Faculty of Science & Engineering

Department of Textile Engineering

B.Sc. in Textile Engineering

Course Name: Project Work Sessional (Code: Tex: 441)

Project Title

APPLICABILITY OF LEAN TOWARDS IMPROVED EFFICIENCY IN SAMPLE PROCESSES

Supervisor:

Md. Juel Sarker

Lecturer

Department of Textile Engineering

Submitted By

Name	ID	Group (AM)
Md. Mehedy Hasan	TEX-1703012010	C
Md. Abdullah Al Momin	TEX-1703012014	C
Md. Saikat Raihan	TEX-1703012075	C
Md. Fazlay Rabby	TEX-1703012046	C
Mst. Topy Khatun	TEX-1703012100	C

DEPARTMENT OF TEXTILE ENGINEERING

SONARGAON UNIVERSITY, DHAKA

Supervisor Certificate

At first, we want to dedicate this Project on **"Applicability of Lean towards Improved Efficiency in Sample Processes"** to the Almighty Allah. Then we have also dedicated it to our parents, who give us lot of support all time. We have also dedicated this report to our honorable supervisor **Md. Juel Sarker**, Lecturer, Department of Textile Engineering, Sonargaon University who helped us a lot to complete this project properly & perfectly.

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Md. Juel Sarker

Lecturer

Department of Textile Engineering

Sonargaon University

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ACKNOWLEDGEMENT

The authors are deeply indebted to their supervisor **Md. Juel Sarker**, Lecturer, Department of Textile Engineering, Sonargaon University (SU) for his continuous guidance, help, criticism, suggestions and encouragement throughout the progress of the project work.

The authors express their profound gratitude to **Md. Kamrul Hasan,** Lecturer & Course Coordinator, Department of Textile Engineering, Sonargaon University (SU) for providing all the facilities and equipment which enabled them to carry out the thesis work.

Finally, the authors are deeply indebted to their parents, siblings and friends for providing mental strength to continue the research work smoothly.

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Md. Mehedy Hasan
TEX-1703012010

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Md. Abdullah Al Momin
TEX-1703012014

....
Md. Saikat Raihan
TEX-1703012075

....
Md. Fazlay Rabby
TEX-1703012046

....
Mst. Topy Khatun
TEX-1703012100

ABSTRACT

It is proven that by the application of Lean techniques in manufacturing, business can be profited by improvement in the level of productivity and cutting down the processes that is responsible for wastages. In Bangladesh, Apparel industries face a lot of challenges and the most difficult of them is to meet the shipment date. To ensure the products have been manufactured and assembled in due time, manufacturers emphasize on choosing the best method of production process. With the help of Kaizen and 5's, it is possible to identify non value added processes and eliminate them from the production process. In this paper, we have taken the production data of a knitted jacket and considered the SMV data in two phases, one with the traditional line and the other one is with the implementation of Lean technique to see the differences of SMV data in different stages of production. 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.

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:

a. Improving line efficiency of an assembly line
b. 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:

- Collecting information from the company's ERP system and data from the shop floor
- Developing a current state map using the collected information
- Analyzing the current state map to identify potential areas for improvement
- Developing a future state map identifying potential improvement opportunities to improve
- line efficiency through line balancing, team based approach, process razing and designing incentive system and 5S and visual management etc.
- improving throughput time through reducing waiting time, excess processing, bundle size reduction and process razing etc.
- Conduct Kaizen events based on future state map
- Analyzing improvement as a result of kaizen event

CHAPTER TWO LITERATURE REVIEW

2.3 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. 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].

2.3 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^{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.

2.4 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 19^{th} 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.

2.5 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. 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.

7. 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.
8. 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.

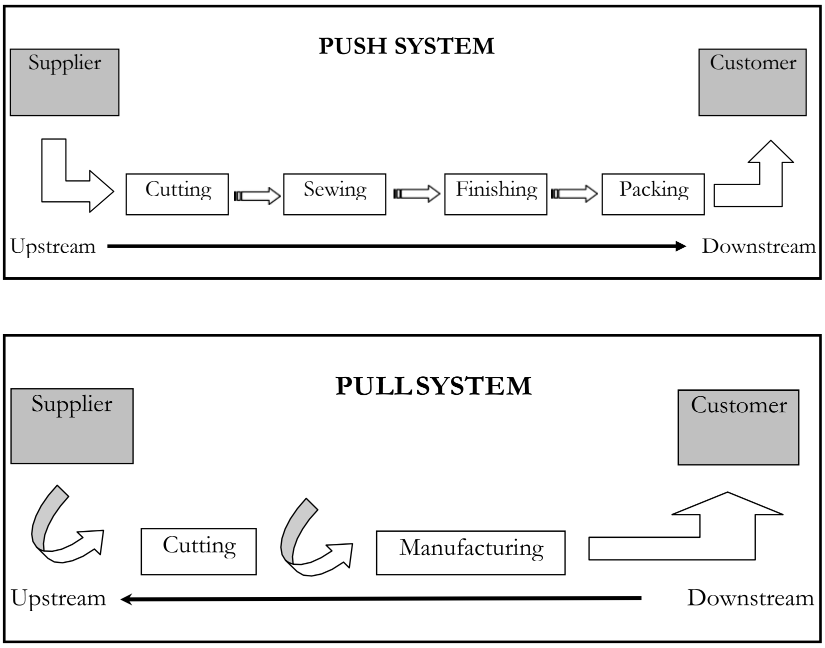


Fig. 1.1 Materials Flow in Push and Pull Systems

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].

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.

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].

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].

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].

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 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

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].

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:

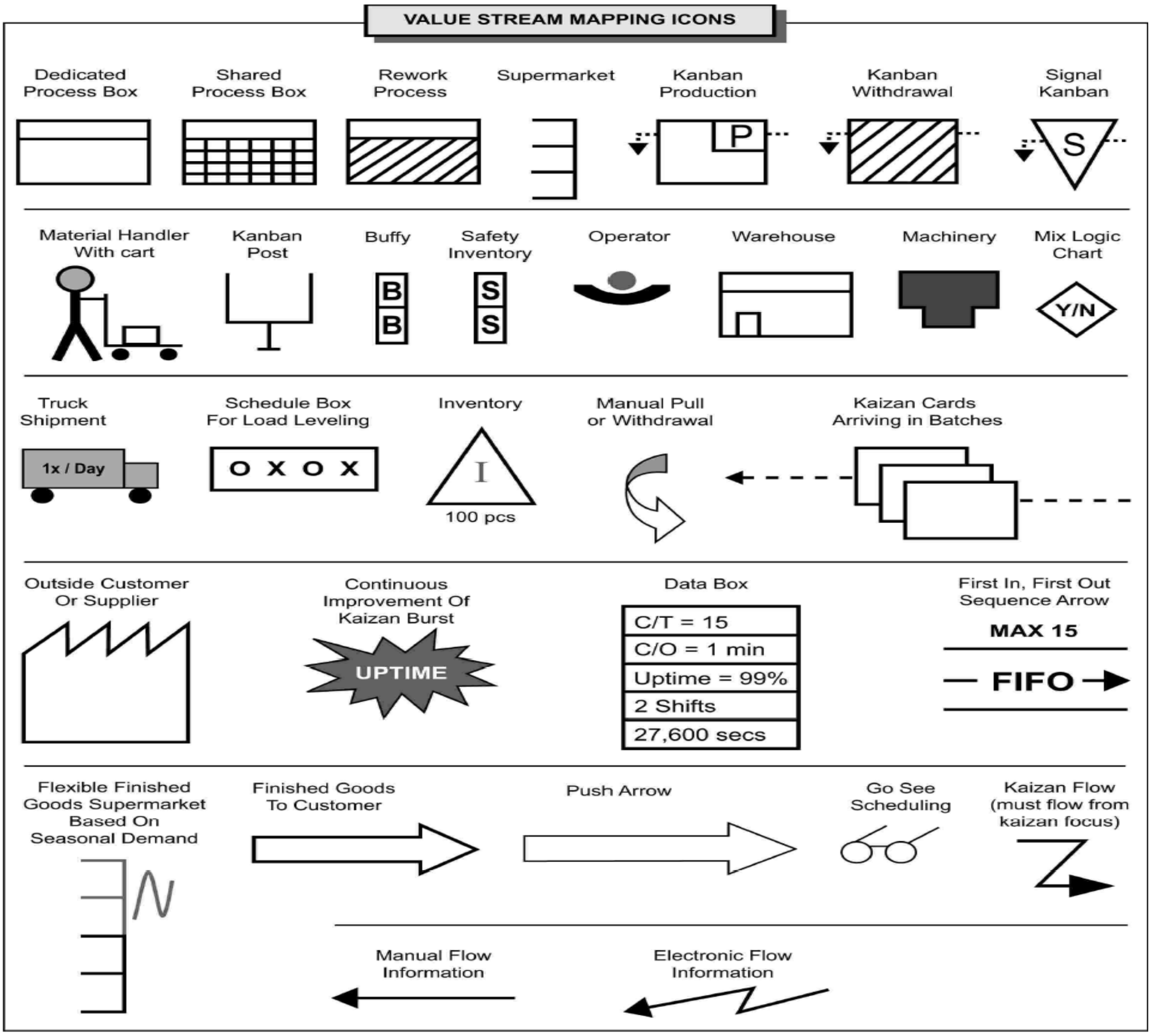


Figure 3.1 : Value Stream Icons

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.

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

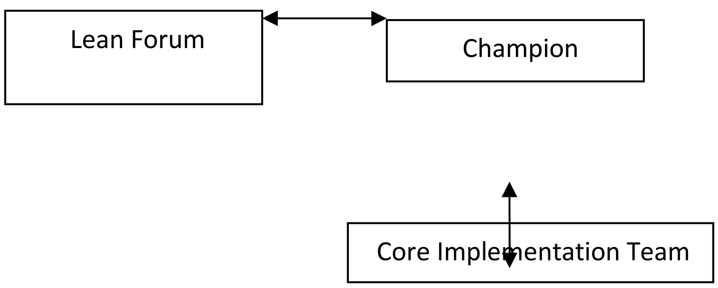


Figure 4.1: Communication & Decision channel in PMT

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.

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.

4.4 Manufacturing Stages of the Factory

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

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.

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.

CHAPTER SIX
ADVANTAGES OF LEAN TECHNIQUES APPLICATION IN APPAREL INDUSTRY

6.1 Introduction

Apparel industries from all over the world faced a great deal of negative impact due to the economic recession back in 2008. And because of this the low cost garments had been urged by most consumer bases from all over the world. Then renowned apparel brands have been forced to cut down the prices to keep their products in the market. They have been shifted their vendors to low cost worker base countries like Bangladesh to keep the competition worldwide. To meet the global challenge, it is really vital to keep the production process in such a way that will not incorporate any types of waste and non-value added process when apparel production process is carried out with lean approach. The terminology is not that much unfamiliar to the manufacturers but they lack in consciousness about the strategic advantages that can be found while lean technique is used in apparel production which is the purpose of our study as well.

6.2 Objectives of the Study

a. To find out the strategic advantages of lean technique in apparel industry.

b. To compare production data in terms of SMV target fulfillment, line efficiency, bottlenecks, capacity utilization in both cases- traditional production line and lean production line.

c. To compare the productivity factors like transportation, inventory analysis, space utilization, defects analysis in both traditional line and lean line.

6.3 Methodology

For comparing productivity, we collected data from sewing floor of Adury Apparels Ltd, a sister concern of Thermax Group. We considered two lines (traditional & lean line) & differentiate between them. To calculate standard time for each operation, time study is conducted in the shop floor. To do this, a knit jacket is selected as a base line because operations differ from style to style and it is difficult to correlate all these operations of individual styles. After that, at least two operators were selected for each operation so that the difference in timing can be cross checked from the observed data of these two operators. To get better results, each operation time is taken for at least 5 cycles. Once time study is made by collecting raw data the performance rating is given to each operator and actual time is calculated for particular operation. Finally the Personal Fatigue and Delay (PFD) component as an allowance is added on the calculated time and the operation time is standardized. For calculation we have used the following formulas:

i. SMV =Basic time + Bundle Handling time +Allowance.

ii. Basic time = Cycle time × Rating.

iii. Cycle time = Pick up time + Stitching time + Dispose time.

iv. Efficiency% of line= (Total production × smv × 100)/ (No of operator × working Hour × 60).

v. Basic pace time (B.P.T) =Total time / total manpower

6.4 Research activities

- Become acquainted about Lean Technique
- Vigorous study on Lean manufacturing tools
- Select a factory for application
- Observe Lean application on a particular floor
- Select a particular style to develop case study
- Analysis Lean and Traditional line
- Collect the necessary data (Figure 1) (Figure 2).

Figure 6.1 Lean line at adury apparel.

Figure 6. 2 Knit jacket.

6.5 Results and discussions

We use time study to balance these sewing lines which is a part of work study. It implements the use of SMV calculation to identify the points where production has gone below the standard level and the places where the production is above the standard. Then it is balanced to remove bottle neck in order to increase productivity. This system was effective and helpful. Considerable improvement observed by using time study as a line balancing technique changing form traditional layout to balanced layout model. The exchanges of work between the operator & helper caused a significant change in line results of reducing wastage of time, minimum no. of worker and which caused high productivity in the manufacturing process. This balancing process also leads to increased output per day, labor productivity, machine productivity and overall line efficiency.

Lean line operation breakdown (Table 1)

Productivity: output/input x100% =78/100 x100% =78%

SMV: 896.44/60=14.94

Standard SMV: 12.77

SMV increased: (14.94-12.77)/14.94x100 =16.99 %

Efficiency% of line: (Total production SMV x 100)/ (No of Operator x working hourx60) = (78x14.94x100)/ (35x1x60) = 55.49%

SMV target fulfillment: (100-78)/100x100%=100%-22%=78%

Basic pace time (B.P.T): Total time/total manpower =896.44/35 =25.61sec

Capacity/hr: 3600/B.P.T =3600pcs /25.61 =140

Traditional operation breakdown of knitted jacket (Table 2)

Productivity: output/input x100 = 64/100 x100 = 64%

SMV: 1013.88/60 = 16.89

Standard SMV: 15.43

SMV increased: (16.89-15.43)/15.43x100 =9.46 %

Efficiency% of line: (Total productionxsmvx100)/(No of operator x working Hourx60)= (64x16.89x100)/ (42x1x60) =42.89%

SMV target fulfillment: (100-64)/100x100% =100%-36%=64%

Basic pace time (B.P.T) =Total time/total man power = 1013.88/42 = 24.14sec.
Capacity/hr=3600/24.14 =149pcs.

Transportation Analysis (Table 3) (Figure 3)

Table 3 Transportation analysis

KPI	Unit of measure	Traditional line	Avg.	Lean line	Avg.	Improvement
		351		145		
		350		143		
Transportation	Feet	348	345	144	143	58.55%
		350		143		
		349		142		

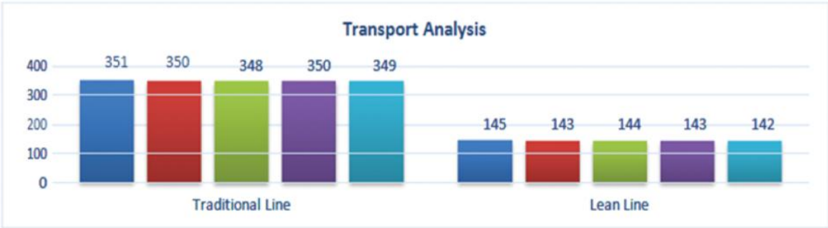


Figure 3 Transport analysis traditional vs lean line.

WIP Analysis (Table 4) (Figure 4)

Table 4 WIP analysis

KPI	Unit of measure	Traditional Line	Avg.	Lean Line	Avg.	Improvement
		815		400		
		810		398		
Inventory/WIP	Quantity	812	813	402	400	50.79%
		816		396		
		810		402		

Figure 4 WIP analysis traditional vs lean line.

Space utilization analysis (Table 5) (Figure 5)

Table 5 Space utilization analysis

KPI Space	Unit of measure	Traditional line	Avg.	Lean line	Avg.	Improvement
		5.77		4.62		
		5.6		4.5		
Utilization	Minute	4.96	5.55	4.45	4.52	18.55%
		5.1		4.62		
		5.55		4.6		

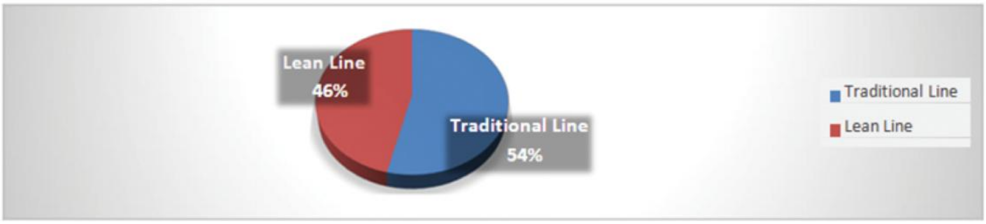
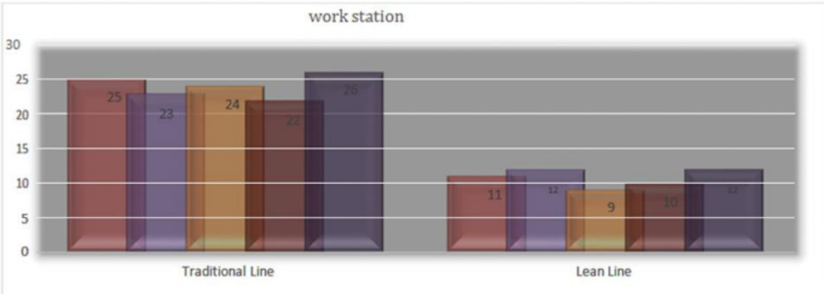


Figure 5 Space utilization traditional vs lean line.

Workstation analysis (Table 6) (Figure 6)

Table 6 Workstation analysis

KPI	Unit of measure	Traditional line	Avg.	Lean line	Avg.	Improvement
		25		11		
		23		12		
Work station	Quantity	24	24	9	11	54.16%
		22		10		
		26		12		



6.6 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)

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.

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.

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 6.3: Before picture *(5S)*

Figure 6.4: Pictures of ‘Sorting’ phase


Figure 6.5: After Pictures *(5S)*

6.7 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.

6.8 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 6.6: Rewarding workers for 5S excellence

6.9 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.

6.10 Findings

Though the lean technique is new for most of the apparel industry in Bangladesh but if a industry implement this technique it helps them to increase their overall productivity. Key findings are:

a. Best utilization of man, machine, materials

b. Increasing productivity

c. Reduce lead time

d. Reduce wastes

e. Ensure just in time shipment

CHAPTER SEVEN
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusion

We have completed our project work successfully by the grace of Almighty Allah. Project send us to the expected destiny of practical life. 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. For a jacket, using traditional system our input was 100pcs/hr and output was 64pcs/hr with a productivity of 64%. But when we applied lean system then our input was same but the system was so efficient that we got an increase output of 78pcs/hr. This is a clear indication for increasing productivity. Lack of knowledge, specifically in production systems and resources management of the operations manager of Garments, resulted to the low productivity and efficiency of manpower. The lean manufacturing system is a continuous improvement method; thereby, its implementation helps the company minimize waste, enhance quality of products and definitely create its sustainability. Lean manufacturing tools contribute to the productivity of both workers and the company. The Time Study monitoring system, an output of the study, is an effective and efficient tool to enhance productivity in the entire sewing section, whose benefits extend to the whole organization.

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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