LEAN CONVERSION OF AN APPAREL ASSEMBLY LINE

- A CASE STUDY

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APRIL 2012

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- A CASE STUDY

by

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A thesis submitted to the Department of Industrial and Production Engineering, Bangladesh University of Engineering and Technology, in partial fulfillment of the requirements for the degree of Master of Engineering in Industrial and Production Engineering.

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APRIL, 2012

CERTIFICATE OF APPROVAL

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CANDIDATE'S DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

S. M. Russel

ACKOWLEDGEMENT

All praises to Allah, the most benevolent and the Almighty, for his boundless grace in the successful completion of this thesis.

I would like to express my sincere respect and gratitude to my thesis supervisor, Dr. Abdullahil Azeem, Associate Professor, Department of Industrial and Production Engineering (IPE), Bangladesh University of Engineering and Technology (BUET), for his encouragement, thoughtful suggestions, proper guidance and cooperation throughout the progress of this research work.

I also express my profound thanks and gratitude to respected teacher Dr. M. Ahsan Akhtar Hasin and Dr. A. K. M. Masud, Professor, Department of Industrial and Production Engineering BUET, Dhaka for their support and cooperation in this thesis work.

I am very much thankful to Mr. David Hasanat, CEO & Chairman, Viyellatex Ltd. for giving me the opportunity to work in his factory. I also express my gratitude to Mr. Saiful Islam (COO), Mr. Arif Islam Bhuiyan (COO), Mr. Didarul Alam (Lean Team), Mr. Dipankar Roy and workers and staff of Viyellatex Ltd. for their all out support and time. I also express my gratitude to my collogues in Productivity Improvement Cell, BKMEA for their support and cooperation in completing the thesis work successfully.

Finally, I would like to express my gratitude to my parents and wife whose continuous supports and inspiration encouraged me to complete the thesis successfully.

ABSRACT

To be competitive and meet ever increasing demand of apparel buyers to reduce cost, supply smaller quantity order at shorter lead time as well as increasing labor cost in the local market has forced the local manufacturers of Bangladesh to improve labor productivity, quality, to reduce lead time and produce small order quantity efficiently. Tools and techniques of Lean manufacturing may play an important role in their quest for meeting ever increasing demand of customers profitably. Lean manufacturing requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products. Lean consists of best practices, tools and techniques from throughout industry with the aims of reducing waste and maximizing efficiency to achieve the ultimate customer satisfaction.

The present study focuses on improving line efficiency, throughput time of an assembly line through identifying wastes using value stream mapping and other analyses, identifying opportunities for improvement and required tools and techniques of lean manufacturing and industrial engineering to implement. An assembly line in an apparel factory is considered to implement this study as well as line efficiency, throughput time, machine utilization, space utilization, WIP and other performance parameters are compared before and after implementing the tools and techniques of lean manufacturing and industrial engineering. Though outcomes of 5S and visual management are difficult to quantify, these tools are foundations for lean implementation.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

Bangladesh earns around seventy five percent of its foreign currency through exporting apparel products. Apparel sector employs more than two million people directly and indirectly. Most of the workers in apparel sector are women. Apparel sector has huge socio-economic impacts on the country.

The apparel sector of the country has been facing challenges for reducing cost, improving quality and reducing cost to remain competitive in the global competition and on the other hand labor costs are increasing in the local market. To survive in the age of globalization where buyers are free to choose from any apparel sourcing country as there are no quota restrictions at this point, the local apparel industry has no other options but reducing cost, improving quality and reducing manufacturing lead time.

After the World War II, Japanese manufacturers faced acute shortage of raw materials, financial and human resources and fierce competition from their western counterparts. Eiji Toyoda and Taiichi Ohno of Toyota motor company developed a discipline and process focused manufacturing system to produce cars at lower cost, higher quality and short lead time and different models of car in the same production line which was known as Toyota Production System (TPS).

TPS was termed 'Lean' by John Krafcik is because it uses less of everything compared with mass production- half the human effort in the factory, half the manufacturing space, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products [1].

Lean consists of best practices, tools and techniques from throughout industry with the aims of reducing waste and maximizing efficiency to achieve the ultimate customer satisfaction. Lean is defined as a systematic approach to maximizing value by minimizing waste, and by flowing the product or service at the pull of the customer demand. The key concepts of "value," "flow," and "pull," align with the ultimate Lean goal: "perfection," or a continuous striving for improvement in the performance of the organization [2].

The local apparel industry can also be benefitted through applying tools and techniques of Lean Manufacturing in a systematic method based on their unique challenges and opportunities not only implementing tools as a piece meal basis.

1.2 Rationale of the Study

The challenges faced by local apparel manufactures can be addressed by the systematic analysis of the manufacturing system and link their problem with the lean tools and techniques to create value for customers.

The application of Lean manufacturing in a business or manufacturing environment, describes a philosophy that incorporates a collection of tools and techniques into the business processes to optimize time, human resources, assets, and productivity, while improving the quality level of products and services to their customers. If the application of lean manufacturing produces positive impact on productivity, quality and lead time, it may have snow ball effects on the whole apparel sector of the country.

1.3 Background of The Thesis

The application of Lean manufacturing in the apparel sector of the country is new. Some factories which are trying to be lean are applying tools and techniques as a piece meal basis without focusing on the overall system approach. This study focuses on creating an improved model of Lean apparel assembly line which will improve line efficiency and throughput time which in terms may improve the competitiveness of local apparel manufacturers.

1.4 Problem Statement

The ever increasing demand from buyer’s side to reduce cost, improve quality and shorter period of lead time as well as smaller quantity orders as well as increasing of labor cost has forced the local apparel manufactures to search for improving labor productivity, quality and reducing lead time to stay competitive in the business and thrive. In this scenario, application of tools and techniques of Lean manufacturing and industrial engineering could benefit the local apparel manufacturers tremendously.

1.5 Objective of the Study

The specific objectives of this project work are:

1. Improving line efficiency of an assembly line
2. Improving throughput time of the assembly line

The possible outcomes of the proposed work are the development an improved model of assembly line that can reduce wastes from flow of works, work practices and processes.

1.6 Methodology

The methodology of the study will be as follows:

1. Collecting information from the company’s ERP system and data from the shop floor
2. Developing a current state map using the collected information
3. Analyzing the current state map to identify potential areas for improvement
4. Developing a future state map identifying potential improvement opportunities to improve

   a. line efficiency through line balancing, team based approach, process razing and designing incentive system and 5S and visual management etc.

   b. improving throughput time through reducing waiting time, excess processing, bundle size reduction and process razing etc.

5. Conduct Kaizen events based on future state map
6. Analyzing improvement as a result of kaizen event

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Many of the concepts in Lean Manufacturing originate from the Toyota Production System (TPS) and have been implemented gradually throughout Toyota's operations beginning in the 1950's. By the 1980's Toyota had increasingly become known for the effectiveness with which it had implemented Just-In-Time (JIT) manufacturing systems. Today, Toyota is often considered one of the most efficient manufacturing companies in the world and the company that sets the standard for best practices in Lean Manufacturing. The term "Lean Manufacturing" or "Lean Production" first appeared in the 1990 book *The Machine that Changed the World*. Lean Manufacturing has increasingly been applied by leading manufacturing companies throughout the world.

2.2 Historical Background

The industrial revolution began in the 1860's, one of the first challenges for manufacturing was how to manage a machine with its enormous product output. The major issue of management within these industries was still the productivity of the workers.

After 1885 the Henry Ford model of assembly line production caused a manufacturing transformation from individual craft production to mass production. This helped to create a market-place based on economies of scale and scope. This dynamic reduced unit costs.

Ford also made contributions to mass production and consumption in the realm of process engineering. The hallmark of this system was standardization of components, manufacturing processes, and a simple, easy-to-manufacture standard product.

By the 1930s, Ford's standardized product, with his direct planning and control systems, was made obsolete by innovations in marketing and organization at General Motors. Just as Ford made history of the horse and buggy, so too did GM's Alfred P. Sloan make history of the Model T. Sloan repositioned the car companies to create a five-model product range from Chevrolet to Cadillac.

The demand for utility transportation, upon which the Model T was founded, was increasingly being served by the rising tide of *used* Model Ts. Many consumers had grown beyond just wanting utility transportation. They had more money, they wanted cars in different colors, cars with roofs, cars with more powerful engines, etc. and they were willing to pay a slightly higher price than Ford was asking for the Model T [3].

The challenge in manufacturing during the 1930s shifted to product variety.

While manufacturing through the 1930s and 1940s was still driven by large-quantity production runs, the huge production runs enjoyed by the 17 years of the Model T were no longer possible.

Consumers were more and more the drivers of change in a product life cycle. As the 1950s began, demand for specialized products started to take hold. Not only were products more specialized, but they also had limited life cycles.

Batch manufacturing methods had arrived! In Batch manufacturing had allowed machines to become productive when large quantities of a product were built. Conversely, batch processing created problems for manufacturing when trying to build a dissimilar mix of products. What is the optimum amount? How much is too much?

During the 1950s, the commercial availability of computers began to have a profound effect on business information processing. Until the advent of the computer, the functions of logistics, inventory management, and production planning constituted a chronic, intractable problem for any discrete manufacturer engaged in multiple-stage production of products from raw material to finished product.

Around the early 1960s, as computing power began to be more cost effective, early pioneers began the development and installation of the early computer-based MRP systems. From the original handful, the number of systems grew to 150 installed systems by 1971.

Since that time and with the help of the American Production and Inventory Control Society (APICS), the number of MRP installations approaches the total number of manufacturing companies. Today, the MRP system is the primary tool used for production planning, inventory control, shop floor control, costing, and capacity planning by the modern manufacturer.

While an MRP system is a valuable weapon in the manufacturing arsenal, practitioners continue to grapple with the still conflicting objectives of batch manufacturing and optimizing inventories. Confronted with the conflicting policies, it is often the MRP system itself that takes the blame for disappointing results. Unless filtered as a system parameter, the MRP solution will solve for the smallest inventory and shortest manufacturing lead time. If followed precisely, MRP recommendations will yield the expected results. Modifications, and work rules put in place to optimize efficiency and utilization of individual work centers, generally degrade the output of the MRP system. Compromise is the culprit of a diminished MRP system.

During the 1950s and 1960s Toyota contended that the standard thinking of Cost + Profit = Sales Price was incorrect. It believed that Profit = Sales Price − Costs. From this premise, Toyota concentrated on the management of costs means wastes and wastes of all varieties were targeted for elimination.

Key areas targeted were work-in-process inventory and safety stock. While many companies in the United States and Europe were attempting to calculate the optimum batch sizes for production, Toyota worked toward the goal of being able to build a mix of products in a one-piece flow. Having the capability to build a mix of products in a one-piece flow (mixed-product Lean line) satisfied many key objectives for Toyota, raising productivity and reducing costs and inventory while simultaneously creating rapid customer response.

Through the 1960s and into the 1970s, these two models of manufacturing developed down separate paths. One sought better ways to manage batch production by making ongoing improvements to the MRP planning model, while the other concentrated on finding and fine-tuning ways to allow a one-piece flow of a mix of products. Soon, the benefits achieved by these two disparate strategies made themselves apparent.

Into the 1980s, many product markets in the United States and Europe started to come under pressure from foreign manufacturers. Products were being brought to market with higher quality and lower price. The days of planned obsolescence were over. Consumers came to expect higher quality and lower prices as a requisite for purchase. Western manufacturers began to lose market share. Some manufacturers faded away while others began to look diligently for better ways to compete. Many abandoned the old batch manufacturing models in favor of the more responsive method of Lean manufacturing in pursuit of the goals of faster response, fewer inventories, higher quality, and reduced costs [4].

2.2.1 Ford System

And then there was Henry Ford. Around 1910, Ford and his right-hand man, Charles E. Sorensen, fashioned the first comprehensive manufacturing strategy. They took all the elements of a manufacturing system – people, machines, tooling and products – and arranged them in a continuous system for manufacturing the Model T automobile. No one person actually invented the assembly line, but Ford’s sponsorship of its use would lead to the explosive success of the system in the 20P$^{\text{thP}}$ century [5].

When Ford first introduced the Model T in 1908, it cost $825 but because of his innovations in efficient manufacturing, that price would drop every year to only $360 in 1916. By 1918, half the cars in America were Model T’s, and before production was terminated, some 15mn units had been produced, a record which was to stand for 45 years. The practice of moving work from one worker to another until it became a complete unit, then arranging the flow of units at the right time and right place to a moving final assembly line from which came a finished product was the basis of Ford production. By the time the system was perfected in 1914, a Model T would come off the assembly line every three minutes, necessitating one-and-a-half man-hours, an eight-fold improvement over the previous 12.5 man-hours required.

There was only one hitch with the dramatically enhanced productivity: slow paint drying time for every color except black. That was why after 1914, Ford was obliged to limit Model T’s to only black until as late as 1926 when faster drying paint was finally perfected. Also instrumental to Ford’s success was his decision in 1914 to offer workers an astonishing wage of $5/day, more than double the previous going rate. Overnight, crippling worker turnover was eradicated, and with the best mechanics flocking to Detroit, greater expertise and improved morale raised productivity and lowered training costs. The goal of every Ford worker was to earn a Model T: in 1914, the average Ford worker could buy one with just four months' wages.

Ford's success inspired many others to copy his methods. But most of his imitators did not truly understand the fundamentals of his strategy and often used his assembly line system for products and processes which would prove unsuitable. It is even doubtful that Henry Ford himself fully understood what he had done and why it was so successful. In fact, as conditions in the world began to change, the Ford system started breaking down because Ford refused to change his methods.

For example, Ford production depended on a labour force that was so desperate for money and jobs that workers would sacrifice their dignity and self-esteem for a steady paycheck. The growing prosperity of the 1920s and the advent of labour unions created great strains on the Ford system. Ford factories were also unable to cope with product proliferation – annual model changes, multiple colours, other options – which customers invariably began demanding. Under the Ford chain system, product moved from station to station in a sequential order. Layout changeovers were considered simply too costly and Ford was reluctant to introduce new models.

At General Motors, Alfred P. Sloan took a more pragmatic approach by developing business and manufacturing strategies for managing very large enterprises and dealing with a variety of products. Sloan is also credited with establishing annual styling changes, thereby inventing the concept of planned obsolescence. He set a pricing structure whereby the different models in the GM stable did not compete with each other, instead insuring that as a family gained purchasing power, they could successfully trade up the GM product ladder without having to look elsewhere. By the mid 1930s, General Motors had passed Ford as the dominant automotive producer in the world, a position it would retain until the end of the 20P^{thP} century.

Yet even in the new competitive era, many elements of Ford production remained sound, including his focus on reducing waste and improving the arrangement of the workplace. He also put great emphasis on ensuring that designs could be efficiently manufactured as well as strict specification and quality criteria. In fact, Ford methods were to prove instrumental in ensuring efficient productivity of wartime equipment during World War II. , Henry Ford hated war and refused to build armaments even after it became clear that the U.S. would be entering the war. However, when Ford plants finally retooled for wartime production, they did so on a fantastic scale as epitomized by the Ford Willow Run bomber plant. When the plant became operative in 1943, it went from producing one B-24 bomber a day to a peak of 600 a month, with the factory operating on 24-hour shifts.

2.2.2 JIT & Toyota Production System

The Allied victory and the impressive American manufacturing capacity inevitably caught the attention of Japanese industrialists. Several Americans would be instrumental in helping the country to rebuild and improve on its post-war manufacturing capabilities. W. Edward Deming was an American statistician best known for his work in Japan. Working under Gen. MacArthur, from 1950 onwards, Deming taught senior managers in Japan how to improve design, service, product quality, testing and sales through various methods, including statistical application. He is widely credited with making a significant contribution to Japan's economic resurgence and reputation for innovative, high-quality products. Joseph M. Juran, known for his work on quality and quality management, would also do important work in Japan. Prior to WW II, although consumer goods in Japan were competitively priced, they were known for their poor quality. Juran's work on quality control would attract the attention of Japanese companies where he worked regularly for four decades. Juran is credited with adding a human dimension to quality management, pushing for the education and training of managers, an idea that had not been initially accepted in the U.S. He also believed that resistance to change was the root cause of quality issues.

Among Japanese working in the field was Kaoru Ishikawa who pioneered quality management processes in Japanese shipyards. Ishikawa's fishbone (because of its shape) or cause-and-effect diagram was first used in the 1960s and designed to illustrate the causes of a certain event. It became one of the seven basic tools of quality management. But it was American automotive production methods, particularly Ford practices, which most caught the attention of Japanese productivity experts.

The Toyota Motor Company's first Lean practices may have started at the end of the 19th century when they were still a textile factory known as Toyoda with the development of looms which stopped themselves whenever a thread broke. By 1934, the company had moved into cars where founder Kiichiro Toyoda dealt with poor quality by intense study of each process leading to the advent of "Kaizen" improvement teams.

It was Kiichiro's plan to switch over entirely to a flow style of operations from batch production, which was being followed in Toyoda Auto Loom, at the new car manufacturing facility. Doing this would stop the buildup of parts and the storage warehouse would no longer be needed. The amount of inventory would be reduced and this would decrease the amount of excess capital being consumed. In other words we would be able to sell our finished products before we would have to pay for the supplied material. With this method in place we would require less operating capital. The summary the style of production that Kiichiro thought of back then it boils down to "Everyday makes the necessary items in the necessary quantity". In order to make this a reality all the operations had to be converted over to his notion of flow production. The words Kiichiro used to describe this in 1937 were a sort of Japanese English phrase he coined called "just-in time." In other words it means it is good if you are right on time [6].

After WW II, Toyota engineers Taichii Ohno and Shigeo Shingo began to incorporate Ford production methods and other techniques into an approach which would eventually be known as the Toyota Production System (TPS). But Japanese manufacturers rebuilding after the war faced drastically reduced human, material and financial resources and low levels of demand. To focus on mass production, low prices and economies of scale in order to reap profits made no sense in Japan and over-production would be fatal for any Japanese company. On an early post-war visit to the Ford plant in Detroit, the Japanese were reportedly unimpressed by the assembly line and appalled by the vast amounts of working capital tied up in inventory. On a visit to an American supermarket, Piggly Wiggly, the delegation found inspiration in an automatic drink supplier where, as soon as a drink was purchased, it was immediately replaced by another. The same supermarket only reordered and restocked goods once they had been bought by customers. Thus was born the idea of Supermarket and Kanban in TPS [7].

The Toyota people also realized that the Ford system had contradictions and shortcomings, particularly with respect to workers. With Gen. Douglas MacArthur actively promoting labor unions during the post-war U.S. occupation period, Ford's harsh attitudes towards workers and demeaning job structures would have been unacceptable in Japan. In fact, they were also unacceptable in the American context, but those who lived through the grim Great Depression years and the generation immediately following would continue to make the system work despite its defects because they had no other choice.

As a result of the early work by Ishikawa, Deming and Juran, Toyota already knew that factory workers had far more to contribute than just muscle power. Another key Toyota discovery involved product variety. The Ford system was built around a single, never-changing product and did not cope well with multiple or new products [5]. Japanese managers rejected the American Ford practice of having specialized jobs for factory workers. Instead, they trained factory workers to handle several types of jobs, now referred to as multi-process handling, which was applied to machine lines in Japan. The combination of multi-process handling and the recognition of the greater potential of workers would lead to the development of U-shaped team cells, one of the three essential principles of early JIT production.

Shingo also worked on the problems of set-up and changeover. Reducing set-ups to minutes and seconds allowed small batch production and an almost continuous flow just like in the original Ford concept. This is known in TPS as One-Piece Flow and is the second of the three JIT essential principles. The Toyota methods would allow for product flexibility that Henry Ford simply refused to believe he needed. The third essential JIT component was Pull Production, the production of only what is demanded or consumed by the customer.

All of these developments took place between 1949 and 1975 and spread, to some extent, to other Japanese companies. As Japanese cars and electronic products began flooding the west and their productivity and quality gains became evident to the outside world, American executives began traveling to Japan to see how things were done. In the early days, they brought back reports related mostly to superficial aspects of concepts such as Kanban and quality circles. Most initial attempts to emulate TPS failed because adopted practices were not integrated into a complete system and because few westerners truly understood the underlying principles.

2.2.3 Lean Manufacturing

The origins of the 'lean approach' can be traced to US fears that the newly emerging Japanese vehicle assemblers held a competitive advantage over their established Western counterparts. These fears prompted benchmarking studies of the global automotive industry to test these fears and to find the causes of any such advantage. The results of these studies are reported in the publication, *The Machine that Changed the World* by Womack, Jones and Roos (1990). For Western manufacturers, this text provided the first data, drawing from the automotive industry, that Japanese manufacturers enjoyed a 2:1 productivity and a 100:1 quality advantage over the West. These gaps were huge and clearly showed that high speed was attributable to excellent levels of quality performance by the Japanese manufacturers and all its suppliers [8].

The term "Lean Manufacturing" was actually first coined by Prof. James P. Womack of the Massachusetts Institute of Technology who spent years studying Japanese companies after WW II and who summarized their accomplishments in works such as *Lean Thinking* (1989) and *The Machine that Changed the World* (1991). The latter book was a straightforward account of the history of automobile manufacturing combined with a study of Japanese, American and European automotive assembly plants. It attributed the superior performance of the Japanese companies to their use of less human effort, capital investment, floor space, materials and time in all aspects of their "Leaner" operations. By eliminating unnecessary steps, aligning all steps in an activity in a continuous flow, recombining labour into cross-functional teams dedicated to that activity, and continually striving for improvement, companies can develop, produce, and distribute products with or less of the human effort, space, tools, time, and overall expense [9].

The new catchphrase – and its principles – caught the imagination of manufacturers throughout the world. Lean implementation everywhere, including in the garment industry, is now commonplace.

CHAPTER THREE

LEAN MANUFACTURING

3.1 Introduction

Lean thinking focuses on value-added flow and the efficiency of the overall system. A part sitting in a pile of inventory is waste and the goal is to keep product flowing and add value as much as possible. The focus is on the overall system and synchronizing operations so that they be aligned and produced products at a steady pace.

3.2 Principles of Lean Manufacturing:

Key principles behind Lean Manufacturing can be summarized as follows:

1. Recognition of waste – The first step is to recognize what does and does not create value from the customer's perspective. Any material, process or feature which is not required for creating value from the customer's perspective is waste and should be eliminated.

2. Standard processes – Lean requires an the implementation of very detailed production guidelines, called Standard Work, which clearly state the content, sequence, timing and outcome of all actions by workers. This eliminates variation in the way that workers perform their tasks.

3. Continuous flow – Lean usually aims for the implementation of a continuous production flow free of bottlenecks, interruption, detours, backflows or waiting. When this is successfully implemented, the production cycle time can be reduced by as much as 90%.

4. Pull-production – Also called Just-in-Time (JIT), Pull-production aims to produce only what is needed, when it is needed. Production is pulled by the downstream workstation so that each workstation should only produce what is requested by the next workstation.

5. Quality at the Source – Lean aims for defects to be eliminated at the source and for quality inspection to be done by the workers as part of the in-line production process.

6. Continuous improvement – A continuous improvement mentality is necessary to reach the company's goals. The term "continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance. Lean requires striving for perfection by continually removing layers of waste as they are uncovered. This in turn requires a high level of worker involvement in the continuous improvement process.

7. Customer Focus - A lean manufacturing enterprise thinks more about its customers than it does about running machines fast to absorb labor and overhead. Ensuring customer input and feedback assures quality and customer satisfaction, all of which support sales.
8. Value - In lean production, the value of a product is defined solely by the customer. The product must meet the customer's needs at both a specific time and price. Identifying the value in lean production means to understand all the activities required to produce a specific product, and then to optimize the whole process from the view of the customer.
9. Perfection - The concept of perfection in lean production means that there are endless opportunities for improving the utilization of all types of assets. The systematic elimination of waste will reduce the costs of operating the extended enterprise and fulfills customer's desire for maximum value at the lowest price [10].

3.3 Value & Waste

Waste is anything that does not contribute to transforming a part to the customer's needs. The aim of Lean Manufacturing is the elimination of waste in every area of production including customer relations, product design, supplier networks, and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible. Essentially, a "waste" is anything that the customer is not willing to pay for [11].

3.3.1 Types of Wastes

a. Overproduction:

Producing more material than the customer demand or produce it before it is needed is termed as overproduction. Overproduction means making more than is required by the next process, making earlier than is required by the next process, or making faster than is required by the next process. The corresponding Lean principle is to manufacture based upon a pull system, or producing products just as customers order them. It is visible as storage of material. It is the result of producing to speculative demand.

b. Waiting:

Material waiting is not material flowing through value-added operations. This includes waiting for material, information, equipment, tools, etc. Lean demands that all resources are provided on a just-in-time (JIT) basis – not too soon, not too late [12].

Waiting for a machine to process should be eliminated. The principle is to maximize the utilization/efficiency of the worker instead of maximizing the utilization of the machines.

c. Inventory or Work in Process (WIP):

Work in Process (WIP) Inventory is material between operations due to large lot production or processes with long cycle times. Material sits taking up space, costing money, and potentially being damaged. Related to Overproduction, inventory beyond that needed to meet customer demands negatively impacts cash flow and uses valuable floor space.

d. Processing waste:

Extra processing not essential to value-added from the customer point of view is waste. Some of the more common examples of this are reworking (the product or service should have been done correctly the first time), debarring (parts should have been produced without burrs, with properly designed and maintained tooling), and inspecting (parts should have been produced using statistical process control techniques to eliminate or minimize the amount of inspection required).

Techniques such as 5 why's, SPC and mistake proofing are available to help identify and eliminate causes of quality defects [12].

e. Transportation:

Moving material does not enhance the value of the product to the customer. Material should be delivered to its point of use. Instead of raw materials being shipped from the vendor to a receiving location, processed, moved into a warehouse, and then transported to the assembly line, Lean demands that the material be shipped directly from the vendor to the location in the assembly line where it will be used. The Lean term for this technique is called point-of-use-storage (POUS). Instead of improving the transportation, it should be minimized or eliminated (e.g. forming cells).

f. Motion Waste:

Any motion that does not add value to the product is waste. Motion of the workers, machines, and transport (e.g. due to the inappropriate location of tools and parts) is waste. Unnecessary motion is caused by poor workflow, poor layout, housekeeping, and inconsistent or undocumented work methods.

g. Making Defective Products:

Making defective products is pure waste. Have to prevent the occurrence of defects instead of finding and repairing defects. Defective products impede flow and lead to wasteful handling, time, and effort. Production defects and service errors waste resources in four ways. First, materials are consumed. Second, the labour used to produce the part (or provide the service) the first time cannot be recovered. Third, labour is required to rework the product (or redo the service). Fourth, labour is required to address any forthcoming customer complaints [12].

3.4 Pull & Push Production

In converting the manufacturing floor, there is a basic difference between a push production system (upstream to downstream) and a pull system (downstream to upstream). In a push system, management typically issues directives – based on sales projections – that push goods from upstream to downstream. For example, in the cutting department, management would provide a fixed master cutting plan for workers to continuously spread and cut materials and to supply the sewing floor on a daily basis regardless of fluctuations in productivity within the sewing assembly lines. Pull production systems, on the other hand, are those where start of one job is triggered by completion of another [13]. In a pull production system, workers are considered to be the closest process to customer demand and synchronize their productivity to the pace of customer demand. In the same cutting department example used above, in a pull system, the downstream sewing team would signal to the upstream cutting department to replace at the appropriate time any cut-piece quantity that has been withdrawn. For any garment factory aspiring to go Lean and adopting Quick Response/Just in Time principles, pull production is the obvious choice.

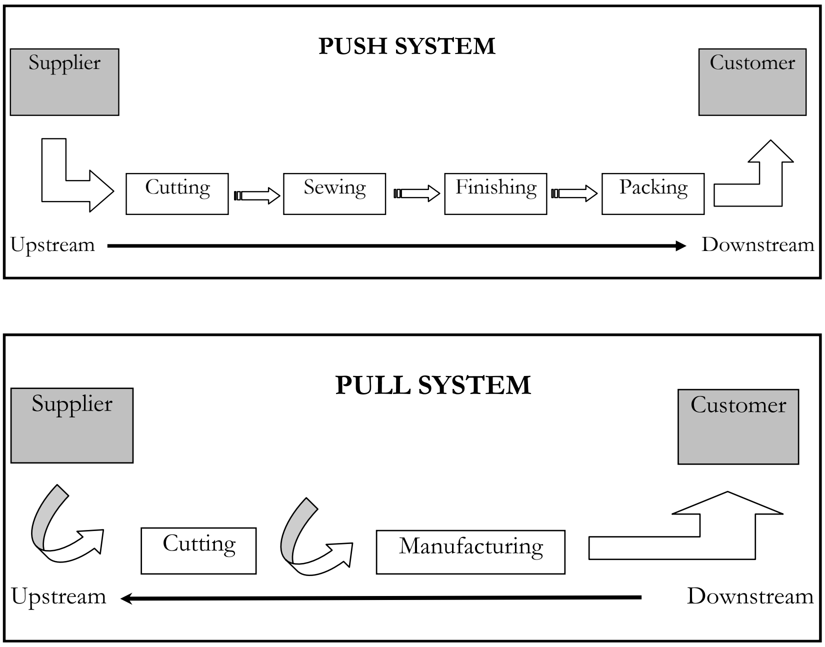

Fig. 1.1 Materials Flow in Push and Pull Systems

3.5 Workplace Organization- 5S

5S is a system to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results. Implementation of this method "cleans up" and organizes the workplace basically in its existing configuration, and it is typically the first lean method which organizations implement.

The 5S pillars, Sort, Set in Order, Shine, Standardize, and Sustain, provide a methodology for organizing, cleaning, developing, and sustaining a productive work environment. In the daily work of a company, routines that maintain organization and orderliness are essential to a smooth and efficient flow of activities. This lean method encourages workers to improve their working conditions and helps them to learn to reduce waste, unplanned downtime, and in-process inventory [12]. The basis of kaizen are constituted by 5S concept, defined by Japanese specialists as a set of good customs and manners, deriving from the traditional manner of behaviour in house and school [14].

3.5.1 First pillar: Sort (Seiri)

Sort, the first S, focuses on eliminating unnecessary items from the workplace that are not needed for current production operations. An effective visual method to identify these unneeded items is called "red tagging", which involves evaluating the necessity of each item in a work area and dealing with it appropriately. A red tag is placed on all items that are not important for operations or those are not in the proper location or quantity. Once the red tag items are identified, these items are then moved to a central holding area for subsequent disposal, recycling, or reassignment.

3.5.2 Second pillar: Set in Order (Seiton)

Proper arrangement -place things in such a way that they can be easily reached whenever they are needed [12].

Set in Order focuses on creating efficient and effective storage methods to arrange items so that they are easy to use and to label them so that they are easy to find and put away. Set in Order can only be implemented once the first pillar, Sort, has cleared the work area of unneeded items. Strategies for effective Set in Order include painting floors, affixing labels and placards to designate proper storage locations and methods, outlining work areas and locations, and installing modular shelving and cabinets [14].

3.5.3 Third pillar: Shine (Seiso)

Shine means sweeping floors, wiping off machinery and generally make sure everything on the floor stays clean. However, maintenance tasks must be taking daily through defined checkpoints.

Once the clutter that has been clogging the work areas is eliminated and remaining items are organized, the next step is to thoroughly clean the work area. Daily follow-up cleaning is necessary to sustain this improvement. Working in a clean environment enables workers to notice malfunctions in equipment such as leaks, vibrations, breakages, and misalignments. These changes, if left unattended, could lead to equipment failure and loss of production. Organizations often establish Shine targets, assignments, methods, and tools before beginning the shine pillar. A well maintained workplace creates a healthy environment to work with [15].

3.5.4 Fourth Pillar: Standardize (Seiketsu)

The first three pillars are activities to organize and maintain the workplace. But standardize is the method you use to maintain the first three pillars Sort-Set in order and Shine. Standardize is related most of the time to shine.

Once the first three 5S's have been implemented, the next pillar is to standardize the best practices in the work area. Standardize, the method to maintain the first three pillars, creates a consistent approach with which tasks and procedures are done. The three steps in this process are assigning 5S (Sort, Set in Order, Shine) job responsibilities, integrating 5S duties into regular work duties, and checking on the maintenance of 5S. Some of the tools used in standardizing the 5S procedures are: job cycle charts, visual cues (e.g., signs, placards, display scoreboards), scheduling of "five-minute" 5S periods, and check lists. The second part of Standardize is prevention - preventing accumulation of unneeded items, preventing procedures from breaking down, and preventing equipment and materials from getting dirty [14].

3.5.5 Fifth Pillar: Sustain (Shitsuke)

Sustain making a habit of properly maintaining correct procedures. The first four pillars can be implemented without any difficulty if the workplace is where employees commit to sustain the 5S conditions Without Sustain the others four pillars will not last longer. 5S is not a technique and different than the other four pillars, result cannot be seeing [14].

Sustain, making a habit of properly maintaining correct procedures, is often the most difficult S to implement and achieve. Changing entrenched behaviors can be difficult, and the tendency is often to return to the status quo and the comfort zone of the "old way" of doing things. Sustain focuses on defining a new status quo and standard of work place organization. Without the Sustain pillar the achievements of the other pillars will not last long. Tools for sustaining 5S include signs and posters, newsletters, pocket manuals, team and management check-ins, performance reviews, and department tours. Organizations typically seek to reinforce 5S messages in multiple formats until it becomes "the way things are done."

3.6 Visual Management

The intent of a visual factory is that the whole workplace is set-up with signs, labels, color-coded markings, etc. such that anyone unfamiliar with the process can, in a matter of minutes, know what is going on, understand the process, and know what is being done correctly and what is out of place [16].

There are two types of application in visual factory: displays and controls.

A visual display relates information and data to employees in the area. For example, charts show monthly revenues of the company or a graphic depicting a certain type of quality issue that group members should be aware of.

A visual control is intended to actually control or guide the action of the group members. Examples of controls are readily apparent in production: Inventory limits, goals, allowances of production delays, etc.

Visual controls describe workplace safety, production throughput, material flow, quality metrics, or other information.

The most important benefit of a visual factory is that it shows when something is out of place or missing.

Visual displays and controls help keep things running as efficiently as they were designed to run. The efficient design of the production process that results from lean manufacturing application carries with it a set of assumptions.

Visual management is an important support for cellular manufacturing. Visual management techniques express information in a way that can be understood quickly by everyone.

Sharing information through visual tools helps keep production running smoothly and safely. Shop floor teams are often involved in devising and implementing these tools through 5S and other improvement activities.

Visual information can also help prevent mistakes. Color coding is a form of visual display often used to prevent errors used for sizes, part of the product.

Thus, visual management is the type of system that will enable even person who know very little about the factory, to apprehend a certain amount of important information related to 6 categories of Control. Visual Control ranks alongside the 5S depending on the plant as a main stay of factory management [17].

3.7 Kanban

“Kanban” is a pull-based material replenishment system that uses visual signals, such as color-coded cards, to signal to upstream workstations when inputs are required at a downstream workstation. In effect, Kanban is a communication tool for pull-based production. A Kanban could be an empty bin, a card, an electronic display or any suitable visual prompt.

Typically there are two main kinds of Kanban:

1. **Production Kanban –** A signal from the internal customer to the internal supplier that something is required from the internal supplier.

2. **Withdrawal Kanban –** A signal from the internal supplier to the internal customer that the supplier has produced something which is available to be withdrawn by the internal customer. In such case the internal supplier doesn't produce more until the withdrawal is made by the internal customer [18].

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There are many variations on the Kanban system and in fact there are many books dedicated to the topic of how to best apply Kanban.

3.8 Quick Changeover

Customers today want a variety of products in just the quantities they need. They expect high quality, a good price, and speedy delivery. Producing to customer requirements means getting batch processes to produce in small lots. Doing this usually creates a need to reduce setup times.

The goal of setup reduction and changeover improvement should be to develop a production system that gets as close as possible to making only what the customer wants, when the customer wants it, throughout the production chain. The result being a strong, flexible manufacturing operation that is adaptable to any manufacturing environment [19].

Many companies produce goods in large lots simply because long changeover times make it costly to frequently change products.

3.9 Kaizen

Kaizen (rhymes with 'dry pen') is a Japanese term meaning "to change for the better." Traditionally, kaizen has meant making small, incremental improvements over a long period of time.

A "blitz" is an intense and lightning-quick version of the kaizen process used to implement a variety of Lean techniques - in a hurry - usually three to eight days in length. It is also sometimes called a Kaizen Event.

It's easy to understand why Lean manufacturers are embracing the kaizen blitz. Improvement in a Lean organization must be an ongoing process and the structure of a kaizen blitz is one of the surest ways to augment continual change, increase efficiency and generate savings.

In a traditional manufacturing setting, it could take weeks - even months - to identify a problem, propose a change to management, get their approval and get employees to change old habits.

A kaizen blitz shifts the change process into high gear. People working in a Lean Enterprise often need to change their mindset. They need to be always thinking about what they can do today, right now, to make things better. Most important, they need to believe that is possible. A Kaizen Event makes them believers.

Unless you've seen a kaizen blitz in action, it's hard to understand just how flexible and effective it can be. Kaizen blitz is, no doubt, a powerful tool. It has a great effect on people buying into the benefits of structured problem-solving and being methodical.

Kaizen blitzes been approved through many and many assignment related to work on set-up reduction, work place organization, point of storage, pull systems and cell design. Some operations see improvements of as much as 80-100% or more, quickly and without major capital investments [20].

It works virtually in any company - the size of the organization is less of an issue than its attitude. It works in companies that are progressive - no matter what their size. Leading companies that know they must change to keep their market share. Other manufacturers may take a wait-and-see attitude. If their competition is doing it, they will too.

Hiroyuki Hirano states ten basics principles for Improvement:

1. Throw out all of your fixed ideas about how to do things.
2. Think of how the new method will work-not how it won't.
3. Don't accept excuses. Totally deny the status quo.
4. Don't seek perfection. A 50-percent implementation rate is fine as long as it's done on the spot.
5. Correct mistakes the moment they're found.
6. Don't spend a lot of money on improvement.
7. Problems give you a chance to use your brain.
8. Ask "why" at least five times until you find the ultimate cause.
9. Ten people's ideas are better than one person's.
10. Improvement knows no limit [21].

3.10 Value Stream Mapping

Value Stream Mapping is a method of visually mapping a product's production path (materials and information) from "door to door".

VSM can serve as a starting point to help management, engineers, production associates, schedulers, suppliers, and customers recognize waste and identify its causes.

The process includes physically mapping your "current state" while also focusing on where you want to be, or your "future state", which can serve as the foundation for other Lean improvement strategies in shorten process and lead time to market.

A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product [22].

There are three areas of the value stream that overlap and flow together:

- Concept to Launch (Administrative area)
- Raw materials to finished products (Manufacturing area)
- Order to cash (Administrative area) Each area contains multiple processes and activities

3.10.1 Steps of Value Stream Mapping

Value stream mapping is done in two steps.

1. **Current state:** The first step is to draw the current state value stream map to take a snapshot of how things are being done now.
2. **Future state:** The second step is to draw the future state map to show how things ought to be done.

Value stream mapping provides both a picture of the current state of affairs as well as a vision of how we would like to see things work. Identifying the differences in the current and future states yields a roadmap for improvement activities [23].

3.10.2 Value Stream Mapping Icons

For visual presentation of value stream mapping, some icons are used in drawing current and future state. These are standard icons to draw a vsm. Some examples of these icons are shown below:

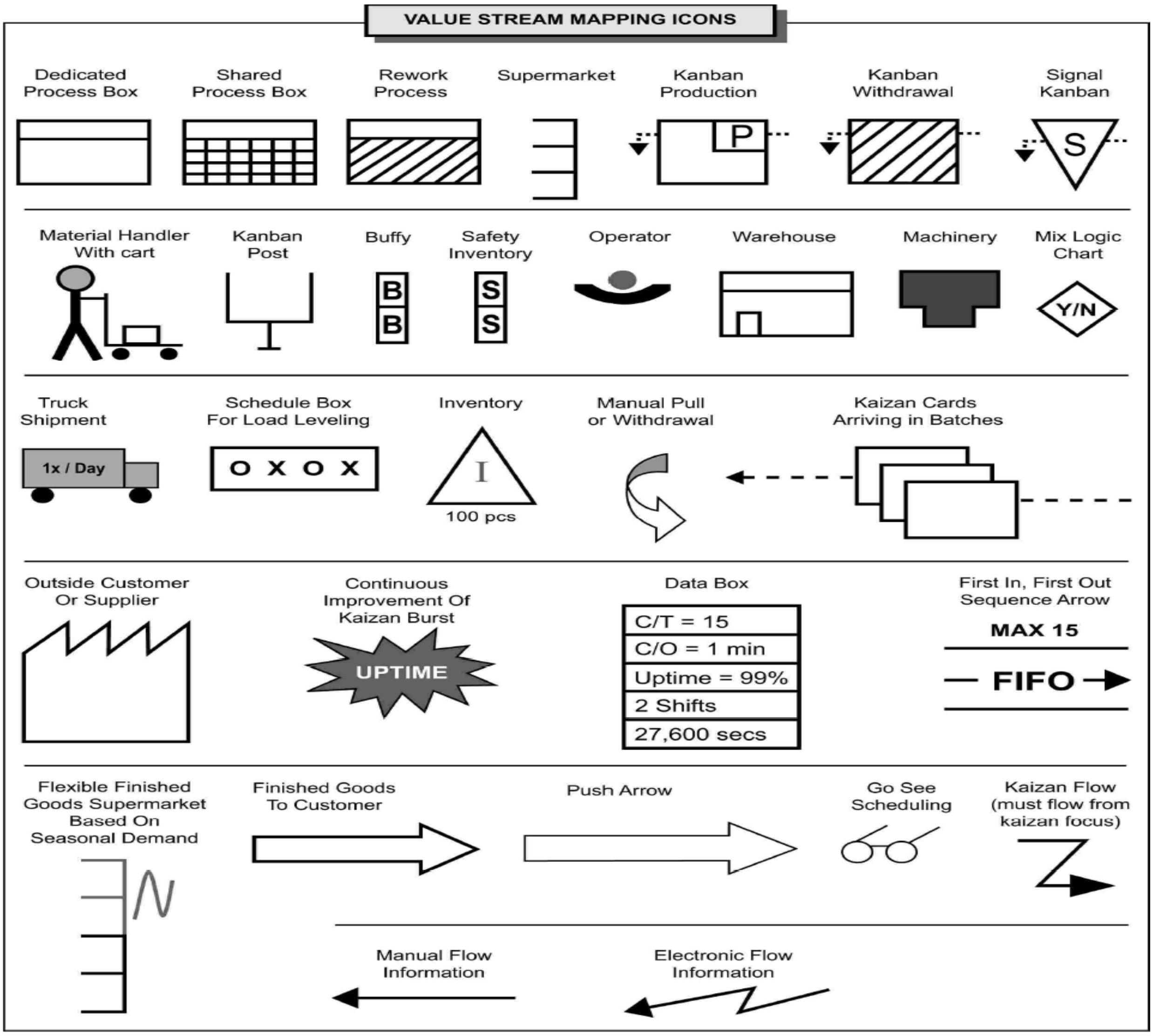

Figure 3.1: Value Stream Icons

3.10.3 Current State Mapping

Each step has some stages to make it possible. It involves the following steps,

Step 1: Select a product family.

Step 2: Understand the customer demand.

Step 3: Form a team.

Step 4: Walk the flow and collect data on the value stream.

Step 5: Calculate total product cycle time.

Step 6: Draw the current state map (material flow and information flow).

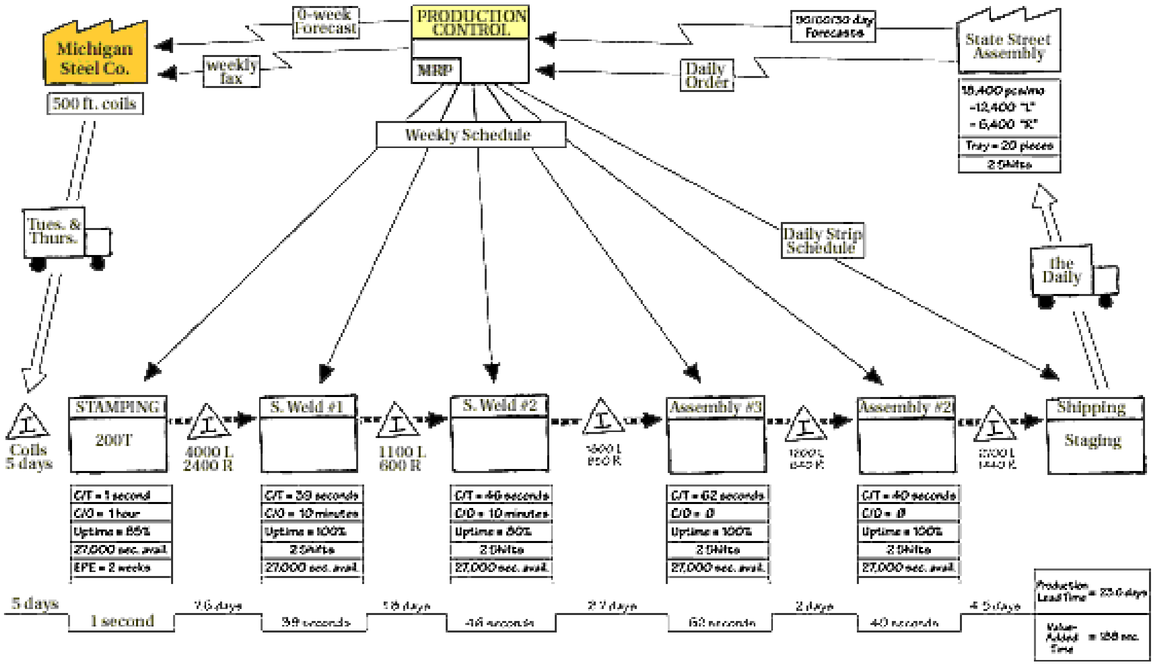

Figure 3.2: Example of Current State VSM

A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product:

The production flow from raw material into the arms of the customer

The design flow from concept to launch

Taking a value stream perspective means working on the big picture, not just individual processes, and improving the whole, not just optimizing the parts [23].

Value Stream Mapping is a pencil and paper tool that helps you to see and understand the flow of material and information as a product makes its way through the value stream. The meaning is simple: Follow a product's production path from customer to supplier, and carefully draw a visual representation of every process in the material and information flow. Then ask a set of key questions and draw a "future state" map of how value should flow [24].

3.10.4 Future State Mapping

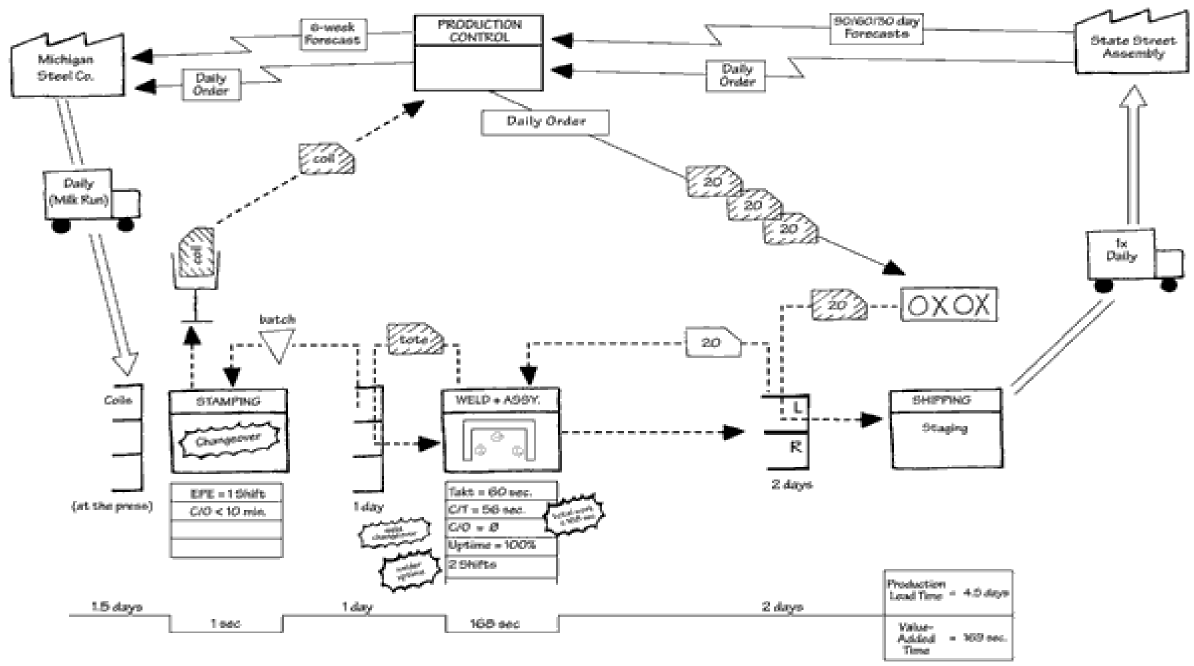

Figure 3.3: Example of Future State VSM

Within the production flow, the movement of material through the factory is the flow that usually comes to mind. But there is another flow - of information - that tells each process what to make or do next. You must map both of these flows.

Value Stream Mapping can be a communication tool, a business planning tool, and a tool to manage your change process. The first step is drawing the current state, which is done by gathering information on the shop floor. This provides the information needed to map a future state. The final step is to prepare and begin actively using an implementation plan that describes, on one page, how you plan to achieve the future state

More and more organizations with successful shop-floor lean efforts are also applying Value Stream Mapping methods and lean principles to administrative areas. Value Stream Mapping provides a simple, yet thorough methodology that relies on relevant data analysis and display. It links reporting requirements, metrics, people, and lean tools to sustain improvement and promote process learning. It gives managers and employees the same tool and language to communicate.

3.10.4 Importance of Value Stream Mapping

- It helps you visualize more than just the single-process level, i.e. assembly, welding, etc.
- It helps you see more than waste it helps you see the sources of waste in your value stream
- It provides a common language for talking about manufacturing processes
- It makes decisions about the flow apparent, so you can discuss them
- It ties together lean concepts and techniques helps you avoid "cherry picking"
- It forms the basis of an implementation plan
- It shows the linkage between the information flow and the material flow

It is much more useful than quantitative tools and layout diagrams that produce a tally of non-value added steps, lead time, and distance traveled, the amount of inventory, and so on.

3.11 Cellular Manufacturing-A Team Based Work

3.11.1 Concept of Cellular Manufacturing

Cellular manufacturing is an approach that helps build a variety of products with as little waste as possible. In cellular manufacturing, production work stations and equipment are arranged in a sequence that supports a smooth flow of materials and components through the production process with minimal transport or delay. Implementation of this lean method often represents the first major shift in production activity, and it is the key enabler of increased production velocity and flexibility, as well as the reduction of capital requirements [26].

3.11.2 Multi-process Handling and the Development of U-shaped Cell

Japanese factory managers rejected American idea of having specialized jobs for factory workers. Instead, they trained factory workers to handle several types of jobs, now referred as multi-process handling. This method was applied to machining lines in Japan. The development of U-shaped cells evolved from the application of multi-process handling.

- A cell consists of the people and the machines or workstations required for performing the steps in a process or process segment, with the machines arranged in the processing sequence.
- Arranging people and equipment into cells helps companies achieve two important goals of lean manufacturing one-piece flow and high-variety production.

Team Design and Placement is a crucial part of the process. Employees must work together in cell teams and are led by a team leader. This team leader becomes a source of support for the cell and is often responsible for the overall quality of the product that leaves his/her cell [27].

3.11.3 One Piece Flow

One-piece flow is the state that exists when products move through a process one unit at a time, at a rate determined by the needs of the customer. The goals of one-piece flow are to make one part at a time all the time, without unplanned interruptions, and to achieve this without lengthy queue times.

One-piece flow (also commonly referred to as continuous flow manufacturing) is a technique used to manufacture components in a cellular environment. The cell is an area where everything that is needed to process the part is within easy reach, and no part is allowed to go to the next operation until the previous operation has been completed.

The goals of one-piece flow are: to make one part at a time correctly all the time to achieve this without unplanned interruptions to achieve this without lengthy queue times.

3.11.4 High-Variety Production

Given the fact that customers expect variety and customization, as well as specific quantities delivered at a specific time, it is necessary to remain flexible enough to serve their needs. Cellular manufacturing offers companies the flexibility to give customers the variety they want. It does this by grouping similar products into families that can be processed on the same equipment in the same sequence. It also encourages companies to shorten the time required for changeover between products. This eliminates a major reason for making products in large lots that changeovers take too long to change the product type frequently [28].

3.11.5 Benefits of Team Based Work

1. Increase productivity.
2. Add Flexibility to high product variety and Improve balancing.
3. Monitor WIP.
4. Eliminate feeding Factor.
5. Eliminate Handling (Excess motions).
6. Improve tremendously Quality.
7. Eliminate lines Time setups.
8. Controle absenteeism and be motived to reduce labor turnover.
9. Standardize work method for consistensy and stability.
10. Assure deliveries on time.
11. Quick response.

3.11.6 Team Based Approach- Zero Waste

1. Waste due to line balancing.
2. Waste due to over-production.
3. Waste due to Excess motions.
4. Waste due to Quality.
5. Waste due to Changeover.
6. Waste due to lack of information.
7. Waste due to excesive space.
8. Waste due to machine breakdown and malfunctioning.

3.11.7 Team Based Approach- Better material Flow

1. One- piece flow (Standing operators).
2. Balanced flow between operations.
3. Min/ max WIP(Seated workers).
4. Synchronized production between shared resourcecs.
5. Balanced material pull through supply Chain.

CHAPTER FOUR

LEAN ASSESSMENT-CURRENT STATE

4.1 Introduction

Assessment was carried out in a selected apparel factory to identify wastes which are affecting line efficiency and through put time through VSM and other analyses.

4.2 Formation of Project Management Team (PMT)

To conduct the assessment and improvement activities in the factory project management team was formed which is consists of

1. Lean Forum
2. Champion
3. Core Implementation Team

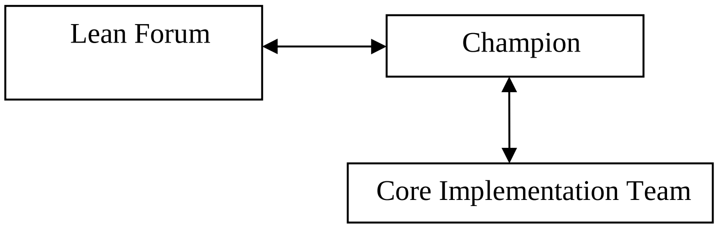

Figure 4.1: Communication & Decision channel in PMT

4.3 Lean Forum

Lean forum role is to monitor and assure project progress in addition to provide support to the champion and the core implementation team to remove any obstacles, blocks, resistance, and to provide guidance and assistance. The lean forum consists of all head departments and two workers representative (*president of the employees' council*). Lean forum should select the champion.

Lean forum is led by the General Manager or Chief Operating Officer or Managing Director.

4.3.1 Roles and Mandates of Lean Forum Members

1. Make strategic decisions related to project implementation.
2. Participate in decision making
3. Develop supportive systems for better run of the project.
4. Coordinate and communicate with supportive departments and personnel.
5. Assure commitment and support from relevant departments is in place.

6. Provide assistance to remove conflicts, resistance and roadblocks.
7. Provide technical guidance and assistance for the project implementation.
8. Identify training need and provide training assistance and dissemination of knowledge required.
9. Prepare and follow up project plan, provide guidance and assistance in implementation.
10. Identify deviation from the plan and take corrective actions as required.

4.4 Champion:

Champion is someone with the authority and the responsibility to allocate the organization's resources. In small organization it may be the general manager, the factory manager or the production manager. In large organization it may be the chief engineer or the Industrial Engineering in charge.

The champion should possess the following attributes:

- A sense of Project ownership
- Authority to make change happen across functions and departments
- Authority to select the implementation core team
- Authority to commit resources

4.5 Core Implementation Team

Factories lack supportive conditions for improvement activities. An employee suggestion system must be established. So factories need to build more team enthusiasm. At step one team members must understand how team activities serve their own desires for personal improvement and self-actualization.

In addition to the champion, it is important to assemble a core implementation team for managing and realizing the improvements. The core implementation team follows the directions of the champion. The team will create plans, communicate to all levels within the organization, make sure people are trained, and implement the value stream process. It is critical for team members to work together, because every aspect of the value stream mapping requires a high degree of collaboration – especially designing the concept or the tool that will lead to the future state.

Based on the above mentioned roles and responsibilities, factory management formed the PMT with following personnel:

Table 4.1**:** The selected Core Implementation Team

Position-PMT	**Name**	**Designation**
Chairman-Lean Forum	Mr. David Hasanat	Chairman & CEO
Member-Lean Forum	Mr. Saiful Islam Khan	COO
	Mr. Md. Matiur Rahman	DGM-Planning
	Mr. Md. Golam Kibria	AGM-Production
	Mr. Razzak	Manager-Cutting
Champion	Mr. Didarul Alam	Executive-Lean management
Core Team Member	Mr. Imrul kaes	Executive-lean Management
	Mr. Selimur Rashid	Officer-IE
	Mr. Mostofa	Executive-IE
	Mr. Nuruzzaman Khan	Production Coordinator
	Mr. Dipankar Roy	Executive-IE
	Mr. Faruque Ahmed	Executive

4.6 Company Profile

The selected apparel manufacturing plant is Viyellatex Ltd. Viyellatex is an export oriented knit garment manufacturing unit established in 1996. Now it is the single largest ISO certified knit garments in Bangladesh. Main products are Tank Top, T-Shirt, Polo Shirt, Shorts, Trouser, and Jacket etc. Currently it has 80 sewing lines in which most of the machines has auto trimmer and mostly oil-free dry head machine with the capacity of 2.50-3.00 million pieces. It is located at Sataish Road, Gazipura, Tongi, Gazipur, Bangladesh. Viyellatex Ltd. has backward and forward linkage sister companies.

Table 4.2: Company Profile

Factory name:	Viyellatex
Factory address:	297, Khortoil, Tongi Gazipur- 1712, Bangladesh
Total direct labor:	4789 persons (*Cutting, sewing and finishing*)
Products range:	T-shirt, Polo-shirt, Jacket, Jogger, Tank top, Children item etc.
Sewing lines:	70 Lines
Sewing operators per line:	33
Helpers per line:	20
Daily working hours:	10
Selected product for mapping:	Gamma Product Family (Cutting, Printing, Sewing, Finishing)
Absenteeism:	5.5%
Days for order changeover:	13

4.7 Manufacturing Stages of the Factory

- Knitting
- Dyeing
- Cutting
- Printing
- Embroidery
- Sewing
- Washing
- Ironing
- Packing
- Needle detecting
- Cartooning

4.8 Data Collection

Data were collected from the ERP system of the company, different departments of the company and through time and motion study of the production system. VSM data were collected through physically following materials from store to all manufacturing stages to carton.

4.9 Data Analysis

4.9.1 Changeover Analysis

Table 4.3: Changeover Analysis

Changeover Time			
Measurement Keys	**Waste**	**Time in Minutes**	**Remarks**
Order Changeover	Machines Adjustment	142.5	L.S.T , T Shirt
	Operators movement		
	Machines Movement		
	Training		
Labor min loss/ changeover time (min)/day			10.96
Days for order changeover		13	
Labor Minute Lost/day/ worker		10.96	

4.9.2 Quality Rework Analysis

Table 4.4: Quality Rework Analysis

Quality Rework & Reject Analysis in Sewing				
Total Available Labor in Sewing & Finishing	3710		Daily Output PCS	38919
Rework Percent	13.40%		Reject Percent	0.32%
Particulars	Daily Average Mistakes (Cutting)	Average Time lost per mistake (Minute)	Total Time Waste (Minutes) for all lines	Minutes Waste per Day-Worker
Rework	5215.15	2.65	13,794	3.72
Reject	123.10	11.20	1,379	0.37
			Total	4.09

* (Appendix-4 for Rework & Reject Percentage Calculation)

4.9.3 Line Balancing Analysis

Table 4.5: Line Balancing Analysis

Line Balancing Analysis											
Style						T Shirt	Target Pieces	Line			14
Total SMV						7.43		SMO			22
Planned Eff %						100%		Helpers & others			17
Minutes Worked						480	2520	Total Workers			39
Mins. Earning as per Eff.						480		Takt Time			0.191
Op. No.	Operation	SMV	No. of operator	Dedicated C/T	Expected Quantity as per Efficiency	Expected Mins Earned	Expected Qty. as per Balancing	Mins. Earned as per Balancing	Variation	Over Capacity	Under Capacity
1	Back part fold	0.13	1	0.13	3692	201	1548	201	32%	**32%**	
2	B & F part matching	0.31	1	0.31	1548	480	1548	480	-63%		**-63%**
3	Care label make	0.09	1	0.09	5333	480	1548	139	53%	**53%**	

Table 4.5: Line Balancing Analysis (Continued)

Op. No.	Operation	SMV	No. of operator	Dedicated C/T	Expected Quantity as per Efficiency	Expected Mins Earned	Expected Qty. as per Balancing	Mins. Earned as per Balancing	Variation	Over Capacity	Under Capacity
4	Sh. Cut	0.25	1	0.25	1920	480	1548	387	-31%		**-31%**
5	Shoulder join	0.21	1	0.21	2286	480	1548	325	-10%		**-10%**
6	Care label join	0.19	1	0.19	2526	480	1548	294	0%		
7	Rib make	0.22	1	0.22	2182	480	1548	341	-15%		**-15%**
8	Rib tack	0.15	1	0.15	3200	480	1548	232	21%	**21%**	
9	Rib rolling	0.25	1	0.25	1920	480	1548	387	-31%		**-31%**
10	Rib join	0.25	1	0.25	1920	480	1548	387	-31%		**-31%**
11	Scissoring Rib	0.17	1	0.17	2824	480	1548	263	11%	**11%**	
12	Twill tape join	0.34	2	0.17	2824	480	1548	263	11%	**11%**	
13	Label position mark	0.14	1	0.14	3429	480	1548	217	27%	**27%**	
14	Label join	0.23	1	0.23	2087	480	1548	356	-21%		**-21%**
15	Twill tape top stitch	0.26	2	0.13	3692	480	1548	201	32%	**32%**	
16	Neck scissoring	0.19	1	0.19	2526	480	1548	294	0%		
17	Trim	0.15	1	0.15	3200	480	1548	232	21%	**21%**	
18	Sleeve matching	0.16	1	0.16	3000	480	1548	248	16%	**16%**	
19	sleeve pair	0.17	1	0.17	2824	480	1548	263	11%	**11%**	
20	Sleeve join	0.54	2	0.27	1778	480	1548	418	-42%		**-42%**
21	Side seam	0.53	2	0.265	1811	480	1548	410	-39%		**-39%**
22	Trim & Folding	0.2	1	0.2	2400	480	1548	310	-5%		
23	Sleeve Tack	0.16	1	0.16	3000	480	1548	248	16%	**16%**	
24	Trim &fold	0.2	1	0.2	2400	480	1548	310	-5%		
25	Body hem tack	0.2	1	0.2	2400	480	1548	310	-5%		
26	Trim	0.17	1	0.17	2824	480	1548	263	11%	**11%**	
27	Folding	0.15	1	0.15	3200	480	1548	232	21%	**21%**	
28	Body hem	0.17	1	0.17	2824	480	1548	263	11%	**11%**	
29	Blind or Churri hem	0.34	2	0.17	2824	480	1548	263	11%	**11%**	

Table 4.5: Line Balancing Analysis (Continued)

Op. No.	Operation		No. of operator	Dedicated C/T	Expected Quantity as per Efficiency	Expected Mins Earned	Expected Qty. as per Balancing	Mins. Earned as per Balancing	Variation	Over Capacity	Under Capacity
30	Trim	0.25	2	0.125	3840	480	1548	194	34%	34%	
31	Security Tack	0.31	**1**	0.31	1548	480	1548	480	-63%		-63%
32	Trim	0.17	1	0.17	2824	480	1548	263	11%	11%	
33	Folding	0.18	1	0.18	2667	480	1548	279	6%	6%	
	Total	7.43	39	6.3		15561		9755			
					Line Balancing Ratio			63%			
					Labor Minutes Lost/Worker/Day			161.29			

Below graph based on cycle time vs. takt time shows line balancing scenario.

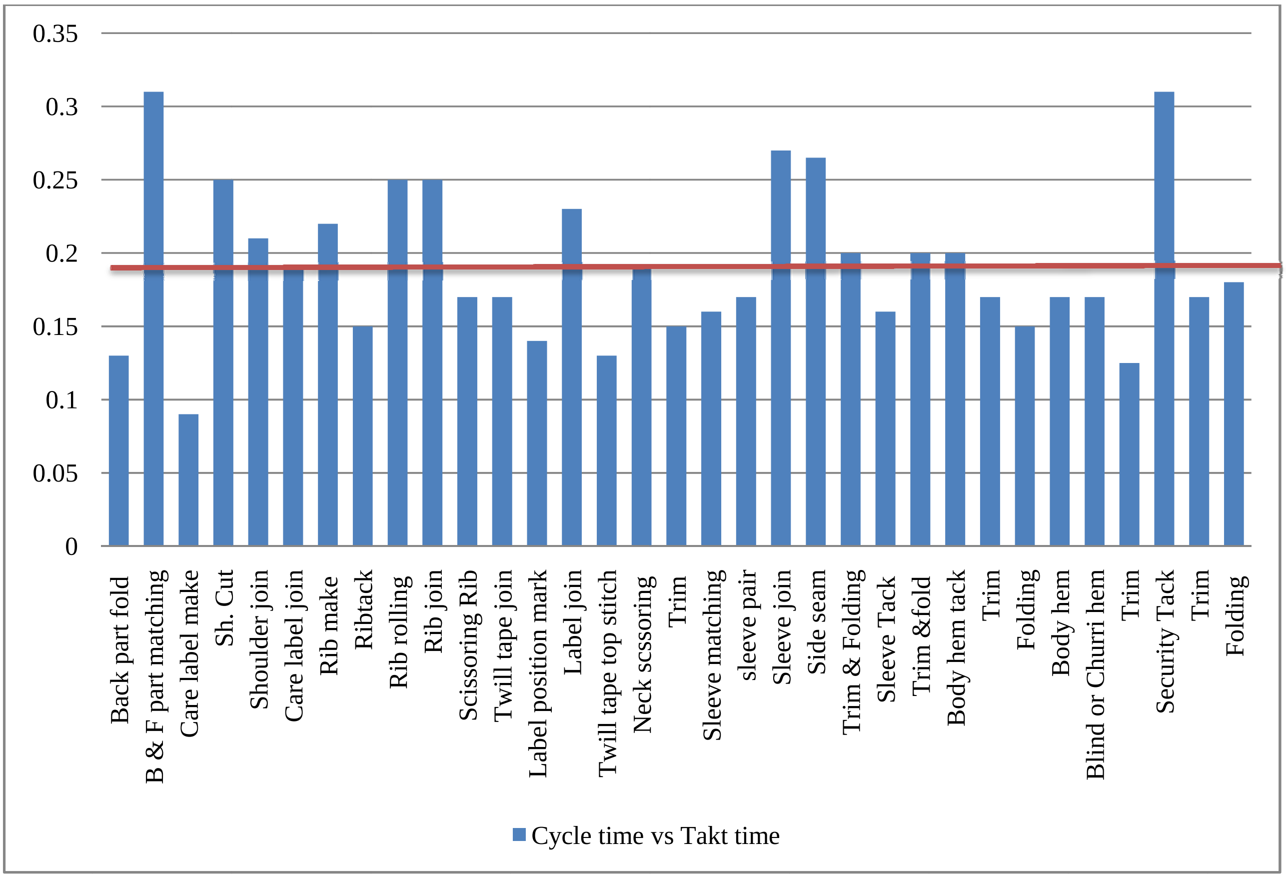

Figure 4.2: Graph Based on Cycle Time & Takt Time Depicting Line Balancing

4.9.4 Line Efficiency Analysis

Table 4.6: Line Efficiency Analysis

Date	Buyer	Style	Item	SMV	Production	Working Hour	Sewing Operator	Assistant Sewing Op.	Produced Minutes	Input Labor Minutes	Efficiency	Input MC Minutes	Input SQF Minutes
11 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1480	8	34	25	13560	28320	47.88%	16320	480960
12 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1360	10	34	26	12460	36000	34.61%	20400	601200
13 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1360	10	34	26	12460	36000	34.61%	20400	601200
15 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	750	8	30	25	6872	26400	26.03%	14400	480960
16 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1128	8	33	27	10335	28800	35.88%	15840	480960
17 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1825	10	35	22	16721	34200	48.89%	21000	601200
18 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	0	10	34	22	0	33600	0.00%	20400	601200
19 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1730	10	36	27	15850	37800	41.93%	21600	601200
20 Aug. 9	WALMART	MM1Q0900	SLV T.S.	9.162	1902	10	36	27	17426	37800	46.10%	21600	601200
22 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	756	10	37	25	6926	37200	18.62%	22200	601200
23 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1650	8	37	27	15117	30720	49.21%	17760	480960
24 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1813	8	38	28	16611	31680	52.43%	18240	480960
25 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1900	8	36	26	17408	29760	58.49%	17280	480960
26 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	625	10	38	27	5726	39000	14.68%	22800	601200
27 Aug. 09	M&S	DSH982 (9215E)	LSV T.S.	9.77	0	8	38	26	0	30720	0.00%	18240	480960
29 Aug. 09	M&S	DSH982	LSV T.S.	9.77	0	8	37	27	0	30720	0.00%	17760	480960
30 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	600	3	38	27	5497	11700	46.98%	6840	180360
30 Aug. 09	M&S	DSH982 (9215E)	LSV T.S.	9.77	0	5	38	27	0	19500	0.00%	11400	300600
31 Aug. 09	M&S	DSH982 (9215E)	LSV T.S.	9.77	296	8	38	28	2892	31680	9.13%	18240	480960
Total					19175				175861	591600	29.73%	342720	9619200

4.9.5 Excess Motion Analysis

Table 4.7: Excess Motion Analysis

Excess Motion Analysis			
Method	Particulars	Minutes	Remarks
PMTS	SMV	7.6	
Time study	SMV	8.77	As per worker pace
Excess Motion	Minutes	1.17	Per piece

4.10 Lean Metrics –Labor Under-utilization

Data were collected from the ERP system of the company, different departments of the company and through time and motion study of the production system.

4.10.1 Work practices Analysis-Waste Related to Work Practices within the Processes.

Table 4.8: Work Practice & Process Analysis-Summary

Measurement Keys	**Waste**	**Current State**	**Methods of measurement**
Order Changeover *(sewing)*	Machines Adjustment	10.96 mins/ day/ worker	Tracking and Cycle Time Follow Up
	Machines Movement		
	Operators movement		
	Training and others		
	First Bundle Run Feeding	4.03 mins/ day/ worker	
	Last Bundle Run Cleaning the Line	4.03 mins/ day/ worker	
Unnecessary Motions*(sewing)*	Hesitation in Pick Ups	1.17 mins/piece	PMTS vs. Time Studies as per Worker Pace
	Excessive Evacuation		
	Excessive Bundle Handling(Cutting)		
Unnecessary Activities *(cutting, sewing, finishing)*	Stickers (cutting)	0.15 mins/piece	Cycle Time Follow Up & VSM Data
	Bundling (cutting)	0.06 mins/piece	
	Marking	0.14 mins/piece	
	Transport	0.04 mins/piece	
	Trimming	2.26 mins/piece	
	Sorting	0.05 mins/piece	

Table 4.8: Work Practice & Process Analysis-Summary (Continued)

Measurement Keys	Waste		Current State	Methods of measurement
	Quality Rework	Sewing	4.09 mins/day/worker	Tracking and Rework Time measurement
		Finishing	4.48 mins/day/worker	
Waiting – Materials	For next Process		4 mins / day/ worker	NPT Report
Waiting – Workers *(sewing)*	For work (Line imbalance)		161.3 mins /day /worker	Line Balancing Analysis

*(Appendix-2 & 5)

4.10.2 Key Result of Current State

Table 4.9: Key Result of Current State

Key Result of Current State		
Measurement Keys	**Unit of Measure**	**Value**
Line Efficiency (Sewing)	Percentage	29.73%
Lack of Line Balancing (Sewing)	Percentage	37%
Daily Output	Pieces Per Factory	38919

4.11 Value Stream Mapping (VSM) -Current State

Value stream mapping is a visual mapping tool which identifies all the value added and non value added actions required to make a product along with information flow and breaking of continuous flow.

4.11.1 Product Family Analysis

To select a product category to draw current state value stream mapping, product family analysis is required to determine which product routing if improved would affect mostly to the overall performance of the factory.

Based on 220 styles which were being produced by the factory previously was considered for the product family analysis. From the analyses, it was apparent that most of the product flows through cutting, printing, sewing and finishing route (Gama Product family) which uses 43.45% labor minutes of the factory. (Appendix-1)

For VSM, a product was selected which follows the cutting, printing , sewing and finishing route. The selected product was a T-shirt, Buyer was Puma. . (Appendix-1)

4.11.2 Data Collection

To collect data for VSM, core team was trained on how to collect data and exercise was carried out to ensure that core team was capable to collect date accurately.

Material flow related data was collected by physically following the material from cutting to sewing to finishing. The time in printing was tracked but material was not followed as the product was printed outside of the factory from supplier.

It required 14113 minutes to make a product from store to carton. (Appendix-2)

4.11.3 Drawing Current State

Based in the collected data, it was observed that flow breaks and WIP accumulates which divides entire flows into 14 processes. Besides collecting material flow information flow required to make a product also had been tracked.

Based on the data analysis in previous sections, information flow and collected data in VSM data log sheet, current state VSM was drawn as follows: (Appendix-3, 4 & 5)

Figure 4.3: Current State VSM

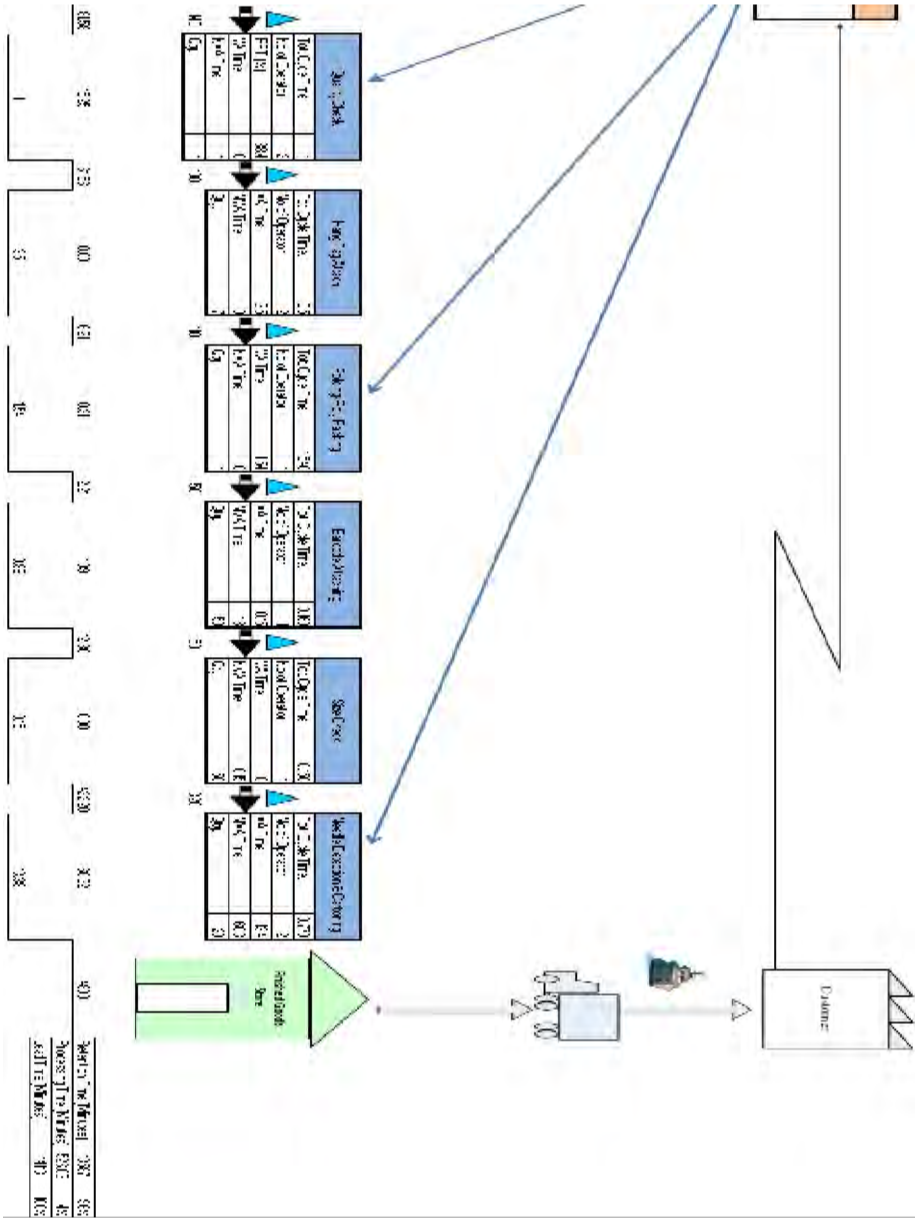

Figure 4.3: Current State VSM (Continued)

CHAPTER FIVE

DESIGNING FUTURE STATE

5.1 Introduction

Future state is what is desired to be achieved and the outlook of future material and information flow. To make a value stream lean, it is desired to create continuous flow wherever possible first then create pull between processes where continuous flow is not possible. Future state is designed criticizing current state map based on Lean principle and thinking.

5.2 Drawing Future State VSM

In current state map, we have breaking in flow between spreading and cutting where continuous flow can be created by forming team consisting of spreaders, cutters and numbering and bundling personnel. Lead time can be reduced through reducing the batch size. Between cutting and printing process, continuous flow cannot be created as cutting is done batch wise where printing is outsource on which factory does not have control over. So, smaller batch can be cut and sent to printing in batches. Material returned from printing can be placed in supermarket where label and accessories will be kept together as those are used in sewing as per point of use system.

In sewing, continuous flow can be enhanced by flowing one product at a time where in current state bundles are being moved from operation to operation. Downsizing the team to reduce handling and create team concept to reduce line balancing lost would impact positively continuous flow and labor utilization. Reducing changeover time would facilitate small production run to produce small quantity efficiently as per customer demand and reduce over production. Between sewing, QC and finishing operation, continuous flow can be created as each operation can be done on single unit which will reduce unnecessary processes like re-quality check, counting, sorting processes. This would reduce tremendously throughput time and labor utilization. Downsizing the team in sewing and finishing, team can be formed consisting of sewing and finishing worker. But creating continuous flow from sewing to cartooning is impossible at this point due to assorted color carton which is yet not possible to produce different color in sewing in continuous flow due to requirement of changing threads in sewing machine. That’s why it would be feasible at this point to create a supermarket where inventory will be accumulated before pulling for carton the products. Due to lower cycle time and considering utilization of needle detection machine, dedicating a needle detection machine would not be feasible. So, it can be centralize for several sewing and finishing team and FIFO principle can be followed.

5.3 Future State VSM

Based on the thinking described in the previous section following future state map was drawn with implementation idea.

5.4 Kaizen Events List

Following are the improvement ideas to achieve in future state

1. 5S in cutting, sewing and finishing
2. Implement visuals
3. Implement team concept in finishing
4. Supermarket pull between printing and sewing
5. Downsize team in sewing and finishing
6. Implement team concept in sewing and finishing
7. Implement Kanban for line balancing in sewing and finishing
8. Implement one piece flow in sewing and finishing
9. Implement quick changeover in sewing
10. Implement quality at the source in cutting, sewing and finishing

5.5 Lean Forum Approval

Lean forum were presented with current state assessment and future state and kaizen implementation ideas. Lean forum reviewed and investigate deeply the ideas and suggested that creating continuous flow between sewing and finishing at this point would be matter of huge structural investment at this point. Rather the forum suggested focusing on sewing where labor utilization is critical factor for the overall performance of the factory. Based on the suggestions of the lean forum, following kaizen events were planned and approved by the lean forum for the first phase and then other decision regarding other kaizen events would be decided based on the achievements in sewing. The forum also opined that incentive system could be developed for the sewing and finishing based on the achievement of team based production.

Event-1: Visual Communication- Team Status Board for Sewing

Event-: Workplace Organization-5S in Sewing

Event-3: Team Concept in Sewing- Downsizing team, Kanban for line balancing and One Piece Flow, Quality at the Source

Event-4: Design and Installation of Incentive System

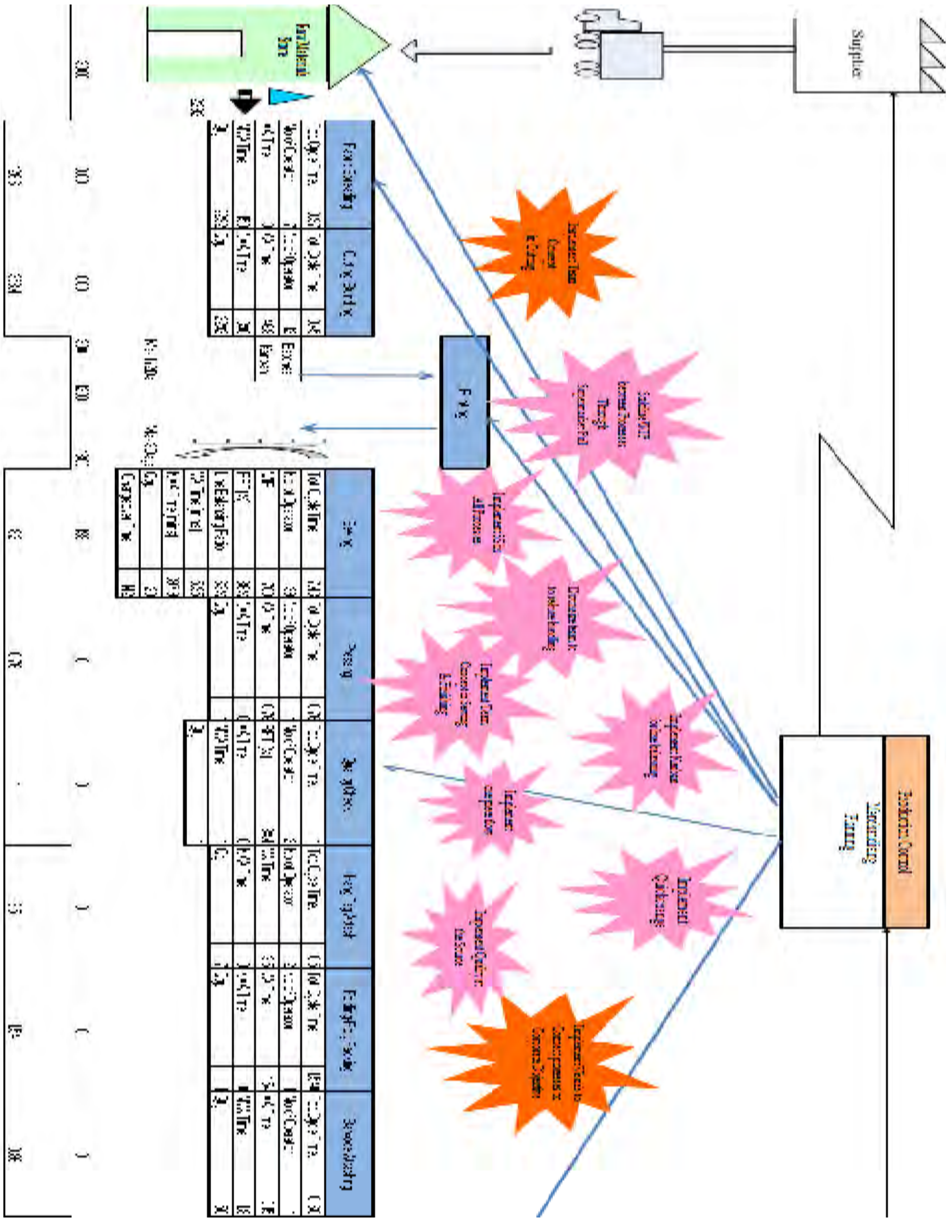

Figure 5.1: Future State VSM

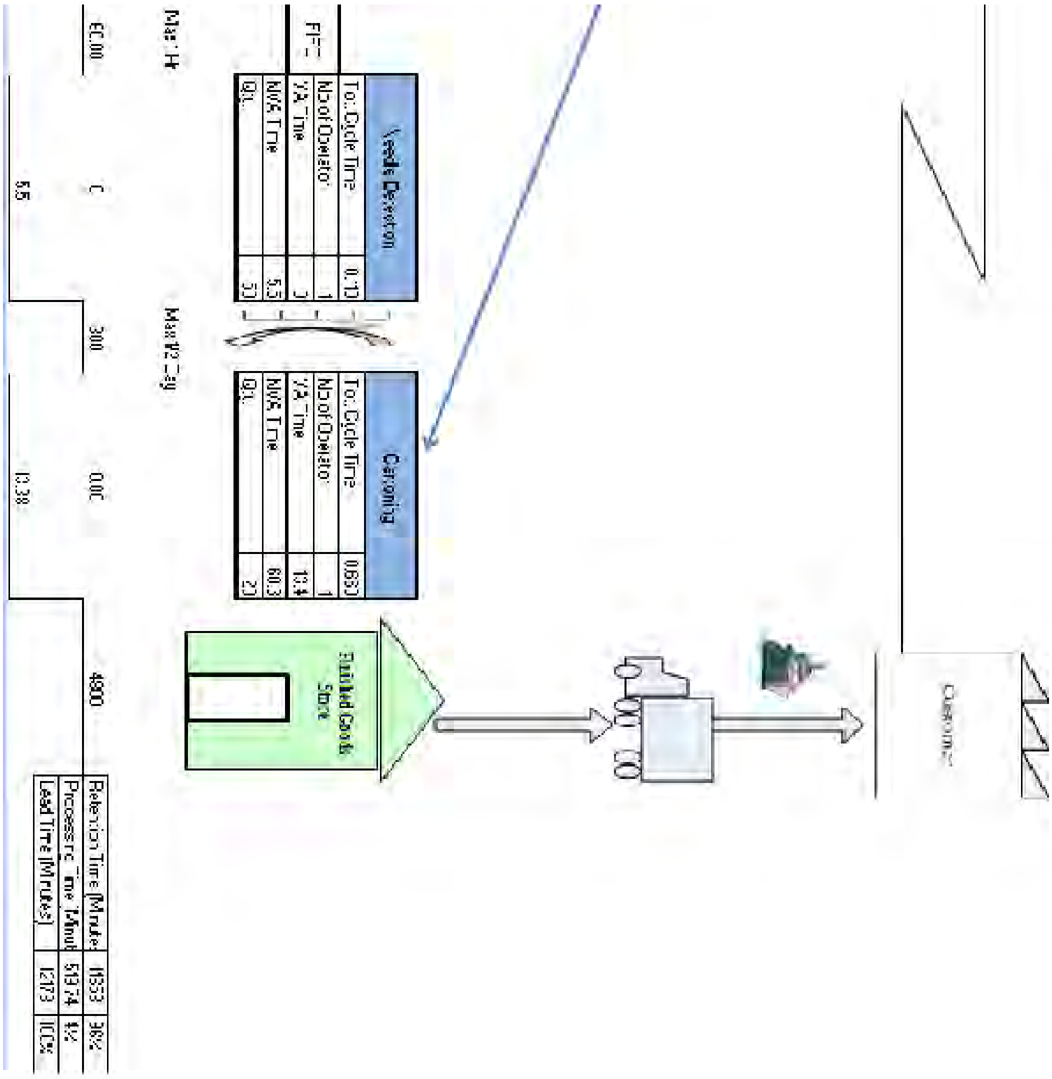

Figure 5.1: Future State VSM (Continued)

CHAPTER SIX

ACHIEVING FUTURE STATE-KAIZEN EVENTS

6.1 Introduction

To achieve future state, kaizen events were carried out as approved by the Lean forum. To make a kaizen event successful, participation of internal stake holder is of paramount importance. Focus was given to participation of workers in the kaizen events.

6.2 Event -1: Visual Communication-Team Status Board

6.2.1 Defining Performance Measures

Discussing with core team and production management personnel, following performance measures of a sewing team were selected:

- Efficiency
- Rework & reject percentage
- Changeover time
- Absenteeism

Besides, following general information were decided to make visual:

- Date
- Number of workers in the line/team
- Total number of machine used
- Hourly production, rework (alteration) & rejects
- Hourly production target
- Total allocated quantity to be produced in the line of the given style
- Total standard minute value (SMV) of the current product
- Buyer of the product
- Style number of the product
- Takt time
- Total absent workers and replacement
- Changeover information
- Kaizen story board

It was also decided that other side of the board will be used to keep following information for one month:

- Safety records:5S graph, safety cross, needle consumptions
- Quality records: Rework & reject graph, pareto analysis (weekly), quality precautions
- Non-productive time: NPT graph, maintenance NPT & Input NPT

- Productivity: Efficiency graph, Skill matrix & absenteeism graph

This side of the board was termed as Safety, Quality, NPT & Productivity board or SQNP board.

6.2.2 Designing Status Board

Following design was proposed by the core team:

			Team Name:						**Team No:**									
Average Team Skill:			Hour	1	2	3	4	5	6	7	8	9	10		Total	Total Allocated qty:		Remarks
Saturday	Target		Out put													T. Member		
Date:	SMV		Cumulative Output													T. M/C		
Takt Time	Buyer		Alter													Absent		
	Style		Reject													Efficiency		
Sunday	Target		Out put													T. Member		
Date:	SMV		Cumulative Output													T. M/C		
Takt Time	Buyer		Alter													Absent		
	Style		Reject													Efficiency		
Monday	Target		Out put													T. Member		
Date:	SMV		Cumulative Output													T. M/C		
Takt Time	Buyer		Alter													Absent		
	Style		Reject													Efficiency		
Tuesday	Target		Out put													T. Member		
Date:	SMV		Cumulative Output													T. M/C		
Takt Time	Buyer		Alter													Absent		
	Style		Reject													Efficiency		
Wednesday	Target		Out put													T. Member		
Date:	SMV		Cumulative Output													T. M/C		

Figure 6.1:Design of Status Board

Average Team Skill:			Hour													Total Allocated qty:		
Takt Time	Buyer		Alter													Absent		
	Style		Reject													Efficiency		
Thursday	Target		Out put													T. Member		
Date:	SMV		Cumulative Output													T. M/C		
Takt Time	Buyer		Alter													Absent		
	Style		Reject													Efficiency		
Friday	Target		Out put													T. Member		
Date:	SMV		Cumulative Output													T. M/C		
Takt Time	Buyer		Alter													Absent		
	Style		Reject													Efficiency		

CHANGEOVER INFORMATION

KAIZEN STORY BOARD

Figure 6.1: Design of Status Board (Continued)

6.2.2.1 Changeover Information Details

Changeover Information						
Previous Style	Starting Time	Starting Date	Ending Time	Ending Date	Total Hours	New Style

Figure 6.2: Design of Changeover Information Board

6.2.2.2 Kaizen Story Board Details

Kaizen Story Board													
Ref. No	Date/time	Style	Color	Waste/ Problem	Who reported	Reporter ID	Who's reported to	Root cause	Trouble Shooter	Trouble Shooter ID	Solution	Status	Future Recommendation

Figure 6.3: Design of Kaizen Story Board

6.2.3 Designing SQNP (Safety, Quality, Non-productive time & Productivity) Board

Following format of SQNP board was designed by the core team:

SQNP Board	Safety	5S Graph	Safety Cross	Needle Consumption	Recognition Board
	Quality	Rework & Reject Graph	Pareto Analysis (Weekly)	Quality Precautions	
	NPT	NPT Graph	Maintenance NPT	Input NPT	
	Productivity	Efficiency	Skill Matrix	Absenteeism Graph	

Figure 6.4: Design of SQNP Board

6.2.4 Define SOP for Maintenance of Status board

Team name: will be proposed by the members of the team and suitable name from those proposals will be selected by the management.

Team no.: a numerical no. will be given to those teams.

Order, style, buyer, date, day, total machine no., total present member no. and absent/replacement no. will be written by the supervisor everyday with in the first hour.

Target, SMV, change over date, time and related information, average team skill, **efficiency** will be written by IE of respective floor everyday with in the first hour (in case of the incidents which may occur other than first hour should be updated within half an hour of the occurrence of the incidents) .

Hourly output, cumulative output, alter and reject status will be written by Quality reporter within 5 minutes every hour.

NPT Graph: NPT graphs will be maintained by the IE.

Safety & Quality Graph: Safety cross & other graph will be maintained by the in-line roaming QC

Productivity Graph: Productivity Graph will be maintained by the supervisor of the line/team

6.2.5 Lean Forum Approval

Lean Forum was approached with the design & SOP of the team status board. The Lean approved the design and SOP of the team status board and advised core team to take necessary steps to make a status board. The measurement of the board was decided to be 5’X4’.

6.2.6 Training on Maintenance of Status Board

Floor management were trained on the maintenance of the team status board and how to calculated different parameters and how fill up different graphs.

6.2.7 Installing Status Board & Coaching

The status board was installed in a line as pilot run basis and relevant personnel who were responsible for maintaining of the status board were trained and coached how to fill the board properly for a week.

6.2.8 Review and Adjusting Status Board

After one week, a review session were arranged to review whether any adjustment were required to the board prior to rolling out in the entire floor. It was decided that no adjustment were required.

6.2.9 Recommendation to Lean Forum

Lean forum was recommended to roll the status board in the entire floor of seven sewing lines and then in the entire factory.

6.3 Event-2: Workplace Organization-5S

6.3.1 Awareness Training for Lean Forum & Core Implementation Team

5S is the first step in implementing Lean system in any industry as it creates neat, clean, safe and disciplined workplace where further improvement will be carried out. Lean can be sustained in a cluttered and disorganized workplace. Moreover, it involves employees in the improvement activities and which has no negative impact rather all the positive effects on the system and people.

An awareness rising training session of one hour on 5S has been arranged to improve their understanding of 5S, potentials benefits of 5S implementation with power point presentation, pictures of organized workplaces and with 5S promotional videos.

6.3.2 Brief Lean Forum & Approval

An implementation plan was developed to implement 5S in a sewing line and then in a entire floor consisted of seven sewing line as a pilot concept before implementing 5S in the entire organization.

The implementation program was divided as follows:

1. Briefing workers on 5S and potential benefits of 5S implementation
2. Taking photographs of the current workplaces for comparison of Before and after
3. Implementing the First 3S’s in the pilot sewing line
4. Set requirements
5. Implement 4^{th} & 5^{th} S in the pilot sewing line
6. Design & launch scoring system
7. Implement 5S in the entire floor
8. Coaching the employees
9. Taking the photographs after implementation of 5S for comparison of before and after
10. Develop recognition system for 5S excellence
11. Implement the recognition system
12. Present result to the Lean forum with recommendation

The lean forum approved the 5S implementation program and suggested us to do 5S with existing tools and furniture at this point as after implementing team concept may require different types of furniture and tools and suggested to implement 5S in sewing line no.58 and then in that floor (3rd floor).

6.3.3 Briefing Workers on 5S and Potential Benefits of 5S Implementation

A briefing session of 30 minutes was arranged for the workers and supervisors of the selected line with 5S promotional videos and pictures of some well organized factories. The workers were inspired seeing the videos and pictures and committed themselves to implement 5S in their line. The potential benefits of 5S were described as follows:

1. Improved health and safety condition
2. Pleasant workplace free of unnecessary items
3. Less searching for needed items
4. Better space utilization
5. higher product quality,
6. Lower costs,
7. Increased customer satisfaction

6.3.4 Taking Photographs of the Current Workplaces for Comparison of Before and After

Supervisors along with core team members were tasked to take some photographs of the selected sewing lines and of the entire floor to compare the outcome of implementing 5S.

6.3.5 Implementing the First 3S's in the Pilot Sewing Line

Core implementation team started with separating needed items for the current style running in the selected sewing line and accumulating unneeded items in a selected red tag area in the floor. Three workers were selected from the line to accumulate all the unnecessary items along with core implementation team (1st S-Short).

After removing all unnecessary items from the sewing line, needed items were stored in a organized way which would facilitate easy storing and recovery of the needed items (2nd S-Set in order).

Then storage location of each items were labeled including type of item, quantity to be stored information and all relevant personnel were asked to keep all the items clean all time.(3rd S-Shine). Moreover, it was decided that music will be played for 5-minute twice a day to signal the employees to conduct clean their workplaces. . Input area and input shelf were demarcated to house all the necessary threads, marking materials, bobbin, patterns and registers and labeled those locations.

6.3.6 Set Requirements

As it was decided in the steering committee meeting not to invest in furniture at this stage as team based layout would be setup and different requirements for furniture would be required, not to invest for furniture at this point. It was decided to use available resources in the sewing line to do workplace organization.

6.3.7 Implement 4th & 5th 'S' in the Pilot Sewing Line

Workers were assigned to clean their workplaces and keep their workplaces free on all unnecessary items. Workers were advised to clean their workplaces before starting their work in the morning and before leaving their workplaces while leaving their workplaces. Besides it was decided that a special music will be played twice in a day for five minutes in each sessions to signal major clean up their workplaces once in the morning and once in the afternoon. Supervisors were tasked to ensure proper cleaning of the sewing line during major clean ups.

To make 5S sustainable, it was decided that all new workers and supervisors will be trained on 5S during their orientation program organized by the Human Resource Department. Besides, a month in every year will be declared as 5S month.

6.3.8 Design & Launch Scoring System

An scoring format were designed as follows to do 5 minutes 5S audit by the in-line roaming QC everyday to identify deviations and coach the workers based on the deviation from standards. The in-line roaming QC will update the 5S-score in the team status board. (See Appendix-7)

6.3.9 Implement 5S in the Entire Floor

A tour and motivation sessions were arranged for the remaining six lines of the sewing floor. In the tour workers, QC and supervisors were briefed on the 5S activities carried in the selected line and workers of the selected line briefed all the steps and benefits they received after doing 5S activities. The workers, supervisors and QC of the remaining six lines were requested to do the same 5S activities in their lines under the guidance of core implementation team within one week time. Afterwards 5S scoring of the all seven lines will be carried out.

6.3.10 Coaching the Employees

Core implementation team visits the sewing floor time to time to find the deviations and arranged short meeting with the workers to coach them on 5S and its benefits.

6.3.11 Taking the Photographs for Comparison of Before and After pictures after Implementation of 5S

After conducting 5S in the sewing lines, pictures were taken to compare before and after of 5S.

Figure 6.5: Before picture *(5S)*

Figure 6.6: Pictures of ‘Sorting’ phase

Figure 6.7: After Pictures *(5S)*

6.3.12 Develop Reward System for 5S Excellence

It was decided in the lean forum meeting that the highest score achiever of week will be recognized through 5S champions badge. Brainstorming with core team, it was decided that a badge made of fabrics and embroidered the letters “5S Champion” and the factory name “Viyellatex” would be written on it. As per the idea, core team was assigned to make the badge for 5S champion of the week. In the core team meeting, it was further decided that the highest scorer of the week would be decided based on 50% of average score of the line as audited by the in-line roaming QC and 50% of average score based on random audit conducted by lean team members.

6.3.13 Implement the Reward System

After 5S activities conducted in all seven lines of the selected floor, the highest score achiever were awarded with ‘5S Champion Badge’ for one week. One representative of the Lean Forum awarded the workers, QC and supervisors of the line with the 5S Champion badge and encouraged them on 5S maintenance.

Figure 6.8: Rewarding workers for 5S excellence

6.3.14 Present Result to the Lean Forum with Recommendations

Lean Forum were briefed on the 5S events and recommended to conduct 5S activities in overall factory. Lean Forum congratulated the core team and workers and instructed the core team to conduct 5S activities in all areas of the factory.

6.4 Event -3: Team Concept in Sewing

6.4.1 Lean Forum Briefing

A briefing session was arranged for the lean forum that team based production system can improve line efficiency, throughput time, quality and overall performance significantly over the current system as the balancing ratio of the current system is very low as work sharing concept is absent and worker perform as individual than a team. Management decided that a piloting may be conducted at a selected line. Management also approved a core team consisting of cross functional team members to carry out the piloting of the team concept.

6.4.2 Selecting Product for Pilot Run

Discussing with core team following, a product was selected to do the piloting which will be produced after 20 or so days as plan and preparation will take some time before all the requirements are fulfilled for the smooth running of the pilot team.

6.4.3 Designing & Assignment of Operations

The IE department of the factory prepares the operation assignment using SMV derived from General Sewing Data (GSD) study based on which line would setup. IE representative in the core team brought the operation assignment to review and design the operations for the proposed team. The traditional layout was as follows:

Table 6.1 : GSD Layout

Style File Number	S0000220
Style Number / Title	ESPRIT-Z21662
Style Description	RNLSTEE,SJ 150 GSM.
Customer	ESPRIT
Product Ref.	BASIC.
SMV	8.267
Hourly Prod Target	180
Balancing Ratio	75%

Table 6.2: Machine Requirements

<table>
<tr><th>MACHINE</th><th>CODE</th><th>QTY</th><th>UTILIZATION</th><th>TOTAL</th></tr>
<tr><td>Manual</td><td>M</td><td>13</td><td>70.59</td><td>13</td></tr>
<tr><td>Overlock Machine [514]</td><td>OL14</td><td>7</td><td>84.34</td><td rowspan="4">20</td></tr>
<tr><td>Lockstitch Machine [301]</td><td>LS1</td><td>10</td><td>71.79</td></tr>
<tr><td>Flat lock / Chainstitch [401]</td><td>MC1</td><td>1</td><td>65.70</td></tr>
<tr><td>2N Flat Lock [406]</td><td>MC6</td><td>2</td><td>94.20</td></tr>
</table>

Table 6.3: Operation Bulletin

SL	OPERATION	SMV	UTILIZATION	NO OF OP	MC
1	BACK-FRONT MATCHING	0.449	1.35	2	M
2	SLD JOINT	0.277	0.83	1	OL14
3	SHOULDER SCISSORING	0.248	0.74	1	M
4	NECK RIB MAKE	0.243	0.73	1	LS1
5	NECK RIB FOLD TACK	0.266	0.80	1	LS1
6	NECK JOINT	0.287	0.86	1	OL14
7	CARE LABEL JOINT	0.183	0.55	1	LS1
8	BACK NECK PIPING	0.187	0.56	1	LS1
9	PIPING CUT ACCORDINGLY	0.220	0.66	1	M
10	MAIN LABEL POSITION MARK	0.248	0.74	1	M
11	MAIN LABEL JOINT	0.184	0.55	1	LS1
12	BACK NECK END TACK	0.283	0.85	1	LS1
13	BACK NECK PIPING TOP	0.260	0.78	1	LS1
14	THREAD CUT	0.443	1.33	2	M
15	FRT NECK TOP	0.219	0.66	1	MC1
16	THREAD CUT	0.274	0.82	1	M
17	SLEEVE HEM OPEN	0.329	0.99	1	MC6
18	SLEEVE PAIR & SLEEVE HEM	0.169	0.51	1	M
19	SLV & BODY MATCH	0.190	0.57	1	M
20	SLEEVE JOINT (LONG SLV)	0.590	1.77	2	OL14
21	SLV OPEN TACK	0.276	0.83	1	LS1
22	SIDE SEAM (LONG SLEEVE)	0.814	2.44	3	OL14
23	BODY FOLDING	0.200	0.60	1	M
24	BTM HEM TUCK	0.271	0.81	1	LS1
25	BTM HEM	0.299	0.90	1	MC6
26	BTM HEM RAW EDGE CUT	0.285	0.85	1	M
27	SLEEVE 1/4 TACK	0.240	0.72	1	LS1
28	THREAD CUT AFTER TUCK	0.333	1.00	1	M
TAKT TIME		0.25			

Below graph based on cycle time vs. takt time shows line balancing scenario.

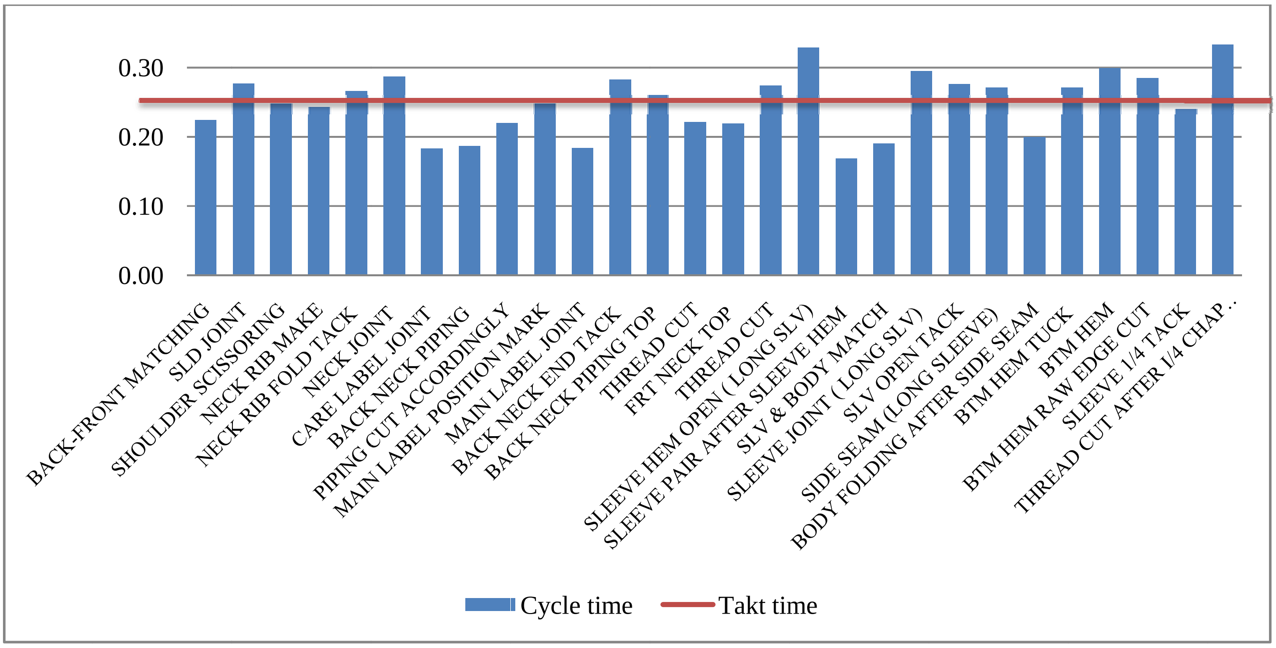

Figure 6.9: Graph Based on Cycle Time & Takt Time Depicting Line Balancing

Based on the layout, the manpower requirements are 20 sewing machine operators(SO) and 13 manual workers (assistant operators –ASO). It would be difficult to form a team with 33 workers as effective communication, work sharing and keeping team coherence will be difficult. Two options were considered:

Option-1: Combining operation and downsizing the requirements of worker as low as 16 to 20 workers.

Option-2: Formation of two teams which would be working together to complete all operations

Option -1 is more beneficial over one as downsizing the worker requirement through elimination of some unnecessary operations and combining the remaining operations will reduce the number of pick up and evacuation of parts which will reduce the work contents of operations which will reduce the cycle time and increase the productivity.

A process flow chart was created to visualize the operations and entry of body parts as follows:

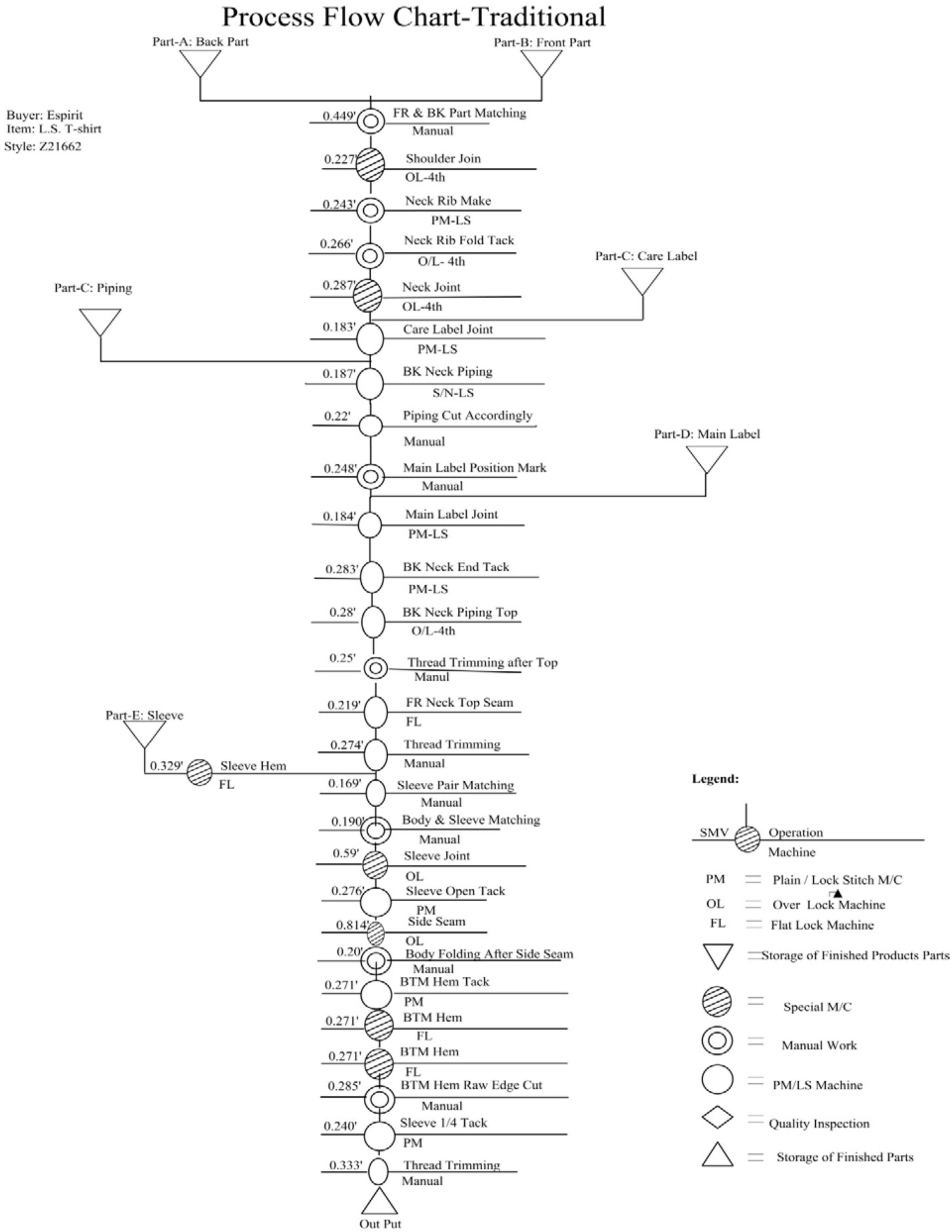

Figure 6.10: Process Flow Chart-Traditional

To combine operations, regrouping of operations which uses similar machines and sewing specifications are required without altering the pre-requisites of operations. Following tables shows the combination and re-sequenced operations:

Table 6.4: Re-sequencing & Combining Operations

Style-Z21662		Buyer- Espirit				Item- L.S. T-shirt		
Op. Seq.	**Operation**	**SMV**	**Out Put/Hr**	**SMVof Combined Operation**	**Worker Req.**	**Out Put/Hr**	**Machine**	**Remarks**
1	Fr & Back Part Matching	0.449	134	0.449	1	134	Manual	
2	Shoulder Join	0.277	217	0.525		114	OL-4TH	
3	Shoulder Scissoring	0.248	242		1			
4	Neck Rib Make	0.243	247	0.509		118	PM	
5	Neck Rib Fold Tack	0.266	226		1			
6	Neck Joint	0.287	209	0.287	1	209	OL-4TH	
7	Back Neck Piping	0.187	321	0.407	1	147	PMP	
8	Piping Cut accordingly	0.22	273					
9	Back Neck End Tack	0.283	212	0.531	1	113	PM	
10	Main Label Position Mark	0.248	242					
11	Main Label Join	0.184	326	0.444		135	PM	
12	Back Neck Piping Top Seam	0.26	231		1			
13	Thread Cut After Top Seam	0.443	135	0.443	1	135	Manual	
14	Front Neck Top Seam	0.219	274	0.493		122	FL	
15	Thread Cut after Top Seam at	0.274	219		1			
16	Sleeve Hem	0.329	182	0.329	1	182	FL	
17	Sleeve Pair after Sleeve Hem	0.169	355	0.359		167	Manual	
18	Sleeve & Body Match	0.19	316		1			
19	Sleeve Joint	0.59	102	0.59	1	102	OL-4TH	
20	Sleeve Open Tack	0.276	217	0.459		131		
21	*Care Label Join*	0.183	328		1		PM	*Elimination Target*
22	Side Seam	0.814	74	1.014	2	118	OL-4TH	
23	Body Folding after Side Seam	0.2	300					
24	*Bottom Hem Tack*	*0.271*	*221*		*0*	*0*	*PM*	*Eliminated*
25	Bottom Hem	0.299	201	0.584		103	FL	
26	Bottom Hem Raw Edge Cut	0.285	211		1			
27	Sleeve Tack	0.24	250	0.573	1	105	PM	
28	Thread cut after Tack	0.333	180					
	Total	8.267		7.996	17			
	Takt time	0.47 minutes			Balancing Ratio			80%

Below graph based on cycle time vs. takt time shows line balancing scenario.

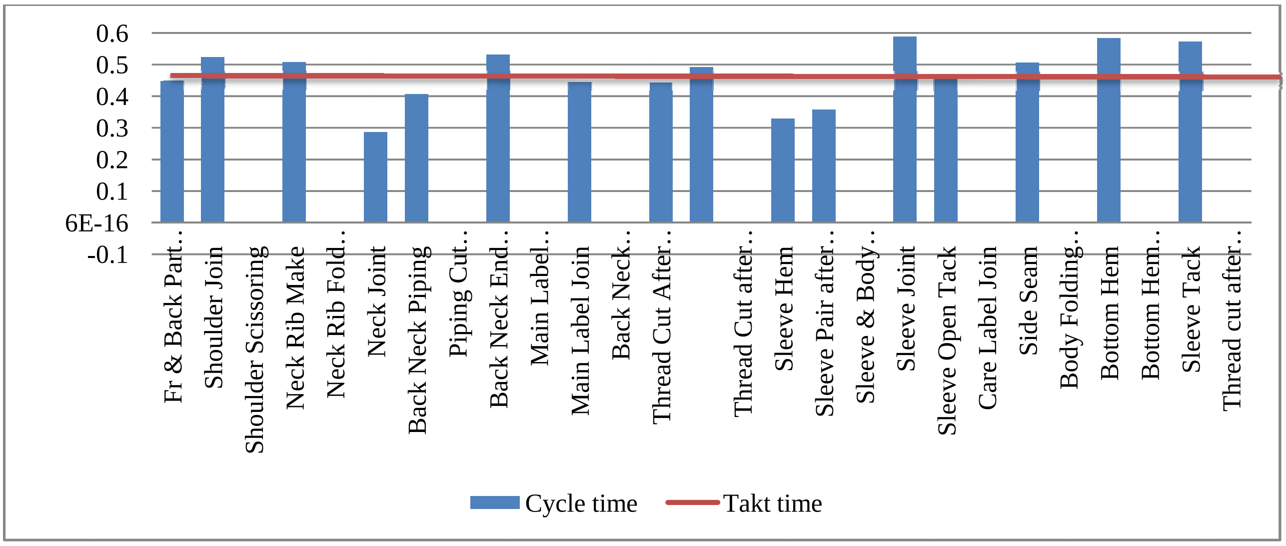

Figure 6.11: Graph Based on Cycle Time & Takt Time Depicting Line Balancing

Summary of Requirements	
Manual Worker	3
Machine Operator	14
Machine	14
Plain Machine-Piping attachment (PMP)	1
Plain Machine (PM)	5
Flat Lock (FL)	3
Over Lock (OL)	5
Matching Table	2
Input Table	1
QC Table	1

From the Analysis, it is apparent that manpower and machine can be reduced to almost half of the conventional setup. Based on the combined operation, following process flow chart was designed to design the layout of workstation.

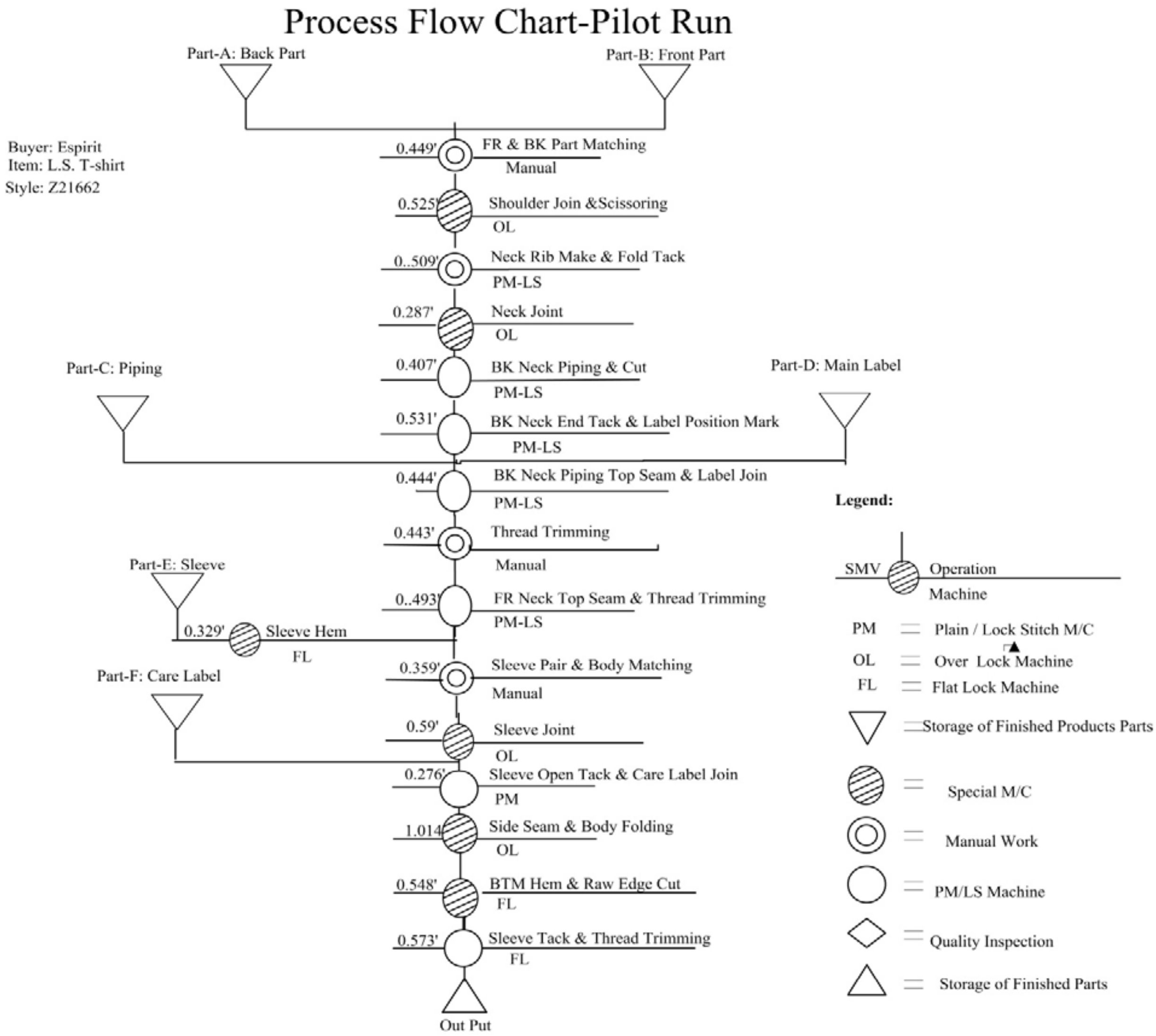

Figure 6.12: Process Flow Chart-Pilot Run

6.4.4 Designing the U-shaped Layout

The U-shape layout and setting up machine side by side was decided to adopt for the pilot line to achieve the following benefits:

1. Ease of communication
2. Ease parts evacuation and pick up
3. Ease of movement of workers
4. Ease of supervision

To design the u-shaped layout in which machine would be set up side by side, linear layouts were designed based on the modified process flow chart to determine the sequence of operations and workstation thereof

Linear Layout-1:

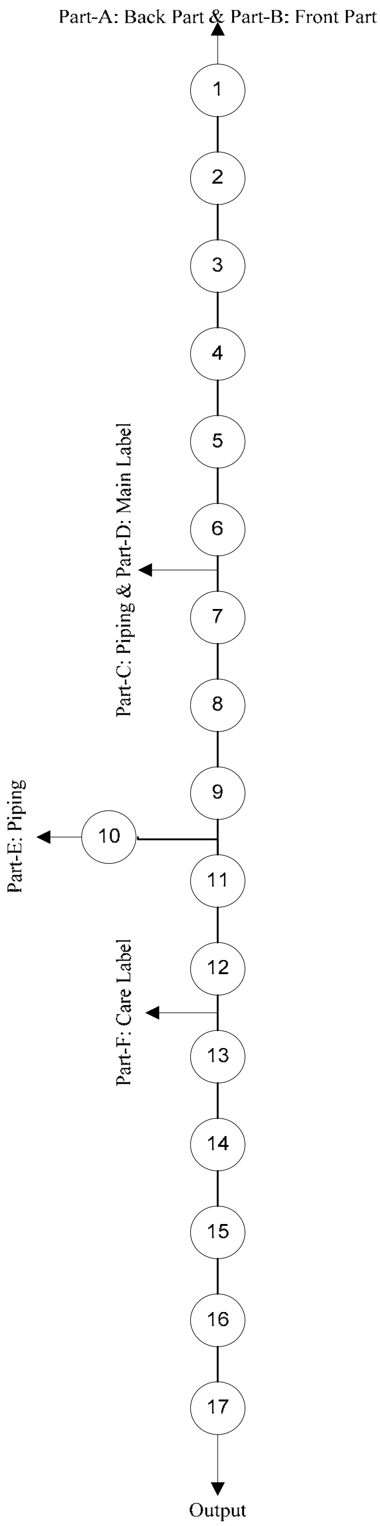

Figure 6.12: Linear layout-1

Based on Linear layout-1, linear layout-2 was designed to set sequence of all operations which will be also the basis of U-shaped physical layout.

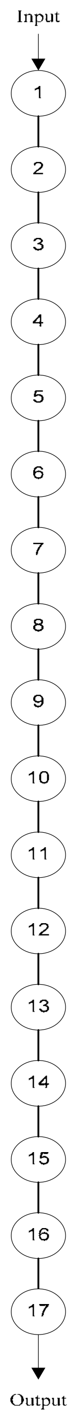

Figure 6.13: Linear Layout-2

Bending the linear layout-2, Operations and workstation sequence were set as below figure:

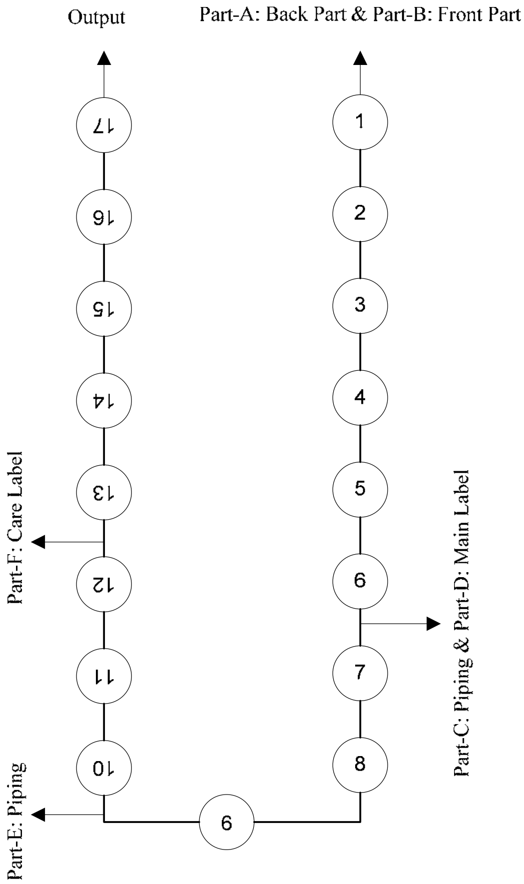

Figure 6.14: U-shaped layout

6.4.5 Set Pre-requirements for Implementation (for one team)

6.4.5.1 Team Structure

- One line composed of …14 ...sewing workers Plus ……3…manual workers.
- 1 input man to support the team for parts and trims distribution
- …1….table QC men
- …1…..inline QC man
- …1 on job trainer with adequate technical knowledge (supervisor)

6.4.5.2 Tools Requirements

- Scissors- **…2……qty**
- In hand scissors (trimmers)……17….**qty**.
- Side table for each operator
- QC Inspection and packing tables (30 inch X 3 or 4 feet)….qty. and two matching table (as per discussion)

- Shelf of 3 or 4 levels maximum height of 5 feet to hold non start parts
- Possible drawers file cabinet for accessories, trims and tools as area of storage
- Necessary sewing patterns for the style.

6.4.5.3 Clean Up Activities

- Hold pieces cut till implementation *(Non Start)*
- Minimize and complete in WIP between workers before implementation
- Move machineries as planned during night time on the day of implementation
- Remove all unnecessary parts, tools, pieces not related to in-process' current style
- Regroup all accessories, trims, parts in one area for workplace organization during implementation
- Clean the machinery tables and empty drawers
- Re-organize the bundles into bulk quantity split by parts category

6.4.5.4 Practices

- In hand scissors *(Clippers)*
- Practice of worker as per designed combined operations

6.4.5.5 Information

- Technical sheet with quality standards, sketch and method of measurement and checking
- Packing sheet and method of packing
- Trim sheet of current style
- Sealed contract sample

Sewing Machines: (as per selected product and analysis)

Table 6.6: Requirement of Machines

Summary of Requirements	
Manual Worker	3
Machine Operator	14
Machine	14
Plain Machine-Piping attachment (PMP)	1
Plain Machine (PM)	5
Flat Lock (FL)	3
Over Lock (OL)	5
Matching Table	2
Input Table	1
QC Table	1

6.4.6 Identify Performance Measures

It was assumed that following metrics would be effected due to the implementation of the team based concept:

- Line efficiency
- Machine utilization
- Space utilization
- WIP
- Throughput time

6.4.7 Train core team on Measurement of Performance Measures

Core team members were trained to measure the metrics of the selected line before any changes were carried out in the selected line for determining the effect of the implementation.

6.4.8 Map Performance Measures

Core team members gathered data from the information system of the company and reviewed the line physically to determine the WIP & throughput time of the line.

Table 6.7: Status of Traditional Line (Before Conversion)

Status of Traditional Line (Before Conversion)													
Date	**Buyer**	**Style**	**Item**	**SMV**	**Production**	**Working Hour**	**Sewing Operator**	**Assistant Sewing Op.**	**Produced Minutes**	**Input Labor Minutes**	**Efficiency**	**Input MC Minutes**	**Input SQF Minutes**
11 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1480	8	34	25	13560	28320	47.88%	16320	480960
12 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1360	10	34	26	12460	36000	34.61%	20400	601200
13 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1360	10	34	26	12460	36000	34.61%	20400	601200
15 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	750	8	30	25	6872	26400	26.03%	14400	480960
16 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1128	8	33	27	10335	28800	35.88%	15840	480960
17 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1825	10	35	22	16721	34200	48.89%	21000	601200
18 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	0	10	34	22	0	33600	0.00%	20400	601200

Table 6.7: Status of Traditional Line (Before Conversion) (Continued)

Date	Buyer	Style	Item	SMV	Production	Working Hour	Sewing Operator	Assistant Sewing Op.	Produced Minutes	Input Labor Minutes	Efficiency	Input MC Minutes	Input SQF Minutes
19 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1730	10	36	27	15850	37800	41.93%	21600	601200
20 Aug. 9	WALMART	MM1Q0900	SLV T.S.	9.162	1902	10	36	27	17426	37800	46.10%	21600	601200
22 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	756	10	37	25	6926	37200	18.62%	22200	601200
23 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1650	8	37	27	15117	30720	49.21%	17760	480960
24 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1813	8	38	28	16611	31680	52.43%	18240	480960
25 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	1900	8	36	26	17408	29760	58.49%	17280	480960
26 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	625	10	38	27	5726	39000	14.68%	22800	601200
27 Aug. 09	M&S	DSH982 (9215E)	LSV T.S.	9.77	0	8	38	26	0	30720	0.00%	18240	480960
29 Aug. 09	M&S	DSH982 (9215E)	LSV T.S.	9.77	0	8	37	27	0	30720	0.00%	17760	480960
30 Aug. 09	WALMART	MM1Q0900	SLV T.S.	9.162	600	3	38	27	5497	11700	46.98%	6840	180360
30 Aug. 09	M&S	DSH982 (9215E)	LSV T.S.	9.77	0	5	38	27	0	19500	0.00%	11400	300600
31 Aug. 09	M&S	DSH982 (9215E)	LSV T.S.	9.77	296	8	38	28	2892	31680	9.13%	18240	480960
Total					**19175**				**175861**	**591600**	**29.73%**	**342720**	**9619200**

Table 6.8: Status of Traditional Line-Summary

Summary	
Efficiency	29.73%
Lab. Productivity (SMV Generation /Labor Hour)	17.84
SMV Generation/Machine Hour	30.79
SMV Generation/SQF Hour	1.10
WIP	800
Throughput Time	500
Avg. Worker/ Line	61.89

6.4.9 Schedule Implementation

As worker requires to cut threads of their own operations and to keep the cycle time of the operations low, practicing operations keeping trimmers in their hand was required. Another requirement was to make the worker to practice the combined operations as per the design. As altering the production line may reduce the productivity of the line for few days, need to be considered to meet the planned lead time of the selected product which needs to be planned in advance.

6.4.10 Develop Guidelines for the Pilot Team

Supervisor and team leader should hold a meeting with the members to explain the operations sequences and the quality points, parts location etc. during starting new styles in the line.

Team leader will always discuss with supervisor to implement any decision in the line and vice-versa.

Conditions & Responsibilities

- **A**ll threads will be trimmed off the operation.
- Scissors are attached to the sewing machine or to the table.
- Modular members are not allowed to remove the scissors off the sewing machine or the table.
- No one is allowed to walk with the scissor or to be kept in her pockets.
- Develop a board that height is similar to the size of regular paper to hang the trim card, the sketch and the specification sheet.
- All pencils should be fixed to the sewing machine or to a table applying the same rules of the scissors.

6.4.10.1 In-Team Quality Procedures & Responsibility

Work Studies and Quality team must develop a standard work method including all needed instruction to perform the checking. The instruction must be posted at the checking area.

- All SMO should adapt some techniques to their sewing machines in order to avoid any excess trimming, or wrong seam allowances.

- In Process, all SMO should check the first piece produced against all critical and measurement points as per the operation.

- In Process, all SMO should check one out of 7 pieces produced against all critical and measurement points as per the operation before issuing the 7 pieces to the next SMO.

- Output checking point must have the following elements:

  1. Measurement sheet,
  2. Critical points list,
  3. Trim card,
  4. All size labels of the current style,
  5. All hang tags of the current style,
  6. Daily Units checking record,
  - Final quality checkers are not allowed to carry a scissor with them or to fix a scissor to a table.
  - All threads are detected at the final checking area should be returned to the SMO workstation for trimming purpose.
  - Final quality checkers will return alter/rework pieces as soon as it is found and inform in line QC for remedial actions.

6.4.10.2 WIP Status

- Fifteen pieces maximum between two operations when parts will move single pieces and stop sewing to help the next operator or any other operations. He/she will return to her operation when WIP drops to 5 pieces.
- When WIP is in maximum level, operator will stops his/ her work and will help the next operator in manual jobs or perform other sewing operation in his/ her or other machine if available.

6.4.10.3 Supervisor Responsibilities

- At first hour, he/she will talk with team leader first and then with all members of the team regarding the last day’s performance (Production, Alter, Reject, Efficiency, 5S score) & how they can overcome the last day’s problems.
- Talk with team leader and operator about bottleneck process & critical operation to quality.
- Check 5S Audit has been done or not, if not then talk with AQC.
- Check all the data of the Visual Status Board & Graphs of SQNP board. If any item is not maintained then he will consult with his superior.
- He will check produced pieces randomly to check quality of the products and will take corrective actions if required.

6.4.11 Lean Forum Approval

Lean forum was presented with the current metrics of the selected line and proposed team based layout, requirements, potential layout, pre-requirements prior to implementation and initial guidelines for the team. Lean forum appreciated the ideas and approved the guidelines and instructed the core team to facilitate all the requirements to implement the pilot team. Lean forum also agreed to share the benefits achieved from the pilot concept with employees in the form of productivity incentive.

6.4.12 Developing Skill of the Worker

Workers were supplied with hand trimmers to practice trimming threads of their operations and practice to work keeping the trimmers in hand wherever possible mainly in all plain machine and flat lock machine operations and practice to do bottom hem without pre-tacking for the duration until the raw materials of the selected product were available and all requirements are met which were supposed to be done in about three weeks.

6.4.13 Implementation with Follow Up

Workers of the selected line were briefed on the pilot team concept and the benefit for worker which includes distribution of workload among the workers, sharing the workload of bottleneck operations to alleviate extra working pressure, good working relations among workers and with supervisory management as productivity would be higher and potential higher income for workers and supervisors once the outcome of the pilot run accepted by the management as satisfactory.

Workers agreed to participate in the concept but raise their concern that management may not share benefits of the team concept with workers at the end. One lean forum members assured the workers if company benefits from the team concept, management was willing to share it with its employees.

Core team members selected required numbers of workers and supervisor as per the set requirements of the team based on willingness of workers and required skills of the worker. Among the selected members, a team leader was selected from the workers by themselves.

Workers were introduced with layout of physical set up and briefed on it. Then workers and supervisors with help of core implementation team changed the physical layout in U-shaped layout.

Workers and supervisors were coached on the concept during the implementation and performance were measured based on different parameters after running the line for several weeks.

6.4.14 Map Improvement

Table 6.9: Status of Pilot Team-After Conversion

Status of Pilot Team (Model Line-After Conversion)													
Date	**Buyer**	**Style**	**Item**	**SMV**	**Production**	**Working Hour**	**Sewing Operator**	**Asst. Sewing Op.**	**Produced Minutes**	**Input Labor Minutes**	**Efficiency**	**Input MC Minutes**	**Input SQF Minutes**
5 Oct. 09	ESPRIT	Z21662	SLV T.S	8.27	300	10	13	4	2481	10200	24.32%	7800	201000
6 Oct. 09	ESPRIT	Z21663	SLV T.S	8.27	400	10	13	4	3308	10200	32.43%	7800	201000
7 Oct. 09	ESPRIT	Z21664	SLV T.S	8.27	2000	10	13	4	16540	10200	162.16%	7800	201000
8 Oct. 09	ESPRIT	Z21665	SLV T.S	8.27	700	10	13	4	5789	10200	56.75%	7800	201000
10 Oct. 09	G-STAR	87540	SLV T.S	7.40	300	10	14	4	2220	10800	20.56%	8400	201000
11 Oct. 09	G-STAR	87540	SLV T.S	7.40	300	10	14	4	2220	10800	20.56%	8400	201000
12 Oct. 09	G-STAR	87540	SLV T.S	7.40	450	8	14	4	3330	8640	38.54%	6720	160800
13 Oct. 09	G-STAR	87540	SLV T.S	7.40	400	10	14	4	2960	10800	27.41%	8400	201000
14 Oct. 09	G-STAR	87540	SLV T.S	7.40	550	10	14	4	4070	10800	37.69%	8400	201000
15 Oct. 09	G-STAR	87540	SLV T.S	7.40	800	10	14	4	5920	10800	54.81%	8400	201000
17 Oct. 09	G-STAR	87540	SLV T.S	7.40	705	10	14	4	5217	10800	48.31%	8400	201000
18 Oct. 09	G-STAR	87540	SLV T.S	7.40	800	10	14	4	5920	10800	54.81%	8400	201000
19 Oct. 09	G-STAR	87540	SLV T.S	7.40	800	10	14	4	5920	10800	54.81%	8400	201000
20 Oct. 09	G-STAR	87540	SLV T.S	7.40	660	10	14	4	4884	10800	45.22%	8400	201000
21 Oct. 09	G-STAR	87540	T.S	7.40	800	10	14	4	5920	10800	54.81%	8400	201000
22 Oct. 09	G-STAR	87540	T.S	7.40	640	8	14	4	4736	8640	54.81%	6720	160800
Total					**10605**	**156**			**81435**	**166080**	**49%**	**128640**	**3135600**

Table 6.10: Status of Pilot Team-After Conversion (Summary)

Summary	
Efficiency	49.03%
Labor Productivity (SMV Generation/ Labor Hour)	29.42
SMV Generation/Machine Hour	37.98
SMV Generation/SQF Hour	1.56
WIP	175
Throughput time-Minutes	130

6.4.15 Present Results to Lean Forum

Lean Forum was briefed on the achievements of the model line and a comparison between traditional line setup and model line was presented.

Table 6.11: Comparison- Traditional Line Vs. Model Line

Performance Measures	Unit of Measurement	Traditional Line	Model Line	Improvement Percent
Line Efficiency	Percentage	29.73%	49.03%	65%
Labor Productivity	SMV Generation/ Labor Hour	17.84	29.42	65%
MachineUtilization	SMV Generation/ MC Hour	30.79	37.98	23%
Space Utilization	SMV Generation/ SQF Hour	1.10	1.56	42%
Throughput Time	Minutes	500	130	-74%
WIP	Pieces	800	175	-78%

The comparison of performance parameters has been shown in histogram below:

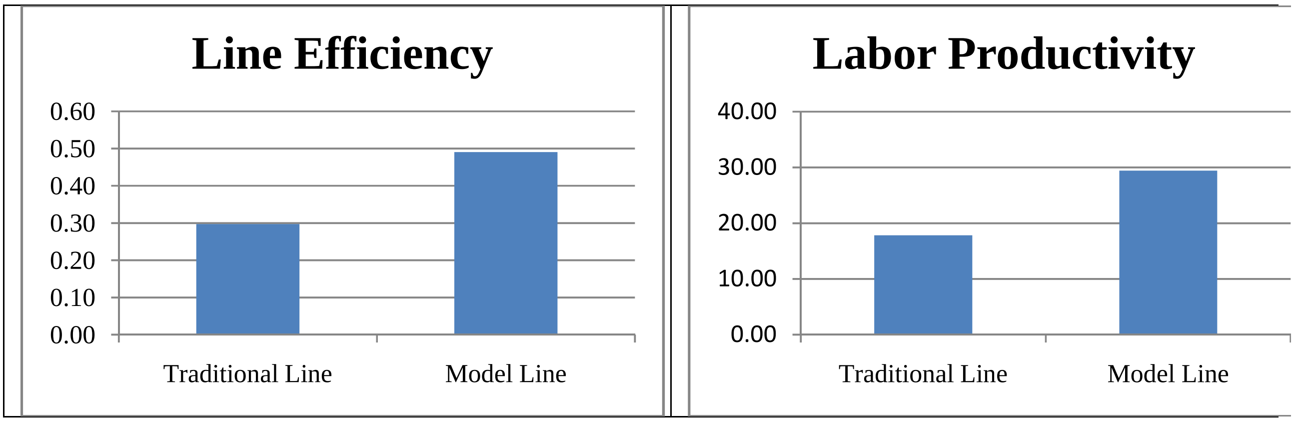

Figure 6.15: Comparison Graph- Traditional Line Vs. Model Line

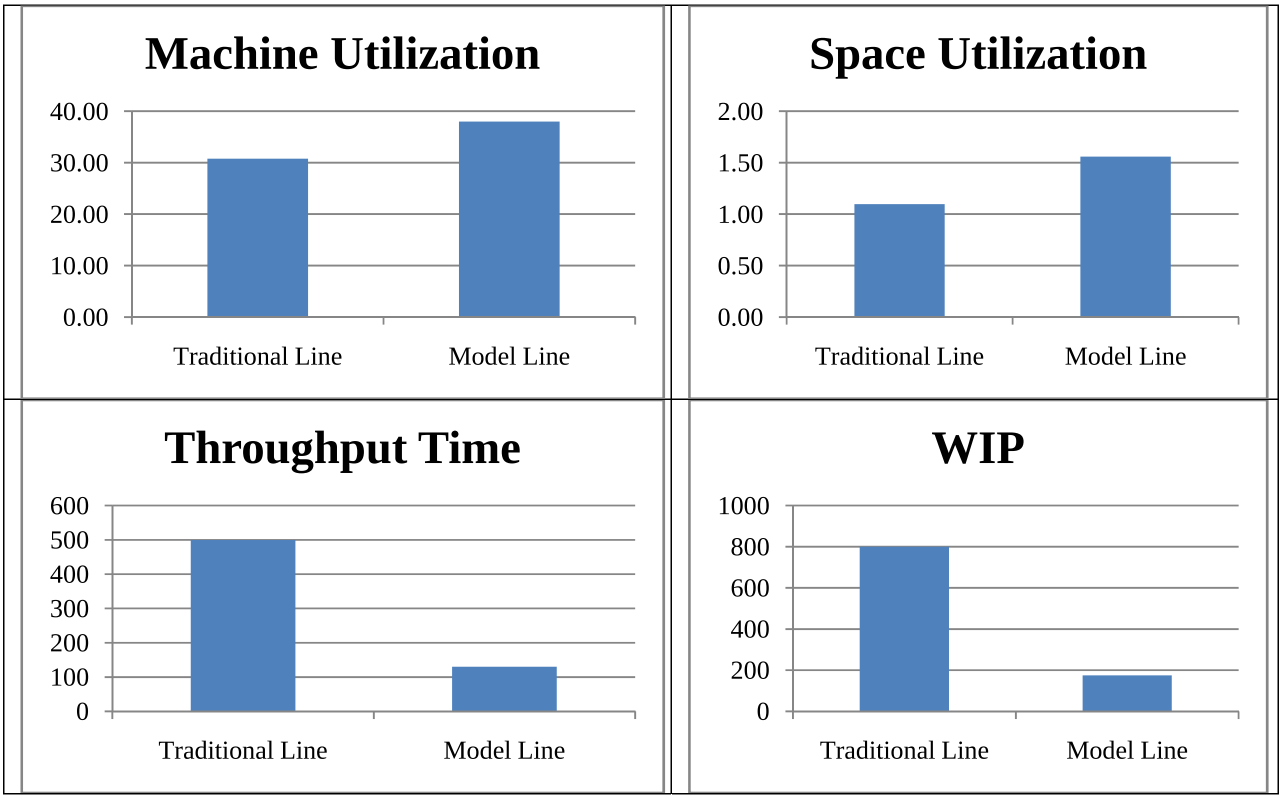

Figure 6.15: Comparison Graph- Traditional Line Vs. Model Line (Continued)

6.4.16 Recommendations for Further Improvement

- Deploy IE functions
- Develop efficient sewing practices
- Increase line efficiency
- Design team concept connecting physically finishing section up to poly packing and create continuous flow
- Design incentive system for sewing workers, quality personnel and supervisors
- Initially roll out team concept in a entire floor
- Then roll out in the entire factory

6.4. 17 Roll Out Plan

Lean forum appreciated the outcome of the pilot team and accepted all the recommendations and instructed the project champion to take necessary steps to fulfill all the recommendations including the incentive system and congratulated all personnel involved in the implementation of pilot team.

6.5 Event-4: Design & Installation of Incentive System

To work as team, it is immensely important to give the team a common objective to achieve and which will motivate workers, supervisors and line quality personnel to work as a team. After achieving the success in pilot team, it was necessary to design a good incentive system for the line personnel for sustainability of the concept and improve further. To develop an incentive system, a core team was selected with personnel from IE, Information system, HR, production, lean team.

6.5.1 Lean Forum Briefing

Lean forum was approached with the incentive system with basic idea that it will be based on efficiency by the team and quality defects rate of the team and it should be a group incentive system which means that incentive earnings will be calculated based on the achievement of the team as a whole not based on individual performance. Lean forum further suggested that the incentive system should be open ended which means that no boundary should be imposed of the amount of money the team can achieve and it should be variable with the achieved efficiency or minutes produced by the team and it should ensure the profitability of the organization as well as higher earnings for the team. When project champion approached the lean forum that financial data need to be analyzed to develop such a system where there will be a breakeven efficiency, then the lean forum advised that financial data are sensitive and core team should advise the breakeven efficiency and lean forum then will set the rate for each extra minutes achieved by the team. Lean forum also advised not to communicate with the incentive system before finalizing the details and prior approval of the system by the lean forum due to sensitivity on the issue.

6.5.2 Designing Incentive System with Core Team

Discussing all aspects, following guidelines were prepared for the proposed incentive system:

Objective: To motivate sewing workers to improve their performance as a team as well as improve their life standards through higher earnings.

6.5.2.1 Guidelines:

- Team based incentive system.
- SO & ASO will get incentive equally.
- Breakeven efficiency will be as follows:

Table 6.12: Breakeven Efficiency

Breakeven Efficiency	SMV
50%	< 10
45%	≥ 10

- For a style running more than 15 days in a line, breakeven efficiency will be as follows:

Table 6.13: Breakeven Efficiency for Style Running more than 15 Days

Breakeven Efficiency	**SMV**
55%	< 10
50%	≥ 10

- For a style running more than 30 days in a line, breakeven efficiency will be as follows:

Table 6.14: Breakeven Efficiency for Style Running more than 30 Days

Breakeven Efficiency	**SMV**
60%	< 10
55%	≥ 10

- Sewing starting time for a certain style will be counted from one and half hours after input acquisition from cutting section. Style closing time will be the starting time of the next style. In case of input shortage of next style, supervisor will inform IE & PO. IE & PO will decide the style end time.
- Incentive will be calculated after completion of sewing for the style or after fifteen days of sewing, whatever comes first.
- A sewing line will get incentive for achieving higher efficiency than breakeven efficiency.
- Efficiency, Breakeven efficiency, SMV generation will be calculated based on output from end table QC pass data and working hour from planning and man power data from HR department.
- SMV of the product will be provided by IE dept.
- Quality requirements: The alteration rate and rejection rate must be lower than or equal to 12% and 1% respectively to qualify for incentive.
- Non productive time (NPT) for fire drill & power shortage will be counted if any case it takes more than ten minutes.
- Breakeven efficiency, incentive rate and defect rate will be adjusted according to corporate objectives periodically.
- No partial hour will be allowed.
- The sewing worker will get earned incentive amount with their monthly salary.
- Supervisor will get twice the amount earned by each worker’s.
- Input man will get the same amount of each worker.

6.5.2.2 Incentive for Sewing Inline Quality Inspector (QI) & End Line Assistant Quality Controller (AQC)

- AQC will be eligible to get incentive if alteration rate found less than 10% at end line quality inspection.
- End line measurement QI & workmanship QI will be eligible to get incentive if defect rate found at finishing section be less than 4% at the measurement & workmanship inspection respectively.
- Each Sewing AQC & QI will get the same amount of each sewing worker of the respective line.

6.5.3 Lean Forum Approval

Lean forum was approached with the proposed guidelines of the incentive system. The lean forum appreciated the prepared guidelines and discussing with core team and the members of the lean forum, Lean forum approved that the sewing team will get TK. 0.30 collectively for 1 SMV for generating more SMV than SMV required for breakeven efficiency and approved the guidelines. The lean forum also suggested that the pilot team should be rewarded Tk. 300 per worker for their achievement prior to implementation of the incentive system for their previous performance.

6.5.4 Review Performance of the Model Line after Implementing Incentive System

After implementing incentive system, the model line was capable of enhancing their efficiency to 52.56% from 49.03% in non-incentive environment which shows 7.19% improvement based on the analysis of 29 days of production data. (See Appendix-6)

Lean Forum was presented with the achievements of the model line and a comparison between traditional line setup and model line after implementing incentive system for model line.

Table 6.15: Comparison- Traditional Line Vs. Model Line After Implementing Incentive System

Performance Measures	Unit of Measurement	Traditional Line	Model Line	Improvement Percent
Line Efficiency	Percentage	29.73%	53%	77%
Labor Productivity	SMV Generation/ Labor Hour	17.84	31.54	77%
MachineUtilization	SMV Generation/ MC Hour	30.79	41.74	36%
Space Utilization	SMV Generation/ SQF Hour	1.10	2.20	84%
Throughput Time	Minutes	500	120	-76%
WIP	Pieces	800	168	-86%

The comparison of performance parameters has been shown in histogram below:

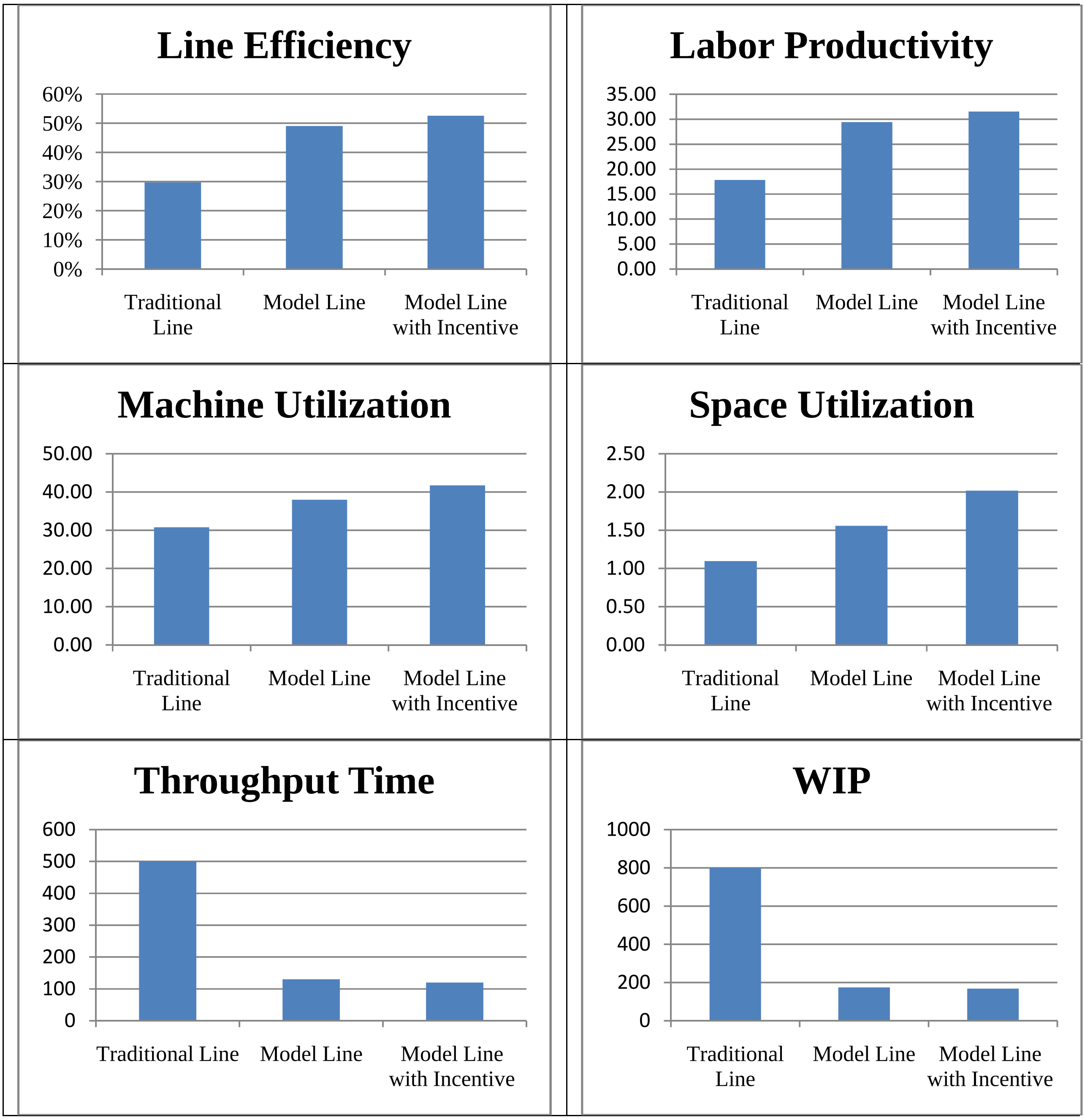

Figure 6.16: Comparison Graph- Traditional Line Vs. Model Line After Implementing Incentive System

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Though tools and techniques of lean manufacturing have been implemented successfully across the industry-manufacturing and services alike around the world, it should be implemented in a systematic way. It is utmost important to assess the current condition of the factory through VSM, identify opportunities for improvements, identify tools and techniques required for improvements and orderly implementing tools and techniques involving all employees in the organization.

In the assessment of current state, it was found in VSM that processing time is only 4% where retention time is 96%. Line efficiency was 29.73% and lack of line balancing was 37% and changeover time was 142 minutes per changeover which shows huge opportunities for improvement in those areas.

Before implementing tools and techniques, employees were trained on wastes and how certain tools can reduce those wastes to align the thinking. Through implementing 5S and team status board, involved employees were able to notice how little changes can make their work simple and improve visibility of off-standards and they were introduced to changing for better.

Through implementing team concept through downsizing the team and better balancing and eliminating unnecessary activities, team achieved 65% improvement in line efficiency, 23% improvement in machine utilization, 42% improvement in space utilization and 74% improvement in throughput time and 78 % reduction in WIP in model line which is encouraging. To sustain the changes and improve further as well as to share benefits of improvements with employees, state of the art incentive system was introduced for workers, supervisors and quality inspectors to encourage them to perform better and work as a team. After implementing incentive system, the line efficiency of the model line was further enhanced by 7.19% over the performance of model line in non-incentive environment and 77% improvement over traditional line. Throughput time reduction was 76%. Though outcomes of 5S and visual management are difficult to measure, these tools are foundations for lean implementation.

7.2 Recommendations

The study was done with a limited scope. The future works may include super market pull between cutting and sewing, standardizing changeover procedures, setting up team concept in cutting and TPM. The future works may also include Hoshin kanri or Balanced Score Card policy deployment procedures to align the objectives of employees with those of corporate objectives.

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APPENDICES

Appendix 1: Product Family Analysis

PRODUCT FAMILIY-ROUTING ANALYSIS													
Product Family	**Product**	**Client**	**Style**	**Total Orders**	**SMV**	**Total Minutes**	**Embroidery before sewing**	**Print before sewing**	**Sewing**	**Washing**	**others**	**Total order minutes**	**%**
ALPHA	T-Shirts	G-star	84804	1490	12	17880	Y	Y	Y	Y		**738674**	**11.60 %**
	T-Shirts	G-star	84804	640	12	7680	Y	Y	Y	Y			
	T-Shirts	G-star	84804	1322	12	15864	Y	Y	Y	Y			
	T-Shirts	G-star	84308	3846	12	46152	Y	Y	Y	Y			
	T-Shirts	G-star	84820	7366	12	88392	Y	Y	Y	Y			
	Tang Top	G-star	84150	4117	7	28819	Y	Y	Y	Y			
	Tang Top	G-star	84150	889	7	6223	Y	Y	Y	Y			
	Tang Top	G-star	84150	1766	7	12362	Y	Y	Y	Y			
	Tang Top	G-star	84150	1729	7	12103	Y	Y	Y	Y			
	Tang Top	G-star	84150	2266	7	15862	Y	Y	Y	Y			
	Tang Top	G-star	84150	1996	7	13972	Y	Y	Y	Y			
	Tang Top	G-star	84150	2558	7	17906	Y	Y	Y	Y			
	Tang Top	G-star	84150	1616	7	11312	Y	Y	Y	Y			
	Tang Top	G-star	94162	1444	13.15	18989	Y	Y	Y	Y			
	Tang Top	G-star	94162	171	13.15	2249	Y	Y	Y	Y			
	Tang Top	G-star	94162	477	13.15	6273	Y	Y	Y	Y			
	Tang Top	G-star	94162	193	13.15	2538	Y	Y	Y	Y			
	Tang Top	G-star	94162	689	13.15	9060	Y	Y	Y	Y			
	Tang Top	G-star	94162	1058	13.15	13913	Y	Y	Y	Y			
	Tang Top	G-star	94162	345	13.15	4537	Y	Y	Y	Y			
	Tang Top	G-star	94162	307	13.15	4037	Y	Y	Y	Y			
	Tang Top	G-star	94162	2230	13.15	29325	Y	Y	Y	Y			
	Tang Top	G-star	84802	2408	7	16856	Y	Y	Y	Y			
	Tang Top	G-star	84802	3761	7	26327	Y	Y	Y	Y			

	Product	Client	Style	Total Orders	SMV	Total Minutes	Embroidery before sewing	Print before sewing	Sewing	Washing	others		
	T-Shirts	G-star	94160	6873	13.959	95940	Y	Y	Y	Y			
	T-Shirts	G-star	94160	1001	13.959	13973	Y	Y	Y	Y			
	T-Shirts	G-star	84162	4304	11.183	48132	Y	Y	Y	Y			
	T-Shirts	G-star	84308	3846	12	46152	Y	Y	Y	Y			
	T-Shirts	G-star	84820	7366	12	88392							
	T-Shirts	G-star	84162	1561	11.183	17457	Y	Y	Y	Y			
BETA	T-Shirts	G-star	84916	528	12	6336	Y	Y	Y				
	T-Shirts	G-star	84916	1325	12	15900	Y	Y	Y				
	T-Shirts	G-star	84916	721	12	8652	Y	Y	Y				
	T-Shirts	G-star	84916	837	12	10044	Y	Y	Y				
	T-Shirts	G-star	84166	196	12.5	2450	Y	Y	Y				
	T-Shirts	G-star	84166	1656	12.5	20700	Y	Y	Y				
	T-Shirts	G-star	84166	580	12.5	7250	Y	Y	Y				
	T-Shirts	G-star	84166	201	12.5	2513	Y	Y	Y				
	T-Shirts	G-star	84166	212	12.5	2650	Y	Y	Y				
	T-Shirts	Espirit	RQ2260	2238	8	17904	Y	Y	Y				
	T-Shirts	SO 6669		1035	8.332	8624	Y	Y	Y				
	T-Shirts	SO 8644		2999	7.333	21992	Y	Y	Y				
	T-Shirts	SO 6669		12541	7	87787	Y	Y	Y				
	T-Shirts	SO 6669		12058	8.332	100467	Y	Y	Y				
	T-Shirts	SO 8644		3171	7.393	23443	Y	Y	Y				
	T-Shirts	PUMA		3720	12.5	46500	Y	Y	Y				
	T-Shirts	ESPRIT		800	12	9600	Y	Y	Y				
	Polo S	G-star		1044	15	15660	Y	Y	Y				
	Polo S	G-star		1179	15	17685	Y	Y	Y				
	Polo S	G-star		442	15	6630	Y	Y	Y				
	Tangtop	G-star		2998	9.916	29728	Y	Y	Y				
	Tangtop	G-star		2470	9.916	24493	Y	Y	Y				
	Tangtop	G-star		2271	9.916	22519	Y	Y	Y				
	T-Shirts	G-star		5537	12	66444	Y	Y	Y				
	T-Shirts	G-star		829	12	9948	Y	Y	Y				
	T-Shirts	G-star		292	12	3504	Y	Y	Y				

	Product	Client	Style	Total Orders	SMV	Total Minutes	Embroidery before sewing	Print before sewing	Sewing	Washing	others		
	T-Shirts	G-star		1048	12	12576	Y	Y	Y				
	T-Shirts	G-star		1202	12	14424	Y	Y	Y				
	T-Shirts	G-star		256	12	3072	Y	Y	Y				
	T-Shirts	G-star		705	12	8460	Y	Y	Y				
	T-Shirts	G-star		348	12	4176	Y	Y	Y				
	T-Shirts	G-star		2726	12	32712	Y	Y	Y				
	T-Shirts	G-star		2706	12	32472	Y	Y	Y				
	T-Shirts	G-star		2603	12	31236	Y	Y	Y				
	T-Shirts	G-star		240	12	2880	Y	Y	Y				
	T-Shirts	G-star		1316	12	15792	Y	Y	Y				
	T-Shirts	G-star		593	12	7116	Y	Y	Y			**1290543**	**20.27 %**
	T-Shirts	G-star		20000	12	240000	Y	Y	Y				
	T-Shirts	G-star		878	12	10536	Y	Y	Y				
	T-Shirts	G-star		1488	12	17856	Y	Y	Y				
	T-Shirts	G-star		3212	12	38544	Y	Y	Y				
	T-Shirts	G-star		307	12	3684	Y	Y	Y				
	T-Shirts	G-star		214	12	2568	Y	Y	Y				
	T-Shirts	G-star		931	12	11172	Y	Y	Y				
	T-Shirts	G-star		574	12	6888	Y	Y	Y				
	T-Shirts	G-star		552	12	6624	Y	Y	Y				
	T-Shirts	G-star		2018	12	24216	Y	Y	Y				
	T-Shirts	G-star		5641	7.206	40649	Y	Y	Y				
	T-Shirts	G-star		995	7.206	7170	Y	Y	Y				
	T-Shirts	G-star		1245	7.206	8971	Y	Y	Y				
	T-Shirts	G-star		1050	7.206	7566	Y	Y	Y				
	T-Shirts	G-star		670	7.206	4828	Y	Y	Y				
	T-Shirts	G-star		1062	7.206	7653	Y	Y	Y				
	T-Shirts	Espirit	RQ2260	2238	7	15666	Y	Y	Y				
	T-Shirts	Espirit		8225	7.206	59269	Y	Y	Y				
GAMA	T-Shirts	G-star	84912	1400	12	16800		Y	Y				

Product	Client	Style	Total orders	SMV	Total mins	Total mins	Embroydary before Sewing	Sewing	Washing	others		
T-Shirts	G-star	84912	2046	12	24552		Y	Y				
T-Shirts	G-star	84912	469	12	5628		Y	Y				
T-Shirts	G-star	84912	547	12	6564		Y	Y				
T-Shirts	G-star	84912	705	12	8460		Y	Y				
T-Shirts	G-star	84912	480	12	5760		Y	Y				
T-Shirts	G-star	84912	837	12	10044		Y	Y				
T-Shirts	G-star	84912	1116	12	13392		Y	Y				
T-Shirts	G-star	84922	1055	12	12660		Y	Y				
T-Shirts	G-star	84924	1421	12	17052		Y	Y				
T-Shirts	G-star	84924	233	12	2796		Y	Y				
T-Shirts	G-star	84924	207	12	2484		Y	Y				
T-Shirts	G-star	84924	2494	12	29928		Y	Y				
T-Shirts	G-star	84810	5162	12	61944		Y	Y			**2771880**	**43.45 %**
T-Shirts	G-star	84810	584	12	7008		Y	Y				
T-Shirts	G-star	84810	601	12	7212		Y	Y				
T-Shirts	G-star	84810	302	12	3624		Y	Y				
T-Shirts	G-star	84810	222	12	2664		Y	Y				
T-Shirts	G-star	84810	1444	12	17328		Y	Y				
T-Shirts	G-star	84810	7726	12	92712		Y	Y				
T-Shirts	G-star	84910	1766 4	12	211968		Y	Y				
T-Shirts	G-star	84908	5275	12	63300		Y	Y				
T-Shirts	G-star	84812	1063 1	12	127572		Y	Y				
T-Shirts	G-star	84906	3852	12	46224		Y	Y				
T-Shirts	G-star	84908	1506 8	12	180816		Y	Y				
T-Shirts	G-star	84920	3899	12	46788		Y	Y				
T-Shirts	G-star	84922	1810 1	12	217212		Y	Y				
T-Shirts	G-star	84362	7955	12	95460		Y	Y				
T-Shirts	G-star	84364	2936	12	35232		Y	Y				
T-Shirts	G-star	84926	3012	12	36144		Y	Y				
LLT	P 810109		2405	12.5	30063		Y	Y				
C. LST	P 810112		1585	12.5	19813		Y	Y				
LST	P 812574		7200	7.22 9	52049		Y	Y				
T-Shirts	P 504038		2370	12.5	29625		Y	Y				
LST	P 504040		1800	12.5	22500		Y	Y				
T-Shirts	P 504174		2841	12	34092		Y	Y				
SWET	P 504418		1050	18	18900		Y	Y				
S.JKT	P 504419		1190	18	21420		Y	Y				

	Product	Client	Style	Total Orders	SMV	Total Minutes	Embroidery before sewing	Print before sewing	Sewing	Washing	others		
	T-Shirts	ES R94620		800	6.927	5542		Y	Y				
	Tanktop	ES QX4622		223	3.995	891		Y	Y				
	T-Shirts	ES S90622		800	8.421	6737		Y	Y				
	T-Shirts	G-star	84910	17664	12	211968		Y	Y				
	T-Shirts	G-star	84908	5275	12	63300		Y	Y				
	T-Shirts	G-star	84812	10631	12	127572		Y	Y				
	T-Shirts	G-star	84906	3852	12	46224		Y	Y				
	T-Shirts	G-star	84908	15068	12	180816		Y	Y				
	T-Shirts	G-star	84920	3899	12	46788		Y	Y				
	T-Shirts	G-star	84922	18101	12	217212		Y	Y				
	T-Shirts	G-star	84362	7955	12	95460		Y	Y				
	T-Shirts	G-star	84364	2936	12	35232		Y	Y				
	T-Shirts	G-star	84926	3012	12	36144		Y	Y				
	Tanktop	ES SX4680		1329	7.238	9619		Y	Y				
	Tanktop	ES R21665		7688	5.183	39847		Y	Y				
	T-Shirts	G-star	94248	1339	12	16068		Y	Y	Y			
	T-Shirts	G-star	94248	265	12	3180		Y	Y	Y			
	T-Shirts	G-star	94248	602	12	7224		Y	Y	Y			
	T-Shirts	G-star	94248	1272	12	15264		Y	Y	Y			
	T-Shirts	G-star	84246	1046	12	12552		Y	Y	Y			
	T-Shirts	G-star	84246	330	12	3960		Y	Y	Y			
	T-Shirts	G-star	84246	235	12	2820		Y	Y	Y			
	T-Shirts	G-star	84246	686	12	8232		Y	Y	Y			
DELTA	T-Shirts	G-star	84246	1897	12	22764		Y	Y	Y			
	T-Shirts	G-star	94246	1788	12	21456		Y	Y	Y			
	T-Shirts	G-star	94246	299	12	3588		Y	Y	Y			
	T-Shirts	G-star	94246	330	12	3960		Y	Y	Y			
	T-Shirts	G-star	94246	918	12	11016		Y	Y	Y			
	T-Shirts	G-star	94802	3583	12	42996		Y	Y	Y			
	T-Shirts	G-star	94802	219	12	2628		Y	Y	Y			
	T-Shirts	G-star	94802	239	12	2868		Y	Y	Y			
	T-Shirts	G-star	94802	485	12	5820		Y	Y	Y			

	Product	Client	Style	Total Orders	SMV	Total Minutes	Embroidery before sewing	Print before sewing	Sewing	Washing	others		
	T-Shirts	G-star	84822	5389	12	64668		Y	Y	Y			
	T-Shirts	G-star	84822	702	12	8424		Y	Y	Y			
	T-Shirts	G-star	84152	4769	9.916	47289		Y	Y	Y			
	T-Shirts	G-star	84152	4343	9.916	43065		Y	Y	Y			
	T-Shirts	G-star	84152	849	9.916	8419		Y	Y	Y			
	T-Shirts	G-star	84152	286	9.916	2836		Y	Y	Y			
	T-Shirts	G-star	84152	742	9.916	7358		Y	Y	Y			
	T-Shirts	G-star	84152	652	9.916	6465		Y	Y	Y			
	T-Shirts	G-star	84152	957	9.916	9490		Y	Y	Y			
	T-Shirts	G-star	84236	5129	12	61548		Y	Y	Y		**781585**	**12.28 %**
	T-Shirts	G-star	84236	543	12	6516		Y	Y	Y			
	T-Shirts	G-star	84236	1296	12	15552		Y	Y	Y			
	T-Shirts	G-star	84236	326	12	3912		Y	Y	Y			
	T-Shirts	G-star	84236	3207	12	38484		Y	Y	Y			
	T-Shirts	G-star	84806	1795	12	21540		Y	Y	Y			
	T-Shirts	G-star	94362	2310	12	27720		Y	Y	Y			
	T-Shirts	G-star	94800	2524	12	30288		Y	Y	Y			
	T-Shirts	SO 4115		7000	12	84000		Y	Y	Y			
	T-Shirts	G-star	84806	1795	12	21540		Y	Y	Y			
	T-Shirts	G-star	94362	2310	12	27720		Y	Y	Y			
	T-Shirts	G-star	94800	2524	12	30288		Y	Y	Y			
	T-Shirts	SO 5002		2339	12	28068		Y	Y	Y			
	T-Shirts	G-star	94350	1536	12	18432	Y			Y			
	T-Shirts	G-star	94352	1167	12	14004	Y			Y			
	T-Shirts	G-star	94354	443	12	5316	Y			Y			
	T-Shirts	G-star	94356	1093	12	13116	Y			Y			
	T-Shirts	Espirit	90642	3600	12	43200							
	T-Shirts	Espirit	90643	2800	12	33600							
Others	T-Shirts	ES Q94684		1000	12	12000	Y						
	T.TOP	ES QX4622		1000	3.995	3995	Y						
	T-Shirts	ES RX4672		1404	12	16848	Y						
	Pant	ES Q90630		1000	15	15000	Y						
	T-Shirts	ES R94620		1000	12	12000	Y						
	L. PANT	P 805963		1896	18	34128	Y						

	Product	Client	Style	Total Orders	SMV	Total Minutes	Embroidery before sewing	Print before sewing	Sewing	Washing	others		
	T-Shirts	G-star		157	12	1884		Y					
	T-Shirts	G-star		5640	12	67680		Y					
	T-Shirts	G-star		3695	12	44340		Y					
	T-Shirts	G-star		653	12	7836		Y					
	T-Shirts	G-star		368	12	4416		Y					
	T-Shirts	G-star		301	12	3612		Y					
	T-Shirts	G-star		514	12	6168		Y					
	T-Shirts	G-star		193	12	2316		Y					
	T-Shirts	G-star		367	12	4404		Y					
	T-Shirts	G-star		3741	12	44892		Y					
	T-Shirts	G-star		2189	12	26268		Y				**783945**	**12.31 %**
	T-Shirts	G-star		484	12	5808		Y					
	T-Shirts	G-star		736	12	8832		Y					
	T-Shirts	G-star		978	12	11736		Y					
	T-Shirts	G-star		2008	12	24096		Y					
	T-Shirts	G-star		2372	10.642	25243	Y	Y					
	T-Shirts	G-star		2254	12	27048	Y	Y					
	T-Shirts	G-star		2377	12	28524	Y	Y					
	T-Shirts	G-star		2280	12	27360	Y	Y					
	T-Shirts	G-star		5693	12	68316	Y	Y					
	T-Shirts	G-star		398	12	4776	Y	Y					
	T-Shirts	G-star		157	12	1884	Y	Y					
	T-Shirts	G-star		1536	12	18432	Y			Y			
	T-Shirts	G-star		1167	12	14004	Y			Y			
	T-Shirts	G-star		443	12	5316	Y			Y			
	T-Shirts	G-star		1093	12	13116	Y			Y			
	T-Shirts	Espirit		3600	10	36000							
	T-Shirts	Espirit		2800	10	28000							

Appendix-2: VSM Data Log-Sheet

	VSM Data Log Sheet										
Order No:	810107		Route			Cutting, PrintingSewing & Finishing					
Buyer:	PUMA		Item			Basic T- Shirt					
Department	Activity	Time(minute)	Parallel Activity	Time (Parallels Activity)	Qty	Manpower	Equipment	Distance (Feet)	Cycle time	VA	NVA
Store	Fabric wait for cutting in store	3000			2292				-		3000
Cutting	Fabric loading to trolly	1.22			2292	2			0.00		1
Cutting	Fabric transport to cutting table	0.92			2292	2	Trolly	50	0.00		1
Cutting	Waiting for spreading	23.74			2292				-		24
Cutting	Transport fabric trolly to cutting table	1.17			2292	2			0.00		1
Cutting	Feeding 1st roll to spreding M/C	1.15			120	2			0.02		1
Cutting	Spreading 1st lay	3.53			2292	5	Spreading M/C		0.01		4
Cutting	2 nd lay	1.65			12	5			0.69		2
Cutting	Marker measuremen t	1.37			2292	2			0.00		1
Cutting	Fabric Spreading - 189 Plies	115.5 6			2268	5	Spreading M/C		0.25		116
Cutting	Waiting	15.6			2292				-		16
Cutting	Transport	0.76			2292	5	AIR Pressure		15	0.00		1

Department	Activity	Time(minute)	Parallel Activity	Time (Parallels Activity)	Qty	Manpower	Equipment	Distance (Feet)	Cycle time	VA	NVA
Cutting	Marker attaching on lay	4.95			2292	4	Manual		0.01		5
Cutting	Waiting	20.25			2292						20
Cutting	Cutting	46.8			2292	4	ST Knife		0.08	46.8	
Cutting	Waiting for sticker arrange	32.34			2292		Manual		-		32
Cutting	Stickering	107.18			2292	4	Manual		0.19		107
Cutting	Waiting	26.31			2292				-		26
Cutting	QC Checking & rejection Cutting	159.24	Lead time		2292	2	Manual		0.14		159
Cutting	Bundling	22.6			2292	2	Manual		0.02		23
Cutting	Store in bag	17.62	604		2292	2	Manual		0.02		18
Cutting	Waiting for Print	51.45			2292				-		51
Cutting	Transport to store	2.85			2292	2	Manual	200	0.00		3
Cutting	Waiting	800			2292				-		800
Cutting	Front Part sent for printing outside of the factory	1200			2292				-	1200	
Cutting	Waiting to go to sewing	2200			2292				-		2200
Sewing	Transport	10.2			2292		Manual/lift	400	-		10
Sewing	Waiting	60.25			2292				-		60
Sewing	Body Matching & folding	0.12			1	1	Manual		0.12		0
Sewing	Waiting	5.6			20				-		6
Sewing	F & B mark	0.17			1	1	Manual		0.17		0
Sewing	Waiting	18.87			20				-		19

Department	Activity	Time(minute)	Parallel Activity	Time (Parallels Activity)	Qty	Manpower	Equipment	Distance (Feet)	Cycle time	VA	NVA
Sewing	Transport	1.62			20		Manual		-		2
Sewing	Waiting	4.89			20				-		5
Sewing	Shoulder join	0.21			1	1	OL		0.21	0.21	
Sewing	Waiting	15			20				-		15
Sewing	Transport	0.52			20		Manual		-		1
Sewing	Waiting	5.05			20				-		5
Sewing	Care label join	0.18			1	1	PM		0.18	0.18	
Sewing	Waiting	3.53			20				-		4
Sewing	Transport	0.05			20		Manual		-		0
Sewing	Waiting	30.72			40				-		31
Sewing	Neck Join	0.87			1	1	OL		0.87	0.87	
Sewing	Waiting	24			60				-		24
Sewing	Cut mark	0.45			1	1	Manual		0.45		0
Sewing	Waiting	10.8			15				-		11
Sewing	Twill tape join	0.4			1	1	PM		0.40	0.4	
Sewing	Waiting	10.8			25				-		11
Sewing	Label making	0.4			1	1	PM		0.40	0.4	
Sewing	Waiting	18.15			40				-		18
Sewing	Main label join	0.33			1	1	PM		0.33	0.33	
Sewing	Waiting	7.56			25				-		8
Sewing	Scissoring	0.28			1	1	Scissors		0.28	0.28	
Sewing	Waiting	10			27				-		10
Sewing	Twill tape top seam	0.23			1	1	PM		0.23	0.23	
Sewing	Waiting	10.75			25				-		11
Sewing	Sleeve matching	0.32			1	1	Manual		0.32		0
Sewing	Waiting	6.02			100				-		6
Sewing	Transport	0.02			20		Manual		-		0
Sewing	Waiting	22.82			20				-		23
Sewing	Sleeve join	0.5			1	1	OL		0.50	0.5	
Sewing	Waiting	60			120				-		60

Department	Activity	Time(minute)	Parallel Activity	Time (Parallels Activity)	Qty	Manpower	Equipment	Distance (Feet)	Cycle time	VA	NVA
Sewing	Side seam	0.63			1	1	OL		0.63	0.63	
Sewing	Waiting	12.43			50				-		12
Sewing	Sleeve tack	0.25			1	1	PM		0.25	0.25	
Sewing	Waiting	20.12			15				-		20
Sewing	Folding	0.05			1	1	Manual		0.05		0
Sewing	Waiting	12.23			15				-		12
Sewing	Hem tack	0.23			1	1	PM		0.23	0.23	
Sewing	Waiting	4.86			17				-		5
Sewing	Folding gmts.	0.18			1	1	Manual		0.18		0
Sewing	Waiting	20.43			40				-		20
Sewing	Body hem	0.22			1	1	FL		0.22	0.22	
Sewing	Waiting	7.56			25				-		8
Sewing	Rew edge cut	0.28			1	1	Scissors		0.28		0
Sewing	Waiting	2.16			30				-		2
Sewing	Folding	0.08			20	1	Manual		0.00		0
Sewing	Waiting	8.91			25				-		9
Sewing	Blind hem	0.33			1	1	FL		0.33	0.33	
Sewing	Waiting	16.2			15				-		16
Sewing	Thread trimming	0.6			1	1	Manual		0.60	0.6	
Sewing	Waiting	6.75			25				-		7
Sewing	Security tack	0.25			1	1	PM		0.25	0.25	
Sewing	Waiting	1.08			15				-		1
Sewing	Thread trimming	0.04			1	1	Trimmer		0.04	0.04	
Sewing	Waiting	16.2			15				-		16
Sewing	Folding	0.6			1	1	Manual		0.60		1
Sewing	Waiting	27.81			25				-		28
Sewing	QC	1.03			1	1	Manual		1.03		1
Sewing	Waiting	9.45			10				-		9
Sewing	Measurement QC	0.35			1	1	Measrement Tape		0.35		0
Sewing	Waiting	43.71			80				-		44

Department	Activity	Time(minute)	Parallel Activity	Time (Parallels Activity)	Qty	Manpower	Equipment	Distance (Feet)	Cycle time	VA	NVA
Sewing	Transport to reporter	1.33			140		Manual	10	-		1
Sewing	Sorting-Size wise	6.55			140	1	Manual		0.05		7
Sewing	Waiting	123.33			140				-		123
Sewing	Transport to finishing	14.59			140		Manual	300	-		15
Finishing	Waiting	5.89			140				-		6
Finishing	Counting	3.71			140	1	Manual		0.03		4
Finishing	Waiting	9.16			140				-		9
Finishing	Transport to iron receiving table	1.64			140	1	Manual	10	0.01		2
Finishing	Received by target man	1.76			140	1	Manual		0.01		2
Finishing	Waiting	37.7			140				-		38
Finishing	Transport to Ironing	0.48			140	1	Manual	15	0.00		0
Finishing	Waiting	6.52			140				-		7
Finishing	Ironing	0.76			1	1	Pressing ta		0.76	0.76	
Finishing	Waiting	65.4			140				-		65
Finishing	Transport to QC table	0.62			45	1	Manual	5	0.01		1
Finishing	Waiting	15.56			45				-		16
Finishing	1st QC-Measurement Check	0.45			1	1	Measurement Tape		0.45		0
Finishing	Waiting	15.25			30				-		15
Finishing	2nd QC-Getup check	0.55			1	1	Manual		0.55		1
Finishing	Waiting	22.41			100				-		22
Finishing	Putting in another table	0.2			100	1	Manual		0.00		0
Finishing	Waiting	38.95			50				-		39
Finishing	Hang tag attach	1.97			7	1	Tag Gun		0.28	1.97	
Finishing	Hang tag ch.	1.53			7	1	Manual		0.22		2
Finishing	Waiting	5.51			110				-		6

Department	Activity	Time(minute)	Parallel Activity	Time (Parallels Activity)	Qty	Manpower	Equipment	Distance (Feet)	Cycle time	VA	NVA
Finishing	Transportation to folding	0.7			110	1	Manual	10	0.01		1
Finishing	Folding	0.93			1	1	Manual		0.93	0.93	
Finishing	Waiting	0.31			5				-		0
Finishing	Poly packing	0.61			1	1	Manual		0.61	0.61	
Finishing	Waiting	1.82			50				-		2
Finishing	Transportation to arranging table	0.39			50	1	Manual	10	0.01		0
Finishing	Arranging gmts.	0.71			50	1	Manual		0.01		1
Finishing	Waiting	1.09			50				-		1
Finishing	Barcode	0.15			1	1	Manual		0.15	0.15	
Finishing	Waiting	12.25			50				-		12
Finishing	Transport to size area	0.55			50		Manual	10	-		1
Finishing	Size check	0.15			1	1	Manual		0.15		0
Finishing	Waiting	420			320				-		420
Finishing	Transportation to cartooning	2.1			100	1	Manual	25	0.02		2
Carton	Needle detector	0.11			1	1	Needle Detector		0.11	0.11	
Carton	Waiting	60.32			80				-		60
Carton	Cartooning	13.27			20	1	Manual		0.66	13.27	
Shipping store	Waiting for shipping	4800									4800
Total		14112.2							16.0	1271	12842

Appendix-3: Information Flow

Information Flow

No.	Type of Information	From	To	Methods		Reasons
				Manual	Electronic	
1	Production Plan	Planning	Sewing, Cutting,Store,Finishing,Q.C,Planning	√		For planning purpose
2	Buyer wise Monthly Plan	Planning	Merchandizer		√	For planning purpose
3	Order Status Report	Planning	Cutting, Sewing, Finishing	√		For planning purpose
4	Order Status Report Summary	Planning	Merchandizer		√	For planning purpose
5	Fast React Plan	Planning	Planning		√	For planning purpose
6	MO Sheet	Planning	Sewing, Cutting, Finishing	√		For planning purpose
7	P.P Meeting Plan	Planning	Sample,Sewing,Store,Planning,Febric Planning	√		For planning purpose
8	Placement Printing Plan	Planning	Printing		√	For planning purpose
9	Febric Requisition	Planning	Febric Planning	√		For planning purpose
10	P.P Meeting sheet	Planning	Sewing, Quality, cutting, Technician	√		For planning purpose
11	Operation breakdown Sheet	I.E	sample	√		For determining Productivity
12	Technical Sheet	I.E	sample	√		for measurement control
13	layout Sheet	I.E	Sewing	√		for line layout
14	Thread consumption Sheet	I.E	Planning	√		For thread requisition
15	Line Feeding report	I.E	Sewing	√		For providing input condition

No.	Type of Information	From	To	Methods		Reasons
				Manual	Electronic	
16	Process flowchart	I.E	Planning		√	For understanding process sequence
17	KPI report	I.E	Sewing, Planning		√	For factory Evalution
18	Production Plan	Production	Production Officer	√		For Achieving target
19	Input target Sheet	Production	Cutting	√		for daily input
20	MO Sheet	Production	Production Officer	√		For Achieving target
21	Sample Requisition Form	Sample	R & D	√		for sample activities
22	P.P Meeting	Sample	Sewing, Cutting, finishing, Quality,Technician	√		for sample activities
23	Accesories Inventory Report	Store	Merchandizer		√	For updating Accsories condition
24	Label Approved Report	Store	Quality	√		For delivery label to sewing
25	Q.C Accessoer inspection Report	Store	Merchandizer		√	For updating Accsories condition
26	Packing list	Finishing	Buyer Q.C	√		For updating packing qty
27	Production CAD Marker	CAD	Cutting	√		For lay cutting
28	Fabric Consumption	CAD	Planning		√	For consumption febric
29	Costing consumption	CAD	Merchandizer		√	For costing purpose
30	Machine breakdown sheet	Maintenance	I.E	√		for loss time calculation
31	Daily reject report	Quality	Production	√		For rejection control
32	Measurement report	Quality	Production	√		for measurement control
33	Daily End table check report	Quality	Production	√		for quality control

No.	Type of Information	From	To	Methods		Reasons
				Manual	Electronic	
34	Daily inline Correction report	Quality	Production	√		for quality control
35	AQL measurement report	Quality	Production	√		for quality control
36	AQL report	Quality	Production	√		for quality control

Apendix-4: Reject & Rework Analysis in Sewing

Quality Status -Sewing			
Date of Observation-18-03-09	Line No.		
Defect Particulars	14	15	Total
Uncut/ loose thread	27	17	44
Broken stitch	2	3	5
Skip stitch	0	0	0
Puckering	0	0	0
SV join open	7	5	12
Neck rip uneven	12	0	12
Neddle Mark	7	0	7
Oil spot	48	78	126
Dirty spot	6	11	17
Needle damage	13	0	13
Fabric fault	0	0	0
Side seam uneven	0	0	0
Tuck/label missing	4	0	4
Total reject	3	3	6
Total alteration qty.	140	114	254
Total inspection qty.	775	1122	1897
Alteration percent	18%	10%	13.4%
Rejection percent	0.4%	0.3%	0.32%
Right First Time (RFT)	82%	90%	86%

Appendix-5: Rework & Reject Analysis in Finishing

Quality Status -Finishing	
Date of Observation-14-19th March-2009	
Defect Particulars	Quantity
Cut stitch	1135
Drop/ skip stitch	408
Needle damage	241
Puckering	558
Measurement	3599
Uneven	699
Dirty spot	7026
Oil spot	8956
Total rejection qty.	1236
Total alteration	22622
Total inspection quantity	205655
Alteration percent	11%
Rejection percent	0.60%
Right First Time (RFT)	88.40%

Appendix-6: Status of Model Line-After Incentive System Implementation

Status of Model Line-After Incentive System Implementation												
Date	**Buyer**	**Style**	**SMV**	**Production**	**Working Hour**	**Sewing Operator**	**Assistant Sewing Op.**	**Produced Minutes**	**Input Labor Minutes**	**Efficiency**	**Input MC Minutes**	**Input SQF Minutes**
22-Dec-09	M&S	0100W/SWIM017	9.99	1040	11	18	5	10386	15180	68.42%	11880	211200
23-Dec-09	M&S	0100W/SWIM017	9.99	1043	7	10	5	10416	6300	165.34%	4200	134400
23-Dec-09	PUMA	812274	8.68	400	4	10	5	3473	3600	96.48%	2400	76800
24-Dec-09	M&S	0100W/SWIM017	9.99	1184	11	13	5	11825	11880	99.53%	8580	211200
25-Dec-09	M&S	0100W/SWIM017	9.99	886	8	17	5	8848	10560	83.79%	8160	153600
26-Dec-09	M&S	0100W/SWIM017	9.99	1111	6	16	5	11096	7560	146.77%	5760	115200
27-Dec-09	G-Star	94850	8.86	579	11	17	5	5130	14520	35.33%	11220	211200
28-Dec-09	G-Star	94850	8.86	705	11	17	5	6246	14520	43.02%	11220	211200
29-Dec-09	G-Star	94850	8.86	841	11	15	5	7451	13200	56.45%	9900	211200
30-Dec-09	G-Star	94850	8.86	605	11	15	5	5360	13200	40.61%	9900	211200
31-Dec-09	G-Star	94850	8.86	895	11	16	5	7930	13860	57.21%	10560	211200
02-Jan-10	G-Star	94850	8.86	1226	11	16	5	10862	13860	78.37%	10560	211200
04-Jan-10	PUMA	812274	8.68	200	11	15	5	1737	13200	13.16%	9900	211200
05-Jan-10	M&S	0169W/LHU3252	6.8	216	11	15	5	1469	13200	11.13%	9900	211200
06-Jan-10	M&S	0169W/LHU3252	6.8	787	11	15	5	5351	13200	40.54%	9900	211200
07-Jan-10	M&S	0169W/LHU3252	6.8	990	11	15	5	6731	13200	50.99%	9900	211200
08-Jan-10	M&S	0169W/LHU3252	6.8	581	8	15	5	3950	9600	41.15%	7200	153600
09-Jan-10	M&S	0169W/LHU3252	6.8	920	11	16	5	6255	13860	45.13%	10560	211200
10-Jan-10	M&S	0169W/LHU3252	6.8	985	13	15	5	6697	15600	42.93%	11700	249600
11-Jan-10	M&S	0169W/LHU3252	6.8	1170	13	15	5	7955	15600	50.99%	11700	249600
12-Jan-10	M&S	0169W/LHU3252	6.8	1197	13	16	5	8138	16380	49.69%	12480	249600
13-Jan-10	M&S	0169W/LHU3252	6.8	1213	13	16	5	8247	16380	50.35%	12480	249600
14-Jan-10	M&S	0169W/LHU3252	6.8	1071	13	16	5	7282	16380	44.46%	12480	249600
16-Jan-10	M&S	0169W/LHU3252	6.8	1449	13	16	5	9852	16380	60.15%	12480	249600
17-Jan-10	M&S	0169W/LHU3252	6.8	1081	13	16	5	7350	16380	44.87%	12480	249600
18-Jan-10	M&S	0169W/LHU3252	6.8	1186	13	16	5	8064	16380	49.23%	12480	249600
19-Jan-10	M&S	0169W/LHU3252	6.8	1170	13	16	5	7955	16380	48.56%	12480	249600
20-Jan-10	M&S	0169W/LHU3252	6.8	1068	13	16	5	7261	16380	44.33%	12480	249600
21-Jan-10	PUMA	812274	8.68	288	13	14	5	2501	14820	16.87%	10920	249600
Total				26087				205818	391560	52.56%	295860	6124800

Appendix-7: 5S Audit Sheet

5S AUDIT SHEET

Line no.:-	**Audit date :-**	**Points**	**Excellent =5**	**Very good =4**	**Good = 3**
Supervisor name:-	**Auditted by:-**		**Average = 2**	**Not good = 0 to 1**	

S.No.	**Points to Consider**	**Area**	**Off Standard Freq.**	**Secured Points**	**Remark**	**CAP**
1	Unnessary M/c , table or any other objects	Sewing line & input, output area				
2	Unnessary thread, label, pattern & other trims from previous styles & garments.					
3	Unnecessary shipped style documents like measurement sheet, OB ,Trim card etc.					
4	All the Acc. & cut pcs are not mixed & are in right places & those places are labelled.	Sewing line & input, output area				
5	All required documents like measurement sheet, trim card ,index sheet etc are in file & set according to uses.					
6	Input area ,output area, check points, line no are labeled & in proper way maintaing the principles of X & Y axis					
7	M/c, table , side stand ,basket and all other equipment & half stitched garments in line are also maintaing the principles of X & Y axis.					
8	M/c & table are clean,painted & working condition	Sewing line & input, output area				
9	Floor space is clean & isles are painted & free of any obstacles.					
10	Maintain status board with updated information & CAP of Previous Audit Followed					
			Total points			
			Avg. points			

Appendix-8: Safety Cross

Team Name:	SAFETY CROSS	Team No:	Month:

"Safety & Quality First"

			1	2			
			3	4			
			5	6			
			7	8			
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
			25	26			
		-	27	28			
		-	29	30			
			31				

Green = Safe Day

Yellow = First Aid Required

Red = Recordable Injury

SAFETY KAIZEN NEWSPAPER

DATE	PROBLEM	ACTION	WHO	WHEN	STATUS

Appendix- 9: Rework & Reject

TEAM NAME:	DAILY REJECT & ALTER GRAPH	TEAM NO:	MONTH:

% of reject & alter																																
	10																															
	9																															
	8																															
	7																															
	6																															
	5																															
	4																															
	3																															
	2																															
	1																															
	0																															
DATE		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Reject=Red Line Alter= Blue Line

Appendix- 10: Efficiency Graph Format

TEAM NAME:	DAILY EFFICIENCY GRAPH	TEAM NO:	MONTH:

$$\text{EFFICIENCY} = \frac{(\text{Production X SMV})}{(\text{Operator X Working hour X 60})} \text{X100\%}$$

EFFICIENCY %	
	100
	90
	80
	70
	60
	50
	40
	30
	20
	10
	0

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Production																															
No of Operator																															
SMV																															
Working Hour																															