^2] \cdot E[|H_l^2|^2] \cdot |Q_{l-k}^1|^2 \\
&+ \sum_{l=0, l \neq k}^{N-1} E[|X_l^1|^2] \cdot E[|H_l^1|^2] \cdot |Q_{l-k}^2|^2 \\
&+ \sum_{l=0, l \neq k}^{N-1} E[|X_l^2|^2] \cdot E[|H_l^2|^2] \cdot |Q_{l-k}^2|^2 \\
&= 2 \sum_{l=1}^{N-1} |X|^2 \cdot |Q_l^1|^2 + |X|^2 \cdot |Q_l^2|^2 \\
&= 2 \sum_{l=1}^{N-1} |X|^2 \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}
\end{aligned} \quad (12)$$

Bit error rate (BER) of a communication system is defined as the ratio of number of error bits and total number of bits transmitted during a specific period.

BER of QPSK modulated MIMO-OFDM system is given,

$$\begin{aligned}
BER &= \frac{1}{2} Q \sqrt{\frac{\sigma_{DRS}^2}{N + \sigma_{ICI}^2}} \\
&= \frac{1}{2} Q \sqrt{\frac{2 \cdot |X|^2 \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}}{N + 2 \sum_{l=1}^{N-1} |X|^2 \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}}} \\
&= \frac{1}{2} Q \sqrt{\frac{2 \cdot \frac{|X|^2}{N} \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}}{1 + 2 \sum_{l=1}^{N-1} \frac{|X|^2}{N} \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}}} \\
&= \frac{1}{2} Q \sqrt{\frac{2 \cdot \frac{E_b}{N} \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}}{1 + 2 \sum_{l=1}^{N-1} \frac{E_b}{N} \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}}}
\end{aligned} \quad (13)$$

BER of QPSK modulated in MIMO-OFDM system with convolution coding is given

$$BER = \frac{1}{2} Q \sqrt{\frac{E_s}{NC_t}} \quad (14)$$

Where, C_t = coding rate. BER of QPSK modulated for $\frac{1}{2}$ convolution coding rate in MIMO-OFDM system is given

$$\begin{aligned}
BER &= \frac{1}{2} Q \sqrt{\frac{2\sigma_{DRS}^2}{N + \sigma_{ICI}^2}} \\
&= \frac{1}{2} Q \sqrt{\frac{4 \cdot \frac{E_b}{N} \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}}{1 + 2 \sum_{l=1}^{N-1} \frac{E_b}{N} \cdot \{|Q_l^1|^2 + |Q_l^2|^2\}}}
\end{aligned} \quad (15)$$

4. RESULT AND DISCUSSION

In order to compare the MIMO-OFDM without and with convolution coding. In theoretically, the system has examined 64 subcarriers, QPSK modulation, normalized frequency offset with $\varepsilon = 0.1$, phase noise variance with $\sigma_\phi^2 = 0.02 \text{ rad}^2$. In the simulation, same subcarrier, alike modulation, IFFT and FFT size 128 and $\frac{1}{2}$ convolution coding.

Fig. 2 shows the theoretical graph of BER vs E_b/N for QPSK modulation in MIMO-OFDM scheme. From the BER curves, convolution coding signal illustrates better performance than without coding signal. At the E_b/N of 10 dB, BER of without convolution coding is very high giving a value of 1.738×10^{-2} while that of convolution coding channel is 2.566×10^{-3} in MIMO-OFDM. This shows a very significant improvement coding has on the channel performance.

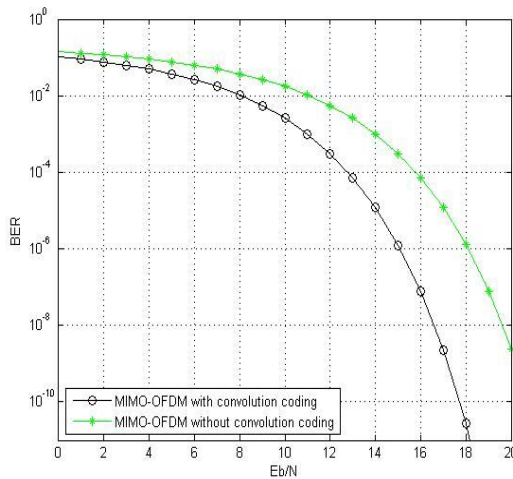


Fig 2: Theoretical plots of bit error rate vs. E_b/N

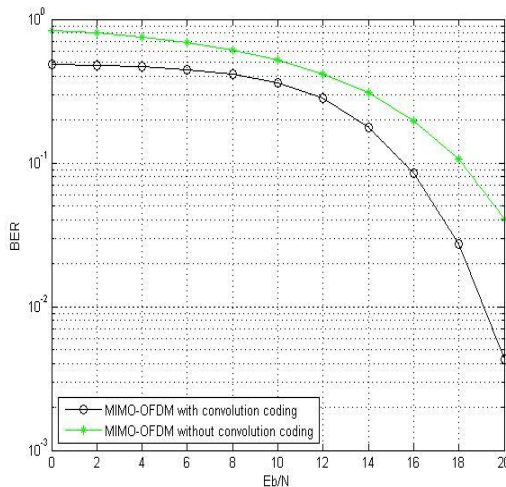


Fig 3: Simulation plots of bit error rate vs. E_b/N

From the Fig. 3, it can be concluded that simulation results of BER. For QPSK modulation, the values of BER for convolution coding and without coding in MIMO-OFDM are approximately 3.591×10^{-1} and 5.188×10^{-1} respectively at same E_b/N . We also found that coding leads to a substantial

improvement in terms of BER. This also agreed with theoretical calculations.

5. CONCLUSION

In this paper, the BER performances are obtained from the theoretical and simulation of the convolution coding in flat fading channel. Coding is essential for improving the bit error rate in the presence of noise and interference. A rate $\frac{1}{2}$ convolution encoder and its corresponding viterbi decoder on the receiver were used to improve BER. It is shown that the improvement of BER using the convolution coding provides a better performance than without coding signal.

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The infrastructural advancement of e-learning in Bangladesh: A case study of present status and future expectations

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Due to globalization, the world is becoming a global village, distances are reduced, and the world is going to make a knowledge based society. At this stage, as a developing country, Bangladesh is going to start e-learning that is the distance learning based on electronic media. To establish this, Bangladesh needs to develop the infrastructural part of e-learning. The main theme of this paper is to study the present status of infrastructural development, gap of the development, and how to establish a framework for e-learning in Bangladesh.

Key words: E-learning, distance learning, Digital Bangladesh, e-learning framework, E-governance, ICT.

1. INTRODUCTION

Education is said to be one of the most important factors for poverty alleviation and economic growth in developing countries. The rapid change of the information and knowledge society does not stop at education [1]. Many western countries, Japan, Israel, Australia, and Malaysia are established distance or e-learning successfully [2]. The interest is using information and communication technologies (ICTs) for dissemination of education is growing and is believed to have a huge potential for government. E-learning has a very distinct role to play in the context of scarcity of resources in developing countries. The most significant limitation of educational framework in these countries is the dearth of educational institution and qualified trainers for higher studies. There exist only few institutions facilitating continuing education for the professional. But the need of such facilities for professional development of the technologies is well recognized. Its demand is further enhanced by rapid evaluation of technology and role of the technologists in economic development of the country. Despite having the potential to contribute in the educational advancement of developing countries, e-learning need to be designed carefully to overcome the technological and infrastructural limitations [3].

1.1 E-Learning

E-learning is the way of facilitating education to students who are unable to attend a traditional campus of university or institution [4]. E-learning includes both purely internet web-based training

and hybrid or blended learning that combines web based and traditional approaches is growing faster than any other sector of post secondary and professional education. Students like accessibility of virtual classrooms. Employer love savings they can take to the bank [5]. Internet based education is a form of distance education in which the course contents are delivered and the interaction are provided by the technologies and methodologies of the Internet. It may occur in places where there is none, extends resources where there are few, expands the learning day and opens the learning place. It is possible to connect people, communities and resources to support learning [5].

1.2 Scope of E-Learning

The scope of e-learning is more comprehensive than the commonly accepted issue of electronic delivery instructional and learning materials. E-learning will open the lifelong learning for the human being. To read a book, to see a journal, to download video recorded lectures, to open the new horizon of learning by communicating with the foreign elites, and to know any sort of unknowns e-learning will play the vital role in this context.

To complete a course of higher studies, E-learning ensures rapid evaluation, collaboration of the users' community, and enhanced security due to source code availability. It is less time dependent and not subject to the geographical locations [2].

The web classroom makes the process of learning quicker and more efficient, solves the problems of finding study literature, old exams, exercises.

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Lecturers can post the course materials, exercises and exam dates quickly.

2. E-LEARNING IN BANGLADESH

There are some universities of Bangladesh where E-learning are implemented. These are Bangladesh University of Engineering and Technology (BUET), Dhaka University (DU), Rajshahi University (RU), Bangladesh Open University (BOU) etc.

2.1 Bangladesh University of Engineering and Technology (BUET)

In October 2004 BUET joined to the E-learning system of School on the Internet Asia Project (SOI Asia) and the Institute of Information and Communication Technology (IICT) was the focal point of SOI Asia. BUET has participated in the live lecture and shared various lecturer contents provided by SOI Asia such as Information Technology, Disaster Management and so on. BUET professors (2007) also contribute to this project by delivering course contents, especially in field of renewable energy [5].

2.2 Bangladesh Open University (BOU)

After the establishment of the Bangladesh Open University (BOU) in 1992, the remarkable progress of E-learning has been done. BOU enrolls over 250000 students all over Bangladesh. BOU is the only public university in Bangladesh that delivers education in open and distance mode. The course is delivered to the students via TV, radio and mobile phones with text books as self study materials. Students have the option to go to a learning centre every other Friday to get assistants from teachers and other students. These learning centers provide face to face lectures and some of them are equipped with TVs and mobile phones. There are about 1000 learning centers in Bangladesh of BOU [6]. BOU has been offered various types of academic programs from certificate to masters levels using, print, TV, audio broadcasts, audio cassettes and face to face tutorials as the media of delivering its academic courses. Asian University of Bangladesh has also been offered some formal academic program through distance mode [7].

3. E-LEARNING FRAMEWORK

3.1. Infrastructural framework of taking classes

The students who can attend their class room will attend there and who cannot attend their traditional class room can take the lectures from the server (video recorded by the lecturers) or participate

through television Channel (Though it is more expensive to broadcast). Students can also download the lectures by their mobile phone using mobile network described in the fig. 2.

3.2. Infrastructural framework for taking examinations

The examinations contain basically three parts through internet that is E-assessment [8]: (i) Assignments (ii) MCQ type tutorials (iii) Short question type tutorials. Final term should be set at the traditional examination hall at a fixed time. All the payments should be taken by mobile phone through short message system. The result should be published on the internet. Certificates should be sent to the e-mail addresses of the students with digital signature of the concerned authority.

4. CHALLENGES

Limited internet connectivity, insufficient computer and communication infrastructure are the major limitations of implementing e-learning in different universities and institutions. However the followings are the specific fields that are the main obstacles for establishing e-learning in Bangladesh.

4.1 Lack of Finance

The major problem of implementing e-learning is the lack of finance. Without strong financial support e-learning will remain a hope for the nation.

4.2 Insufficient Infrastructure

The administrations of the universities do not feel any need to provide computer lab facilities, communication equipments, other information science components and necessary infrastructures required. E-learning requires a certain investment of hardware, software, and support staff.

4.3 Lack of Knowledge

One of the main limitations of e-learning is that students do not know how to use a particular information technology. We have also insufficient high teachers to implement e-learning in the universities.

4.4 Lacking of supporting national policy

The Government has not implemented any policy for improving e-learning in Bangladesh.

4.5 Lacking of High Quality Teachers

Most of the senior teachers of old age and they are not ready to any change in the nature of the subject. There exists skilled fresh teachers but they stand as juniors and work under pressure of seniors.

Experienced senior teachers are not much involved in the distance education program for lacking of appropriate training [10].

4.6 Language proficiency

From different sources, it has been learnt that, English literacy rate in Bangladesh is less than one percent. Whereas, English literacy rates in India

and Pakistan are 60% and 20% respectively. There is a strong correlation between English literacy and e-learning. Hence, English literacy is a must for e-learning implementation. Unfortunately, in this case our position is the worst in the sub-continent [11].

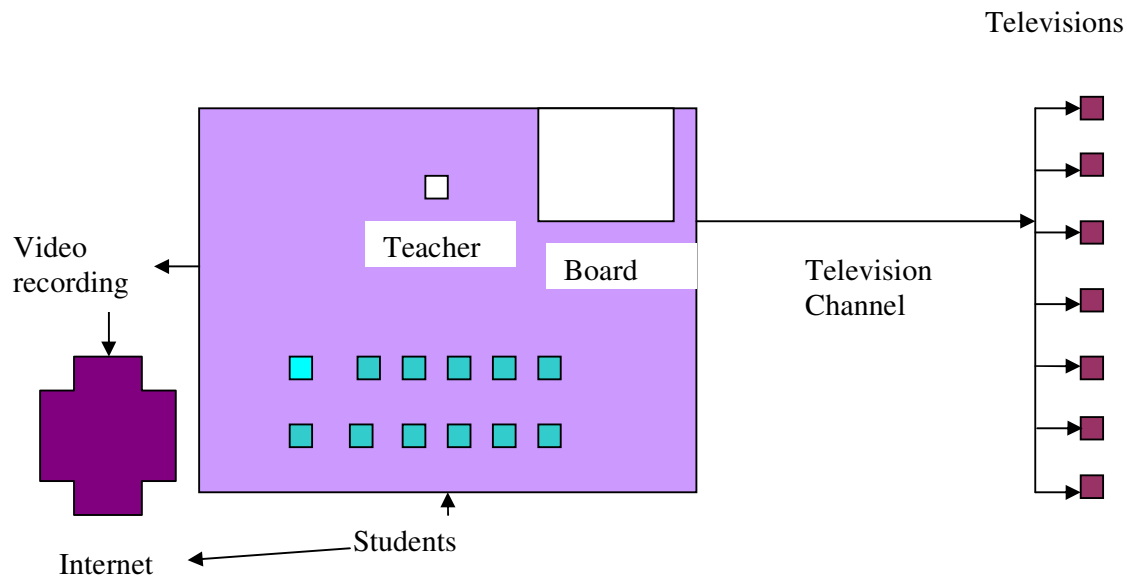


Fig. 1: E-Learning Framework

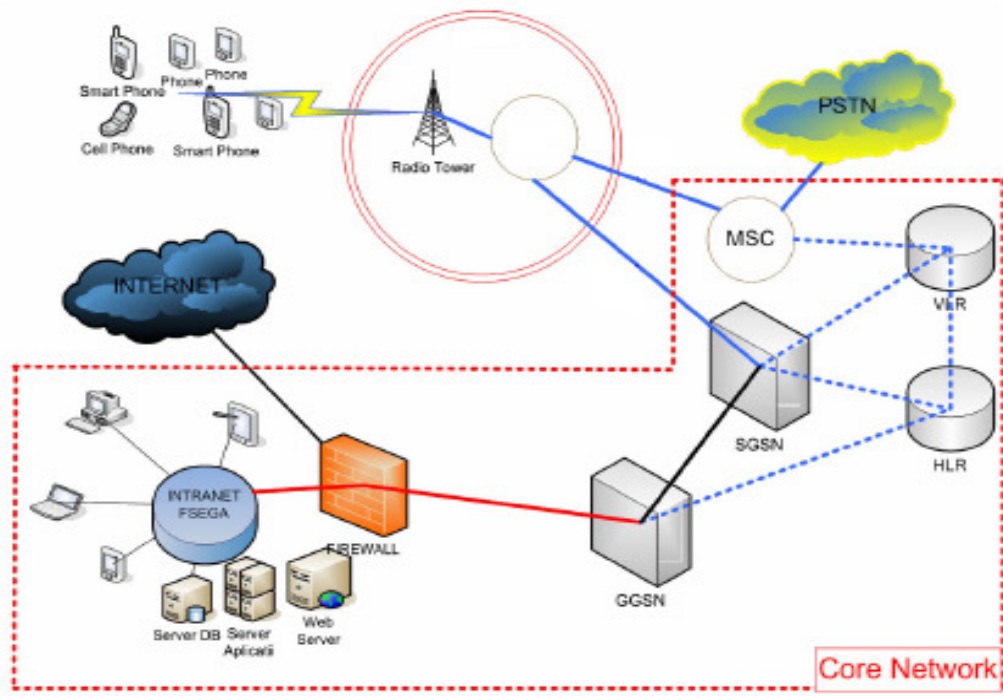


Fig. 2: Mobile based E-Learning [9]

5. RECOMMENDATIONS

Latest statistics reveal that Bangladesh faces a power deficit of up to 2000 MW against a demand of 5000 MW daily. It may be noted that for proper ICT development an uninterrupted power supply is a must [11]. For establishing e-learning strong ICT infrastructure is a must. To build up strong ICT infrastructure the government should arrange the broadband internet facilities up to grass root levels using fiber optic cables; reduce the cost of PCs and accessories. University Grants commission (UGC), and different universities should arrange seminars, conference for making awareness of e-learning in Bangladesh.

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COMPARATIVE STUDY OF HAZARDS BY FLOODS AND CYCLONES IN BANGLADESH

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Bangladesh is one of the most natural disaster prone countries in the World. Most of the disasters are water related such as flood, cyclone, drought, river erosion etc. Almost every year the country faces severe catastrophic natural hazards. This study is conducted in July 2010 to find and compare property and live losses in major floods and cyclone in Bangladesh. Here only major floods and strong devastated cyclone are considered which have precise records. The results of this study reveal that from 1987 to present, average yearly death loss is 283 persons and property loss is 377 million USD by major floods. But strong cyclone from 1970 to 2010, average yearly death loss is 19500 persons and property loss is 366 million USD. Cyclone causes huge scale yearly live loss compared to floods while average property are near about to same by these two natural disaster.

Key words: Natural hazards; Floods; Cyclone

1. INTRODUCTION

The Earth is a dynamic system and experiencing a lot of natural changes within the system. The natural changes often cause great havoc to human being. When a natural phenomena cause destruction of human life and property, it termed as hazard. Various hazards are categorized according to the natural components or related to them such as water, wind etc. Common water related hazards are flood, drought, storm-surge and riverbank erosion. Every year, peoples of the different regions of the world are affected by natural hazards (Chowdhury, 2006). Bangladesh is located between latitude 20° 34' to 26° 38' N and longitude 88° 01' to 92° 41' E which is a flood and cyclone affected country. These two events occasionally devastate a large amount of properties and lives.

Unusual or above normal surface-water flow that inundates the high ground is called a flood. About one half of the land area in Bangladesh is at an elevation of less than 8 meters above mean sea level. The height ranges from 60 m above mean sea level at the northern tip to less than 3 m at the southern coast. Bangladesh, a low-lying delta plain, is one of the world's most vulnerable regions to

floods because of its geographical location. Bangladesh has been experiencing more devastating floods than ever before and the intensity of floods is increasing year to year (Khalil, 1990, and Islam & Sado, 2000 & 2002).

Floods are two types: '*major*' and '*minor*'. These two types can be differentiated in terms of the intensity and duration of inundation (Paul and Rashid, 1987 and Khalequzzaman, 2000). The former refers to the less frequent but catastrophic that inundates 35% or more area of the country and continues for two months or more. Devastating floods usually occurs at longer interval, but during the recent years, repetitions of abnormal floods were frequent with an increase in its magnitude (Saqui, 1992). In the 19th century there were six major floods occurring in 1842, 1858, 1871, 1875, 1885 and 1992. 18 major floods occurred in the 20th century which are: 1900, 1902, 1907, 1918, 1922, 1954, 1955, 1956, 1962, 1963, 1968, 1970, 1971, 1974, 1984, 1987, 1988, and 1998 were of catastrophic consequence and the latest two severe floods in the 21st century are 2004 and 2007. According to Islam et al., 2010, property loss in every major flood is roughly more than 1 billion U.S. dollar and also kills huge human beings.

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Cyclone is another natural disaster which also damages lots of properties and lives. Out of sixty four districts, nineteen southern districts having proximity to the Bay of Bengal have been grouped into the coastal zone in terms of three geo-physical characteristics: interplay of tidal regime, salinity in soil and water, and cyclone and storm surge (Miyani, 2010). Almost every year, strong or weak cyclone hits Bangladesh. According to Cyclone Shelter Preparatory Study (CSPS), 38 small or large cyclone affected Bangladesh in between 1960 and 1995, which took at least 780000 human lives. Every cyclone costs a large amount of property of the country which creates a huge burden for development of the country. A large number of lives were lost due super cyclone of 1991, which mainly struck in three coastal districts in the Eastern Zone: Chittagong (79,697 dead and 2600 injured), Cox's Bazar (51,147 dead and 133,000 injured) and Noakhali (8,878 dead and 995 injured). The economic losses alone from the cyclone were estimated at US\$ 2.4 billion. The main characteristic of this cyclone was a strong storm of exceptional intensity with wind velocities up to 225 km/hr. However, the losses of life were substantially less than the 1.2 million people killed by the 1970 cyclone (MOHFW, 1992). According to Wikipedia, live loss in Cyclone Sidr (2007) are 10,000, it is lower compared with 1970 and 1991 due to the improved preparedness and concern of people and government. It damaged property which value is US \$1.7 billion. Again cyclone Nargis (2008) damaged more properties compared to Sidr

which is equivalent to US \$10 billion and killed 138,366 human lives. Cyclone Aila devastated properties of US \$552.6 million and killed 325 people and remained missing of 8,000 people (Wikipedia).

2. METHODOLOGY

The major floods and strong devastated cyclones which have precise records were considered only for this study. The data of different floods and cyclones were presented in tabular format. Yearly average of live and property losses were calculated for both cases to observe their effects and devastation.

3. RESULTS AND DISCUSSION

3.1 Effects of different Floods

In 1954, severe flood surrounded about 54% land area of Bangladesh causing damage to crops of 1.14 million ha. In 1974, approximately 57% of the land area went under flood water. Approximately 30 million people were affected and crop loss was estimated to be nearly 2 million tons (Sahabuddin, 1991). In 1984 flood, struck for different times, the crops were lost excluding life and property that was estimated to be 0.15 million (BBS, 1987). The effects of major floods from 1987 to present are presented in table- 1.

Table 1. The effects of different major floods in Bangladesh

Year	Area Inundated	Duration of flood (days)	Property Loss (\$ USD)	Death Loss
1987	57,300km ² (40% of the country), 40 districts affected	> 40	0.95 billion	Affected 41,000,000
1988	82,000km ² (60% of the area), 52 districts affected	15-20	1.8 billion	3,000 (Affected 30,000,000)
1998	100,000 km ² (68 percent of the country)	> 65	2-3 billion	> 2,000 (Affected 30,000,000)
2004	55,000 km ² (38 % of the country), 39 districts affected	12	2.2 billion	800 (Affected 36,000,000)
2007	39 districts affected	44	1.1 billion	1000 (Affected 16,000,000)

Source: Islam et al., 2010

3.2 Effects of different Cyclones

The impact of cyclone on human lives and properties along with lowest wind pressure and

maximum wind velocity are presented during the period 1970 to present, which has precise records, are depicted in Table 2.

Table 2. The effects of different cyclones in Bangladesh

Year	Type of Cyclone	Lowest Pressure (mbar)	Wind Velocity (km/hr)	Property Loss (\$ USD)	Death Loss
1970 (Bhola)	Very severe cyclonic storm (IMD) Category 3 tropical cyclone (SSHS)	966	185 (3 min) 205 (1 min)	480 million	300,000-500,000
1991	Super cyclonic storm (IMD) Category 5 tropical cyclone (SSHS)	918	240 (3 min) 260 (1 min)	2 billion	138,000
2007 (Sidr)	Very severe cyclonic storm (IMD) Category 5 cyclone (SSHS)	944	215 (3 min) 260 (1 min)	1.8 billion	10,000
2008 (Nargis)	Very severe cyclonic storm (IMD) Category 4 Tropical Cyclone (SSHS)	962	165 (3 min) 215 (1 min)	10.1 billion	138,366
2009 (Aila)	Severe cyclonic storm (IMD) Category 1 cyclone (SSHS)	968	110 (3 min) 120 (1 min)	553 million	8325

Source: Wikipedia

From 1987 to 2010, total live loss by major floods is 6800 persons and property loss is US \$ 9.05 billion; the average yearly death loss is 283 persons and property loss is US \$ 377 million. Cyclone of 1970 to 2010 has destructed more lives compared to major floods. The total death toll by cyclone is near about to 80000 persons and property loss is US \$15 billion; average yearly death loss is 19500 persons and property loss is US \$ 366 million. Average live loss and property loss clearly show that cyclone destructs more life than that of major floods while property losses by these two disasters are near about to same. Besides these effects many people has affected by various types of diseases which will create long term sufferings. Huge numbers of people lost their future prospects and hopes due to effects of floods and cyclone.

7. CONCLUSIONS

Cyclone is a short term disaster compared to floods. During floods people get time to prepare themselves transferring from one place to another but when cyclone occurs in many cases people do not have time to transfer themselves. So during cyclone, human beings affected more than floods and loose their lives. To safe the life of people from cyclone, the warning system should be modernized and make it easy understand to all level of people. Management and rescue systems after cyclone should be developed in such a way that rescue team can be activated immediately after cyclone. The analysis of major floods data indicates that, death loss is decreased even in a strong major flood which causes huge property loss; this may be due to the increase of awareness among the people. When floods and cyclone take place, they disrupt normal agricultural activities and render agricultural related people jobless. It hinders the development of the countries progress and for a developing country like

Bangladesh left many people hungry and may cause famine. So, Government of Bangladesh should take steps to educate or warn people about the devastating effects of cyclone and floods by mass media. Proper forecasting and warning may save a significant amount of damage. So more researches and works on cyclones and floods are deemed to minimize the future devastation.

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DEVELOPMENT OF A HOUSEHOLD COMPOST GENERATION SYSTEM WITH ORGANIC HOUSEHOLD WASTE

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Bangladesh is a heavily populated country, specially its townships. Due to the lifestyle and the food habit its citizens produce enormous amount of house-hold solid waste. It is quite difficult for the local governments of the townships to manage this bulk amount of solid wastes and keep townships environmentally clean and habitable. As these wastes are mostly organic (more than 75%), one of the solutions lies in composting the solid waste. In this study a composter was developed for this purpose. Samples of 5-6kg house-hold solid wastes were put to test in the composter. After 15 days of composting the average production of the compost was appx. 38%. The quality of the compost was good enough as the manure met the national standards. The produced compost contained 21.5% organic matter, 2.9% Potassium (K), 2.56% Total Nitrogen(N), 1.52% Phosphorus (P), 0.59% Sulfur (S) and 0.01% Zinc (Zn).

Key words: Environmental pollution, waste management, solid waste, compost, manure

1. INTRODUCTION AND LITERATURE REVIEW

The climbing of the human civilization has its basis on the utilization of natural and other resources. People cannot obviously utilize these resources fully, which results in wastes. With the growth of civilization, especially of the urban based civilization and of the human population these wastes grew to an insurmountable size, demanding the management of the same. The waste generation of DCC (Dhaka City Corporation) area was no less than 3,700 tons per day (Imtiaz and Alam, 2002). DCC sources and some other reports state that the waste generated in the DCC area is about 4,000 to 5,000 tons/day (The Daily Star, 21 June 2004). Only 42% of the waste is collected by DCC and disposed off in open crude landfill site. As a result uncollected waste lies on road sides, open drains, low lying areas, thus contributing to the deteriorating quality of life and environment of the city (JICA, 2004).

Despite high demand for all forms of recyclable material in Bangladesh and a large number of people involved collecting and recycling industrial, commercial and kitchen refuse, solid waste is one of the most visible forms of pollutants found in city streets, open areas, unused public and private lands, ditches and water bodies (World Bank, 2000), which demands its systematic and economic management.

Solid Waste Management refers to all activities pertaining to control, collection, transportation, processing and disposal of the waste in accordance with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations. It includes all the procedures from the source to the final disposal in a socio-legally acceptable, economically viable, technically feasible and environmental friendly manner.

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Problems associated with improper management of solid waste:

- Can cause more than 40 diseases(diarrhea, cholera, etc);

Boback, M. (2010) reported on environmental impacts and health hazards as a result from inadequate management of organic household waste in developing countries. Her report gave details of water and soil contamination, air pollution and spread of diseases through expanding breeding grounds for pathogens, vectors and rodents.

- Pollution of surface water, ground water, soil and air;
- Emission of Green House Gas (GHG) from crude dumping sites;
- Organic waste is left unutilized

Modes of removal of solid waste

- Dumping-

Open dumping of solid wastes is practiced extensively in Bangladesh, because it is cheap and requires little planning. But dumping of solid waste has a lot of disadvantages e.g., it creates bad odor and inconvenience to the population, pollutes the surface water, the ground water and the soil, unsystematic dumping blocks the drainage system resulting in flooding of the locality and the generation of mosquito. Furthermore, the population loses its economic value. Added to this, Bangladeshi city administrations collect only 40% to 50% of waste generated with open dumping

- Composting

Composting is an ideal process to manage organic waste and the compost produced has a commercial value, because it can be sold as fertilizer and the by-product is biogas. Field trials (Mbuligwe et al., 2002) of the compost product improved yields of vegetable crops by more than 35% and extended their production period by more than a month. Also, the temperature developed during the waste composting process was high enough to kill pathogens, making the solid waste safer for soil application and disposal.

- Incineration

Open burning of waste leads to toxic contamination of both ground water and air. Closed incineration needs high investment in the hardware.

- Generation of electricity

Alam and Bole (2001) analyzed the electrical energy recovery potential from urban solid waste of Dhaka city and its economic feasibility and emphasized that the 1.28 million tonnes of municipal waste generated annually in the Dhaka city could potentially produce about 71MW of electricity.

2. OBJECTIVE OF THE STUDY

Table 1 shows that 80 – 84% of solid waste of Dhaka City originates in kitchens.

This study concentrates on the composting of house-hold organic solid waste (mainly the kitchen waste). In such a case the composting can be carried out at the house hold level without asking for an industrial venture. Other points in favour are:

- There is no need for collection, transportation, storage and subsequent marketing
- Low income families can take the advantage of its economic value and/or its use to fertilize their backyards.
- If composting can be carried out at a large scale, the nation can get rid of significant amount of chemical fertilizer

Table 1: The composition of solid waste in Dhaka City

Materials	Quantity (%)	
	Residential Area	Commercial Area
Food waste (organic)	84.37	79.49
Paper/cardboard	5.68	7.22
Textiles	1.83	1.59
Plastics	1.74	1.48
Glass/metals and construction debris	6.38	10.22

3. EXPERIMENTAL DESIGN

The aerated waste decomposes to form fertilizer and leachate. The leachate can also be used as liquid fertilizer. Decomposition is a time dependant activity. The longer time the waste is left for decomposition, the more matured is the produced fertilizer. But with time the process becomes costlier and more kitchen waste accumulates on the sidelines. The waste, dumped into the aerated waste collector was left for 15 days, which was sufficient enough to achieve the national standard of fertilizer.

The duration of composting was limited to 15 days for two reasons-

- The longer the duration, the larger is the quantity of organic waste, which will demand the larger storage space and pollute the house-hold environment through pollution,
- The larger amount of organic waste will need bigger composter and more investment.

Composter:

The composter has the following components:

1. The digester is a metallic box (fig.1), which houses the waste collector and the leachate collector. It has a lid, on which the gas vane is fixed.
2. The waste is stored in the plastic waste collector, which is 9.5 inch in diameter and 16 inch in height. 0.2 inch holes were drilled on its surface one inch apart. The holes at the top facilitate aeration of the compost and those at the bottom helps oozing out of the leachate from the waste collector.
3. The leachate collector collects the leachate.
4. The gas vane lets out the bio-gas, which is odorous, at a sufficient height away from human range.

The height of the composter was 7 ft. Its cost was tk. 2000.

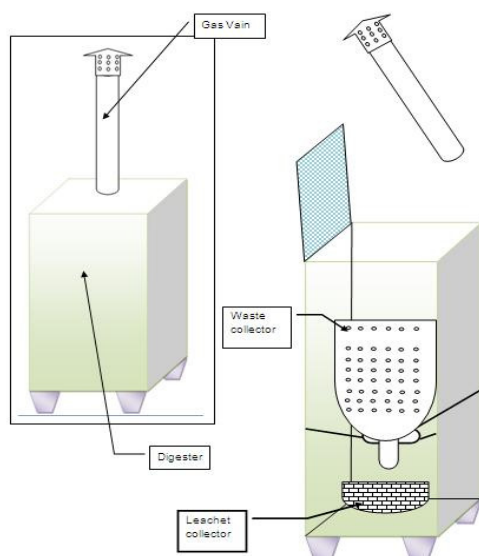


Figure 1: The designed composter

4. EXPERIMENTAL RESULTS

Table 2: Amount of compost generated from the organic waste by using the prototype composter.

No. of experiments	Sample 1	Sample 2	Sample 3	Sample 4
Amount of waste (kg)	1.5	4.5	4	5
Amount of compost by weight (kg)	0.5	1.6	1.6	2
Produced leachate (ml)	250	750	690	850
Time duration (days)	15	15	15	15

The average yield of compost from the organic waste was about 38%. The amount is higher than 25%, because the time duration the waste left in the digester for composting was less. The moisture in the compost was removed by sun-drying process and the weight was brought down to 25% of the original weight. Chemical test was then performed.

Table 3: Chemical characteristics of produced compost

Parameters/ samples	Sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Sample 4 (%)	Average
pH	7.8	7.4	7.5	7.6	7.575
Organic matter	21	20	22	23	21.5
Potassium K	3.15	2.90	2.85	2.75	2.9125
Total Nitrogen N	2.80	2.51	2.30	2.65	2.565
Phosphorus P	1.8	1.5	1.4	1.4	1.525
Sulfur	0.76	0.52	0.51	0.6	0.5975
Zinc	0.01	0.01	0.1	0.1	0.01

pH value

The pH value varies from 7.4 to 7.8, the average being 7.6 which is within the National Fertilizer Standard (6 – 8.5)

Organic matter

The content of organic matter varies from 20% to 23%, the average reading being 21.5%

Potassium K

Potassium varies from 2.75% to 3.15%, the average being 2.91% which is within the National Fertilizer Standard (1-3%).

Total Nitrogen N

It varies from 2.30 % to 2.80%, the average reading of 2.56%. This average is in agreement with the National Fertilizer Standard (0.5- 4%)

Phosphorus P

The content of Phosphorus varies from 1.4 to 1.8%, whose average is 1.525%. The National Fertilizer standard states that phosphorus should be between 0.5 and 1.5%.

Zinc

It varies from .01 to 0.1%, bringing the average value to 0.055%. According to National Fertilizer Standard, Zinc can be present upto a maximum of 0.1%.

5. CONCLUSION

This study is one step towards the disposal of the kitchen waste in a socio-legally acceptable, economically viable, technically feasible and environment-friendly manner. Important conclusions include: the disposal of the kitchen waste can be done at source (there is no need for collection and transportation) and low income families can take the advantage of its economic value and/or use it as fertilizer in their backyard. If composting can be carried out at a large scale, the nation can get rid of significant amount of chemical fertilizer

Further studies may be carried out comparing composting with the disposal with electricity generation.

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HEAVY METAL REMOVAL USING GRAFTED ACRYLIC ACID FOR THE WATER COMING FROM ABANDONED MINES

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Heavy metal contamination of water around abandoned mines was observed in South Korea. In that assessment, the highest concentrations of 88, 5, 116 and 244 $\mu\text{g L}^{-1}$ of copper (Cu), cadmium (Cd), lead (Pb) and zinc (Zn), respectively, were found in water within 1km from the mine. Acrylic acid was graft polymerized onto plasma-treated cellulose filter papers to develop a sorbent capable of removing the heavy metals. The ability of the grafted sorbent to remove a mixture of Cu, Cd, Pb and Zn from synthetic mine-water samples was evaluated in batch test at a starting pH of 6.5. The sorbent dosage was set at 20g L^{-1} . The Freundlich isotherm model also explained the data. Three different grafting percentages of 42, 122 and 148 were used to evaluate the effect of percentage grafting on adsorption. The amount of metal adsorption decreased with increasing percentage graft. The solid phase adsorption for the different grafted percentages decreased in the following order: Zn > Cu > (Cd $\approx$ Pb). Admittedly, it was found that one gram of plasma-treated acrylic acid filter paper was capable of removing approximately 111, 39, 36 and 117 μg of Cu, Cd, Pb and Zn respectively.

Key words: Abandoned mine; Freundlich isotherm; Grafting; Metal removal; Oxygen plasma

1. INTRODUCTION

Mining and milling operations, together with grinding, concentrating ores and disposal of tailings, provide obvious sources of contamination in the surface environment, along with mine and mill wastewater. In Korea, various mines were distributed all over the country and were actively operated until the early 1980s, since then, however, most have been closed, mainly due to economic reasons. After mine closure, mine waste materials, including tailings, were left without full environmental treatment, leading to the contamination of soils, plants, waters and sediments in the vicinity of the mines by potentially toxic elements from tailings by clastic movement through wind and water. The extent and degree of heavy metal contamination around the mines vary depending on the geochemical characteristics and mineralization of the tailings. For example, tailings containing large quantities of sulfide minerals could influence nearby agricultural lands and streams. In 2008, metal contamination around 44 abandoned mines in South Korea was measured and the highest concentrations of Cu, Cd, Pb and Zn in

surface water were 88, 5, 116 and 244 $\mu\text{g L}^{-1}$ respectively.

Sorption, utilizing low-cost filter materials, is an attractive option for small businesses, industries and municipalities to remove significant portions of the total metal concentrations to levels which will be less detrimental to public health and environmental quality (Okieimen et. al., 2005). Graft copolymers of cellulosic materials have advantages such as chemical resistance, radiation stability and inexpensive production compared to conventional ion exchange (Chauhan et. al., 2000). Many investigators have studied the feasibility of less expensive materials such as bone char (Cheung et. al., 2000), bagasse (Mohan and Singh, 2002) etc. for the removal of heavy metals from water. In this study, filter paper was used as a cellulose source. Oxygen (O_2) plasma was treated to form a reactive surface on filter paper for the further reaction with acrylic acid (AA). The main objective of the study was to form a sorbent capable of enhancing heavy metal removal from mine's surface water. Plasma-induced graft polymerization is an attractive way of modifying the surface chemistry and morphology

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of polymeric materials (Gupta et. al., 2002).

2. MATERIALS AND METHODS

AA underwent graft polymerization by a two-step method (Gupta et. al., 2002). Cellulose filter papers were treated for 120s in an argon (Ar) plasma reactor operating at a radio frequency (RF) of 13.6MHz, gas pressure of 5mbar, argon flow rate of 50sccm and power of 100W, as described elsewhere (Gupta et. al., 2002). Immediately after the treatment, O₂ was introduced into the chamber that was maintained at atmospheric pressure for 1h to generate hydroperoxide as well as other functional groups on the sample surface. The operation of plasma onto cellulose filter paper, as shown in Fig. 1, was done through Plasma Enhanced Chemical Vapor Deposition (PECVD) apparatus. It had a cylindrical reactor made of stainless steel (diameter 50cm) and a parallel plate electrode configuration with an electrode spacing of 14cm. Both of the stainless steel electrodes were circular in shape; the lower grounded electrode was 30cm in diameter. The precursor gas was fed through a gas shower head built in the upper electrode. The pressure of the reaction chamber was measured through a Baratron gauge (122B, MKS Instruments). The chamber was evacuated to a base pressure of 1.6Pa using a rotary pump before plasma treatment. AA was graft polymerized onto the plasma-treated filter papers under a nitrogen atmosphere (Gupta et. al., 2002). The filter papers were placed in a tube containing aqueous AA of predetermined concentration (30%) and nitrogen was bubbled through the solution. The tube equipped with a positive nitrogen pressure was subsequently placed in a constant temperature water bath for 1~5h. After the grafting reaction, the filter papers were removed from the tube and underwent soxhlet extraction with water overnight to remove any homopolymer adhering to their surface (Gupta et. al., 2002). The percentage graft was calculated from the following relation (Eromosele and Bayero, 2000):

$$\text{Percentage grafting} = \frac{(W_2 - W_1)}{W_1} \times 100$$

where, W₁ and W₂ are the weights of the filter paper and the grafted filter paper respectively.

Sorption experiments were carried out using synthetic solutions in 50 ml beakers at room temperature (28±1°C). The required concentrations of Cd, Cu, Pb and Zn were obtained by step-by-step diluting their stock commercial solutions to the desired concentrations. The ionic strength of the water samples was controlled using 0.01M NaCl, and the pH changes during the experiments were minimized using 0.003M NaHCO₃ (Genç-Fuhrman

et. al., 2007). Before starting the batch experiments, the pH of all solutions was adjusted to 6.5 using strong acid or base solutions. Afterwards, the dosage of plasma-treated AA-filter paper (PAAF) was set at 20g L⁻¹ (Genç-Fuhrman et. al., 2007) in the predetermined synthetic solutions. The solutions with sorbents were then mixed by gently shaking the batches in a mechanical shaker at 100 rpm for 24h. Later, the batches were taken from the shaker and filtered through 0.45µm filter paper, after which the filtrates were acidified to pH 1.5~2 and stored at 4°C until the heavy metal measurements. One set was also run as a control batch with sorbent but without any heavy metal addition. All the chemicals used were reagent grade and were used without any further purification.

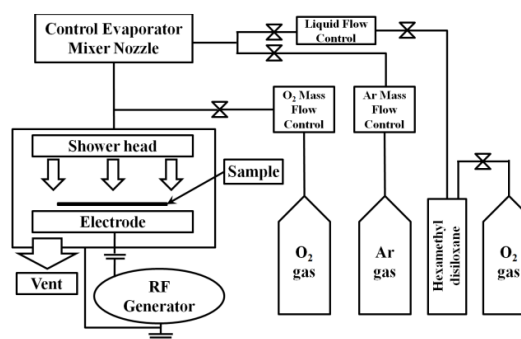


Fig. 1: Schematic diagram of PECVD system

In this study, we attempted to use realistic concentration ranges where the lowest values were below or about US Environmental Protection Agency's fresh water acute limits and the highest values were significantly higher, as shown in Table 1. The purpose was to evaluate and compare the sorbents at both highly and slightly polluted conditions, since some sorbents are known to be effective at rather high concentrations but are less efficient at low concentration (Genç-Fuhrman et. al., 2007).

For PAAF, the solid phase heavy metal concentration, q_e (µg g⁻¹), was determined by analyzing the corresponding heavy metal concentration before and after the treatment using the equation, $q_e = \frac{(C_0 - C_e)X}{n}$, where, C_e is the equilibrium heavy metal concentration in the solution (µg L⁻¹), and X the sorbent dosage (g L⁻¹). Moreover, the equation, $\log q_e = \log K + \frac{1}{n} \log C_e$ was used as the linear form of the Freundlich isotherm to fit the sorption data where, K is correlated with the quantity of sorbate associated with the sorbent, and n is the Freundlich isotherm constant related to the strength of the sorption.

Table 1: Initial concentrations (C_0) of heavy metals for batch experiments

	C_0 ($\mu\text{g L}^{-1}$)			
	Cd	Cu	Pb	Zn
USEPA	2	13	65	120
Batch 1	9018	10900	9726	11020
Batch 2	4425	5242	4715	5850
Batch 3	2664	3130	2832	3287
Batch 4	892	1041	976	1192
Batch 5	438	520	516	722
Batch 6	90	120	170	323
Batch 7	3	22	73	161

3. RESULTS AND DISCUSSION

Table 2 shows Freundlich isotherm constants with the r^2 values for all grafting percentages investigated in this study. For Pb, at the percentage grafting of 42, the r^2 values were comparatively lower. However, the r^2 values ≥ 0.5 signify statistically significant correlation. Although $r^2 \geq 0.5$ shows a fair correlation, using the estimated Freundlich isotherm for prediction is considered highly uncertain unless r^2 is close to 1 (Genç-Fuhrman et. al., 2007). Accordingly, most of the investigated heavy metals showed the most correlated result to fit the isotherm. Cu showed a better correlation than the others as $0.95 \leq r^2 \leq 0.98$.

The solid phase adsorption of metal was corrected for the grafting percentages in the batches. As depicted in Fig. 2, the adsorption per dosage of adsorbent versus grafting percentage was drawn while keeping the other parameters constant. The adsorption per dosage of the adsorbent generally improved with low grafting percentage at all heavy metal concentrations. Alternatively, the amount of metal sorbed decreased with increasing percentage graft. Pb and Cd showed similar sorption criteria that were lower than those of Zn and Cu sorption. In the study, Zn was more sorbed than Cu.

The results of the simultaneous removal of Cd, Cu, Pb and Zn are presented in Fig. 3 on a double logarithmic scale for batch tests. As expected, the amount of heavy metal removed increased with increasing initial heavy metal concentration in all of the batches. The sorbent dosage was set at 20g L^{-1} for all the batches. All of the batches were investigated at three different grafting percentages. The highest amount of adsorbed Cu in batch 1 was $111\mu\text{g g}^{-1}$.

Table 2: Freundlich isotherm constants for different grafting percentages

Heavy metals	Percentage grafting								
	42			122			148		
	K	1/n	r^2	K	1/n	r^2	K	1/n	r^2
Cd	0.06	0.67	0.96	0.006	0.89	0.92	0.001	0.98	0.98
Cu	0.08	0.76	0.95	0.03	0.85	0.98	0.019	0.87	0.98
Pb	0.82	0.36	0.84	0.001	1.06	0.87	0.001	0.89	0.91
Zn	1.41	0.45	0.90	0.004	1.10	0.96	0.005	1.00	0.99

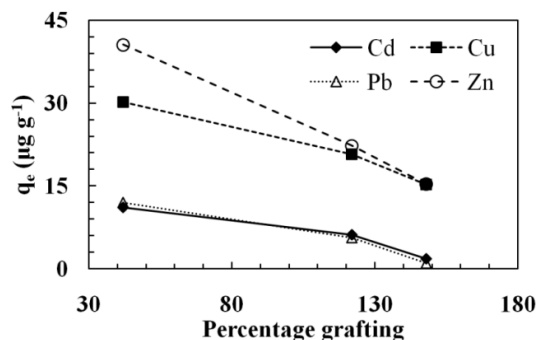


Fig. 2: Solid phase sorption of Cd, Cu, Pb and Zn at different grafting percentages

4. CONCLUSION

This study has presented the effective use of PAAF to remove trace heavy metal elements in the water coming from abandoned mines. The heavy metal sorption showed satisfactory results in the batch study. The sorption of the heavy metals was dependent on the grafting percentage with a lower grafting percentage exhibiting better solid phase metal sorption. PAAF was suitable for batches with low concentrations of heavy metals.

No sorbent leaching occurred during the batch tests, indicating an acceptable adsorbent quality. The effect of sorbent dosage should be investigated in future study to determine the effects on heavy metal removal.

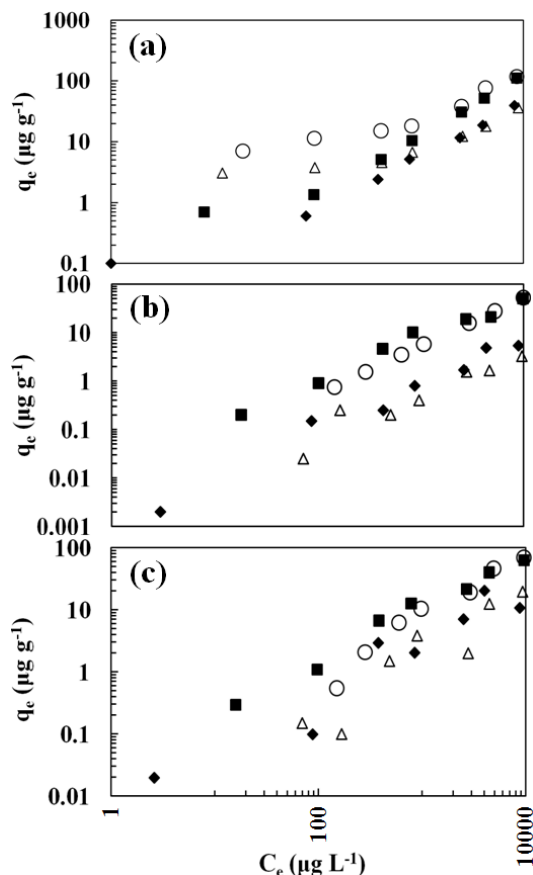


Fig. 3: Cd (◆), Cu (■), Pb (Δ) and Zn (○) removal at the following different grafting percentages:
(a) 42%, (b) 122% and (c) 148%

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IMPACT ON SUSTAINABILITY OF HAIL HAOR BY INTEGRATED WATER MANAGEMENT ACTIVITIES

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ABSTRACT

This study concerns with the activities running through the projects under different well-known institutions and the effects of the projects on sustainability of the environment of Hail haor. Hail haor is the main water reservoir of Moulobhi bazar-Sreemangal area. Hundreds of Choras discharge water in this haor. Huge amount of water also carries tones of sediments. This causes siltation of the haor as well as the Choras. As the depth of the haor decreases, the living place of the aquatic animals reduces. As the water reservation capacity of the haor and conveying capacity of the discharge channel reduces; as a result, in the Monsoon the haor can't provide sufficient places for incoming water, which causes flood. Moreover, in the month of April and May flash flood occur which causes devastating damage to the crops (specially the Boro crops) and breaks down the local economic condition. Again, flood carries much of silts which make the soil fertile. If it is possible to save the Boro crops up to mid-May from flash flood then it would be very much beneficial. On other hand, deficiency of water occurs tremendously in the dry season.

KEY WORDS: Sustainability, Haor, Integrated water management, Checklist.

1. INTRODUCTION

Sustainable development is an approach to economic planning that attempts to foster economic growth while preserving the quality of the environment for future generations. Proper water management is essential for sustainable development (Hunter and Jones, 2002). Depending on the terrain, water management may involve extensive works to achieve optimum utilization and to get the maximum benefit from a water reservoir in such a way that its quality should be preserved in its original or a controlled condition as a means of future use. It includes storing, discharging of surplus water, protection of surrounding areas from flood and draught, providence of safe and sufficient places for aquatic plants and animals, satisfy the needs of the people who depends on it etc.

Haor is a large saucer like low land with a very smooth and gentle slope which have some natural tributary streams and a well defined outlet and which is being used as temporary water reservoir and velocity controller especially at monsoon. GIS can be used for scientific investigations, resource management and development planning.

The topography of the north-eastern part of Bangladesh is uneven. Hills surround the Hail Haor

basin to the west, east and north. Approximately 50% of the watershed area is hilly and managed by different tea estates, lemon-pineapple garden owners and the State Forest Department. People are converting the landscape by cutting hills for different patterns of agricultural farming and also for making roads and establishing human settlements. The elevation of hilltops ranges from 60 to 66 meter above mean sea level (MSL) while the base of the hills range from 25 to 35 meter; and wetland basin itself is in the range of 2-6 m above MSL. The water shed area of Hail haor is about to 600 square kilometer (237 sq-miles). All water in the basin originates from the surrounding hills, with approximately 85% from India and 15% from within Bangladesh. Hail haor plays an important role in balancing ecosystem of the country. Here, all the hilly charas are coming from the hills and met in the flood plain area of the haor and drain though the only outfall the Gopla river, which ultimately fall into Old Surma river (Alam, 2002). Therefore, the flooding, drainage and water logging are largely depended on the functional capacity of the Gopla River. So, an attempt has been taken in this study to check the sustainability of the hail hoar.

2. OBJECTIVES

The specific objectives of the study are as follows:

- (i) To find out the present situation and the impact of different activities running through different projects on sustainability of the environment of Hail haor.
- (ii) To recommend some measures for the sustainability of the environment of Hail haor.

3. METHODOLOGY

Step-1: Visiting of the Whole Area

- Survey work has been conducted from Jan'05 to December'05.
- Using of the resource full libraries of different institutions to square knowledge about different national and international water management projects.
- Almost the whole area was visited well enough to observe and know the way of the project execution with a specialist.
- Different hydrology measuring stations were observed properly when they were performing their duties.
- Different Important choras were observed.
- Different types of dam were observed with their constructional specialties.
- Getting of information from different field offices.
- Observation of the conditions of the flood control structures with the effects.

Step-2: Consultations with the Stakeholders

- Consultation was done under RRA (Rapid rural appraisal) and PRA (Participatory rapid appraisal) projects.
- Consultations with different peoples of different places and standards about the present situation.
- Consultations with different peoples of different places and standards about the remaining problems.
- Consultations with different peoples of different places and standards about their thinking of solutions with their benefits.

Step-3: Consultation with the Specialists

Consultation with Hydrologists

Consultation with different hydrologists was done in different context of Hail haor. Flow pattern of water of Hail haor, different flood problem, causes, after effects etc. were being discussed with him. Effect of the projects on natural hydrology was also being discussed with him.

Consultation with Environmentalists

Present condition of the environment on Hail haor was being discussed with him. Effects of the

running projects on the environment were also being discussed.

Consultation with Construction Engineers

Consultation with the dam designers and engineers was being done. Constructing materials with the design considerations and the objectives of the dam was discussed with practical observations in field with future plans.

Consultation with the Hydrology Monitoring Personnel

Consultation with the monitoring personnel was being done in details. How the instruments works was being observed.

Step-4: Taking Help from GIS Lab

Different uses of GIS in planning, monitoring and future prediction were discussed. Ecology, depth of the haor in different positions, moisture holding ecosystem of different stages, geographical locations, agricultural land, settlements, hilly regions etc were discussed with them through the satellite image of Hail haor.

Step-5: Sustainability Evaluation with Checklist Method

200 experts from different BWDB *(Bangladesh Water Development Board), CEGIS (centre for Environment and Geographical Information System), IWM (Institute of Water Modeling) and NGO's related with wetland management (MACH, IDEA, IUCN) have been introduced a scale on environmental parameters for sustainability checking (Hossain and Chowdhuary, 2003). From the checklist, the sustainability has been evaluated.

Scale of point measurement

Impacts Severity (s)

- 1=No effect
- 2=Minor effect (single receptor)
- 3=Minor effect (multiple receptor)
- 4=Significant effect (single receptor)
- 5=Significant effect (multiple receptor)
- 6= Dynamic effect on single/multiple receptor

Probability (p)

- 1=Negligible
- 2=Slight
- 3=Possible
- 4=Likely
- 5=Very likely
- 6=Inevitable

Grading

Impact Value (IV) = p * s	Insignificant	< 4
"	Low	4 to 8
"	Medium	8 to 10
"	High	> 10

4. RESULTS AND DISCUSSION

Hail Haor, through the View of GIS

Ecology

Hail Haor is composed of unique status in the region as the largest shallow permanent lake unlike other haors of the northeast of Bangladesh. Hail haor supports highest biodiversity of plants and animals in its unique geographical location.

The area is confined three sides by hilly lands so there are about 352 charas originated from the surrounding hills and entered into the Hail haor. Out of 352 charas only 56 charas are live and contributing huge amount surface runoff that generates flash flood in every year. In addition to these charas, there are a number of rivers namely Gopla River, Dainka River, Buda River, Bilash River and Kodaligang River in the haor area. Among the river, Gopla is most important river, which runs through north to south and the main water discharge channel (MACH, 2004).

Depending on water retention by depth and duration, moisture holding capacity of soils, topography and vegetation, Hail haor area can be divided described as following ecological zones through the white broken line drawn in figure 1:

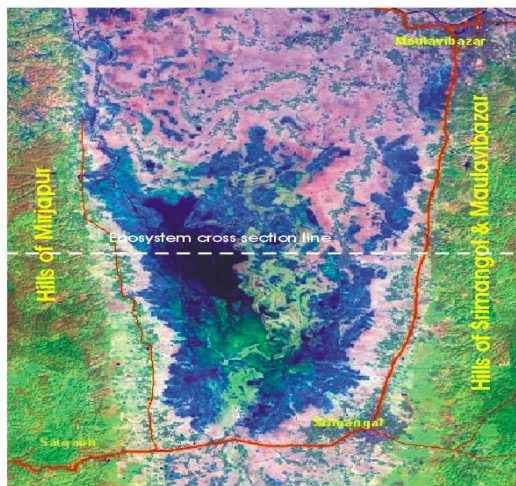


Figure 1. Landsat Image of 2003, the white broken line touch almost all ecosystem of Hail haor areas.

Deepest part of the haor

These areas (Figure 1) are represented by deep-blue to blackish dark color in the Landsat image. Most of the lower perennial water bodies are within this range. This perennial wetlands situated under the Kalapur union almost at the center of the haor. More than hundred (locally popular 352 choras of streams finally reaches the hail haor deeper areas. Water from hills of three sides (east, west and

south) arrives at the center first. These areas act as primary reservoir unlike haors of the north like Korchar or halir haors. These areas act as over wintering ground for all aquatic resident creatures. Water then spell to the next ecosystem, the high moisture holding ecosystem.

High Moisture Holding Ecosystem

These areas (Figure 1) are represented by Indigo color in the Landsat image. These are most important shallow aquatic ecosystem that act as best grazing land for all aquatic and wetland depended creatures. High moisture holding capacity, fertile soils and consistency provides highest biodiversity of flora and fauna of the overall haor. The area covers the inner part (towards haor center) of the following unions the Mirjaput Nazirabad, Giasnagar, eastern part of Kalaput part of Srimangal and Bhunabir. Makhna (*Eurayle ferox*) and Padoo (*Nelumbo nucifera*), both rooted floating plants, are still found only in Hail Haor. These plants grow under this ecosystem.

Rivers and Choras

There is only one major river that cross the hail haor name Gopla River and the minor river name Fulchori which is also connected with Golpla River. Gopla River finally meet with Surma River in the north crossing all type of ecosystem. Gopla is the only drainage outlet for hail haor. Water flows unidirectional in choras. Rainwater or water from hills comes to the haor almost round the year. During the monsoon these are so vigorous that washes every thing along the sides and finally take to the haors. Wastes from urban areas of Srimongal and Maulavibazar, Tea garden wastes, rural household wastes and finally agricultural runoff turn haor to acidic condition and post monsoon. The vast agricultural land of the nearby ecosystem contributes filling wetlands. Intensive agricultural intrusions over this ecosystem caused serious ecological disaster and eliminate lot of haor characteristics permanently. Loss of wetland seasonal vegetation, resident and migratory birds and habitat conversion for invertebrates are major changes.

Low Moisture Holding and Hard Dry Soils Agricultural Land

These areas (Figure 1) are represented by conspicuous pink color in the Landsat image. These are genuine agricultural land. Within these land mass and it periphery are the next ecosystem the settlements.

Settlements

Except the northern side the settlements of Hail haor are designed as marginal. The northern

settlements are scattered and can be recognized as unplanned invasion by time. These areas (Figure 1) are represented by Pale green color in the Landsat image. The invasion of human settlement between haor wetland areas and the connecting road between Upper Kagabata and the Maulvibazar sadar are not older than 50 years. As long as going inner side of haor areas land conversion took place from all sides. Settlements are well vegetated and orchards are used as vegetable cultivation and rice processing. Big landowners manage their land by poorer community, which encourage using more land with lower yield of crops rather than minimizing agricultural land with higher production.

Foothills and Hilly Areas

Teagardens, major marginal permanent settlements, schools, roads, other infrastructures and fellow land areas can be encompasses under this ecosystem. These areas are well vegetated. Jackfruits, Shimul, Koro and Bettlenuts are dominating vegetation.

Problems Identified

Conflict between fishers and farmers

There is conflict between farmer and fisherman. In the Boro plantation period farmer wants to remove water rapidly, but fisherman created obstacle on the river with different fishing gear. So, some time plantation has delayed. Project will have to go for appropriate measures for resolution of conflicts.

Conflict between farmer and sand traders

There is conflict between farmer and sand traders in the area. Sand traders want more sand from Choras for their more profit but some time sand carpeting is a very much problematic for farmer in haor area. Here it is noted that, now days sand carpeting is regular problem than previous time. In the past Hill was covered full by different type of bush and tree but now it is clean from bush or tree for different crop cultivation as a result sand come more and more.

Problems remains

As the work of the project is done in two steps but it has been not possible to ensure the internal extraction system properly. As a result, flashy water from more than 50 Choras of south-west and because of rain water in April/May flood occurs here. As the water cannot be removed too fast, water congestion damages the crop fields. Moreover, Water congestion also damages the Aman fields. Gopla river is the main outlet of Hail haor. Because of the lack of proper maintenances the bed of some contributory cannels around the haor and Gopla River is being partially clogged because of over siltation as a result the capability of transportation of water is being reduced.

Consequently, every year rain water and the flashy water from upstream causes water clogging on the vicinity of the haor in April/May.

Effects of the projects on local environment

After surveying the project area and analyzing the project activities of Hail haor rehabilitation and development project, the effects found on environmental factors have been shown in [table 1](#).

Running water management projects have very few negative effects on the environment. Hail haor rehabilitation and development project (BWDB) assures full protection of the residential area of the haor area and protection of the agricultural area only for a short period of time (Up to harvest of the Boro crop). It also helps to Solve the over siltation problem as well as causing no harm to the aquatic animals. Management of Aquatic Ecosystem through Community Husbandry (MACH) does not concern with flood protection, it only deals with the diversity of the aquatic ecosystem, which has no adverse effect of the environment. It also helps to provide erosion of the Choras at upstream. It does not hamper any natural process. So, through the observed water management projects sustainability of environment assures in almost all ways.

Present and future scenarios of Hail haor

If sedimentation continues in Hail Haor at present rate, around 75 % of the present dry season water area will be reduced by 20 years (figure 2). This result is obtained considering the above parameters. EGIS lab facilities have been taken to predict the future condition.

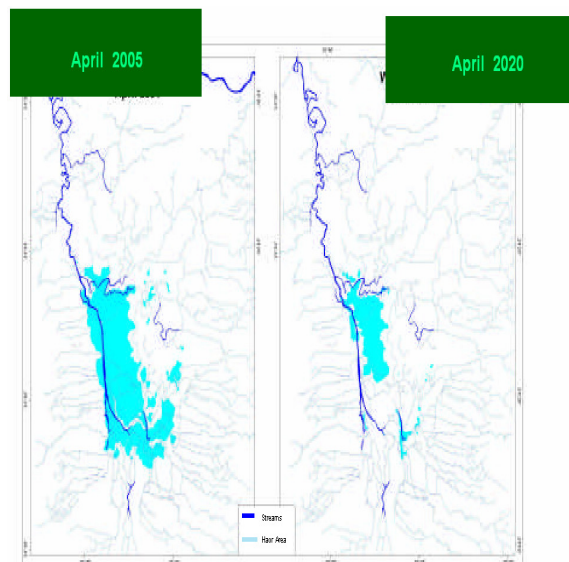


Figure 2: Around 75% of the present dry season water area will be reduced by 20 years.

Environmental Component	Types of Impact							Evaluated Grading		
	Probability (p)	Severity (s)	Impact Value (IV) = p * s	No Impact	Positive Impact	Negative impact	Insignificant	Low	Medium	High
ENVIRONMENTAL FACTORS										
Water resource										
Water quality	1	1	1	√			√			
Ferry transportation	3	4	12		√					√
Flood protection	5	4	20		√					√
Deposition of silt	1	1	1	√			√			
Irrigation	5	5	25		√					√
Extraction of flood water	4	5	20		√					√
<i>Aquatic resource</i>										
Fish	3	4	12			√				√
Fish diseases	1	1	1	√			√			
Human resource related										
Destruction of houses	1	1	1	√			√			
Transportation	4	2	8		√			√		
Educational system (Training)	1	1	1	√			√			
Income from fishing	4	5	20		√					√
Status of life	3	5	15		√					√
Erosion of soil	1	1	1	√			√			
Employment in agriculture	4	3	12		√					√
Different ways to income	4	5	20		√					√
<i>Problems</i>										
Destruction of embankment	6	6	36		√					√
Destruction of river bank	1	1	1	√			√			
Conflicts between groups	1	1	1	√			√			

Table 1: Checklist for sustainability evaluation (Source: Chowdhury, 2006)

RECOMMENDATIONS

Immediate Measures

The eroded sediments are carried by the streams and ultimately reaching to Haor, filling beels. If this process keeps continued for a decade several inches of sediment will be piled up and many beels will lose their perennial nature and lose habitats.

Therefore, sediment intrusion into the Haor will be stopped immediately.

Check dam construction: As immediate measures, Check Dams may be constructed on some sediment carrying streams to accumulate some portion of the carrying sediment at a specified location. Check dam concept is new in Bangladesh but widely used

in many countries like Indonesia, Philippines, and India. This is also known as sediment storage dam, this artificial dam is usually designed to intercept and trap waterborne sediment. The dam has a principal spillway that allows water to slowly flow through, allowing the sediment to settle out. The spillway may be in the form of notch or box inlet. Already Chhora Resource Management Organization (CRMO) has been formed in the Joita Chhora reach. So, as an experimental basis, Check dams may be constructed on this Chhora. The CRMO can manage the check-dam, remove sediment each year from the site and earn money by selling the sand. Therefore, there are two-way benefits from the check dam, rapid sedimentation of beels will be slow down and the local people will have a source of income (Garg, 1999).

Bank protection: There are some places along the stream reach which are vulnerable to bank erosion. These skewed portion of the Choras need to be protected from erosion immediately.

Long-term Measures

Check dam and others are not the permanent solution of stopping rapid sedimentation. To reduce the soil erosion proper watershed management is must by the active participation of the community. The following measures should be taken.

Riparian plantation: Riparian plantation along the Chhora reach will help in dissipate energy of the hilly streams by creating obstruction and thereby reduce the bank erosion.

Cropping pattern change: Present cropping pattern of lemon and pineapple is a major cause of soil erosion. Vertical plantation of the pineapple will be changed to contour plantation. Already MACH has demonstrated a contour pineapple garden in Sreemongal, and MACH is receiving very positive response from the professional pineapple garden owner (BWDB, 2003).

Upper shed plantation: Upper shed plantation is necessary to develop the sub- watershed.

Controlling herbicides use in tea garden: Study showed that tea estate has also great contribution to present sediment loading. Though the tea land is covered with trees, splashing of rain can't reach to the soil, however the soil is beard due to the use of herbicides which is extensively being used in the tea estate. The use of herbicides should be controlled.

Proper use of stream water: Stream is the only source of irrigation water in Hail Haor site. Earthen dams usually constructed across the stream to pile up water at a section and gravitational irrigation is

done. Therefore, virtually stream flow can't reach up to Haor causing water scarcity in the Haor in the dry season. Most of the cases, diversion of water continued beyond the actual demand of water. Therefore, proper sharing of water is essential leaving a portion of water for Haor (CEGIS, 2004; NEMAP, 1995).

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IMPORTANCE AND SCOPE OF CONSERVATION OF WETLAND TO PROTECT ENVIRONMENTAL DEGRADATION

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ABSTRACT

Wetlands constitute a part of human heritage. It has played a significant role in the development of human culture and society. More over it contains very rich components of biodiversity of local, national, and regional significance. They also provide habitat for a variety of resident and migratory waterfowl, a significant number of endangered species, and a large number of commercially important species. Mangrove wetlands are unique environments of floral-faunal assemblages, providing a complex detritus-based food-web for a number of marine and brackish water organisms. Wetlands in Bangladesh have great importance for the country's economic, industrial, ecological, socioeconomic, and cultural aspects. There are 43 designated wetlands, and some are under threat from indiscriminate utilization, encroachments and reclamation, urbanization and drawbacks from agricultural development, and flood control. Almost 50% of the country's people are directly dependent on wetlands resources. The vast majority of the poor people in the wetlands areas are dependent on wetlands resources for their nourishment. Wetlands have potential and have been recognized as a driving force for biodiversity conservation and rural socioeconomic improvement. Smart-use of wetlands can solve the ecosystems problems in the floodplain areas. A comprehensive analysis of the various issues leading to wetlands degradation is made in this study. The country needs an adequate interdisciplinary policy and political will to implement it for sustainable management and protection of wetlands and ecologically sensitive ecosystems in Bangladesh. Therefore, considering the causes and effects of degradation of wetland, a reliable guideline is provided in this study to enhance the conservation measures initiated by the Government.

Key words: Wetland; Environment; Degradation; Conservation; Guideline

1. INTRODUCTION

Wetlands are defined as low-lying ecosystems where the groundwater table is always at or near the surface, including areas of marsh, fen, bog, floodplain, and shallow coastal areas (Alam and Chowdhury 2003). In other words, wetlands are transitional lands between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered by shallow water (Mitsch and Gosselink 1986). They are neither just land, nor just water. They can actually be both at the same time, or seasonally aquatic, or terrestrial. To be classified as a wetland, the area must have one or more of the following attributes:

- i. at least periodically, the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or
- ii. the substratum is predominantly undrained soils that are saturated, flooded or ponded

long enough to develop anaerobic conditions in the upper layers, or

- iii. the substratum is not soil and is saturated with water, or covered by water at some time.

The main characteristic of the geography of Bangladesh is abundance of water and wetlands. Most of Bangladesh lies in the largest delta in the world, the Bengal Basin, formed by the Ganges, Brahmaputra, and Meghna (GBM) river system (Fig. 1). It comprises only 7% of the total GBM catchment area (Coleman 1969). The Bengal Basin is vast lowland. It is thought that this lowland basin was once one of the largest wetlands in the world; during the past few thousand years, the wetlands have almost all been converted into rice-growing areas (Chowdhury 1998). During the monsoon season, the total area of wetlands in Bangladesh is estimated to be 7–8 million hectares, or about 50% of its total land surface (Khan 1993). This includes

5.4 million hectares of open and closed lakes on floodplains that are inundated every year (Ali 1990). Ninety percent of wetlands of Bangladesh are dependent on flow from three major rivers, but are now threatened by diversion of water in India from the Ganga–Padma river (Gopal 1995).

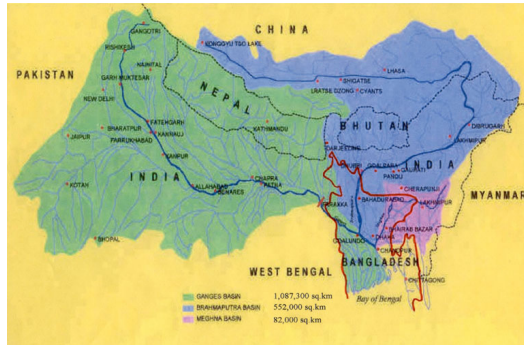


Fig-1: GBM Basin

2. OBJECTIVES

The specific objectives of the study are as follows:

- (i) To understand the present ecological situation of wetlands in Bangladesh and the environmentally sensitive ecosystems, economic benefits, and its significance in different aspects
- (ii) Provide a guideline to enhance the conservation measures of these wetlands.

3. METHODOLOGY

This paper is mainly based on primary and secondary data. Primary data were collected through participatory rural appraisal (PRA), field survey, observation, and interview with experts. Critical perusals of secondary data included relevant books, articles, reports, unpublished theses, maps, relevant documents, newspaper cuttings, and in situ personal experiences. Collected data were critically reviewed and discussions carried out with experts and local people. It is believed that the management issues of wetlands of Bangladesh have been brought together herein.

4. RESULTS AND DISCUSSION

Wetland Resources:

Wetlands in Bangladesh have great importance for the country's economic, industrial, ecological, socioeconomic, and cultural context (Islam and Gnauck, 2007a). They contain very rich components of biodiversity of all valuable ecosystems (Kundzewicz, 2003). This ecosystem serves as habitat for a variety of resident and

migratory waterfowl and endangered and commercially important species of national and international interest (Nishat, 1993; Islam and Gnauck, 2007b,2009a). Wetlands support essential natural resources and services, and the people of Bangladesh depend on wetlands for fishery and agriculture. The fate of Bangladesh, its people, and its prospects for sustainable development are determined by the association of water and wetlands, and they are the central pillar of the natural resource base. It is observed that communities are most densely settled in and around wetlands, and for centuries society adapted a culture that maintained a close relationship between wetlands nature and human actions.

Wetlands encompass many different habitats, including ponds, marshes, and swamps, and are ecologically significant areas as they are the meeting place of land and water, and are themselves wet. Plants and animals that are present in wetlands are from both land and water habitats. They are very rich depositories of vegetations, aquatic plants, reeds, and algae, which make them highly productive environments. The flora composition is relatively uniform throughout the haors, beels, jheels, and baors but dominance varies seasonally. Typical wetlands trees are hizal (*Barringtonia acutangula*), tamal (*Diospyros cordifolia*), barun (*Crataeva nurvala*), madar (*Erythrina variegata*), gab (*Diospyros peregrina*), dumur (*Ficus hispida*), chalta (*Dillenia indica*), and dehua (*Artocarpus lacucha*) (Alam and Chowdhury 2003). Wetlands function as ecotones, transitions between different habitats, and have characteristics of both aquatic and terrestrial ecosystems.

Values of Wetland:

Wetlands are the most productive ecosystems, and countless species of plants and animals depend on them for survival. A high concentration of fishes, amphibians, reptiles, birds, mammals, and invertebrate species are supported by them (Khan et al. 1994). Fishes from wetlands provide the main source of protein for the people of Bangladesh. Rice cultivated in wetlands is the main food in Bangladesh. They also provide important ecological functions, socioeconomic services, and products, and are important for their ecological, socioeconomic, and commercial value. Wetlands contain very rich components of biodiversity of local, national, and regional significance. Among the estimated 5,000 species of flowering plants and 1,500 species of vertebrates in the country, up to 300 plant species and some 400 vertebrate species are judged to be dependent on wetlands for all or part of their lifespan. Wetlands also provide habitat for a variety of resident and migratory waterfowl, a significant number of endangered species of

international interest, and a large number of commercially important species. The inland capture fishery is based on the vast freshwater resources, with some 260 species of finfishes and 25 shellfishes (Khan et al. 1994). Wetlands are precious for the environment, ecology, and biodiversity. They are an integral part of the local ecosystem and closely related with local cultures, and also support the livelihoods of millions of people based on diverse activities such as fishing and agriculture. Values of wetlands are increasingly receiving attention as they contribute to a healthy environment in many ways. The values of the wetlands of Bangladesh can be classified into three major groups: environmental, economic, and social.

Storage and recycling of nutrients and organic waste, recharge and discharge of groundwater and storage of surface water, natural drainage, flood control and flow regulation, fish breeding ground, and maintaining ecological balance are some examples of the environmental value of wetlands. Wetlands agriculture, freshwater, fish, wild foods, forest resources, agricultural land, and biomass are some examples of the economic value of wetlands. Transportation, human habitat and settlement, research, education, and aesthetic are some examples of the social value of wetlands in Bangladesh. Table 1 summarizes the overall values of wetlands of Bangladesh.

Table 1 Values of wetlands in Bangladesh

Category	Values
Environmental	Storage and recycling of nutrients and organic waste, storage and discharge of surface water, recharge and discharge of groundwater, natural drainage, control of flooding and regulation of water flow and water regimes, reduction of water logging and storage of flood water, transport of sediments and sediment/toxicant retention, storage and recycling of human waste, control of erosion and salinity, purification of water and maintaining the water table high and relatively stable, relief of drought and stabilization of climate and control of microclimate, stabilization of shoreline and reduction of erosion, reduction of sediment and pollutant load, maintenance of soil structure and helping soil formation, protection against river bank erosion, helping nutrient retention/removal, protection against storm surges, helping carbon sequestration, maintaining ecosystem stability and the integrity of other ecosystems, fish breeding grounds, maintaining biological and genetic diversity, supporting food chains and habitat for wildlife and protecting wildlife, helping pollination, work as ecotones (vital links between land and water), habitats for a variety of resident waterfowl and a significant number of endangered species of international interest and as internationally important wintering areas for migratory waterfowl, principally ducks and shorebirds
Economic	Agricultural activities, crop production, freshwater fish production, provision of forage resources, production of wild food, production of vegetables, as agricultural land, providing forest resources, supply of irrigation water, helping stock farming, grazing places for domestic livestock, helping water duckery, supply of wildlife, supply of fuel wood, as a place of primary activities, provision of medicinal plants and genetic resources, provision of subsistence-oriented economy and livelihoods, supply of raw materials for building, construction, and industrial use, provision of places for industrial and pharmaceuticals plants, as places of primary economic activities, as pasture, and as storehouses of plant genetic material
Social	For transportation, tourism and recreation, provision of settlement places, help in research and education, uniqueness, cultural heritage, cultural value, aesthetic value, heritage value, spiritual and inspirational values, bequest value, ecotourism, as leisure or recreational place, place of education and amusement, fostering of beneficial rural-urban links, and transformation and empowerment of poor user groups as resource managers

Present State of Wetland:

Since independence there has been an accelerated expansion of physical infrastructure in the floodplains and haor areas. In recent years, decentralization of administration at the Upazila (sub-district) level also led to a rapid expansion of roads and feeder roads even in the rural areas of the

haor basins. These infrastructures were often done without proper planning or due regard to natural water flows. These poorly planned roads and drainage structures created water logging and had serious impact on the water regimes in the flood plains.

Nishat, A. 1993 pointed out that the degradation of wetlands in Bangladesh were mainly due to: increase of population and expansion of human habitats; expansion of agriculture and subsequent conversion of wetlands through drainage into rice fields; flood control and irrigation project for enhancement of agricultural productivity; national, local and rural infrastructures like ill-planned roads; narrow culvert etc.; over-felling of wetland trees; over-grazing by livestock; over-fishing and associated disturbances; siltation due to degradation of watershed areas which are often transboundary in nature; indiscriminate control/regulation / use of water flows of main river

systems in upper riparian; and pollution of water due to industrial, urban, agrichemical and other types of pollutants including pollution from transboundary sources.

Causes and effects of wetlands degradation:

Wetlands and their habitats are under constant threat due to various causes. Wetlands productivity and biodiversity are declining all over the country. The overall cause and effect relationships of the wetlands degradation of Bangladesh may be stated as follows:

Causes	Effects
1. Population growth. 2. Extensive agriculture and urbanization. 3. Expansion of human habitats in the wetlands. 4. Land reclamation and expansion of agriculture. 5. Conversion of wetlands through drainage of water bodies in to rice growing fields. 6. Flood Control Drainage and Irrigation (FCDI) projects for enhancement of agricultural productivity and control flood. 7. Ill-planned national, local and rural infrastructure like roads, narrow culverts etc. 8. Lack of institutional coordination among infrastructure development authorities. 9. Lack of awareness and top-down approach during project implementation. 10. Lack of community involvement in Government project for management of wetlands. 11. Over fishing and introduce of alien species and extensive shrimp cultivation. 12. Over-cutting of wetlands vegetations without replacement. 13. Siltation due to the degradation of associated watershed areas. 14. Increased use of fertilizer and pesticides for rice monoculture.	1. Change in chemical and physical properties of (such as nutrient availability, degree of substrate anoxia, soil salinity, sediment properties and pH.) 2. Extinction and reduction of wildlife. 3. Many species of flora and fauna of wetlands are threatened. 4. Extinction of many indigenous wild and domesticated rice varieties. 5. Loss of many indigenous aquatic plants, herbs, shrubs and weeds. 6. Degeneration of wetland based ecosystem. 7. Reduction of fish diversity and depleted the resource bases, particularly fisheries of many of the fresh water wetlands. 8. Deterioration of fisheries habitat. 9. Loss of biodiversity. 10. Loss of natural water reservoirs and of their resultant benefits and increase in the occurrence of flooding and loss of natural soil nutrients. 11. Worsen of wetland's water quality. 12. Decrease of crops productivity. 13. Heavy siltation, water logging and increased water pollution. 14. Weakening of wetlands based occupations, socio-economic institutions and cultures.

5. CONCLUSION

From the findings of the study, for stopping further degradation of the wetland and to enhance the conservation measures of wetlands following recommendations may be concluded:

- (i) For stopping further degradation of wetlands:
 - Significance of wetlands in the national, zonal and local level planning process must be recognized;

- Sustainable and comprehensive agricultural practices and land use patterns need to be devised;
- Functions of selected wetlands be rehabilitated;
- Introduction of sustainable management practices at all levels;
- Technical knowledge, planning and management capabilities be enhanced; Attention given to awareness, education and research aspects.

- (ii) Towards proper management of wetlands:
- Wetland mapping and landscape planning
 - Declaration of critical wetlands as protected areas, if considered necessary.
 - Identification of problems through PRA exercise; conservation and protection measures including eutrophication abatement,
 - Wildlife conservation and fisheries development;
 - Environmental awareness and organizational set-up.
 - Develop institutional funding arrangements through integrated mechanisms at national, regional and international levels.
 - Legislation is needed to regulate all activities which impact wetlands.

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PREDICTION OF FUTURE TEMPERATURE IN NORTH-EASTERN REGION OF BANGLADESH BY USING HISTORICAL DATA

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The temperature of the World is increasing day by day. This has a tremendous impact on global climate change; Bangladesh is not the exception of this trend, which is revealed from several studies on temperature performed in recent years in various parts of the country. This study was conducted using historical data of temperature from 1975 to 2007 of north-eastern region of Bangladesh collecting from Bangladesh Meteorological Department. The data of average maximum and minimum temperature is analyzed dividing the season in two parts: wet season (May to October) and dry season (November to April). The highest maximum temperature is 32.1°C in August (wet season) and lowest minimum temperature was found 12.3°C in January (dry season). Analyzing the maximum temperature of August and minimum temperature of January, it is found that temperature shows an increasing trend and two equations are derived to predict the future temperature. The predicted temperature in 2100 for maximum temperature of August and minimum temperature of January are 37.62° C and 20.95° C respectively. The results predict that the winter season may be abolished and temperature all the year round will be high.

Key words: Climate change; temperature change; north-eastern region; wet season; dry season

1. INTRODUCTION

As a study area North-Eastern region of Bangladesh, Sylhet, is very interesting because of its natural resources like Tilas (small hills) and Hills, jungles, over 150 tea gardens which are sensitive to heavy rainfall, nearly 400 Haors of around 4,450 to 25,000 km square and its role to the ecosystem of that area supporting diverse livestock's including human. This region recharging ground water table greatly to keep the natural balance through out the country due to having rainfall around 5000 mm per year. Sylhet region is suffering from regular flash flood, river erosion, heat waves, storms, contamination of iron and arsenic in ground water. The temperature of this region is also increasing due to various reasons (Das and Kashem, 2009), which will increase these natural calamities.

It is now proved from scientific study that our mother climate has undergone an abnormal human induced change. This change mainly occurs due to change of global temperature. According to

Intergovernmental Panel on Climate Change (IPCC) global surface temperature increased 0.74 ± 0.18 °C during the 100 years ending in 2005. It also noticed that the rise of mean annual temperature will be 3.3 °C per century (IPCC, 2007). The mean annual temperature of Bangladesh has increased during the period of 1895-1980 at 0.31°C over the past two decades (Parathasarathy et al., 1987 and Divya and Mehritra, 1995). Another study which use the data of 1961-1990 for Bangladesh projected that annual mean maximum temperature will increase to 0.4°C and 0.73°C by the year of 2050 and 2100 respectively (Karmakar and Shrestha, 2000). By using historical data of some selected meteorological stations Chowdhury, Debsharma (1992) and Mia (2003) also revealed the fact that the temperature has been changed in Bangladesh in last decades.

The objective of this study is to analyze the changes of temperature and derive an equation using historical data of temperature to predict the future maximum and minimum temperature in the north eastern region of Bangladesh.

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2. METHODS

The data of average maximum and minimum temperature from 1975 to 2007 is collected from Bangladesh Meteorological Department. The average temperature is sorted in two seasons: wet season (May to October) and dry season (November to April). Separate graphs are drawn for average maximum and minimum temperature against under the category of dry season and wet

season. The months of highest maximum and lowest minimum temperature are selected from these graphs. Then two separate graphs are drawn for maximum and minimum temperature for these two particular months of maximum and minimum temperature for the year 1975-2007. Two equations are derived by Microsoft excel for the trend of maximum and minimum temperature and the future temperature is predicted using these two equations.

3. RESULTS AND DISCUSSION

Fig. 1 and 2 show the average maximum temperature for dry and wet season respectively from 1975 to 2007.

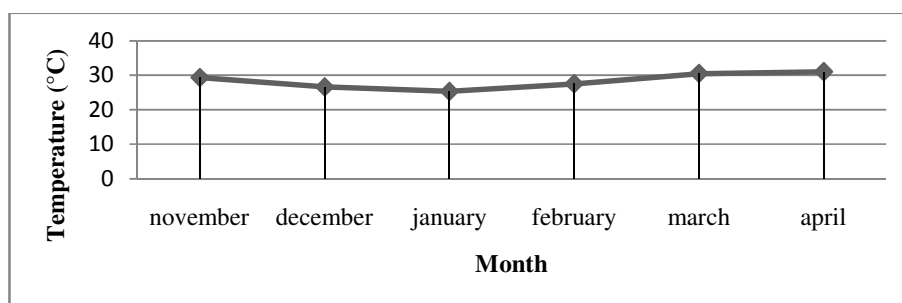


Fig. 1 Average maximum temperature for dry season (1975-2007)

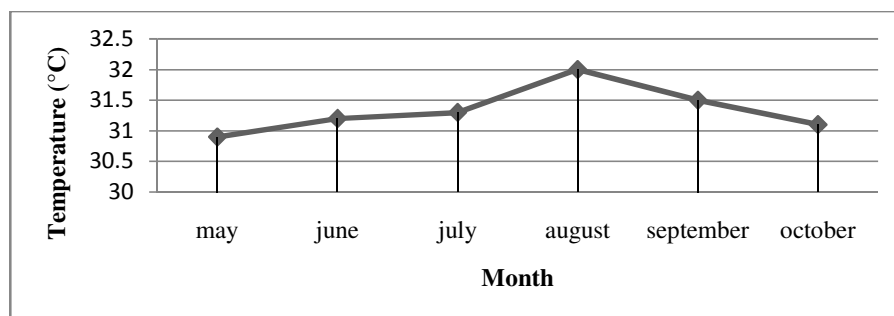


Fig. 2 Average maximum temperature for wet season (1975-2007)

From Fig. 1 and 2, it is found that in dry season the maximum temperature is highest in April (30.8°C) and in wet season it is found in August (32.1°C). Again maximum temperature is lowest in January (25.7°C) for dry season and for wet season it is found in May (30.9°C). It is also found that the temperature of wet season is higher than that of dry season. The average maximum highest temperature of the whole year is found in August which is 32.1°C and the maximum lowest temperature is in January which is 25.7°C.

Conversely, Fig. 3 and 4 shows the average minimum temperature for dry and wet season respectively from 1975 to 2007. These figures reveal that in dry season the minimum temperature is highest in April (21°C) and in wet season it is found in May (27.4°C). Average minimum temperature is lowest in January (12.3°C) for dry season and for wet season it is found in October (22.8°C). The So average minimum temperature for the whole year is 12.3°C which is prevailed in January. Temperature variation during the whole year is from 12.3°C to 32.1°C.

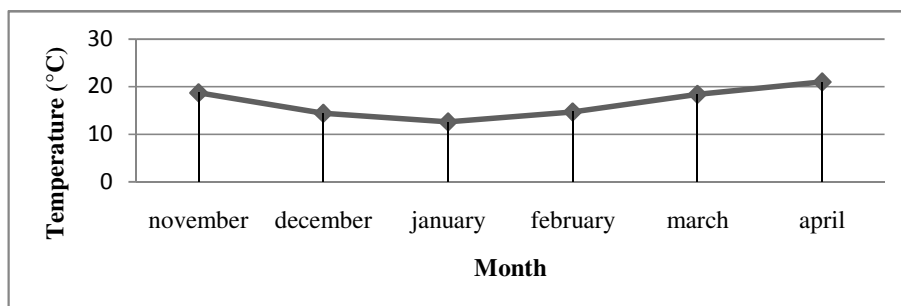


Fig. 3 Average minimum temperature for dry season (1975-2007)

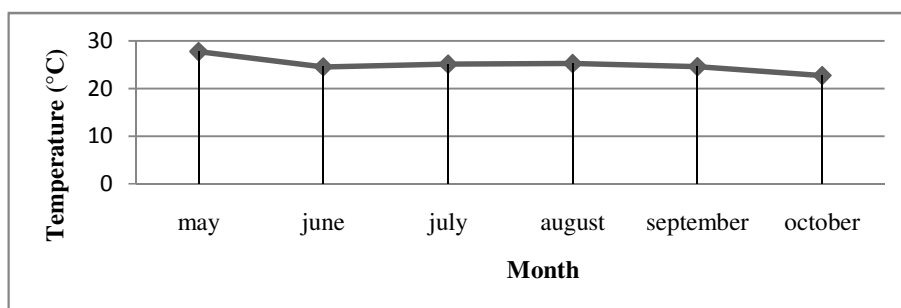


Fig. 4 Average minimum temperature for wet season (1975-2007)

Fig. 5 shows maximum temperature for August and Fig. 6 minimum temperature for January from 1975 to 2007. In the brackets of Fig. 5 and 6 indicate the values of variable x. For maximum temperature in August the trend line equation of $y = 0.052x + 31.07$ is found. Using this equation the maximum temperature in August for the future can be predicted. In 2020, 2040, 2060, 2080 and 2100 the maximum temperature can be predicted as 33.34, 34.50, 35.54, 36.58 and 37.62° C respectively. For minimum temperature in January the estimated

equation is $y = 0.08x + 10.87$. Using the equation of minimum temperature of January, in 2020, 2040, 2060, 2080 and 2100 the predicted temperatures are 14.55, 16.15, 17.75, 19.35 and 20.95° C respectively. So, in 2100 the maximum temperature will reach to 37.62° C and minimum lowest temperature will reach to 20.95° C which indicates there will be no winter season if present trend continues.

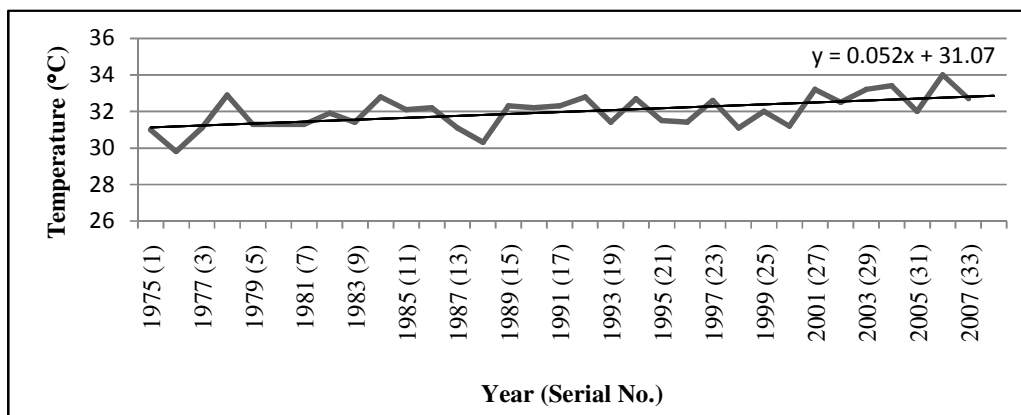


Fig. 5 Maximum temperature variation for August

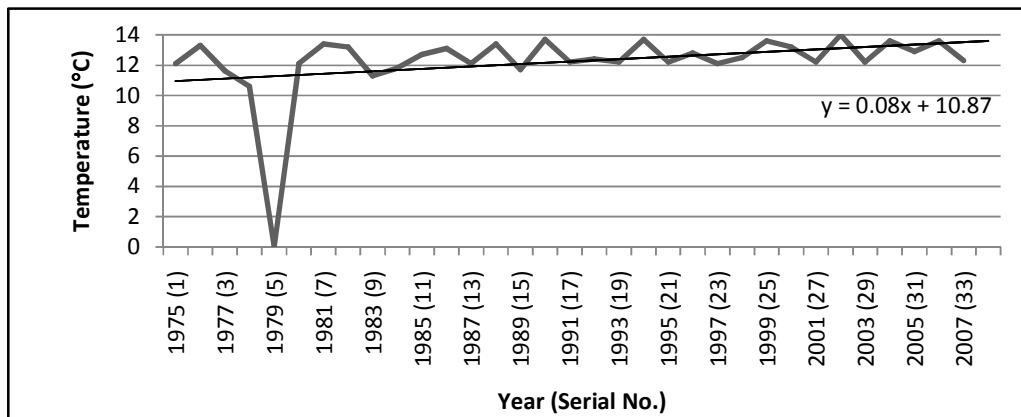


Fig. 6 Minimum temperature variation for January

4. CONCLUSION

It is found from the analysis that presently the maximum temperature is highest in August and minimum temperature is lowest in January. The trend line equation of temperature variation reveals that the maximum (August) and minimum (January) temperature will be 37.62 and 20.95° C respectively in 2100. In further study, more than one month of maximum and minimum temperature should be taken to get more appropriate maximum and minimum temperature in 2100. In future, the trend of temperature variation may be changed and the predicted temperature may be different from the actual temperature.

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Resource Recovery from Water Treatment Sludge

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Abstract:

Due to rapid urbanization and industrialization, number of water treatment plant is increasing day by day. Subsequently the production of water treatment sludge is also increasing. And it is becoming a concern to manage this huge amount of sludge effectively as it causes many environmental problems. The motto of our research is to contribute to the reduction of environmental problem as well as recover the resource from water treatment sludge. These sludge contains significant amount of many metals. In this thesis work, we studied with sludge from Arsenic Iron Removal Plant (AIRP) of Manikganj. First we determined the amount of arsenic and iron in sludge. Then sludge was used incorporate with clay at a definite weight percentage to produce ceramic tiles. Finally we observed various parameters like compressive strength, water absorption, firing shrinkage, density and loss on ignition (LOI) which are the key factors in using these tiles in various purposes. The tiles made with mixed proportion of sludge (0-15%) and clay were found to satisfy desired properties and quality. Ultimately this study showed that arsenic and iron sludge could be used as raw material for tiles.

Key words: Water treatment sludge, tiles, compressive strength, firing shrinkage, loss on ignition.

Introduction:

Arsenic is a contaminant of well-known toxicity and it is not an uncommon contaminant in groundwater. It is the twentieth most abundant element in the earth's crust, fourteenth in seawater and it is the twelfth most abundant element in the human body (Cullen & Reimer, 1989). Although arsenic is necessary as a nutrient to humans in small quantities, it also leads to death in chronic intakes. Arsenic contamination of the surface and subsurface water has been reported in many parts of the world, including South-Western Taiwan, Southern Thailand, Inner Mongolia, China, West Bengal of India, Bangladesh, and Northern Mexico. It is present in many different minerals, the most common of which is arsenopyrite. Arsenic is also found in the atmosphere. One-third has entered naturally, most from volcanic eruption. Organic forms of arsenic that may be present in food are less toxic to humans; however, inorganic forms of arsenic dissolved in drinking water constitute the most significant toxicity. Recent studies conducted to understand the long term health risks associated with ingestion of low levels of arsenic have indicated that arsenic in drinking water is more dangerous than previously suspected. Therefore, the World Health Organization (WHO) and The U.S. Environmental Protection Agency (USEPA) promulgated more stringent arsenic regulations to minimize these risks.

Arsenic could be concentrated in liver, kidney, lung and skin tissues by ingestion of arsenic in drinking water (Bissen & Frimmel, 2003). In Bangladesh, ground water is contaminated by As. Thousands of people have already shown the symptoms of arsenic and several millions are at risk. It is also evident that arsenic contaminated water also contain ample amount of iron that is also not good for health and other purpose. Ferric iron is seldom found in true solution in water. Unless they are highly acidic, because of formation of insoluble ferric oxide hydrate. Different technologies available at present, which may offer solution to this menace. Using the available (oxidation, precipitation, absorption onto coagulated flocs, ion-exchange, membrane technique) technologies, arsenic and iron can be removed from drinking water. There is a strong demand for environmentally safe reuse of and effective disposal methods for iron and arsenic contaminated sludge out of water treatment plant due to the increasing amount of sludge generated by the water treatment plants in Bangladesh. At present, 18 number of large scale Arsenic and Iron Treatment Plant are in Bangladesh (Rouf & Hossain, 2003). As the volume of sludge generated continues to increase, traditional sludge disposal methods are coming under increasing pressure to change. The sludge

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disposed during the various water treatment processes can be a major concern for water treatment plants. Our environment is polluted due to uncontrolled disposal of sludge. By taking proper steps it can be possible to reduce the pollution of surface water, ground water and mainly to make our environment pollution free. The use of water treatment sludge in various industrial and commercial manufacturing processes has been reported in UK, USA, Taiwan and other parts of the world. Successful pilot and full-scale trials have been undertaken in brick manufacture, cement manufacture, commercial land application

(Tay,1987). The mineralogical composition of the “water treatment sludge” is particularly close to that of clay and shale. This fact encourages the use of water treatment sludge in manufacturing of bricks, tiles. In this paper an attempt is taken to find a way to use arsenic-iron sludge in ceramic tiles which has some economic values. All the tests were performed in the laboratories of the Department of chemical engineering & polymer science and the Department of Civil And Environmental engineering, Shahjalal University of Science & Technology, Sylhet. The time of completion of all the testes was August to November,2010.

Materials and methods:

The sludge used in this study were the arsenic and iron sludge collected from Arsenic And Iron Removal Plant (AIRP) of Manikganj Sadar of Manikganj district near the Pourashava office. After collecting ,sludge sample were oven dried for 24 hours at 105 c and allowed for cooling for 24 hours. Then the dried sludge was blended by manual blending using a pestle and mortar to reduce the size of large particles. Major chemical composition of the sludge were aluminum, iron, arsenic, nickel and, magnesium. Basic physicochemical characteristic including moisture content and pH of arsenic and iron was determined by acid digestion with a HNO_3 :HCL volume of ratio of 1:3.

The clay sample of these tiles was collected from Khadim Ceramic located at Khadim Nagar in Sylhet. Three types of soil are available there. Here we use white colored clay soil which is 50% Madobpur and 50% Mymensingh clay. Small amount of water was added to moisture the powder and also for

homogenous mixing. Various proportion of sludge was mixed with clay soil on basis weight(5%,10%,15%).One batch of 100% clay was prepared for reference purpose .After complete mixing, the samples were fired at 1180°C for 56 hours. By this process the samples were gain hardness, strength, stability and reduced porosity. At last the samples produced were analyzed for various parameter such as compressive strength, loss on ignition, firing shrinkage and water absorption.



Figure:

Photography of tiles with varying sludge percentage

Result and discussion:

Sludge property analysis:

The suitability of arsenic iron sludge were determined by analysis of some physical properties such as moisture content ,pH etc. Table-2 represent the various physicochemical properties of arsenic iron sludge

Table-1 : Physicochemical properties of water treatment sludge

Serial No.	Physicochemical property parameter	Unit	Values
1	Moisture content	%	79.82
2	pH		7.12
3	Arsenic	mg/g	0.0945
4	Iron	mg/g	10.12

Effect of sludge addition on compressive strength:

Compressive strength determines the potential for application of the tiles. It is usually affected by the porosity, pore size, and type of crystallization. Compressive strength is usually defined as the failure stress measured normal to the bed face of the tiles. The compressive strength is the most important for assuring the quality of tiles. The result of this test on the tile made from clay and sludge mixtures are shown in following figure. **Error! Not a valid link.**

Figure: Compressive strength of tiles from various additions of sludge

Effect of sludge addition on water absorption:

Water absorption means the mass of water absorbed by a porous ceramic material, under specified condition ,expressed as a percentage of the of the dry material. It is a key factor affecting the durability and strength of the tiles. Low water absorption ceramic tiles are generally referred to as fully vitrified, impervious and porcelain. Water absorption is calculated from the amount of water absorbed by the tiles after immersion in water for 24 hours.

$$\text{Water absorption (\%)} = [(W_2 - W_1) / W_1] * 100\%$$

Where W_1 and W_2 =weight of the specimens before and after the immersion. The result of this test is graphically shown bellow.

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Figure: Water absorption of tiles from various additions of sludge

Effect of sludge addition on loss on ignition:

Loss on ignition is a test used in inorganic analytical chemistry, particularly in the analysis of minerals. This test is designed to measure the amount of moisture or impurities lost when the sample is ignited under the condition specified in the individual monograph. LOI is consist of strongly heating a sample of the material at a specified temperature, allowing volatile substance to escape. This may be done in air or inert atmosphere. The LOI is calculated as-

$$\text{LOI} = [(W_1 - W_2) / W_1] * 100\%$$

Where W_1 and W_2 =weight of the specimen before and after sintering respectively. . The result of this test is graphically shown bellow.

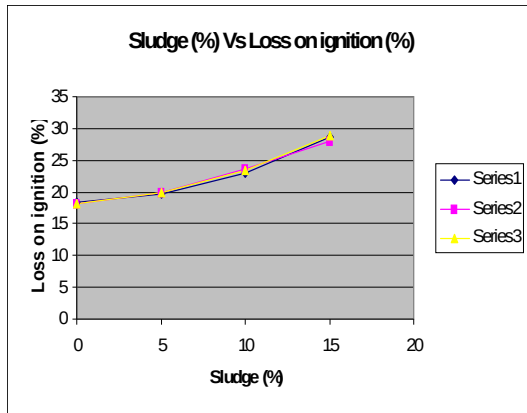


Figure: Loss on ignition of tiles from various addition of sludge

Effect of sludge addition on firing shrinkage:

Firing shrinkage is the key factor for using tiles in various purposes. The quality of tiles can be assured according to the degree of firing shrinkage. The firing shrinkage is calculated as follows-

$$\text{Firing shrinkage} = [(V_1 - V_2) / V_1] * 100\%$$

Where V_1 and V_2 are volumes of specimen before and after sintering respectively. The result of this test is graphically shown below.

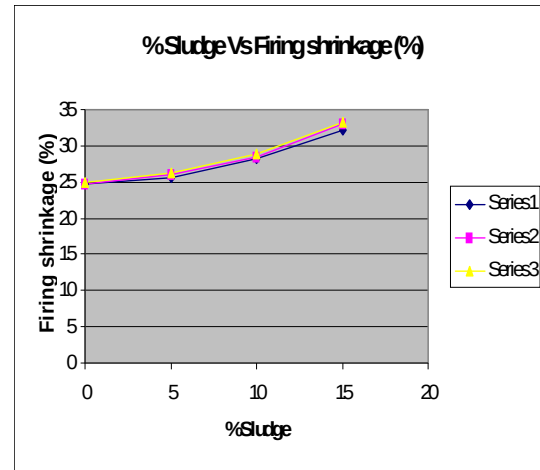


Figure: Firing shrinkage of tiles from various additions of sludge.

Conclusion:

Based on the experimental program executed in this research, and limited on both the tested materials and the testing procedures employed, we can conclude that tiles can be successfully produced from water treatment plant sludge under the conditions, firing temperatures, and manufacturing methods used in this study. The water treatment plant sludge almost resembled the tiles clay in its chemical composition but higher sintering temperatures are required. Incineration of water treatment plant sludge is needed before using in brick manufacturing to evaporate the major part of its relatively high organic content, which indicated by its high loss on ignition (L.O.I) value. The physical properties of sludge tiles can be

enhanced by the addition of clay, but the maximum percentage of water treatment plant sludge, which can be used in the mixture, is dominated by the practiced firing temperatures. By operating at the temperatures commonly practiced in the brick factories, 5% was the optimum sludge addition to produce tiles. This research evaluates the exact proportion of sludge which will not affect the quality of tiles. Further study may be conducted to determine the strength of tiles at different firing temperature. More research works may be conducted to make hollow bricks or blocks using the arsenic-iron contaminated sludge.

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SELECTION OF POTENTIAL STRAIN FOR THE PRODUCTION OF CITRIC ACID BY SOLID STATE BIOCONVERSION USING OIL PALM EMPTY FRUIT BUNCHES

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An investigation was carried out to select the potential strain of *Aspergillus niger* for the production of citric acid from oil palm empty fruit bunches (EFB) through solid state bioconversion (SSB). This study evaluated the potentiality of twenty six wild strains of *Aspergillus niger* which were isolated from sewage treatment plant sludge, lemon and orange. Factors considered in the evaluation process were citric acid production, sugar consumption and protein content as growth indicator. Two strains of *Aspergillus niger*, IBO-103MNB and IBO-114MNB isolated from orange were found to have great potential with citric acid production 128.43 ± 6.3 and 140.50 ± 1 g/kg of dry EFB; sugar consumption $63.43 \pm 3.4\%$ and $57.29 \pm 0.9\%$ of initial sugar (50 g/kg of EFB); protein content as growth indicator 26.05 ± 3.7 and 32.93 ± 1.7 g/kg of treated EFB; pH evolution of 2.72 ± 0 and 2.64 ± 0 and bioconversion time 4 and 8 days, respectively. Therefore, the strains IBO-103MNB and IBO-114MNB can be used as the potential strains for the production of citric acid from EFB by solid state bioconversion.

Keywords: citric acid, solid state bioconversion, wild strain, *Aspergillus niger*, empty fruit bunches

1. INTRODUCTION

Citric acid is one of the largest and most demanded fermentation products which is widely used in the household, preparation of numerous industrial products and many industrial areas such as food processing, beverage, cosmetic, pharmaceutical, chemical, textile, electroplating industry (Lofty et al. 2007). It is also used as a cleaning agent (Lofty et al. 2007) and for bioremediation of heavy metal contaminated soil (Kim and Barrington, 2003). The demand for citric acid is increasing by 4-5% every year (Pandey et al. 2001) that can only be met economically by using less expensive and renewable agro industrial residues as raw materials through solid state bioconversion with appropriate microorganism (Barrington and Kim, 2008).

The oil palm empty fruit bunches (EFB) as a lignocellulosic residue is produced from oil palm

industries, which are abundantly available in Malaysia. The annual production of EFB is more than 17 million tones (Chew and Bhatia, 2008) which shows a great challenge to the solid waste management for its safe, scientific and environment friendly disposal. Therefore, oil palm EFB was considered to be a potential alternative renewable raw material for the citric acid production by solid state bioconversion with locally isolated *Aspergillus niger*. Empty fruit bunches (EFB) is a lignocellulosic material, which is mainly polysaccharides (lignin 21.2%, cellulose 49.6% and hemicellulose 18%) (Tanaka et al. 2006; Khalil et al. 2007). The efficient bioconversion of EFB towards the production of citric acid through degradation of polysaccharides to monosaccharide and its utilization depends on potentiality of strain to produce lignocellulolytic enzymes and citric acid. In such a situation, a microbial mixed culture might be advantageous over a single culture to produce the different metabolic products through the same bioconversion.

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Mixed microbial culture can influence better substrate utilization in bioconversion process through effective multi enzymatic systems (Kubicek, 1992). The symbiotic mixed culture improves their colonization on the substrate and increases the yield (Duenas et al. 1995). The vital and the most important determinants in mixed culture are strain compatibility (Duenas et al. 1995). On the other hand, detrimental results may occur with an incompatible association. Therefore, this study was undertaken to ascertain the single potential strain or potential compatible mixed culture of locally isolated *A. niger* for the production of citric acid from EFB as a new substrate through solid state bioconversion.

2. MATERIALS AND METHODS

2.1 Microorganisms and Inoculum

A total 26 wild strains of *A. niger* were isolated, purified and identified. A thorough screening experiment was carried out for citric acid production from EFB and three fungal strains of local isolates *A. niger* IBO-103MNB (IMI396649), *A. niger* IBO-109MNB (IMI396650) and *A. niger* IBO-114MNB (IMI396651) were selected from twenty six isolates (Alam et al., 2010). Finally, the best potential strain was selected through mixed culture among them. The stock cultures were maintained on 3.9% w/v of potato dextrose agar (PDA, Mark) slants, sub-cultured once in a month and stored at 4°C. The cultures were grown on PDA plates at 32°C for 4 days for inoculum preparation. Plate cultures were washed with sterilized distilled water and collected in 100 ml Erlenmeyer flask by filtering with Whatman No. 1 filter paper. The spores were counted by haemocytometer to maintain the concentration of inoculum at 1×10^8 spores/ml.

2.2 Fermentation Media

Twenty gram of media containing five gram (25% w/w) of major substrate – EFB (particle size ≤ 1 mm)

with 1 gm (5% w/w) of sucrose and 1 ml (5% v/w) of mineral solution containing $\text{NH}_4\text{H}_2\text{PO}_4$ (2 g/l), KH_2PO_4 (0.6 g/l), K_2HPO_4 (0.4 g/l), $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ (0.5 g/l), $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ (74 mg/l), Ferric acid citrate (12 mg/l), $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ (6.6 mg/l), MnSO_4 (5 mg/l), $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (1 mg/l) and balance of substrate are consisting of water and inoculum..

2.3 Experimental Design and Procedures for Fungal Mixed Culture

The experiment was carried out to evaluate the compatibility/incompatibility through plate culture on PDA and flask culture with nutrient media. Three different strains of *A. niger* IBO-103MNB, *A. niger* IBO-109MNB and *A. niger* IBO-114MNB were represented as A, B and C, respectively. The experiment for fungal mixed culture was designed with four combinations of AB, AC, BC and ABC. A total of seven experiments (three single cultures and four their mixed cultures) were conducted to evaluate the potential of single and mixed cultures. The parameters observed were mutual growth in plate cultures, citric acid production, sugar utilization, protein (growth) content in flask cultures.

2.4 Evaluation of Mutual Growth in the Plate Cultures

The PDA plate culture was carried out to examine the compatibility/incompatibility of mixed cultures. The spores of each strain were placed at 4 cm apart from each other for mixed cultures on PDA plate and at the center of the plate for single cultures. The PDA plates with mixed culture and single culture were incubated at 32°C for 7 days. The interactions of mixed fungal growth were studied by dual and triple direct opposition mycelial cultures. Interactions between the opposition colonies were visually assessed using a key based on the observations of Porter (1924) and Stahl and Christensen (1992) which are shown in Table 1.

Table 1. Modes of interactions in fungal mixed cultures

Modes of interactions [Porter (1924)]	Modes of interactions [Stahl and Christensen (1992)]
a. Mutually intermingling growth where both fungi grew into one another without any macroscopic signs of interactions.	a. Neutral intermingling – one or both colonies grow into the other with no apparent adverse effect on the mycelium of either.
b. (i) Intermingling growth, where the fungus being served is growing into the opposed fungus either above or below or above and below its colony, and its corollary.	b. Replacement – one mycelium grows into the other and begins to consume and replace it.
b. (ii) Intermingling growth, where the fungus under observation has ceased growth and is being over-growth by another colony.	c. Deadlock – neither mycelium can enter territory occupied by the other
c. Slight inhibition, where the fungi approached each other until almost in contact and a narrow demarcation line, 1-2 mm, between the two colonies was clearly visible.	
d. Mutual inhibition at a distance of >2 mm.	

The observation and measurement of growth in plate culture were carried out after 3 and 7 days. The parameters recorded were: growth rate (grown individually), maximum colony diameter (grown with partner and individually), mycelial growth

2.5 Evaluation of Strain for Citric Acid Production through Single and Mixed Culture

The experiments were carried out according to experimental design in 250 ml Erlenmeyer flask with initial moisture content of 70% by weight adjusted with mineral solution, distilled water and inoculum. The sample was inoculated with 5% spore suspension inoculum (1×10^8 spores/ml) after autoclaving at 121°C for 15 minutes. Mixed culture of two strains was inoculated with equal 2.5% inoculum of each strain and 1.67% inoculum of each strain was used for mixed culture of three strains. The culture was incubated at 32°C for 10 days.

2.6 Extraction of Citric Acid

Citric acid was extracted from fermented substrate by adding 50 ml (2.5 times of total substrate) distilled water and shaking for 1 hour at 150 rpm at the room temperature ($28 \pm 1^\circ\text{C}$). The supernatant was collected by filtering with Whatman no. 1 filter paper and immediately analyzed to determine the content of citric acid.

2.7 Analytical Methods

The concentration of citric acid in extraction was determined by using spectrophotometer at 420 nm using pyridine-acetic anhydride method as suggested by Marrier and Boulet (1958). The consumption of total sugar during the bioconversion was estimated by subtracting the existing total sugar after bioconversion from the initial total sugar and sugar released from EFB during the bioconversion. The existing total sugar was determined by the phenol sulfuric acid method of Dubois et al. (1956). Folin-Phenol-Reagent method was adopted to analyze soluble protein using Bovine Serum Albumin (BSA) as standard (Lowry et al. 1951). Biomass was

towards the other colony, mycelial growth transversely of the other colony, mycelial growth away from the other colony. Outcomes of the interactions were also recorded at the time while the interactions were taken place properly.

estimated by subtracting the initial protein content of sample from the protein content of treated sample after bioconversion.

3. RESULTS AND DISCUSSION

3.1 Evaluation of Mixed Culture on PDA

The growth rates of cultures grown on PDA plate were measured in diameter after 3 days of incubation. From the observation, it was found that the strains '*A. niger* C' was first growing with the growth rate of 2.43 cm/day. The less growing was strain '*A. niger* A' with the growth rate of 2.20 cm/day. The growth rate of the strain '*A. niger* B' was found 2.33 cm/day (Table 2).

Similar growth patterns and interactions were observed in all combinations of mixed culture. The two fungal strains met with each other and further growing ceased after the contact point (case iv). None of the situations of (i) mutual intermingling, (ii) partial mutual intermingling, (iii) inversion/replacement (a: early stage and b: later stage) and (iv) inhibition/deadlock at distance as shown in Fig.1 were recorded in any of the mixed cultures.

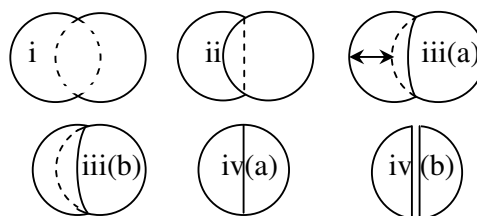


Fig. 1. Schematic diagram of interactions between two different fungal strains

Table 2: Interaction responses of fungal isolates at day 3 and 7 grown on PDA plate

Fungal culture	Day 3				Day 7			
	Diameter (cm)		Gap	Outcomes	diameter (cm)		Gap	Outcomes
	Towards	Transverse			Towards	Transverse		
A+B	4.2+4.8	6.6+7.2	No	No	4.2+4.8	Full plate	No	No
A+C	4.2+4.8	6.6+7.3	No	No	4.2+4.8	Full plate	No	No
B+C	4.45+4.55	7.1+7.3	No	No	4.45+4.55	Full plate	No	No
A+	3.2, 3.3	3.5	No	No	3.2, 3.3	Full plate	No	No
B+	3.6, 3.8	4.1			3.6, 3.8	Full plate		
C	3.6, 3.9	4.3			3.6, 3.9	Full plate		

The growth of the strain '*A. niger* A' towards and transverse directions of the strain '*A. niger* B' were 4.2 and 6.6 cm after 3 days (Table 2, Fig. 2).

Similarly, growth of '*A. niger* B' towards and transverse directions of '*A. niger* A' were 4.8 and 7.2 cm at the same day. The antagonistic (inhibition

or deadlock) behaviour to each other at the contact

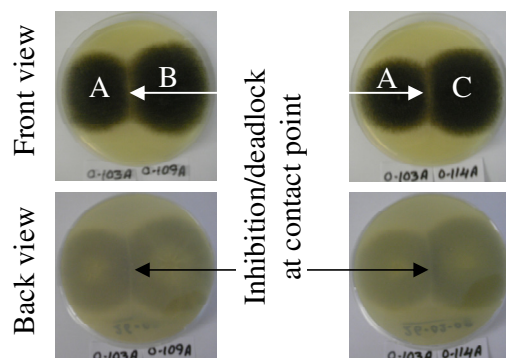


Fig. 2. Mixed cultures of *A. niger* (A+B, A+C, B+C and A+B+C) grown on PDA plate for 3 day

In the second combination, the growth of '*A. niger* A' towards and transverse directions of the '*A. niger* C' were same as that of the first combination with '*A. niger* B' (Table 2, Fig. 2). In case of '*A. niger* C', growths were 4.8 and 7.3 cm towards and transverse directions of '*A. niger* A' respectively after 3 days. Here again antagonistic (inhibition or deadlock) behaviour to each other at the contact point was observed.

Almost same growths (4.45 and 4.55 cm) were observed between '*A. niger* B' and '*A. niger* C' towards each other, but in transverse direction it was 7.1 and 7.3 cm respectively after 3 days (Table 2, Fig. 2). Similar antagonistic (inhibition or deadlock) behaviour was exhibited to each other at the contact point. The antagonistic (inhibition or deadlock) behaviours to each other at the contact point among the three strains were very pronounced when they were cultured in a same plate (Table 2, Fig. 2). It was also observed that there was no secretion appeared in the contact points of the mixed cultures.

3.2 Evaluation of Compatible/Incompatible of Mixed Cultures through Citric Acid Production

The production of citric acid by single culture of *A. niger* (A), *A. niger* (B) and *A. niger* (C) and their mixed cultures were observed to evaluate the compatibility (Fig. 3). The maximum production of citric acid was 181.25 ± 1.5 g/kg of dry EFB obtained by single culture of *A. niger* (C) after 8 days of bioconversion followed by other single cultures of *A. niger* (A) and *A. niger* (B) after 6 days of bioconversion as well as their mixed culture combinations of BC, AC, ABC and AB in decreasing order after 4, 8, 8 and 6 days of bioconversion respectively. It was observed that the combination BC produced higher citric acid compared to the mixed culture of all combinations.

point appeared.

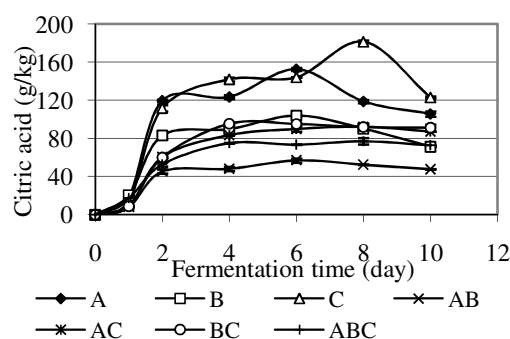
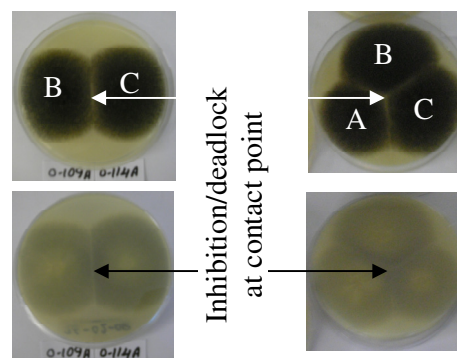


Fig. 3. Production of citric acid by single and mixed culture

The highest production of 95.26 ± 1 g/kg from third combination BC was 92% and 52% of their individual production, respectively. Again, the production of citric acid by the combination AC and BC was nearly the same and 1.6 and 1.7 times higher than the production by the combination AB. It revealed that the presence of the strain *A. niger* C in any combination produced more citric acid. This is due to might be its in higher production capability that also observed in its single culture.

The rate of citric acid production varied from 17.3-25.4 g/kg-day and 9.50-23.81 g/kg-day among the single cultures and mixed cultures respectively. The maximum rate of citric acid production was 25.40 g/kg-day obtained from the single culture of strain *A. niger* C, while second highest rate of citric acid production was 23.81 g/kg-day obtained from the mixed culture combination BC. The yield of citric acid production on the basis of sugar consumption for *A. niger* (A) was 89.5% which was more than the yield obtained (85%) by Prado et al. (2005b) from cassava bagasse.

3.3 Consumption of Sugar

Utilization of substrate is an important parameter for the evaluation of microbial potentiality to produce the product. At the beginning of the bioconversion, total sugar was 272 g/kg of dry EFB. Sugar consumptions by the single cultures varied from 23.6 to 37.1, 66.2 to 111.1, 139.4 to 151.4, 154.2 to 184.4, 158.6 to 162.2 and 166.3 to 174.3 g/kg of dry EFB after 1, 2, 4, 6, 8 and 10 days of bioconversion respectively while it was varied by the mixed cultures from 41 to 58, 78.5 to 87.9, 134.3 to 147.7, 164.1 to 191.4, 162.6 to 176.5 and 174.1 to 189.2 g/kg of dry EFB with similar bioconversion period, respectively (Fig. 4).

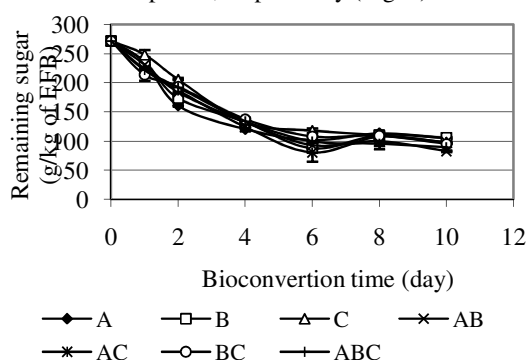


Fig. 4. Consumption of sugar during the bioconversion of EFB for citric acid production

It was observed that the consumption of sugar by the mixed cultures was almost 1.5-2 times higher than the single cultures on day 1 of bioconversion. On the other hand, sugar consumptions were comparatively higher by the single cultures on day 2 of bioconversion. However, sugar consumption for both the single cultures and mixed cultures were almost same on the other days of bioconversion except on 6 day of bioconversion by the mixed culture combination AC.

The consumption of sugar was very high within the first 2 days compared to those of 4, 6, 8 and 10 days of bioconversion. These phenomena could be explained by the fact that initially more sugar might be needed for initial fungal growth and the metabolism (Kumar et al. 2005). Furthermore, the rates of consumption of sugar were 23.38, 30.73 and 17.43 g/kg-day by the single cultures of strain *A. niger* (A), *A. niger* (B) and *A. niger* (C), respectively. On the other hand, the consumption rates varied from 17.68 to 18.92 g/kg-day for the mixed cultures except for the combination AC. The mixed culture combination AC consumed sugar at the highest rate of 31.90 g/kg-day.

3.4 Protein Content as Growth Indicator

One of the most important factors of solid state bioconversion with filamentous fungus, both in laboratory and industrial scale, is the estimation of biomass. It is known that growth limitation is an important factor in citric acid production (Prado et al. 2005). In fact, there is no direct method to determine the fungal growth in SSB. However, protein measurement is a simple indirect method for the estimation of fungal growth (Raghavarao et al. 2002).

Fig. 5 shows the protein content as fungal growth indicator in treated substrate during the solid state bioconversion. The maximum fungal growth in terms of protein content was observed for both single and mixed culture during 4 to 6 day of bioconversion. The maximum protein content of 34 ± 0.3 g/kg of dry treated EFB was obtained for *A. niger* (A) after 6 days of bioconversion. The results showed that the growth indicated by the protein for all the treatments was found in similar trend of batch growth pattern. The growth of single cultures was almost 1.5 times higher than the growths of mixed cultures which correlated the production of citric acid (Fig. 3 and 5). It was also observed that the lag phase was within 0-1 day and exponential phase of growth was within 1-2 day in terms of protein content.

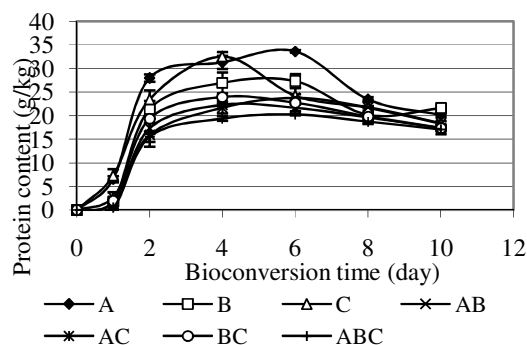


Fig. 5: Protein content as growth indicator in treated EFB

4. CONCLUSIONS

The result obtained in this study through plate culture indicated that all the combinations of fungal strains did not grow mutually intermingling, rather grow as inhibition/deadlock at the contact point. The results of flask cultures showed that the production of citric acid reduced by the mixed cultures compared to the single cultures due to their antagonistic effect during bioconversion process. Therefore, the single culture of *A. niger* (A) and *A. niger* (B) which have shown superiority with higher productivity would be potential for citric acid production from EFB through solid state

bioconversion and production could be enhanced with further process development.

5. ACKNOWLEDGEMENTS

The authors are grateful to the Department of Biotechnology Engineering, International Islamic University Malaysia for their support, and to the Ministry of Science, Technology and Innovation (MOSTI), Malaysia, for financing the research project (No. 02-01-08-SF0050).

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TECHNO-ECONOMICAL EVALUATION OF WATER FILTRATION SYSTEM BY USING LOCAL INGREDIENTS

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This paper presents the findings of a comprehensive evaluation for the water supply system of an urban building to remove iron from storage water. An integrated filtration system was introduced by using locally available materials for the drinking and washing purpose and academic building 'B' of Shahjalal University of Science and Technology was selected as a model object. The technical target was to reduce iron to standard iron level. The cost calculation was based on the analysis of its several components such as construction materials and their respective quantities, required mechanical equipment, energy consumption, chemical consumption and operational and maintenance expenses. This integrated filtration system was compared to the traditional unitary filtration system and all pecuniary flows were converted into local market price. The result provides a first level of estimation, which could be utilized for a quick financial evaluation of the similar systems as well as the general decision making plan.

KEYWORDS: Ground water; Iron removal; Cost

1. INTRODUCTION

Iron is a harmless, though sometimes annoying, element present in public and private water supplies which is categorized under the secondary standards of pollutants in water according to Environmental Protection Agency (EPA). The conscious people now-a-days use general filter which is described as unitary filtration system here, is not totally out of risk as the water undergoes heat treatment (boiling) and this water can form bacteria on the filtration medium which annihilates the purpose of safe water. Standard Secondary Maximum Contaminant Level (SMCL) of iron is 0.3 milligrams per liter (mg/L) for drinking water (Colter and Mahler, 2006). Though the concentration of iron varies in the range of 0.5-3 mg/L around the Sylhet city, the concentration is >1 mg/L in Shahjalal University of Science and Technology (SUST). The objective is to find a way to reduce the iron concentration to 0.3 mg/L and to do so; we proposed an integrated filtration system which is unique in perspective of SUST. We projected the system anticipating that it will be capable of filtering 2500 liters serving 500 people for drinking and washing purpose per day (5 liters per person per day) (Garg, 2004). At the end we also performed an approximate cost analysis to

compare this system with the prevailing unitary filtration systems.

2. PROPOSED IDEA

The idea of this system is based on minimal operating cost and power consumption. The system constitutes four tanks,

- i) Sedimentation tank
- ii) Filtration tank
- iii) Disinfection tank and
- iv) Storage tank

2.1 Sedimentation tank:

The inlet water comes from the water reservoir due to gravitational force through a control valve and a nozzle. The purpose of the former is to control the flow rate and later is to aerate the water. Baffles are used to increase the aeration time. We can use the Stokes' equation to determine the settling velocity assuming that the particle diameter is 0.05 millimeter and the average specific gravity of the particle present in the water is 2.65 gm/cm³ (ASAE data, 1984). For these conditions, we find settling velocity 13.2 cm/min. As we know, for the

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sedimentation purpose, settling velocity should be greater than over flow velocity. In engineering practice, overflow velocity is assumed maximum 80% of the settling velocity (Garg, 2004); thus overflow becomes 5cm/min.m^2 . We take detention time 20 minutes as the 75 microns diameter particles settle in 5 to 10 minutes (Haman, 1984). After the sequential calculations, we find the approximate length 1m, height 0.4 m (including sludge zone) and a width of 0.25m.

type of filtration is 100-200 liters per hour per sq meter (Garg, 2004). This filtration process is attributable to mechanical straining, flocculation and sedimentation in the voids of filter and biological metabolism. The filtration rate diverges with the type and size of particles which should be experimental. Assuming the filtration rate 200 liter per hour per sq meter and the bed height 0.5 m, the required surface area for the demand of 2500 liter is 0.52 m^2 and the length and breadth is 0.72 m (assuming they are equal).

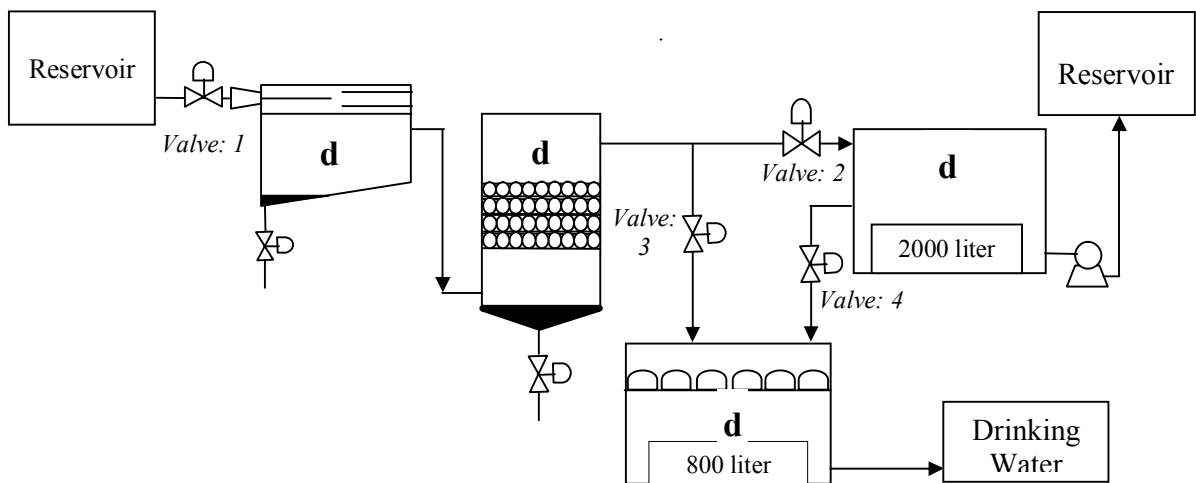


Figure: Schematic diagram of the proposed integrated filtration system

a)Sedimentation Tank; b)Filtration Tank; c)Disinfection Tank; d)Storage Tank

2.2 Filtration tank:

Sedimentation removes a large percentage of suspended particles; nonetheless the resultant water will not be pure and may contain fine particles and impurities. To produce potable water, the water is filtered through the beds of fine granular materials (filters). In this system, water flows from the bottom to the top of the tank which is exceptional from the conventional filtration system, with the intention that the iron precipitates, co-joining with the iron particles on its way of deposition will form floating coagulation and will accelerate the rate of deposition. It is also beneficial in a way that the iron precipitates can be removed easily from the tank using the discharge valve. When the water exits filtration tank, it is almost iron free and can be used in washing purpose.

As the requirement of water is low (104 liter/hour), we used 'slow sand filter' system, as the rate of this

The stone chips are kept 30-40 mm at the bottom, 15-25 mm in the middle and 3-5 mm at the top. As the water flows from bottom to top, a space of 0.3 m is kept both at the bottom and top of the filter bed at the filtration tank and thus the height of the unit is 1.1 m. The service life of filter bed is based on experimentation and should be done in laboratory scale.

The sludge produced is rich in iron content, which can be used for arsenic removal.

2.3 Disinfection tank:

Disinfection tank comprises a disinfection unit and a storage tank. The water inflowing this tank is almost free from iron as most of the iron was separated as colloidal particles in the filtration tank. We used a traditional disinfection unit consists of ceramic material in semicircular shape which is available in local markets. The disinfection unit has a dimension of $0.68\text{ m} \times 0.68\text{ m} \times 0.3\text{ m}$, where 72

semi-circular ceramic filter balls (diameter 4.5 cm and height 6 cm) are placed onto a fixed surface in two independent stages. The filter balls and the disinfection unit can be removed individually which permits easy replacement for former and mobility for the later. These filters even block the penetration of bacteria.

This tank should not be exposed to direct sunlight as it tends to form algae and pathogen of cholera. After completing the disinfection period the water is totally pure and safe to drink.

2.4. Storage tank:

The water found from the filtration tank is almost free from iron and can be utilized for washing and household purposes. Based on the consumption of 2500 liters, we assumed 750 liters will be used as drinking purpose and the rest (1750 liters) will be used as washing and household purpose, which will go directly to the storage tank from the filtration tank.

3. OPERATING SCHEDULE

The maneuver of the system is simple and based on manual controlling. Controlling system consists of four control valves. The operation of the valves is time centric and the cycle of the operation is based on our university office hour as far as the labor cost concern. *Valve 1* controls the flow of the water to the sedimentation tank from the reservoir. *Valve 2* and *valve 3* control the flows to the storage tank and disinfection unit respectively. At 9:30 am *valve 2* is closed and *valve 3* remains open until 5 pm, which delivers water to the disinfection unit. At 5 pm, *valve 3* closes and *valve 2* remains open until 9:30 am next morning, and the time being water flows from the filtration tank to the storage tank directly. At 9:30 am, *valve 2* closes and *valve 3* opens again. The water of the storage tank is pumped to the supply system by a 1.5 HP pump. An additional *Valve 4* controls the water flow from storage tank to distribution unit, in cases of water level in disinfection unit is lowered and starting the operation at disinfection unit.

4. COST ANALYSIS

The project evaluation was based on the following assumption:

Project life: 20 years

4.1. Initial Fixed Investment:

4.1.1. Land

Total Area = 12 Sq m

Construction Area = 10 Sq m

Open Space = 2 Sq m

Cost of Land = Not applicable for present model (provided by university)

4.1.2. Constructional Cost

Cost of concrete tank per m³ = Tk 9,000

Cost of plastic tank per liter capacity = Tk 7.2

Types	Total cost
Sedimentation tank	Tk 6,000
Filtration tank	Tk 5,500
Storage tanks (two pieces)	Tk 20,160
Reservoir	Tk 20,000

4.1.3. Cost of Machineries and Equipments

Types	Quantity	Total cost
Disinfection unit (ceramic balls)	72	Tk 14,400
Filter bed	1	Tk 5,000
Piping and fittings		Tk 6,500
Valves	4	Tk 1,000
Pump	1	Tk 7,500

4.1.4. Others

Total Initial Fixed Investment = Tk (6,000 + 5,500+20,160+20,000+14,400+5,000+6,500+1,000 +7,500+6,000) = Tk 91,560

4.2. Operating Cost

The operating cost components and their costs are given below.

4.2.1. Raw material Cost: Not applicable

4.2.2. Cost of other inputs

Labor cost	Not applicable (University operator will be assigned)
Electric power/month	Tk 50
Electric power per annum	Tk 600
Stone chips	Tk 200

Total cost per annum = Tk (600 + 200) = Tk 800

4.2.3. Maintenance Cost at 10 percent of Sale Price of Supplier per annum

Filter balls	Tk 1,440
Pumps	Tk 750
Total maintenance cost	Tk 2,190

4.2.4. Depreciation

Not applicable

Total operating cost per annum = Tk (800 + 2,190)
= Tk 2,990

4.2.5. Expenditure in the base year

Initial fixed investment	Tk 91,560
Operating cost	Nil

4.2.6. Expenditure in Future Years

In future, no investment in terms of machinery and equipment will be involved. Operating cost as in the first year of operation will be there in all years.

4.3. Benefits

The benefits were calculated on the basis of the following data:

Volume of water processed per batch = 750 liter
Volume of water processed per annum = 750
liter $\times$ 300 (batches) = 225,000 liter
Fixed cost return per annum = Total fixed cost /
Desired life time = $91,560 / 20 = \text{Tk } 4,578$
Total operating cost per annum = Tk 2,990
Cost of processed water per liter = $\text{Tk } (4,578 + 2,990) / 225,000 \text{ liter} = \text{Tk } 0.034$

5. COMPARISON

Though the initial set up cost is huge compared to the unitary filtration system used in domestic purpose, regarding the service life and amount of water to be treated, this system is much more competent than the traditional system. As the economical comparison not only depends on the monetary matter but also on socioeconomic and health issues, this system provides much beneficitation in those sectors.

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VULNERABILITY ANALYSIS OF BANGLADESH DUE TO MULTIPLE NATURAL HAZARDS USING GIS TECHNIQUE

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Bangladesh is one of the most natural disaster prone areas in the World. The different types of disasters like flood, cyclonic storms, tidal surges, droughts, tornadoes, riverbank erosion, earthquake, etc. occur frequently in Bangladesh. Identifying the vulnerable areas with reference to natural hazards causing damage to the housing stock and the related infrastructure are most important for infrastructures development.

In this study, four natural hazards which are the most common for damaging in Bangladesh, namely earthquake, cyclones, tornadoes and floods are considered to develop the district wise map on the basis of combination of local hazard intensity and vulnerability on observed performance. Risk analysis as indicated in the district-wise are trying to be identified.

This study will find out the disaster prone areas of Bangladesh and also the damages, history, severity of these areas, intensities of those natural disasters and housing vulnerability. GIS based disaster database is very crucial and an important aspect for environmental management strategy for planning and disaster mitigation, preparedness and preventive actions. The information will assist the environmental management, different field of sciences such as engineering, agriculture, fisheries, and policy making and planning of Bangladesh and should be an integral part of the whole process of economic and social development in Bangladesh. The findings of this study would be beneficial for engineers and city planners. They constitute a fundamental means which should guide officials at the national and regional levels in the formulation of development strategies in multi-hazard active zones, land use management, revision and enforcement of appropriate building codes and formulation of plans for mitigating measures against hazard risks affecting the region considered.

Keywords: Tornado, Earthquake, Cyclone, Flood and Natural Hazards

1. INTRODUCTION

Bangladesh is one of the most natural disaster prone areas in the World. The different types of disasters like flood, cyclonic storms, tidal surges, droughts, tornadoes, riverbank erosion, earthquake, etc. occur frequently in Bangladesh. The most devastating cyclones and floods of the world occurred in Bangladesh. The 1988 flood killed 1517 people and nearly half of the population was affected (Islam & Sado, 2002). The 1970 cyclone killed almost 500,000 people. About 1300 people were killed by tornado at Saturia of Manikganj district in Bangladesh in 1989 (EIA, 2004). The 1897 Great Indian Earthquake with a magnitude of 8.7, which was one of the severe damaged earthquakes in the world, killed 1542 peoples and

affected almost the whole of Bangladesh. Crop and livestock losses were extremely high.

Major factors responsible for disasters in Bangladesh are flat topography, rapid run-off and drainage congestion, low relief of the floods plains, low river gradients, heavy monsoon rainfall, and enormous discharge of sediments, funnel shapes and shallow Bay of Bengal etc.

Cyclones and floods are the major disasters in Bangladesh. But other disasters are also creating severe damages. Drought leaves a permanent damage and encourages the desertification process that is going on in some parts of North Bengal. River erosion takes away thousands of hectares of land every year in a country where land is the

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scarcest resource. Earthquakes may cause billions of Taka worth of damage. Perhaps the most disturbing but ignored fact about disasters is that they are all linked to each other.

At times, some areas normally subjected to drought situation have got flooded in certain years. Hazards like earthquakes, landslides, etc. occur quite suddenly but they are restricted in their impact in terms of time. The extent of the impact of an earthquake depends on its magnitude. Natural calamities may be broadly grouped into major and minor types depending upon their potential to cause damage to human life and property. While natural hazards like earthquakes, droughts, floods, Tornadoes and cyclones could be regarded as major landslides, riverbank erosion, groundwater contamination, fires, tsunamis etc., whose impact is localized and intensity of the damage is much less can be categorized as minor hazards. So far as damage to housing and infrastructure is concerned, floods, cyclones, tornadoes and earthquakes turn out as the four major disasters confronting the country.

Considering the major disasters of Bangladesh, disaster mitigation is needed and should be undertaken. Generally the hazards should be evaluated. In particular, the first step in disaster mitigation is to recognize the existence of these risks. The next step is to quantify the risks and to minimize the effects. The total elimination of risks may be difficult and impractical. Moreover in developing countries like Bangladesh, economic considerations usually take precedence over safety and engineering design.

Multihazard maps are practical tools in disaster mitigation planning, design of structures because they provide important guidance when it is not feasible to do the hazard assessment at particular sites. These maps give a good indication on the area extent of expected high risk areas for overall natural disaster. The risk score is the indicator of the severity of areas affected by overall natural disaster situation for a particular area. Intensity scales gives the damage severity of disasters. Intensity scales are subjective and depend upon social condition and construction status of a country, they need revising from time to time.

This study will find out the disaster prone areas of Bangladesh and also the damages, history, severity of these areas, intensities of those natural disasters and housing vulnerability. GIS based disaster database is very crucial and an important aspect for environmental management strategy for planning and disaster mitigation, preparedness and preventive actions. The information will assist the

environmental management, different field of sciences such as engineering, agriculture, fisheries, and policy making and planning of Bangladesh and should be an integral part of the whole process of economic and social development in Bangladesh. The findings of this study would benefit engineers and city planners. They constitute a fundamental means which should guide officials at the national and regional levels in the formulation of development strategies in multihazard active zones, land use management, revision and enforcement of appropriate building codes and formulation of plans for mitigating measures against hazard risks affecting the region considered.

2. METHODOLOGY

A proper methodology is always necessary for the successful completion of a research work. It is helpful regarding the organization of the experiences, observations, examinations and analysis of found data and information and their logical interpretation in a systemic process to achieve the ultimate goal and the objectives of the research.

An extensive survey of all the available and relevant literature was made to analyze the findings and recommendations from different journals, research publications and study reports related with this research topic were considered. At the same time this tool of literature survey has been used to collect secondary data and information also.

Secondary data and information have been collected from the census report as well as various government, non-government and international organizations such as Bangladesh Meteorological Department (BMD), SPARISO, Disaster Management Bureau (DMB) and concerned non-government organizations (NGO). Besides this, some information was collected from the CDMP/ UNDP projects and web sites of different organizations.

2.1 Identify the disaster prone areas for multi-hazard with GIS

The study has been executed exploring the historical disaster events, duration and damages information, and Geographic Information System (GIS). As GIS is a powerful planning tool which has been used to identify the disaster prone area in Bangladesh, the large amount of disaster data were collected from different organizations and sources. The zoning maps prepared by different organization in different time were also used in this study. Further the disaster data and zoning maps were analyzed and comparing the data and zoning map,

all the zoning maps were digitized and converted to geo-referenced maps separately and then the data were converted into GIS and finally superimposed to the base map. The location, type, year and damages etc were digitized to put the database into GIS system. The available historical data gathered from different sources for the disaster prone area of Bangladesh have been identified through GIS based analysis and finally a multi hazard map is prepared by using GIS technique.

3. ESTIMATION OF RELATIVE RISK SCORE FOR NATURAL HAZARD

Risk Score [for particular hazard e.g. Cyclone(c) / Flood (f)/ Tornado (t) / Earthquake (e)] = Weighting factor (WT)

WT = $\int$ (Frequency (fr)) $\times$ Risk (R=potential damage magnitude)

$$TR(c/f/t/e) = WT = f \times R \quad (1.1)$$

For Cyclone:

$$R(c)_i = \int (w, h, cp) \quad (1.2)$$

where i=0, 1, 2, 3, 4, 5 and w=wind, h=storm surge, cp=central pressure

$$WT(c)_j = \int (fr) \quad (1.3)$$

where j=1, 2, 3, 4, 5, 6, 7, 8, 9, 10
and fr =frequency

$$TR(c)=R(c)_i \times 0.1 WT(c)_j \quad (1.4)$$

For Tornado:

$$R(t)_i = \int (w) \quad (2.1)$$

where i=0 and 5 and w=wind

$$WT(t)_j = \int (fr) \quad (2.2)$$

where j=1, 2, 3, 4, 5, 6, 7, 8, 9, 10
and fr =frequency

$$TR(t)=R(t)_i \times 0.1 WT(t)_j \quad (2.3)$$

For Flood:

$$R(f)_i = \int (hw) \quad (3.1)$$

where i=1, 2, 3, 4, 5 and hw=water height

$$WT(f)_j = \int (fr) \quad (3.2)$$

where j=1, 2, 3, 4, 5, 6, 7, 8, 9, 10

and fr =frequency

$$TR(f)=R(f)_i \times 0.1 WT(f)_j \quad (3.3)$$

For Earthquake:

$$R(e)_i = \int (m, p) \quad (4.1)$$

where i=2, 3, 4 and m=magnitude, p=peak ground acceleration

$$WT(e)_j = \int (fr) \quad (4.2)$$

where j=1, 2, 3, 4, 5, 6, 7, 8, 9, 10

and fr =frequency

$$TR(e)=R(e)_i \times 0.1 WT(e)_j \quad (4.3)$$

Total Risk Score:

$$TR = \sum_{k=1}^n TR_k \quad (5.0)$$

Where, k=1 for cyclone, k=2 for tornado, k=3 earthquake, k=4 for flood, and k=n disaster. In these equations, two of the hazards have locations with a risk score of 0 (Cyclone and Tornado). In case of Cyclone, the maximum extent of the hazard risk does not realistically include the entire county and is limited to proximity to coastal waters. Tornado may always have high risk, i.e score 5 for all the tornado prone area. For the locations with no consideration of risk for Tornado was given a score of 0. Again earthquake hazard of Bangladesh was expressed as minimum by 2 and as maximum by 4.

The minimum risk score for each of the remaining hazards is 1 since there is some potential that each of these hazards could occur anywhere throughout the county. This scoring system has been used according to our district-based database. For particular district of Bangladesh the hazard for Earthquake, Tornado, Cyclone and Flood is calculated. Then adding those scores, then the total risk score for each of the 64 districts was determined.

Table 1. Proposed Risk Score

SL. No.	District Name	Risk Score/Disaster Type				Total Risk Score
		Tornado	Earthquake	Cyclone	Flood	
1.	Dhaka	9.0	4.8	0.0	7.6	21.4
2.	Narayanganj	5.5	4.4	0.0	7.6	17.5
3.	Munshiganj	6.0	4.8	0.0	7.2	18
4.	Narsingdi	1.0	6.0	0.0	7.6	14.6
5.	Manikganj	7.0	5.2	0.0	7.6	19.8
6.	Gazipur	7.0	6.5	0.0	5.7	19.2
7.	Mymensingh	9.0	7.0	0.0	6.0	22
8.	Kishoreganj	7.5	7.0	0.0	8.0	22.5
9.	Jamalpur	7.0	8.5	0.0	8.0	23.5
10.	Sherpur	5.5	8.5	0.0	5.7	19.7
11.	Netrokona	5.5	8.5	0.0	5.7	19.7
12.	Tangail	6.0	7.0	0.0	8.0	21
13.	Faridpur	7.5	4.8	0.0	7.6	19.9
14.	Madaripur	5.5	4.4	1.0	7.6	18.5
15.	Shariatpur	6.5	4.4	1.0	7.6	19.5
16.	Rajbari	5.5	5.2	0.0	7.6	18.3
17.	Gopalganj	6.5	3.3	1.0	5.7	16.5
18.	Chittagong	5.5	5.2	9.0	7.2	26.9
19.	Rangmati	1.0	6.5	1.0	1.4	9.9
20.	Cox's bazar	5.5	6.5	8.5	6.4	26.9
21.	Bandaban	1.0	6.5	1.0	6.0	14.5
22.	Khagrachari	1.0	6.0	1.0	1.0	9.0
23.	Noakhali	8.0	4.4	7.5	5.1	25
24.	Lakshmipur	5.5	4.4	5.0	7.2	22.1
25.	Feni	5.5	4.4	5.5	5.1	20.5
26.	Comilla	7.0	4.8	1.1	7.2	20.1
27.	Chandpur	5.5	4.8	1.1	8.0	19.4
28.	Brahmanbaria	1.0	6.0	0.0	7.6	14.6
29.	Rajshahi	5.5	4.8	0.0	7.2	17.5
30.	Nawabganj	1.0	4.4	0.0	7.2	12.6
31.	Natore	1.0	5.2	0.0	7.6	13.8
32.	Naogaon	1.0	4.8	0.0	7.6	13.4
33.	Pabana	6.0	5.2	0.0	7.6	18.8
34.	Sirajganj	7.0	6.5	0.0	7.6	21.1
35.	Bogra	5.5	7.0	0.0	7.6	20.1
36.	Joypurhat	1.0	6.5	0.0	4.8	12.3
37.	Rangpur	6.0	6.5	0.0	7.6	20.1
38.	Kurigram	5.5	8.0	0.0	8.0	21.5
39.	Nilphamari	6.0	5.5	0.0	7.2	18.7
40.	Lalmonirhat	6.0	7.0	0.0	5.1	18.1
41.	Gaibandha	7.0	7.5	0.0	7.6	22.1
42.	Dinajpur	1.0	4.4	0.0	6.4	11.8
43.	Thakurgoan	1.0	5.5	0.0	1.4	7.9
44.	Panchagarh	5.5	5.5	0.0	1.5	12.5
45.	Khulna	6.5	3.3	7.5	1.0	18.3
46.	Bagerhat	6.0	3.3	6.0	1.6	16.9
47.	Satkhira	1	3.3	6.0	1.4	11.7
48.	Jessore	6.0	3.3	0.0	1.4	10.7
49.	Magura	6.0	4.8	0.0	5.4	16.2
50.	Jhenaidah	1	4.4	0.0	1.0	6.4
51.	Narail	7.0	3.6	0.0	3.8	14.4
52.	kushtia	6.0	4.8	0.0	6.0	16.8
53.	Meherpur	5.5	4.8	0.0	1.4	11.7
54.	Chuadanga	1	4.4	0.0	4.2	9.6
55.	Barishal	6.5	3.3	8.0	7.6	25.4
56.	Jhalkati	1	3.3	1.0	1.4	6.7
57.	Pirojpur	5.5	3.3	1.0	3.0	12.8
58.	Potualkali	1	3.3	6.5	1.0	11.8
59.	Barguna	1	3.3	5.5	1.5	11.3
60.	Bhola	6.0	3.3	6.0	5.1	20.4
61.	Sylhet	1	8.0	0.0	8.0	17
62.	Sunamganj	1	8.0	0.0	8.0	17
63.	Habiganj	1	7.0	0.0	8.0	16
64.	Moulvibazar	5.5	8.0	0.0	6.0	19.5

Table 2. Hazard index and risk score

SN	HI	TRS	Hazardous Districts
1.	High	20-30	Dhaka, Bogra, Sirajganj, Feni, Comilla, Cox's bazaar, Lakshmipur, Noakhali, Chittagong, Tangail, Mymensingh, Kishoreganj, Jamalpur, Rangpur, Bhola, Barishal, Kurigram, Gaibandha
2.	Moderate	10-20	Sylhet, Gazipur, Manikganj, Narsingdi, Narayanganj, Munshiganj, Netrokona, Sherpur, Gopalganj, Rajbari, Shariatpur, Madaripur, Sunamganj, Pabana, Bandaban, Faridpur, Naogaon, Natore, Nawabganj, Rajshahi, Brahmanbaria, Joypurhat, Chandpur, Lalmonirhat, Nilphamari, Dinajpur, Magura, Khulna, Satkhira, Bagerhat, Jessore, Panchagarh, Meherpur, Kushtia, Habiganj, Narail, Moulvibazar, Potuakali, Pirojpur, Borguna.
3.	Low	1-10	Jhalkati, Chuadanga, Rangmati, Thakurgoan, Khagrachari, Jhenaidah

HI:Hazard Index, TRS=Total Risk Score

Table 3. Explanation of the multi hazard zonation map (for Chittagong Division)

SN.	Code	Explanation
1.	Z(TP_EZ2_CHR_FM)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g Cyclone High Risk Area Moderate Flooding Area
2.	Z(TP_EZ2_CHR_FL)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g Cyclone High Risk Area Low Flooding Area
3.	Z(TP_EZ2_CHR_FN)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g Cyclone High Risk Area Non Flood Affected Area
4.	Z(TP_EZ2_CR_FS)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g Cyclone Risk Area Severe Flooding Area
5.	Z(TP_EZ2_CR_FM)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g Cyclone Risk Area Moderate Flooding Area
6.	Z(TP_EZ2_CR_FL)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g Cyclone Risk Area Low Flooding Area
7.	Z(TP_EZ2_CR_FN)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g Cyclone Risk Area Non Flood Affected Area
8.	Z(TP_EZ2_CW_FS)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g High Wind Area Severe Flooding Area
9.	Z(TP_EZ2_CW_FM)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g High Wind Area Moderate Flooding Area
10.	Z(TP_EZ2_CW_FL)	Zone: Tornado Prone Area Earthquake Zone 2=0.15g High Wind Area Low Flooding Area

4. DISTRICT WISE RISK SCORES

Total Risk Scores for four individual hazards (Tornado, Earthquake, Cyclone and Flood) for each of 64 districts were estimated following the above methods. Table 1 summarizes the total risk scores for individual Districts of Bangladesh. This table is calculated by the summation of four individual hazard score calculated by using Eq. 1.1-5. For Dhaka district Total Score for Tornado, Earthquake, Cyclone and Flood are respectively 9.0, 4.8, 0.0 and 7.6. So the total risk score for Dhaka district is 21.4. Similarly total risk score for others districts were calculated.

From the proposed risk score, a district risk-ranking map for Bangladesh is proposed which is shown in Figure 1. This map indicates the risky districts of Bangladesh for multi hazard (Cyclone, Flood, Tornado and Earthquake) which also shows risk scenario of Bangladesh at a glance.

The risk areas were combined and the scores were added together to create summary scores for every location in the county. These summary scores were used to develop a summary risk area map. The summary scores also provide the foundation for ranking high-risk areas in the remainder of the assessment. The ranking of the risk scores are categorized in the Table 2. From the Table 1 and 2 the hazard index for all districts of Bangladesh were categorized by total risk score of different districts of Bangladesh for different hazards like tornado, flood, cyclone and earthquake shown in the Table 3.

5. RESULT AND DISCUSSION

To develop a multi-hazard map of Bangladesh based on a recently compiled disaster database, . Tornado, Earthquake, Flood and Cyclone zonation data were considered and the data base was updated

5.1 Development of individual hazard map

The prime objective of this study is to identify the vulnerable areas with reference to natural hazards causing damage to the housing stock for earthquakes, cyclones, tornadoes and floods. Due to that for a basic requirement a complete database of those natural hazards were prepared for this study. Different intensity scales for these disasters were also reviewed. The GIS maps of earthquake, cyclone, tornado and flood hazards were developed and these data were used to

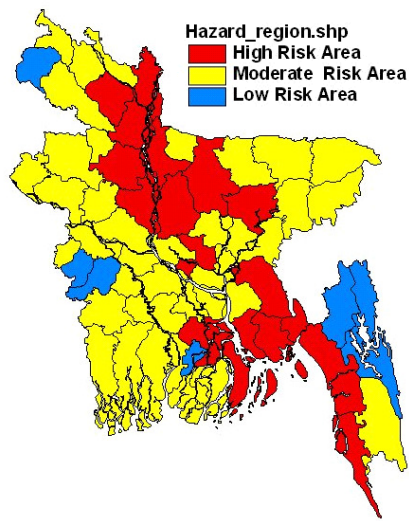


Fig. 1: Multi hazard map

vulnerability risk analysis of Bangladesh, wherein the risk score was tabulated for different districts of Bangladesh which is not shown in this paper.

5.2 Development of multi-hazard map

The district of Bangladesh was subdivided in to three risk areas based on risk score (shown in Table 2). The districts of Dhaka, Bogra, Sirajganj, Feni, Comilla, Cox's bazaar, Lakshmipur, Noakhali, Chittagong, Tangail, Mymensingh, Kishoreganj, Jamalpur, Rangpur, Bhola, Barishal, Kurigram, Gaibandha show the high risk score while Jhalkati, Chuadanga, Rangmati, Thakurgoan, Khagrachari, Jhenaidah district show the total low score and remaining districts show the moderate total score (shown in Fig. 1). By using the risk score and different individual maps for different hazard (Cyclone, Flood, Tornado and Earthquake), a zonation map for different degrees of risks for Tornado, earth quake, high wind velocity and flood was developed and which is proposed as a multi-hazard map (shown in Fig. 2). Legend of the map for Chittagong divisions is only shown in this Figure among the 60 different combinations for 6 divisions. This multihazard map can be used by policy makers to take decision for disaster management and preparedness. From this map one can easily identify the hazard area with the hazard type and intensity. This map will be easily comprehensible to everybody.

The probabilities of occurrence for different disasters were not considered in the risk score assessment. The probabilities of occurrence of different disaster of same time duration make this risk score assessment more reliable.

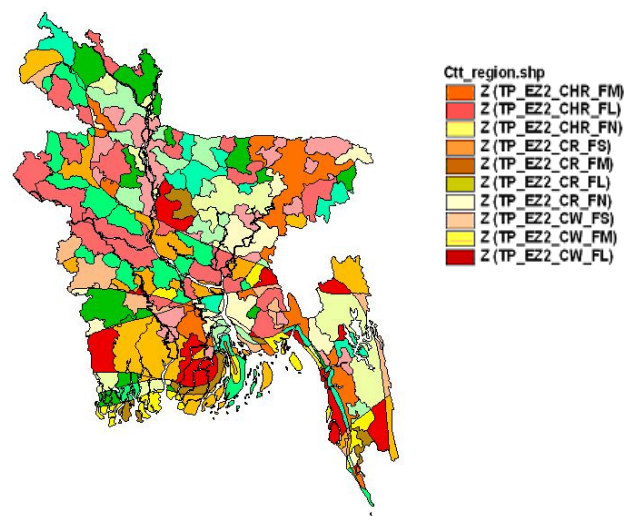


Fig. 2: Proposed Multi Hazard Zonation Map of Bangladesh (legend is only for Chittagong Division according to Table 3)

Model-GIS interface and Digital Elevation Models (DEM) are widely used to assess risk and development of floodplain zoning maps all over the world. The main constraint to develop such maps in Bangladesh is that the topographic and land elevation data are very old (Karim 2004).

6. CONCLUSIONS

The research findings are crucial and an important aspect for management strategy for planning and disaster mitigation, preparedness and preventive actions. The information will assist the environmental management, different field of sciences such as engineering and policy making and planning of Bangladesh and should be an integral part of the whole process of socio-economic development in Bangladesh.

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