ANALYSIS OF FURNITURE MANUFACTURING PROCESSES AND PRODUCT-MIX IN TERMS OF PROFITABILITY: A CASE STUDY IN OTOBI

By

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March 2005 Author

ABSTRACT

The world around us is always changing with respect to the demand of the era. The demand of this era is nothing but the improvement; improvement in every aspect. Now a day we don't satisfy ourselves by a particular improvement; rather we want our whole system improved. Industry is one of the major factors of our system improvement. By ensuring the quality, improving new techniques and increasing profitability we can achieve a dream industry.

Presently the engineering and the managers of the industrial concerns are under constant pressure of time, cost and quality of products and services. The research and development of a product, it's manufacturing and marketing have to be achieved within a short period.

The main objectives of this research work are to have a comprehensive idea of a typical manufacturing system and to establish a mathematical linear programming model to solve any typical problems of the manufacturing industries. We hope that a case study in Otobi have to experience and realize how the scientific and technical knowledge is applied to real situation.

Basically, most of the furniture industries in Bangladesh are followed the traditional methods of manufacturing processes. We are trying to proof mathematically that there is a big scope to improve furniture industries using a mathematical model which will help to analysis the present situation of the industry and forecast for the future and to make production schedule properly. If modern technology is applied to the existing furniture industries and proper attention is taken in both the manufacturing of furniture and its products and making positive exporting policy to other countries, huge amount of foreign currency may possible be earned from this sector.

Analysis of furniture manufacturing processes and product-mix in terms of profitability is a subject to know how , we can maximize the profit per month than the traditional method. The content is constructed and edited mainly for the purpose of maximizing the profit of furniture industries regarding the Global Market achievement

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Chapter-1

Introduction

1.1 Introduction

Furniture is one of the basic needs of human being. It is useful in home, Office, Institution. All class of human being use furniture to furnished their home, office, hospital, institution etc. Normally furniture is manufactured for various classes of human being according to their taste and propensity. Among them following are the main types of furniture such as wood furniture, steel furniture and plastic furniture. For all classes of customers wood furniture is more popular than any other furniture. But we need a lot of tree or plant to make wood furniture. As a result, forests are destroyed all over the world. Otobi gives us world class products without harming the nature, specially the forest.

Over the two and half decades of tireless endeavor Otobi has earned the image of unique manufacturer of world class furniture. Otobi make all kinds of metal, laminated board and plastic furniture for office, household and hospital purpose. Otobi guarantee international standard because of their products are design by a team of professional product designers who take special care to combine functional utility and durability with elegance, taking into account modern requirement of efficient use of floor space. Currently Otobi management is planning to introduce numerous new products and has brought about qualitative improvement in existing product line with imported high quality raw materials. We have now introduced a wide range of products of economic series to satisfy the demand of various segments of the society. We have diversified product range into workstation and kitchen cabinet. In addition to furniture, we are now doing interior decoration on turnkey basis.

Otobi is a furniture manufacturer, creator of products that are outstanding in style, quality and service. We strive to provide the highest levels of customer satisfaction through designs, functionality, materials and the added value that our products explicitly convey when becoming part of their home or office.

In our pursuit to maintain and further our reputation as a manufacturer that is dedicated to recognize customer needs, we are committed to using superior materials, experienced craftsmanship, innovative designs and be obsessive about the high quality of our products and service. Our objective is to continue to be a leader in the industry we represent.

We work as a team. Constantly nourishing open and honest communication, equal and fair treatment in an atmosphere that encourages professionalism, creativity, ownership, participation and pride in our work. Our excellence comes from people, our most valuable asset. We foster ambition, honesty, growth and independent thought through a caring, honorable, ethical and straightforward leadership that rewards people's efforts with praise and promotion.

We are mindful of how our operations may have an impact on our community and environment. We make every effort to be good citizens by being sensitive to environmental needs, a respected employer in the community and giving back through programs involving charitable organizations or special events.
Our goal is to manufacture the best-valued product in the marketplace, in a good, safe, caring and rewarding workplace. To maintain and grow our segment in the marketplace which will provide Otobi Furniture with the financial integrity and profit to our shareholders in return for their investment.

The use of higher quality materials, a wide range of color selections and plus a variety of fine accessory products, which include laminated board furniture and mixed furniture are excellent selling points to our valued customers. Our sales force offers support to our dealers by educating their floor sales people about our products to better serve our customers. OTOBI provides Quality, Excellence, Service, and an Atmosphere of Creative Innovation with People, through People, for People.

Otobi's melamine coated laminated board furniture has brought revolutionary changes in the modern concept of furniture. Scratchproof boards multiple color options and elegant designs have made the laminated board furniture the choice of the modern corporate world. Moreover the unique knockdown system allows customer to handle the furniture conveniently, specially where frequent shifting is required.

Laminated Board Section is one of the biggest units in Otobi. Maximum turnover comes from this section. But it is newly established in Otobi, which has been started since 1999. This is more attractive product in Otobi and already build-up a great demand in Bangladesh. No doubt, it has bright future to capture the whole market of the furniture world. Because day-by-day increases the demand have laminated board furniture instead of wood furniture in Bangladesh.

There is a lot of scope to improve traditional methods of production process of laminated board furniture in Otobi using suitable methods. In view to improve the traditional methods, we are trying to establish suitable methods, which partially will be helpful for laminated board furniture manufacturing section in Otobi. So, we are formulated a model solution in linear programming. We can determine the proper lot size of products, which is produces monthly basis according to the demand of market. It will help to plan properly of raw materials requirement and inventory control. In present, **OTOBI ISO 9001: 2000 certified company.**

1.2 Objectives of the research

The specific objectives of the project would be

- To study the type and nature of Laminated Board Furniture Manufacturing Processes.
- To study and investigate the appropriate Product-mix.
- To identify and quantify the processing needs of these furniture.
- To study the common processing facilities and optimize in terms of identified Product-mix.
- Assess the benefits of the Furniture Company.

1.3 Methodology:

A survey and study of the furniture manufacturing company will be carried out and statistical analysis will be done to determine the nature of the manufacturing process and operations and their demands.

Linear programming exercises will be carried out to optimize the profitability of the furniture manufacturing company. Finally a qualitative / quantitative analysis will be done to asses the benefits of the furniture company.

1.4 Scope of the research

Otobi's melamine coated laminated board furniture has brought revolutionary changes in the modern concept of furniture. Scratchproof boards multiple color options and elegant designs have made the laminated board furniture the choice of the modern corporate world. Moreover the unique knockdown system allows customer to handle the furniture conveniently, specially where frequent shifting is required.

Laminated Board Section is one of the biggest units in Otobi. About 60%-70% of total turnover comes from this section. But it is newly established in Otobi, which has been started since 1999. This is more attractive product in Otobi and already build-up a great demand in Bangladesh. No doubt, it has bright future to capture the whole market of the furniture world. Because day-by-day increases the demand have laminated board furniture instead of wood furniture in Bangladesh.

Although Otobi get maximum turnover from it, but it is not enough organized. There is a lot of scope to improve traditional methods of production process of laminated board furniture in Otobi using suitable methods. In view to improve the traditional methods, we are trying to establish suitable methods, which partially will be helpful for laminated board furniture manufacturing section in Otobi. So, we are formulated a model in linear programming. We can determine the proper lot size of products, which is produces monthly basis according to the demand of market. It will help to plan properly of raw materials requirement and inventory control.

We are considering OTOBI Limited as a model to study of research works and we have collected few data from OTOBI to establish and formulate the mathematical model.

1.5 Importance of Furniture Industry in Bangladesh

Furniture Industry can participate in Major economic activities in Bangladesh. Because furniture is one of the basic needs of human being. There is a big scope to earn foreign currency to export furniture all over the world like other sectors such as Garments, Textiles, Leather, Tea, Jute etc. We can enter into the global market to fulfil our national demands of furniture. There is a big market in U.S.A., Canada, Australia, Europe and Middle East. We need to promote worldwide.

Actually furniture-manufacturing company is worker-based company. But workers are available in cheap rate in Bangladesh compared to other developing and developed countries. Our main competitors are Malaysia, Taiwan and china. They are importing manpower from Bangladesh for their furniture company in high rate compare to Bangladesh and they are exporting worldwide their furniture in cheap price and earning a handsome amount from this furniture sector and contribute to their national income. Because they have come out from they're traditional methods of furniture manufacturing processes. They are applying modern technology in Furniture Company to reduce their production cost. So, they are capable to enter the world furniture market. We think that we have all resources available in Bangladesh excepts established modern methods, trained workers etc. in this moments, we are importing furniture's to meet up our national needs. If we can able to come out from our traditional methods and established modern methods and trained up our local human resources. So, we can also earn foreign currency exporting furniture worldwide after meet up our local demands, which will contribute in our national income.

Due to free market economy from 2005, it will be difficult to face the challenge without optimize production as well as quality and reduce the production cost. Competitive pressures in the Bangladesh furniture industry are pressing manufacturers to look outside of the Bangladesh for searching new markets. Several trends within the industry point toward an increasingly competitive environment. Sales have been increasing day by day, consolidation among a smaller

number of large firms are dominating shipments and product brands within the industry, low profitability is low as evidenced by low after tax returns on sales, and advances in production technologies are increasingly important but costly for smaller firms. So, we have great opportunity to earn money from furniture sector, but we need professionalism, modernization, realization and mentality to improve this sector.

1.6 Background or History of Otobi Ltd.

Born in 1935 at Dinajpur, Painter and Sculptor Mr. Nitun Kundu graduated from Institute of Fine Arts, Dhaka in 1959, and securing 1st class 1st position. The same year he started his career as a Designer in the United States Information Services (USIS) Dhaka. He left USIS as Chief Designer in 1971 and participated in the liberation war. After the war he turned into a free-lance painter. In 1974 he conceived the idea of embarking into commercial venture and started manufacturing decorative items at his residence and later at Shukrabad, in addition to normal activities of painting and sculpture. The name of this mini workshop was **"The Designers"**, employing only 3 / 4 persons.

A recipient of National Award for painting in 1965 and Bangabandhu Award in 1992. Mr. Nitun Kundu set up a small workshop in a tin-shed at Topkhana Road in February 1977 and named it **"Art in Craft"**. Here, in addition to coat pin, cup, crest, trophy etc. he started manufacturing decorative items, table lamp and various types of metal furniture.

Bangladesh is traditionally used to in wooden furniture, but forest resources being extremely limited, Mr. Nitun Kundu anticipated the need for metal furniture and in 1978 he opened a show room at 230 New Elephant Road, Dhaka and gradually started marketing all kinds of metal furniture in a proper manner.

Having widely traveled all over the East and West, Mr. Nitun Kundu gained sufficient confidence and experience by 1984, when he started commercial production under the name and title **"OTOBI"**. A great deal of emphasis was given to meet the need of customers and Otobi products started gaining popularity.

While pursuing his commercial venture, Mr. Nitun Kundu continued his artistic activities, for which at times he worked 18 hours a day. He designed and manufactured President's National

Film Award, National Export Fair Trophy, Industrial Exhibition Trophy, President's Gold Cup for Football Federation, President's Gold Cup for Bangladesh TV, Monogram for President's House, Crests and Medals for Bangladesh Army. Mr. Nitun Kundu also designed and created Hemisphere Foundation at the crossing of Topkhana Road and Park Road, a fountain to beautify the Tarqa Mossque, a Fountain in Sangsad Lake and a Submersible Fountain in the lake of Ansar Training Centre at Shafipur and a few fountains in the houses of some dignitaries. The culmination of success of Mr. Nitun Kundu as an artist was through designing and construction of war memorial "Saabash Bangladesh" at Rajshahi University in 1991 and SAARC Fountain at Dhaka in 1992.

In 1984 a commercial land was acquired at Mirpur and the factory building was constructed in 1985. It was a four storied building with a total floor space of 50,000 sq. ft. Mr. Nitun Kundu gradually engaged Industrial Designers and Engineers. Special efforts were made to build up a core team of highly skilled craft men. All kinds of metal furniture were being manufactured at Mirpur Factory and marked through the Show room at Elephant Road by 1988. Because of its superior quality, Otobi products continued gaining popularity. Mr. Nitun Kundu developed a wide rage of furniture for office, hospitals, and residence and slowly created a much wider demand for Otobi products.

Following a visit to Japan by Mr. Nitun Kundu, the quality of Otobi products as well as sales and marketing methods were so successful that by 1992 Mr. Nitun kundu constructed a four storied building at 14 Dilkusha C/A and opened a display centre there on October 10, 1993.
The market demand for Otobi product coutinued to rise and the company experienced difficulty in 1994 to meet the market demand with its existing production resources. Therefore, Mr. Nitun Kundu set up another factory at Shyampur, Dhaka covering land space of 64,000 sq. ft. which went into experimental production in November 1994. The factory is now full operational with latest machines to manufacture a wide range of most sophisticated furniture so that Otobi can compete in the international market.

The special feature of Otobi products is that it takes special care to combine functional utility with elegance, keeping in view the efficient use of floor space. Otobi is now equipped with the

latest machines and technology to manufacture all kinds of sophisticated metal furniture including hospital furniture and such other items.

Mr. Nitin Kundu felt the need for introducing professionalism in his company and accordingly engaged highly qualified management talent to meet the functional need of the present day challenges.

Otobi entered into the international market by exporting chairs to Russia in 1994. Export in now temporarily suspended due to present production constraints.

Otobi is fully conscious of its obligation to the society as a corporate citizen and is currently making all possible efforts to play its role effectively.

1.7 OTOBI MISSION:

At Otobi, we have always had, and will continue to promote, an atmosphere that encourages our employees to apply their Old World skills and the freedom to participate in improving the quality of the Otobi product.

It is the dedication and pride in workmanship that our company is based on that enables us to create superior products and provide reliable services that form solid and lasting alliances with our customers.

Otobi is synonymous with excellence in that we are committed to delivering a product that is of a constant high quality and that all business affairs are handled in an ethical and honorable fashion.

Devotion to quality, reliability, and ethics are the qualities that ensure Otobi's place as a world class organization and insures success for itself as well as its customers.

1.8 OTOBI VISION:

Under the vision, direction and leadership of Otobi's owners, Otobi has become a "World Class Furniture Manufacturer" in Bangladesh. Otobi has grown to become the first largest furniture manufacturing company in Bangladesh. Otobi has a rich history of success stories that illustrate its dramatic transition from a 'virtual unknown' to a significant force in the industry. For over thirty years, the company has remained committed to its Vision Statement, **"We Want To Be the Best Furniture Company."**

Innovative marketing concepts, quality products and state-of-the-art manufacturing methods have always been driven by the demand for customer satisfaction. At Otobi the stream of satisfied customers continues to grow as Otobi continues to be creative and diversifies to expand business, and improve quality into the next millennium.

Otobi furniture is designed for the way you live. It's about real life.

1.9 OTOBI Product Range:

- Office furniture
- Household furniture
- Plastic furniture
- Hospital furniture
- Computer furniture
- Kitchen cabinet
- Work station
- Storage rack
- Dunnage
- Decorative
- Interior decoration

1.10 Quality Policy of Otobi Limited:

Quality Policy

Of

OTOBI Limited

OTOBI Limited is committed to satisfy customers with

- Quality of Products.
- Timely delivery.
- Competitive Price and
- Service

OTOBI Limited

- Reviews
- Evaluates and
- Measures

Performance of the processes for continual improvement of the Quality management.

Nitun Kundu

Managing Director

1.11 Organization of the research

This research work consists of seven chapters' altogether. The first chapter gives a general idea of furniture industry, importance of furniture industry in Bangladesh, background of Otobi and Otobi quality policy. In chapter two furniture manufacturing concept, product and production concept, modeling and decision making, optimization of mathematical model by linear programming. In chapter three includes laminated board furniture processing, details of raw materials used, machine and cutter used, conception about laminated board furniture. In the chapter four description about demand of laminated board furniture in Bangladesh and abroad. Export opportunity of laminated board furniture. In the chapter five data collection and model formulation. In chapter six solution of the model and result analysis comparison between present and expected production sensitivity analysis. In chapter seven conclusion and recommendations of this research work and scope for further research work.

Chapter-2

Background Study & Literature Survey

2.1 Furniture Manufacturing Concept

The furniture-manufacturing concept holds that organizations are to determine the needs and wants of customers with desired satisfaction. Furniture will be attractive in design with competitive prices.

2.2 Product and Production concept

The **Product concept** holds that consumers will favor those products that offer the most quality, performance or innovative features. Organizations focus on making superior products and improving them over time. Buyers admire well-made products and can appraise quality and performance. Product oriented companies often design their products with little or no customer input. They trust that their engineers can design exceptional products. Very often they will not even examine competitors' products.

The **Production concept** holds that consumers will prefer products that are widely available and inexpensive. The production concept is one of the oldest concepts in business. Production oriented business concentrate on achieving high production efficiency, low costs and mass distribution. They assume that consumers are primarily interested in product availability and low prices. This orientation makes sense in developing countries , where consumers are more interested in obtaining the product than in its features. It is also used when a company wants to expand the market.

2.3 Overview of Operations research

The principal components of an operations research (OR) model- namely , alternatives, restrictions and an objective criterion. Generally, the alternatives of the decision problem may take the form of unknown variables. These variables are then used to construct the restrictions and the objective criterion in appropriate mathematical functions. The end result

is a mathematical model relating the variables, constraints and objective function. The solution of the model then yields the values of the decision variables that optimize(maximize or minimize) the value of the objective function while satisfying all constraints. The resulting solution is referred to as the optimum feasible solution.

A typical OR mathematical model is usually organized as follows:

Maximize or minimize (Objective function)
Subject to (Constraints)

Though mathematical models are the cornerstone of most OR studies, there is more to the solution of the decision making problem than the construction and solution of the mathematical model. Specially decision problems usually include important intangible factors that may not be readily quantifiable. Foremost among these factors is the presence of human element in most decision environments. Indeed, decision situations have been reported where the effect of human behavior has so influenced the decision problem that the solution obtained from the mathematical model is deemed impractical. The mathematical aspect of OR should be viewed in the wider context of the decision making process.

2.4 Operations Research Techniques

In Operations Research (OR) models, the decision variables may be integer or continuous, and the objective and constraint functions may linear or nonlinear. The optimization problems posed by these models give rise to a variety of solution methods, each designed to account for the special mathematical properties of the model. The most prominent and successful of these techniques are **linear programming, where** all the objective and constraint functions are linear and all the variables are continuous. Other techniques that deal with other types of mathematical models are **dynamic programming, integer programming, nonlinear programming, goal programming and network programming.**

2.5 Product Mix Analysis

Production and business systems are key building blocks in the structure of modern industrial societies. Different human activities and the prosperity of whole nations are highly dependent on the performance of production and business systems. Companies and industrial

firms, through which production and business operations are usually performed, represent the major sector of today's global economy. Therefore, in the last decade, companies have made the continuous improvement of production and business systems a milestone in their strategic planning for the new millennium. To remain competitive, companies have to maintain a high-level of performance by maintaining high quality, low cost, low manufacturing lead times, and high customer satisfaction. It is usually asserted that production and business operations have the potential to strengthen or weaken a company's competitive ability. Therefore, and as a result of fierce competition and decreasing business safety margins, efficient and robust production and business operations become a necessity for survival in the marketplace.

Because of this, improving the performance of production and business systems has been the primary interest of decision-makers and engineers. Indeed, Industrial Engineering (IE), as a profession and a science, plays a central role in the efforts towards improvement in these systems. Many industrial engineering subjects such as Operations Research, Quality Control, and Systems Modeling offer robust and efficient design and problem-solving tools with the ultimate aim of performance enhancement. Examples of this performance can be the throughput of a factory, the quality and reliability of a product, or the profit of an organization.

Designing flexibility into production and business systems is, therefore, a key matter for success and survival in today's market. Businesses have inevitable obligation to deal with supply and demand fluctuations, changes in work scope, and trend dynamics of the market. Therefore, lean production and business systems demand continual improvement of delivery times, operating costs, capacities, material utilization, and information flow.

Dynamic changes in demand, supply, and manufacturing strategies force companies to make continuous changes to the product-mix. Making such changes gracefully and effectively can be only accomplished when systems design is based on flexible production and business operations. The issue becomes even more challenging when the frequency of product-mix change increases. Therefore, under such conditions, determining the optimum product-mix and analyzing its implications as an integral part of the design process become essential for achieving robust and flexible production and business systems.

2.6 Modeling and Decision Making

An Operations Research must be rooted in teamwork, where both the OR analysts and the client work side by side. The OR analysts with their expertise in modeling will need the experience and cooperation of the client for whom the study is being carried out.

As a decision making tool, OR must be viewed as both a science and an art. It is a science by virtue of the embodying mathematical techniques it presents and it is an art because the success of all the phases the proceed and succeed the solution of the mathematical model depends largely on the creativity and experience of the operations research team.

The principal phases for implementing OR in practice include:

- Definition of the problem
- Construction of the model
- Solution of the model
- Validation of the model
- Implementation of the solution

Of all five phases, only phase three dealing with model solution is the best defined and the easiest to implement in an OR study because it deals with mostly precise mathematical theory. The implementation of the remaining phases is more an art than it is a theory.

Problem definition involves defining the scope of the problem under investigation. This is a function that should be carried out by the entire OR team. The end result of the investigation is to identify three principal elements of the decision problem- namely,

- The description of the decision alternatives
- The determination of the objective of the study, and
- The specification of the limitations under which the modeled system operates.

Model construction entails translating the problem definition into mathematical relations. If the resulting model fits into one of the standard mathematical models, such as linear programming, a solution is usually attainable by using available algorithms. Alternatively, if the mathematical relationships are too complex to allow the determination of an analytic solution. the OR team may opt to simplify the model and use a heuristic approach, or the team may consider the use os simulation, if appropriate. In some cases a combination of

mathematical, simulation and heuristic models may be appropriate for solving the decision problem.

Model solution, by far, is the simplest of all OR phases because it entails the use of well-defined optimization algorithms. An important aspect of the model solution phase is ***sensitivity analysis***. It deals with obtaining additional information about the behavior of the **"optimum"** solution when the model undergoes some parameter variations. Sensitivity analysis is particularly needed when the parameters of the model cannot be estimated accurately. In these cases, it is important to study the behavior of the optimum solution in the neighborhood of the initial estimates of the model's parameters.

Model validity checks whether or not the proposed model does what it is supposed to do-that is, does the model provide a reasonable prediction of the behavior of the system under study? Initially, the OR team should be convinced that the output of the model does not contain "surprises." In other words, does the solution make sense? Are the results intuitively acceptable? On the formal side, a common method for checking the validity of a model is to compare its output with historical output data. The model is valid if, under similar input conditions, it reproduces past performance. Generally, however, there is no assurance that future performance will continue to duplicate past behavior.

Implementation of the solution of a validated model involves the translation of the model's results into operating instructions issued in understandable form to the individuals who will administer the recommended system. The burden of this task lies primarily with the OR team.

2.7 Product Mix Decision

An organization's product-mix is the percentage of total output devoted to each product. In production, for example, in furniture manufacturing might have a product-mix of fast moving, medium moving and slow moving products. Product mix analysis focuses on determining the optimum product-mix and highlights the implications of varying the percentage of each product on different production and business activities. Since different products have different production rates, the capacity requirements for each mix of products may, in some cases, drastically change. For example, increasing the proportion of a certain product in a production schedule may require duplicating a certain machine tool to cope with

the rate of production, which may eventually lead to adding a parallel processing line and a new line of products to make use of the added capacity. Therefore, product-mix analysis aims at answering the question. How does product-mix changes affect system capacity? System capacity can be defined in terms of buffer sizes and manufacturing resources types, set-up, utilization, and availability.

Product-mix decisions are usually influenced by the product selection decision. When a firm has a current market for two or more products, a decision is usually taken to introduce more than one product to the market in an effort to increase market share and profitability. Deciding to produce more than one product type or to provide more than one-service leads to the issue of product-mix selection. Product selection decision is usually based on the organization goals, environment, and the organization's production, marketing, and financing strategies. Once product types are selected, decisions must again be made within each product line with respect to which mix of products to produce and which production processes to use in view of cost, capacity, and the theory of constraints. Product-mix decisions are typically dependent on market research and marketing strategies. Therefore, the product-mix in a production plan is not usually fixed. The mix may change dynamically at different time periods.

2.8 Product Mix Decision using Linear programming (LP)

LP is a quantitative method of product-mix analysis with extensive in the applications in the production and business Arenas. Many firms have found that Linear Programming (LP) methods are useful techniques for assisting in the product-mix decisions. LP is an analytical approach that is utilized to determine the optimum product-mix so that a certain criterion is met. Using LP an objective function is maximized or minimized subject to a certain set of constraints. In most cases, the least costly mix of products is obtained from the solution of the LP problem. Other LP applications beside product-mix determination include capital budgeting, financial planning, work scheduling, and line balancing. Therefore, product-mix determination can be considered as one application of LP for short-term scheduling. LP problems can be solved using graphical method or using simplex method. Most large-scale problems now a day are solved using software tools by the computer. However, it is always essential to gain at least a basic understanding of the solution methodology along with the knowledge of how to formulate and set up the problem, interpret the results, and draw the

right inferences. Johnson and Montgomery. Presented a Mathematical formulation for the product-mix problem as a constrained LP model. They also illustrated two approaches for dealing with uncertainty in demand. Applying the LP model requires the following information:

- Revenue obtained from selling one unit of each product type.
- Unit variable cost of producing a unit of each product type.
- Required minimum production level of each product type in the Planning period.
- Maximum potential sales of each product type in the planning period.
- Number of units of each resource that are required to produce one unit of each product type.
- Amount of each resource available during the planning period.

Here in this problem between the three categories of product depends on market demand which products in the same series of machines should be produced in which quantity to ensure maximum income as well as maximum profit, a linear programming analysis is done. With several constraints (demand, supply ratio, capacity and non-negative), the objective is to maximize total income.

2.9 Linear Programming

Linear programming is a mathematical modeling technique designed to optimize the usage of limited resources. Otherwise, Linear programming is one of the simplest tool which typically deals with the problem of allocating limited resources among competing activities in the best possible (i.e., optimal) way. The method is applicable for the solution of problems in which the objective function and the constraints appear as linear functions of the decision variables. The constraint equations in a linear programming may be in the form of equalities or inequalities. This is the most widely used in the areas of military, industry, agriculture, transportation, economics, health systems and even behavioral and social sciences. These models are attractive to system planners because they have standard solution procedures.

Practically all operations research techniques result in computational algorithms that are iterative in nature. This means that the problem is solved by iterations, where each new iteration bringing the solution closer to the optimum. The iterative nature of the algorithms

typically gives rise to voluminous and tedious computations. It is thus imperative that the computer executes these algorithms.

The usefulness of the technique is enhanced by the availability of highly efficient computer codes. Indeed, LP, because of its high computational efficiency. is the basis for the development of solution algorithms of other (more complex) types of Operation Research models, including integer, nonlinear, and stochastic programming. Although different and more general types of constrained decision-making models exist, it is nevertheless true that in many applications linear programming is most useful. It has been successfully applied to literally thousands of different types of managerial decision-making problems.

These problems of allocation can arise whenever one must select the level of certain activities that complete for scares resources necessary to perform those activities. The variety of situations to which this description applies is diverse indeed ranging from the allocation of production facilities to products to the allocation of national resources to domestic needs, from portfolio selection of shipping patterns, from agricultural planning to the design of radiation therapy and so on. However, one of the common ingredients in each of these situations is the necessary for allocating resources to activities.

The Linear programming, as in any operation research model, includes three basic elements like,

- Decision **variables** that we seek to determine
- **Objective** (goal) that we aim to optimize and
- **Constraints** that we need to satisfy.

The proper definition of the decision variables is an essential first step toward the development of the model. Once the variables are defined, the task of constructing the objective function and constraints should not be too difficult.

If any of the functions among the objective and constraint functions is nonlinear, the problem is called a nonlinear problem. This is the most general programming problem and all other problems can be considered as special cases of the nonlinear problem. A key assumption of linear programming is that all its functions (objective function and constraint functions) are

linear. This assumption essentially holds for numerous practical problems. It is sometime possible to reformulate non-linearity into a linear programming format.

The computations in linear programming, as in most operation research models, are typically voluminous and tedious, and, hence, require the use of computer. The user-friendly EXCEL-SOLVER add-in program package is designed to solve this computational burden. The proper decision of the decision variables is an essential first step toward the development of the model. Once the variables are defined, the task of constructing the objective function and the constraints should not be too difficult.

2.10 Linear programming related Definition

- **Feasible solution:** any solution that satisfies all the constraints of the model.
- **Optimum feasible solution:** the solution that yields the maximum total profit.
- **Nonnegativity restrictions:** an implicit (or " understood-to-be") restriction on the model is that the variables must not be negative.
- **Slack variable:** a slack variable thus represents the amount by which the available amount of the resource exceeds its usage by the activities. For constraints of the type($\leq$), the right-hand side normally represents the limit on the availability of a resource, and the left-hand side represents the usage of this resource by the different activities (variables) of the model.
- **Surplus variable:** a surplus variable represents the excess of the left-hand side over the minimum requirement. Constraints of the type ($\geq$) normally set minimum specification requirements.
- **Unrestricted variable:** the nature of the variables requires assuming nonnegative values. There are situations, where a variable can assume any real value. The specific selection between the two constraints depends on which one yields a better optimum. In fact we do not know whether the constraint should operate with a slack or with a surplus. A logical way to account for the situation is to replace the two constraints.
- **Sensitivity analysis:** an LP model is a snapshot of a real situation in which the model parameters (objective and constraint coefficient) assume static values. It appears natural that we study the effect of making changes in the model parameters on a given optimum LP solution. This type of investigation is called sensitivity analysis.

- **Dual prices:** the dual price actually represents the unit worth of a resource. It gives the contribution to the objective function resulting from a unit increase or decrease in the availability of a resource. Other less common names for the dual price include **Shadow prices** and **Simplex multipliers.**

2.11 Overview of Solver

Solver is an add-in package to Excel that numerically optimizes constrained models, such as an LP model. In doing this, Solver uses a technique called a mathematical programming algorithm to efficiently find the optimal decisions for a given spreadsheet model. An algorithm is simply a computer code that follows an iterative recipe for finding the optimal decisions. For LPs Solver uses a very efficient optimization algorithm that works only on LP models called the simplex method. Not surprisingly, to benefit from this powerful capability there is some prices to pay. We must set up the spreadsheet model in the appropriate form so that solver can optimize it; we must adhere to certain technical restrictions imposed on our spreadsheet model by solver, and most importantly, we must understand the limitations of optimization models to properly interpret Solvers results.

Solver can optimize both linear and nonlinear models. For now, we will focus only upon linear models because they are far less prone to technical difficulties. For LP optimization every formula in our model that includes the decision variables directly (or indirectly via a chain of cell reference) and that directly or indirectly affects the objective function cell must be linear. The restriction (linearity) is imposed by Solver's Simplex linear programming method that works correctly only for spreadsheet formulas involving linear relationships.

The solver add-in package consists essentially of two programs. The first is an Excel Visual Basic program that translates your spreadsheet model to an internal representation used by the second program. The second program, residing in memory outside of Excel as a separate software module, carries out the actual optimization and returns the solution to the first program for updating of the spreadsheet. The two communicate by means of Microsoft's application programming interface, the details of which need not concern us. Upon choosing the "Solver" item from Excel's Tool menu, you evoke the first Solver program that prepares

your spreadsheet for optimization and calls the second optimizer program. The following steps should be considered during using the solver.

- Start Excel and perform spreadsheet-modeling operations normally. You can develop your Excel models perform "What if"? And debugging analyses and prints results in the usual way.

- Once the model is developed and debugged (and saved to disk!), you optimize it by choosing the Solver item from Excel's Tools menu.

- The Solver add-in and its optimization module will be loaded into memory. When the loading is finished, Solver brings up a dialog box to collect information for the optimization process.

- After specifying certain housekeeping details, such as which cell contains the objective function formula to be optimized and which cells contain decision variables, you click the dialog's "Solve" button.

- Solver will then translate your model and begin the optimization process. For small LP models this takes several seconds, or for big models, several minutes or longer.

- Assuming there are no errors in your spreadsheet LP model, Solver will bring up a Solver Results dialog box in which you can request reports and have Solver up-date your original model with the optimal decision cell values. Solver creates each requested report on a separate worksheet in your workbook that you can save or print.

- At this point, you are now in a position to continue "What if" projections to, for example, perform sensitivity analyses in the neighborhood of the optimum

- Decisions. Fig.2.1 shows the diagramatic view of the steps in using solver.

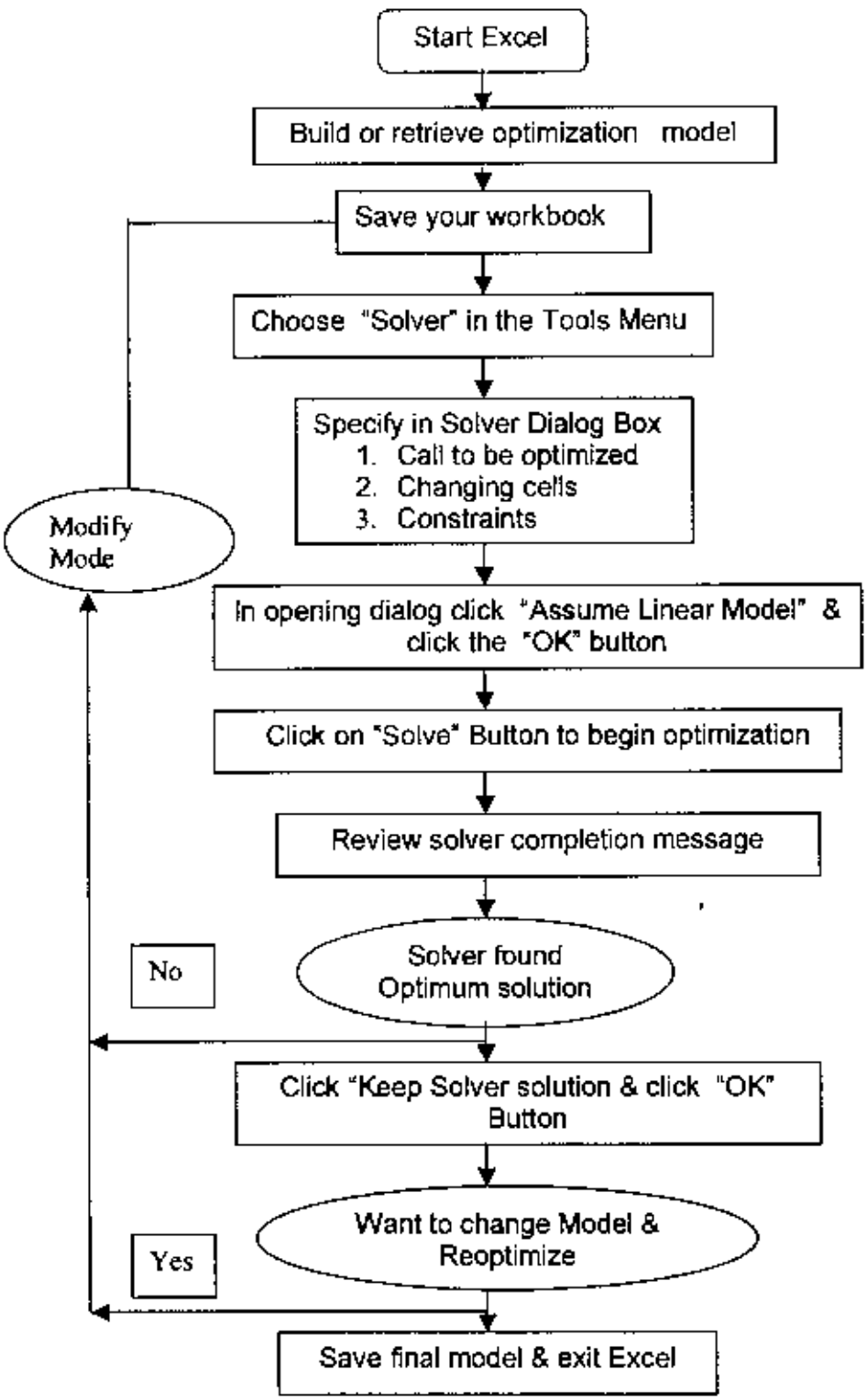


Fig. 4.1 Solution process of MS Excel solver Flowchart

2.12 Solver Terminology

We have the "big picture" of how solver works, we turn to details of how to instruct solver to optimize our LP model. First we need to clarify the terminology Solver uses to view our LP model. This change in terminology is necessary because solver views the world only through the cells of a spreadsheet and not as the symbolic representation that use in LP models. Otherwise, the differences are nominal. Table 3.3 summarizes the differences in nomenclature between that used for our LP models and Solver.

One additional consideration is important to remember for LP models. Typically, negative decisions have no meaning and so, often there should be a nonnegativity constraint on the LP's decision variables. Because they are so obvious, these nonnegativity constraints are rarely listed explicity on the excel spreadsheet version of the LP model. Overlooking this nonnegativity specification on the decision variables is by far the most common oversight when using solver for optimizing LP models.

If negative decisions have no meaning, remember to specify the nonnegativity constraints on our LP model's decision variables before optimizing it with Solver.

Table 3.3: Solver Terminology

LP Modeling Terminology	Solver Terminology
Objective Function	Target Cell
Decision Variables	Changing Cell
Constraints	Constraints
Constraints Function(LHS)	Constraints Cell Reference
RHS	Constraint
LP Model	Assume Linear Model

Chapter-3

Technology of Laminated Board Furniture Processing

3.1 Laminated Board (LB) Department:

We are considering the process of Laminated Board Furniture to develop our research work in view to the importance of laminated board furniture in the furniture world. So, we are trying to describe briefly the process of the laminated board furniture to easily understand the research work. Laminated board department divided into the following section:

- Laminated Board Section(floor-1 & floor-2)
- Lamination Plant
- Structural Table Section
- Special Section
  - Special cabinet section
  - Workstation
  - Kitchen cabinet

Laminated Board Section:

There are two floors (Floor-1 & Floor-2) in Laminated Board Section. Mainly batch product produces in this section and give support to the others Sections. This is the knockdown product. Knockdown means the furniture, which is fitting end of the customer with fixing kits.

Otobi's melamine coated laminated board furniture has brought revolutionary changes in the modern concept of furniture. Scratchproof boards multiple color options and elegant designs have made the laminated board furniture the choice of the modern corporate world. Moreover the unique knockdown system allows customer to handle the furniture conveniently, specially where frequent shifting is required.

Laminated Board Section is one of the biggest units in Otobi. About 60% of total turnover come from this section. But it is newly established in Otobi, which have been started since

1999. This is more attractive product in Otobi and already build-up a great demand in Bangladesh. No doubt, it has bright future to capture the whole market of the furniture world. Because day by day increase the demand of laminated board furniture instead of wood furniture

3.2 LB Furniture Processing Operations:

Laminated Board (LB) furniture processing operations are classified as follows:

3.2.1 Cutting Operation:

This is the first stage of LB furniture manufacturing processes. There are five stages of operations.

3.2.1.1 Panel Saw:

Raw laminated board cutting operations is started from the panel saw. We always follow the operation plan and cutting plan for each product. Detail information of any products is explained in the operation plan such as cutting size of product components, color of board, fiber direction for beech color board etc. but in the cutting plan indicates the board-cutting plan of the product components in view to save the wastage of boards.

Normally large components cutting operations is performed in the panel saw. Panel saw bed length is very large about 5500mm. During cutting operation, cutter moves, but jobs (board) fixed. There is three steps cutter speed, which is seated according to the job size. We keep the components size 5mm larger than the final size of the components. We get the final size from the DET machine. There are two sizes carbide tips Saw Blades. Larger one is called sizing saw and smaller one is scoring saw blade. Sizing saw blade rotates clockwise and scoring saw rotates anti-clock wise. During cutting operations to fix the jobs air pressure is required about 7 bar. Air pressure applied on the jobs with the push bar. Clamping device clamps the job to move along the cutter as per cutting size that is input with the PLC control. Maximum cutting thickness of the job is 80mm.cutter return sped is double then the cutting speed which is done by the inverter.

3.2.1.2 Table Saw:

Normally small product components cutting operations are performed in the Table Saw. Because small components cutting in the panel is time consuming. Table Saw is small in size just like a table. There are two types of operations are possible in the table Saw that is cutting

operation and groove cutting. For both operations are followed the operation plan and cutting plan of the product. In this operation cutter fixed but jobs moves with the help of the feeder roller. Not required any air pressure, pressure applied mechanically on the jobs. There are two types of saw blades, sizing and scoring saw blades. Sizing saw blade rotation is clock-wise and scoring saw blade is anti-clock wise. This is better for small components cutting operations. Few small components cutting is performed in final size, which is not possible in the DET, machine. Otherwise components size will be 5mm larger than the final size.

3.2.1.3 Double End Tenoning Operation:

This operation is done to keep the product components perfectly rectangular size that is strictly maintaining the same diagonal length due to Knockdown products. It is difficult to assemble any product properly without perfect rectangular size. This operation is done two sides of the component at a time. First tenoning operation must be in lengthwise and second tenoning operation will be widthwise. Due to some technical advantages and facilities this operation system is followed. Otherwise it is not possible to get perfect rectangular size. Two sets of sizing and scoring saw blades are worked in the both sides at a time. Both sizing and scoring saw blades rotate clockwise. Cutter is fixed but jobs move with help of the conveyer chain drives. Jobs pressed with rubber conveyer belt on the upper faced of the components. Another two operations are possible with DET machine, Groove cutting and rounding operation. Maximum and minimum width of components is 2300mm and 260mm respectively.

3.2.1.4 Band Saw:

Normally rough and irregular cutting operations are performed with the band saw. It is done only to reduce the extra cutting load and to make easy for the next operation. Band strip blade rotates with the help of the motor pulley and jobs feeding are done manually.

3.2.1.5 Routing Operation:

It is used to make various types of profiles as per design of the product. Rotating speed of the cutter of the copy router machine is very high compare to other furniture manufacturing machines. There are two types of router machines available in Otobi. One – jobs fixed but cutter or router bit moves manually as per profile of the product components. Here, air pressure is required to clamp the job with the help of clamping devices. Two- cutter fixed but jobs moves manually as per profile of the product components. But no need any air pressure

is required. Router bits shape and design as per functional activities. Tips of the router bit made with the tungsten carbide.

3.2.2 Edge Banding Operation: Two types of edge banding machines:

3.2.2.1 Profile edge-banding machine:

Profile edge banding operation is done by Profile Edge Banding Machine. Straight edge banding operation also possible with this machine. PVC edge banding material is used to band edge of the product components. Hot melt glue-120 is used as additive and heat is applied from 120^0 C to 140^0 C to melt the glue. The main function of this operation is to make water resist the component edge. PVC materials are available in various colors, which is decorative item. Edge banding material feeding is done with the help of pressure roller and glue has taken from glue roller. Then product component presses manually against edge banding materials to paste on edge of the components. After this operation, trimming operation is done to remove the excess edge banding materials from the edge. Air Pressure is required for pressure roller.

3.2.2.2 Straight Edge banding machine:

Only straight edge banding operation is possible in straight banding machine. Fully automatically operate to paste the edge banding materials. Product components move with the help of conveyer belt. There are several operations to finish the component such as pressing, milling, trimming, corner rounding, scraping and buffing operations. In this machine hot melt glue 180 is used. Required temperature is applied 180^0C to 200^0C. Air pressure is required. All operations are performed as per edging plan of the product.

3.2.3 Boring Operation: there are two types of boring machine:

3.2.3.1 Multi Boring (Big):

It is performed to drill the component as per boring plan of the product. There are two types of boring bits, blind bit for blind hole and through bit for through hole in various diameters are used to perform the boring operation. This is called the carbide bit. Boring operation is possible both in horizontally and vertically. Job is fixed during boring operation with the help of pressure bar. Air pressure is required for this purpose. Normally it is preferable for large components.

3.2.3.2 Multi Boring (small):

Small multi boring use for same purposes but it is better for small components. Horizontal and vertical operations are performed here. Another operation is possible in angle. Air pressure is required.

3.3 Planning of LB Products Processing:

The sales forecast are explained in details in the Sales & Marketing Department. From this Sales Forecasting, the Upper Management derives a production plan for the entire Year. Depending on the Yearly production plan, Planning Department of Laminated Board section makes a Monthly production plan and monitor the production. Currently the production planning for regular products is done on the following basis:

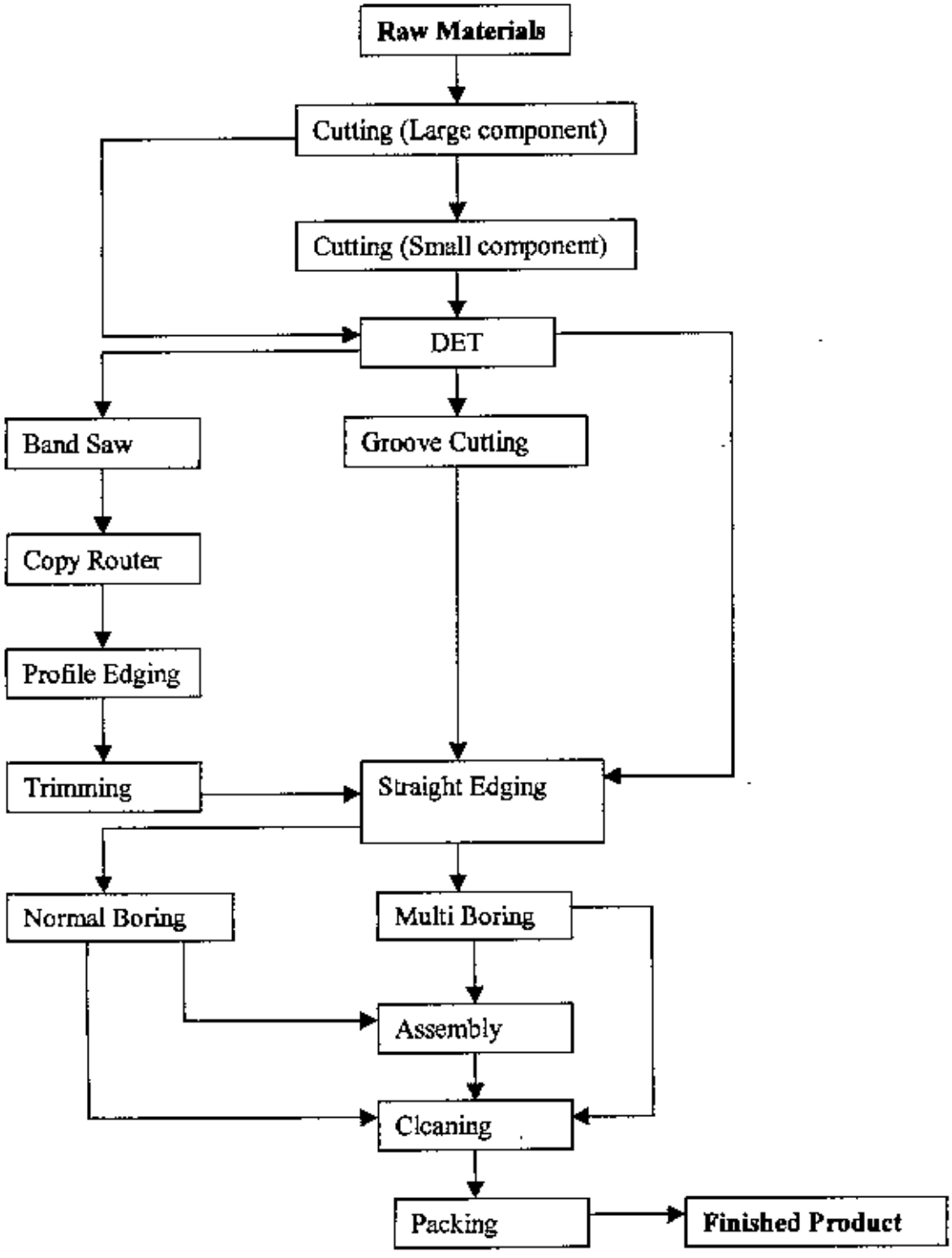
- Make- to – Order
- Make –To – Stock

There are many activities including for laminated Board furniture processing works. Without proper planning it is very difficult to perform any activities properly. We classified our planning works as follows:

- Raw Materials planning
- Modelwise product planning
- Bill of materials
- Costing Sheet
- Operation Plan
- Cutting Plan
- Boring Plan
- Check List
- Kit pack list

3.4 Process flowchart of LB Furniture

Production Process Flow Chart



3.5 Laminated Board Products

There are various types of Laminated Board Furniture are available in OTOBI. OTOBI makes furniture for different categories for different classes of customers such product lines are Home Furniture, Office Furniture, Furniture for Institution, Hospital Furniture etc. in this regards, we stated name of Laminated board furniture which are available in different colors, sizes and designs,

- Double Bed , Single Bed and Bed Side Cabinet
- Cupboard
- Wardrobe
- Dressing Table and Dressing Table Stools
- Reading Table
- Shoe Rack
- Book Shelves and Book Case
- Computer Table
- Executive Table and Sr. Executive Table
- Conference Table

3.6 Raw-materials of LB Products

There are various types of raw materials are used to manufacture Laminated board furniture. Key raw materials of laminated board furniture are Laminated chips board, MDF, Plywood, Block wood.

3.6.1 Laminated chips board

There are four types of laminated chipboard, these are melamine coated chips board, PVC coated chipboard, Resin coated chipboard and paper laminated chipboard. Melamine coated chip boards are the best quality and reliability among these board. Melamine coated boards are widely used in furniture manufacturing purposes. Melamine faced chip boards are produced in completely most modern state-of-the art technology. Melamine faces (sheets) are mechanically pasted on both sides of the board. In view to these reasons, we are described the unique features in below:

3.6.1.1 Unique features of melamine faced chipboard:

- Smooth, Neat and compact.
- Scratch, Chemical and Stain proof in normal use.
- Maintenance free board, no need to color and polish.

- Melamine board surface is water-resistant.
- Long lasting, no seasonal effect.
- Higher bonding, screw holding capacity.
- Multiple color options in beech, Grey, Graphite, Black, Cherry, Green & Blue.
- Available Sizes: 8'X6', 8'X4' in different thickness 6mm, 9mm, 12mm, 15mm, 16mm, 18mm, and 25mm

3.6.1.2 Utility & area of use of Melamine faced chipboard:

- Partition
- Shop Decoration
- Hospital furniture
- Kitchen Cabinet
- All Sorts of School, College, University, Home and Office furniture: like Almirah, bookshelves, Side Rack, Showcase, TV Trolley, Shoe Rack, Computer Table etc.

MDF (medium density fibre), Plywood, Blockwood are used Except melamine coated board.

3.6.2 Edge Banding Materials:

This raw material is used as decorative items and to make water resistance. Because in touch of water, chips board sucks water and loss it's strength and has become unusable. So it is used to save from water. It is found in different colors, sizes and thickness. Normally it is PVC materials.

3.6.3 Fixing Accessories:

As knockdown products, it is important to assemble at the end of customer. Various types of screw, Hinges, Channels, Stoppers are used as fixing accessories.

3.7 Machine used for LB Products Processing

3.7.1 Panel Saw:

3.7.1.1 Panel Saw Features:

- Heavy and rigid constructure to ensure high cutting accuracy and productivity.
- Standard equipped with scoring saw unit to obtain the best finishing cut on any kind of panel.
- Top pressure beam is designed of the pneumatic lifting system with visible linkages and combined with suction unit.
- Lifting and lowering of saw carriage is pneumatically controlled, the moving stroke if saw carriage by limit switch.
- Automatic machine is equipped with electronically controlled system with front loading device for stacks of panel and positioning pusher with grippers.
- The saw carriage rail is surface supported instead of weld-supported traditionally the stable support to ensure the longitudinal high cutting accuracy.
- The top pressure beam is drived by two pneumatic cylinders and it moves with the link bar connected to two racks and pinions. The movement will be simultaneously and the pressure will be even.
- Main saw blade and scoring saw blade is drived by one 10hp motor and one 3hp motor separately. This design makes the perfect cutting efficiently.
- In order to move the panel easy, the machine is equipped with phenolic surface on the working table.
- According to the panel length, the saw carriage runs the cutting stroke automatically. As long as cutting finish, the saw carriage return back soon. This design is to shorten time cost and raise the productivity.
- The dust extraction system is formed by the dust extraction groove being covered by two rubber strips to ensure perfect dust proof.
- The sectional safety cover actually prevents not only for wood dust/chips, but also for safety wise.
- The feeding system is controlled by servomotor to assure the high procession positioning.
- The error code and message will appear on the control cabinet display, the alarm light will be put off after eliminating the machine error.
- The machine equipped with jump scoring saw system for cutting postforming panels.

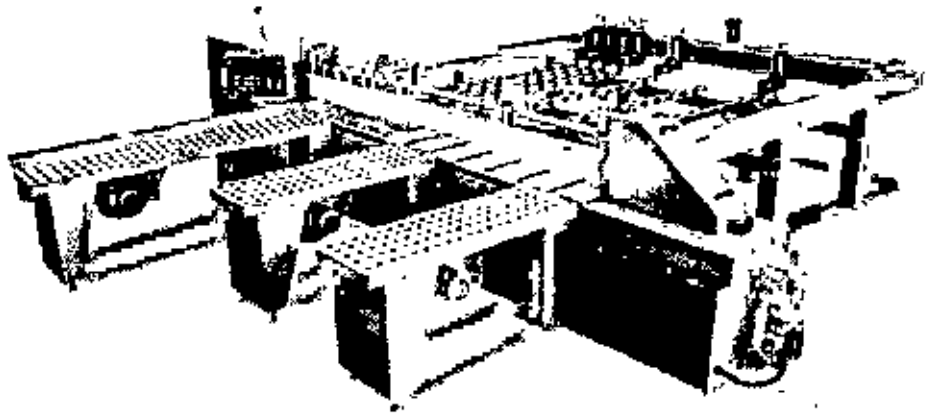


Figure 3.1: Panel Saw

3.7.1.2 Technical Data:

Sl#	Description	Unit	Size & Specifications
1.	Max. Cutting Length	mm	3200
2.	Max. Cutting Thickness	mm	80
3.	Main Motor Saw	HP	10
4.	Main Saw Blade Diameter	mm	355
5.	Main Saw Arbor Diameter	mm	40
6.	Main Saw Rotation	RPM	4800
7.	Scoring Saw Motor	HP	1
8.	Scoring Saw Blade Diameter	mm	180
9.	Scoring Saw Blade Arbor Diameter	mm	30
10.	Scoring Saw Rotation	RPM	7200
11.	Feeding Motor	HP	2
12.	Feeding Speed (Forward)	m/min.	17
13.	Feeding Speed (Backward)	m/min.	34
14.	Auto Feed Motor	HP	1
15.	Auto Feed Speed	m/min.	8
16.	Working Air Pressure	Bar	5-6
17.	Table Height from Floor	mm	850
18.	Net Weight	Kg	2400
19.	Gross Weight	Kg	2900

20.	Machine Size	mm	5590x6890x1850

3.7.2 Table Saw:

3.7.2.1 FEATURES

- It is very small in size like a working Table.
- Feeder roller is designed to feeding the jobs in the machine.
- The feeder roller is drived by one feeder motor
- Main saw blade and scoring saw blade is drived by one 3hp motor and one 1.5hp motor separately. This design makes the perfect cutting efficiently.
- The dust extraction system is formed by the dust extraction groove being covered by two rubber strips to ensure perfect dust proof.

Fig-3.2: Table Saw

3.7.2.2 Technical Data:

S#	Description	Unit	Size & Specifications
1.	Max. Cutting Length	mm	infinity
2.	Max. Cutting Thickness	mm	50
3.	Main Motor Saw	HP	3
4.	Main Saw Blade Diameter	mm	300
5.	Main Saw Arbor Diameter	mm	30
6.	Main Saw Rotation	RPM	4800
7.	Scoring Saw Motor	HP	1.5

8.	Scoring Saw Blade Diameter	mm	180
9.	Scoring Saw Blade Arbor Diameter	mm	30
10.	Scoring Saw Rotation	RPM	7200
11.	Feeding Motor	HP	2
12.	Feeding Speed (Forward)	m/min.	9 & 13
13.	Table Height from Floor	mm	750
14.	Machine Size	mm	1300x1120x1640

3.7.3 Double End Tenoner

3.7.3.1 FEATURES:

The DET series Double End Tenoner is designed for those factories that manufacturing panel and / or solid wood furniture. The DET series feature of sequence range for mass production and possibility for sizing, cutting, hogging, trimming, squaring, tenoning, moulding, rounding, sanding, chamfering and grooving. The working stock of the DET series is no limit for longitudinalwise. The working width can be of min. for 260mm-upto max. For 2300mm. The working thickness concerned is standard with 60mm.

Heavy and rigid constructure to ensure sizing, squiring and tenoning with high precision and productivity. The bed carrying with high precision linear guide way to get perfect parallel at x-axis. Feed chain track system is enriched with precision track linkage, which mounted withdust-proof and free lubricated needle bearing to ensure perfect parallel at y-axis. The high precision linear guide way + feed chain track to form the double crisscross movement to guarantee squaring. High accurate needle bearing mounted in precision chain track linkage for dust-proof and free lubrication for 5 years.

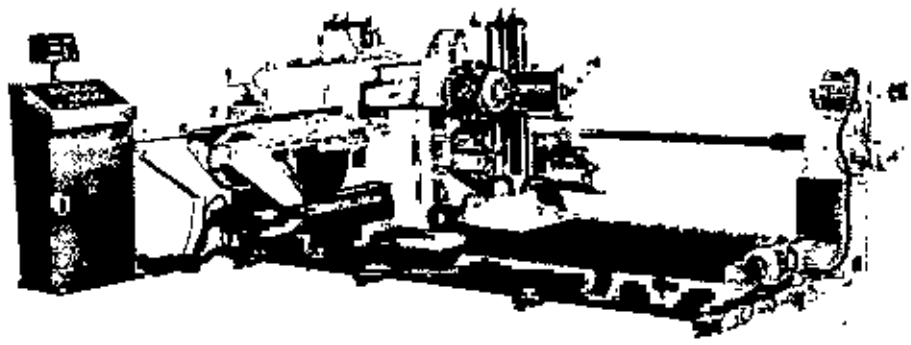


Figure 3.3: Double End Tenoner

3.7.3.2 TECHNICAL DATA:

Sl#	Description	Unit	Specifications
1	Max. Working Width	mm	2300
2	Min. Working Width	mm	260 (on both side)
3	Min. Working Width	mm	120(on one side)
4	Max. Working Thickness	mm	60
5	Scoring Saw Unit	HP,RPM	2 HP x 2 at 3450 RPM
6	Main Saw Unit	HP,RPM	5 HP x 2 at 3450 RPM
7	MouldingUnit	HP,RPM	5 HP x 2 at 6000 RPM
8	Feed Motor	HP,RPM	2 HP at 6-24 m/min(Variable)

3.7.4 Band Saw:

3.7.4.1 FEATURES

The model of the Band Saw is Centauro. Band strips are rotate with the help of wheel, which is equipped with motor pulley. In this machine, smooth cutting edge is not possible.

3.7.4.2 TECHNICAL DATA:

Sl#	Description	Unit	Specifications
1	Table Area	mm	1200x1200
2	Panel Length	mm	60 to infinity
3	Panel Width	mm	Any size
4	Panel Thickness	mm	10 to 100
5	Band Saw Width	mm	10 to 40
6	Band Saw Length	mm	4870 to 4970
7	Band Saw Thickness	mm	0.6
8	Rotating Speed of Wheel	R.P.M.	765
9	Power Required	K.W.	5.5
10	Net Wt.	Kgs	300

3.7.5 Copy Router:

3.7.5.1 FEATURES

This is the very high speed machine among the others wood working machines. It is specially designed to bear the working load. Model is Bermaq. This is used to make profile according to design features of the product components. Router bit is guided by the strip, which connected with motor.

3.7.5.2 TECHNICAL DATA:

Sl#	Description	Unit	Specifications
1	Table Area	mm	2500x1200
2	Panel Length	mm	1500
3	Panel Width	mm	1120
4	Panel Thickness	mm	10 to 50
5	Air Pressure	Bar	6
6	Rotating Speed	R.P.M.	18000 to 22000
7	Power Required	K.W.	3.75
8	Collate Diameter	mm	10
9	Router Bit diameter	mm	3 to 60

3.7.6 Profile Edge Banding Machine:

3.7.6.1 FEATURES

Model of profile edge banding machine is Marmuka. It is designed for gluing edges of PVC, melamine or veneer on straight, round or shaped panels with hot melt glue 120^0. However, it is enriched for edging ABS or solid lipping up to 3mm thickness which to be cut to size by a reinforced pneumatic knife.

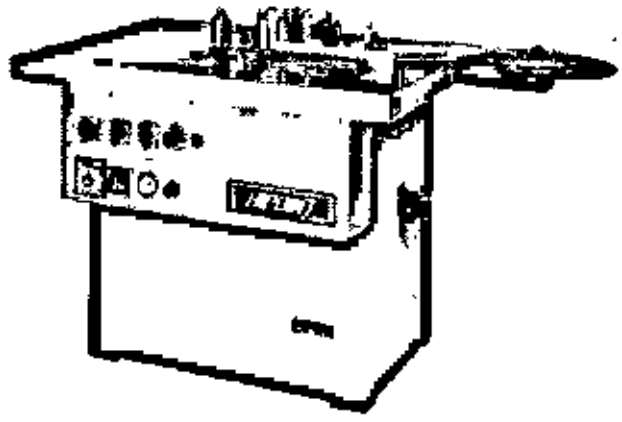


Figure 3.4: Profile Edge Banding Machine

3.7.6.2 TECHNICAL DATA:

Sl#	Description	Unit	Specifications
1	Table Area	mm	1100x800
2	Panel Length	mm	Min. 160 to infinity
3	Panel Width	mm	Min. 65 to infinity
4	Panel Thickness	mm	10 to 50
5	Edging Thickness	mm	0.4 to 3
6	Glue Pot Capacity	Kgs	3
7	Heating Element	K.W.(H.P.)	1.8 (2.4)
8	Feed Speed	M.P.M.	10/15/20
9	Power Required	K.W.(H.P.)	0.75 (1)
10	Weight N.W. (G.W.)	Kgs	350 (450)
11	Machine Size	mm	1520x800x1000
12	Packing Size	mm	1720x910x1190

3.7.7 Table Trimmer:

3.7.7.1 FEATURES:

The table trimmer is used to remove excess edge banding materials from finished components, which edge banding is completed in the profile edge-banding machine. This is very small and simple machine. Two trimming cutter is equipped in the machine.

Figure 3.5. : Table Trimmer

3.7.7.2 Technical Data:

Sl#	Description	Unit	Specifications
1	Table Area	mm	1100x800
2	Panel Length	mm	Min. 160 to infinity
3	Panel Width	mm	Min. 65 to infinity
4	Panel Thickness	mm	10 to 50
5	Edging Thickness	mm	0.4 to 3
8	Cutter Speed	R.P.M.	11200
9	Power Required	K.W.(H.P.)	0.75 (1)

3.7.8 Straight Edge Bander:

3.7.8.1 FEATURES

Model of the Straight edging machine is Optimat KD-67 .This linear series are designed for edging straight panel with hot melt glue 180^0 by through feed system, which consists of top pressure rollers, and bottom feed chain. The edging material can be of PVC, melamine or veneer in strip or coil. Solid lippings with a maximum thickness of 20mm are also applicable.

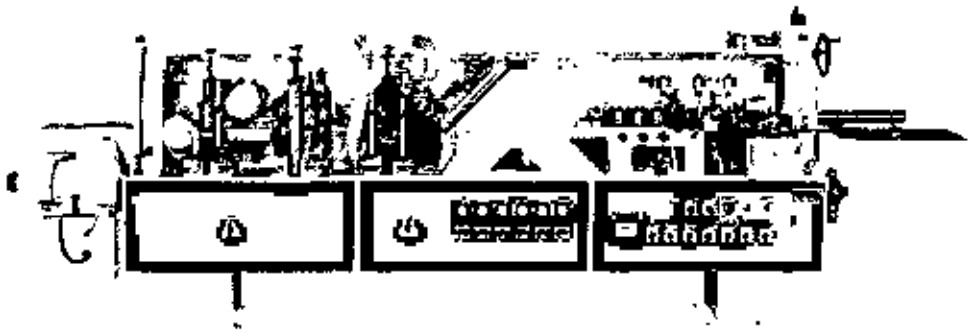


Figure 3.6: Straight Edge Banding Machine

3.7.8.2 TECHNICAL DATA:

Sl#	Description	Unit	Specifications
1	Table Area	mm	5150x1525x2135
2	Panel Length	mm	Min. 140 to infinity
3	Panel Width	mm	Min.55 to infinity
4	Panel Thickness	mm	10 to 60
5	Edging Thickness	mm	0.4 to 3
6	Glue Pot Capacity	Kgs	4
7	Heating Element	K.W.(H.P.)	1.8 (2.4)
8	Feed Speed	M.P.M.	10/15/20
9	Power Required	K.W.(H.P.)	1.5 (2)
10	Weight N.W. (G.W.)	Kgs	1300 (1510)

3.7.9 Multi Borer (Big) :

3.7.9.1 FEATURES

Rational designed structure, advanced technology adopted, to be operated and adjusted conveniently and working steadily and reliably. And correct making precision and high efficiency.

This machine tool is able to finish drilling horizontally and vertically at a times. There are five gangs drilling vertically lower face of the work piece and two gangs drilling on upper face of the work piece. Horizontal drilling is done from both sides of the work piece. This machine tool is operated automatically by PLC during the course of work, loading clamps and supplying blades are controlled fully pneumatically. Need air pressure about 7 bar. Which is fairly suitable for dense process of the wood pieces with multi-ranges and holes on a large scale and batch, especially those required with top technology.

Figure 3.7 : Multi Boring machine (Big)

3.7.9.2 Technical Data

1. Maximum diameter of drilled holes : 35mm
2. Maximum depth of drilled holes : 60mm
3. Max. Center Distance between first and last spindle: 3500x 1500mm
4. Min. Center Distance between first and last spindle: 180x 32mm
5. Total Gangs: Type A: Five, Type B: Two, Type C: Two
6. Total collet: Type A: 24x5bits, Type B: 50x2 bits, Type A: 30x2bits
7. Fitting Diameter of drill joints : 10mm
8. Pressure of compressed air: 7 bar.
9. Fitting motor power: Type A:P=1.5KWx 5, Type B:P=1.5 KW x 2 Type C:P=1.5 KW x 2
10. Conveyer Belt Motor: 1.5 Kw X 1

3.7.10 Multi Borer (Small) :

3.7.10.1 FEATURES

Rational designed structure, advanced technology adopted, to be operated and adjusted conveniently and working steadily and reliably. And correct making precision and high efficiency.

This machine tool is able to finish drilling tens of holes in three ranges through only once adjustment and the single head also can be revolved from 0- 90 degree. Finishing drilling holes in any direction as required.

This machine tool is operated semi-automatically during the course of work, loading clamps and supplying blades are controlled fully pneumatically. Which is fairly suitable for dense process of the wood pieces with multi-ranges and holes on a large scale and batch, especially those required with top technology.

Figure 3.8: Multi Boring Machine (Small)

3.7.10.2 Technical Specifications:

1. Maximum diameter of drilled holes: 35mm
2. Maximum depth of drilled holes : 60mm
3. Max. Center Distance between first and last spindle: 1600x 640mm
4. Min. Center Distance between first and last spindle: 180x 32mm
5. Total Heads: Type A: Three, Type B: Five

6. Total spindles: Type A: 21x3bits, Type B: 11x4+22x1 bits
7. Fitting Diameter of drill joints : 10mm
8. Pressure of compressed air: 0.5-0.6Mpascal
9. Fitting motor power: Type A: P=1.5KW x 3, Type B: P=1.5 KW x 5

3.7.10.3 Safety operation Rules:

1. Those who are appointed to operate the machine should be adults trained in this line.
2. Before starting the machine operators are read the instruction carefully and remember the main points of operation.
3. Operators should wear working uniforms, shoes and caps trimly. And long hair wrapped in the cap. In case of inflnencing oporation and emergence of accident because they are shaved or taken by the motive components of the machine.
4. This machine is only fit for processing wood. Never do any other things, such as metal etc.
5. Avoid processing over-long, over-large and over-small pieces, and those with big curvature ones as well.
6. Keep working spots bright, make sure that there are no obstacles and 0other useless things on the machine.
7. Strictly forbid those who are sick, drunk, absent-minded etc. to operate the machine.
8. While the machine is working, operators mnst concentrate their minds, stick to their positions and operate carefully and exactly.
9. Non-operators are forbidden to stay about the work places.

3.7.11 CNC Machine:

3.7.11.1 FEATURES:

CNC means Computer Numerically Controlled machine. Actual name of this CNC machine in Wood processing industries is CNC point to point wood processing machine. There are five operations are possible in this machine such as Cutting Operation, DET Operation, Grooving Operation, Routing Operation and Boring Operation. There has a software 'Woodwop' which is used to design and input all activities of these operations through Computer. So, it is most nseful to design any complicated and sophisticated drawing easily and accurately. There is a control units to control the machine with PLC-CPU.

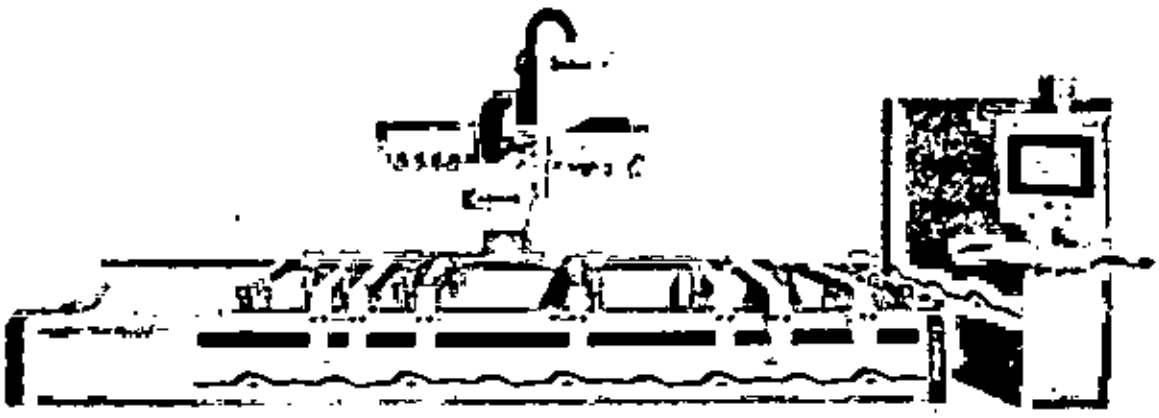


Figure 3.9: CNC Machine

3.7.11.2 TECHNICAL DATA:

S#	Type	Description	Units	Specifications
1	Space Requirement	Length	mm	5250
		Width	mm	3310
		Height	mm	1970
2	Supporting Table	Length	mm	2750
		Width	mm	1050
		Panel Thickness	mm	50
3	Positioning Range	X-Axis	mm	3105
		Y-Axis	mm	1370
		Z-Axis	mm	135
4	Speed	X-Axis	m/min.	60
		Y-Axis	m/min.	50
		Z-Axis	m/min.	20
5	Pneumatic	Standard Compressed Air Quality according to ISO 8573-1	Quality Class 3	
		Connection	Inch	R 1/2
		Pressure in the feeding pipe line	Bar	Min. 7
		Air Consumption NL/Cycle/Side		CA 10 NL

6	Dust Collection	Suction Connection	mm	Dia.200
		Total Dust Extraction Capacity		
		Air Velocity	M/sec	Min. 28
		Loss of Pressure	Pascal	Min 2000
7	Electrical	Operating Voltage	Volt	400
		Frequency	Hz	50/60
		Nominal current approx.	Amp.	21
		Recommended Fuse	Amp.	25
		Total Connected Load Approx.	KW	11.5
8	Loading Measure	Length	mm	5400
		Width	mm	2300
		Height	mm	2250
9	Foundation	Weight of the machine Approx.	Kgs.	3150
		Surface pressure in the point of support	N/mm^2	1.20
		Min. Concrete Thickness	mm	200
		The foundation has to be Ground level		

3.7.12 Post Forming Machine:

3.7.12.1 FEATURES

Forming of the surface material and pressing onto the workpiece is carried by means of a flat electrically heated and pressurized moveable bar. This forming bar brings the surface material up to the necessary forming temperature by means of contact heat. The bar automatically follows the shape of the relevant profile, applying a constant even pressure and glues the surface material to the workpiece. Processing a wide variety of surface materials decorative laminates real wood veneers, PVC paper and finish foils. All formable laminates possibilities for universal application economical production of individual or series workpieces. A wide variety of profiles and radii without the need for jigs quick resetting times setting in minutes without special tools. It is reliable gluing with PVC or Urea glues. The pressure bar adapts to every positive profile, guaranteeing reliable gluing even in the difficult places. Simple to use bending process carried out automatically.

3.7.12.2 TECHNICAL DATA:

S#	Description	Unit	Specifications
1	Table Area	mm	4800x1000x2270
2	Panel Length	mm	2400
3	Panel Width	mm	100
4	Panel Thickness	mm	16 to 200
5	Forming Panel Radious	mm	10 to more
6	Heating Time	Sec.	30 to 120
7	Heating Element	Amp	15
8	Pressure Required	Bar	6

3.8 Cutter used in Machine:

There are different types and brands cutters & tools are used in furniture processing industries especially in wood and laminated chips board furniture processing industries. Mainly Tungsten Carbide Toots are used. Worldwide available branded are **Leuco, freud, ABC, Virutex** etc. Precision's Cutters and Tools are most important to obtain higher productivity and quality products.

3.8.1 Tips for a correct use of a Saw blade:

To obtain the best performance from a saw blade to follow these simple instructions:

- The machine must be in good conditions, free of vibrations.
- The flanges used to secure the blade must be of the same diameter, at least 1/3 of the blade's diameter.
- The flanges must be parallel to each other. Also, check tolerances on diameters, sides and concentricity, by using a clock gauge.
- The spacers must be perfectly parallel.
- The spindle must be perfectly straight and with an tolerance.
- After continuous use, remove the blade and clean it, making sure to get rid of resin build up with the appropriate solvents. For the Teflon coated blades it's sufficient to worm water. In any case, avoid using solvents containing caustic soda.
- The blades must be sharpened as soon as they become dull, maintaining the original tooth angles.
- For sharpening, always use the correct grinding wheels and plenty of cooling liquid.

- Maximum reboring of the blade is 20mm of the original bore size. Above this value, the blade will loose its original tuning and overall performance will be affected.
- Always keep spacers and flanges clean.
- When sharpening, the shoulder of the teeth must not be lowered more than needed. This operation must be done with appropriate precision machinery and never by hand. There is the risk of breaking the tip or upsetting the blade balance.
- On ripping machines, the feeding track must be leveled with fixed table.
- Before starting the cut of the material, make sure the blade is correctly locked according to the machine's specifications.

Router Bits are designed and manufactured to the highest quality and with the finest materials. The tips are made of special micro-grain carbide for long life and a better finish. Anti-kickback design is an added feature to make these bits exceptionally safe to use.

Cutterheads, Brazed cutters, Knives, Spurs Blank Tips are new quick and effective locking system which prevents the risk of accidental breakage or expulsion of the knives. Resharpenable knives 3-mm thickness knives can be resharpened up to 6-8 times. Hook and shear angles are expressly studied to achieve the best finish.

3.8.2 Cutting Speed:

Cutting Speed means surface speed of the cutter. Cutter, Tools or Blades are designed with different cutting speed depending on the different types of hardness of the materials. So it is very important to follow the following chart during cutting operation to increase the tool life and proper operation of the machines.

3.8.3 Feed rate per tooth:

Feed Rate per tooth means amount of materials to be cut by per tooth. It is designed depends on the hardness of the materials. Normally it will be high for soft materials and low for hard materials.

3.8.4 Chip Thickness:

Chip thickness means size of the chips to be removes from the materials during cutting operation. Chip thickness fully depends on cutting speed and Feed rate of the materials.

Table 3.1:Cutting Speed in Various Materials:

Materials to be Cut	V_c (m/s)	s_z (mm/tooth)	h_m(mm)
Softwoods	60-100	0.10-0.20	0.20-0.40
Hardwoods	60-100	0.03-0.08	0.40-0.60
Exotic woods	50-85	0.03-0.08	0.60-0.80
Veneers	70-100	0.03-0.10	0.10-0.40
High-density plywood	40-65	0.03-0.08	0.30-0.60
Compressed woods	40-65	0.03-0.08	0.40-0.60
Panels veneered on two sides	60-90	0.03-0.10	0.10-0.40
Plywood	50-80	0.05-0.25	0.30-0.60
Raw particle board	50-80	0.05-0.25	0.35-0.80
Hardboard	50-80	0.03-0.08	0.20-0.60
Softboard	60-100	0.10-0.20	0.20-0.40
Plastic laminated panels	60-80	0.03-0.06	0.35-0.80
Particle board	60-80	0.05-0.25	0.35-0.80
MDF	60-80	0.10-0.20	0.20-0.40
Laminated particle board	60-80	0.05-0.25	0.35-0.80

3.8.5 Formula for Cutting Speed Calculation:

$$\text{Cutting Speed, } V_c = \frac{d \times \text{pie} \times n}{1000 \times 60} \quad \text{(m/s)}$$

Where,

d = outer diameter of the cutter

n = revolution per minute of the cutter

Feed rate per tooth = s_z (mm/tooth)

Chip Thickness = h_m (mm)

3.8.6 Tool Operation:

Up Cutting Work: Usual method of operation. Cutting motion of the tool and the relative feed motion of the work run counter to one another. Cutting does not start as soon as the wood makes contact with the edge. But only a short distance thereafter. The edge will scrape and push within this area and cutting proper begins subsequently, producing a stretched-out chip with a thickness increasing towards the outlet. The up cut method only is permitted for hand feeding.

Down Cutting method: The cutting motion of the tool and the relative feed motion of the work are unidirectional. Cutting starts when the edge hits the work, producing a compact chip with a thickness decreasing towards the outlet. Suitable for mechanical feeding only.

3.9 Instrument & Software used in Furniture Industry

No need any high precision instruments for the Laminated Board furniture manufacturing industries. The following equipment is used for furniture industries.

- Vernier calipers
- Measuring tape

Software's are:

- OTOBI MIS used in Central Distribution Center
- LB MIS used in Laminated Board Section
- Matrix under installation and testing for ERP.

3.10 Quality Control Activities in LB Furniture Industry

During production process, the products go through various stages of production. A quality inspection after every stages of production and thus only the quality passed items goes into the next stage of production and the rejected items are kept separately. The quality parameters for the inspection procedure vary from product to product and depend mostly on the nature of the product. Each quality parameter has standard value, which varies from item to item.

In Otobi, there has no any separate quality control or quality assurance department to maintain the product quality. Quality related all activities are performed by the production department personnel. As a result it is very difficult to maintain the quality of the product. There has no any quality record for the future:

Chapter-4

Demands of Furniture

4.1 Demand of Furniture

Furniture is the most important part of life of human being. Demands of furniture in worldwide are always constant. It may be varies in different countries depends on style and taste of the customers. No one can continue his life without any touch of furniture such as home, office, hospital, institution etc. So, demands of furniture never are decline and moreover, it will increase day by day with the development of the economic condition of any country. There are lots of opportunities to earning of foreign exchange from the furniture industries in Bangladesh to meet up our local demands. The economic potential of these resources in terms of value addition, export earning and employment still remains unutilized for lack of appropriate processing and product diversification.

Furniture Industry can participate in Major economic activities in Bangladesh. Because furniture is one of the basic needs of human being. There is a big scope to earn foreign currency to export furniture all over the world like Garments, Textiles, Leather, Tea, Jute etc. We can enter into the global market to fulfil our national demands of furniture. There is a big market in U.S.A., Canada, Australia, Europe and Middle East. We need to promote worldwide.

Competitive pressures in Bangladesh furniture industry are pressing manufacturers to look outside the Bangladesh for new markets. Several trends within the industry point toward an increasingly competitive environment. Sales have been increasing day by day, consolidation among a smaller number of large firms are dominating shipments and product brands within the industry, low profitability is low as evidenced by low after tax returns on sales, and advances in production technologies are increasingly important but costly for smaller firms.

4.2 Export

The demand of furniture of OTOBI in Bangladesh is great. This is the first established of branded furniture manufacturer in Bangladesh. Now OTOBI has started to export furniture to foreign country, especially in India. OTOBI has begun to campaign from Northwest portion of India i.e. Tripura, Gohati. Recently, OTOBI has been participated in the Trade fair of Kalkata, January 2005. The objective of OTOBI is to save our forest. The laminated board furniture has replaced wooden furniture of urban society. OTOBI manufactures various types of household furniture which includes bed, dressing table, computer table, reading table, showcase, cupboard, bed side cabinet, dining table, chair etc. not OTOBI manufactures household furniture but also it makes office

Table-4.1 : Export Report of OTOBI for the Year 2004 & Year 2005

Sl#	Month	Year	Export	Amount in $US	Remarks
1	March	2004	India	22540	
2	April	2004	India	31250	
3	May	2004	India	12540	
4	June	2004	India	16580	
5	July	2004	India	26590	
6	August	2004	India	25120	
7	September	2004	India	17225	
8	October	2004	India	34260	
9	November	2004	India	35620	
10	December	2004	India	45050	
11	January	2005	India	25890	
12	February	2005	India	39250	

Data source: This report has collected from the export report of the marketing department. This is report of OTOBI limited, which indicates the monthly export amount in $US dalars only in India. It is easy to understand there is big furniture market in India.

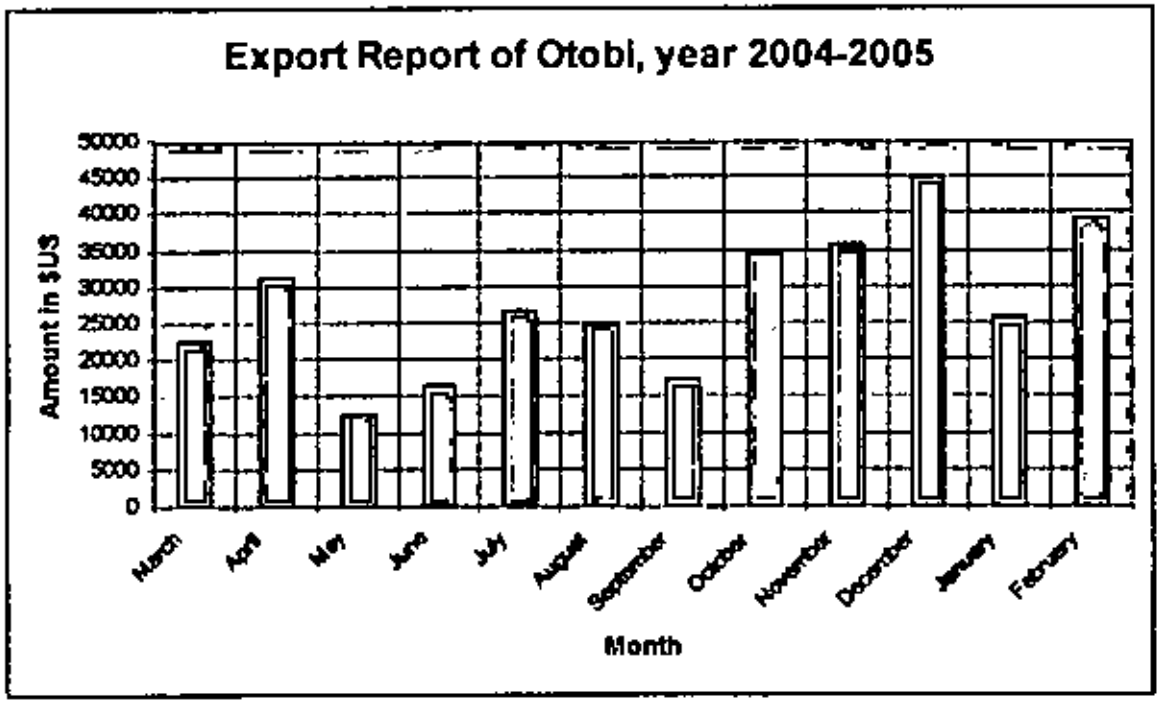


Figure 4.1: Chart of Export Report of Otobi for the Year 2004-2005 in India.

We could not collect the actual export figure for Bangladesh to compare the present export conditions. But if we look at the export report of Otobi, it is clear that there are lots of opportunities to export. We need proper guideline from the government to promote the export.

Export markets can provide an outlet for future growth for furniture manufacturers. One of the highest concentrations of furniture companies in the nation is located in Dhaka City. The furniture industry in this region has a number of advantages—it is strategically located center of major wood and suppliers, it has a good reputation for traditional styles of furniture, and it is home to a domestic trade show or fair that attracts international attention. There is some evidence that the region's furniture manufactures are starting to take advantage of export opportunities—but at a lower rate than the industry nationally.

The industry has not fully realized its potential to export. Executives in the furniture industry are optimistic that exporting increase. Yet firms are reluctant to aggressively seek out foreign markets. The main furniture manufacturer's association in the Bangladesh has virtually no export promotion programs. Few companies in Bangladesh have full-time export managers

who travel abroad, seek foreign distributors, or attend overseas trade shows. Export sales of the industry's top few firms are, on average, three to five percent of total sales. Many firms export in a reactive manner by "order-taking" from the growing number of foreign buyers who attend the Bangladesh furniture shows.

Given the scale and capacity of the industry, its strategic location near quality, wood-based raw materials, and its utilization of advanced production methods, it is surprising that exports have not been greater. There are two critical problems impeding the growth of exports and accompanying growth in employment: (1) lack of skilled workers to run advanced woodworking equipment, and (2) lack of active, internal export systems within the firms. To help furniture industry grow, demonstration projects should be initiated within this cluster to assist firms with cooperating on worker training and export development.

Qualitative change in export earnings of furniture industries is found in the last few years. Exports of wood furniture as well as metal and cane furniture including laminated board furniture significantly increased. Although it is limited within the few furniture industries like Otobi Limited, Akhter furnishers, Hatil Furnishers Proficy Furniture industries etc. Because they always maintain quality of product and give better performance. Table-4.1 shows the export performance of the furniture of Otobi Limited in India.

We should adopt new technologies and techniques to the furniture industry so that we can use mass production methods for our customized products. CNC machinery and other advanced machinery's are install for large and mid-sized firms. The single most important obstacle to growth—noted by every respondent—was skilled labor shortages. They cannot use new technologies effectively without skilled employees to operate them. Some firms noted a shortage of workers altogether, regardless of skills. Others were concerned about high labor turnover rates. Workers will move to other local manufactures in the same or related industry within the cluster area for higher pay.

- promotional furniture has an element of being "cheap" while overseas customers are looking for attractive style furniture that is quality oriented and higher priced and
- Upholstered furniture is difficult to export because its bulk makes transportation costs high. But it is easy to transport laminated board furniture due to knock down products.

We should offer value to our customers by selling quality furniture at low prices. The survey also revealed an interesting industry practice with respect to quality versus price. The same products sold through promotional channels can also be sold to higher-end markets. But firms making promotional items are unable to enter these markets alone because of high costs of marketing, advertising, and sales promotion needed to establish their own product image and brand. As in the domestic market, export markets offer opportunity for all types of products sold at different price levels. Because of rapid economic growth, upwardly mobile consumers with rising income are able to purchase reasonably priced furniture.

Majority investors agreed that exports are "important" or "very important" to the industry's future. Most firms had not received export assistance, did not seek out information about exporting or export service providers, and were generally unfamiliar with the availability of export services.

- the top two competitive advantages of the industry are product design and price;
- the main barriers to exporting are (1) lack of market information, (2) product specifications, transportation costs, and (3) export procedures; and
- to increase exports, owners must be committed, have dedicated export staff and budgets, travel to foreign trade shows, and improve product quality and price.

There are three obstacles to overcome before a real shift in export development can occur.

- **The skill levels of the existing work force must be raised.** Companies are using more advanced machinery and production methods, but cite a strong need for skilled workers trained to run the machinery. This is essential to stay competitive on the domestic market and the export market.
- **More skilled and more committed workers are needed.** More youth have to be encouraged to pursue technical employment opportunities in the industry and more companies have to find ways to reward and involve workers in ways that build loyalty.
- **Firms need to transition from the passive (order-taking) export sales approach, which is commonplace to a more aggressive stance.** Companies must hire export specific staff and provide them with a budget to seek out foreign markets, attend trade shows abroad, and identify and establish distribution networks.

4.3 Suggestions:

The industry is ripe for cooperation and networking. We can take initiatives in the two areas of export development and worker training would be well received by the industry. The survey highlighted several facts that support this statement.

- The firms were not proactive exporters now, but see it as a future opportunity. The firms that had full-time export managers were doing better than those that did not have one.
- The firms were not cooperative now evidenced by the low level of trust, but they would be willing to do so in the areas of technical support and export development among non-competing firms.
- The industry has several "export" advantages including close access to wood based raw materials and other components, a growing reputation overseas for quality craftsmanship in furniture, an abundance of product design and production capabilities, and a large number of firms that are flexible enough to introduce new product lines twice per year at the domestic trade shows.
- Lack of skilled workers and the need for training on advanced manufacturing equipment and accompanying production systems was a barrier to growth.

Export promotion, which provides more market information, foreign product specifications, and access to foreign trade shows, was a primary need.

- Evaluate the need, feasibility, and cost for a major, regional export promotion service at the industry level.
- **Conduct new market research** which profiles overseas furniture markets distributor profiles, product specifications, and retailing trends.
- **Target and promote the use of existing export financing programs** specifically to furniture companies that have export potential.

Chapter-5

Data collection & Model formulation

5.1 Mathematical Model:

The mathematical model for this research work consists of some variables such as monthly production of any products, objective function is to maximize profit of that products which will provide as variables in a mathematical model. To fulfil mathematical model, we will collect few data like expected processing time in each machine for each product and actual machine hours available processing those products. Compete mathematical model is explained step by step in the following sections.

5.2 Assumptions

We have considered few assumptions in order to simplify the formulation of mathematical models.

5.2.1 Classification of the Product

We have considered the laminated Board furniture as fast moving products, medium-moving products and slow moving products depending on sales report of the marketing department. In the proposed production planning, we have considered that production of the fast moving products may be double of the present stock, production of the medium moving products may be one and half of the presents stock and production of the slow moving products may half of the present stock. According to sales trend of those classified products, we have considered the profit as follows:

- For fast moving products profit is 25%
- For medium moving products profit is 20%
- For slow moving products profit is 15%

This assumptions has taken depends on the production cost of the products. The number of fast moving product is produced more than one hundred pieces. But for medium and slow moving products, it is below hundreds and below fifty respectively. If we increase the product lot size, production time decreases and also production cost also decreases.

To make a comparison between present production planning system and proposed production planning (model production) system, we have considered the production data from June, 2004 to December, 2004 of Laminated board section-2 of Otobi Limited.

5.2.2 Expected processing time

Previously Expected-processing time in all machines for all products of laminated Board furniture section has been calculated by industrial engineer to proper planning of the production. We have collected those data of the expected processing from the planning department to implement in the proposed production (model production) planning of the research work. For an example and clear explanation, we have discussed in a short about the technique of the calculation of the expected processing time in the following section.

5.3 Motion & Time Study of Laminated Board Section

Time is very important to an Industry. It is very often said, "Time is Money". Hence proper utilization of time is the key to have success in a factory. To make best use of time and to increase efficiency of workers we have to know how much time they take in operations and how should be needed. The second one can be known from MTM standard but we have to find out the first one. Here we are assigned to find out the first one and to compare with the second.

5.3.1 Key Content

- MTM
- Some assumptions
- Cutting time & comparing variable time with standard time.
- Remarks
- Detail Calculation

5.3.2 MTM

MTM refers to motion time measurements. In industries it is known as THERBLIGs. Machine processing time is constant for an operation and varies depending on machine quality. Hence for a given machine there is a little scope to improve. Here we can shorten total processing time increasing workers' efficiency i.e. decreasing time for each movement.

According to B.M.T. (Basic Motion Study) the basic motion identified are of major two kinds with subdivision:

- Arm, hand, and finger motion
  - ♣ *Reach*
  - ♣ *Move*
  - ♣ *Turn*
- Body motions

1. Foot motion	*7. Leg motion*
2. Sidestep	*8. Bend*
3. Stoop	*9. Kneel*
4. Arise	*10. Sit*
5. Stand	*11.Turn body*
6. Walk	*12.Eye motion*

5.3.3 Some assumptions

The various types of motions are performed within so short time that we can't measure them with out motion picture camera. Hence we make some assumptions like:

- ***Grab:*** Reach to the job and touch it.
- ***Lift:*** Lift the job and carrying it to the working place.
- ***Unloading:*** After operation keeping the job into work in process inventory.

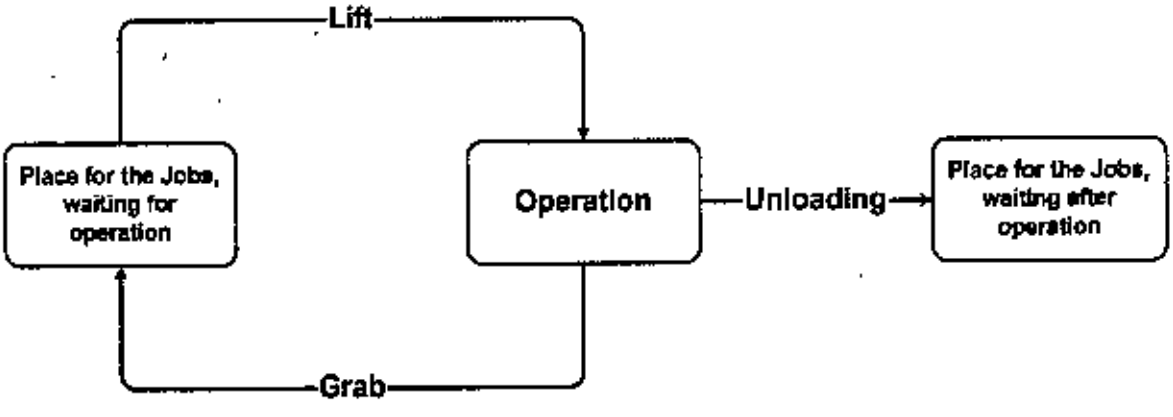


Figure 5.1: Technique of Loading and Unloading of the materials

5.4 Time measurement for Panel Saw:

5.4.1 Panel Saw

Measuring expected processing time in Panel Saw is very difficult because of large product variation and time consuming to measure each product. We have grouped number of products of close length and number of pieces to be cut. We have taken data of some standard operation and calculated standard time of various products. Now by this procedure the standard time is calculated by us and it is compared with practical observations.

We have measured the expected processing time of Dressing Table, model-DDZ14G to explain the method of time study measurement.
To cut a laminated board it needs material handling. The process is to calculate the time for,

- Initial material handling
- Intermediate material handling
- Final material handling
- Cutting

Formula for time measurement:

- Standard time = material handling time + material cutting time
- Material handling time = (initial + intermediate + final) material handling time
- Material cutting time = push & pull + push bar down + cutting time + push bar up)

Time calculation for mirror back of DDZ14G, Size: 1802x562mm, cutting from laminated board, size: 2440x1830x18mm. (Two pieces board per cut). Step by step observations and calculations shown in the following:

Table-5.2: Calculation of material handling time

No. of observations	Material handling time in sec.			Total
	initial	intermediate	final	Time in sec.
1	40	20	18	
2	35	22	19	
3	35	23	29	
4	30	18	22	
5	35	17	24	
Avg. time in sec.	35	20	24	75

Cutting time: to cut a required length there are some operations. They are

- Push & Pull
- Push bar Up
- Push bar Down

Table-5.3: Calculation of Push bar movement time

No. of observations	Push bar movement time in sec.			Total
	Push & Pull	Push bar Down	Push bar Up	Time in sec.
1	10	6	6	
2	8	6	6	
3	6	6	6	
4	7	6	6	

5	9	6	6	
Avg. time in sec.	8	6	6	20

Table-5.4: cutting time

observations	Cutting length in mm	Required time in sec.	Cutting time In sec/mm
1	1830	10	
2	1830	9.58	
3	1830	10.02	
4	1830	10	
5	1830	9.98	
Avg. cutting time		10	.00546

Material handling of laminated particleboard is a heavy work. So, we have considered the fatigue is 20%.

Standard time for material handling = 75x1.2 = 90 sec.

Cutting time = (20÷1830x0.00545) x 2 + (20+1802x0.00545) x 4 = 180sec.

Standard time = 180+ 90 = 270sec.for three pieces mirror back

Standard time for single piece = 90 sec.

Table-5.5: Standard processing time in seconds for one piece DDZ14 in different machine:

Components	Qty.	Machinewise time in sec.										
		PS	TS	DET	BS	CR	PE	TT	SE	MB	NB	CNC
Mirror Back	1	47		26			90	72				150
Side (M/R)	2	31		14					19	45		
Top(small)	1	12		13	62	75	45	35				52
Top(large)	1	15		15	85	112	48	43				67
Side(L)	1	15		11					9	42		
Shelf-1	1	16		11					4	31		
Shelf-2	1	16		10					4	32		
Bottom	1	19	11	10					5			65
Bottom Bit	2		20	7					5		52	
Dr. Front	1		13	7					7		85	
Dr. Side	2		10	7					3		65	
Dr. Back	1		10	10					3		35	
Door	1	17							8			
Back ply	1	7										
Dr. bottom ply	1	9										
Total Time in sec.		204	64	141	147	187	183	150	67	150	237	334

5.4.2 Remarks of work study

1. During our work-study we find that workers are not habituated with the frequent and uncertain visit of the top management in the floor. Then they feel a sort of psychological pressure and their overall efficiency falls down. To avoid this sort of problem they should be made habituated with this.

2. During time study and with the help of our obtained data we find that night shift productivity is lower than the day shift. We believe that this happens because of the absence of management personnel in the night shift. So the company should take care of this matter for better performance.

3. We find that the bottlenecks of both the floors are **DET** and **Normal Borer**. So most of the time queue is found before these two machines. Again sufficient space is not allocated for this queue. So this also lowers the productivity. So we suggest taking care of reducing the queue by eliminating bottleneck and also take a good care about the space problem.

Table-5.6: Machine wise Expected processing time per unit product

SL#		MODEL	LOT	PS	CS	DET	BS	CR	PE	TT	SE	MB	NB	CNC
1	Fast	BDD16Z	120	5.46	1.65	4.20	3.52	2.30	3.28	3.12	1 75	2.15	3.50	2.23
2	Moving	BDDP06	150	6.50	2.53	4 65	4.25	3.54	3.47	2.54	2.16	2 55	4.88	5.05
3	Products	KWDP05	100	7.10	5.50	7.25	0.00	0 00	0.00	0 00	5.75	6.52	7.24	5.03
4		DDZ12G	150	2.21	1.91	2.64	1.10	3 20	2.60	2.90	2.64	2 95	4.79	4.94
5		DSZ13Z	150	1.80	0.54	2 25	3.57	0.00	1.75	1.45	2.11	0 00	2.56	6.42
6		KRO15H	150	2.21	0.75	2.25	0.00	0.00	2.02	1.95	1.95	3.95	2.23	3.48
7		KROP04	120	2.58	0.82	2 54	0.00	0.00	0.00	0.00	2.44	4 33	4.72	2 5
8		KSO15H	120	3 20	0.29	4.45	0.00	0.00	0.00	0.00	4.58	4.56	2.14	0
9		KSO16	150	4.15	0.45	6.54	0.00	0.00	0.00	0.00	6.85	5.75	1.46	0
10		TCC13H	250	2.64	1.25	2.75	0.00	0.00	0 00	0.00	3.75	4.12	2.42	1.75
11		TCC19H	200	3 15	1.60	3.41	2.20	1.60	0.91	2.80	4.95	4.75	4.58	2.28
12		TEZ23H	150	2.64	1 00	1.36	0.00	1.50	2.30	2.21	1.20	0.75	2.83	2.54
13		KRD12H	250	1.20	3.25	1.25	0.00	0.00	0 00	0.00	1.03	0.00	1.25	0
14		TRZ12H	150	4.11	3.00	3.24	2.64	2.40	2.10	1.68	1.56	2.80	3.41	3.51
15		TMZP04	120	2.75	0 79	2 06	0.00	0.85	1 76	1.56	1.21	1.89	3.22	2.34
16		TVT11Z	150	2.85	1.12	2 42	1.94	0.00	2.43	2 50	1.25	2.22	2.98	4.68
17		TVT12Z	250	1.75	0.50	1.14	0.95	0.00	1.22	1.64	0.75	0.52	1.45	2.52
18	Medium	BDD17Z	50	2.95	1.43	2.14	4.68	3.87	2.93	2.67	2.45	2 02	0.00	2.77
19	Moving	KPD16Z	50	6.75	3.25	7 02	0.00	0.00	0.00	0 00	5 25	3.75	10 21	9.38
20	Products	DDZ14Z	90	3.40	1.07	2 35	2.45	3.12	3.05	2.50	1.21	2 50	3.95	5.57
21		DDZ15G	75	2.73	2.17	1.25	2.75	2.70	2.35	2.97	1.71	0 94	4.25	2.44
22		DSZ12Z	50	5.25	5.50	6.47	0.00	0 00	0.00	0.00	3.75	7 77	7.50	13.17
23		KSD14Z	50	2.70	2.16	4 62	0.00	0.00	1.52	0 00	2.80	5.16	5.25	0
24		TCC22H	60	2.54	0.94	3.61	2.40	3.10	0.00	2.64	1.96	5 01	3.64	0
25		TOZ18H	75	1.73	0.57	1.75	0.00	0.00	0.00	0.00	0.63	3.25	1.02	2.37
26		TOZ19H	75	2.13	0.94	1.85	0.00	0.00	0.00	0.00	0.66	1.52	1.02	3.07
27		TOZ20H	75	2.25	1.04	1.85	0.00	0.00	0.00	0.00	0.68	0.95	1.02	3.1
28		TOZ21H	75	1.50	0.00	1.25	0.86	0.67	0.93	0.84	0.55	0.00	0.00	4.12
29		TRZ13H	50	2.75	2.16	5.68	2.65	3.15	2.67	3.45	2.36	5.40	6.85	7.18
30		TVT13Z	60	2.95	1.34	2.64	2.40	2.75	1.14	1.67	1.18	3.50	3.95	3.38
31		TVT14Z	75	4.10	0.56	2.74	2.30	2.41	1 06	2.10	2.76	5.22	2.95	2.5
32		BCZ13Z	50	1.49	0.37	1.79	1.10	1.40	1.98	1.21	0.79	2.89	1.95	0
33	Slow	BCZ15Z	40	1.61	0.44	2.06	0.94	0.86	0.00	0.88	1 26	1.42	2.25	0
34	Moving	BDD15Z	30	3.95	0.98	1 44	3.87	2.75	2.25	2.21	0 85	0.72	0.00	6.23
35	Products	BSD12W	40	3.95	1.92	1 54	2 67	2.85	1.95	2 25	1.40	5.76	0.00	1.56
36		KPD12Z	25	5.98	6.68	7.82	0.00	0 00	0.00	0.00	6.54	4 26	12.25	9.77
37		KWD15H	50	11.75	4.16	11.25	0 00	0.00	0.00	0.00	5.56	17.38	12.54	0
38		DWD16Z	30	8.75	9.50	9.50	4.50	2.75	2.52	3.12	4.34	7.68	12.53	8.7
39		TCC15H	40	3.82	1.35	2.75	0.00	0 00	0.00	0.00	1.95	2 16	4.19	3.57
40		TEZ24H	50	3.52	0.68	1.25	0.00	1.25	2.06	1.20	1.52	0.71	2.30	1.18
41		TEZ28H	50	4.56	0.00	2.65	1.50	1 20	1.75	1.75	3.58	2.44	0.00	3.26
42		TVC11Z	20	15.00	13.65	13 55	8.44	7.51	7.55	6.89	14.55	15 05	14.85	14.15

Note: we have considered 42 no. Of products in the above Table 5.6, Where indicates the expected processing time in minutes per product per machine and actual forecast demand of the marketing department.

Table-5.7: Product wise marketing demands, Unit Price & Unit Profit of the products

SL#		MODEL	Demands	Unit Price (TK.)	Unit Profit (TK.)	Remarks
1	Fast	BDD16Z	120	16000	4000	
2	Moving	BDDP06	150	16600	4150	
3	Products	KWDP05	100	12800	3200	
4		DDZ12G	150	6500	1625	
5		DSZ13Z	150	4150	1037.5	
6		KRO15H	150	4200	1050	
7		KROP04	120	4400	1100	
8		KSO15H	120	6100	1525	
9		KSO16	150	8100	2025	
10		TCC13H	250	4500	1125	
11		TCC19H	200	4800	1200	
12		TEZ23H	150	4700	1175	
13		KRD12H	250	2750	687.5	
14		TRZ12H	150	5300	1325	
15		TMZP04	120	7400	1850	
16		TVT11Z	150	5300	1325	
17		TVT12Z	250	3300	825	
18	Medium	BDD17Z	50	15000	3000	
19	Moving	KPD16Z	50	19500	3900	
20	Products	DDZ14Z	90	6200	1240	
21		DDZ15G	75	5200	1040	
22		DSZ12Z	50	15300	3060	
23		KSD14Z	50	5000	1000	
24		TCC22H	60	4500	900	
25		TOZ18H	75	3100	620	
26		TOZ19H	75	4500	900	
27		TOZ20H	75	5000	1000	
28		TOZ21H	75	3200	640	
29		TRZ13H	50	8200	1640	
30		TVT13Z	60	5400	1080	
31		TVT14Z	75	6000	1200	
32		BCZ13Z	50	2100	420	
33	Slow	BCZ15Z	40	2300	1230	
34	Moving	BDD15Z	30	14500	810	
35	Products	BSD12W	40	11200	900	
36		KPD12Z	25	19700	315	
37		KWD15H	50	14600	345	
38		DWD16Z	30	16500	2175	
39		TCC15H	40	4800	1680	
40		TEZ24H	50	5350	2955	
41		TEZ28H	50	6500	2190	
42		TVC11Z	20	21000	2475	

5.4.3 Calculation of available processing time

We have considered our LP model for maximize profit on month basis. Because the production of the Laminated board section-2(LB-2) of OTOBI is planned on month basis.

Actual Available processing time = Total Working Hours- Machine Idle Time

Total working Hours per month = 8 hours X 2 shift/day X 25 days = 400 hours = 24000 minutes.

Where,

Working hours per shift = 8 hours
Shift per day = 2 shift
Working days per month = 25 days (we assume 25 days per month)

So, Available-processing Time per machine per month is equal to 24000 minutes.

Table-5.8: Machine Stoppage report of November 2004 & Actual available time

SL #	Machine	Maintenance	Material Shortage	Power Failure	Total Stoppage Time in minute	Actual avail. Time in min.
1	Panel Saw	2050	900	950	3900	20100
2	Table Saw	250	750	950	1920	22080
3	Double End Tenoner	2710	1860	950	5520	18480
4	Band Saw	200	250	950	1500	22500
5	Copy Router	1810	2400	950	5160	18840
6	Profile Edging	100	150	950	1200	22800
7	Table Trimmer	1100	1250	950	3300	20700
8	Straight Edging	3850	3000	950	7800	19500
9	Multi Boring(Big)	2020	1050	950	4020	19980
10	Multi Boring(Small)	2410	1800	950	5160	18840
11	CNC machine	1000	750	950	2700	21300

We have collected above this data from the production log register for the month of November 2004. This above data may be vary for different month due to the situation of that month.

5.4.4 Variables

Fast moving Products			Medium moving Products			Slow moving Products		
Model No.	Solver Variable	Solver Result	Model No.	Solver Variable	Solver Result	Model No.	Solver Variable	Solver Result
BDD16Z	X1		BDD17Z	X18		BCZ15Z	X33	
BDDP06	X2		KPD16Z	X19		BDD15Z	X34	
KWDP05	X3		DDZ14Z	X20		BSD12W	X35	
DDZ12G	X4		DDZ15G	X21		KPD12Z	X36	
DSZ13Z	X5		DSZ12Z	X22		KWD15H	X37	
KRO15H	X6		KSD14Z	X23		DWD16Z	X38	
KROP04	X7		TCC22H	X24		TCC15H	X39	
KSO15H	X8		TOZ18H	X25		TEZ24H	X40	
KSO16	X9		TOZ19H	X26		TEZ28H	X41	
TCC13H	X10		TOZ20H	X27		TVC11Z	X42	
TCC19H	X11		TOZ21H	X28				
TEZ23H	X12		TRZ13H	X29				
KRD12H	X13		TVT13Z	X30				
TRZ12H	X14		TVT14Z	X31				
TMZP04	X15		BCZ13Z	X32				
TVT11Z	X16							
TVT12Z	X17							

To maximize profit, we have taken some products as variables in Solver LP model. By changing these variables, we will get the optimum results.

5.5 Formulation of Linear Programming

5.5.1 Objective Function

Maximize Profit, $Z = \sum CjXj = C_1X_1 + C_2X_2 + C_3X_3 + \ldots\ldots\ldots\ldots\ldots\ldots + C_nX_n$

Where,

X_j refers to the number of model wise random production per month, where j =1, 2, 3,.......................................n;

C_j refers to the profit per unit products, where j= 1,2,3, ...n

A_{ij} refers to the expected processing time in each machine for each product of j=1,2,3..n and i = 1,2,3..........................m

B_i = monthly actual machine hour available in each machine in minute, where, i =1,2,3, ...m

5.5.2 Constraints:

$\sum A_{ij}.X_j$ =< Bi ....(i)

Or,

$A_{11}X_1 + A_{12}X_2 + A_{13}X_3 + \ldots\ldots\ldots\ldots\ldots\ldots + A_{1n}X_n =< B_1$

$A_{21}X_1 + A_{22}X_2 + A_{23}X_3 + \ldots\ldots\ldots\ldots\ldots\ldots + A_{2n}X_n =< B_2$

. . . . .

. . . . .

. . . . .

$A_{m1}X_1 + A_{m2}X_2 + A_{m3}X_3 + \ldots\ldots\ldots\ldots\ldots\ldots + A_{mn}X_n =< B_m$

$X_J >= 0$

5.6 Data input in Formula

As per formulation of the above section, we have input data in objective function and in the constraints to calculate the optimum results of the objective function using Solver LP model.

5.6.1 Objective Function

We have input the profit of the per unit product to find the optimum value and of the variables which will be profitable for any furniture manufacturing company.

$Z = \sum C_j X_j =$

Maximize Profit, $Z = 4000X_1 + 41500X_2 + 3200X_3 + 1625X_4 + 1037X_5 + 1050X_6 + 1100X_7 + 1525X_8 + 2025X_9 + 1125X_{10} + 1200X_{11} + 1175X_{12} + 687X_{13} + 1325X_{14} + 1850X_{15} + 1325X_{16} + 825X_{17} + 3000X_{18} + 3900X_{19} + 1240X_{20} + 1040X_{21} + 3060X_{22} + 1000X_{23} + 900X_{24} + 620X_{25} + 900X_{26} + 1000X_{27} + 640X_{28} + 1640X_{29} + 1080X_{30} + 1200X_{31} + 420X_{32} + 345X_{33} + 2175X_{34} + 1680X_{35} + 2955X_{36} + 2190X_{37} + 2475X_{38} + 720X_{39} + 802X_{40} + 975X_{41} + 3150X_{42}$

5.6.2 Constraints

We have constructed the formula of the constraints in view to the expected processing time per product per machine and the available machine hour per month per machine. We have considered only for machining work, not for the assembly and packing section which is done manually.

$\sum A_{ij}. X_j =< Bi$

For Panel Saw:

$5.46X_1 + 6.50X_2 + 7.10X_3 + 2.21X_4 + 1.80X_5 + 2.21X_6 + 2.58X_7 + 3.20X_8 + 4.15X_9 + 2.64X_{10} + 3.15X_{11} + 2.64X_{12} + 1.20X_{13} + 4.11X_{14} + 2.75X_{15} + 2.85X_{16} + 1.75X_{17} + 2.95X_{18} + 6.75X_{19} + 3.40X_{20} + 2.73X_{21} + 5.25X_{22} + 2.70X_{23} + 2.54X_{24} + 1.73X_{25} + 2.13X_{26} + 2.25X_{27} + 1.50X_{28} + 2.75X_{29} + 2.95X_{30} + 4.10X_{31} + 1.49X_{32} + 1.61X_{33} + 3.95X_{34} + 3.95X_{35} + 5.98X_{36} + 11.75X_{37} + 8.75X_{38} + 3.82X_{39} + 3.52X_{40} + 4.56X_{41} + 15.00X_{42} =< 20100 \quad \ldots\ldots(1)$

For Table Saw:

$1.65X_1 + 2.53X_2 + 5.50X_3 + 1.91X_4 + 0.54X_5 + 0.75X_5 + 0.82X_7 + 0.29X_8 + 0.45X_9 + 1.25X_{10} + 1.60X_{11} + 1.00X_{12} + 3.25X_{13} + 3.00X_{14} + 0.79X_{15} + 1.12X_{16} + 0.50X_{17} + 1.43X_{18} + 3.25X_{19} + 1.07X_{20} + 2.17X_{21} + 5.50X_{22} + 2.16X_{23} + 0.94X_{24} + 0.57X_{25} + 0.94X_{26} + 1.04X_{27} + 2.16X_{29} + 1.34X_{30} + 0.56X_{31} + 0.37X_{32} + 0.44X_{33} + 0.98X_{34} + 1.92X_{35} + 6.68X_{36} + 4.16X_{37} + 9.50X_{38} + 1.35X_{39} + 0.68X_{40} + 13.65X_{42} =< 22080 \quad \ldots\ldots(2)$

For Double End Tenoner:

$4.20X_1 + 4.65X_2 + 7.25X_3 + 2.64X_4 + 2.25X_5 + 2.25X_6 + 2.54X_7 + 4.45X_8 + 6.54X_9 + 2.75X_{10} + 3.41X_{11} + 1.36X_{12} + 1.25X_{13} + 3.24X_{14} + 2.06X_{15} + 2.42X_{16} + 1.14X_{17} + 2.14X_{18} + 7.02X_{19} + 2.35X_{20} + 1.25X_{21} + 6.47X_{22} + 4.62X_{23} + 3.61X_{24} + 1.75X_{25} + 1.85X_{26} + 1.85X_{27} + 1.25X_{28} + 5.68X_{29} + 2.64X_{30} + 2.74X_{31} + 1.79X_{32} + 2.06X_{33} + 1.44X_{34} + 1.54X_{35} +$

$7.82X_{36} + 11.25X_{37} + 9.50X_{38} + 2.75X_{39} + 1.25X_{40} + 2.65X_{41} + 13.55X_{42} =< 18480$.....(3)

For Band Saw:

$3.52X_1 + 4.25X_2 + 1.10X_4 + 3.57X_5 + 2.20X_{11} + 2.64X_{14} + 1.94X_{16} + 0.95X_{17} + 4.68X_{18} + 2.45X_{20} + 2.75X_{21} + 2.40X_{24} + 0.86X_{28} + 2.65X_{29} + 2.40X_{30} + 2.30X_{31} + 1.10X_{32} + 0.94X_{33} + 3.87X_{34} + 2.67X_{35} + 4.50X_{38} + 1.50X_{41} + 8.44X_{42} =< 22500$.....(4)

For Copy Router:

$2.30X_1 + 3.54X_2 + 3.20X_4 + 1.60X_{11} + 1.50X_{12} + 2.40X_{14} + 0.85X_{15} + 3.87X_{18} + 3.12X_{20} + 2.70X_{21} + 3.10X_{24} + 0.67X_{28} + 3.15X_{29} + 2.75X_{30} + 2.41X_{31} + 1.40X_{32} + 0.86X_{33} + 2.75X_{34} + 2.85X_{35} + 2.75X_{38} + 1.25X_{40} + 1.20X_{41} + 7.51X_{42} =< 18840$.....(5)

For Profile Edging machine:

$3.28X_1 + 3.47X_2 + 2.60X_4 + 1.75X_5 + 2.02X_6 + 0.91X_{11} + 2.30X_{12} + 2.10X_{14} + 1.76X_{15} + 2.43X_{16} + 1.22X_{17} + 2.93X_{18} + 3.05X_{20} + 2.35X_{21} + 1.52X_{23} + 0.93X_{28} + 2.67X_{29} + 1.14X_{30} + 1.06X_{31} + 1.98X_{32} + 2.25X_{34} + 1.95X_{35} + 2.52X_{38} + 2.6X_{40} + 1.75X_{41} + 7.55X_{42} =< 22800$.....(6)

For Table Trimmer:

$3.12X_1 + 2.54X_2 + 2.90X_4 + 1.45X_5 + 1.95X_6 + 2.80X_{11} + 2.21X_{12} + 1.68X_{14} + 1.56X_{15} + 2.50X_{16} + 1.64X_{17} + 2.67X_{18} + 2.50X_{20} + 2.97X_{21} + 2.64X_{24} + 0.84X_{28} + 3.45X_{29} + 1.67X_{30} + 2.10X_{31} + 1.21X_{32} + 0.88X_{33} + 2.21X_{34} + 2.25X_{35} + 3.12X_{38} + 1.20X_{40} + 1.75X_{41} + 6.89X_{42} =< 20700$.....(7)

For Straight Edging machine:

$1.75X_1 + 2.16X_2 + 5.75X_3 + 2.64X_4 + 2.11X_5 + 1.95X_6 + 2.44X_7 + 4.58X_8 + 6.85X_9 + 3.75X_{10} + 4.95X_{11} + 1.20X_{12} + 1.03X_{13} + 1.56X_{14} + 1.21X_{15} + 1.25X_{16} + 0.75X_{17} + 2.45X_{18} + 5.25X_{19} + 1.21X_{20} + 1.71X_{21} + 3.75X_{22} + 2.80X_{23} + 1.96X_{24} + 0.63X_{25} + 0.66X_{26} + 0.68X_{27} + 0.55X_{28} + 2.36X_{29} + 1.18X_{30} + 2.76X_{31} + 0.79X_{32} + 1.26X_{33} + 0.85X_{34} + 1.40X_{35} + 6.54X_{36} + 5.56X_{37} + 4.36X_{38} + 1.95X_{39} + 1.52X_{40} + 3.58X_{41} + 14.55X_{42} =< 19500$.....(8)

For Mutli Boring machine(Big):

$2.15X_1 + 2.55X_2 + 6.52X_3 + 2.95X_4 + 3.95X_6 + 4.33X_7 + 4.56X_8 + 5.75X_9 + 4.12X_{10} + 4.75X_{11} + 0.75X_{12} + 2.80X_{14} + 1.89X_{15} + 2.22X_{16} + 0.52X_{17} + 2.02X_{18} + 3.75X_{19} + 2.50X_{20} + 0.94X_{21} + 7.77X_{22} + 5.16X_{23} + 5.01X_{24} + 3.25X_{25} + 1.52X_{26} + 0.95X_{27} + 5.40X_{29} + 3.50X_{30} + 5.22X_{31} + 2.89X_{32} + 1.42X_{33} + 0.72X_{34} + 5.76X_{35} + 4.26X_{36} + 17.38X_{37} + 7.68X_{38} + 2.16X_{39} + 0.71X_{40} + 2.44X_{41} + 15.05X_{42} =< 19980$.....(9)

For Mutli Boring machine(small):

$3.50X_1 + 4.88X_2 + 7.24X_3 + 4.79X_4 + 2.56X_5 + 2.23X_6 + 4.72X_7 + 2.14X_8 + 1.46X_9 + 2.42X_{10} + 4.58X_{11} + 2.83X_{12} + 1.25X_{13} + 3.41X_{14} + 3.22X_{15} + 2.98X_{16} + 1.45X_{17} + 10.21X_{19} + 3.95X_{20} + 4.25X_{21} + 7.50X_{22} + 5.25X_{23} + 3.64X_{24} + 1.02X_{25} + 1.02X_{26} + 1.02X_{27} + 6.85X_{29} + 3.95X_{30} + 2.95X_{31} + 1.95X_{32} + 2.25X_{33} + 12.25X_{36} + 12.54X_{37} + 12.53X_{38} + 4.19X_{39} + 2.30X_{40} + 14.85X_{42} =< 18840$.....(10)

For CNC machine:

$2.23X_1 + 5.05X_2 + 5.03X_3 + 4.94X_4 + 6.42X_5 + 3.48X_6 + 2.50X_7 + 1.75X_{10} + 2.28X_{11} + 2.54X_{12} + 3.51X_{14} + 2.34X_{15} + 4.68X_{16} + 2.52X_{17} + 2.77X_{18} + 9.38X_{19} + 5.57X_{20} + 2.44X_{21} + 13.17X_{22} + 2.37X_{25} + 3.07X_{26} + 3.10X_{27} + 4.12X_{28} + 7.18X_{29} + 3.38X_{30} + 2.50X_{31} + 6.23X_{34} + 1.56X_{35} + 9.77X_{36} + 8.70X_{38} + 3.57X_{39} + 1.18X_{40} + 3.26X_{41} + 14.15X_{42} =< 21300$.....(11)

For **Fast moving products**, we have considered that the production should be between the present market demands and double of the present market demands of the products:

For BDD16Z $240> = X_1 > = 120$.....(12)
For BDDP05 $300> = X_2 > = 150$.....(13)
For KWDP05 $200> = X_3 > = 100$ .....(14)
For DDZ12G $300> = X_4 > = 150$.....(15)
For DSZ13Z $300> = X_5 > = 150$.....(16)
For KRO15H $300> = X_6 > = 150$.....(17)
For KROP04 $240> = X_7 > = 120$.....(18)
For KSO15H $240> = X_8 > = 120$.....(19)
For KSO16H $300> = X_9 > = 120$.....(20)
For TCC13H $500> = X_{10} > = 250$.....(21)
For TCC19H $400> = X_{11} > = 200$.....(22)
For TEZ23H $300> = X_{12} > = 150$.....(23)
For KRD12H $500> = X_{13} > = 250$.....(24)
For TRZ12H $300> = X_{14} > = 150$.....(25)
For TMOP04 $240> = X_{15} > = 120$.....(26)
For TVT11Z $300> = X_{16} > = 150$.....(27)
For TVT12Z $500> = X_{17} > = 250$.....(28)

For **Medium moving products**, we have considered the production should be between the present market demands and one & half of the present market demands of the products:

For BDD17 $75> = X_{18} > = 50$.....(29)
For KPD16Z $75> = X_{19} > = 50$.....(30)
For DDZ14G $135> = X_{20} > = 90$ .....(31)
For DDZ15G $110> = X_{21} > = 75$.....(32)
For DSZ12Z $75> = X_{22} > = 50$ .....(33)
For KSD14Z $75> = X_{23} > = 50$.....(34)
For TCC22H $120> = X_{24} > = 60$.....(35)
For TOZ18H $110> = X_{35} > = 75$.....(36)
For TOZ19H $110> = X_{26} > = 75$.....(37)
For TOZ20H $110> = X_{27} > = 75$.....(38)
For TOZ21H $110> = X_{28} > = 75$.....(39)

For TRZ13H $75> = X_{29} > = 50$.....(40)
For TVT13Z $90> = X_{30} > = 60$.....(41)
For TVT14Z $110> = X_{31} > = 75$.....(42)
For BCZ13z $75> = X_{32} > = 75$.....(43)

For **Slow moving products**, we have considered the production should between the present market demands and half of the present market demands of the products:

For BCZ15Z $40> = X_{33} > = 20$ .....(44)
For BDD15Z $30> = X_{34} > = 15$ .....(45)
For BSD12W $40> = X_{35} > = 20$.....(46)
For KPD12Z $25> = X_{36} > = 12$.....(47)
For KWD15H $50> = X_{37} > = 25$.....(48)
For DWD16Z $30> = X_{38} > = 15$.....(49)
For TCC15F $40> = X_{39} > = 20$.....(50)
For TEZ24H $50> = X_{240} > = 25$.....(51)
For TEZ28H $50> = X_{41} > = 25$.....(52)
For TVC11Z $20> = X_{42} > = 10$.....(53)

We have input this above data into the Solver LP model and have found the result of solver variables which is shown in following Table 5.8.

Table-5.8: Results of mathematical model:

Fast moving Products			**Medium moving Products**			**Slow moving Products**		
Model No.	Solver Variable	Solver Result	Model No.	Solver Variable	Solver Result	Model No.	Solver Variable	Solver Result
BDD16Z	X1	240	BDD17Z	X18	75	BCZ15Z	X33	30
BDDP06	X2	300	KPD16Z	X19	75	BDD15Z	X34	30
KWDP05	X3	200	DDZ14Z	X20	90	BSD12W	X35	40
DDZ12G	X4	300	DDZ15G	X21	75	KPD12Z	X36	15
DSZ13Z	X5	251	DSZ12Z	X22	75	KWD15H	X37	25
KRO15H	X6	300	KSD14Z	X23	50	DWD16Z	X38	20
KROP04	X7	120	TCC22H	X24	60	TCC15H	X39	30
KSO15H	X8	240	TOZ18H	X25	88	TEZ24H	X40	50
KSO16	X9	300	TOZ19H	X26	120	TEZ28H	X41	50
TCC13H	X10	250	TOZ20H	X27	120	TVC11Z	X42	10
TCC19H	X11	200	TOZ21H	X28	120			
TEZ23H	X12	300	TRZ13H	X29	50			
KRD12H	X13	500	TVT13Z	X30	60			
TRZ12H	X14	150	TVT14Z	X31	75			
TMZP04	X15	240	BCZ13Z	X32	50			
TVT11Z	X16	300						
TVT12Z	X17	500						

Chapter-6

Solution of the Model and Result Analysis

6.1 Solution of the model

All linear programming models have two important features in common. The first feature is the existence of constraints, which consists with some variables. The second feature is that in every linear programming model there is single performance measure to be maximized or minimized. In our model, the objective function is to maximize profit of the Furniture Company, which is measure in the previous chapter-5, equal to **TK.9775531.** Optimal solver variable results are given in the following table.

Table-6.1: Solver Result of the mathematical model:

Fast moving Products			**Medium moving Products**			**Slow moving Products**		
Model No.	Solver Variable	Solver Result	Model No.	Solver Variable	Solver Result	Model No.	Solver Variable	Solver Result
BDD16Z	X1	240	BDD17Z	X18	75	BCZ15Z	X33	30
BDDP06	X2	300	KPD16Z	X19	75	BDD15Z	X34	30
KWDP05	X3	200	DDZ14Z	X20	90	BSD12W	X35	40
DDZ12G	X4	300	DDZ15G	X21	75	KPD12Z	X36	15
DSZ13Z	X5	251	DSZ12Z	X22	75	KWD15H	X37	25
KRO15H	X6	300	KSD14Z	X23	50	DWD16Z	X38	20
KROP04	X7	120	TCC22H	X24	60	TCC15H	X39	30
KSO15H	X8	240	TOZ18H	X25	88	TEZ24H	X40	50
KSO16	X9	300	TOZ19H	X26	120	TEZ28H	X41	50
TCC13H	X10	250	TOZ20H	X27	120	TVC11Z	X42	10
TCC19H	X11	200	TOZ21H	X28	120			
TEZ23H	X12	300	TRZ13H	X29	50			
KRD12H	X13	500	TVT13Z	X30	60			
TRZ12H	X14	150	TVT14Z	X31	75			
TMZP04	X15	240	BCZ13Z	X32	50			
TVT11Z	X16	300						
TVT12Z	X17	500						

The values obtained by using Solver linear program has been rounded off. There are some alternative solutions but total production remains same.

6.2 Analysis of the Solver Result:

This following Table 6.1 shows that the actual Quantity of any specified model is to be producing for the month of November 2004, which will maximize our profit, and also the net total production of the company using the same existence facilities of the company. Our original solver spreadsheet in which solver has recorded the optimal decision values is shown in the following table 6.1. The spreadsheet calculates to produce the profit-maximizing payoff of **TK.9775531.**

Note that the cells in the slack column have changed to reflect the optimal production decisions. If the slack cell for a constraint shows '0' slack, then that constraint is said to be **"binding at optimality."** Binding constraints prevent solver from producing more profit. Increasing profit by additional production would drive one or more slack cells below '0', violating one or more constraints. Constraints having nonzero slack are not binding at optimality. Nonbinding constraints cannot hamper solver ability to produce additional production or profit. This is true regardless of whether we optimize a maximize model. As a result, it is the binding constraints that are of interest for us in any LP model. The occurrences of zero slack in the departments of **DET & NB machines available processing time** constraints means that these are the two binding constraints; that is, **"bottlenecks"** that prevent further improvement in the production.

Alternatively, we can see the immediate effect on adding additional hours of capacity in DET and NB machines by changing the proper right-hand side cell and then running Solver again to re-optimize the model with new right-hand side values. In this way, we can explore how much profit is helped or hurt by such a change. A proposal to increase DET and NB machines capacities by adding the additional hours of the third shift's operation or adding higher capacity machines. We need to recalculate the profit margin for the new adding capacity using Solver LP models finding the optimal values.

Table-6.2: Calculation of Total Production using solver results:

SL#		MODEL	Results	Unit Price (TK.)	Total Production (TK.)	Remarks
1	Fast	BDD16Z	240	16000	3840000	
2	Moving	BDDP06	300	16600	4980000	
3	Products	KWDP05	200	12800	2560000	
4		DDZ12G	300	6500	1950000	
5		DSZ13Z	251	4150	1041650	
6		KRO15H	300	4200	1260000	
7		KROP04	120	4400	528000	
8		KSO15H	240	6100	1464000	
9		KSO16	300	8100	2430000	
10		TCC13H	250	4500	1125000	
11		TCC19H	200	4800	960000	
12		TEZ23H	300	4700	1410000	
13		KRD12H	500	2750	1375000	
14		TRZ12H	150	5300	795000	
15		TMZP04	240	7400	1776000	
16		TVT11Z	300	5300	1590000	
17		TVT12Z	500	3300	1650000	
18	Medium	BDD17Z	75	15000	1125000	
19	Moving	KPD16Z	75	19500	1462500	
20	Products	DDZ14Z	90	6200	558000	
21		DDZ15G	75	5200	390000	
22		DSZ12Z	75	15300	1147500	
23		KSD14Z	50	5000	250000	
24		TCC22H	60	4500	270000	
25		TOZ18H	88	3100	272800	
26		TOZ19H	120	4500	540000	
27		TOZ20H	120	5000	600000	
28		TOZ21H	120	3200	384000	
29		TRZ13H	50	8200	410000	
30		TVT13Z	60	5400	324000	
31		TVT14Z	75	6000	450000	
32		BCZ13Z	50	2100	105000	
33	Slow	BCZ15Z	30	2300	69000	
34	Moving	BDD15Z	30	14500	435000	
35	Products	BSD12W	40	11200	448000	
36		KPD12Z	15	19700	295500	
37		KWD15II	25	14600	365000	
38		DWD16Z	20	16500	330000	
39		TCC15H	30	4800	144000	
40		TEZ24H	50	5350	267500	
41		TEZ28H	50	6500	325000	
42		TVC11Z	10	21000	210000	
	Total	monthly	production	For November ,04	41912450	

6.3 Comparison between present & expected production

The result of the LP model shows that, maximum profit of the Laminated Board Section-2 for the month of November 2004 is **TK.9775531** and optimal production for the month of November 2004 **TK. 41912450,** which is calculated in the Table 6.2. But by the traditional method the production during the month of November 2004 was **Tk. 38243000** and the net profit was **Tk.7494662**. So, there had been a scope to make profit about an additional amount of **TK. 3669450** by utilizing the same facilities. We have considered all data & calculation for month of November 2004. Because that was the maximum production for any month for any floor like LB-1 & LB-2 which is shown in the following table 6.3. We are trying to proof that optimal product-mix by using LP Excel Solver is greater than that of the maximum production of the traditional methods.

Table-6.3: Traditional Production Records of LB-1 & LB-2 from June to December 2004

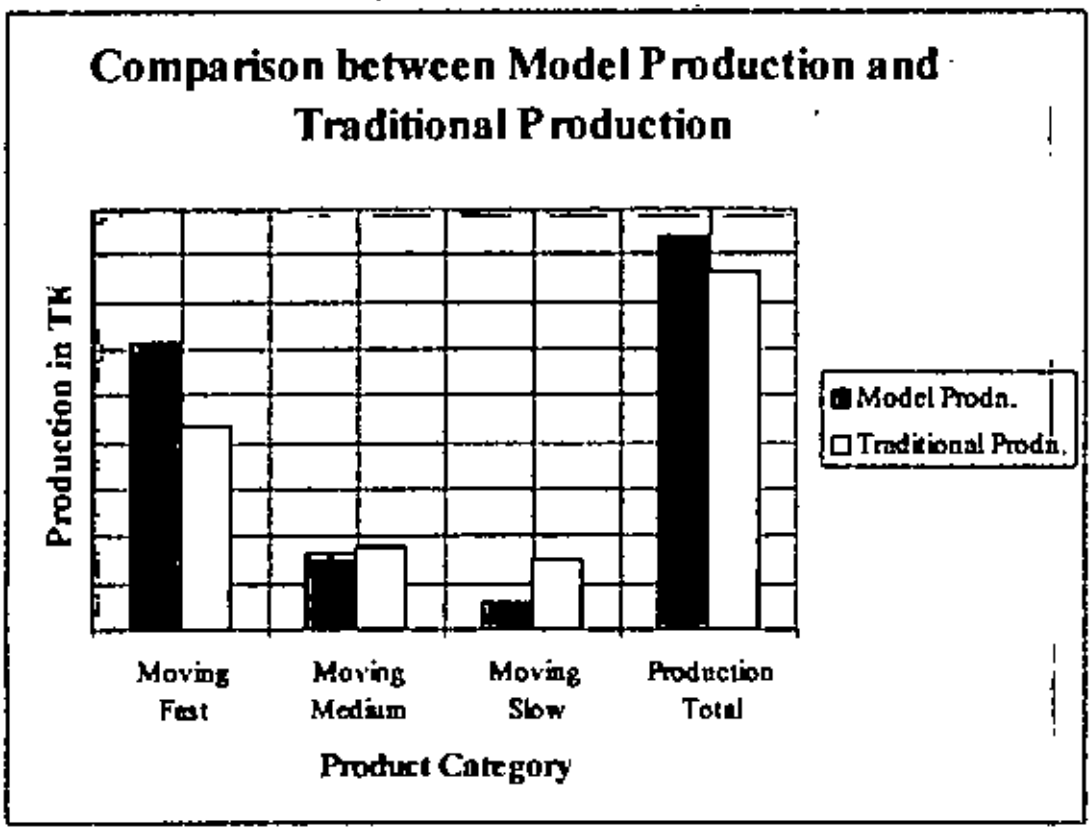
Sl#	Month	LB-1	LB-2
1	June	22267080	29837550
2	July	22009950	23478700
3	August	30391400	31341150
4	September	20390150	25111530
	October	15355900	15690800
5	November	33079800	38243000
7	December	27339550	31877850
	Average	24404832	27940082

It is evident from Table 6.3 & Table 6.4 the maximization of product-mix with LP model by Excel solver is greater than the production rate LB-1 & LB-2 by the traditional method. The main cause of this reduced production is due to non-optimal production planning and machine capacity utilization.

The reliability of the data in any mathematical model is important to obtain a useful solution for practical problems. Some of this data are influenced owing to the instability and uncontrollability of certain aspects such as urgent order, machines problem, operator's lagging, unavailability of raw materials and poor quality of the supplied raw materials. On basis of those limitations optimum production may vary.

Table-6.4: Model Production & Traditional Production of LB-2 for November 2004.

	Fast Moving Products	Medium Moving Products	Slow Moving Products	Total Production Products
Model Production	30734650	8288800	2889000	41912450
Traditional production	21749500	8883000	7610500	38243000



We have compared the model production and the traditional production of the LB-2 for the month of November 2004, which is the highest traditional production of the previous records. From the Table 6.4 & Chart, it is essay and clears to understand that the fast moving products of the model production suggest producing more than the traditional production. But for slow moving products, model production suggests producing less than the traditional production. Because fast moving products are more profitable than the slow moving products. So, we can easily identified from the LP Solver results that which type of products to be produce for higher benefits.

6.4 Solver Sensitivity Analysis

We stated that the process of analyzing an optimization model for different parameter values is termed sensitivity analysis. Sensitivity analysis deals with making single changes in the coefficients of the objective function and the right-hand sides of the constraints. We observe in the sensitivity report that the reduced cost is zero. So the activity of the associated variables is economically attractive in the optimum solution, signifying an equilibrium point has been reached at which the output (unit profit) equals the input (unit cost of the resources).

The shadow price on the solver sensitivity report is the rate of change in objective value (OV) as the RHS is increased. The shadow price of the sensitivity report corresponding to the constraints reflects valid range 242 minutes for DET machine and 192 minutes for NB machine. These constraints show the amount in the optimal objective value as the RHS of those constraints is increased a unit, with all other data held fixed. It means that the additional profit obtained, if additional processing time is available in DET and NB machines. Allowable increase for DET & NB machines are 26 & 13 and allowable decrease for DET & NB machines are 11 & 30 in profitability without changing any variables.

In the solution, we see that capacity utilization of DET & NB machines are 100%. This reflects in the solution list where these two slack variables are zero. But another machines are under ntilization and the constraints of those machines show the positive slack. That situation is not allowable for any commercial organizations. So, we should increase the shadow price, which describe earlier to maximize the utilization of all machines. Where as, this is not typical of most LP model, we formulated-out this model in the particular terms and conditions. The solution is quite sensitive to changes in the coefficients of resource constraints. This is so, because all these constraints are binding. So, it will be important to accurately input the associated coefficient values.

In this model, we can identify that which variable's coefficient increase is profitable and how much profitable. So if we have the available resources in future, we will increase only those variable's coefficient, which will give us the maximum output.

From this sensitivity analysis management can come to a decision that which machines capacity increase is more profitable and which machine will be used for what type of product. But is also important to consider the profit margin of different type of product. Definitely the profit margin of different product will be different. But we have to keep in mind that a customer will not place only that type of product, which will be more profitable. Marketing department can use this information to set the strategy of business and target more value added customer for future. We didn't consider those factors in our LP model. Our main target was to utilize the maximum machine capacity and time to increase the total production. Another LP model can be done basis on profit margin.

Chapter-7

Conclusions and Recommendations

7.1 Conclusions:

In this research work, we are trying to establish a practical analysis of laminated board furniture manufacturing processes and a Linear Programming mathematical model is constructed to determine an optimum product-mix of the laminated board furniture in terms of profitability. We have studied manufacturing process of the laminated board furniture and have showed it in the research work. We feel that Today's Furniture industries are not in the national boundaries; now enter into the global market. Only individual companies and their supply chain can be win, not countries, depends on their proper strategic plan. Bangladesh entrepreneurs and policymakers can't operate as though the world furniture industries. The economical condition of Bangladesh decreases day by day and create a workless situation. This situation will be dangerous due free market economy from January 2005. So, this is the time to optimize the production as well as quality and reduce the production cost with lead-time to face the challenge from 2005. Because a huge amount of furniture is imported from Malaysia, Taiwan and China in cheap rate.

This research work can be applied in any furniture industries to optimize the production. It will help to prepare an early production plan to get optimum production or set a standard production target for laminated board furniture industries. Using this linear mathematical model of any furniture industries, it will be easy to evaluate actual product mix to optimize the production. That is, it will indicate the optimum number of products which will be profitable for any industries to manufacture. Mathematical model is a superior method in planning of production schedule.

LP model is more tight schedule calculated program than the traditional method and shows the maximum utilization of the resources. Finally, the LP model is used to adapt the system design to

most possible combinations of the product-mix. This approach can be implemented at the production system at all levels.

LP model by Excel Solver is a superior method in planning of production schedule. Sensitivity analysis can be performed to take into account of the variation of resource level. Limit report analysis can be performed to take into account the lower limit and upper limit.

From this study, it was concluded that the overall monthly production of the laminated board section-2 of the traditional method for the month of November is about TK. 38 million. On the other hand, optimizing by LP model for 16 hours per day (2 shift per day) monthly production for the month of November is about TK.42 million, which is about 10% higher than the amount as produced by the traditional method.

Finally we can conclude that LP mathematical model is a strong and important tools for management to take decisions for the future.

7.2 Limitations:

There are some limitations in this research work which influence the result of the mathematical models:

- The reliability of the data collection is important in obtaining a useful solution of practical problems.
- The instability and uncontrollability of certain aspects such as urgent order, machines problem etc.
- Inefficient worker those who operate the machines and shortage of worker.
- Shortage of raw materials and poor quality of supplied raw materials.
- Work load distribution in each machine for monthly production is not clearly defined or identified in which way is best for optimize the production.

On the basis of those limitations optimum production may vary.

7.3 Recommendations:

On the basis of the study of the furniture manufacturing processes, our recommendations would be as follows:

- To prepare monthly production plan where allocate the all machine for different product and monitor daily performance.
- To make proper forecasting of the product
- To study processing time of the products for any machine
- To motivate the workers to increase their own interest on the work.
- To reduce machine idle time need proper maintenance schedule.
- To arrange training program for the worker to increase the skillness and awareness
- To add DET and Multi Boring (Small) to reduce the bottleneck.
- Otobi should establish R & D and QC department
- Expansion of the furniture industry should be horizontally, should not be vertically.but Otobi is expanded in vertically which is not adviceable.

In addition of the above facilities, we can able to get more productivity in furniture manufacturing processes. From our research work on furniture industries, it is clear that there has a big opportunity and scope to study more for further improvement of the furniture industries, which will be more beneficial for all industries in Bangladesh.

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Appendix-A :

- **Otobi products**
- **Product Profile**
- **Cutter Status**

OTOBI PRODUCTS:

We all are working towards a common aim: SATISFIED CUSTOMER

Bed Room Furniture:

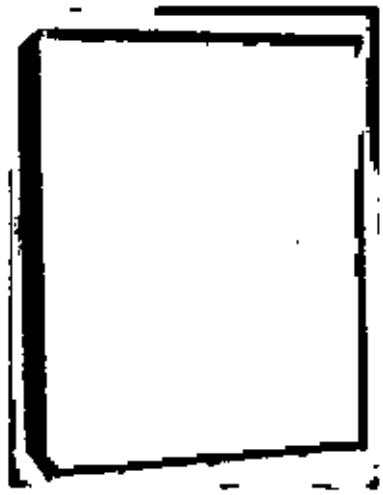
Double Bed & Bed Side Cabinet

Dressing Table

OTOBI offers.....

- Multiple Colors
- Knock Down System
- Elegant Design
- Competitive Price
- After Sales Service

Wardrobe



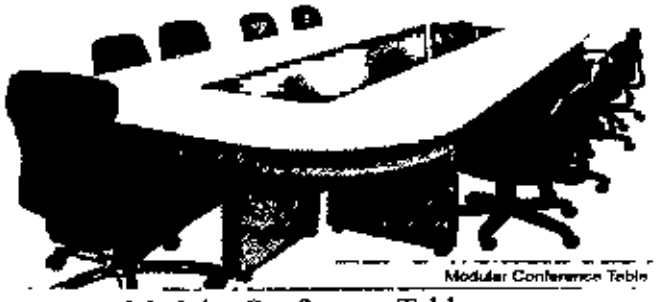
Cupboard

Where dream comes into being.....

In a room where the members of the family spend their valuable time, where easy movement, convenient storage facility, hygienic environment and maximum utilization of space are your prime consideration, Otobi goes beyond the conventional system and responds to the need of the time.

Laminated board cabinets are overwhelmingly the most popular choice in today's home due to their classic beauty and natural warmth. Quality workmanship ensures that they will be long lasting, easy to clean and maintain.

Office Furniture:

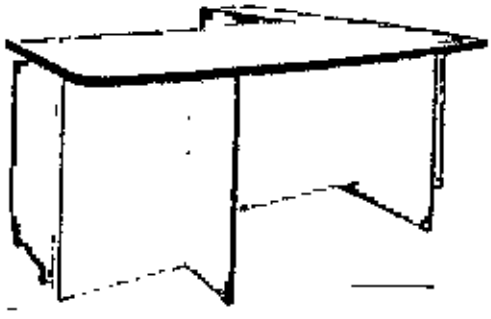


Modular Conference Table

OTOBI .....
Creating a healthy work environment
Choice of modern executives
Technological changes coupled with a long legacy of traditional know-how have been employed to produce a robust, reliable and responsible range of elegant office furniture.

In today's modern concept of office furniture, Elegantly designed to generate an energetic and productive working environment-undoubtedly reflects a dynamic and modern work place of today's demanding business world. And in a world Of unpredictable changes, it helps to reduce Maintenance cost.

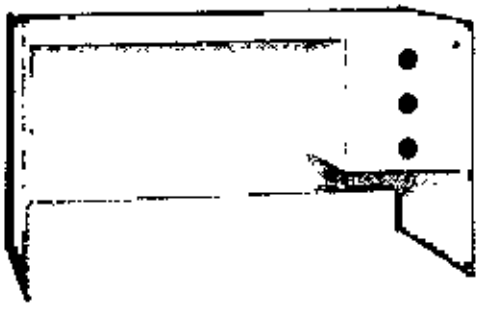
Computer Table



Senior Executive Table

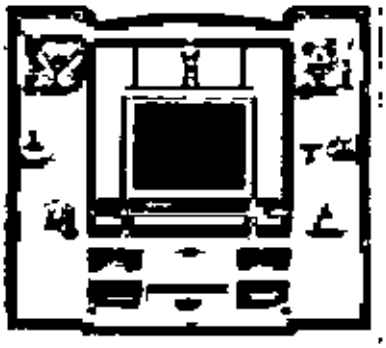
Operational efficiency is enhanced dramatically when opportunities for improved performance

Enjoy the Unlimited Forms of Functionality



Executive Table

Drawing Room Furniture:



TV Cabinet

Showcase

Otobi Home Furniture's create your ideal home environment.

Otobi's melamine coated laminated board furniture has brought revolutionary changes in the modern concept of furniture. Scratch proof boards, multiple color options and elegant designs have made the laminated board furniture the choice of the modern corporate world. Moreover the unique knock-down system allows our customer to handle the furniture conveniently, specially where frequent shifting is required.

Shoe Rack

Book Shelves

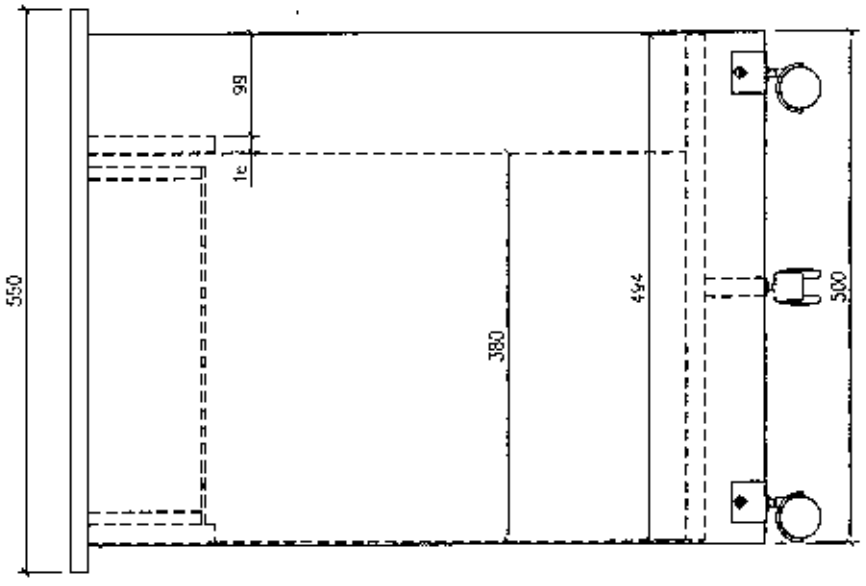
Otobi products are backed by warranty facility along with after sales service. Teams of dedicated sales personnel are always ready to meet your need.

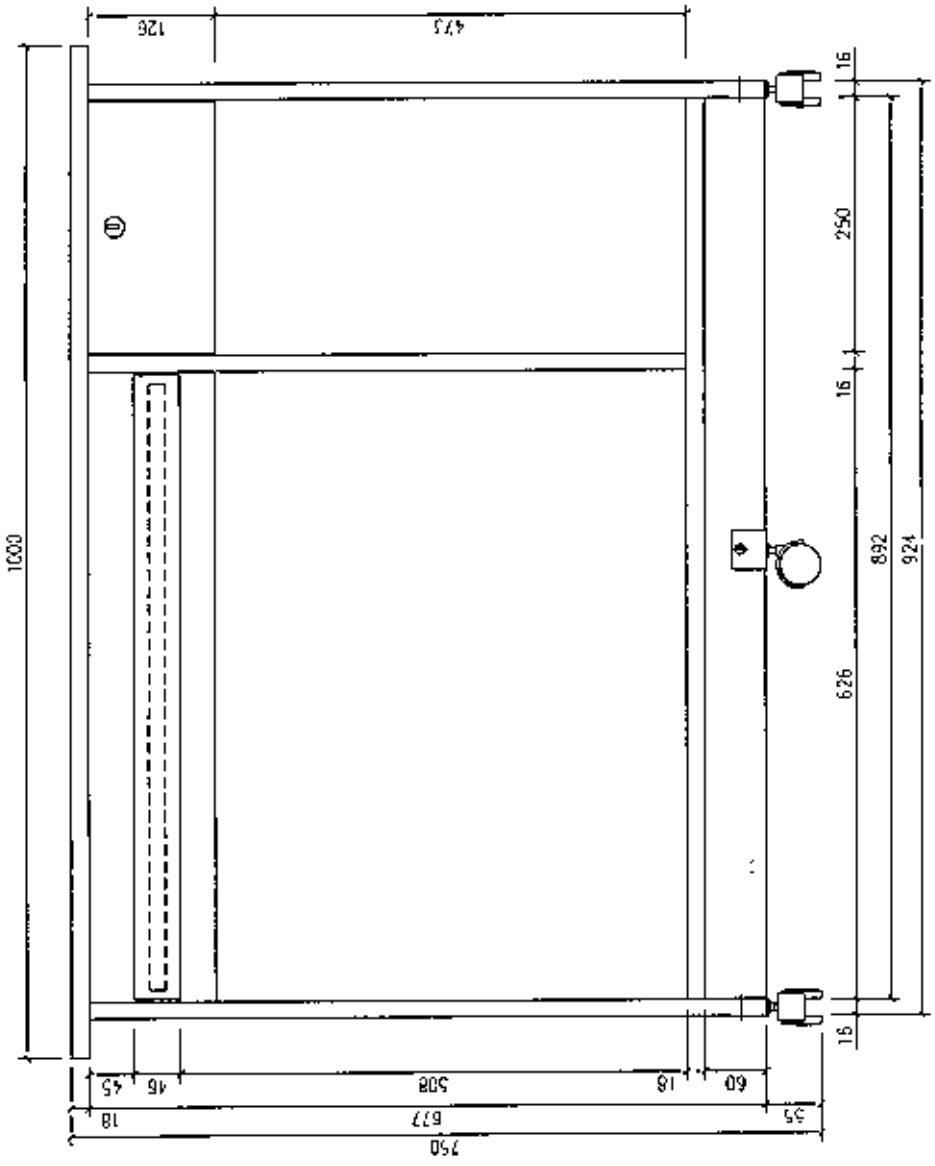
Otobi does not compromise quality. Otobi provides comfort and convenience.

Otobi stands for elegance and design. Otobi believes in customer satisfaction.

MODEL: TCC P02 (TCC-13F/H)

Size: 1000(L)x550(D)x748H





TCC-13F (1st Edition) NEW DESIGN WITH WHEEL

TITLE :	CAD BY.	PLANNED & CHECKED BY:	SHEET NO.
COMPUTER TABLE	SANTOSH SAMADDER	MD. MIZANUR RAHMAN	
F:\NEED\PRO DATA\BOR.\TCC P02	DATE:- 15/07/02	APPROVED BY:-	01 OF 08

OTOBI LIMITED

Shyampur, Dhaka

OPERATION PLAN

Model: TCC14H **Lot Size:** **Date:**

SL #	Component	Nos.	Materials		Cutting Size	Tenoning Size	Edging					Full Size	Total Nos.
			Color	Thickness	Dimension	Dimension	L	W	Thick.	Height	Color	Dimension	
1	Top	1	Beech	16	633x501	628x498	2	2	1	19	Beech	630x500	
2	Side	2	Beech	16	681x403	676x398	2	1	1	19	Beech	677x400	
3	Bottom	1	Beech	16	523x353	518x348	2		1	19	Beech	518x350	
4	Keyboard tray	1	Beech	16	499x325	494x325	1		0 5	19	Beech	494x326	
5	Mouse tray	1	Beech	9	295x197		2	2	0.5	19	Beech	296x198	
6	KB tray front bit	1	Beech	18	516x55	511x55	2	2	1	22	Beech	513x57	
7	KB tray bottom bit	1	Any color	16	462x40							462x40	
8	KB tray bottom ply	1	Any color	3	462x50							462x50	
9	Shelf	1	Beech	16	304x245	299x240	1	2	0.5	19	Beech	300x240	
10	Partition	1	Beech	16	298x244	293x239		2	0.5	19	Beech	294x239	
11	Front support	1	Beech	16	523x125	518x125	1		0.5	19	Beech	518x125	
12	Bottom support	1	Beech	16	523x59	518x59	1		0.5	19	Beech	518x59	

Components marked with single ' * ' would be grooved on one side.
Components marked with double ' * * ' would be grooved on both side.
Underline in dimension means beech color board fibre follow the underline.

Prepared by

Checked by

Approved by

OTOBI LIMITED

Shyampur, Dhaka

Bill of Material

Product Name: Computer Table
Model: TCC-13H
Size: 906(L)X450(W)X750(H)

Date: 21/06/2003

Material/Componen Name	Color	Size(mm)		Nos.	Unit of Material	Total Material	Rate in TK.	Total Cost in TK.
		L	W					
Top	Beech 16mm	1001	551	1	Sft	5.94	44.5	264.33
Side	Beech 16mm	681	503	2	Sft	7.37	44.5	327.97
Partition	Beech 16mm	604	383	1	Sft	2.49	44.5	110.81
Bottom	Beech 16mm	897	492	1	Sft	4.75	44.5	211.38
Bottom Support	Beech 16mm	897	59	1	Sft	0.57	44.5	25.15
Front Support	Beech 16mm	897	125	1	Sft	1.21	44.5	53.85
Keyboard Tray	Beech 16mm	607	330	1	Sft	2.16	44.5	96.12
KB Tray Front Bit	Beech 16mm	624	55	1	Sft	0.37	48	17.59
KB Tray Bottom Bit	Beech 16mm	570	40	1	Sft	0.25	44.5	11.13
KB Tray Bottom Ply	Beech 3mm	570	50	1	Sft	0.31	18	5.58
Mouse Tray	Beech 9mm	295	197	1	Sft	0.63	37 13	23.39
Dr. Front	Beech 18mm	249	123	1	Sft	0.33	48	15.70
Dr. Side	Beech 18mm	350	75	2	Sft	0.57	44.5	25.37
Dr. Front Support	Beech 16mm	192	94	0.5	Sft	0.10	44.5	4.45
Dr. Back Support	Beech 16mm	192	75	1	Sft	0.16	44.5	7.12
Dr. Bottom Ply	Beech 3mm	345	224	1	Sft	0.83	18	14.94
Edging	Beech-2x19				m	5.07	21.58	109.41
Edging	Beech- 1x22				m	2.085	13.05	27.21
Edging	Beech-.5x19				m	4.05	4.81	19.48
Edging	Beech-1x19				m	4.85	14.75	71.54
Glue	Total Edging(16.2+1.4+.75=18.35)				m	17	4	68.00
Kit Pack Fixing Components								
JRN nut, Nickel Star Type (M6X10X13)				12	Nos.		1.57	18.84
JCBC Allen head screw, Black (M6X50)				12	Nos		1 24	14.88
Housing(13mm)				8	Nos.		2.96	23.68
Housing pin(41.5mm)				8	Nos		3 19	25.52
Housing cap, Black				8	Nos.		0.59	4.72
Dowel				8	Nos		1.11	8 88
Wood pin(dia.6x29)				2	Nos.		0.15	0.3
M.S.L-Clamp(3/4"x3/4")				2	Nos.		2	4
Tin screw, star head round(No8x1/2")				4	Nos.		0.3	1.2
Caster Wheel(16mm clamp) with break				2	Nos		8.5	17
Caster Wheel(18mm clamp) without break				3	Nos		7	21
Allen Key(4mm)				1	Nos.		1.78	1.78
Dr. Channel(350mm)				2	Nos.		44	88
(+) CSK Wood Screw (No 5x3/4")				10	Nos		0.14	1.4
Tin screw, star head flat(No3.5x12mm)				18	Nos		0.4	7.2
Lock138				1	Nos.		49	49
Hollowgram Sticker				1	Nos		1	1
Monogram				1	Nos		1	1
Carton				1	Nos.		55	55
								1854 89

OTOBI LIMITED

Shyampur, Dhaka

Costing

Product Name: Computer Table
Model: TCC-13H
Size: 906(L)X450(W)X750(H)

SL#	Particulars	Rate	Hours	Amount in TK.	Remarks
A	Materials			1855	
B	Wages	22	4	88	
C	Prime Cost			1943	
D	Manufacturing Overhead	26	4	104	
E	Wastage and Safety Factor @ 15% On A	15%		278	
F	Manufacturing Cost (C+D+E)			2325	
G	Administrative Factor @ 15% On F	15%		349	
H	Selling Overhead @ 20% On F	20%		465	
I	Cost of Goods Sold (F+G+H)			3139	
J	Profit @ 25% On I	25%		785	
K	Selling Price Without VAT(I+J)			3924	
L	VAT @ 6% On K	6%		235	
M	Selling Price Including VAT (K+L)			**4159**	
N	Cost Based on 2.5 Times of Materials cost			4638	
O	Proposed Price			4650	
P	Approved Price			4500	

)TOBI LTD.	DOCUMENT TITLE: CHECKLIST(IN PROCESS)	ISSUE:"A"
		DATE:
	DOCUMENT NO: QC-LB-15	TIME:

MODEL NO: TCC-13

WORKER ID:

ATCH NO :

I.	Componemts	Size	No.	OK
1	Top	1000x550x16	1	
2	Side	677x500x16	1	
3	Partition	601x380x16	1	
4	Bottom	892x494x16	1	
5	Bottom support	892x60x16	1	
6	Front support	892x126x16	1	
7	Keyboard tray	602x330x16	1	
8	KB tray front bit	622x57x16	1	
9	KB tray bottom bit	570x40x16	1	
0	KB tray bottom ply	570x50x16	1	
1	Mouse tray	296x198x9	1	
2	Dr. Front	246x126x16	1	
3	Dr. Side	350x78x16	2	
4	Dr. Back	192x78x16	1	
5	Dr. Bottom Ply	338x201x3	1	
6	Dr. Channel, Set	350mm	2	
7	Kit Pack		1	
8	Fixing Manual		1	
9	Carton		1	
0	Hologram		1	
1	Monogram		1	

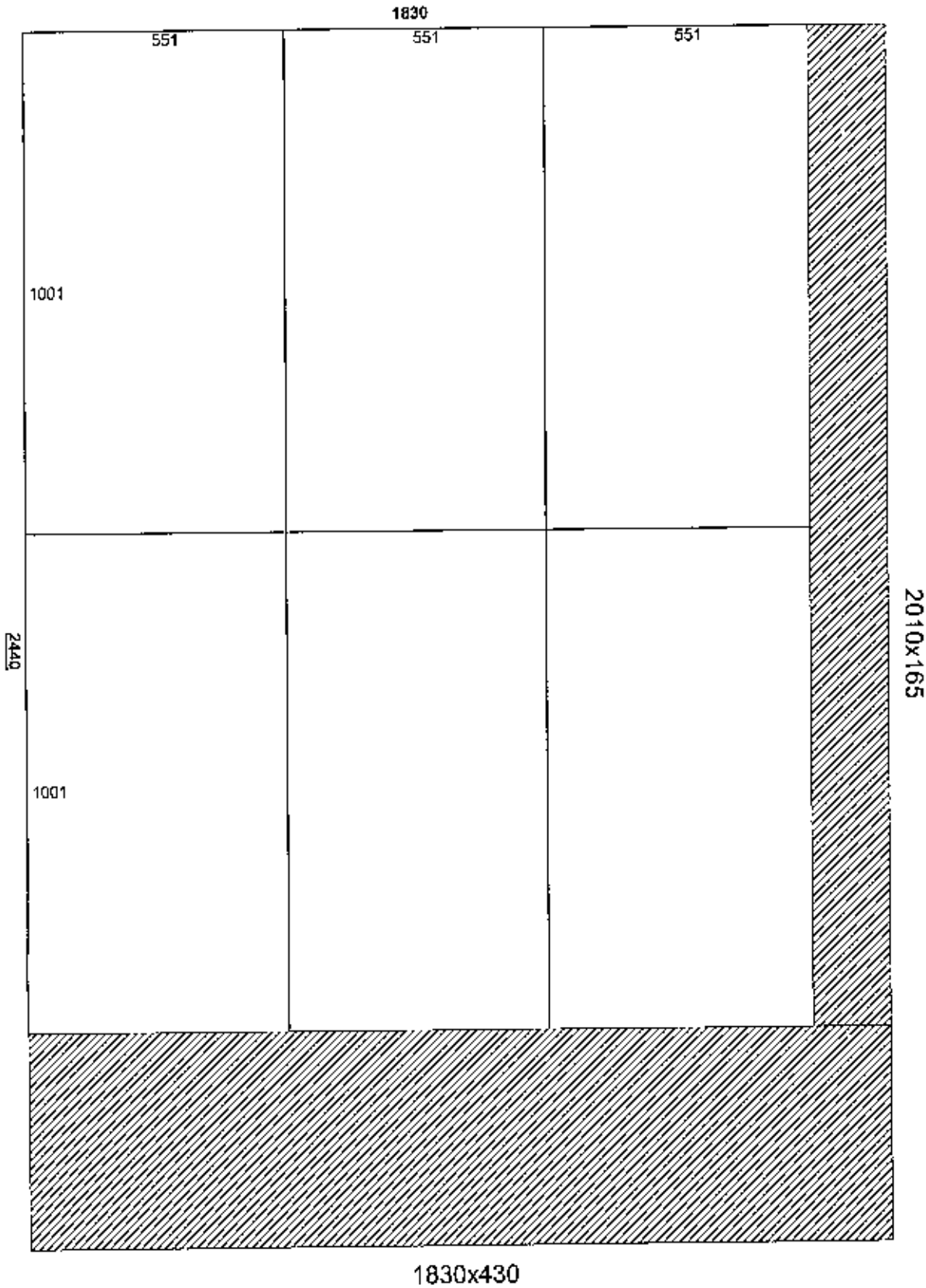
Kit Pack	Qty	Remarks
Housing (13mm)	10	
Housing pin(41.5mm)	10	
Housing Cap (Beech)	10	
JCBC Allen Screws M6x50(Rainbow)	12	
JRN Nut M6x10x13	12	
Wood Pin M6x30	6	
M.S. Seat Clamp (3/4"x1"x1")	2	
Shelf-tapping Screw, Star pan head(No.8x1/2")	4	
Caster with Brake	2	
Caster without Brake	2	
Star Pan Head Screw M6x25(Black)	5	
JCBC Allen Screw M7x50 (Nickel-Unita)	2	
M.S. Hexagonal Nut M6	5	
(+)CSK Self-tapping Screw(No.3.5x1/2")	32	
(+)CSK Wood Screw(No.5x3/4")	4	
Lock (138) 22mm	1	
Allen Key (4mm)	1	

n case of any defect, please fill out the space in the 'Remarks' column of this paper inside the packet stating
ne defect and send it back to D.G.M.

Packing in Charge

Cutting Plan

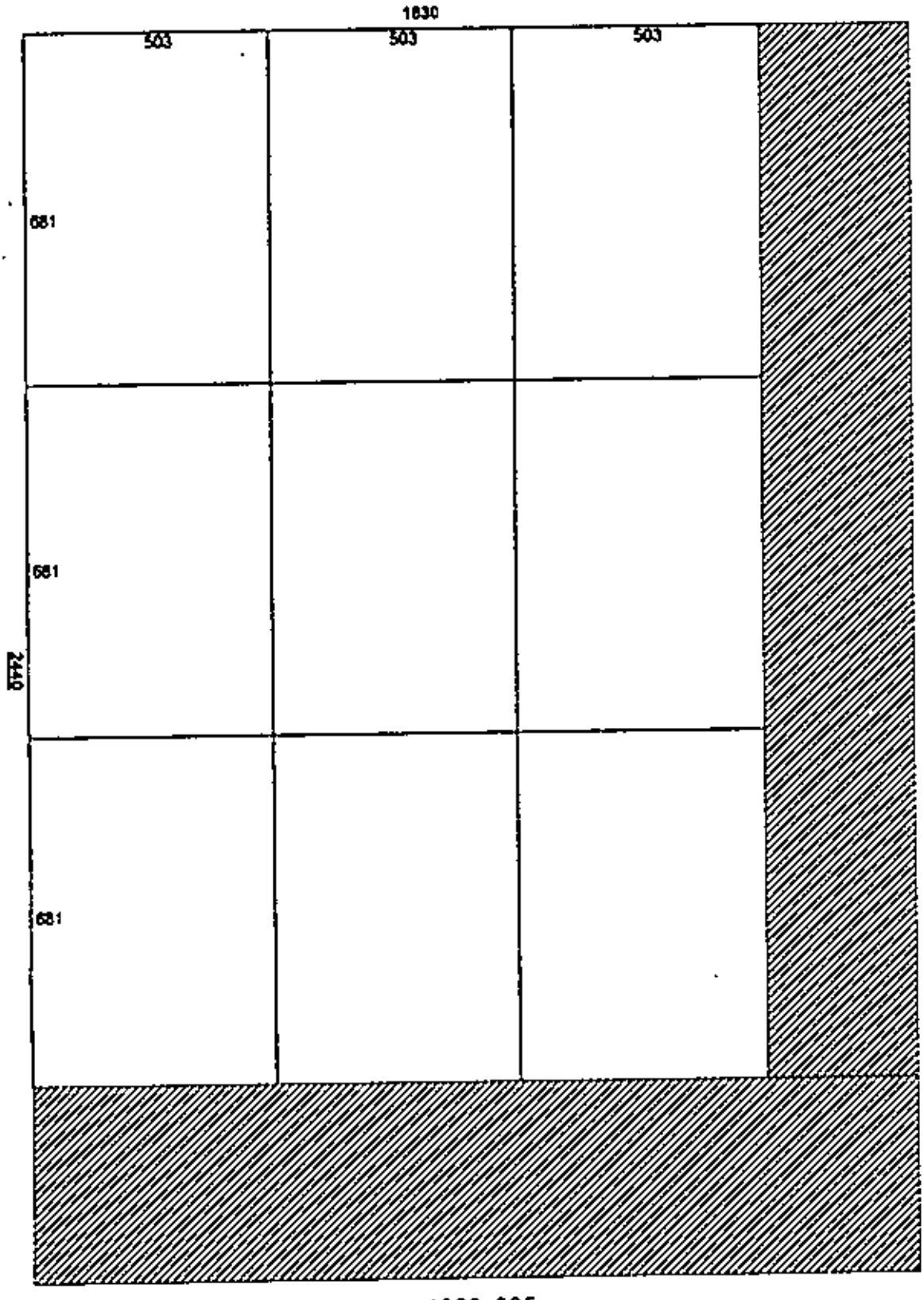
Prod. Name	Computer Table	Board Size	2440x1830	Sheet No.	1
Model	TCC P02 LB B02	Board Thickness, Clr	16 mm Beech Imported	Cut Piece-1	1830x430
Comp.	Top	Fiber	Lengthwise	Cut Piece-2	2010x165
Lot Size		Cutting Size	1001x551	Req. Time	
No of Comp.	1	Component/Board	6	Start Time	
Total Qty		Required Board		End Time	



Date	Prepared by	Checked by	Approved by
15/03/05; 2:55:04 AM	M. Islam		

Cutting Plan

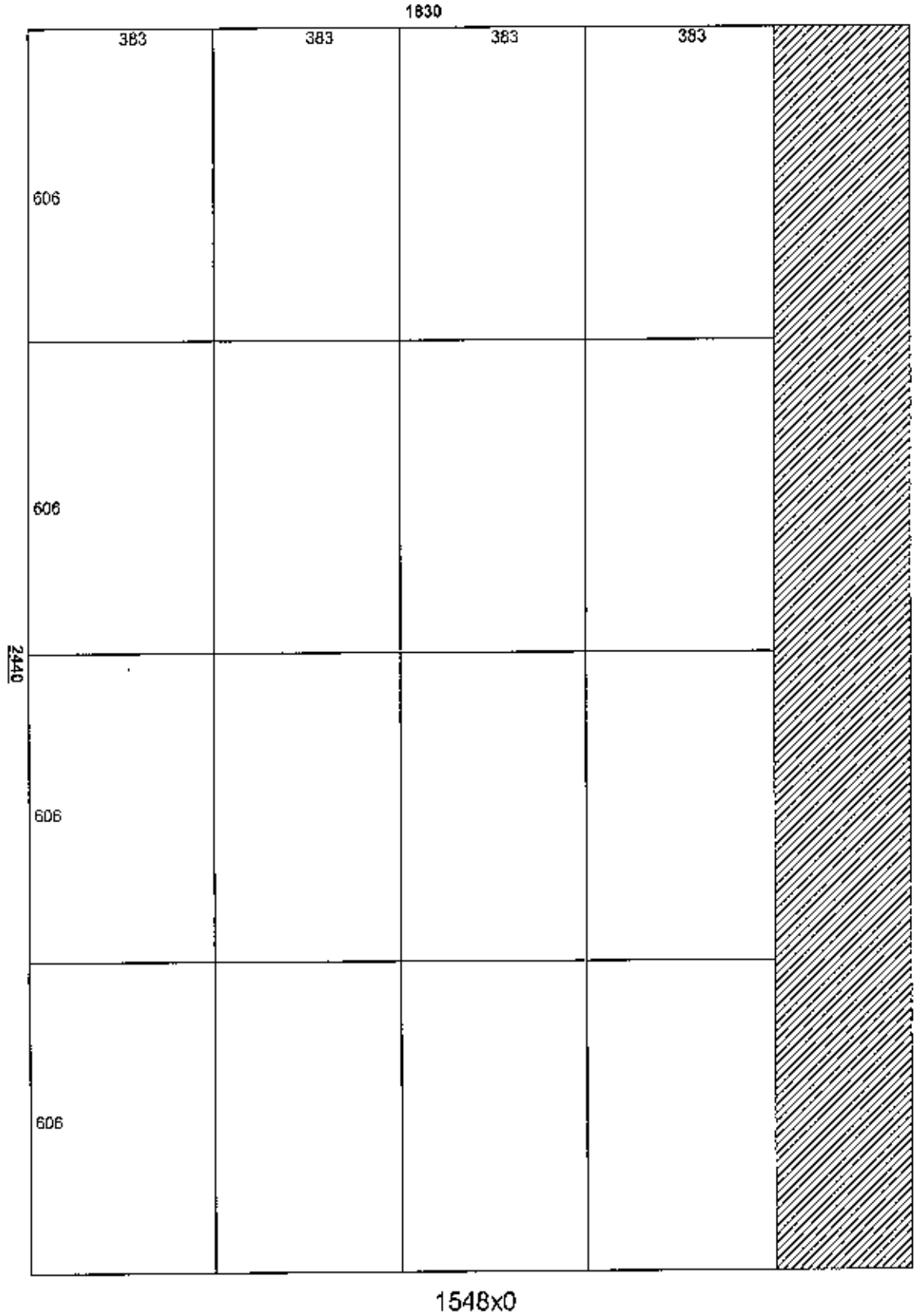
Prod. Name	Computer Table	Board Size	2440x1830	Sheet No.	2
Model	TCC P02 LB B02	Board Thickness, Cir	16 mm Beech Imported	Cut Piece-1	1830x385
Comp.	Side	Fiber	Lengthwise	Cut Piece-2	2055x309
Lot Size		Cutting Size	681x503	Req. Time	
No of Comp.	2	Component/Board	9	Start Time	
Total Qty		Required Board		End Time	



Date	Prepared by	Checked by	Approved by
15/03/05; 2:55:04 AM	M. Islam		

Cutting Plan

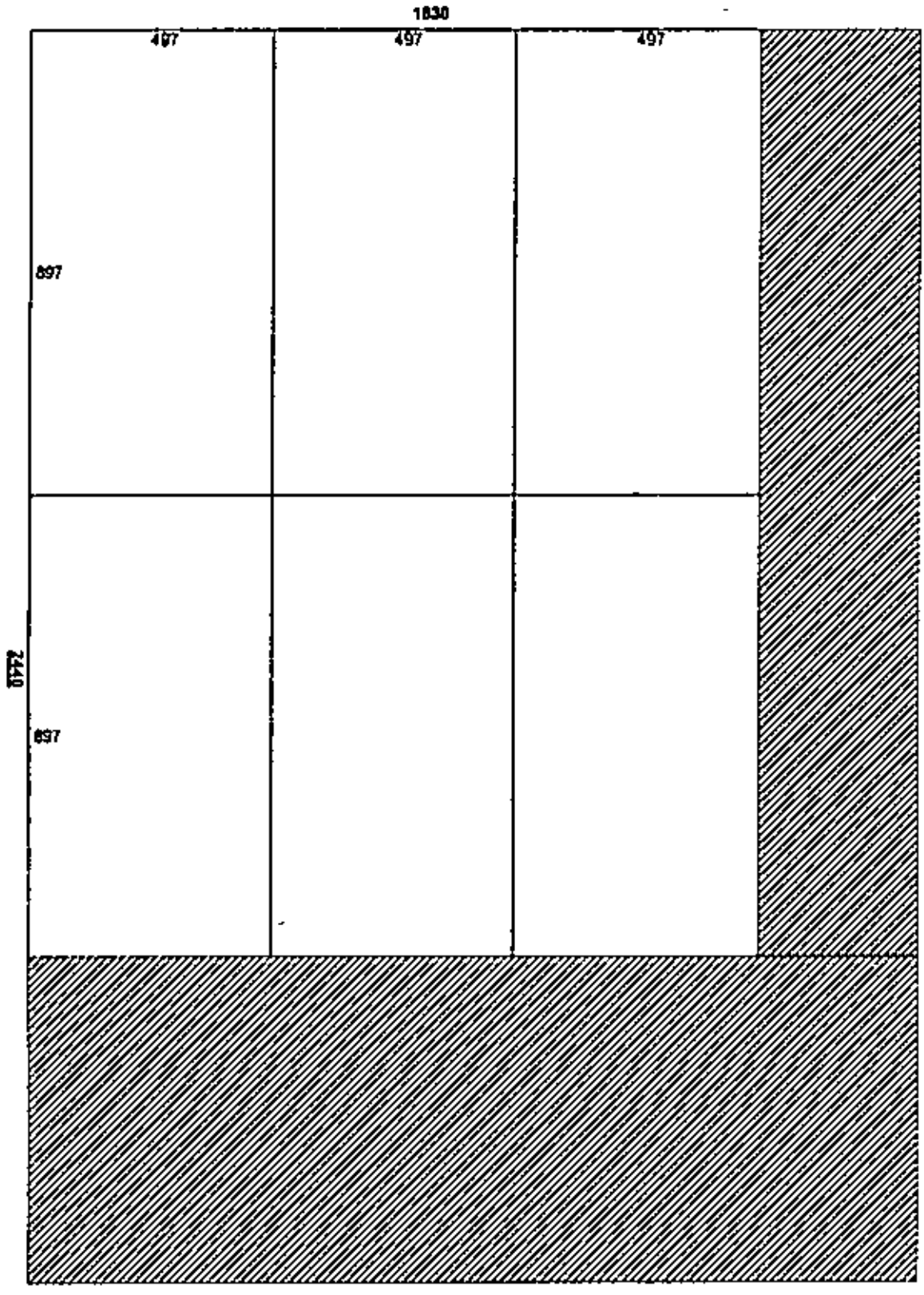
Prod. Name	Computer Table	Board Size	2440x1830	Sheet No.	3
Model	TCC P02 LB B02	Board Thickness, Clr	16 mm Beech Imported	Cut Piece-1	2440x282
Comp.	Partition	Fiber	Lengthwise	Cut Piece-2	1548x0
Lot Size		Cutting Size	606x383	Req. Time	
No of Comp.	1	Component/Board	16	Start Time	
Total Qty		Required Board		End Time	



Date	Prepared by	Checked by	Approved by
15/03/05; 2:55:04 AM	M Islam		

Cutting Plan

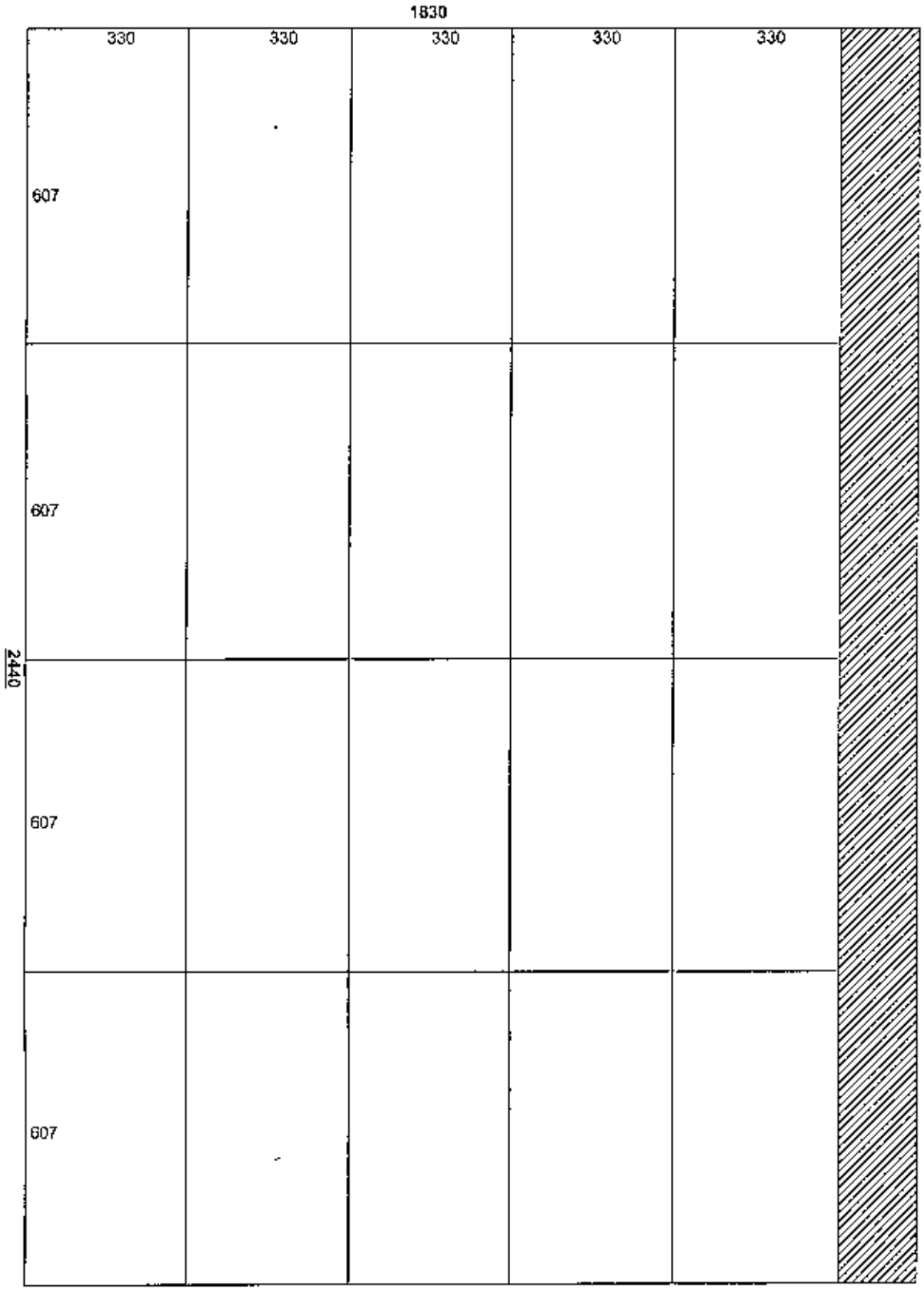
Prod. Name	Computer Table	Board Size	2440x1830	Sheet No.	4
Model	TCC P02 LB 802	Board Thickness, Ctr	16 mm Beech Imported	Cut Piece-1	1830x638
Comp.	Bottom	Fiber	Lengthwise	Cut Piece-2	1802x327
Lot Size		Cutting Size	897x497	Req. Time	
No of Comp.	1	Component/Board	6	Start Time	
Total Qty		Required Board		End Time	



Date	Prepared by	Checked by	Approved by
15/03/05; 2:55:04 AM	M. Islam		

Cutting Plan

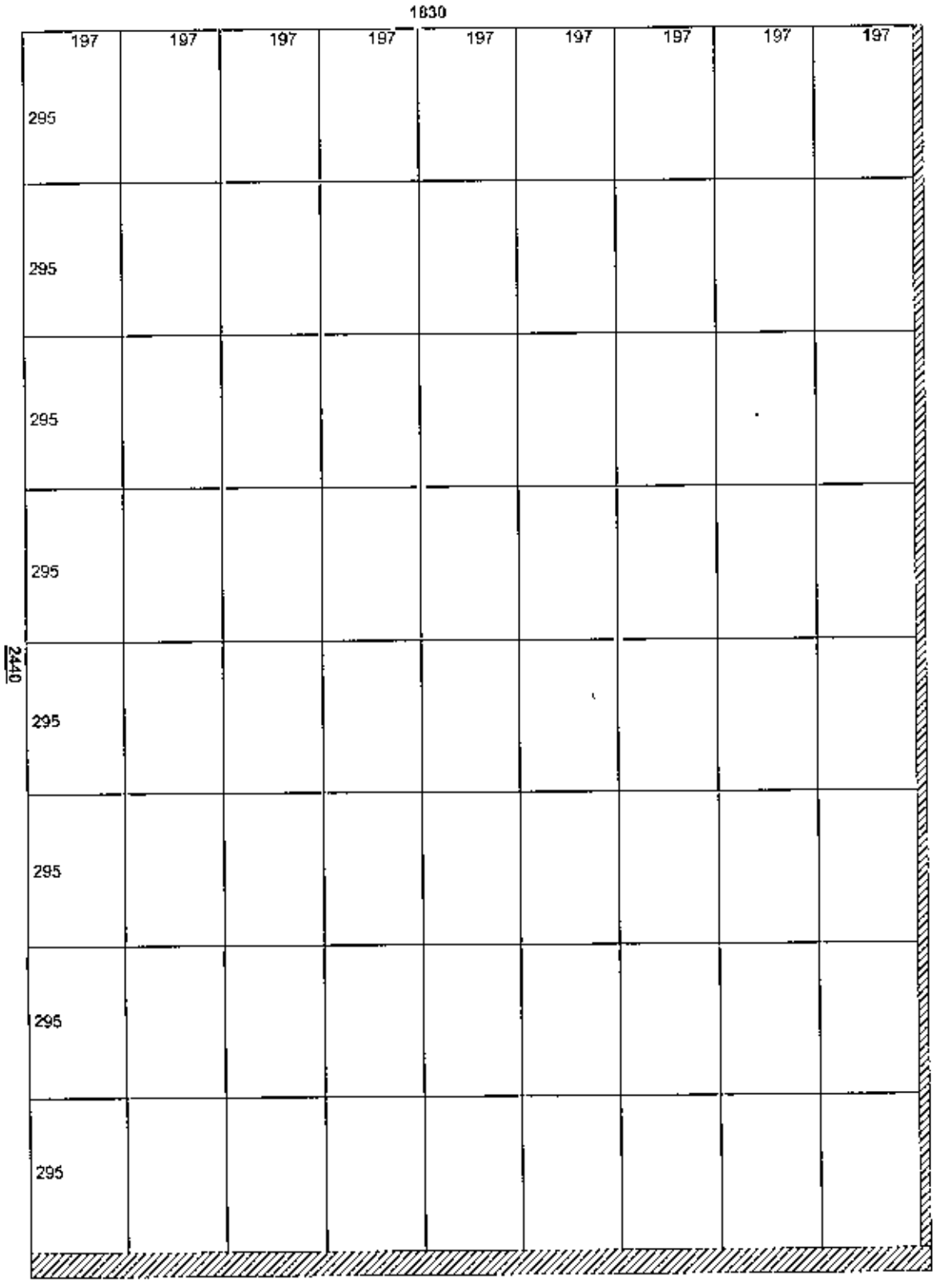
Prod. Name	Computer Table	Board Size	2440x1830	Sheet No.	5
Model	TCC P02 LB B02	Board Thickness, Clr	16 mm Beech Imported	Cut Piece-1	2440x160
Comp.	KB Tray	Fiber	Lengthwise	Cut Piece-2	1665x0
Lot Size		Cutting Size	607x330	Req. Time	
No of Comp.	1	Component/Board	20	Start Time	
Total Qty		Required Board		End Time	



Date	Prepared by	Checked by	Approved by
15/03/05; 2:55:04 AM	M. Islam		

Cutting Plan

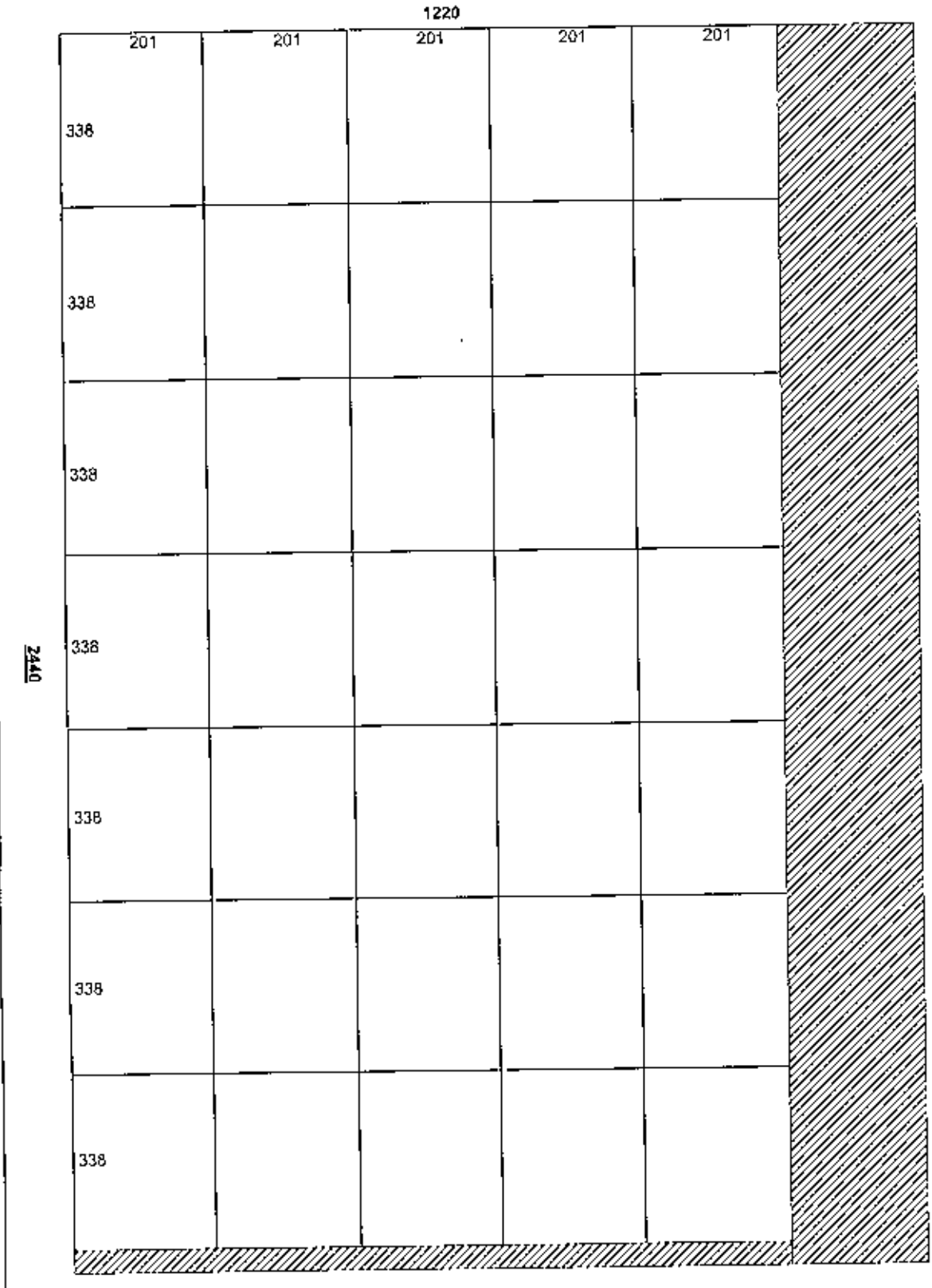
Prod Name	Computer Table	Board Size	2440x1830	Sheet No.	6
Model	TCC P02 LB B02	Board Thickness, Clr	09 mm Beech Imported	Cut Piece-1	1830x48
Comp.	Mouse Tray	Fiber	Lengthwise	Cut Piece-2	2392x21
Lot Size		Cutting Size	295x197	Req. Time	
No of Comp.	1	Component/Board	72	Start Time	
Total Qty		Required Board		End Time	



Date	Prepared by	Checked by	Approved by
15/03/05, 2.55.04 AM	M. Islam		

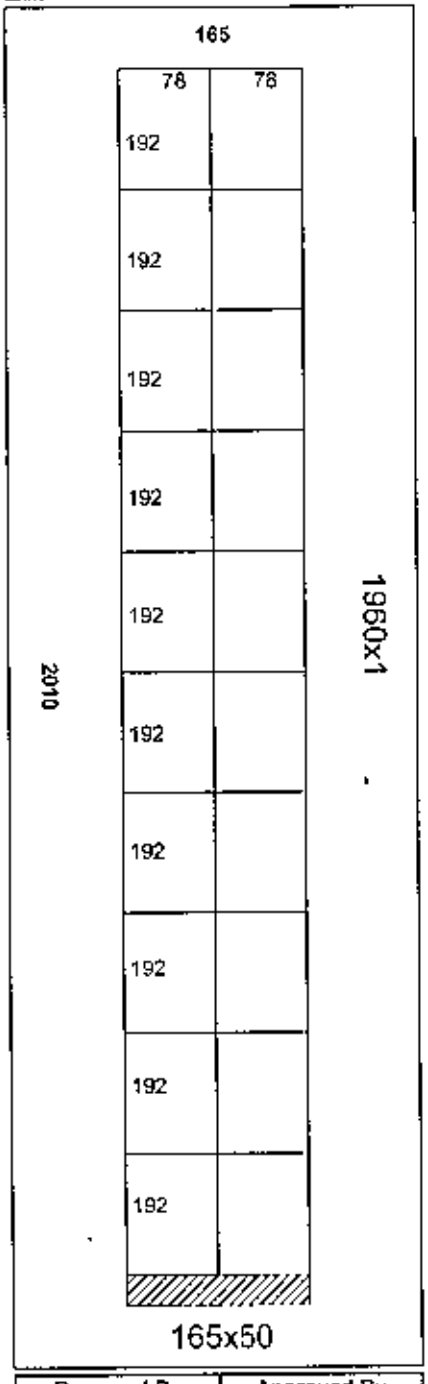
Cutting Plan

Prod. Name	Computer Table	Board Size	2440x1220	Sheet No.	7
Model	TCC P02 LB B02	Board Thickness, Clr	03 Beech Ply	Cut Piece-1	2440x195
Comp.	Dr. Bottom Ply	Fiber	No	Cut Piece-2	1025x46
Lot Size		Cutting Size	338x201	Req Time	
No of Comp.	1	Component/Board	35	Start Time	
Total Qty		Required Board		End Time	



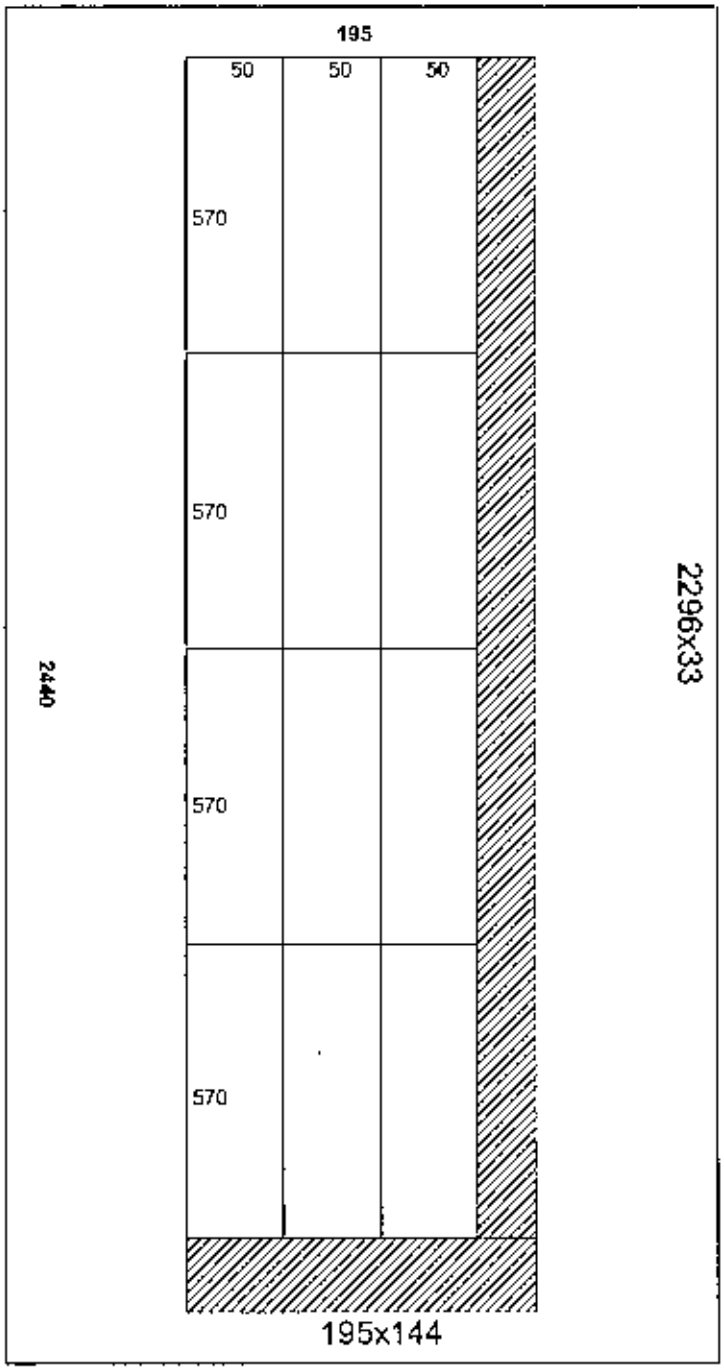
Date	Prepared by	Checked by	Approved by
15/03/05; 2:55:04 AM	M. Islam		

Cutpiece Plan	
Mother Component	
Top	
Child Component	
Dr Back	
Cutpiece Size	2010x165
CP-1	165x50
CP-2	1960x1
Comp Size	192x78
No of Comp	20
Model	TCC P02 LB B02
Sheet No	
Sub Sheet No	1/2



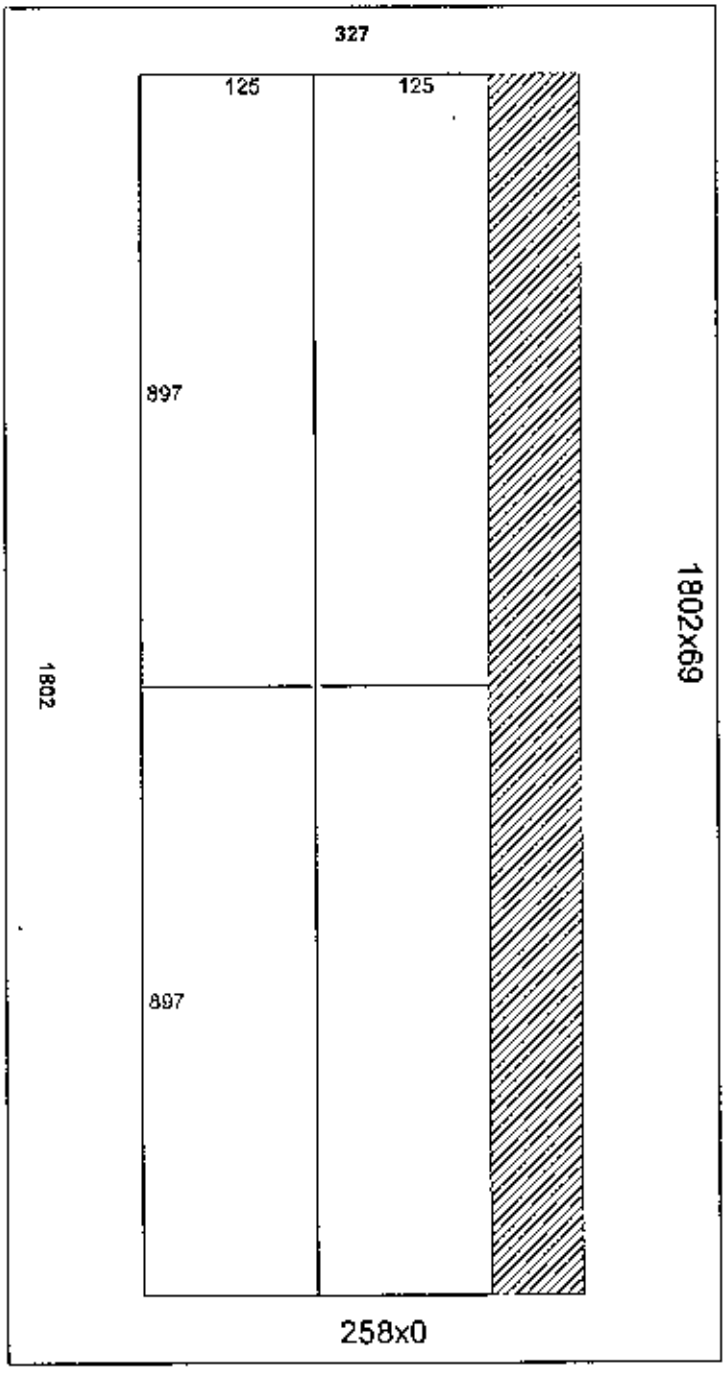
Prepared By	Approved By
M. Islam	

Cutpiece Cutting Plan			
Mother Comp	Dr. Bottom Ply	Child Comp	KB Tray Bott. Ply
Cutpiece Size	2440x195	Size	570x50
Model	TCC P02 LB B02	No of Comp	12
Sheet No		CP-1	195x144
Sub Sheet No	7/1	CP-2	2296x33



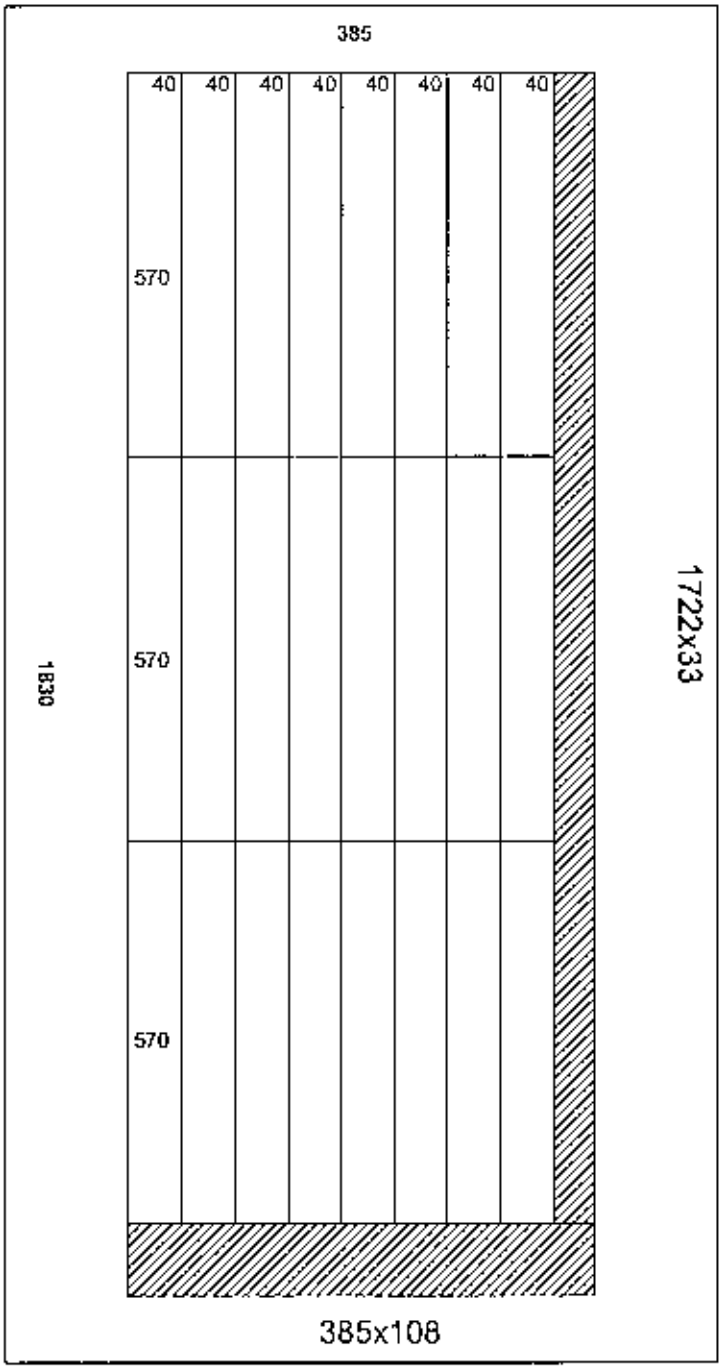
Prepared By:	Checkd By:	Approved By:
M. Islam		

Cutpiece Cutting Plan			
Mother Comp	Bottom	Child Comp	Front Supt.
Cutpiece Size	1802x327	Size	897x125
Model	TCC P02 LB B02	No of Comp	4
Sheet No		CP-1	1802x69
Sub Sheet No	4/2	CP-2	258x0



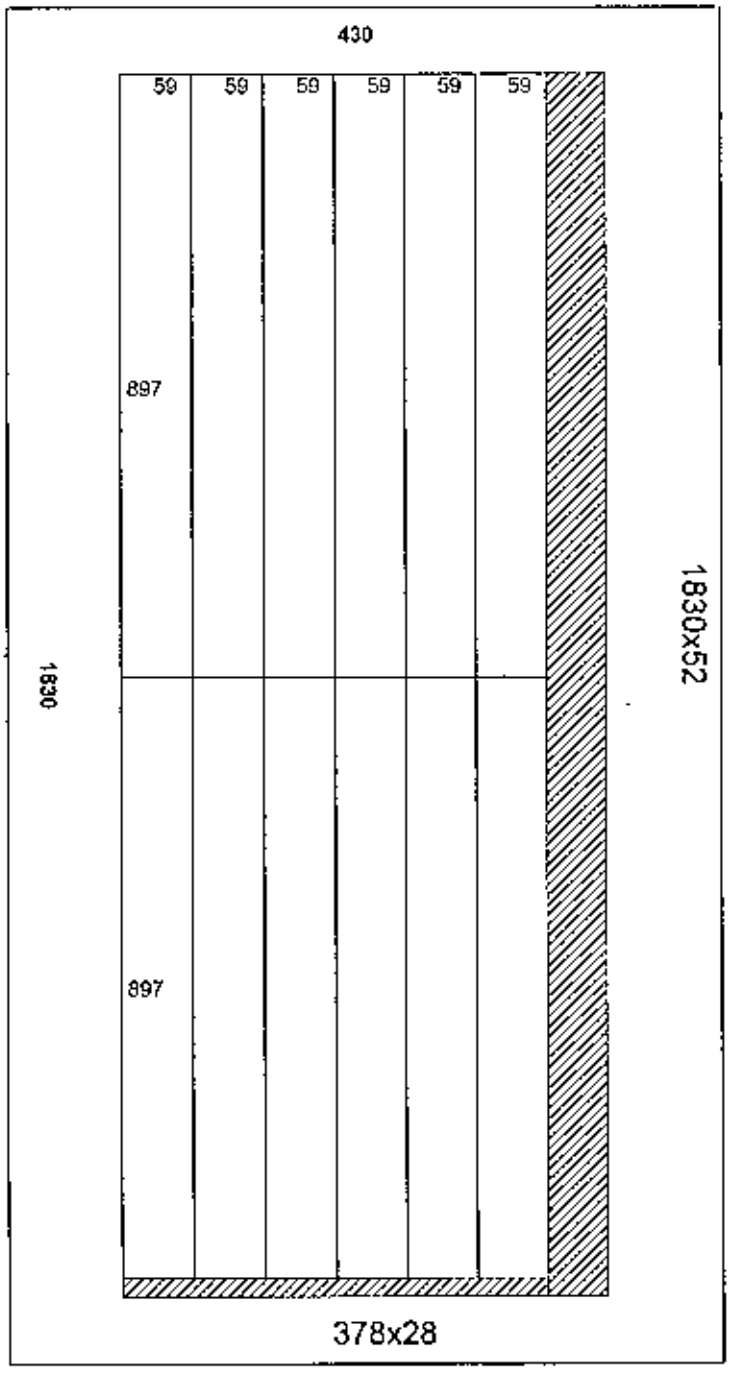
Prepared By:	Checkd By:	Approved By:
M. Islam		

Cutpiece Cutting Plan			
Mother Comp	Side	Child Comp	KB Tray Bott. Bit
Cutpiece Size	1830x385	Size	570x40
Model	TCC P02 LB B02	No of Comp	24
Sheet No		CP-1	385x108
Sub Sheet No	2/2	CP-2	1722x33



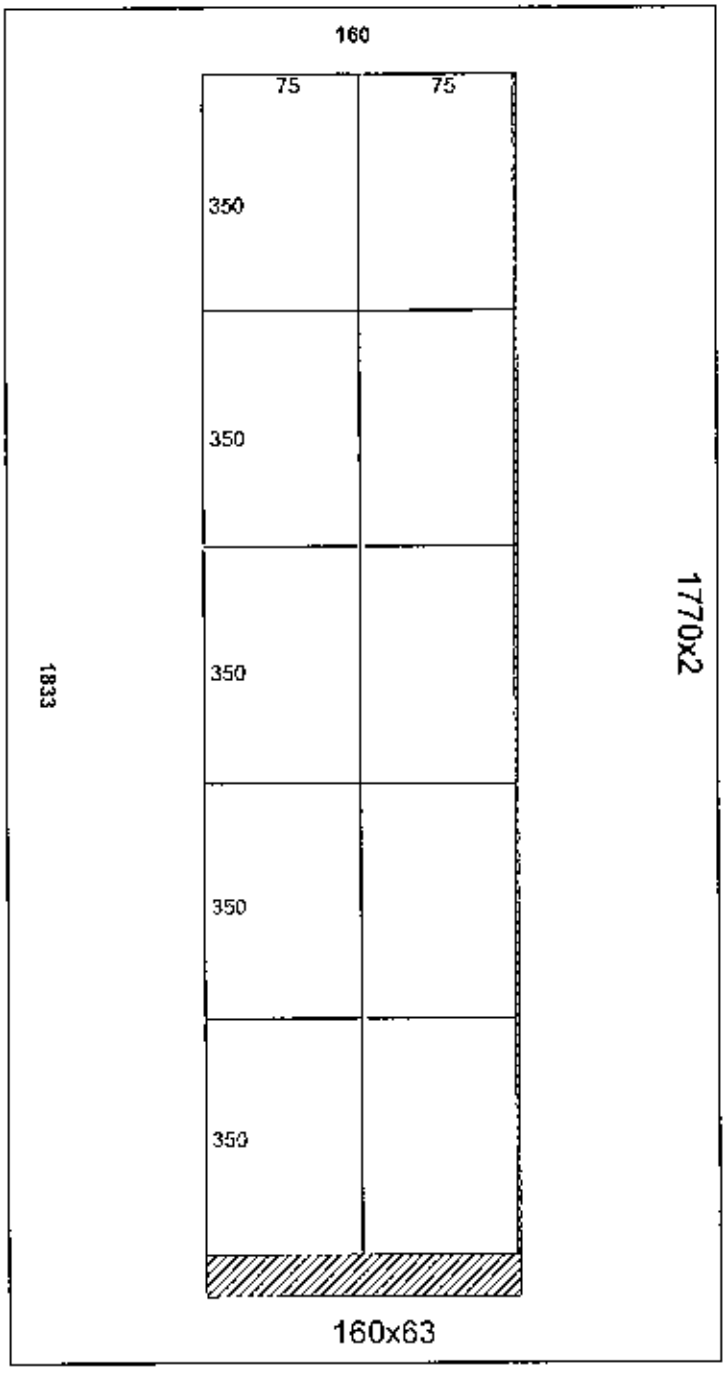
Prepared By:	Checkd By:	Approved By:
M. Islam		

Cutpiece Cutting Plan			
Mother Comp	Top	Child Comp	Bottom Supt.
Cutpiece Size	1830x430	Size	897x59
Model	TCC P02 LB B02	No of Comp	12
Sheet No		CP-1	1830x52
Sub Sheet No	1/1	CP-2	378x28



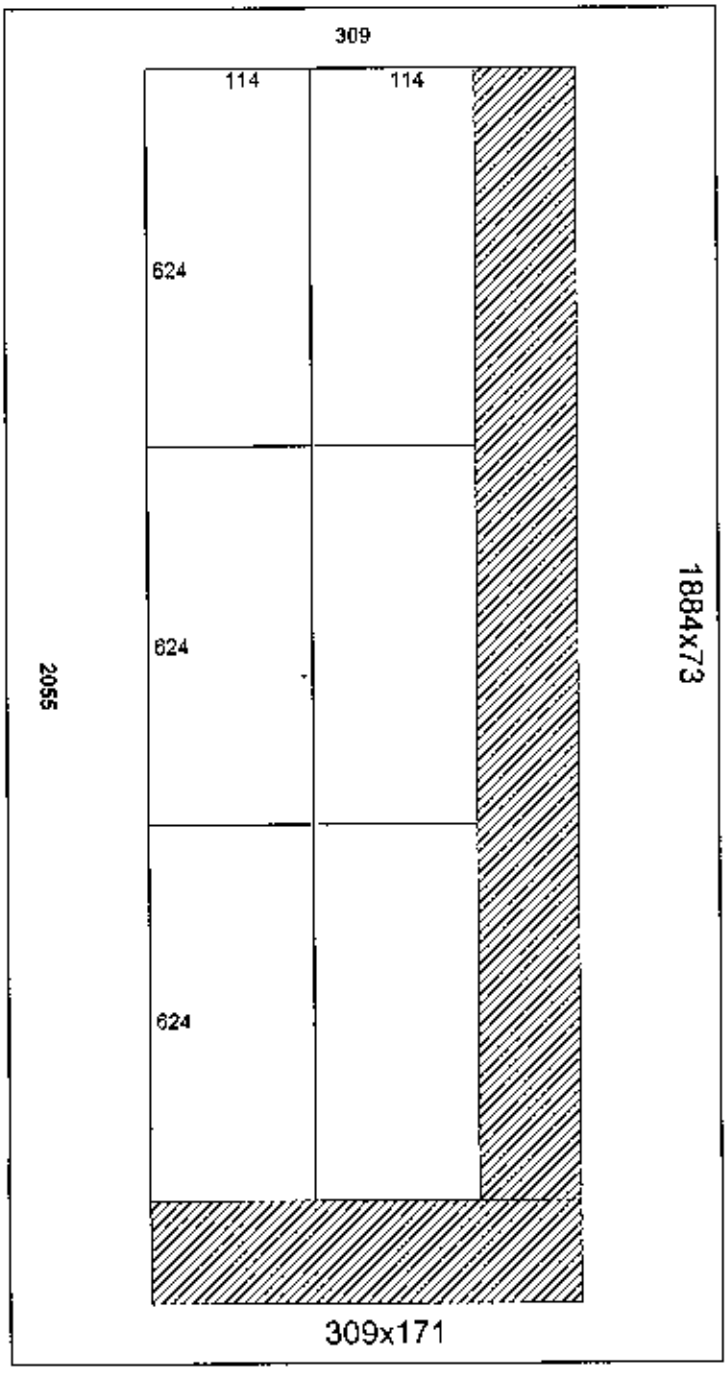
Prepared By:	Checkd By:	Approved By:
M. Islam		

Cutplece Cutting Plan			
Mother Comp	KB Tray	Child Comp	Dr. Side
Cutplece Size	1833x160	Size	350x75
Model	TCC P02 LB B02	No of Comp	10
Sheet No		CP-1	160x63
Sub Sheet No	5/1	CP-2	1770x2



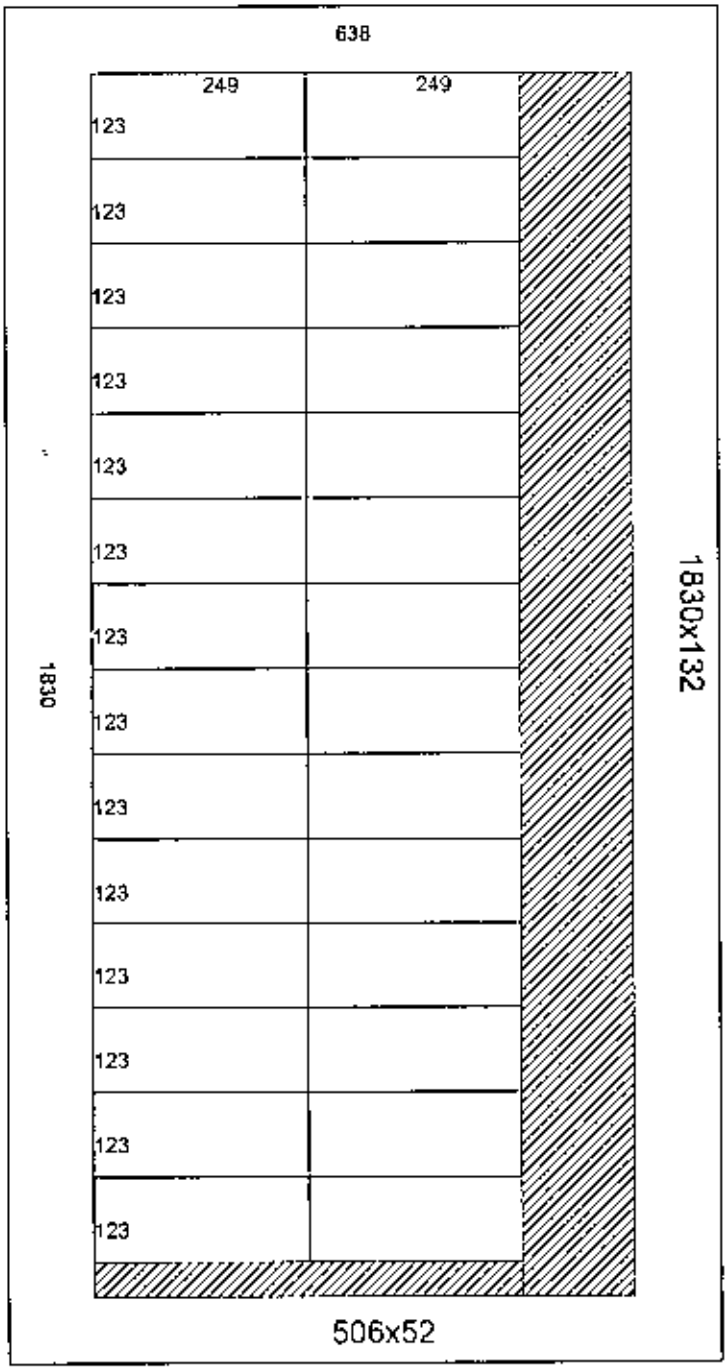
Prepared By:	Checkd By:	Approved By:
M. Islam		

Cutpiece Cutting Plan			
Mother Comp	Side	Child Comp	KB Tray Front Bit
Cutpiece Size	2055x309	Size	624x114
Model	TCC P02 LB B02	No of Comp	6
Sheet No		CP-1	309x171
Sub Sheet No	2/1	CP-2	1884x73



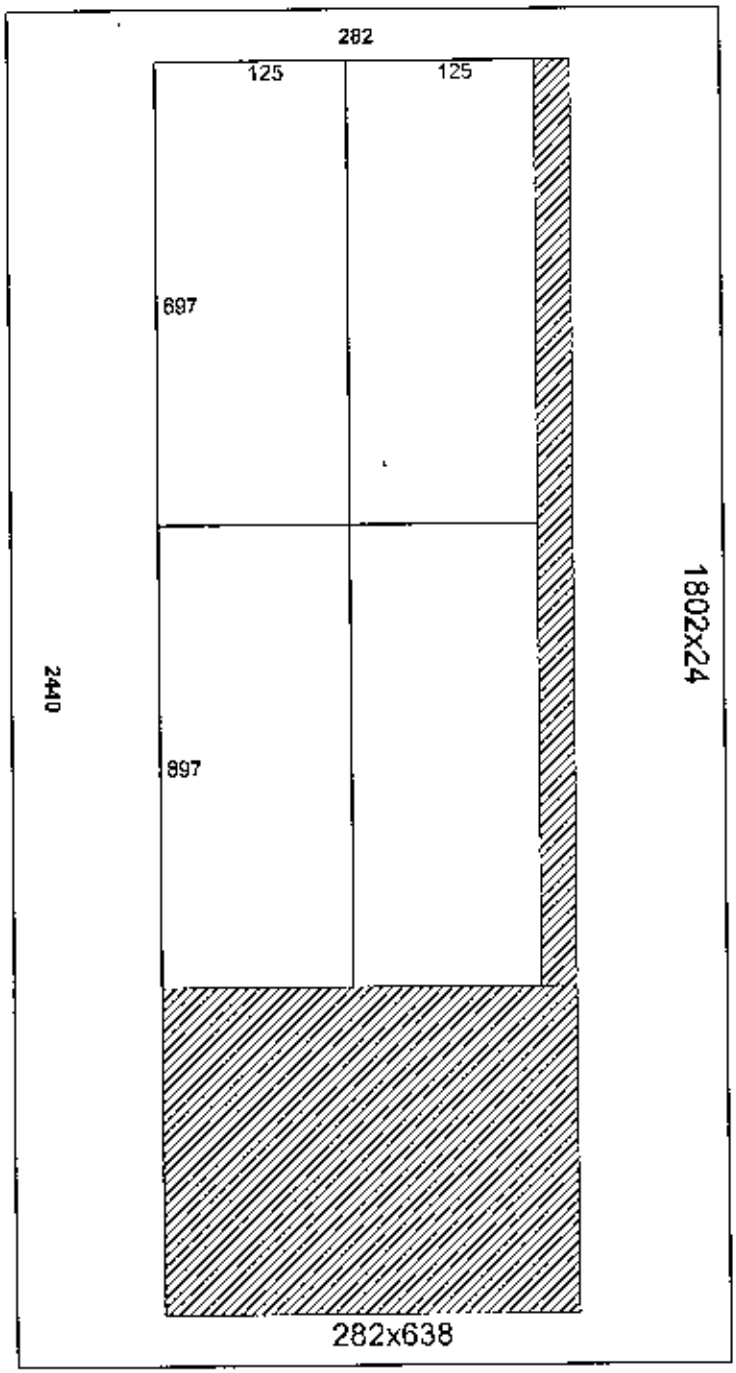
Prepared By:	Checkd By:	Approved By:
M. Islam		

Cutpiece Cutting Plan			
Mother Comp	Bottom	Child Comp	Dr. Front
Cutpiece Size	1830x638	Size	249x123
Model	TCC P02 LB B02	No of Comp	28
Sheet No		CP-1	1830x132
Sub Sheet No	4/1	CP-2	506x52



Prepared By:	Checkd By:	Approved By:
M. Islam		

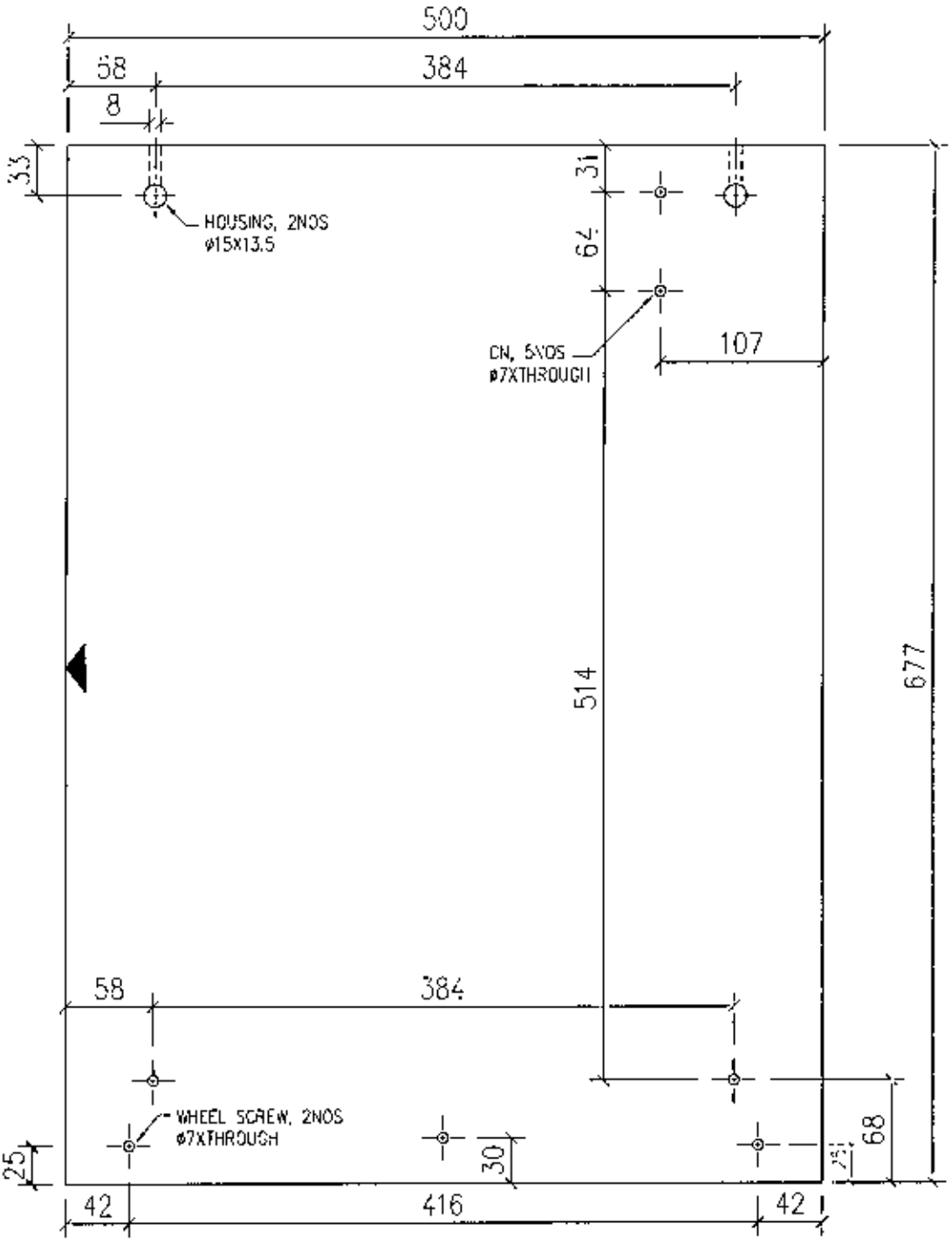
Cutpiece Cutting Plan			
Mother Comp	Partition	Child Comp	Front Supt.
Cutpiece Size	2440x282	Size	897x125
Model	TCC P02 LB B02	No of Comp	4
Sheet No		CP-1	282x638
Sub Sheet No	3/1	CP-2	1802x24



Prepared By:	Checkd By:	Approved By:
M. Islam		

MODEL:-TCC P02 (TCC-13F/H)

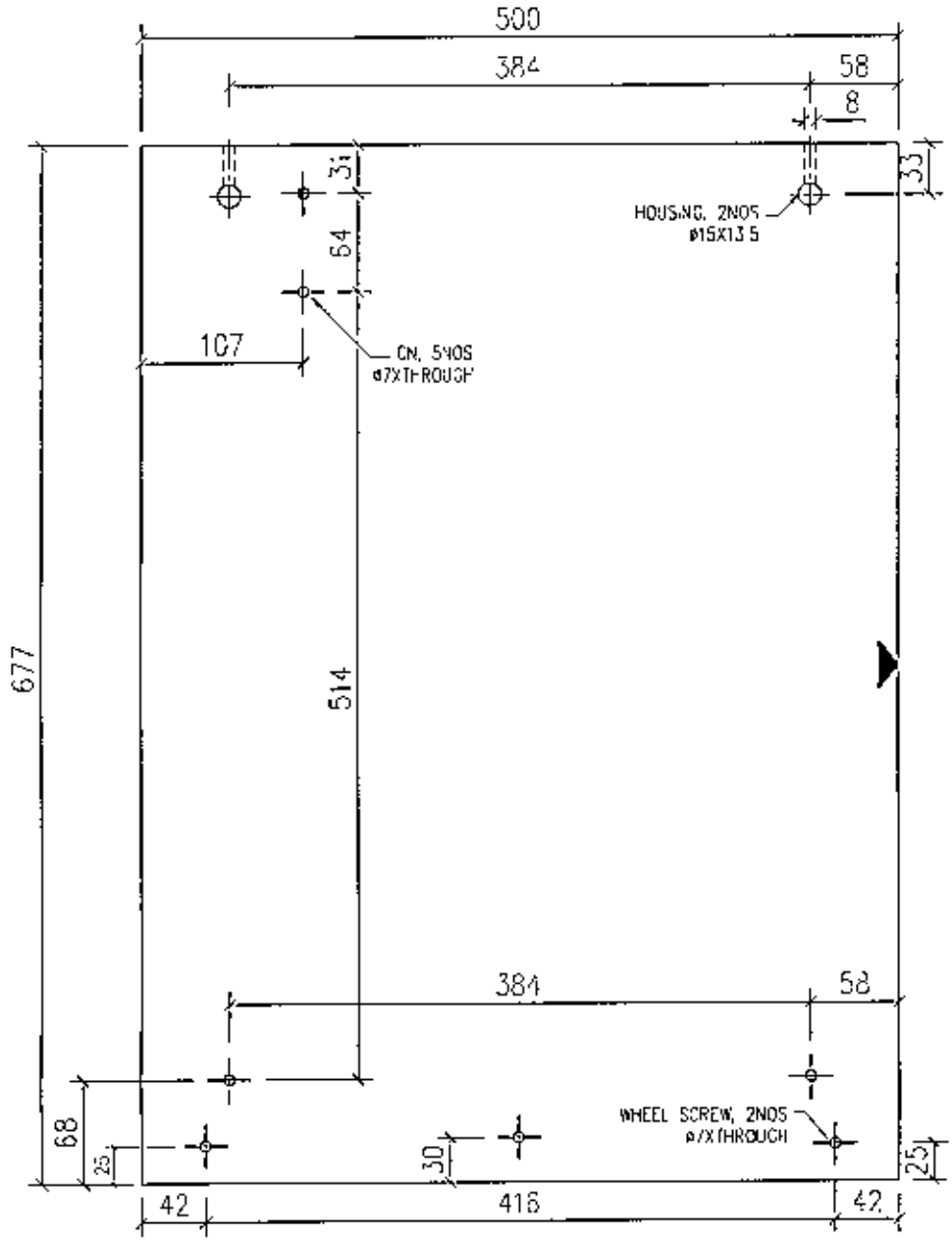
LEFT SIDE - 16mm



TITLE :	CAD BY:	PLANNED & CHECKED BY:	SHEET NO.
COMPUTER TABLE	SANTOSH SAMADDER	MD. MIZANUR RAHMAN	02 OF 08
F:\NEED\PRO DATA\BOR.\TCC P02	DATE:- 15/07/02	APPROVED BY:-	

MODEL:-TCC P02 (TCC-13F/H)

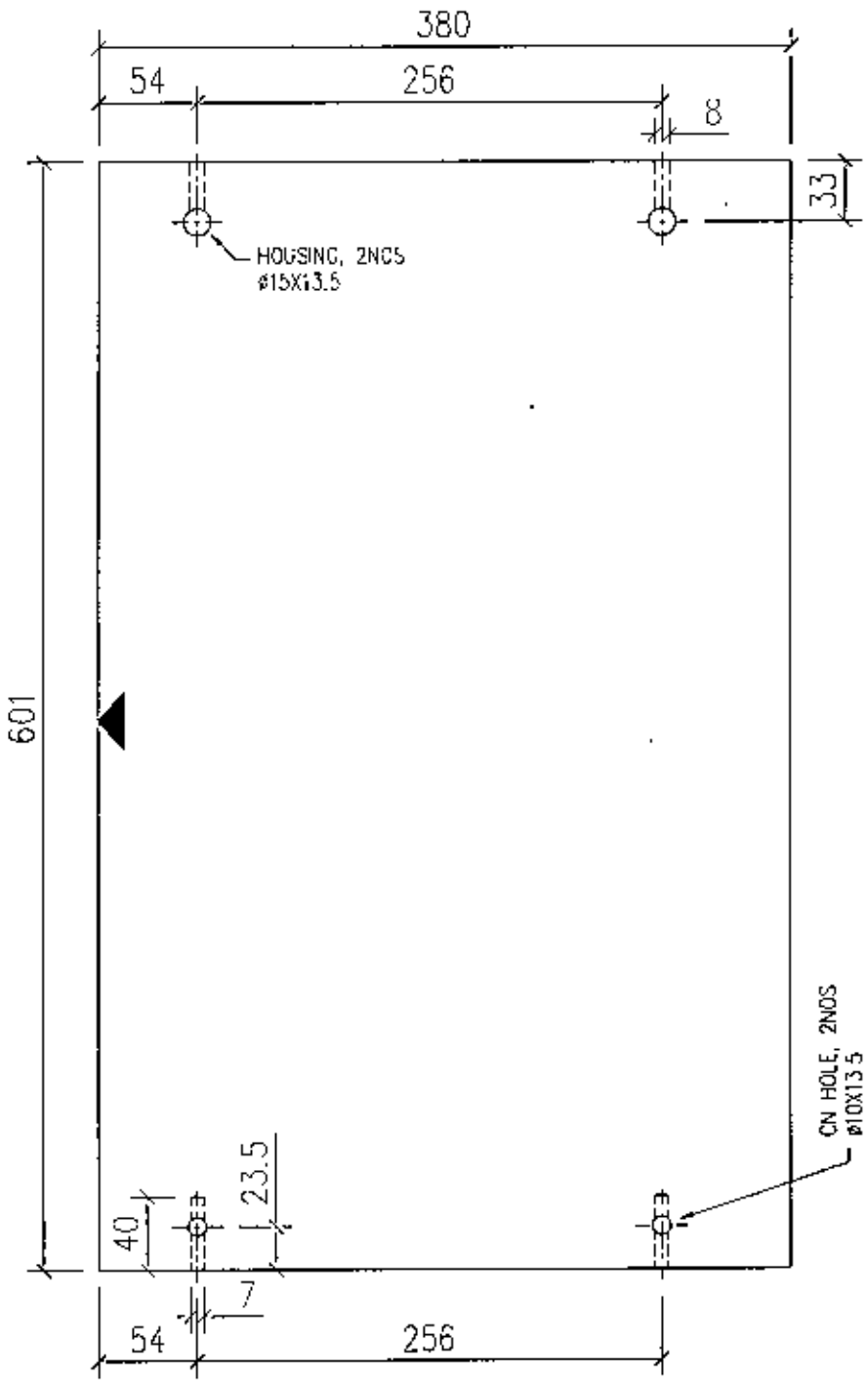
RIGHT SIDE - 16mm



TITLE :	CAD BY:	PLANNED & CHECKED BY:	SHEET NO.
COMPUTER TABLE	SANTOSH SAMADDER	MD. MIZANUR RAHMAN	03 OF 08
F:\NEED\PRO DATA\BOR.\TCC P02	DATE:- 15/07/02	APPROVED BY:-	

MODEL:TCC P02 (TCC-13F/H)

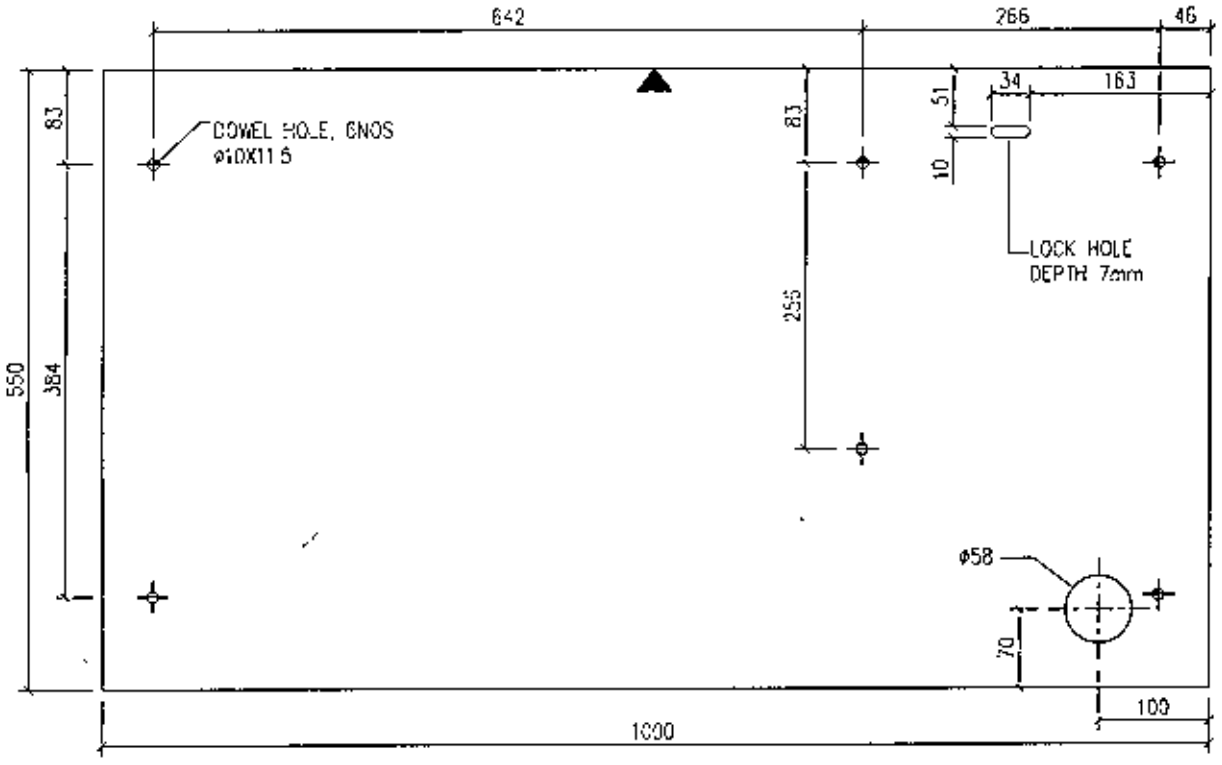
PARTITION - 16mm



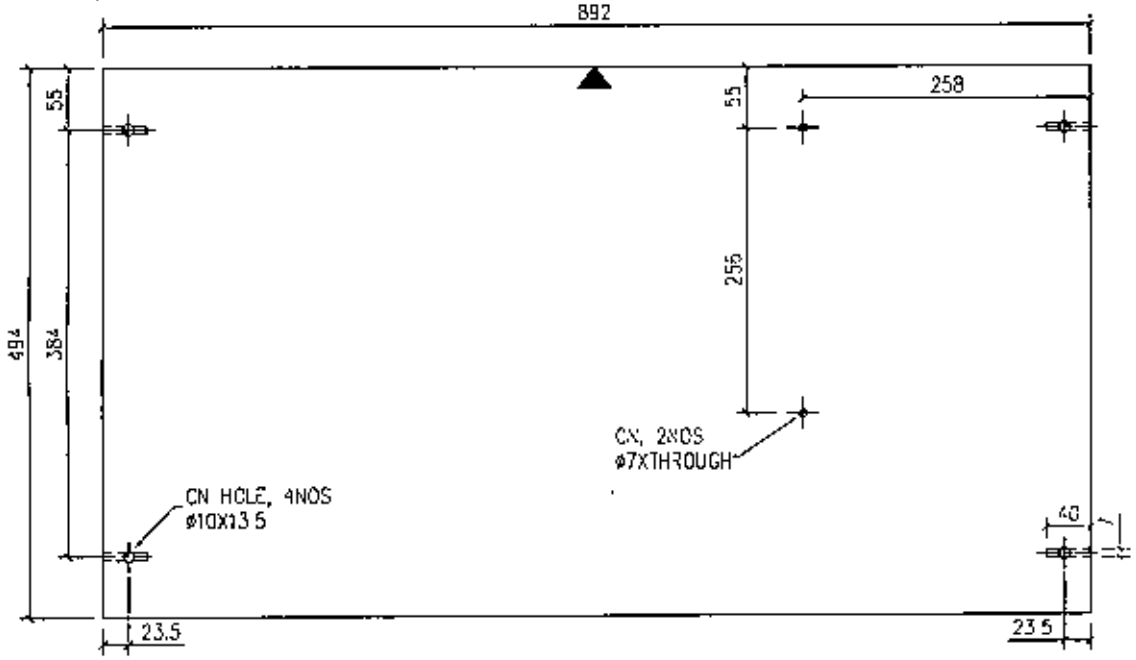
TITLE :	CAD BY:	PLANNED & CHECKED BY:	SHEET NO.	otobi
COMPUTER TABLE	SANTOSH SAMADDER	MD. MIZANUR RAHMAN	04 OF 08	
F:\NEED\PRO DATA\BOR.\TCC P02	DATE:- 15/07/02	APPROVED BY:-		

MODEL: TCC P02 (TCC-13F/H)

TOP - 16mm
LOWER FACE

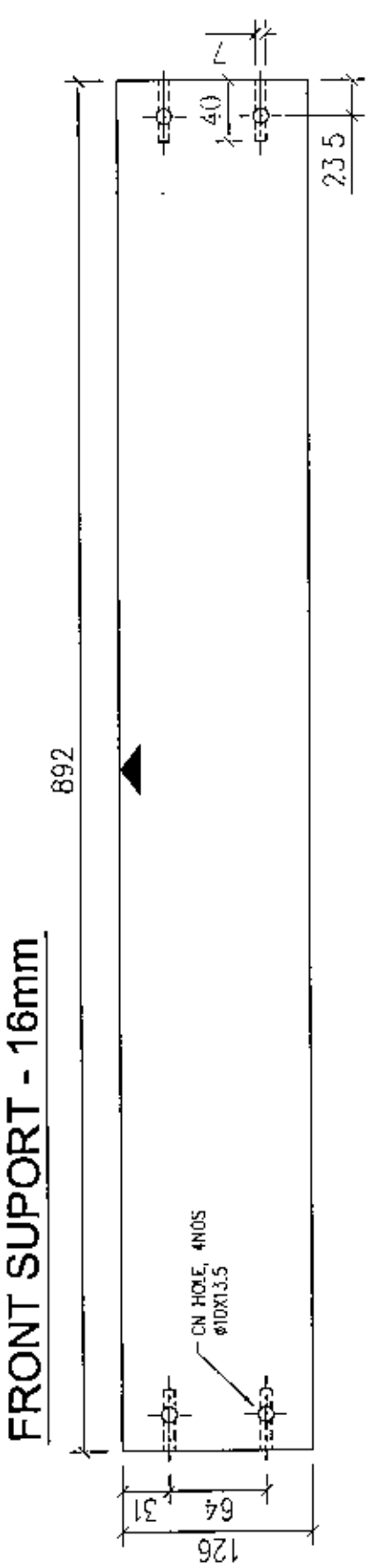


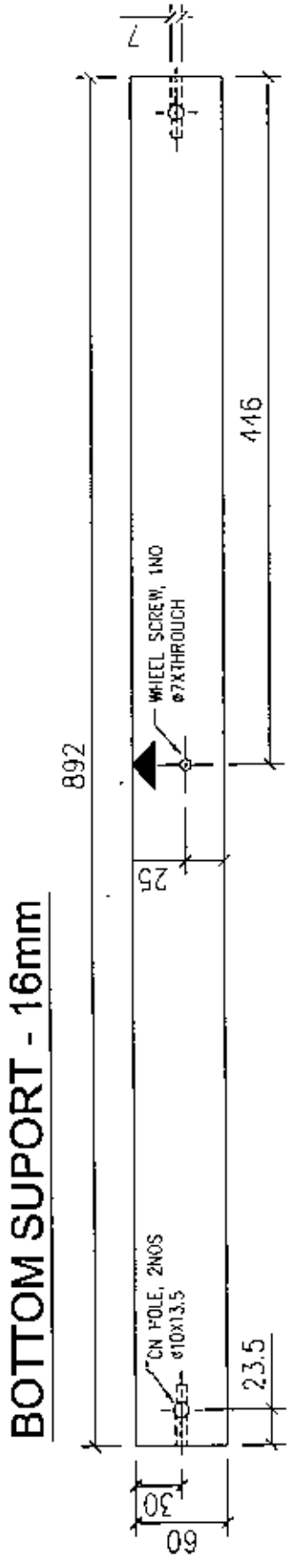
BOTTOM - 16mm
(LOWER FACE)



TITLE :	CAD BY:	PLANNED & CHECKED BY:	SHEET NO.	otobi
COMPUTER TABLE	SANTOSH SAMADDER	MD. MIZANUR RAHMAN		
F:\NEED\PRO DATA\BOR.\TCC P02	DATE:- 15/07/02	APPROVED BY:-	05 OF 08	

MODEL:TCC P02 (TCC-13F/H)

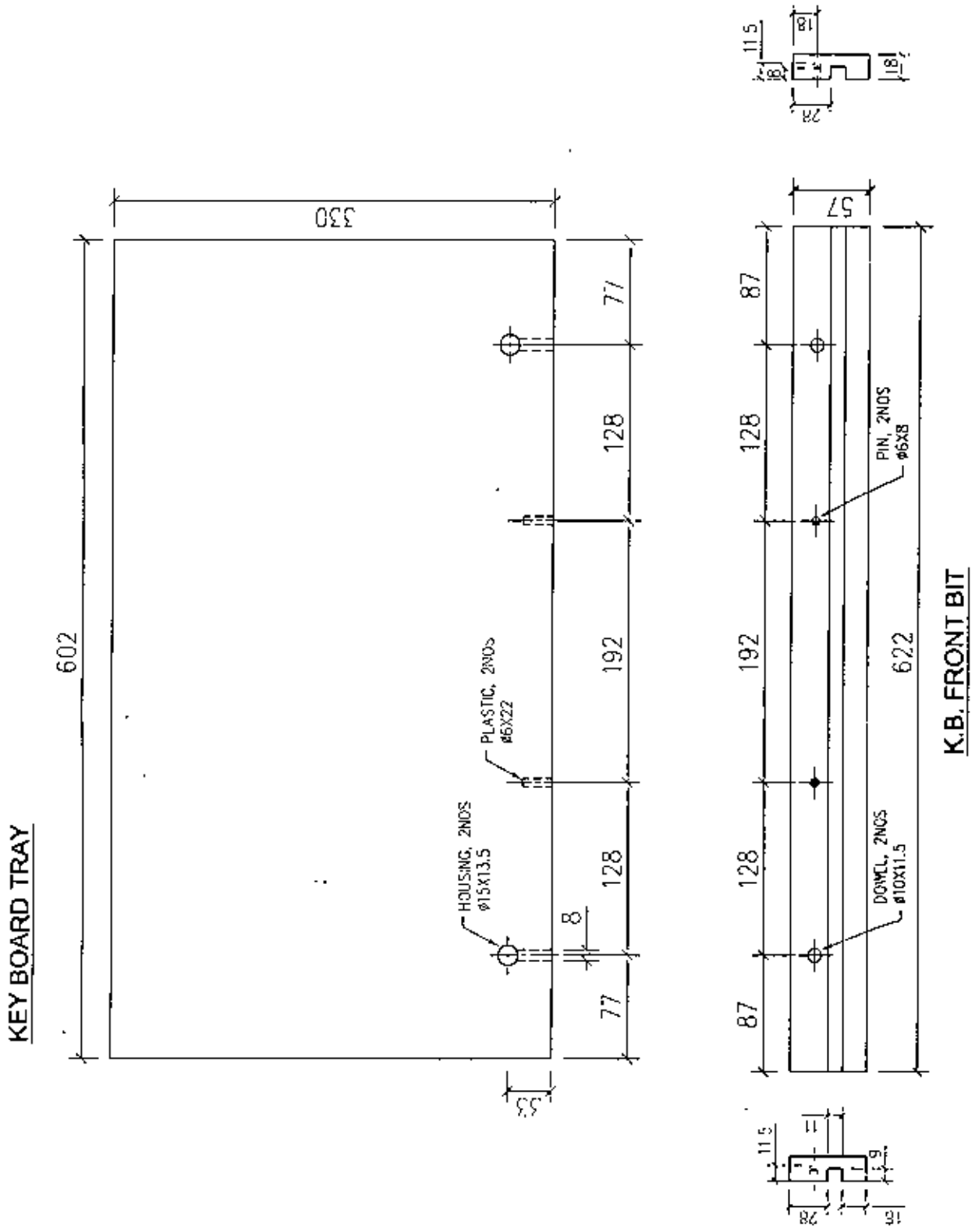




TITLE :	CAD BY:	PLANNED & CHECKED BY:	SHEET NO.
COMPUTER TABLE	SANTOSH SAMADDER	MD. MIZANUR RAHMAN	06 OF 08
F:\NEED\PRO DATA\BOR.\TCC P02	DATE:- 15/07/02	APPROVED BY:-	

otobi®

MODEL: TCC P02 (TCC-13F/H)

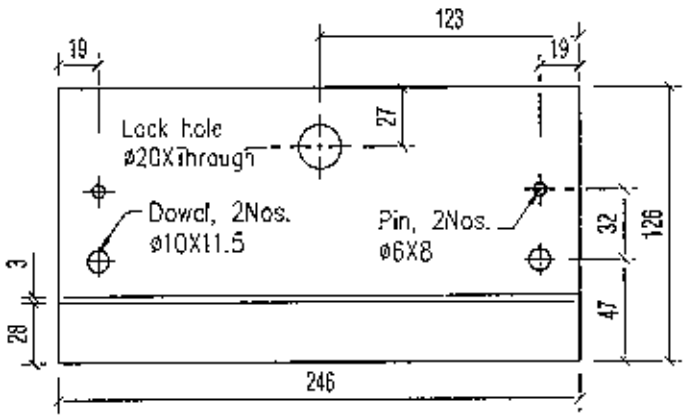


TITLE :	CAD BY:	PLANNED & CHECKED BY:	SHEET NO.
COMPUTER TABLE	SANTOSH SAMADDER	MD. MIZANUR RAHMAN	07 OF 08
F:\NEED\PRO DATA\BOR.\TCC P02	DATE:- 15/07/02	APPROVED BY:-	

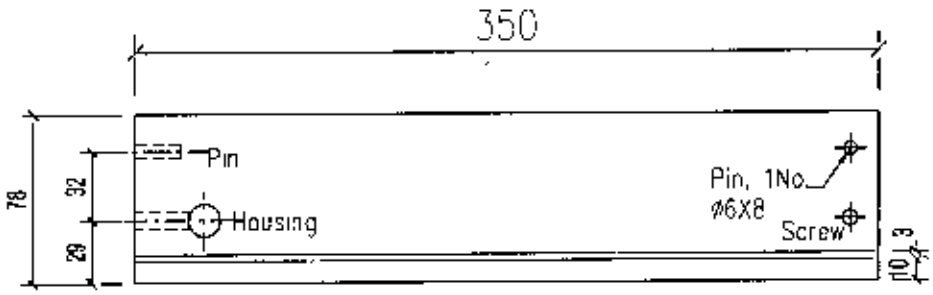
otobi

MODEL: TCC P02 (TCC-13F/H)

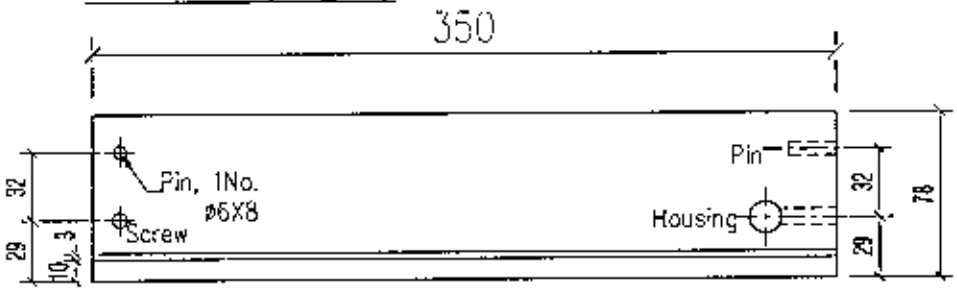
Dr. Front



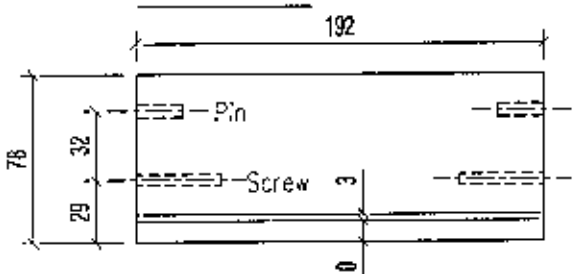
Dr. Side (Left)



Dr. Side (Right)



Dr. Back



TITLE :	CAD BY:	PLANNED & CHECKED BY:	SHEET NO.	
COMPUTER TABLE	SANTOSH SAMADDER	MD. MIZANUR RAHMAN		
F:\NEED\PRO DATA\BOR\TCC P02	DATE:- 15/07/02	APPROVED BY:-	08 OF 08	

OTOBI LIMITED

Shyampur, Dhaka

Cutter Status and Requirement

Laminated Board Section

SL#	MACHINE	CUTTER	SPECIFICATIONS				
			D	B	b	d	Z
1	Panel Saw	Sizing Saw Blade	355	3 2	2.2	30	72
	Technik, PSW 32011	Scoring Saw Blade	120	3.2	2.8	20	24
2	Panel Saw	Sizing Saw Blade	355	4 4	3	75	72
	Mazza	Scoring Saw Blade	300	4.4	3.2	65	48
3	Sliding Saw	Sizing Saw Blade	300	3.2	2.2	30	60
	Lazzari TEMA-3000 IS	Scoring Saw Blade	125	3.2	2 2	30	30
4	Table Saw (4 nos.)	Sizing Saw Blade	300	3.2	2.2	30	72
	Otobi	Scoring Saw Blade	120	3 2	2 8	20	24
5	Double End Tennoner	Sizing Saw Blade	300	3.2	2.2	30	72
	Soda, JWM SI.135	Scoring Saw Blade	150	3.2	2 2	30	36
6	Double End Tennoner	Sizing Saw Blade	300	3.2	2.2	30	72
	Soda, JWM SI.135	Scoring Saw Blade	150	3.2	2 2	30	36
		Grooving Cutter Head	150	2.5	1.5	32	12
			150	3.5	2.5	32	12
			125	3	2	30	12
			125	7	5	30	12
			150	8	5	32	12
			180	11	7	32	18
			225	19	11	24	6

Legend:

D- Cutter Outer Diameter

B- Cutter Carbide Thickness

b- Cutter Plate Thickness

d- Cutter Inner Diameter

Z- Number of Teeth

OTOBI LIMITED

Shyampur, Dhaka

Cutter Status and Requirement

Laminated Board Section

SL#	MACHINE	CUTTER	SPECIFICATIONS					
			D	d	L1	L2	L3	Z
1	Copy Router Bermaq & Shoda R0-116	Router Bit	20	12.7	70	30	35	2
		Router Bit	20	12.7	85	45	35	2
		Router Bit	20	12.7	100	60	35	2
		Router Bit	20	12.7	80	40	35	2
		Router Bit	10	12.7	65	25	35	2
2	Multi Borer(Big) m/c Morbidelli/ BIESSE-TS-74	Through Hole Bit	5	10	70	43	25	
		Through Hole Bit	6	10	70	43	25	
		Through Hole Bit	7	10	70	43	25	
		Through Hole Bit	8	10	70	43	25	
	Multi Borer(small) m/c Vitap/ Gannomat	Through Hole Bit	8.5	10	70	43	25	
		Boring Bit(Blind Hole)	5	10	70	43	20	
		Boring Bit(Blind Hole)	6	10	70	4343	20	
		Boring Bit(Blind Hole)	10	10	70	43	20	
		Cylinder Boring Bit	15	10	70		26	
		Cylinder Boring Bit	20	10	70		26	
		Cylinder Boring Bit	30	10	70		26	
		Cylinder Boring Bit	35	10	70		26	
3	Pneumatic Drill	Cylinder Boring Bit	58.5	12.5	140		50	
		Cylinder Boring Bit	56	12.5	140		50	

Legend:

D- Cutter Shank Diameter
d- Cutter Cutting Diameter
L1- Cutter Total Length
L2- Cutter Shank Length
L3- Cutter Cutting Length
Z- Number of Teeth

OTOBI LIMITED

Shyampur, Dhaka

Cutter Status and Requirement

Laminated Board Section

SL#	Machine Name	Cutter Description	SPECIFICATIONS						
			R	D	D1	B	b	d	Z
1	Edge Bander Optimat KD-67	Clipping Saw Blade for Trimming	–	100	–	2.6	1.6	32	30
		Edge Rounding Cutter Head	3	56	50	16	11	16	4
		Edge Rounding Cutter Head	3	73	61	16	11	16	3
2	Edge Bander M/c IMA	Clipping Saw Blade for Trimming	–	160	–	3.2	2.2	22	48
		Edge Rounding Cutter Head	3	80	69.4	20	12	20	4
3	Corner Trimmer M/c IMA, KFMI	Corner Rounding Bits	3	30	19	10	–	8	4
4	Table Trimmer M/c Fravol	Edge Banding/Jointing Cutter Head	–	50	–	12	10	16	6

			R	D	D1	B	H	S	d	Z
5	Edge Bander M/c Optimat KD-67	Scraper Turnover Knife	3			12	20	2	4	
6	Edge Bander M/c IMA	Scraper Turnover Knife	3			12	20	2	4	
7	Copy Router Bermaq	Rounding Cutter	12.7	39.4	14				12.7	2
8	Hand Trimmer Makita 3700B	Rounding Cutter	4	20	12				6.35	2
			3	18	12				6.35	2
			5	22.2	12.7				6.35	2

Legend:

R-Cutter cutting surface Radious
D- Cutter Outer Diameter
D1-
B- Cutter Carbide Thickness
b- Cutter Plate Thickness
d- Cutter inner Diameter
Z- Number of Teeth
H-
S-

Appendix-B :

- **Solver Result sheets**

Microsoft Excel 8.0 Answer Report
Worksheet: [KAMAL.xls]DATA11
Report Created: 2/26/05 10:47:29 PM

Target Cell (Max)

Cell	Name	Original Value	Final Value
$AR$4	UNIT PRICE Z	9658126.912	9775531.926

Adjustable Cells

Cell	Name	Original Value	Final Value
$B$3	REQ. QTY. BDD16Z	240.00	240.00
$C$3	REQ. QTY. BDDP06	300.00	300.00
$D$3	REQ. QTY. KWDP05	200.00	200.00
$E$3	REQ. QTY. DDZ12G	150.00	300.00
$F$3	REQ. QTY. DSZ13Z	150.00	251.55
$G$3	REQ. QTY. KRO15H	300.00	300.00
$H$3	REQ. QTY. KROP04	120.00	120.00
$I$3	REQ. QTY. KSO15H	240.00	240.00
$J$3	REQ. QTY. KSO16H	300.00	300.00
$K$3	REQ. QTY. TCC13H	423.78	250.00
$L$3	REQ. QTY. TCC19H	200.00	200.00
$M$3	REQ. QTY. TEZ23H	300.00	300.00
$N$3	REQ. QTY. KRD12H	500.00	500.00
$O$3	REQ. QTY. TRZ12H	150.00	150.00
$P$3	REQ. QTY. TMZP04	240.00	240.00
$Q$3	REQ. QTY. TVT11Z	300.00	300.00
$R$3	REQ. QTY. TVT12Z	500.00	500.00
$S$3	REQ. QTY. BDD17Z	75.00	75.00
$T$3	REQ. QTY. KPD16Z	75.00	75.00
$U$3	REQ. QTY. DDZ14Z	179.30	90.00
$V$3	REQ. QTY. DDZ15G	75.00	75.00
$W$3	REQ. QTY. DSZ12Z	75.00	75.00
$X$3	REQ. QTY. KSD14Z	50.00	50.00
$Y$3	REQ. QTY. TCC22H	87.77	60.00
$Z$3	REQ. QTY. TOZ18H	75.00	88.95
$AA$3	REQ. QTY. TOZ19H	75.73	120.00
$AB$3	REQ. QTY. TOZ20H	76.02	120.00
$AC$3	REQ. QTY. TOZ21H	76.08	120.00
$AD$3	REQ. QTY. TRZ13H	50.00	50.00
$AE$3	REQ. QTY. TVT13Z	88.66	60.00
$AF$3	REQ. QTY. TVT14Z	75.00	75.00
$AG$3	REQ. QTY. BCZ13Z	73.71	50.00
$AH$3	REQ. QTY. BCZ15Z	38.11	30.00
$AI$3	REQ. QTY. BDD15Z	30.00	30.00
$AJ$3	REQ. QTY. BSD12W	40.00	40.00
$AK$3	REQ. QTY. KPD12Z	15.00	15.00
$AL$3	REQ. QTY. KWD15H	25.00	25.00
$AM$3	REQ. QTY. DWD16Z	20.00	20.00
$AN$3	REQ. QTY. TCC15H	37.38	30.00
$AO$3	REQ. QTY. TEZ24H	49.89	50.00
$AP$3	REQ. QTY. TEZ28H	21.36	50.00

$AQ$3	REQ. QTY. TVC11Z	10 00	10.00

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$AR$6	PS LHS	19497.52248	$AR$6<=$AT$6	Not Binding	602.4775195
$AR$7	CS LHS	9723.688037	$AR$7<=$AT$7	Not Binding	12356 31196
$AR$8	DET LHS	18480	$AR$8<=$AT$8	Binding	0
$AR$9	BS LHS	7270.292078	$AR$9<=$AT$9	Not Binding	15229.70792
$AR$10	CR LHS	5996 1	$AR$10<=$AT$10	Not Binding	12843.9
$AR$11	PE LHS	8303.216705	$AR$11<=$AT$11	Not Binding	14496.7833
$AR$12	TT LHS	8609 850984	$AR$12<=$AT$12	Not Binding	12090.14902
$AR$13	SE LHS	14623.51212	$AR$13<=$AT$13	Not Binding	4876.487876
$AR$14	MB LHS	16789.07746	$AR$14<=$AT$14	Not Binding	3190.92254
$AR$15	NB LHS	18840	$AR$15<=$AT$15	Binding	0
$AR$16	CNC LHS	18723 4206	$AR$16<=$AT$16	Not Binding	2576.579396
$AR$17	BDD16Z LHS	240	$AR$17>=$AT$17	Not Binding	120
$AR$18	BDDP08 LHS	300	$AR$18>=$AT$18	Not Binding	150
$AR$19	KWDP05 LHS	200	$AR$19>=$AT$19	Not Binding	100
$AR$20	DDZ12G LHS	300	$AR$20>=$AT$20	Not Binding	150
$AR$21	DSZ13Z LHS	251.5524027	$AR$21>=$AT$21	Not Binding	101.5524027
$AR$22	KRO15H LHS	300	$AR$22>=$AT$22	Not Binding	150
$AR$23	KROP04 LHS	120	$AR$23>=$AT$23	Binding	0
$AR$24	KSO15H LHS	240	$AR$24>=$AT$24	Not Binding	120
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$AR$26	TCC13H LHS	250	$AR$26>=$AT$26	Binding	0
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$AR$28	TEZ23H LHS	300	$AR$28>=$AT$28	Not Binding	150
$AR$29	KRD12H LHS	500	$AR$29>=$AT$29	Not Binding	250
$AR$30	TRZ12H LHS	150	$AR$30>=$AT$30	Binding	0
$AR$31	TMZP04 LHS	240	$AR$31>=$AT$31	Not Binding	120
$AR$32	TVT11Z LHS	300	$AR$32>=$AT$32	Not Binding	150
$AR$33	TVT12Z LHS	500	$AR$33>=$AT$33	Not Binding	250
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$AR$42	TOZ19H LHS	120	$AR$42>=$AT$42	Not Binding	45
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$AR$55	TCC15H LHS	30	$AR$55>=$AT$55	Binding	0
$AR$56	TEZ24H LHS	50	$AR$56>=$AT$56	Not Binding	20
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$AR$60	BDDP06 LHS	300	$AR$60<=$AT$60	Binding	0
$AR$61	KWDP05 LHS	200	$AR$61<=$AT$61	Binding	0
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$AR$72	TRZ12H LHS	150	$AR$72<=$AT$72	Not Binding	150
$AR$73	TMZP04 LHS	240	$AR$73<=$AT$73	Binding	0
$AR$74	TVT11Z LHS	300	$AR$74<=$AT$74	Binding	0
$AR$75	TVT12Z LHS	500	$AR$75<=$AT$75	Binding	0
$AR$76	BDD17Z LHS	75	$AR$76<=$AT$76	Binding	0
$AR$77	KPD16Z LHS	75	$AR$77<=$AT$77	Binding	0
$AR$78	ODZ14Z LHS	90	$AR$78<=$AT$78	Not Binding	90
$AR$79	ODZ15G LHS	75	$AR$79<=$AT$79	Not Binding	75
$AR$80	OSZ12Z LHS	75	$AR$80<=$AT$80	Binding	0
$AR$81	KSD14Z LHS	50	$AR$81<=$AT$81	Not Binding	25
$AR$82	TCC22H LHS	60	$AR$82<=$AT$82	Not Binding	30
$AR$83	TOZ18H LHS	88.94691076	$AR$83<=$AT$83	Not Binding	31.05308924
$AR$84	TOZ19H LHS	120	$AR$84<=$AT$84	Binding	0
$AR$85	TOZ20H LHS	120	$AR$85<=$AT$85	Binding	0
$AR$86	TOZ21H LHS	120	$AR$86<=$AT$86	Binding	0
$AR$87	TRZ13H LHS	50	$AR$87<=$AT$87	Not Binding	25
$AR$88	TVT13Z LHS	60	$AR$88<=$AT$88	Not Binding	30
$AR$89	TVT14Z LHS	75	$AR$89<=$AT$89	Not Binding	45
$AR$90	BCZ13Z LHS	50	$AR$90<=$AT$90	Not Binding	25
$AR$91	BCZ15Z LHS	30	$AR$91<=$AT$91	Not Binding	10
$AR$92	BDD15Z LHS	30	$AR$92<=$AT$92	Binding	0
$AR$93	BSD12W LHS	40	$AR$93<=$AT$93	Binding	0
$AR$94	KPD12Z LHS	15	$AR$94<=$AT$94	Not Binding	10
$AR$95	KWD15H LHS	25	$AR$95<=$AT$95	Not Binding	25
$AR$96	DWD16Z LHS	20	$AR$96<=$AT$96	Not Binding	10
$AR$97	TCC15H LHS	30	$AR$97<=$AT$97	Not Binding	10
$AR$98	TEZ24H LHS	50	$AR$98<=$AT$98	Binding	0
$AR$99	TEZ28H LHS	50	$AR$99<=$AT$99	Binding	0
$AR$100	TVC11Z LHS	10	$AR$100<=$AT$100	Not Binding	10

Microsoft Excel 8.0 Sensitivity Report
Worksheet: [KAMAL.xls]DATA11
Report Created: 2/26/05 10:47:31 PM

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$3	REQ. QTY. BDD16Z	240.00	0.00	4000	1E+30	2309.905263
$C$3	REQ. QTY. BDDP06	300.00	0.00	4150	1E+30	2085.757895
$D$3	REQ. QTY. KWDP05	200.00	0.00	3200	1E+30	52.3684213
$E$3	REQ. QTY. DDZ12G	300.00	0.00	1625	1E+30	65.10210561
$F$3	REQ. QTY. DSZ13Z	251.55	0.00	1037	17.21968875	9.569929941
$G$3	REQ. QTY. KRO15H	300.00	0.00	1050	9.45357E+17	76.39473693
$H$3	REQ. QTY. KROP04	120.00	0.00	1100	422.218947	1E+30
$I$3	REQ. QTY. KSO15H	240.00	0.00	1525	1E+30	35.58947365
$J$3	REQ. QTY. KSO16H	300.00	0.00	2025	2.20377E+17	159.7810523
$K$3	REQ. QTY. TCC13H	250.00	0.00	1125	6.263157811	1.87385E+17
$L$3	REQ. QTY. TCC19H	200.00	0.00	1200	506.1389471	1E+30
$M$3	REQ. QTY. TEZ23H	300.00	0.00	1175	1E+30	301.7926318
$N$3	REQ. QTY. KRD12H	500.00	0.00	687	1E+30	143.9736843
$O$3	REQ. QTY. TRZ12H	150.00	0.00	1325	115.1821051	1E+30
$P$3	REQ. QTY. TMZP04	240.00	0.00	1850	1E+30	732.2505266
$Q$3	REQ. QTY. TVT11Z	300.00	0.00	1325	1E+30	166.1221054
$R$3	REQ. QTY. TVT12Z	500.00	0.00	825	1E+30	270.2073685
$S$3	REQ. QTY. BDD17Z	75.00	0.00	3000	1E+30	2481.44421
$T$3	REQ. QTY. KPD16Z	75.00	0.00	3900	1E+30	237.5484217
$U$3	REQ. QTY. DDZ14Z	90.00	0.00	1240	88.25789439	1E+30
$V$3	REQ. QTY. DDZ15G	75.00	0.00	1040	79.34210483	1E+30
$W$3	REQ. QTY. DSZ12Z	75.00	0.00	3060	1E+30	51.42736883
$X$3	REQ. QTY. KSD14Z	50.00	0.00	1000	1128.051579	1E+30
$Y$3	REQ. QTY. TCC22H	60.00	0.00	900.0000001	674.0231578	1E+30
$Z$3	REQ. QTY. TOZ18H	88.95	0.00	620	11.82347574	8.579937192
$AA$3	REQ. QTY. TOZ19H	120.00	0.00	899.9999999	1E+30	255.7684208
$AB$3	REQ. QTY. TOZ20H	120.00	0.00	1000	1E+30	355.7684209
$AC$3	REQ. QTY. TOZ21H	120.00	0.00	640.0000002	4.44043E+16	337.1052632
$AD$3	REQ. QTY. TRZ13H	50.00	0.00	1640	1052.274737	1E+30
$AE$3	REQ. QTY. TVT13Z	60.00	0.00	1080	318.5294733	1E+30
$AF$3	REQ. QTY. TVT14Z	75.00	0.00	1200	30.65578937	1E+30
$AG$3	REQ. QTY. BCZ13Z	50.00	0.00	420.0000001	388.3505261	1E+30
$AH$3	REQ. QTY. BCZ15Z	30.00	0.00	344.9999997	586.4073685	1E+30
$AI$3	REQ. QTY. BDD15Z	30.00	0.00	2175	1E+30	1826.065263
$AJ$3	REQ. QTY. BSD12W	40.00	0.00	1680	1E+30	1306.833684
$AK$3	REQ. QTY. KPD12Z	15.00	0.00	2954.999999	1293.198947	1E+30
$AL$3	REQ. QTY. KWD15H	25.00	0.00	2190	2945.052631	1E+30
$AM$3	REQ. QTY. DWD16Z	20.00	0.00	2475	2234.078947	1E+30
$AN$3	REQ. QTY. TCC15H	30.00	0.00	719.9999999	751.2894732	1E+30
$AO$3	REQ. QTY. TEZ24H	50.00	0.00	801.9999999	1E+30	57.26315818
$AP$3	REQ. QTY. TEZ28H	50.00	0.00	974.9999999	1E+30	332.8631576
$AQ$3	REQ. QTY. TVC11Z	10.00	0.00	3150	2986.142104	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$AR$6	PS LHS	19497.522	0	20100	1E+30	602.4775195
$AR$7	CS LHS	9723.688	0	22080	1E+30	12356.31196
$AR$8	DET LHS	18480	242.3157896	18480	26 50429688	11 90390626
$AR$9	BS LHS	7270.2921	0	22500	1E+30	15229.70792
$AR$10	CR LHS	5996.1	0	18840	1E+30	12843.9
$AR$11	PE LHS	8303.2167	0	22800	1E+30	14496 7833
$AR$12	TT LHS	8609.851	0	20700	1E+30	12090.14902
$AR$13	SE LHS	14623.512	0	19500	1E+30	4876.487876
$AR$14	MB LHS	16789.077	0	19980	1E+30	3190.92254
$AR$15	NB LHS	18840	192.105263	18840	13 54400001	30.156
$AR$16	CNC LHS	18723.421	0	21300	1E+30	2576.579396
$AR$17	BDD16Z LHS	240	0	120	120	1E+30
$AR$18	BDDP06 LHS	300	0	150	150	1E+30
$AR$19	KWDP05 LHS	200	0	100	100	1E+30
$AR$20	DDZ12G LHS	300	0	150	150	1E+30
$AR$21	DSZ13Z LHS	251.5524	0	150	101.5524027	1E+30
$AR$22	KRO15H LHS	300	0	150	150	1E+30
$AR$23	KROP04 LHS	120	-422 218947	120	16 47828833	7.400913161
$AR$24	KSO15H LHS	240	0	120	120	1E+30
$AR$25	KSO16H LHS	300	0	150	150	1E+30
$AR$26	TCC13H LHS	250	-6.263157811	250	19.10595613	42.53981191
$AR$27	TCC19H LHS	200	-506.1389471	200	43.06906185	19.34365878
$AR$28	TEZ23H LHS	300	0	150	150	1E+30
$AR$29	KRD12H LHS	500	0	250	250	1E+30
$AR$30	TRZ12H LHS	150	-115.1821051	150	49.00144716	39.75588691
$AR$31	TMZP04 LHS	240	0	120	120	1E+30
$AR$32	TVT11Z LHS	300	0	150	150	1E+30
$AR$33	TVT12Z LHS	500	0	250	250	1E+30
$AR$34	BDD17Z LHS	75	0	50	25	1E+30
$AR$35	KPD16Z LHS	75	0	50	25	1E+30
$AR$36	DDZ14Z LHS	90	-88.25789439	90	23 62911371	10 61257184
$AR$37	DDZ15G LHS	75	-79.34210483	75	10 66420432	4.789626724
$AR$38	DSZ12Z LHS	75	0	50	25	1E+30
$AR$39	KSD14Z LHS	50	-1128 051579	50	25	23 65489041
$AR$40	TCC22H LHS	60	-674.0231578	60	28.97869915	39 38462685
$AR$41	TOZ18H LHS	88.946911	0	75	13.94691076	1E+30
$AR$42	TOZ19H LHS	120	0	75	45	1E+30
$AR$43	TOZ20H LHS	120	0	75	45	1E+30
$AR$44	TOZ21H LHS	120	0	75	45	1E+30
$AR$45	TRZ13H LHS	50	-1052 274737	50	25	17.09068601
$AR$46	TVT13Z LHS	60	-318.5294733	60	30	14.31309005
$AR$47	TVT14Z LHS	75	-30 65578937	75	45	44 70921151
$AR$48	BCZ13Z LHS	50	-388.3505261	50	25	50
$AR$49	BCZ15Z LHS	30	-586.4073685	30	10	30
$AR$50	BDD15Z LHS	30	0	20	10	1E+30
$AR$51	BSD12W LHS	40	0	20	20	1E+30
$AR$52	KPD12Z LHS	15	-1293 196947	15	8.994869626	4 039876454
$AR$53	KWD15H LHS	25	-2945.052631	25	21.19312321	10.11060173

$AR$54	DWD16Z LHS	20	-2234.078947	20	10	7.869335067
$AR$55	TCC15H LHS	30	-751.2894732	30	10	12.76397907
$AR$56	TEZ24H LHS	50	0	30	20	1E+30
$AR$57	TEZ28H LHS	50	0	20	30	1E+30
$AR$58	TVC11Z LHS	10	-2986.142104	10	10	8 70077673
$AR$59	BDD16Z LHS	240	2309.905263	240	10 59228364	23.5839416
$AR$60	BDDP06 LHS	300	2085 757895	300	32.98051948	27.87937848
$AR$61	KWDP05 LHS	200	52.3684213	200	13.42466961	20 06786731
$AR$62	DDZ12G LHS	300	65.10210561	300	16 8821378	7.582294552
$AR$63	DSZ13Z LHS	251.5524	0	300	1E+30	48.44759728
$AR$64	KRO15H LHS	300	76.39473693	300	41.04242425	65.85256615
$AR$65	KROP04 LHS	120	0	240	1E+30	120
$AR$66	KSO15H LHS	240	35.58947365	240	4 633419496	10.31640566
$AR$67	KSO16H LHS	300	159.7810523	300	2.264479025	5.041910027
$AR$68	TCC13H LHS	250	0	500	1E+30	250
$AR$69	TCC19H LHS	200	0	400	1E+30	200
$AR$70	TEZ23H LHS	300	301 7926318	300	23.51120968	10.55961746
$AR$71	KRD12H LHS	500	143 9736843	500	78.64258069	116.0087672
$AR$72	TRZ12H LHS	150	0	300	1E+30	150
$AR$73	TMZP04 LHS	240	732.2505266	240	34.41767273	15.45805013
$AR$74	TVT11Z LHS	300	166.1221054	300	80.78788319	38 54146948
$AR$75	TVT12Z LHS	500	270.2073685	500	161.411217	77.00443739
$AR$76	BDD17Z LHS	75	2481 44421	75	5.562573019	12.38518545
$AR$77	KPD16Z LHS	75	237.5484217	75	13.56667267	6.093215772
$AR$78	DDZ14Z LHS	90	0	180	1E+30	90
$AR$79	DDZ15G LHS	75	0	150	1E+30	75
$AR$80	DSZ12Z LHS	75	51.42736883	75	34.00331004	16.22195661
$AR$81	KSD14Z LHS	50	0	75	1E+30	25
$AR$82	TCC22H LHS	60	0	90	1E+30	30
$AR$83	TOZ18H LHS	88.946911	0	120	1E+30	31.05308924
$AR$84	TOZ19H LHS	120	255.7684208	120	12.48422779	27.79639493
$AR$85	TOZ20H LHS	120	355 7684209	120	12.48422779	27.79639493
$AR$86	TOZ21H LHS	120	337 1052632	120	9.523125007	21.20343749
$AR$87	TRZ13H LHS	50	0	75	1E+30	25
$AR$88	TVT13Z LHS	60	0	90	1E+30	30
$AR$89	TVT14Z LHS	75	0	120	1E+30	45
$AR$90	BCZ13Z LHS	50	0	75	1E+30	25
$AR$91	BCZ15Z LHS	30	0	40	1E+30	10
$AR$92	BDD15Z LHS	30	1826.065263	30	8.266601571	10
$AR$93	BSD12W LHS	40	1306.833684	40	7.72980926	17.21058238
$AR$94	KPD12Z LHS	15	0	25	1E+30	10
$AR$95	KWD15H LHS	25	0	50	1E+30	25
$AR$96	DWD16Z LHS	20	0	30	1E+30	10
$AR$97	TCC15H LHS	30	0	40	1E+30	10
$AR$98	TEZ24H LHS	50	57.26315818	50	34.35493671	15.42987343
$AR$99	TEZ28H LHS	50	332 8631576	50	4 492040099	10 00162146
$AR$100	TVC11Z LHS	10	0	20	1E+30	10

Microsoft Excel 8.0 Limits Report
Worksheet: [KAMAL.xls]DATA11
Report Created: 2/26/05 10:47:32 PM

Cell	Target Name	Value
$AR$4	UNIT PRICE Z	9775531.926

Cell	Adjustable Name	Value	Lower Limit	Target Result	Upper Limit	Target Result
$B$3	REQ. QTY. BDD16Z	240.00	120.00	9295531.93	240.00	9775531.93
$C$3	REQ. QTY. BDDP06	300.00	150.00	9153031.93	300.00	9775531.93
$D$3	REQ. QTY. KWDP05	200.00	100.00	9455531.93	200.00	9775531.93
$E$3	REQ. QTY. DDZ12G	300.00	150.00	9531781.93	300.00	9775531.93
$F$3	REQ. QTY. DSZ13Z	251.55	150.00	9670222.08	251.55	9775531.93
$G$3	REQ. QTY. KRO15H	300.00	150.00	9618031.93	300.00	9775531.93
$H$3	REQ. QTY. KROP04	120.00	120.00	9775531.93	120.00	9775531.93
$I$3	REQ. QTY. KSO15H	240.00	120.00	9592531.93	240.00	9775531.93
$J$3	REQ. QTY. KSO16H	300.00	150.00	9471781.93	300.00	9775531.93
$K$3	REQ. QTY. TCC13H	250.00	250.00	9775531.93	250.00	9775531.93
$L$3	REQ. QTY. TCC19H	200.00	200.00	9775531.93	200.00	9775531.93
$M$3	REQ. QTY. TEZ23H	300.00	150.00	9599281.93	300.00	9775531.93
$N$3	REQ. QTY. KRO12H	500.00	250.00	9603781.93	500.00	9775531.93
$O$3	REQ. QTY. TRZ12H	150.00	150.00	9775531.93	150.00	9775531.93
$P$3	REQ. QTY. TMZP04	240.00	120.00	9553531.93	240.00	9775531.93
$Q$3	REQ. QTY. TVT11Z	300.00	150.00	9576781.93	300.00	9775531.93
$R$3	REQ. QTY. TVT12Z	500.00	250.00	9580281.93	500.00	9775531.93
$S$3	REQ. QTY. BDD17Z	75.00	50.00	9700531.93	75.00	9775531.93
$T$3	REQ. QTY. KPD16Z	75.00	50.00	9678031.93	75.00	9775531.93
$U$3	REQ. QTY. DDZ14Z	90.00	90.00	9775531.93	90.00	9775531.93
$V$3	REQ. QTY. DDZ15G	75.00	75.00	9775531.93	75.00	9775531.93
$W$3	REQ. QTY. DSZ12Z	75.00	50.00	9699031.93	75.00	9775531.93
$X$3	REQ. QTY. KSD14Z	50.00	50.00	9775531.93	50.00	9775531.93
$Y$3	REQ. QTY. TCC22H	60.00	60.00	9775531.93	60.00	9775531.93
$Z$3	REQ. QTY. TOZ18H	88.95	75.00	9766884.94	88.95	9775531.93
$AA$3	REQ. QTY. TOZ19H	120.00	75.00	9735031.93	120.00	9775531.93
$AB$3	REQ. QTY. TOZ20H	120.00	75.00	9730531.93	120.00	9775531.93
$AC$3	REQ. QTY. TOZ21H	120.00	75.00	9746731.93	120.00	9775531.93
$AD$3	REQ. QTY. TRZ13H	50.00	50.00	9775531.93	50.00	9775531.93
$AE$3	REQ. QTY. TVT13Z	60.00	60.00	9775531.93	60.00	9775531.93
$AF$3	REQ. QTY. TVT14Z	75.00	75.00	9775531.93	75.00	9775531.93
$AG$3	REQ. QTY. BCZ13Z	50.00	50.00	9775531.93	50.00	9775531.93
$AH$3	REQ. QTY. BCZ15Z	30.00	30.00	9775531.93	30.00	9775531.93
$AI$3	REQ. QTY. BDD15Z	30.00	20.00	9753781.93	30.00	9775531.93
$AJ$3	REQ. QTY. BSD12W	40.00	20.00	9741931.93	40.00	9775531.93
$AK$3	REQ. QTY. KPD12Z	15.00	15.00	9775531.93	15.00	9775531.93
$AL$3	REQ. QTY. KWD15H	25.00	25.00	9775531.93	25.00	9775531.93
$AM$3	REQ. QTY. DWD16Z	20.00	20.00	9775531.93	20.00	9775531.93
$AN$3	REQ. QTY. TCC15H	30.00	30.00	9775531.93	30.00	9775531.93
$AO$3	REQ. QTY. TEZ24H	50.00	30.00	9759491.93	50.00	9775531.93
$AP$3	REQ. QTY. TEZ28H	50.00	20.00	9746281.93	50.00	9775531.93
$AQ$3	REQ. QTY. TVC11Z	10.00	10.00	9775531.93	10.00	9775531.93