TRANSITIONAL CHANGE OF CONVENTIONAL MANUFACTURING SYSTEM TOWARDS LEAN MANUFACTURING SYSTEM INTO THE APPAREL MANUFACTURING INDUSTRY: A CASE STUDY

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ABSTRACT

Traditionally operated garment industries are facing problems like low productivity, longer production lead time, high rework and rejection, poor line balancing, low flexibility of style changeover etc. These problems were addressed in this study by the implementation of lean tools like cellular manufacturing, single piece flow, work standardization, just in time production etc.

After implementation of lean tools, results observed were highly encouraging. Some of the key benefits entail production cycle time decreased, number of operators required to produce equal amount of garment is decreased, rework level reduced production lead time. Apart from these tangible benefits operator multi-skilling as well as the flexibility of style changeover has been improved. This study is conducted in the Cutting, Sewing and Finishing section in knitwear manufacturing company. Study includes time studies, the conversion of traditional batch production into single piece flow and long assembly line into small work cells.

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With best wishes to all of them,

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Athuor

DECLARATION

This is to declare that the project "**Transitional change of conventional manufacturing system towards lean manufacturing system into the Apparel Manufacturing Industry: A case study**" and related audit were carried out by the authors under the supervision of PROF. DR. SHAMSUDDIN AHMED, Department of Mechanical and Chemical Engineering, Islamic University of Technology (IUT).

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CHAPTER 1 : INTRODUCTION

1.1. IMPORTANCE OF THE STUDY

The apparel industry in Bangladesh now has become the most successful sector as it holds the major share of the total export volume of Bangladesh. Environmental changes, international competition, consumer demand and market trends of variety and short product life cycle, compel the Bangladeshi apparel industry to focus increasingly on the consumer as a way to meet these challenges (Mazedul *et al*, February-2013). Even though labor cost is cheaper than developed countries; due to specific market nature of the Apparel industry, for example: the short production life cycle, high volatility, low predictability, high level of impulse-purchase, and the quick market response; the Apparel industries are facing challenges these days (Daly and Towers, 2004). But now the recommended wage structures, the minimum wages in the industry would increase by about 80 percent. According to the labor law and act of Bangladesh government, the RMG (must write in full somewhere earlier) work is categorized into seven grades and the minimum wage for the seventh grade worker is BDT 5,300 per month while for the first grade worker it is BDT 13,000 (Ministry of Labor and Employment, 2013).The implementation of a new wage structure would increase the total production cost. Again a few inhibiting factors stand in the way of reaping the full benefits, such as scattered existence of suppliers, difficulty in establishing long-lasting relationship of suppliers, trade union having political backing, political turbulence and frequent disruption of electricity supply(Farhana,2009). But nowadays due to small order quantities and complex designs, the Apparel industry has to produce multiple styles even within a day; this needs higher flexibility in volume and style change over (Shahram and Cristian, 2011). The term “lean” as Womack and Jones (1994) define it denotes a system that utilizes less, in terms of all inputs, to create the same outputs as those created by a traditional mass production system, while contributing increased varieties for the end customer. 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. So implementation of lean manufacturing system would be best the solution through reduction of production lead time, reduction of the inventory, increasing productivity, training operators for multiple work and by reducing rework

1.2. PROBLEM STATEMENT

Under the pretext of rapid change of fashion design, varying order quantities and increasing quality levels, traditional manufacturing process in Apparel manufacturing industry cannot meet the desirable output on the basis of cost, quality and delivery. In Bangladesh, Apparel industry is producing products under make-to-order environment and its units are working on assembly basis. It is a labor intensive industry. Almost all machineries are imported. Orders are to make ready under strict time-frame. Therefore, higher utilization of man power, machine and time are inevitable in this industry. Based on some factory visits and discussions with the industry officials, some major problems, which are found in Apparel industries are as follows:

1. High takt time and cycle time.
2. Low workplace management.
3. High WIP in traditional type of batch production is the major problem faced by industries. Batch processing flexibility cannot be achieved easily; which is the current demand of garment industry.
4. Batch process operators are given specific jobs, so the operator knows one or a few more operations only.
5. High rejection rate of the final product.

These problems are the cause of high WIP (work in progress) inventories that creates less productivity and efficiency. This study will try to evaluate all these problems by proposing implementation of Cellular manufacturing system in different sections of an Apparel manufacturing factory.

1.3. OBJECTIVE

Manufacturing performances are measured based on four criteria - cost or productivity, quality, flexibility, and production and delivery time. These four criteria cannot be fully accomplished simultaneously. However, a manufacturer need to make a good balance and focus on that more than one criterion at-a-time is important (Technopak, 2011). The term lean is coined to represent half the human effort in the company, half the investment in tools and half the engineering hours to develop a new product in half time (Naresh paneru, 2011) (this sentence does not match here. It can be somewhere in Literature review). The aim of this study is propose implementation of lean manufacturing system (LMS) in a non-lean conventional manufacturing unit in order to satisfy some of the aforesaid criteria. The specific objectives of this research are follows:

I. To identify different types of non-value added activities and propose certain strategies to minimize or optimize them.
II. To standardize the relevant strategies by linking the relevant activities and conducting time and layout studies.
III. To minimize or eliminate idle or waiting time in the concerned production lines.
IV. To introduce single-piece-production-flow strategy, and use planned takt time approach.
V. To generate flexibility of style change over.

1.4. SCOPE AND LIMITATION

- This work will focuses on a single export-oriented garments company. Hence the findings may not provide generalized conclusions.
- This study will focuses only one style which can be different from others. Different style has different operation time and operator needed.

1.5. METHODOLOGY

The work schedule is presented in () in the form of flow chart. Below are the summary of the methodology.

1. Literature review on the published work such as journals, books and articles.
2. An export-oriented garments factory is selected to conduct a case study.
3. Data collection in qualitative and quantitative form by observation, interview and document collection from managers and employees.

The steps considered in the process are given below:

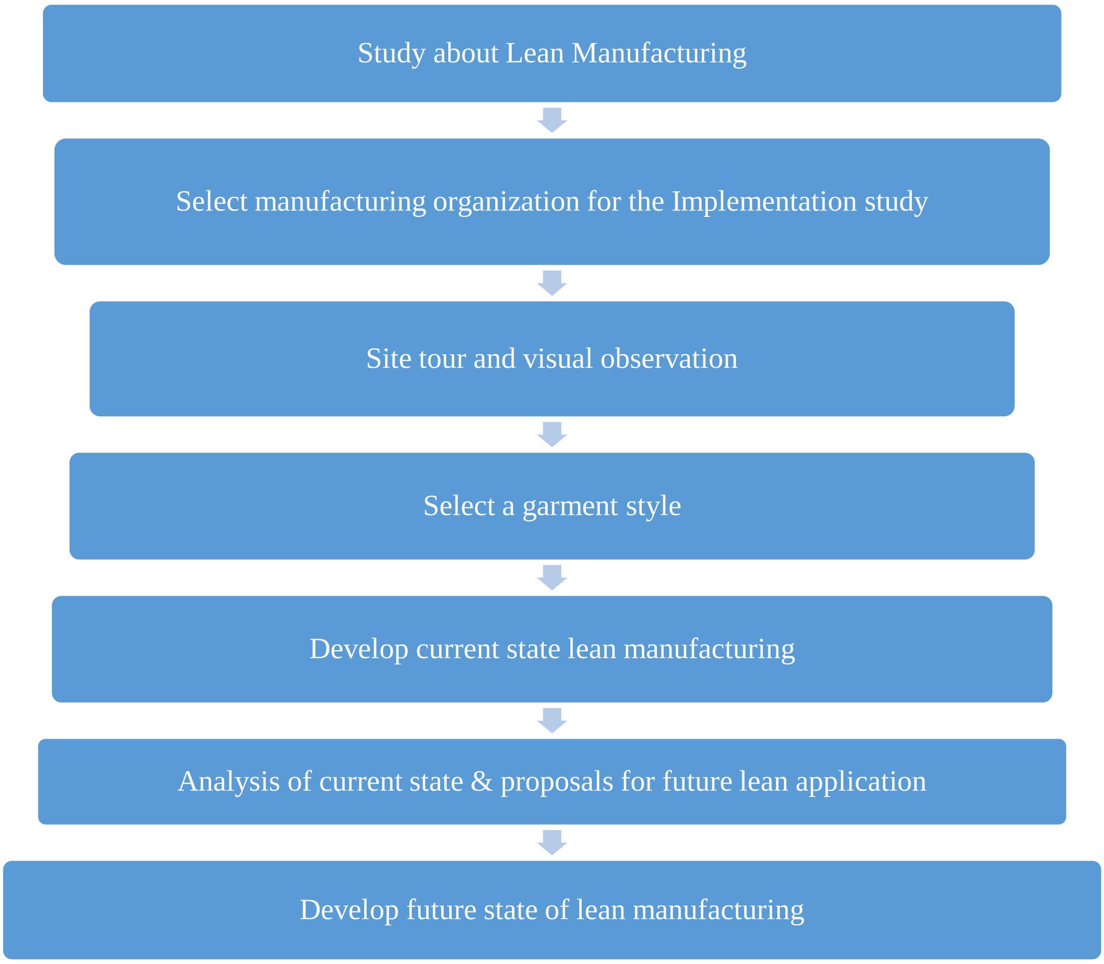

Figure 1.1 : Work Schedule Flowchart

1.6. CONTRIBUTION OF THE STUDY

This study will help in identifying the factors that are hampering in implementing modern production systems which are designed to reduce waste in an organization. Furthermore, this study will also help to address some of the prevalent waste that are seen in garments factories in Bangladesh.

1.7. ORGANIZATION OF THE THESIS

The text consists of five chapters. A standard format is used throughout the thesis. Each chapter begins with an introduction of the chapter. Chapter one covers the importance of this study, the objectives and the scope of the study. Chapter two discusses literature review of the thesis. Chapter three covers the details on research design. Chapter four deals with the data collected and analysis of the data. Chapter five provides discussions on the findings of chapter four and draws conclusion.

CHAPTER 2 : LITERATURE REVIEW

2.1. HISTORY OF LEAN:

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” (Womack, Jones and Ross, 1990), 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 (Womack et al.,1990).

Definition of lean:

• It is a comprehensive set of techniques that, when combined and matured, will allow you to reduce and then eliminate the seven wastes. This system not only will make your company Leaner, but subsequently more flexible and more responsive by reducing waste.(Lonni Wilson,2009, chpt-2) The term "lean" as Womack and his colleagues define it denotes a system that utilizes less, in term of all inputs, to create the same outputs as those created by a traditional mass production system, while contributing increased varieties for the end customer (Panizzolo, 1998) Lean is the systematic approach to identifying and eliminating waste through continuous improvement by flowing the product or service at the pull of your customer in pursuit of perfection (Nash, Poling and Ward, 2006, p. 17). "Lean" focuses on abolishing or reducing wastes (or "muda", the Japanese word for waste) and on maximizing or fully utilizing activities that add value from the customer's perspective. From the customer's perspective, value is equivalent to anything that the customer is willing to pay for in a product or the service that follows. So the elimination of waste is the basic principle of lean manufacturing. For industrial companies, this could involve any of the following (Womack et al., 1990; Ohno, 1997; Monden, 1998; Shingo, 1997; Mid-America Manufacturing Technology Center, 2000):

• Material: Convert all raw materials into end products. Try to avoid excess raw materials and scrap.

• Inventory: Keep constant flow to the customer and to not have idle material.

• Overproduction: Produce the exact quantity that customers need, and when they need it.

• Labor: Get rid of unwarranted movement of people.

• Complexity: Try to solve problems the uncomplicated way rather than the complex way. Complex solutions tend to produce more waste and are harder for people to manage.

• Energy: Utilize equipment and people in the most productive ways. Avoid unproductive operations and excess power utilization.

• Space: Reorganize equipment, people, and workstations to get a better space arrangement.

• Defects: Make every effort to eliminate defects.

• Transportation: Get rid of transportation of materials and information that does not add value to the product.

• Time: Avoid long setups, delays, and unexpected machine downtime.

• Unnecessary Motion: Avoid excessive bending or stretching and frequently lost items

Seven Types of Waste:

Waste is defined as anything that does not add value to the final product. Every organization wastes certain amount of its resources. Therefore it is important to have a closer look at these wastes. For the ease of understanding, these wastes are categorized in to seven categories. Every waste one will come across in the organization or even in day (technopak, 2011)

1. Overproduction: Lean manufacturing relies on manufacturing at the rate of customer demand. Production should be scheduled according to demand both in terms of volume and time. Demand is both external and internal. Thus, sewing should produce as much as finishing needs, and finishing should schedule its performance to the delivery timelines and quantities. Producing more than required is a waste of unwanted or mistimed value addition. For example, high cut to ship ratio is an indicator of overproduction.

2. Waiting: Whenever the pieces are not moving or being processed, the waste of waiting occurs. Much of a product's lead time is tied up in waiting for the next operation; this is usually because material flow is poor, production runs are too long, and distances between work centers are too great. Linking processes together so that one feeds directly into the next can dramatically reduce waiting.

For example fabric, waiting to be cut and unshipped finished cartons, WIPs within cutting sewing, finishing sections waiting to be processed either due to capacity shortfall or non-receipt of trims and accessories.

3. Excess 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.

For instance, any WIP which is more than the requirement will cause excess inventory, thereby causing pressures of extended lead times, and hence, higher working capital cost.

4. Transportation: Transporting products between processes is a cost incursion which adds no value to the product. Excessive movement and handling can cause damage and are an opportunity for quality to deteriorate and quantity to dwindle (lost WIP). Unplanned workflow management in material warehouse, cutting, sewing, finishing and finished warehouse increase the material movement. This is the primary cause of high Man-Machine Ratio (MMR) in a factory. As any form of material movement would require extra manpower and space, which gets added into the MMR and required area causing higher overheads and hence increased product cost.

5. Excess Motion: This waste is related to ergonomics and is seen in all instances of bending, stretching, walking, lifting, and reaching out to pick up garment pieces which can be lessened. Examples are ill-defend work stations, adding up to extra work content, as a result of extra body movement. Workstation should be defend for an easier pickup and dispose of garment parts along with trims in distinctly separate areas.

6. Inappropriate Processing: Correct tooling for the job is necessary to complete an operation. Correct tools are not the tools which are expensive or complex. They are the best tools for the particular purpose. Using inappropriate tools in the manufacturing process is a waste because it will take more resources and also it may not deliver the expected result.

Example: Trouser/ Denim pocket facing attach operation, which can be done by one machine cover stitch machine but is planned with one over lock and one lockstitch. Tis adds cost to the garment without adding value.

7. Defects: Having a direct impact on the bottom line, quality defects resulting in rework or scrap are a tremendous cost to organization. Associated costs include quarantining inventory, re-inspecting, rescheduling, and capacity loss. Higher rate of reworks and high number of rejections caused due to incorrect work processes or failure to identify the same at the right time and place are indicators of defects. The defect in garments like skip stitches, needle holes, and stains causes lot of back and forth in material movement- negatively affecting productivity and Line supervisor focus.

8. Unused Employee Creativity: Loosing of getting better ideas, improvement, skills and learning opportunities by avoiding the presence of employee is termed as unused employee creativity (Liker, 2003, p. 29).

2.2. LEAN MANUFACTURING TOOLS AND 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.

1) Cellular Manufacturing:

Cellular manufacturing is one of the cornerstones when one wants to become lean. Cellular manufacturing is a concept that increases the mix of products with the minimum waste possible. A cell consists of equipment and workstations that are arranged in an order that maintains a smooth flow of materials and components through the process. It also has assigned operators who are qualified and trained to work at that cell. (Abdullah, 2003)

There are lots of benefits of cellular manufacturing over long assembly lines. Some of them are as follows (Heizer and Render, 2000, p. 345-346):

- . Reduced work in process inventory because the work cell is set up to provide a balanced flow from machine to machine.
- Reduced direct labor cost because of improved communication between employees, better material flow, and improved scheduling.
- High employee participation is achieved due to added responsibility of product quality monitored by themselves rather than separate quality persons.
- Increased use of equipment and machinery, because of better scheduling and faster material flow.
- Allows the company higher degrees of flexibility to accommodate changes in customer demand.
- Promotes continuous improvement as problems are exposed to surface due to low WIP and better communication.

- Reduces throughput time and increases velocity for customer orders from order receipt through production and shipment.
- Enhances the employee's productive capability through multi-skilled multi-machined operator.

2) Continuous Improvement:

Continuous improvement is not about the things you do well - that's work. Continuous improvement is about removing the things that get in the way of your work. The headaches, the things that slow you down, that are what continuous improvement is all about.

Bruce Hamilton (as cited in Wells, 2010, p.91)

According to (Gersten and Riss, 2002, p. 41) Continuous improvement (CI) can be defined as the planned, organized and systematic process of ongoing, incremental and company-wide change of existing practices aimed at improving company performance. Activities and behaviors that facilitate and enable the development of CI include problem-solving, plan-do-check-act (PDCA) and other CI tools, policy deployment, cross-functional teams, a formal CI planning and management group, and formal systems for evaluating CI activities. Successful CI implementation involves not only the training and development of employees in the use of tools and processes, but also the establishment of a learning environment conducive to future continuous learning.

The short description of PDCA cycle is given below:

Plan: Identify an opportunity and plan for change.

Do: Implement the change on a small scale.

Check: Use data to analyze the results of the change and determine whether it made a difference.

Act: If the change was successful, implement it on a wider scale and continuously assess the results. If the change did not work, begin the cycle again.

 Successful CI implementation involves not only the training and development of employees in the use of tools and processes, but also the establishment of a learning environment conducive to the future continuous learning (Paneru, 2011).Its goal is to get better and better, and the way to measure a plant's performance is to see how little WIP it requires to operate. As large inventory hides the problems and make it go unnoticed and unsolved, but, with the draining off some inventory, problems are not only found, but are also solved (Dilworth, 1992)

3) Just-In-Time:

"The more inventories a company has… The less likely they will have what they need"

Taiichi Ohno(as cited in Liker,2004,p.104)

Just-in-time manufacturing is a Japanese management philosophy applied in manufacturing. It involves having the right items with the right quality and quantity in the right place at the right time. The ability to manage inventory (which often accounts for as much as 80 percent of product cost) to coincide with market demand or changing product specifications can substantially boost profits and improve a manufacturer's competitive position by reducing inventories and waste. In general, Just in Time (JIT) helps to optimize company resources like capital, equipment, and labor. The goal of JIT is the total elimination of waste in the manufacturing process. Although JIT system is applied mostly to manufacturing environment, the concepts are not limited to this area of business only. The philosophy of JIT is a continuous improvement that puts emphasis on prevention rather than correction, and demands a companywide focus on quality. The requirement of JIT is that equipment, resources and labor are made available only in the amount required and at the time required to do the work. It is based on producing only the necessary units in the necessary quantities at the necessary time by bringing production rates exactly in line with market demand. In short, JIT means making what the market wants, when it wants, by using a minimum of facilities, equipment, materials, and human resources (Roy, 2005, p. 170).

JIT principles are based on the following (Shivanand, 2006, p. 4):

• It is commonly used to describe the stockless production manufacturing approach, where only the right parts are completed at the right time. • It is not a destination but a journey. • Reducing inventory, improving quality and controlling cost.

• A "Pull System" where the parts are produced only when they are required.

4) Poka yoke:

"Poka Yoke recognizes that as humans we'll inevitable forget things, we should at least make certain we don't forget that we have forgotten."

Shigeo Shingo (as cited in Larsson, 2006, p.13) A good poka yoke definition is simply ‘mistake proofing’. Of note, the term poka yoke is of Japanese origin and is one of the handful of the more commonly used Japanese terms that have become mainstream in Lean circles. Poka yokes keep processes from producing errors. Preventing errors obviously improves quality, but it also plays a major role in improving productivity. With no rework, and easier production, cycle times and lead times both become much shorter. And, of course, faster production with fewer defects means lower costs.

Examples of Real-World Poka Yokes:

- In the process of manufacturing of air duct, through the blow molding technology, excess material is removed manually with the help of a sharp knife. The removal process is totally dependent on the worker’s skill so there are high chances of improper removal which rejects the material. The human error elimination is required in such a way that it eliminates the error. (Parikshit, February 2013)
- The socket for USB on the computer is designed in such a way that the pen drive or any corresponding pin cannot be connected in opposite or wrong way. It is a control poka yoke system. (Patil, February 2013)
- In some supermarkets when people want to use trolleys, they should put a coin in a small box on them to release one. Once their shopping is finished and they want to leave there, they turn back the trolley to the specific area outside the supermarket and by locking it to other trolleys, they could collect their coin back. This helps the supermarket to better manage the internal space. (Shahin,November 2010)

5) Kanban:

Kanban is like the milkman. Mom didn't give the milkman a schedule. Mom didn't use MRP. She simply put the empties on the front steps and the milkman replenished them. That is the essence of a pull system.”

Ernie Smith (as cited in El-Homsi & Slutsky, 2010, p.84)

The Kanban Method is a Pull-style re-ordering system by which a downstream process requests goods from an upstream process. The request is by means of a re-ordering Tag (called, in Japanese, kanban). The method may be extended to the entire manufacturing process or only to part of it. It is normally applied to repetitive operations, both in Catalogue Manufacturing and in Contract Manufacturing.

- VSM along with the kanban system was used by Alvarez et al. (2009) to implement lean manufacturing on an assembly line. A current state map was prepared and analyzed in order to note down the cycle time of various activities involved in the production of the component. It had been clearly highlighted that a push system was usually adopted on manufacturing lines, which was a big problem for the assembly line process. A kanban system was generated to replace the push system with a pull system.
- Abdulmalek and Rajgopal (2007) developed a simulation model to show conditions before and after implementing a kanban system. Large amount of the work in process inventories, lower value added time were major weaknesses which had been visualized during analysis. The Kanban system played a vital role in making a better product flow.

6) Value Stream mapping:

A value stream is a collection of all actions value added as well as non-value added that care 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 (Rother and Shook, 1999). 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 (Rother and Shook, 1999). 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 stream (McDonald, Van Aken, and Rentes, 2002). 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.

Lately, and in particular over the last few years a number of companies have utilized value stream mapping. The application crosses over different types of industries and organizations such as automotive, aerospace, steel, and even non-manufacturing industries including information technology. One application of value stream mapping was found in steel manufacturing. A current state map was created for a steel producer, a steel service center and a first-tier component supplier (Brunt, 2000). The map shows the activities from hot rolling steel through delivery to the vehicle assembler. The overall goal of the study was to improve the supply chain performance lead-time. The current state map identified huge piles of inventory and long lead-time. A future state map was then developed. On the future state map target areas were subjected to different lean tools including kanban, supermarket, continuous flow and EDI. The results obtained by implementing the future state map were reduction in lead-time from between 47 and 65 days to 11.5 days, and a reduction of cycle time from 7262 sec to 6902 sec (Brunt, 2000).

Paranitharan et al. (2011) have analyzed and reformatted an assembly line in the automobile industry. Bottleneck times of 155 seconds in machining and 78 seconds in the assembly process were found by analyzing the current state map. The current layout showed that there was a separate station for ram assembly and the cylinder greasing operation. The layout was modified and the idea of a single modular trolley was introduced for the elimination of this problem.

Value stream mapping can serve as a good starting point for any enterprise that wants to be lean. Rother and Shook (1999) summarize other benefits of value stream mapping as follows:

- It helps you visualize more than just the single process level (e.g., assembly, welding) in production. You can see the entire flow.
- Mapping helps you not only see your waste but also its source in the value stream.
- It provides a common language for talking about manufacturing processes.
- It ties together lean concepts and techniques, which help you avoid “cherry picking.”
- It forms the basis for an implementation plan. By helping you design how the whole door-to-door flow should operate a missing piece in so many lean efforts value stream maps become a blueprint for lean implementation.

7) 5S:

“5S is a way to help people gets more done by working half as hard so that the company can make more money.”

Larry Simmons (as cited in Sakthivel et al., 2012, p.63)

The 5S methodology originated in Japan and is based on the simple idea that the foundation of a good production system is a clean and safe work environment. Translated from Japanese words that begin with the letter “S,” the closest English equivalents normally used are Sort, Set in order, Shine, Standardize, and Sustain. The following list is a combination of many variants of the 5S list found in various publications:

- **Sort** (separate, scrap, sift) – Separate the necessary from the unnecessary and get rid of unnecessary.
- Set in order (straighten, store, simplify) – Organize the work area (red/yellow tag campaign, shadow boards, etc.) and put everything in its place.
- **Shine** (scrub, sweep) – Sweep, wash, clean, and shine everything around working area.
- **Standardize** – Use standard methods to maintain the work area at a high level so that it is easy to keep everything clean for a constant state of readiness.
- **Sustain** (systematize, self-discipline) – Ensure that all 5S policies are followed through the entire organization by means of empowerment, commitment, and accountability.

5S has been implemented by Gunasekaran and Lyu (1997) in a small Taiwan company that produces a variety of automobile lamps.

Simmons et al. (2010) have found large lead times, low quality and low efficiency to be big problems in scale industries. 5S is the basic starting tool used to make companies neat and standardized. Bottlenecks can be found by the line balancing tool.

8) Kaizen:

“If you are content with the best you have done, you will never do the best you can do.”

Ho (2002, p.56)

Kaizen means small, continuous improvements with zero investment (Mahajan, 2008). It comes from the Japanese words “Kai” meaning school, continuous or change and “Zen” meaning wisdom, improvement which collectively means “approach to work” where workers are committed towards two types of tasks in exchange of security of their job. One is to sincerely perform the job assigned to them, and the second is to make an effort to continuously improve it (Pieterse, 2005). More formally it was developed by Ohno and Shigeo as a practice, implying choice and practices of the techniques the team has agreed to try, until it is mastered and standardized, experimented to find a better way and repeat forever. Kaizen is considered to be the "building block" of all lean production methods (Brown, Collins, & McCombs, 2006). Kaizen requires the continuous questioning of the basic workings of an operation. The continuous identification and solution of problems by involving and empowering the workers creates a culture of ongoing continual improvement with an organization. Two methods by which involvement can be increased are the ‘Kaizen circles’ and ‘Suggestion programs’. In Kaizen circles, 6-8 workers in a group are formed which generate ideas for solving particular problems. Typically a Kaizen Circle will meet for around one hour per week for 6-8 weeks, and at the end of that period will present some proposals to their managers on how to solve the particular problems. While in Suggestion programs, people are strongly encouraged to make suggestions and rewards are awarded for successfully implementing the suggestions (Mekong Capital, 2004).It improves quality, safety, cost structures, environments, and customer service. Each improvement may be small but the cumulative effort is tremendous (PTU’s Gian Jyoti School of TQM & Entrepreneurship, 2010).

9) Jidoka:

In the case of machines, we build devices into them, which detects abnormalities and automatically stop the machine upon such an occurrence. In the case of humans, we give them the power to push buttons or pull cords called andon cards-which can bring our entire assembly line to a halt. Every team member has the responsibility to stop the line every time they see something that is out of standard. That’s how we put the responsibility for quality in the hands of our team members. They feel the responsibility-they feel the power. They know they count.

Alex Warren (as cited in Liker, 2004, p.129)

Jidoka is one of the pillars of Toyota Production System. Jidoka has two different meanings in Japanese, one is automation (Imai, 1986) meaning changing a manual process into a machine process and other is ‘automatic control of defects’ meaning incorporated the insight or mind of a human to troubleshoot and correct failures. It is ‘automation with a human mind’ including process or technique of detecting and correcting production defects. It always incorporates the following devices: a) a mechanism to detect abnormalities or defects, and b) a mechanism to stop the line or machine when abnormalities or defects occur.

Jidoka is a quality control process that applies the following four principles:-

- Detect the abnormality.

- Stop the line to remove the cause of the problem or when something goes a miss. This type of automation implements some supervisory functions rather than production functions. Whenever, there is an abnormal situation, the machine stops and the worker will stop the production line.
- Fix or correct the immediate condition.
- Investigate the root cause and install a countermeasure (Kachru,2007)

The first two steps can be mechanized or automated. Poka-Yoke devices are one method to allow a process to detect a problem and stop. The 3rd and 4th steps cannot be automated. They are entirely the domain of people because they require diagnosis, analysis and problem solving methods. Various problem solving techniques are used to expose the root cause and implement the remedy. These two steps help in correcting the abnormal situation so that the production can resume either by finding a temporary solution or shutting the line till the defect is corrected. It prevents the production of defective products, eliminates overproduction and focuses attention on understanding the problem and ensuring that it never recurs.

2.3. LEAN IMPLEMENTATION STRATEGY

Adopting Lean is to empower the worker to think, act and be ready to take quick decisions taking full responsibility for his actions. It is more a working culture and without the active involvement of the workers no Lean program can be successfully implemented.

Roshan Baid (as cited by Wickeramasinghe, 2011, p.19)

Lean implementation is seen as a process of adoption. The term implementation process means “progression of events” (Ahlstrom, 2000 as cited in Kovacheva, 2010, p.17). The lean implementation is defined as a process of adoption, involving the necessity of innovation and adaptation by the organization, not just following a certain sequence of steps from a preliminary designed plan as given below.

A) Precursors of lean:

Before the implementing a lean initiative, there are some major precursors or foundational issues that must be put in place in a manufacturing unit to make a lean initiative successful. The following seven precursors must be built into the lean initiative plan in the proper sequence are:-

- High levels of stability and quality in both the product and the processes.
- Mission and vision shared created by top management and shared among the team members.
- Excellent machine availability
- Talented problem solvers, with a deep understanding of variation.
- Mature continuous improvement philosophy.
- Strong proven techniques to standardize.
- Enough workers for the customer orders (Bowes, 2010; Wilson, 2010; Wong & Wong, 2011b).

B) **Steps to follow in the lean implementation:**

Various steps followed in the implementation of Lean are as follows:-

1. Learn about lean concepts and lean thinking. Before implementation, it is very important to make the management aware of the concept and importance of the lean philosophy.

2. Commit the management to lean. The total commitment and support of the management helps in solving the problems which arise during the implementation of the lean production systems and is essential, for the success of the process. The leaders should always practice what they preach and lead by example so that workers under them can have a better understanding about the lean manufacturing and emulate the way leaders do things (Bowes, 2010; Wong & Wong, 2011b).

3. Engaging lean expert. Services of lean manufacturing experts should be obtained to help the units to implement the lean manufacturing systems. In particular, the shift from a push-based to a pull-based production system can potentially be quite disruptive. So, it is best to be guided by someone who has significant experience in this.

4. Building awareness regarding lean. The management should communicate the need and importance of lean implementation. Basic concept of lean must be understood by all the employees including the management. Trainings and workshops must be conducted to educate the employees about the principles and fundamentals of lean manufacturing.

5. Effective building of effective team. Lean team should be built with members having qualities of openness, sincerity, respect, trust and also interdependence. Team members should accept different views and respect other people's opinions, communicate and exchange values and beliefs pleasantly. Nevertheless, support and motivation is needed to motivate them to give

more ideas for improvement (Wong & Wong, 2011b).Applying lean principles are not enough without building the human system to support lean practices and processes otherwise it collapses.

6. Mapping the current state. Value Stream Mapping should be done to carry out the baseline survey to identify wastes and non-value added operations in the processes. Developing the basic knowledge and skill. Lean team members are trained to perform improvement activities related to industrial engineering and quality control.

7. Developing the basic knowledge and skill. Lean team members are trained to perform improvement activities related to industrial engineering and quality control.

8. Designing the future Value Stream Map. Milestones are set to form trial concept.

9. Set up key performance indicators. KPI are chosen which reflect true business improvements and related to reduction in waste.

10. Organize projects. Long term projects (month long) and small (week long) Kaizen events be started to bring about process changes through PDCA, A3 problem solving format and cause and effect analysis.

11. Implement trial concept. Units must implement lean as a test case at a small part of their operations before applying it through their entire operations, especially for the shift from a push-based to a pull-based system, since this can potentially be disruptive. It can be a single production line or a small series of processes.

12. Monitor, evaluate and adjust implementation trial concept. Review of the process should be done again and again as it is absolutely necessary.

13. Starting the change with a partial implementation of lean. After the positive results are understood from the lean implementation, manufacturing units must initially implement only some of the lean manufacturing and gradually shift towards a more complete implementation. Starting the change with a partial implementation of lean. After the positive results are understood from the lean implementation, manufacturing units must initially implement only some of the lean manufacturing and gradually shift towards a more complete implementation.

14. Develop roll-out plan and follow-up. It should be made sure that the changes brought out by the lean sticks to implementing visual management tools and working habits.

15. Training and retraining along with regular audits. Best practices should be identified and rewarded. Video and photo evidence of before and after noticing the improvements should be displayed for motivation. Surplus staff should be retained and integrated into the new production process. Performance measurement through manufacturing key performance indicators:

"It is an immutable law in business that words are words, explanations are

Explanations, promises are promises but only performance is reality."

Harold Geneen(as cited in Weylman,2013,p.61)

Performance measurement is the important diagnostic tool which can be performed in terms of key performance indicators (KPI), quantifying processes for the effectiveness of the intended action. Effective assessment is very important for the timely and reliable measurement of the improvements (Andreeva, 2009).Performance of a manufacturing unit measured as KPIs are generally considered for the evaluation of the production effectiveness but it should be integrated to the company's performance measurement. The performance measurement gives feedback to managers and presents the information for the planning, monitoring and improvement of a business strategy (Shehi, Guxho, & Spahija, 2012; Spahija et al., 2012; Tupa, 2010). KPIs continuously help in reviewing the performance and providing feedback to users. As it captures relationship between actions and measures, the performance gap can be easily ascertained (Perera & Perera, 2012).

2.4. FOUR KEY PERFORMANCE INDICATORS

A) **Productivity:**

"What you get out of an activity for what you put in is productivity."

Jackson Grayson (as cited by Saurabh, 1999, p.14)

Productivity is the relationship between input and output. The output in apparel factories can be in the form of pieces of finished garments in sewing section, meters of fabric inspected in inspection section, cut components in cutting section, or number of garments ironed in the ironing section, whereas the input of the sections or departments within the garment factory could be in the form of man-hours, machine hours, meters of fabric consumed or electricity consumed. In simple words it is concerned with the efficient utilization of resources in producing the goods.

Therefore, Productivity= Output/Input

The output and input both can be measured in physical units or in financial terms depending on the organizational needs. Labor input is generally measured in physical units like number of operators employed, minutes, hours, days or months. Capital inputs like machines can also be measured in terms of time. In garment industry, productivity is measured in terms of number of garments produced per sewing machine per shift or per operator per shift.

There are three methods for the measurement of productivity as described below:-

- Physical productivity measurement method. It uses the quantity of output and input as data for calculation.

- Labor productivity=Volume of output/Volume of labor input
- Material Productivity=Volume of output/Volume of material input
- Machine Productivity=Volume of output/Volume of machine input
- Energy Productivity= Volume of output/Volume of energy input
- Total physical productivity=Total volume of outputs/Total volume of all inputs

2) Value productivity measurement method. It uses the value of outputs and inputs as data for calculation.

- Labor productivity=Value of output/Labor inputs
- Material Productivity=Value of output/Value of material inputs
- Capital Productivity=Value of output/Capital inputs
- Machine Productivity=Value of output/Value of machine input
- Energy Productivity= Value of output/Value of energy input
- Total physical productivity=Total value of outputs/Total value of all inputs

iii. Value-added productivity measurement method. This method uses the value of outputs and inputs as data for calculating, where the

Value added=Current income (before tax) +personal expenses + financial costs +rent +tax+ depreciation cost. This type of method is used where organization has diverse outputs or have expensive raw material and is as follows:-

- Labor productivity=Value Added/Labor inputs.
- Capital productivity=Value added/Capital (Bheda,2006)

Productivity acts as the basic yardstick of an organizational health and is one of the most popular metric in the industry. It is said to be high when more output is derived from the same input, or the same output is obtained from a less input (Kachru, 2007). This does give an indicative figure, but, one should refrain from comparing this figure from one factory to another unless both are producing the same garment (Ambastha, 2012).

B) **Efficiency:**

“Efficiency is doing things right while effectiveness is doing the right things.”

Peter Drucker (as cited in “Are You Doing …… Things?”, 2012)

It is the comparison of what is actually produced or performed with what can be achieved with the same consumption of resources (money, time, labor, etc.).Line efficiency is defined as “percentage utilization of available time” Formula for calculating efficiency is given below:-

Efficiency = SAM produced/Utilized minutes

SAM produced = Achieved production (Garment produced) X Standard minute value

Utilized minutes =Number of Operators X Number of working hours (Ambastha, 2012, p.32)

C) **Work in Progress (WIP):**

The key is to have minimal buffers, but design them for maximum protection."

Umble & Srikanth (1997) (as cited in Lean manufacturing quotes,n.d.)

Work in progress is a direct result of over production and waiting. Every imperfection in the system creates a requirement for the work in progress. Therefore, work in progress is also known as the mirror of the wastes that the system has. It means that the number of garment or parts made during production in the factory at any one time. WIP of garments is expressed in the number of pieces by simply recording daily production figures between each process and accumulating the difference between sequential processes (Gibson, 2008). It is the inventory that begins the manufacturing process and it is no longer included in raw materials inventory, but it is not yet a completed product. A buffer WIP in between the operations helps to overcome the problem like machine breakdown, and bottleneck operations (constraint to throughput that limits the volume of work that can be completed in a workday).It also helps in balancing the workflow. It can be measured in the whole factory, in a production line or between two operations in terms of number of pieces or number of minutes of workload. Formula for work in progress is given below:-

Work in Progress in line = Total number of pieces in the line (pieces) =Total number of pieces unloaded from the line- Total number of pieces loaded (Ambastha, 2012, p.26)

D) **Quality:**

"Quality is an endless journey: like walking towards the horizon-no matter How far you walk, it does not change where the horizon is." Bernard Fournier (as cited by Ho, 2002, p. 241)

In simple terms, quality can be interpreted as the "Customer's expressed and implied requirement which are met fully" (Bhatt & Raj, 2006, p.3).Dr. Shigeo Shingo devised a special formula for quality control as given below:-

Quality control= Poka-Yoke techniques to correct defects + Source inspection to prevent defects = Zero"

The concept of quality has changed over the last decade. Traditional definitions have focused on conformance to standards (Kachru, 2007). Quality is stated as 'the totality of features and characteristics of a product or service that bears on its ability to meet a stated or implied need'. It is 'fitness for use' and 'conformance to the requirement'. New definitions have emerged as 'providing extraordinary customer satisfaction' or 'achieving value entitlement' (Ho, 2002, p.5). It can be measured in different ways as follows:

I. Defects per hundred units (DHU):

It is the ratio of number of defects per lot or sample, expressed in percentage. It is possible that one garment may have more than one defect. Each defect is counted separately as every defect represents additional workload of repair and rework. This is a very important measure of quality on production floor and the analysis of this data can also highlight quality bottlenecks. Formula for calculation of defect hundred unit is given below:-

Defects per hundred unit = Number of defects found/Number of units inspected 100 (Ambastha, 2012, p.31).

II.Percentage defective level. It is the basic measure of quality percentage that most factories use at the end line and in the finishing department. It is also called defect percentage. This is calculated on hourly, daily, line wise or on complete order. Factories measure defect percentage on hourly basis to continuously monitor the quality. Lesser the defect percentage, the better is the quality performance. Formula for calculation of percentage defective level is given below:-

Percentage defective level= Total defective garments/ Total garments inspected X 100

2.5. LAYOUT DESIGN

Layout is one of the key decisions that determine the long-run efficiency of operations. Layout has numerous strategic implications because it establishes an organization's competitive priorities in regard to the capacity, processes, flexibility and cost as well as quality of work life, customer contact and image. An effective layout can help an organization to achieve a strategy that supports differentiation, low cost, or response (Heizer et al., 2000, p. 336).

The layout must consider how to achieve the following:

1. Higher utilization of space, equipment, and people.

2. Improved flow of information, material or people.

3. Improved employee morale and safer working conditions.

4. Improved customer/client interaction.

5. Flexibility (whatever the layout is now, it will need to change).

Summary:

This chapter briefly describes lean history, manufacturing tools and techniques for waste reduction and efficiency enhancement. Literature defines lean manufacturing, describes some lean tools (most relevant to this research), lean implementation strategy and key performance indicator for lean. The lean tools selected consist of cellular manufacturing, single piece flow, just in time (pull production), work standardization methods, continuous improvement process, and some other waste reduction tools. The chapter ends with lean implementation strategy and key performance indicators for lean tool. For adapting lean method we need to be clear about lean tools and techniques and how it can be used in process industries. To get better output from lean process lean tool should be implied on its own way. The preceding literature review suggests that JIT, Kanban, 5s approaches have been applied at some process facilities and good results have been reported. This literature review also suggests that what type of proceedings should be followed to implement lean manufacturing tools and how can we measure benefits of lean after implementing it.

In order to adapt lean manufacturing tools to the process industry, one needs to thoroughly examine different characteristics of the same and develop a systematic approach to best utilize these techniques at a process facility.

CHAPTER 3 : RESEARCH DESIGN

3.1. INTRODUCTION

This study is concerned with developing means for the identification, categorization and elimination of waste in a garments factory. This involves properly addressing practical issues that relates to waste defined in terms of lean manufacturing and relating them to relevant theories. Therefore the design of the research is important in order to achieve the objectives of this research. A case study was conducted in order to provide a real life experience and experimentation for this study.

This case study was conducted in a small, make to order (MTO) export-oriented garments industry. The plant chosen for case study had not applied any modern production system for waste reduction and hence justify the need of this research.

The research design was divided into four phases.

1. Reviewing literature for selecting area of work, generating problem statement and setting preliminary objectives.
2. Investigating and collecting data along with reviewing literature for selected topics.
3. Analyzing the collected data.
4. Providing solutions and recommendation according to findings.

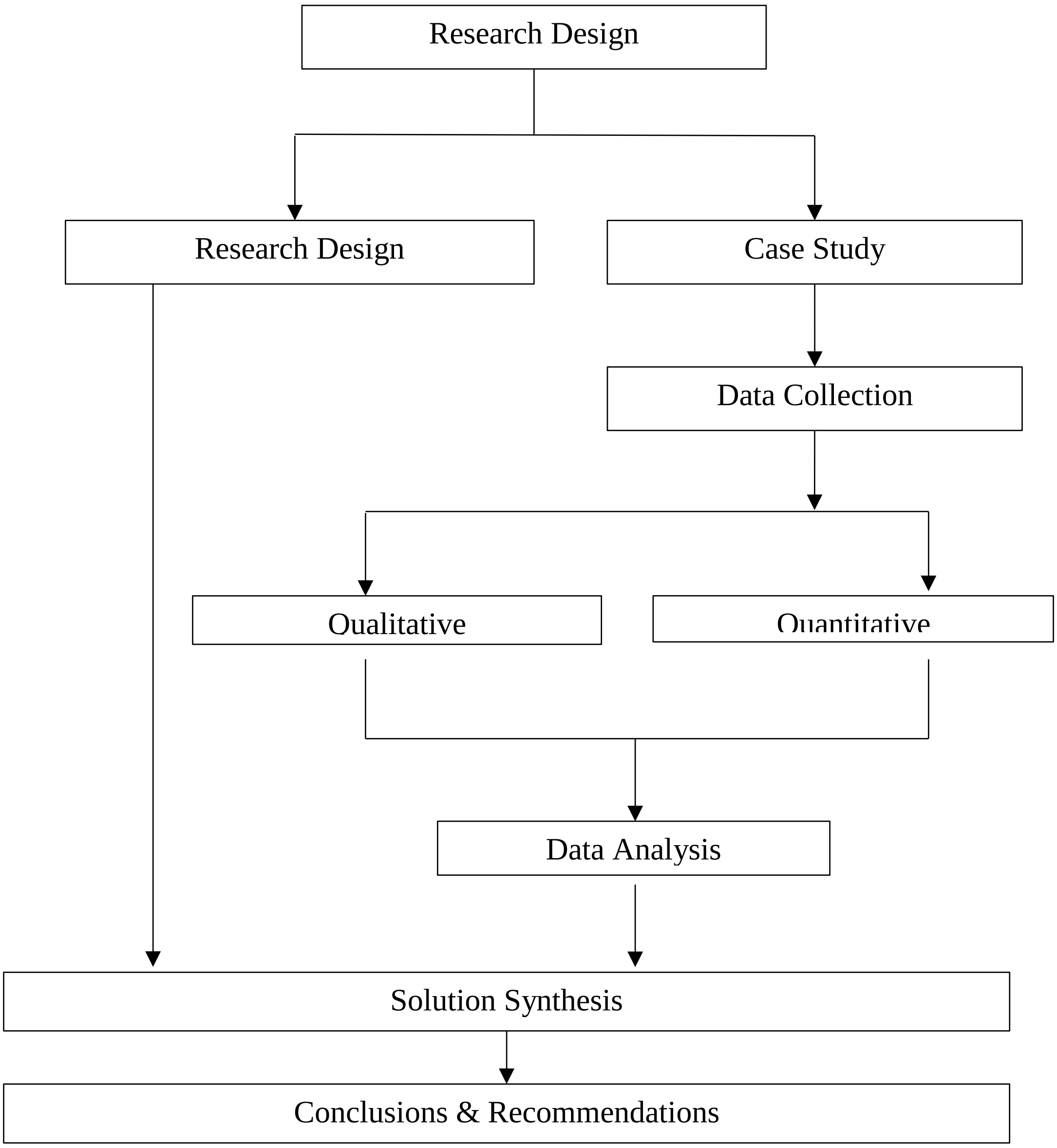

Figure 3.1 : Research Methodology Flow Chart

3.2. RESEARCH DESIGN

Phase One

The first stage was the research design phase. In order to identify a research need and finding a suitable research strategy, a review of literature was done. During this empirical enquiry, the strategy adopted was twofold comprising literature review and case study.

The literature review begins with examining the definitions of waste. Following this, different categories of wastes are studied in details. Then, literature review was done for realizing the scenario of waste in Bangladesh in general.

Single fieldwork case study was the research strategy. The usage of case study for testing theory is strongly advocated by Yin (2013). The fieldwork case study was to be done in a garments factory without implantation of modern manufacturing techniques like TQM, Lean manufacturing, JIT, TPM etc.

Phase Two

Mostly qualitative data was acquired from the fieldwork case study. The research method for collecting qualitative data comprised of semi-structured interviews, open interviews and observations. Using semi-structured interview, respondents were asked to describe the overall work process of their respective divisions and were asked about the current situation. Open interviews were used to see the insight of the garments factory. Observation was to inspect activities and nature of some processes without eliciting anyone's attention.

On the quantitative side, numerical data were collected. Time study was done at Cutting, Sewing and Finishing section.

Phase Three

At this stage, all data that were collected in the previous phase were cleaned and analyzed. This analysis phase took place my means of using different tools.

Phase Four

In this last phase, the interpretation and conclusion from qualitative and quantitative analysis of the available data was used to determine suitable solutions and provide guidelines and recommendations. Finally, conclusions of this research was drawn.

CHAPTER 4 : GARMENT MANUFACTURIGN PROCESS

4.1. INDUSTRY BACKGROUND

The research is conducted in garment industry whose major products are men's and women's knit wear in various order size. The factory consists of central cutting department, 7 independent stitching lines and central finishing (packing) section. Generally, operators are responsible for the quality of individual work, even after that there is quality check (audit) at the end of each section (department) so that there should not be any defective parts transferred from one section to another section. The overall production flow chart:

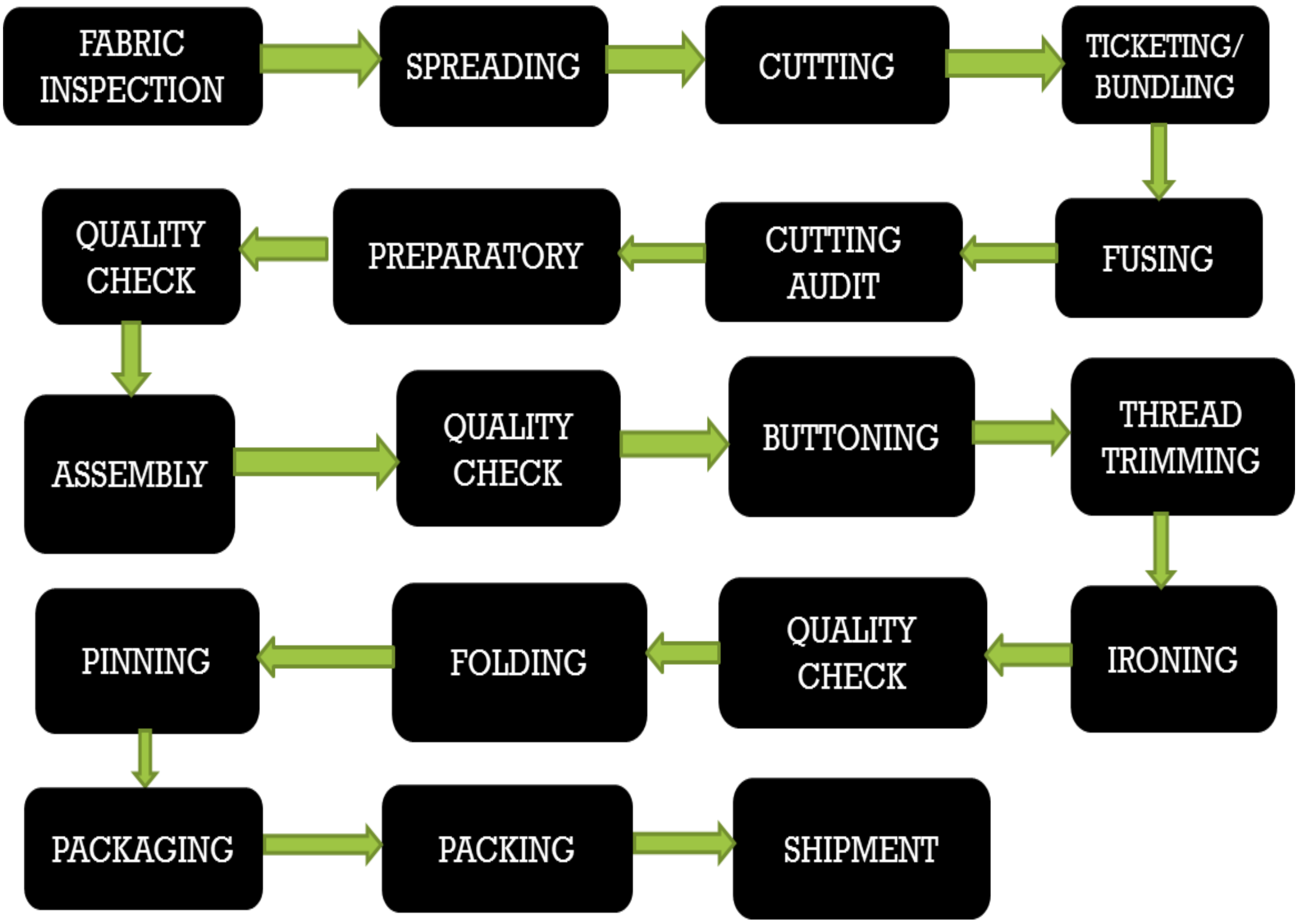

Figure 4.1: Garment production process flow chart

4.2. GARMENT MANUFACTURING PROCESS

Garment manufacturing process consists of series of different steps. These steps are broadly divided into two categories pre-production and production process. The preproduction process consists of designing the garment, pattern design, sample making, production pattern making, grading and marker making. Once the sample is approved for commercial production, final marker is made for cutting. The production process consists of cutting, stitching (preparatory and assembly) and finishing all these process are described here.

Cutting Section

In cutting section fabric rolls are inspected as per work order. These inspected rolls are segregated on two sides as the quality pass and fail. The pass rolls are taken into the next operation whereas the fail rolls returned to store with red tags on them. After this, depending upon the order, size and quantity ratio; the spreader spreads the fabric for cutting. Once cutting is done, bundles of approx. 20 to 30 pieces are made and fusing is done simultaneously. After fusing, all the parts are collected and put in the cutting audit. The bundles which pass the cutting audit are forwarded to the sewing section (i.e. preparatory section) whereas the fail bundles were re-worked for correction

Sewing section:

This section consists of 29 operations to make one full garment. The machines are kept in single straight line according to the operation sequence. The final garment from last operation is fully checked and corrected immediately for any defects. WIP movement inside the assembly is made by the help of work aids attached with each machine. The operator, after completing his (her) operation forwards the semi-finished garments to the next machine with the help of work aids attached to each machine. This process continues to the end of sewing line for each operation. At the same time the required parts from preparatory are carried up to the sewing section manually.

Finishing Section:

Finishing section consists of three several operations: Inspection, thread cleaning, ironing and final packing. But in some garment washing is needed, in this case washing should be done before buttoning to minimize damages in garments for longer washing cycles.

CHAPTER 5 : DATA COLLECTION & ANALYSIS

5.1. INTRODUCTION

A case study was conducted in a small, export-oriented make to order (MTO) garments factory. The plant chosen for case study had not applied any modern production system for waste reduction and hence justify the need of this research. The profile of the factory is given in the next section.

Following the profile of the plant, is the description of the plant's production process. The production process is presented in the form of a flow chart for easy understanding. The analysis of the data collected qualitatively and quantitatively is presented behind this section.

5.2. RESEARCH ON EXISTING OPERATION:

The research consists of conducting time and motion study of cutting, sewing and finishing operations. By doing this, operations will be standardized and production targets for each operation will be fixed. Secondly, batch processing is converted into single piece movement by the implication of new layout. This will serve the purpose of WIP reduction. For the ease of operator movement between machines. The worker multi-skilling is achieved by the concept of single piece flow production.

Finally, flexibility in production is achieved by reduced WIP and multi-skilled operators, who can work on multiple styles immediately.

Sewing Section:

Task time and man required existing sewing section is given below-

Process No	Process Name	Task time(s)	Man Required
1	Moon servicing	8	1
2	Moon attach (2)	60	2
3	Front shoulder shearing	11	1
4	Joint shoulder	19	1
5	Shoulder t/s	9	1
6	Neck joint	10	1
7	Back tape piping	10	1
8	Back tape two side tack	11	1
9	Back tape close with main label (2)	40	2
10	Neck front two side (2)	22	2
11	Front seafty tack	11	1
12	Placket binding (2)	50	2
13	Placket t/s (2)	26	2
14	Placket inside tack (2)	50	2
15	Placket box (2)	60	2
16	Placket end tack	30	1
17	Sleeve hem (2)	20	2
18	Flap make (4)	252	4
19	Flap servicing	14	1
20	Flap t/s (2)	56	2
21	Flap mouth side o/l	15	1
22	Flap attach with sleeve (2)	40	2
23	Side seam and binding end cut (2)	132	2
24	Sleeve tack and sleeve 1/4 tack	44	1
25	Bottom servicing	25	1
26	Bottom t/s (2)	42	2
27	Bottom hole (2)	74	2
28	Button stich (2)	76	2
29	Hanger loop attach (2)	38	2
	Helper	60	10
	TOTAL	1315 second	57

Table 5.1: Time and man required for existing layout

In existing process there are 29 operation where 57 operators are worked there. There are some operation where 2/3 operators work. Layout of existing sewing section is given below:

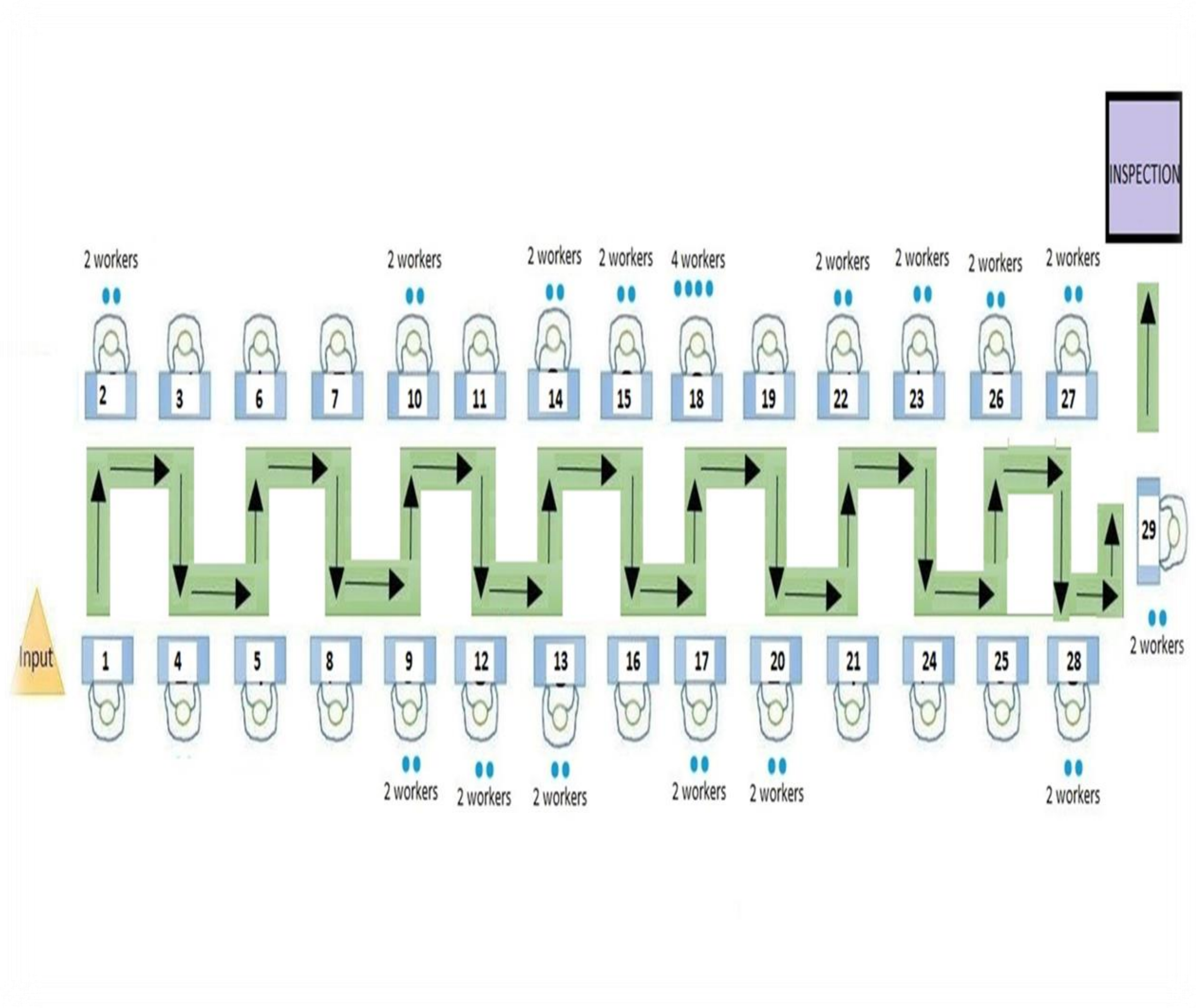

Figure 5.1: Layout of Existing Sewing section

5.3. CONDUCTING TIME STUDY

To calculate standard time for each operation, time study is conducted in the shop floor. To do this, the standard style 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 15 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.

5.4. CREATING U-SHAPE LAYOUT FOR SINGLE PIECE FLOW PRODUCTION:

In new U-shape layout some operations were removed from the existing one. First, the quality checking points were removed from the preparatory, because the operator who is producing garments should be aware of quality standards and should work accordingly. Recommended Layout is given below:

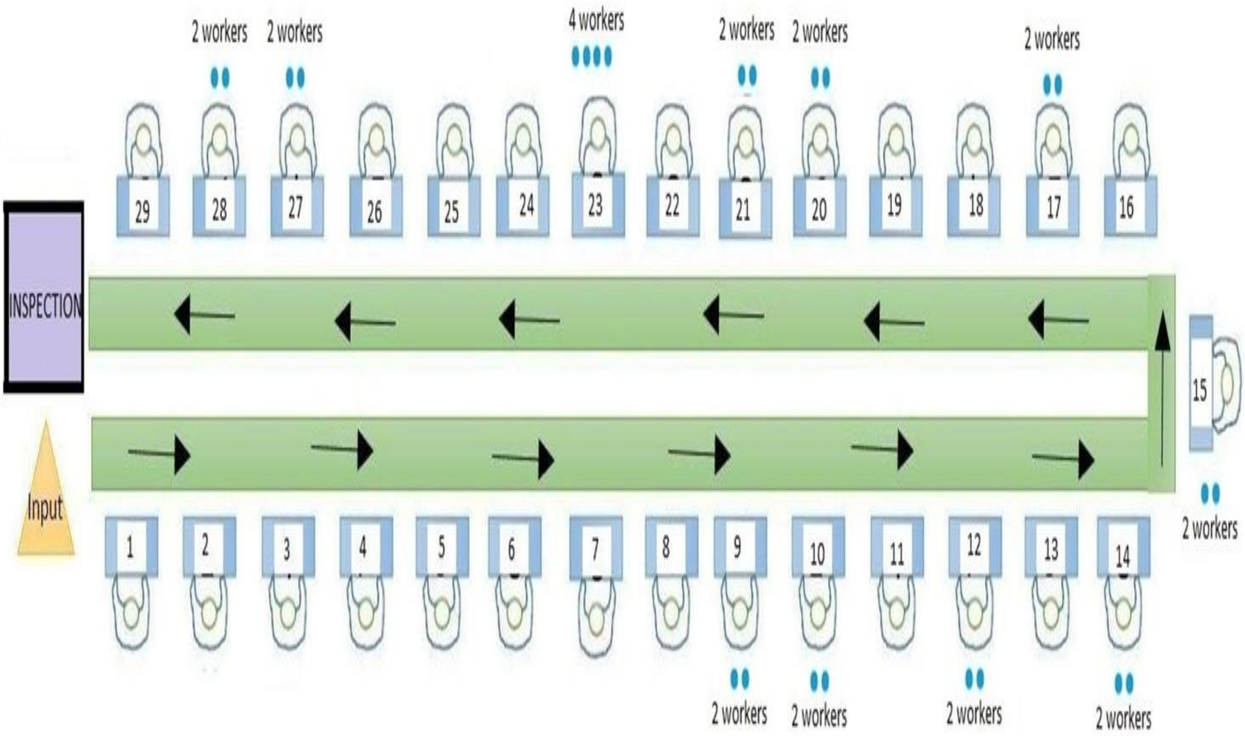

Figure 5.2: Recommended layout for sewing section

Time and Man required for recommended layout:

Process No	Process Name	Time (s)	Man Required
1	Moon servicing	8	1
2	Front shoulder shearing	11	1
3	Joint shoulder	19	1
4	Shoulder t/s	9	1
5	Neck joint	10	1
6	Back tape piping	10	1
7	Back tape two side tack	11	1
8	Front safety tack	11	1
9	Back tape close with main label (2)	40	2
10	Moon attach (2)	60	2
11	**Neck front two side (1)**	**22**	**1**
12	Placket binding (2)	50	2
13	Placket t/s (1)	26	1
14	Placket inside tack (2)	50	2
15	Placket box (2)	60	2
16	Placket end tack	30	1
17	**Sleeve hem (1)**	**20**	**1**
18	Flap servicing	14	1
19	Flap mouthside o/l	15	1
20	Flap attach with sleeve (2)	40	2
21	Side seam and binding end cut (2)	120	2
22	Sleeve tack and sleeve 1/4 tack	44	1
23	Flap make (4)	252	4
24	**Flap t/s (1)**	**56**	**1**
25	Bottom servicing	25	1
26	**Bottom t/s (1)**	**42**	**1**
27	Bottom hole (2)	74	2
28	Button stich (2)	76	2
29	**Hanger loop attach (1)**	**38**	**1**
	Helper	40	7
	TOTAL	1283	48

Table 5.2: Time and man required for recommended layout

Finishing and Packaging section:

Existing layout of Packaging section is given below:

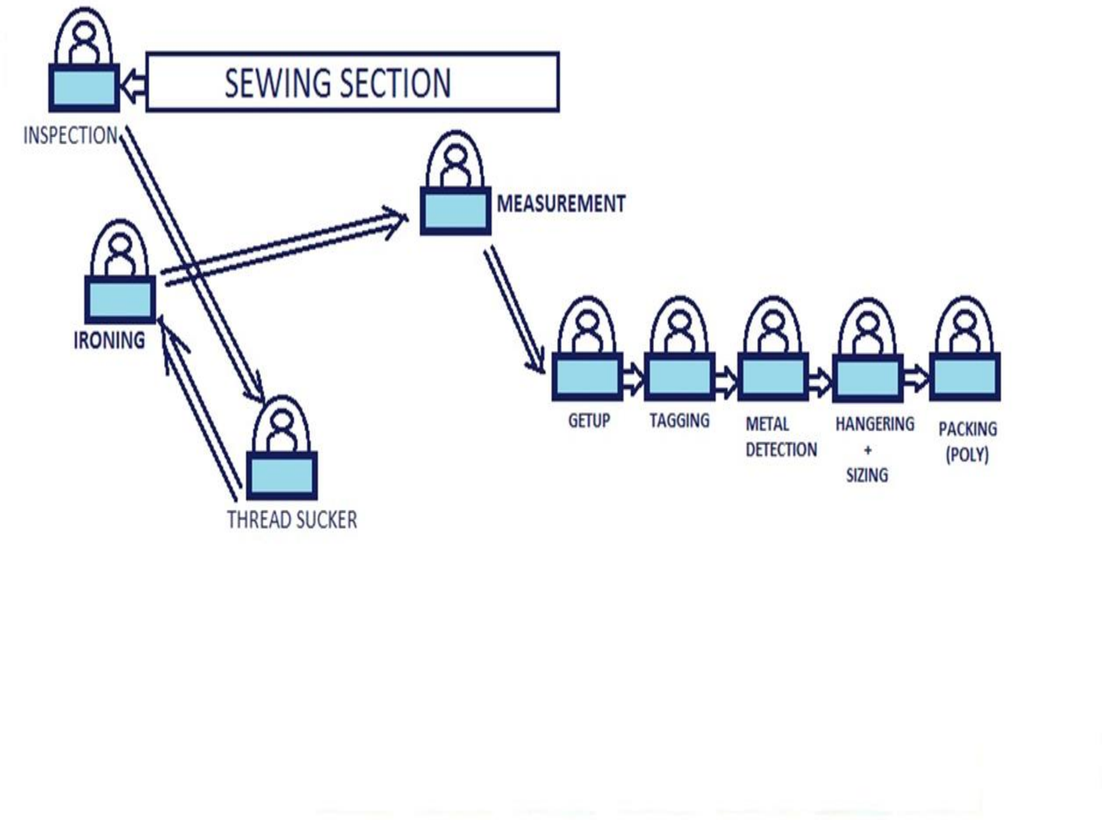

Figure 5.3: Existing Layout of finishing and packaging section

Time and man required for existing layout:

PROCESS NO	PROCESS NAME	TASK TIME	MAN REQUIRED
1	Inspection	38	1
2	Thread sucker	3	1
3	Ironing	24	1
4	Measurement	10	1
5	Getup	10	1
6	Tagging	7	1
7	Metal detection	3	1
8	Hungering + Sizing	12	1
9	Packing (Poly)	12	1
	Waiting time	20	
	TOTAL	139	9

Table 5.3: Time and man required for existing layout of finishing and packaging section.

Recommended single piece flow layout:

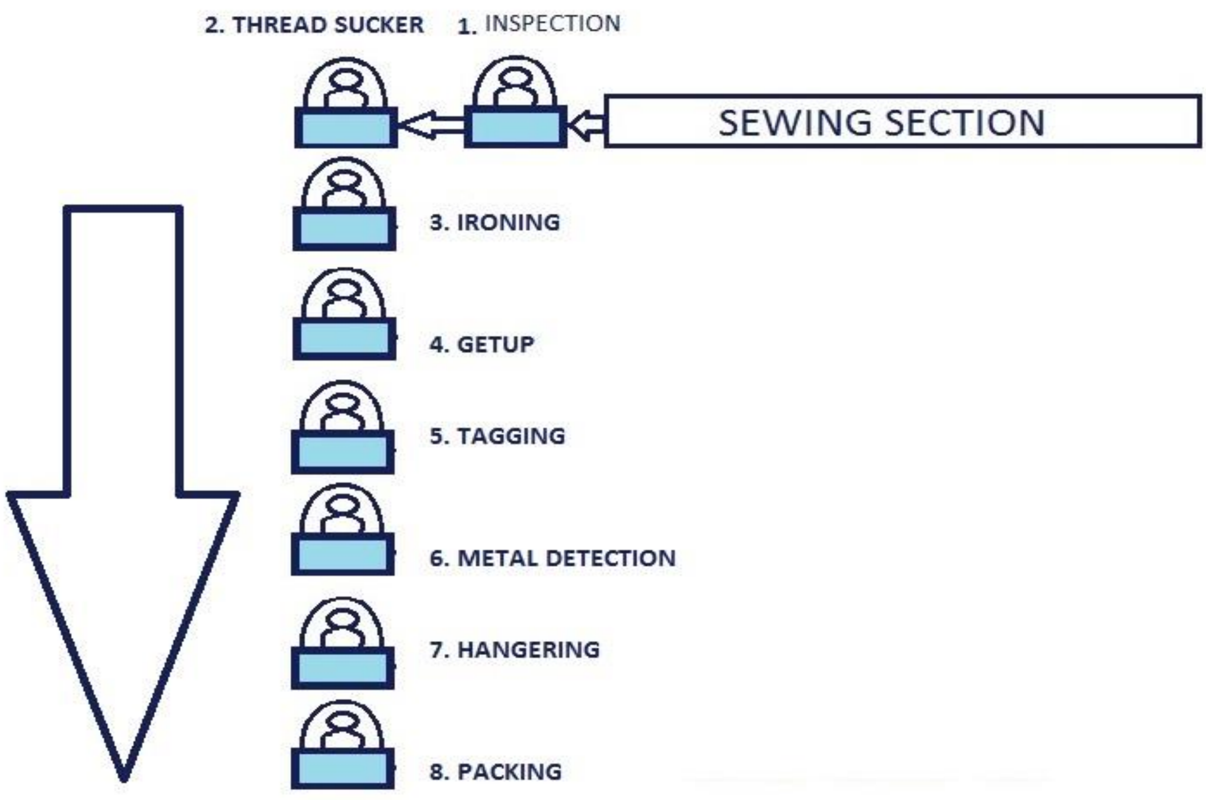

Figure 5.4: Recommended layout of finishing and packaging section.

Time and Man required for recommended layout:

PROCESS NO	PROCESS NAME	TASK TIME	MAN REQUIRED
1	Inspection	38	1
2	Thread sucker	3	1
3	Ironing	24	1
4	Measurement	10	1
5	Getup	10	1
6	Tagging	7	1
7	Metal detection	3	1
8	Hungering + Sizing	12	1
9	Packing (Poly)	12	1
	Waiting time	20	
	TOTAL	139	9

Table 5.4: Time and Man required for recommended layout of finishing and packaging section.

CHAPTER 6 : RESULT ANALYSES

Productivity Increase of Sewing Section:

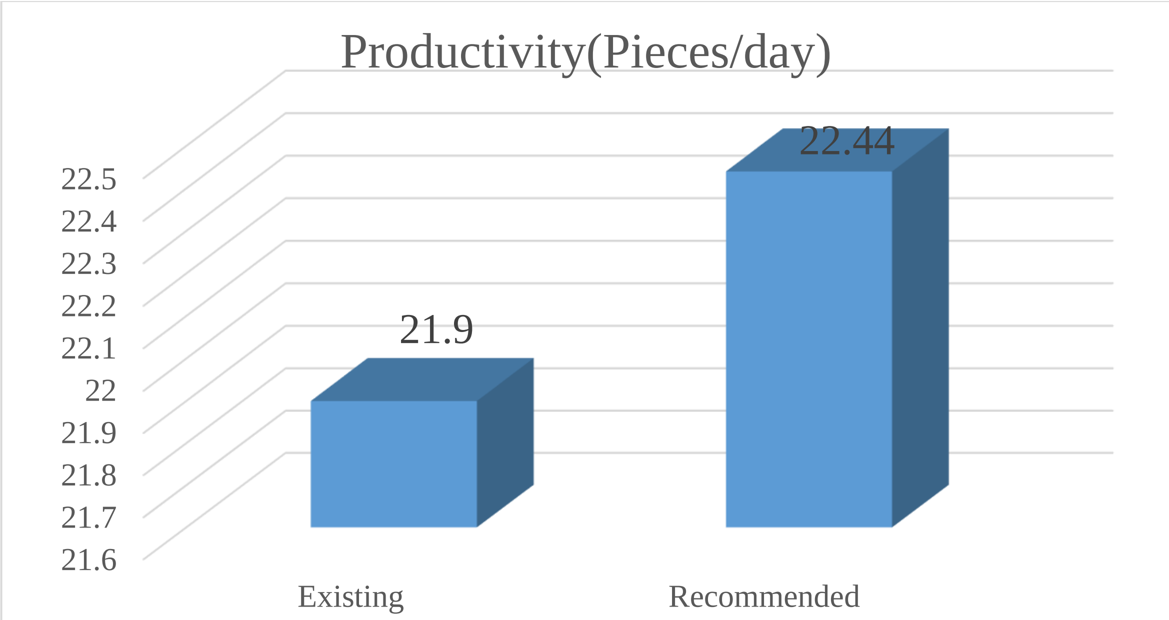

Figure 6.1: productivity increase in sewing section

Productivity increase in finishing and packaging section:

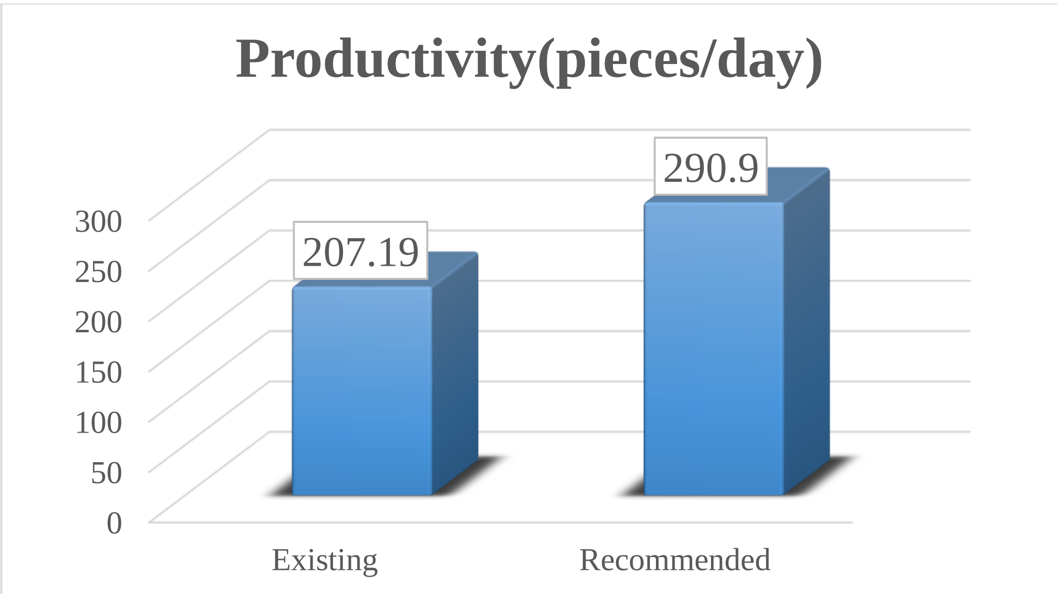

Figure 6.2: Productivity increase in finishing and packaging section

CHAPTER 7 : CONCLUSION

In this study the lean manufacturing tools and techniques were studied and used in case company (garment manufacturing industry). The problem of batch processing of existing company is addressed by using single piece movement of WIP. Thus by converting long assembly line into single piece flow production, the assumed worker multi-skilling seems effective as well as communication between operators is fast and accurate. The other benefits observed are the flexibility of style changeover and rework reduction. Thus the initial assumptions were solved by this study in the case company.

Firstly, the problem of low flexibility is eliminated by cellular manufacturing, because there is very low WIP inside the process, so the line can be changed immediately if needed. This helps to make different kinds of products in the same production line depending upon requirements, whereas in case of old production layout this cannot be implemented. Because when there is a need to change the style, the pile up of existing WIP takes time to finish before loading new style. In some cases it may take a few days also to clear it whereas the delivery time may pass out by that time. Although, in some exceptional cases, if the management tries to produce urgent orders in the existing line it is very difficult because the running WIP should be packed for future and new style will run in the line. This increases the chances of mixing trims (threads, labels, buttons etc.) of two different styles; which increases rework percentages.

Secondly, by following JIT for production and purchase of items reduces in house WIP which serves two things. First, the unnecessary handling of large amount of raw materials and finished goods is reduced which saves store people’s time as well as warehouse space. Secondly, the working capital requirement is also low because of small order size and fast rotation of fund due to short production lead time. In this way, small amount of money can generate significant profit.

Thirdly, all stitching operations were standardized by means of time and working procedures, this will help management to know the production target per line and can make the production plan before loading actual products in the shop floor. This advance knowledge of the production target helps to allocate production operators on different styles according to the delivery schedule.

Similarly, allocation of workers in different work cells is as per the standard operation time. This motivates operators towards their work, because everybody is given equal work load by this system. At the same time each operator inside the cell should have to work on multiple operations. This eliminates accusing to supervisors for inappropriate allocations of operators in difficult operations.

The other benefit of using single piece flow production is consistent output. In existing batch processing, if the critical operators were absent or there is any problem in machines of critical operations, the final output may drop drastically because there are few operators who can work on multiple jobs. Whereas there is no such problem in case of cellular layout, because there are lots of operators who can do multiple operations. This eliminates the problem of production hikes and lows. In this way, consistent output can be achieved in single piece flow production.

7.1. LIMITATIONS OF THE STUDY

This research is limited to the sewing section only, but the lean principles can be implemented in other areas of the shop floor also like cutting and finishing. The lean can bring lots of improvements in cutting area also. For example, even if the small amount of fabric can be saved by the implementation of lean it will save significant amount of money because fabric is the most expensive part of any garment. So the research can be extended to the other areas of the industries also. The line balancing is made as per manual calculation and assuming every operator knows at least three to four operations of respective cells, but operators may not necessarily know this much operation fluently. Thus while selecting operators for the particular cell it is necessary to check whether the operator is suitable for that work or not because the cell will perform best if all the group members have the same skill level. Thus, if there is a high skill gap, between operators of the same cell it is difficult to balance and will give reduced efficiency. The study compares different parameters of the existing production system and the recommended system for example production time, rework percentages, operator multiskilling, operation flexibility etc. but this study cannot correlate all these data to their equivalent financial values. It would be important to do this to attract top management’s attention, because the top management can decide whether to continue the lean or stop it by evaluating financial figures.

7.2. RECOMMENDATION FOR FUTURE RESEARCH

In this research, only sewing and finishing & packaging section of a women T-shirt are standardized due to time limitation and availability of running style during the time of research. But this work can be extended for any new style and data bank should be prepared for other styles also. This will minimize the duplication of work and it is easier to calculate standard time of new style by reallocation of some operations over existing.

In the research the idea of cellular manufacturing has been implemented to increase the productivity. This can be further improved by using the system of group incentive and reward systems. Similarly, the sitting operations have been converted into standing operations for the better movement of operators in between the machines, from the perspective of work balancing and uniform work load distribution. But it is necessary to understand whether this standing operation is appropriate from the ergonomic point of view or not. Similarly if there is any short (long) term health problem of standing operation or not. Because most of the workers were ladies and this mass consists of some pregnant women also. So this issue needs to be reviewed some other way also, rather than productivity point of view only.

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