

Application Of Lean Manufacturing Tools In Garments Production

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of Bachelor of Science in Textile Engineering

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DECLARATION

I hereby declare that, this project has been done by me under the supervision of **Engr. Md.Mahfuzur Rahman, Senior Lecturer, Department of Textile Engineering**, Daffodil International University. I also declare that neither this project nor any part of this project have been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

This project is on “Application of Lean Manufacturing Tools in Garments Production”.

The goal of this project is to investigate how the tools of lean manufacturing can be adapted from the discrete to the continuous manufacturing environment and to evaluate their benefits at garments Industry. The project hypothesizes that there are big opportunities for improvement in the garments industries if lean tools are utilized. Although the process and discrete industry share several common characteristics, there are also areas where they are very different. Both manufacturing settings have overlap, but at the extreme, each has its unique characteristics. The objective is to look at commonalities between discrete and continuous manufacturing where lean techniques from the discrete side are directly applicable, and to also examine ways to do so in other areas where this may not be quite so straightforward. The objective is to systematically demonstrate how lean manufacturing tools when used appropriately can help the Apparel industry to eliminate waste, have better inventory control, better product quality, and better overall financial and operational procedures. The ideas are tested on a garments manufacturing company International Classic Composite Ltd. (referred to as ICCL). Value stream mapping is used to first map the current state and then used to identify sources of waste and to identify lean tools to try to eliminate this waste. To quantify the benefits gained from using lean tools and techniques in the value stream mapping.

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1.1 Introduction:

Lean is to manufacture only what is needed by the customer, when it is needed and in the quantities ordered. The manufacture of goods is done in a way that minimizes the time taken to deliver the finished goods, the amount of labor required, and the floor-space required, and it is done with the highest quality, and usually, at the lowest cost . This Project are addresses the application of lean manufacturing concepts to the continuous production/ process sector with a focus on the Apparel industry. The basic idea behind the system is eliminating waste. Waste is defined as anything that does not add value to the end product from the customer's perspective. The primary objective of lean manufacturing is to assist manufacturers who have a desire to improve their company's operations and become more competitive through the implementation of different lean manufacturing tools and techniques. This project are also covered with reducing non value added work, Workplace organization, maximize the Efficiency, reducing the Sewing thread & fabric wastage with respect to Lead time. The initial step in this project is to systematically study and define the history of the lean manufacturing concept and its different tools and techniques. It will then examine where most of the lean tools and techniques have been used. This will be followed by a literature review of the garment industry and a study of the findings regarding applications of lean concepts to continuous manufacturing, and the Clothing industry in particular. To study the effect of lean tools in the process sector the Apparel industry is used to illustrate the procedures of implementing lean tools at a process facility. First, value stream mapping is used to map the current state for International Classic composite Ltd(ICCL) . This is used to identify sources of waste and then identify

lean tools to try to reduce this waste. The future state map is then developed for a system with lean tools applied to it. Second, a simulation model is developed for ICCL to quantify the benefits gained from using lean tools and techniques in the value stream mapping.

2.1 Literature Review:

Attaining success for a garments manufacturer in the world today is a complex business. Not only must company accurately define the unit cost, it must also monitor & measure each value added increment for each product, door to door. At the same time the company must have procedures in place to eliminate waste throughout the factory floor & in its information & management system. Otherwise targeted profitability simply cannot be reached or maintained. Unfortunately very few companies today in Bangladesh have been able to reach these goals. Most factories are still too focused on short term survival and finding new business, Not enough operation are placing a high enough value on engineered solutions. Yet it is only through continuous improvement program based on engineered systems that factories can thrive today in the apparel industry. Another widespread problem in Bangladesh is the serious shortage of the trained professional for the garment industry. Although the number of educational institutions teaching apparel related classes has risen, many courses are offering outdated material which has not helped the industry to progress. This gap between what schools are teaching & what the industry requires has given rise to many apparel industry consultancies operating in Dhaka. But most of these consultants do not thoroughly understand the principle & practices of a continuous improvement culture & are instead offering one-size-fits-all solutions with set recipes for all their clients. On the plus side, since most workers have already acquired basic technical skills, factories can in fact make major improvements in their production lines once management and

engineered thinking is in place. the irony here is that even plant engineering improves, it is the line workers who are receiving the least recognition for their contribution & hard work. In Bangladesh, workers wages have been frozen & management is turning a blind eye to the importance of happy employee. But factories managers find themselves trapped between steadily rising the production cost & product requirement and the equally intense downward pressure on the prices their customers are willing to pay. At the same time , customers are pitting heavy emphasis on the social compliance of their Bangladeshi suppliers .So not only are factories challenged to implement system that enhance productivity ,they must also make investment to satisfy social compliance requirement on a long term basis.

Another problem related to both productivity & social compliance is the uneven knowledge & skill levels is different production departments, managers & line workers, particularly in the areas of health & safety awareness & practice, & Conflict resolution/industrial relation. Senior factory management need to be made aware of these discrepancies and then, even more importantly, must fully commit to closing those gaps so that change can be driven through the organization. Lean manufacturing is one of initiatives that focus on cost reduction by eliminating non-value added activities. These tools and techniques of lean manufacturing have been widely used in the discrete industry starting with the introduction of the original Toyota Production System. Tools including just in time, cellular manufacturing, total productive maintenance, single-minute exchange of dies, and production smoothing have been widely used in discrete parts manufacturing sectors such as automotive, electronic and appliance manufacturing.

Applications of lean manufacturing to the continuous process industry have been far fewer. In part, it has been argued that this is because such industries are inherently more efficient and present relatively less need for such improvement activities. Managers have also been hesitant to adopt lean manufacturing tools and techniques to the continuous process industry because of reasons such as high volume and low variety products, large inflexible machines, and the long setup times that characterize the process industry. As an example, it is difficult to use the cellular manufacturing concept in a process facility due to the fact that equipment is large and not easy to move.

In order to compete in today's global competitive market the continuous process industry also needs to look for more ways to gain a competitive edge.

After World War II Japanese manufactures were faced with the dilemma of vast shortages of material, financial, and human resources. The problems that Japanese manufacturers were faced with differed from those of their Western counterparts. These conditions resulted in the birth of the “lean” manufacturing concept. Toyota Motor Company, led by its president Toyoda recognized that American automakers of that era were out-producing their Japanese counterparts; in the mid-1940's American companies were outperforming their Japanese counterparts by a factor of ten. In order to make a move toward improvement early Japanese leaders such as Toyoda Kiichiro, Shigeo Shingo, and Taiichi Ohno devised a new, disciplined, process-oriented system, which is known today as the "Toyota Production System," or "Lean Manufacturing." Taiichi Ohno, who was given the task of developing a system that would enhance productivity at Toyota is generally considered to be the primary force behind this system. Ohno drew upon some ideas from the West, and particularly from Henry Ford's book "Today and Tomorrow." Ford's moving assembly line of continuously flowing material formed the basis for the Toyota Production System. After some experimentation, the Toyota Production System was developed and refined between 1945 and 1970, and is still growing today all over the world. The basic underlying idea of this system is to minimize the consumption of resources that add no value to a product . In order to compete in today's fiercely competitive market, US manufacturers have come to realize that the traditional mass production concept has to be adapted to the new ideas of lean manufacturing. A study that was done at the Massachusetts Institute of Technology of the movement from mass production toward lean manufacturing, as explained in the book "The Machine That Changed the World" , awoke the US manufacturers from their sleep. The study underscored the great success of Toyota at NUMMI (New United Motor Manufacturing Inc.) and brought out the huge gap that existed between the Japanese and Western automotive industry. The ideas came to be adopted in the US because the Japanese companies developed, produced and distributed products with half or less

human effort, capital investment, floor space, tools, materials, time, and overall expense [1].

3.1 Lean Manufacturing:

Lean production is based on a system developed by car manufacturer Toyota. It focuses on continuous improvement and elimination of waste in factories in order to improve productivity. Lean attempts to create an industrial culture in which all factory staff work to improve processes to minimize delays, reduce costs and improve quality

[1].

Lean manufacturing improves operating performance by focusing on the quick and uninterrupted flow of products and materials through the value stream. To achieve this, the various forms of manufacturing waste must be identified and eliminated. Waste can include any activity, step or process that does not add value for the customer [1].

If we try to define Lean Then we can say “A systematic approach to identifying & eliminating waste (Non Value added Activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection”.

Lean Manufacturing is a unified, comprehensive set of philosophies, rules, guidelines, tools, and techniques for improving and optimizing discrete processes.

Lean Manufacturing, often called Just In Time (JIT) or Agile Manufacturing, is an operating strategy that seeks to maximize operational effectiveness by creating value in the eyes of the end customer. The focus is not on a department, area or process, but on the optimization of the entire value stream -- the series of processes between receipt of customer order and delivery of finished product [1].

3.2 Principle of Lean Techniques:

The five-step thought process for guiding the implementation of lean techniques is easy to remember, but not always easy to achieve [2]:

- Specify value from the standpoint of the end customer by product family.
- Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
- Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer. As flow is introduced, let customers pull value from the next upstream activity.

As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste. [2]



Figure 1.1: Principles Of Lean

3.3 Lean Production in the RMG Industry:

Productivity is measured by the ratio of inputs (labor, capital, etc.) used to outputs produced. Major improvements can be realized from the elimination of waste (i.e. all non-value-added activities) through standardization of work practices and efficient use of the work force, space and machinery [2].

Other substantial improvements (innovations) may emerge from machinery upgrading, quality system enhancement and adopting more economical production methods. Overall productivity levels of the Bangladesh RMG sector are low compared to regional competitors. Hence, there is a significant potential to increase the competitiveness of the industry [2].

One way to improve productivity and to make more efficient use of physical and human resources is through lean manufacturing, introduced by PROGRESS and its partners [2].

4.0 Various types of Wastes:

Waste is anything that doesn't add value but add only cost to be product. Waste is also known as MUDA. Waste is the use of any material or resource beyond what the customer requires and is willing to pay for [3].

Lean Manufacturing aims to identify and eliminate waste to improve the performance of the business. Shigeo Shingo identified "Seven" forms of waste (Plus one – The eighth waste, under utilization of people) these seven (7) forms of waste are shown below:

The 7 Wastes

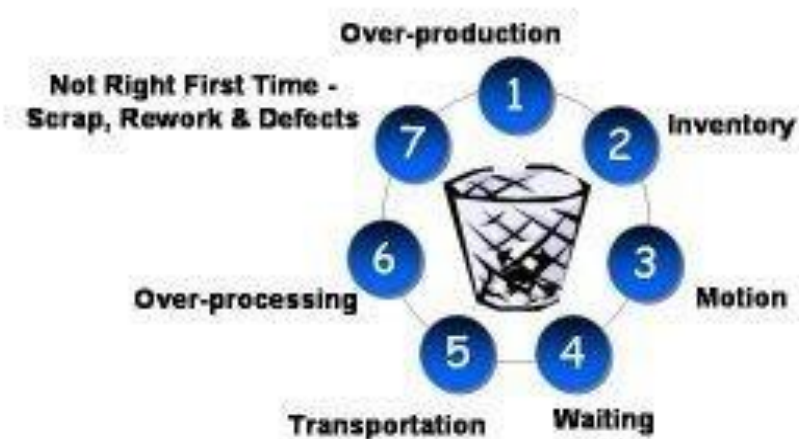


Figure 1.2: Seven Wastes

4.1.1 Over Production:

Overproduction is to manufacture an item before it is actually required. Overproduction is highly costly to a manufacturing plant because it prohibits the smooth flow of materials and actually degrades quality and productivity.

Overproduction manufacturing is referred to as “Just in Case” [3, 4].

-To produce sooner, faster or in greater quantities than the absolute customer demand.

-Manufacturing too much, too early or “Just in Case”.

-Overproduction discourages a smooth flow of goods or services.

-Takes the focus away from what the customer really wants.

-Leads to excessive inventory.

Various types of Causes:

- MRP push rather than kanban pull.
- Large batch sizes.
- Poor people utilization.
- Lack of customer focus, etc.

4.1.2 Inventory:

Work in Progress (WIP) is a direct result of overproduction and waiting. Excess inventory tends to hide problems on the plant floor, which must be identified and resolved in order to improve operating performance. Excess inventory increases lead times, consumes productive floor space, delays the identification of problems, and inhibits communication [3, 4].

By achieving a seamless flow between work centers, many manufacturers have been able to improve customer service and slash inventories and their associated costs. Any raw material, work in progress (WIP) or finished goods which are not having value added to them [3, 4].

Various types of Causes:

- Production schedule not level.
- Inaccurate forecasting.
- Excessive downtime/set up.
- Large batching.
- Unreliable suppliers, etc.

4.1.3. Motion:

This waste is related to ergonomics and is seen in all instances of bending, stretching, walking, lifting, and reaching. These are also health and safety issues, which in today's litigious society are becoming more of a problem for organizations [3, 4].

Various types of Causes:

- No standard operating procedure.
- Poor housekeeping.
- Badly designed cell.
- Inadequate training, etc.

4.1.4 Waiting:

Whenever goods are not moving or being processed, the waste of waiting occurs. Typically more than 99% of a product's life in traditional batch-and-queue manufacture will be spent waiting to be processed. Much of a product's lead time is tied up in waiting for the next operation [3, 4].

Various types of Causes:

- Shortages & unreliable supply chain.
- Lack of multi-skilling/flexibility.
- Downtime/Breakdown/Layout time.
- Ineffective production planning.
- Quality, design, engineering Issues, etc.

4.1.5 Transportation:

Transporting product between processes is a cost incursion which adds no value to the product. Excessive movement and handling cause damage and are an opportunity for quality to deteriorate. Material handlers must be used to transport the materials, resulting in another organizational cost that adds no customer value. Furthermore, it is often hard to determine which processes should be next to each other. Mapping product flows can make this easier to visualize [3, 4].

Unnecessary movement of parts between processes

- Complex material flow paths
 - Poor close coupling
 - Wasted floor space
 - Unnecessary material handling
 - Potential damage to products
- Various types of Causes:
- Badly designed process/cell.

- Poor value stream flow.
- Complex material flows.
- Sharing of equipment, etc.

4.1.6. Over-Processing:

Processing beyond the standard required by the customer by improving processing efficiency we ultimately use less resource to achieve the same customer satisfaction [3, 4].

Various types of Causes:

- Out of date standards.
- Attitude - „Always done it like this“.
- Not understanding the process.
- Lack of innovation & improvement.
- Lack of standard operation procedures, etc.

4.1.7. Non-Right First Time (Scrap, Rework and Defects):

Having a direct impact to the bottom line, quality defects resulting in rework or scrap are a tremendous cost to organizations. Associated costs include quarantining inventory, re-inspecting, rescheduling, and capacity loss [3, 4].

A defect is a component which the customer would deem unacceptable to pass the quality standard.

- Defects reduce or discourage customer satisfaction

- Defects have to be rectified
- Rectification costs money with regard to time effort and materials
- Defects in the field will lose customers
- Right first time is the key

Various types of Causes [3, 4]:

- Out of control/Incapable processes.
- Lack of skill, training & on the job support.
- Inaccurate design & engineering.
- Machine inaccuracy.
- Black art processes, etc.

4.1.8 Factory Management Commitment:

We know Eliminating is so far to achieve but we can minimize these seven type of wastes. For Minimizing wastes, Factories Management must commit to the following:

1. Ensure consistency of a Lean Forum “Steering Committee” regrouping all areas in-charges and including some of the employees prior to improvement.
2. Select core team members with appropriate skills as per the needs to be designated to the improvement project on full time basis.
3. Be ready to invest in people and Time. (Some implementation efforts, require a training for the workers

Which they must be off work for few hours within one week. Production would be planned in advance.

4. Ensure that factory team members are truly empowered.
5. Ensure Lean steering committee members attendance to all training sessions for better understanding of our joint efforts.
6. Allow Workers to express and develop changes ideas.
7. Fully Follow Up and motivate team and staffs by top management.
8. Empower the Lean Forum members.
9. Share information cross the organization and manage expectations (i.e. resistance, conflicts).
10. Be ready to remove roadblocks (i.e. people, layout, systems).
11. Create an atmosphere of experimentation, toleration, patience, risk taking..
12. Install reward systems, if possible.
13. Do away with rigid performance goals during implementation, following the kaizen events metrics.
14. Stay away from decision making based on experience.

5.0 Lean Manufacturing Tools & Techniques:

Once companies pinpoint the major sources of waste, tools such as continuous improvement, just-in-time production, production smoothing, and others will guide companies through corrective actions so as to eliminate waste. In the following sections a brief description of such tools is given.

5.1.1 Cellular Manufacturing:

Cellular manufacturing is a manufacturing process that produces families of parts within a single line or cell of machines operated by machinists who work only within the line or cell. A cell is a small scale, clearly-defined production unit within a larger factory. This unit has complete responsibility for producing a family of like parts or a product [5].

Arranging people and equipment into cells has great advantage in terms of achieving lean goals. One of the advantages of cells is the one-piece flow concept, which states that each product moves through the process one unit at a time without sudden interruption, at a pace determined by the customer's need. Extending the product mix is another advantage of cellular manufacturing. This will also shorten the time required for changeover between products, which will encourage production in smaller lots. Other benefits associated with cellular manufacturing include [5]:

- Reduced transport and material handling.
- Better space utilization.
- Lead time reduction.
- Identification of causes of defects and machine problems.
- Improved productivity.
- Enhanced teamwork and communication.

-Enhanced flexibility and visibility.

.1.2 Continuous Improvement:

Continuous improvement is another fundamental principle of lean manufacturing. Kaizen, which is the Japanese word for a continuous endeavor for perfection, has become popular in the west as a paramount concept behind good management. Kaizen is a systematic approach to gradual, orderly, continuous improvement. In manufacturing settings improvements can take place in many forms such as reduction of inventory, and reduction of defective parts. One of the most effective tools of continuous improvement is 5S, which is the basis for an effective lean company. 5S is a first, modular step toward serious waste reduction. 5S consists of the Japanese words Seiri (Sort), Seiton (Straighten), Seiso (Sweep and Clean), Seiketsu (Systemize), and Shitsuke (Standardize). The underlying concept behind 5S is to look for waste [6].

5.1.3 5S Program:

The term "5s" refers to the five Japanese words that describe the five steps .5S is a part of lean manufacturing that helps reduce waste and improve quality and productivity, through cleaning up and getting organized. Although 5S utilizes common sense principles, getting a 5S program started involves changing employee work habits, and that can be difficult [6].

5S is a basic, fundamental, systematic approach for productivity, quality and safety improvement in all types of business. The Five S program focuses on having visual order, organization, cleanliness and standardization. The results you can expect from a Five S program are: improved profitability, efficiency, service and safety [6].

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

5

existing configuration, and it is typically the first lean method which organizations implement [6].

.1.3.1 5's:

The 5S pillars, Sort (Seiri), Set in Order (Seiton), Shine (Seiso), Standardize (Seiketsu), and Sustain (Shitsuke), 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 [7]:

1. Seiri- Sort - The first step in making things cleaned up and organized.
2. Seiton-Set In Order - Organize, identify and arrange everything in a work area
3. Seiso - Shine - Regular cleaning and maintenance
4. Seiketsu- Standardize - Make it easy to maintain - simplify and standardize 5.
- Shitsuke - Sustain - Maintaining what has been accomplished

5.1.3.2 Seiri- Sort -Clean Up-Clear unnecessary materials:

Sorting is the first step in making a work area tidy. It makes it easier to find the things which one we want and frees up additional space [7]:

- Remove unused & unusable materials.
- Clear defective product.

5

- Clear superfluous things.

- Remove idle equipment & tools.

All these result in clean and tidy workplace & better work environment.

5.1.3.3 Seiton- Set In Order-Ensure good workplace keeping:

This comprises in arranging right materials at right place for quick access & disposal. This leads to better organization of materials and congenial work environment [7] .

Seiton result in less time in accessing materials and disposing them for production. This result is higher productivity [7].

5.1.3.4 Seiso- Shine- Regular Cleaning-keep machine , workplace, floor etc.

Seiso leads to machinery in good condition , workplace neat & clean [7]:

- Fabric and garments not dirty or spoiled.
- Less working & rework.
- Good environment.
- Higher performance.
- Productivity & quality.

There are several steps in the cleaning process:

- Increase the lighting in the work area.
- Divide the area into zones.
- Define responsibilities for cleaning.
- Repair any leaks on machines.
- Identify proper methods and tools for cleaning.
- Provide protection for the persons doing the cleaning (gloves, face-masks).

- Clean machines, floors, walls and ceilings.
- Paint machines, floors, walls and ceilings.
- Identify the sources of dirt.
- Try to eliminate the need to clean inspect machines and tools while cleaning.

5.1.3.5 Seiketsu- Standardize –Simplify:

Standardize is to ensure that the - Shine ,Set In Order, Sort program continue to be effective, the fourth step is to simplify and standardize. One of the hardest steps is avoiding old work habits. Use standards to help people work into new habits that are a part of your Five S program [7].

5.1.3.6 Shitsuke - Sustain - maintaining what has been accomplished:

Training leads employee to achieve higher skill & workmanship:

- Higher dedication & motivation.
- Better work habits.
- Higher worker performance & productivity & quality.

5.1.3.7 Benefits of 5S [8]:

- Improve safety.
- Decrease down time.
- Raise employee morale.
- Identify problems more quickly.
- Develop control through visibility.
- Establish convenient work practices.
- Increase product and process quality.
- Strengthen employees' pride in their work.
- Promote stronger communication among staff.
- Empower employees to sustain their work area.

5.1.4 Just in Time (JIT):

Closely associated with lean manufacturing is the principle of just-in-time, since it is a management idea that attempts to eliminate sources of manufacturing waste by producing the right part in the right place at the right time. This addresses waste such as work-in-process material, defects, and poor scheduling of parts delivered[9] .

Inventory and material flow systems are typically classified as either push (traditional) or pull (just-in-time) systems. Customer demand is the driving force behind both systems. However, the major difference is in how each system handles customer demand. Just-in-time is a tool that enables the internal process of a company to adapt to sudden changes in the demand pattern by producing the right product at the right time, and in the right quantities [9].

Moreover, just-in-time is a critical tool to manage the external activities of a company such as purchasing and distribution. It can be thought of as consisting of three elements: JIT production, JIT distribution, and JIT purchasing. More details are given for each in the following sections [9].

5.1.4.1 Benefits of implementing Just-in-Time system:

JIT(Just in Time) is world's one of the best proven production systems. If implemented according to its core principles and lessons learnt through its theory and practice, a company can successfully achieve the following benefits [9]:

- ✓ Reduction of direct and direct labor by eliminating non-value added activities.
- ✓ Reduction of floor space and warehouse space per unit of output.

- ✓ Reduction of setup time and schedule delays as the factory becomes a continuous production process.
- ✓ Reduction is waste, rejects, and rework by detecting errors at the source.
- ✓ Reduction of lead time due to small lot sizes, so that downstream work centers provide feedback on quality problems.
- ✓ Better utilization of machines and facilities.
- ✓ Better relations with suppliers.
- ✓ Better integration of and communication between functions such as marketing, purchasing, design, and production.
- ✓ Quality control built into the process.

5.1.5 Standardization Work:

A very important principle of waste elimination is the standardization of worker actions. Standardized work basically ensures that each job is organized and is carried out in the most effective manner. No matter who is doing the job the same level of quality should be achieved [10, 11].

5.1.6 Takt time:

„Takt time“ is the average customer demand time for an article. This takes into account the average productive, working time of the manufacturing process. It is measured in “seconds per unit”[12].

Takt Time=Total daily Operating time/Total production requirement

Takt Time=480/100=4.8 min/Vehicles

Using the above formula the pace of work is set according to the market demand. For example there is a pull or market demand of 100 vehicles per day, this demand if divided by 480 minutes available in a day, will give you the number of units you can produce to serve your customers. This means that time available to produce parts or sub-assemblies of parts on each station or each assembly process is 4.8 minutes.

5.1.7 Total productive maintenance:

Machine breakdown is one of the most important issues that concerns the people on the shop floor. The reliability of the equipment on the shop floor is very important since if one machine breaks down the entire production line could go down. An important tool that is necessary to account for sudden machine breakdowns is total productive maintenance. In almost any lean environment setting a total productive maintenance program is very important.

5.1.8 Value stream Mapping:

are required to bring a product or a group of products that use the same resources through the main flows, from raw material to the arms of customers. These actions are those in the overall supply chain including both information and operation flow, which are the core of any successful lean operation. Value stream mapping is an enterprise improvement tool to assist in visualizing the entire production process, representing both material and information flow.

The goal is to identify all types of waste in the value stream and to take steps to try and eliminate them. Taking the value stream viewpoint means working on the big picture and not individual processes, and improving the whole flow and not just optimizing the pieces. It creates a common language for production process, thus facilitating more thoughtful decisions to improve the value. While researchers and practitioners have developed a number of tools to investigate individual firms and supply chains, most of these tools fall short in linking and visualizing the nature of the material and information flow in an individual company.

At the level of the individual firm many organizations have moved toward becoming lean by adapting different lean tools such as JIT, setup reduction, 5S, TPM, etc. In many of these cases firms have reported some benefits; however, it was apparent that there was a need to understand the entire system in order to gain maximum benefits.

Function	Mass production	Lean Manufacturing
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Labor	Narrowly & unskilled production workers	skilled production workers
Product	High volume of homogeneous products	High volume with wide variety of products
Organization	Vertical integration or Decentralized divisions	Team oriented
Product volume	High	High
Unit production cost	Low	Low
Machinery & tools	Single-purpose machines	Flexible automated machines
Ultimate goal	Good enough	Perfection
Flexibility	Low	High
Inventory turn	Low	High
Inspection	Sampling	100% source
Scheduling	Forecast, push	Customer order, pull
Manufacturing lead time	Long	Short
Batch size	Large with queue	Small, continuous flow
Layout	Product	Product

Table 1.1 : Comparison Of lean manufacturing with mass production system.

5.1.9 Other benefit of Lean implementation:

- Better utilization of labor(70 % reduction in number of helpers per production line).

- Higher income per worker due to higher productivity.
- Retention of surplus labor through upgrading helps to operators.
- Labor Productivity: The average performance of the team members (output versus target).
- Production Cost: The actual cost of the labor excluding overhead.
- Throughput Time: The manufacturing pace at which the first piece reaches the shipping. This includes order changeover.
- Lead Time: The amount of time required to produce a single product, from the time of customer order to shipping which is the sum of retention and processing time. In this case it only covers from cutting to shipping.
- Floor Space / Worker: This includes area of manufacturing along with relevant support services divided by total direct labor.
- Line Balancing: The level of balancing between workers due to variation in workers pace and operations difficulty.
- Labor Utilization: The effective time worked of the direct labor minus their availability.
- Retention Time: This covers the time of materials stop flowing (idle) due to inventories, WIP or over-processing. Retention time is the first element to extend time-delivery.
- Processing Time: The time spent on producing value added activities by the team members of which is paid the buyer.

6.0 Experimental Work:

6.1.1 Work Assessments:

Lean strategic approach:

Phase 1: Lean assessment

Phase 2: Skill enhancement

Phase3: Awareness program

Phase 4: Develop new concept

Phase 5: Implementation & trail new concept.

Phase 6: Follow up new concept.

Productivity Improvement Program& Technique:

- Low Manpower.
 - Incentive: Provide sporadic rewards to teams for good performance
 - Maintenance of machines.
 - Establish communication channels.
 - To ensure friendly stress-free environments.
 - Make employees feel like they have a greater.
Involvement/responsibility in their work.
 - Reducing absenteeism.
 - Motivation.
- ✓ Pilot project on 6 lines.
 - ✓ Motivation / Learning Program.(In Line Mobile Motivation/Learning Program)
 - ✓ Quality Motivation.
 - ✓ Select 5s maintaining groups who may follow up the total 5s Program & Submit
report on daily basis. Motivation /learning season

TR (Team Representative) & Quality0.25 day/month.

Operator0.25 day/month.

There are 4 rules are used in my working Project:

- Simplify, structure & standardized every process.
- Analyze, simplify & connect every process.
- Connect visually workers too customers & corporate objective.
- Improve continuously through work practice and experimentation with worker participation.

The three wide-ranging categories affecting the Cost and Lead Time are assessed as follows:

6.1.2. Experiment 1: Retention time in materials and information flow.

Direct Impact: Shorten and stabilize Lead Time; Direct

Impact: Enhance cash flow.

Indirect Impact: Reduce Operating Overhead Cost.

Category 1	Findings
Retention time in materials and information	

Retention Time	Related to retained raw materials	<ul style="list-style-type: none"> •Waiting in Storage •Waiting to be cut •Waiting In Process for workers due to line balancing •Waiting in process for trims or instruction •Waiting for Finishing •Waiting for Approval •Waiting for instruction •Space Utilization •Stock turnover in days •Stock turnover ratio
Processing Time	Related to Flowing Materials	• Flowing Materials through practices

Table 1.2: Retention time in materials and information.

6.1.3 Experiment 2: Processing of manufacturing activities

Direct impact: Reduce of Cycle time.

Direct impact: Reduce Manufacturing Cost.

Category 2	Findings
Processing of manufacturing activities	

Wasteful Motions	Related to work practices caused by line setups, staffing and unorganized work practices	<ul style="list-style-type: none"> • Excess Evacuation • Excess Handling • Hesitation Pick ups • Excess Trimming
Order Changeover	Related to line set up of new order	<ul style="list-style-type: none"> • Machineries movement and adjustment • Feeding and flashing the line

Unnecessary activities	Related to none value activities and motions	<ul style="list-style-type: none"> • Bundling • Marking • Loading • Sorting • Transport • Stickers
Rework	Related to quality failure	<ul style="list-style-type: none"> • Over-processing by workers • Re-inspection
Rejects	Related to damaged parts	<ul style="list-style-type: none"> • Cost of rejects • Cut to Ship ratio and on-time delivery

Table 1.3: Processing of manufacturing activities.

6.1.4 Experiment 3: Continuous Improvement Culture through Performance Management Policy Deployment to sustain both objectives 1 and 2.

-Pleasant work environment and conditions for workers

-Learning organization

Tools: Investigation through questioning and systems evaluation:

Category III		Findings
Management Practices		
Management Practices	Assess management capability, skill and systems related to performance	<ul style="list-style-type: none"> •Engineering •Factory and Supervisory • Workers Skill •Planning •Troubleshooting •Workplace organization and visual management •Layout and Production Set ups •Mechanics Role •Quality Policy and System

Conclusion of the three categories		Findings
Underutilized Resources	Improving the above will increase the capacity due to:	<ul style="list-style-type: none"> •Machineries Utilization •Labor utilization •Productivity Level •Unit Cost

Table 1.4: Management Practices.

6.1.5 Experiment 4: Minimization of Daily sewing threads Losses.

According to the lean assessment it was found there are (ICCL) lots of sewing thread are wastes daily respect to per line .This technique are applied no the pilot line. It is helping to achieve reduction of sewing thread in ICCL.

-Confirm Order.

-Confirm the sewing thread consumption.

-Calculate the amount of sewing thread required everyday respect too the **Production Per Line**.

Let

Operation	Machine	SMV	No of Machine	No of Thread	Total no of Thread
Sleeve Hem	3T FL	0.28	1	1*3	3
Shoulder Join	4T OL	0.29	1	1*4	4
Neck V tack	SNL	0.26	1	1*1	1
Neck V make	SNL	0.27	1	1*1	1
Neck Sub tack	SNL	0.67	2	1*2	2
Neck Join	SNL	1.84	3	3*1	3
Neck O/L	4T OL	0.24	1	1*4	4
Neck Piping	3T FL	0.28	1	1*3	3
Neck Label T/s	SNL	0.57	2	2*1	2
Sleeve join	4T OL	0.72	2	2*4	8
Side Seam	4T OL	0.81	3	3*4	12
Sleeve sub tack	SNL	0.29	1	1*1	1
Sleeve kara tack	SNL	0.26	1	1*1	1
BTM Hem	SNL	0.30	1	1*1	1
Total		7.08	21		46

Table1.5: SMV & Thread Consumption

Now

Total SMV for these T-Shirt: 7.08 [SMV= Basic Time + Allowance; Where Basic Time = Cycle time * performance rating]

Total no of m/c=21

Total No of cone required on machine wise = 30 [Respect to No of needle Thread, Bobbin thread & Lopper thread

Mp: 21+3=24

100% efficiency target for 8 hours=1627 pcs

75% efficiency target for 8 hours=1220 pcs

Let

Thread required to sewing basic T-shirt=150 m

No of cone required for each garments (T-shirt) =150/5000=0.03 cone

No of cone required for 1220 pcs=1220*0.03=37*5 %(allowance) =39

This line required 39 cones for complete 1220 pcs garments

Who receive the thread in beginning of work(Supervisor) are responsible to give the report(use of thread) after finish the work.(As like as **broken needle policy**).If we use broken needle policy then we will able to also **use** the above 5 % allowance by **Re-Coning** .

Benefits:

- ✓ Easier to identify how much thread are used according to per line to meet the production target & also how much sewing thread are required to confirm the ship qty.
- ✓ Easy to identify the accuracy & Lack ness of consumption.
- ✓ Maximize the inventory system.
- ✓ Easy to Identify the Daily sewing threads uses with respect to different buyer with production.
- ✓ Increase the transparency & Accountability where everybody careful about the daily sewing threads losses.
- ✓ Easy to find out no of uses machine per day.

Next Action:

Sewing Thread Booth:

By using re coning system we may able to create a Sewing thread Booth where a lot of threads are storage (Allowance thread which we provide during consumption) according to Color, Color code, Count, Buyer etc.

Buyer:

Count:

Color:

Color code:

No of Cone:

It may Uses as following arena:

- For same buyer.
- For product development.
- For sampling.

7.0 Result and Discussion:

Based on my observations, I was unimpressed by the manufacturing practices and appalled by the vast amounts of working capital tied up in inventory. To focus on mass production, low prices and economies of scale in order to reap profits made no sense for world class manufacturers and over-production is fatal for any company. However, the manufacturing process must be pulled rather than pushed the same as the supermarket only reordered and restocked goods once they had been bought or ordered by customers. This is the idea of Just in Time (JIT).

Here below, are the details of the findings split by the three wide-ranging categories demonstrating the results of the current state and highlighting the potential of the future ideal

7.1.1 Experiment I – Retention time in Materials and Information Flow:

This part of the mapping covers the flow of the raw materials and parts from the stores up to the shipping area going through the manufacturing stages.

This part responds to objective 1 leading the analyst to the causes of the retention time.

The mapping covers the following areas: A)

Lead time.

B) Information Flow.

C) Stock turnover in days.

D) Stock turnover ratio.

E) Line Balancing.

F) Space Utilization.

A) Lead time:

The amount of time required to produce a single product, from the time of customer order to shipping. The total time a customer must wait to receive a product after placing an order. Lean manufacturing is the ultimate solution, to achieve pull production. The results and improvement potential are given below:

Lead Time (Materials Flow)						
		Before		After		Achivement
1	Processing Time	291	12%	223	36%	
2	Retention Time	2128	88%	400.00	64%	
Throughput time of 1st piece <i>Minutes</i>		2419.00		623.00		74%
Throughput time of 1st piece <i>Day</i>		4.03		1.04		(2.99)

Table 1.6: Improvement (%) of Lead time .

Here, Achievement(%)=Before-After/Before*100 ; Net Achievement =Before – After

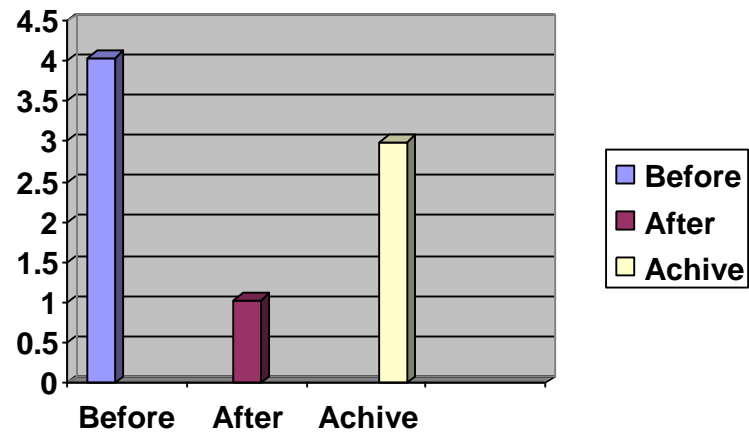


Fig 1.3: Achievement (%) of Lead time. B)

Information Flow:

The information system is longer than the operations breakdown and factory must simplify to connect workers to the information system not to isolate them. This is a big change for factory because currently the scheduling and information related to the product are really owned by the management staffs and any changes had to be approved by them. That just slowed down production, disconnect workers from corporate objectives and I wanted to make sure workers on the floor owned the information, the schedule and re- order point. The new information system improves operational efficiency and gives ownership to workers on the floor.

C) Stock turn over in days:

Monetary value of stocks as a ratio of daily overheads was not calculated due to the absence of the information related to stock value. However I analyzed the number of days of available quantity vis-à-vis productivity capacity of the factory. D)

Stock Turn over ratio:

Stock will increase in times of expansion and decrease in times of contraction. For garment factories, a high stock turnover ratio is essential in order to make any profit.

A low stock turnover could indicate the presence of slow-moving stock, which should be disposed of rapidly resulting in large quantity in inventories and work in progress and holding capital. E) Line balancing:

Line balancing is the assignment of work to stations in a line so as to achieve the desired output tare with the smallest number of workstation

Line Balancing Ratio		
Before	After	Achievement
71%	90%	-27%(-19)

Table 1.7: Achievement ratio of Line balancing.

Here, $Achievement(\%) = \frac{Before - After}{Before} * 100$; Net Achievement = Before – After

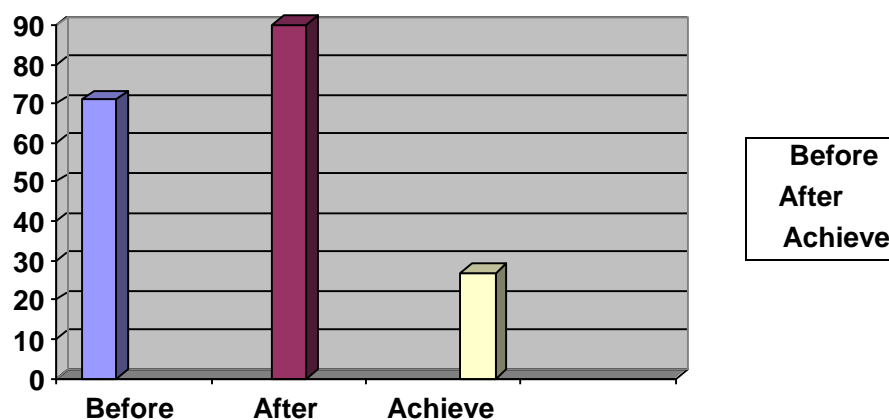


Fig 1.4: Achievement ratio of Line balancing.

Technique used to improve line balancing:

- By using proper time study & capacity for specific task on specific worker.
- By using method study on specific task.

- By using production study.
- Motivation & Training.

Tools used for line balancing:

1. Garments Stopwatch.
2. Calculator.

The main key is to reduce retention time is to eliminate overproduction by producing only what quantity and when is needed and by continuously flowing parts through the manufacturing chain without stoppage. Line balancing can be realized only when production lines are downsized and flexible, takt time is established between processes and Kanban supermarket are identified and planned. F) Space utilization:

According to factory record, the Inventory occupies additional space of 7,540 SQFT equivalents to 410 sewing operators' workstations. The reduction of stock turnover in days will help in adding new capacity to the sewing lines as mentioned above. Space for shipping and stores are not included.

Space Utilization – Inventories				
Performance Measure		Before	After	Achievment
1	Space for Inventories in process	7500 SQFT	3250 SQFT	56%(4250 sqft)

Table 1.8: Potential Achievement of space utilization.

Here, $Achievement(\%) = \frac{Before - After}{Before} * 100$; Net Achievement = Before – After

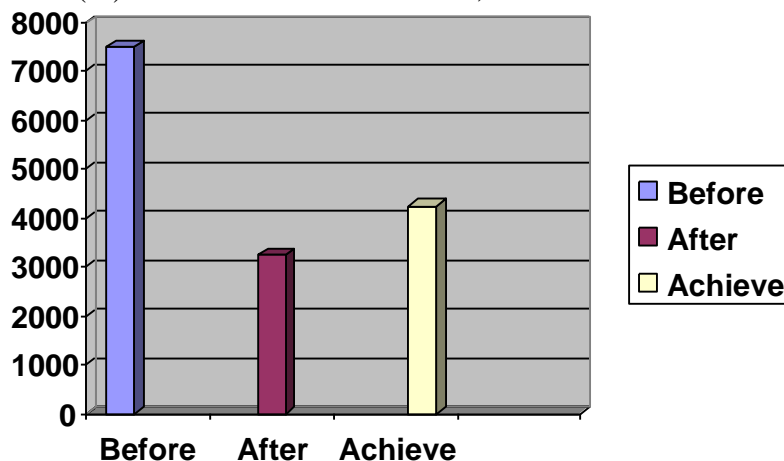


Fig 1.5: Potential Achievement of space utilization

7.1.2 Experiment II – Processing of manufacturing Activities (Cycle Time):

Wasteful activities and motions have direct impact on unit cost which is driven by cycle time. Unit cost covers the operating expenses (overhead) and the manufacturing cost of the direct labor. The lowest productivity level is the higher overhead gets and vice versa. From buyer's side, wasteful activities and motions are not considered as value added of which buyer is not willing to pay for and not part of international practices.

The reason behind Wasteful activities and motions relate to management and engineering practices caused by lack of creativity and innovation and definitely are not caused by workers performance. The study has covered eight "8" areas as follows:

A) Wasteful motion (within value added activities).

B) Order Changeover.

C) Delays (Downtimes).

D) Reworks.

E) Cut to Ship Ratio and On-time Delivery.

F) Rejects.

A)- Wasteful Motions within the value added activities:

Work practices are composed of valuable and wasteful motions. My observations demonstrated many unnecessary motions are merged with valuable motions and this is due to hesitation in pick up, excessive parts handling and evacuation caused by the existence of large number of workers in each production lines and due to lack of standardization and disorder in the workplace. B) Order Changeover:

Order Changeover and Equipment Adjustment is extremely high averaging in 40 changeovers a month and 360 minutes of waste per worker per changeover. Workers are almost idle during the changeover creating another unavoidable delay related to

labor utilization and materials retention. This concept will make it difficult if factory move into only few production hours at each workstation.

Order Changeover			
Performance Measure	Before	After	Achieve
Changeover per line / order	450 Minutes	210 Minutes	53%(240 min)

Table 1.9: Potential Achievement of Order Changeover.

Here, Achievement(%)=Before-After/Before*100 ; Net Achievement =Before – After

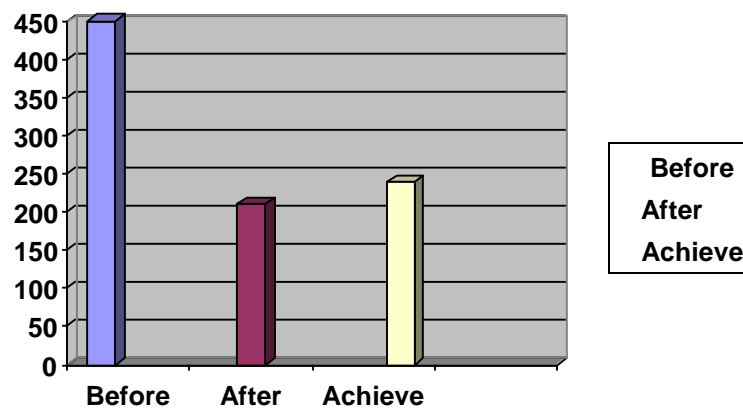


Fig 1.6: Potential Achievement of Order Changeover.

Technique Use to Order Changeover time:

Before finish the current style responsible person should to inform that they may able to finish the work within 3-4 hours with maintaining pull system. C) Additional Delays (downtimes):

There was no data background to illustrate the details of possible delays such as: Machine breakdowns, training, lack of work and accessories, etc; which have another impact on labor utilization. D) Reworks:

Workers are wasting very little of their daily working minutes on rework. E) Cut to Ship Ratio and On-time Delivery:

If a delivery is done in full quantity as ordered with right quality at agreed date, such a delivery is classified as an on time delivery. If a customer has given a delivery tolerance and the actual delivery is within that tolerance (even though it is not 100%) such a delivery too is considered as an on time delivery. But If the quantity needed to be delivered on certain date and only 99% of the order was actually delivered at the agreed date, then Cut to ship ratio or on-time delivery is zero. Factory main objective is to respond to customer demand under Just in Time Principles. A mechanism must be built to avoid failure and to reduce rejects.

F) Rejects

Reviewing the chart above, there is some difference between cut quantity and shipped quantity, the difference is turned out as rejects. The cost of rejects is extremely high which cuts into profits,

7.1.3 Experiment III -Management Practices:

The factory is suffering from lack of engineering and factory management and standardized practices. The systems must be in place in order to implement further improvement. Here are below a summary of the consultant recommendations followed with the details.

Management Practices			
	Systems	Weaknesses	Recommendations
1	Planning	Production Plan	

2	Quality Practices	No comments, must be looked at	To Develop
3	Compliance Practices	Excellent	Need workplace organization to enhance
4	Meeting Structure and effectiveness	Average	
5	IE practices and effectiveness	Available	To Implement
6	AQL Practices	OK	To Coach sustainability
7	Procedures of Rework	Average	Require limitation in Pieces and Corrective action Plan
8	Layout design	NO	IE Practices
9	Line Balancing Techniques	NO	IE Practices
10	Work methods training	NO	IE Practices
11	Mechanics practices	Yes	
12	Factory Manager Role and Skill	Good	
13	Production Manager Role and Skill	Excellent	
14	Supervisors Skill	no knowledge of line balancing only limited to technical knowledge	Need to enhance the Knowledge
15	Communication between departments	No proper Information flow process	To Implement Point of Use System
16	Productivity Monitoring System	No Proper tracking	To Implement Visual

Table 2.1: Management weakness and recommendation

7.1.4 Potential Achievement:

Following data has Shows the Current state & future state of the Factory. It also shown the which tools may involve to get the better Improvement ratio of this factory:

	Waste affecting performance drivers	U/M	Current	Future	Improvement Ratio	Lean Tools
1	Retention Time of first bundle	Minutes	2128	600	74%	Continuous Flow Kanban / Supermarkets One point flow One small lot flow Management Support Concept
2	Inventories and WIP	Pieces	304,200	160,000	-47%	Pull Production
3	Stock turnover in days	Days	Not estimate			Pull Production
4	Stock turnover ratio	Percent	5%	10%	90%	Pull Production
5	Line balancing	Percent	71%	90%	27%	Team function Takt Time In production Kanban
6	Processing Time Reducing Cycle Time / style	Minutes	18	13	-27%	Team Function See Unnecessary Activities Management Support Concept
7	Order Changeover Layout Time per sewing line per changeover	Minutes	450 (Almost one working day)	210	-53%	Fixed Position Strategy Layout standardization Operations Breakdown Standardization Simplification of internal and external set ups Management Support Concept

8	Throughput time in sewing (including changeover) of 1st piece	Minutes	650	240	-63%%	See Changeover One Piece Flow at feeding
9	Reworks / day / Worker	Minutes	8	3.7	53%	Quality at the Source Management Support Concept
10	Rejects / month	\$	Not Estimate		-	Quality at the source Management Support Concept
11	Downtimes		Not estimate			Team Function Management Support Concept

Table 2.2: Potential Achievement after Implementation lean tools & technique.

8.0 Future Plan:

-Areas for Improvement:

Based on the root causes of lower performance of our garment industry , here are the main areas for improvement as follows:

➤ Supportive Management Concept:

Simplification in procedures and paperwork must be considered. Management concept must be designed in order to provide only the information and the adequate tools required to the workers to perform a complete task without relying on section

supervisors. Every system related to operators' performance must be designed as per the Lean tools covering time set up reduction, layout, quality within the team, Takt time and re-orders point, kanban requirement etc.

- Standardization and stabilization of work practices:

Work practices related to stores, cutting, Sewing, Finishing, packing and cartooning must be improved to ease the work of the workers and to reduce the time of handling and evacuation that will lead to maximize the utilization of the equipment and workers and stabilize the manufacturing flow. Industrial Engineering department must be set in place.

- Throughput Time & Feeding time: implement floating pieces (restricted WIP) system can eliminate totally the feeding loss and accelerate the throughput time of first piece out at the rate of the total SMV of one piece.
- Employees Involvement: All innovations and improvements start with everyone in the organization becoming aware of the need for change and the role each will play in the realization of that change. The most important step is to begin by catching people's attention and raising their awareness. To sustain the changes employees participation in decision making is a must that lead to improve the moral of the workers. It is important to implement a culture which support team work' involvement and empower the workforce through a support management system.
- 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.
- Workplace organization: there is no improvement without implementing 5S among the processes in order to organize the workstations to eliminate hesitation and disorder and to ease information and materials flow, workers should be able to locate for example, the WIP, the assignment, the information, the tools, etc. Lot of additional space can be saved, especially within the areas

occupied by large quantity of inventory with better organized storage and visual displays. So 5S can eliminate significant amount of space generated from disorder. 5S is the foundation of any improvement.

- Manufacturing Concept and Planning System: the manufacturing processes to make one final product are split into multiple processes and planning systems adding tremendous excessive costs as relate to handling, waiting, storing etc. manufacturing concept must be changed by downsizing and combining the entire manufacturing concept as it relate to the product making.
- Labor utilization: Emphasizing team work functions by synchronizing workers pace on minimum and maximum inventory level considered as “In production Kanban”. This is part of work practices standardization. Under the format of team function and tasks design, this will lead to maximize labor and equipment utilization and improve the lead time working against only what is required, when is needed for better balanced activities.
- Changeover and Time Set-ups: Changeover activities must be re-analyzed, redesigned and standardized in order to eliminate all the delays incurred within the changeover activity as is the case at the plant. The changeover activities are done in unreliable manner which they are unpredictable and affecting the flow and the pace of the product. Stabilizing the position of the workers through short-term development plan to avoid dislocating workers through the production cell and make it easier on feeding new style.
- Pay Incentive System: In most organizations, significant salary gains come from job-promotions that move people to a higher salary grade, not from merit increases or motivation. Studies show that, organizations that reduce pay differences between the highest- and the lowest-paid employees tend to perform much better. Conventional wisdom says that workers should be evaluated and paid based on results under their control. When Team members play a significant role in achieving corporate objectives performing complete job sharing the responsibility of producing good quality product in the time required they should share in any reward or bonus equally.

9.0 Conclusion:

The mentioned improved areas will help in reducing tremendously the operating expenses since costs related to low productivity can be eliminated and productivity can be increased generating higher profitability. The team based functions through standardization will help to reduce the time waste by workers and motivate workers to earn more incentive leading to engaging workers in continuous improvement. This kind of set up requires investment in both People and Time for tomorrow's success.

APPENDIX

Waste: Any activity that adds to cost without adding to value of the product.

Value Added: Any activity that transforms a product or service to meet the customer need.

Non Value Added: Any activity that absorbs or consumes resources (e.g. material, time, equipment, people, paper, space, etc.) without creating value to the product adding only cost which buyers won't pay.

SMV: Standards Minutes Value is a combination of several elements (Hand motions and Sewing cycle) to complete one task or operation as per the international benchmark. Applying this to the SMV for a particular garment yields the C&M cost. So Revenue is the result of total earned SMV (Minutes standards value) produced by the direct labor (sewing machine operators).

Inventory: Usually the highest cost category, inventory is all raw materials, purchased parts, work-in- progress and finished goods that are not yet sold to a customer.

Work In process (WIP) : Items waiting between operation steps to be processed.

Order Changeover: Changing existing set up of a production line into new style which requires changing and adjusting machineries, training workers and Feeding the line.

Lead Time: The amount of time required to produce a single product, from the time of customer order to shipping.

Machineries Utilization: utilizing a sewing machine is based on needle dips so it calculates the time of the time needle dip functioning within a day over the time sewing machine was available.

Team based module: The arrangement of people, machines, materials and methods such that processing steps are adjacent and in sequential order so that parts can be processed one at a time (or in some cases in a consistent small batch that is maintained through the process sequence). Typically, in a U-shaped configuration where operators remain within the cell and materials are presented to them from outside of the cell. The purpose of a cell is to achieve and maintain efficient continuous flow.

Five S'S: A method of workplace organization and visual controls developed by Hiroyuki Hirano. "S" Sort, Set in order, Shine, Standardize, Sustain.

Future State - A potential improved view of the workflow.

Kaizen: Continual incremental improvements which accumulate and significantly drive out waste.

Kaizen Event :A time-sensitive, rapid-deployment methodology that employs a focused, team-based approach to small but non-ending incremental improvements.

Kanban : Visual signal. Typically a small card, sign or signboard, an instruction to produce or supply something. A re-order card or other method of triggering the pull system, based on actual usage of material. A central element to JIT system. There are two types; production and withdrawal. It should be located for use at the point of manufacturing.

Value Stream Mapping: A systematic method to identify all the activities (door-to-door) required producing a product or product family. The "Map" will include both the flow of the material and the flow of information. It should first be used to describe the current state and then redone to depict the future state.

Visual Control: Creating standards in the workplace that make it obvious if anything is out of order and by displaying the status of an activity so every employee can see it and take appropriate action.

Mass Production: Mass production is the name given to the method of producing goods in large quantities at low cost per unit. But mass production, although allowing lower prices, does not have to mean low-quality production. Instead, mass-produced goods are standardized by means of precision-manufactured, interchangeable parts.

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