# Lean Six Sigma Implementation in Textile Industry

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**Abstract** - *Lean and Six Sigma are two widely acknowledged business process improvement strategies available to organisations today for achieving dramatic results in cost, quality and time by focusing on process performance. Lean Sigma combines the variability reduction tools and techniques from Six Sigma with the waste and non-value added elimination tools and techniques from Lean Manufacturing, to generate savings to the bottom-line of an organisation. This paper proposes a Lean Sigma framework to reduce the defect occurring in the final product of textile industry. The proposed framework integrates Lean tools within Six Sigma DMAIC methodology to enhance the bottom-line results and win customer loyalty. This paper contributes towards the research upon a structured implementation of LSS in textile industry where it addresses the issues faced by previous works regarding LSS implementation in SMEs*

***Key Words***: Lean six sigma, DMAIC, Productivity, Quality

## 1. INTRODUCTION

Lean Six sigma is a combination of waste elimination and process improvement techniques Lean Manufacturing and Six Sigma. Lean Six Sigma (LSS) concept is the integration of two quality management concepts which are Lean Manufacturing and Six Sigma where by it attempts to increase the scope and size of improvements achieved by either concept alone. Together lean manufacturing and six sigma become more powerful and eliminates the cons of each approach. It applies the tools and techniques of both Lean manufacturing and six sigma. DMAIC are applied with lean environment to achieve bottom line results. Many researchers have been discussing about integrating Lean Manufacturing and Six Sigma to form Lean Six Sigma (LSS) as the latest quality management concept (Hoerl and Gardner 2010;Assarlind et al. 2012). The integration of both models will facilitate the achievement of zero defect manufacturing in organizations complemented by the elimination of non-value added activities which leads to greater results than either system can achieve alone (Snee 2010). This paper aims to provide a structured LSS framework which can be adopted in the SME label printing company in order to reduce waste and variation in their production; aiming to increase its productivity while reducing the cost of production.

## 2. LEAN SIX SIGMA METHODOLOGY

Lean Six Sigma (LSS) concept is the integration of two (2) quality management concepts which are Lean Manufacturing and Six Sigma whereby it attempts to increase the scope and size of improvements achieved by either concept alone. However, different individual and companies view LSS in different ways. Some would perceive LSS as a fully integrated system between Lean Manufacturing and Six Sigma while others would perceive LSS as two different concepts which is adapted in parallel (Assarlind et al. 2012). Moreover, the integration between the two quality management concepts varies between each integration as Assarlind et. al. (2012) points out that each integration may involve transferring of different tools, ideas and philosophies. This leads to many theories on how Lean and Six Sigma could be integrated. Some authors recommended that Six Sigma should lead the initiatives, with Lean tools added during the analysis phase of the initiatives while other authors recommend that Lean should be the backbone of the framework and Six Sigma is used to reduce and then eliminate the variation found. Lean Manufacturing focuses on waste reduction and non-value added activities in production (Womack et al. 1990) while Six Sigma focuses on process variation reduction with both concepts aiming to reduce waste. There is a need towards this integration in quality management as a solution provided via Lean Manufacturing concept would be of no use if the execution of the solution has high variation. The Six Sigma concept on the other hand would give too much focus in reduction of variation only leading to high risk of providing poor service due to long lead times even if the company are operating at Six Sigma level. Even though most would agree that there is a need for the integration of Lean and Six Sigma, most companies would prefer to implement both concepts in isolation (Smith 2003) or in parallel but this would lead to increase of projects and resources while causing conflicts of interest between the two quality management concepts (Bendell 2006). Implementation of both concepts in isolation too will not enable each concept to be adopted effectively as it is constraint by one another's needs in the organization. Lean and Six Sigma can be compatible whereby both are of quality management (Shah et al. 2008)

## 3. CASE STUDY

The developed LSS framework is verified in small scale textile industry. The textile industry produces various types of products like shirt, T-shirt, baba suit, Kurta etc. The management wants to implement LSS because the low productivity and produces high wastage; where it increases the lead time of the production and the cost of the product.

### 3.1 Lean Six Sigma Framework

#### 3.1.1 Phase 1: Define the problem - Data Collection Define Research Case

As quality plays a pivotal role in all aspects of life, reducing the number of defectives, wastes and lead time in textile industry is an important function. Textile industries in India are facing stiff competition from China, Sri Lanka and Bangladesh. At this critical juncture, it is paramount for the manufacturers to reduce defects in their products and become competitive. In order words, the production of the company should strive towards operating at six sigma level and aiming towards lean.

**Problem Statement**: The textile industries are suffering from higher defects rate in their products and wastes.

**Goal Statement:** To reduce the defect% to minimum level and there by improve quality, reduce wastes and increase productivity.

## 3.2.1 Phase 2: Measure

**3.2.1.1 Data Collection Period**:-The team prepared a systematic data collection plan of collecting data for a period of three months (from December 2016 to January 2017).The company manufactures variety of garment products like T-shirts, Kurta, Shirt and Baba Suit .One product, i.e., Executive Baba suit is inspected for defects since this was the critical product for the company as it had lot of demand and the profit margin for this particular product is high. Table.3.2.1 indicates the total number of shirts checked and the number of defectives.

**Table.3.2.1.1:** Inspection of Baba Suit

| Batch Number | Checked Pieces | Defective |
|---|---|---|
| 1 | 320 | 25 |
| 2 | 340 | 28 |
| 3 | 310 | 26 |
| 4 | 340 | 29 |
| 5 | 330 | 22 |
| 6 | 320 | 20 |
| 7 | 330 | 27 |
| 8 | 320 | 28 |
| 9 | 340 | 31 |
| 10 | 310 | 25 |
| 11 | 350 | 33 |
| 12 | 340 | 32 |
| | Total-3950 | Total-326 |

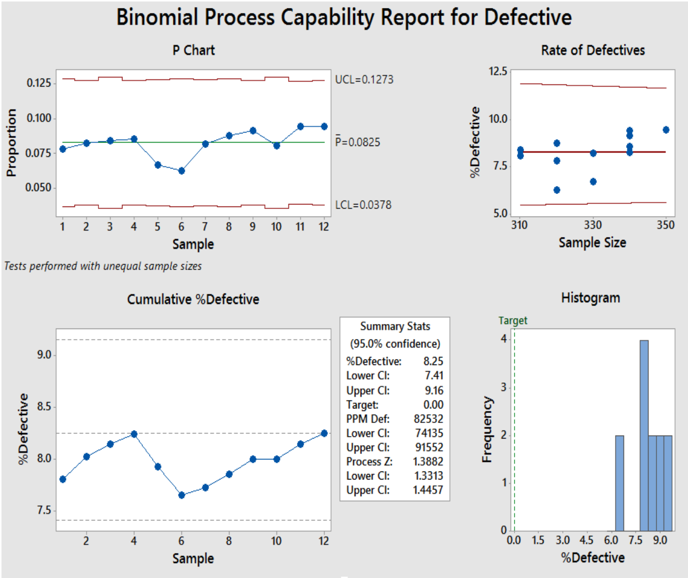



**Figure 3.3.1.1: Capability study**

**3.2.1.2 Capability Study:-**The analysis is carried out using Minitab Software. The results are evident from the Figure.3.2.2

**Table 3.2.1.2**

| Sr NO. | Total Checked | 3950 |
|---|---|---|
| 1 | Number of Defective | 326 |
| 2 | % Defective | 8.25 |
| 3 | dpmo | 82500 |
| 4 | Sigma | 2.9 |
| 5 | yield | 91.75 |

### 3.2.1.3 Current Line Balancing

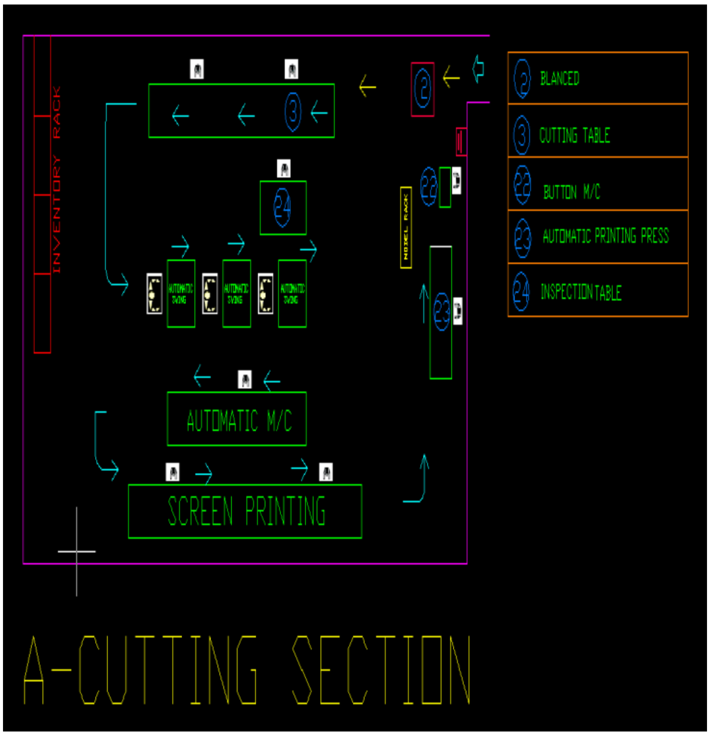
Sewing assembly line is selected. Table 3.2.1.3 shows the operations and time taken for the entire garment to produce. The line consists of 16 work stations.

**Table.3.2.1.3** Sewing Operations

| Task Description | Task Time (Min) |
|---|---|
| Main label tack | 0.51 |
| Shoulder attach | 0.51 |
| Shoulder placket attach | 0.84 |
| Shoulder placket tack | 0.84 |
| Neck binding | 0.50 |
| Shoulder placket tack | 0.65 |
| Sleeve gathering | 1.05 |
| Sleeve hemming | 0.69 |

| | |
|---|---|
| Sleeve hemming | 0.69 |
| Sleeve attach | 1.62 |
| Sleeve attach | 1.62 |
| Side seam close with wash care label | 1.35 |
| Side seam close | 0.60 |
| Side seam close both sides | 1.59 |
| Bottom hemming | 0.81 |
| Sleeve tack & Neck tack | 1.20 |

From the hourly production report, it was calculated that, for 10 hours production, the maximum production was 300pcs/day. So, the hourly sewing output would be 30pcs. A schematic scenario of present sewing section layout is given in the Figure 3.2.1.1. The number of manpower working in the current layout is 18.



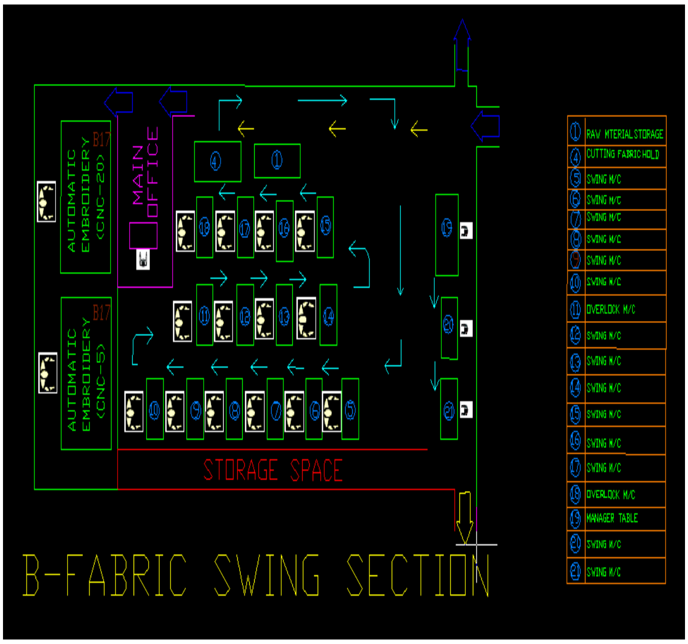




**Fig.3.2.1.1:** Show current scenario layout

**Drawbacks in the current scenario:-**

- Processes are not broken down properly.
- Inefficient use of manpower which is not uniformly distributed.
- High level of in-process inventory.
- Haphazard layout results huge amount of cross and back flows of garments.
- Low level of productivity than it should be with the existing level of resources.
- Cutting fabric (raw material) transfer from section "A" to "B" required more time.

**Assembly Line Balancing**

Assembly is a manufacturing process in which interchangeable parts are added in a sequential manner using certain material flow and design layouts. The line assembly is the efficient utilization of facilities with minimum material handling as well as easy production control. Since different workstations have different working capacity it is then important to apportionment the sequential work activities into workstations in order to achieve a high utilization of labour, equipment, and time. The Assembly Line Balancing in sewing line assigns a given set of tasks to an ordered set of work stations and ensures that the precedence constraints are satisfied while the given performance measure is optimized. The line balancing process is performed first by calculating certain parameters such as the Customer Takt Time, Line balancing efficiency etc.

***Customer Takt Time***

Customer Takt time is defined as the ratio between the planned operating time per to the customer demand.

Customer Takt Time = available working time/ daily demand

= 90 seconds/piece

### 3.2.3 Phase 3: Analyse

In this phase data collected in the previous phase have been analysed in order to identify the root cause(s) or source(s) of defects. Frequency of defects were also measured & recorded (Table -3.2.3.1). The tools used in this phase were Pareto chart and Cause & effect diagram

**Table 3.2.3.1** Types of defects

| Sr. No. | Defects | Occurrence | %Occurrence |
|---|---|---|---|
| 1 | Front and Back Shoulder | 18 | 9.1 |
| 2 | Misplaced Printing | 14 | 7.1 |
| 3 | Rundown | 73 | 36.9 |
| 4 | Broken | 45 | 22.7 |
| 5 | Labels and Button | 18 | 9.1 |
| 6 | Oil Strains | 12 | 6.1 |
| 7 | Embroidery | 8 | 4 |
| 8 | Different Shades | 10 | 5.1 |
| | | 201 | |

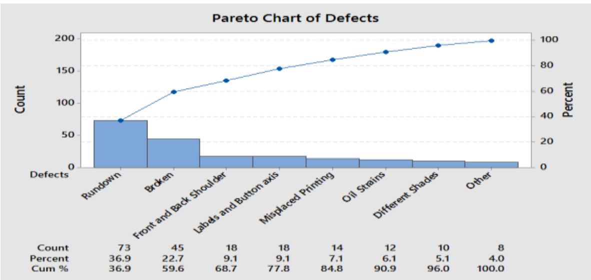



**Figure 3.3.1:Pareto chart of Defects**

The major types of defects were identified through Pareto Chart which is shown in fig 3.3.1.The chart was constructed using MiniTab software.The major defects from Pareto Chart is considered for analysis and the defects are listed in Table: 3.2.3.2

**Table 3.2.3.2**

| SR NO | Defect Type |
|---|---|
| 1 | Rundown |
| 2 | Broken |
| 3 | Front and Back Shoulder |
| 4 | Labels and Button axis |
| 5 | Mispalced Printing |

Through brainstorming with the shop supervisors, end line quality inspector all potential causes were identified. The identified causes are given in Figure 3.2.3.1 Cause & Effect diagram. Only the major types of defects are considered for the cause and effect diagram. This diagram is constructed using MiniTab.

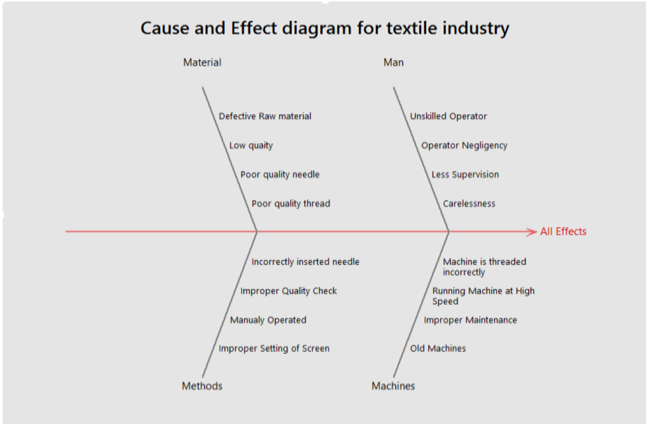



**Figure 3.2.3.1** Cause and Effect Diagram for Textile Industry

### 3.2.4 Improve Phase

Through discussions with the managers and supervisors the following remedial actions were implemented for the each cause which is indicated in the Table.3.2.4.1

**Table3.2.4.1:** Defects and Remedial action

| Defects | Action |
|---|---|
| **Rundown** | The operators are trained to control the speed of the machine. |
| **Broken** | The broken threads are due to the fabric and the initial swatch test is tightened so that wrong fabric does not roll out. |
| **Front and Back shoulder** | The operator are trained to increases accuracy in joining the front and back shoulder. |
| **Labels and Button Axis** | The operator are trained to minimize the error in attachments of labels and button. |
| **Misplaced printing** | The operator are trained for the placing the screen on table and printing the T- shirt with an accuracy |

Based on the Cause and Effect diagram as shown in fig 3.2.4.1, the operators are trained in all aspects of their job and after the remedial actions are taken, the products are checked for defects. The details are indicated in Table.3.2.4.2

**Table: 3.2.4.2** Inspection of Baba Suit

| Batch No. | Checked Pieces | Defective |
|---|---|---|
| 1 | 330 | 18 |
| 2 | 310 | 15 |
| 3 | 340 | 20 |
| 4 | 340 | 22 |
| 5 | 310 | 16 |
| 6 | 330 | 18 |
| 7 | 350 | 19 |
| 8 | 310 | 19 |
| 9 | 340 | 23 |
| 10 | 330 | 17 |
| 11 | 320 | 15 |
| 12 | 340 | 20 |
| | Total-3950 | 222 |

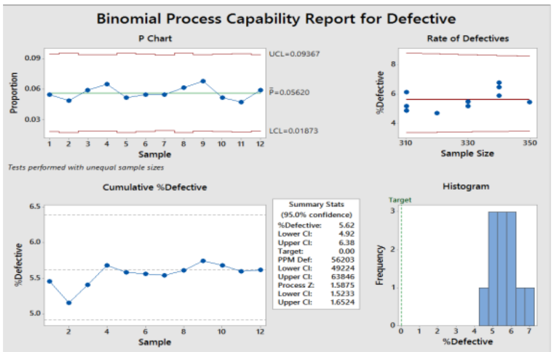



**Fig 3.2.4.1** Capability study

The results are indicating that the sigma level goes up 2.9 to 3.1 and % of defectives has been reduced to 2.63%.

**3.2.4.1 Capability Study:-**The analysis is carried out using Minitab Software. The results are evident from the Figure.3.2.2

**Table 3.2.4.1.1**

| Sr NO. | Total Checked | |
|---|---|---|
| 1 | Number of Defective | 222 |
| 2 | % Defective | 5.62 |
| 3 | dpmo | 56200 |
| 4 | Sigma | 2.9 |
| 5 | yield | 94.38 |

**Largest Candidate Rule Algorithm (LCR)**

Known as the main aim of the Line Balance is to distribute the total workload on the assembly line as evenly as possible, despite the reality in which it is impossible to obtain a perfect line balance among the workers. It is then the role of line balance efficiency which is related to the differences in minimum rational work element time and the precedence constraints between the elements. The Largest Candidate Rule (LCR) accounts for work elements to be arranged in a descending order (with reference to the station time and work elements) to each station value which is not exceeding the allowable preceded. Table 3.2.4.2 depicts the precedence relationship and immediate predecessor between these tasks.

**Table 3.2.4.2. Task Precedence Relations and Immediate Predecessors**

| Task Description | Task Time (Min) | Immediate Predecessor(s) |
|---|---|---|
| Main label tack | 0.51 | - |
| Shoulder attach | 0.51 | 1 |
| Shoulder placket attach | 0.84 | 2 |
| Shoulder placket tack | 0.84 | 3 |
| Neck binding | 0.50 | 4 |
| Shoulder placket tack | 0.65 | 5 |
| Sleeve gathering | 1.05 | - |
| Sleeve hemming | 0.69 | 7 |
| Sleeve attach | 1.62 | 8,6 |
| Sleeve attach | 1.62 | 9 |
| Side seam close with wash care label | 1.35 | 10 |
| Side seam close | 0.60 | 10 |
| Side seam close both sides | 1.59 | 12,11 |
| Bottom hemming | 0.81 | 13 |
| Sleeve tack & Neck tack | 1.20 | 13 |

A task can be done by machines of different types and also by operators of different labor types. The processing time of any task is a variable determined by the skill level and efficiency of the operator. The work is divided in such a way that each operator gets equal work load. The conceptual framework proposed and briefly summarized in the preceding section serves the purpose of demonstrating how the proposed framework would work.

Table 3.2.4.3 depicts the work elements arranged according to stations. Then figure 3.2.4.2 shows the Operator line balancing chart after the line balancing process and the operator cycle times have been increased by providing the workers with extra operations and the idle times of the workers was reduced and to improve the productivity. Thus the operation in the line assembly which was handled by 18 workers is now reduced by 40 % to 12 workers.

Line balancing Efficiency (To-be) = 85.5%

**Table.3.2.4.3** Work elements assigned to stations

| Station | Task Assigned | Task Description | Task Time (min) |
|---|---|---|---|
| 1 | 7 | Sleeve gathering | 0.51 |
| | 1 | Main label tack | 0.51 |
| 2 | 8 | Sleeve hemming | 0.84 |
| 3 | 2 | Shoulder attach | 0.84 |
| 4 | 3 | Shoulder placket attach | 0.50 |
| | 4 | Shoulder placket tack | 0.65 |
| 5 | 5 | Neck binding | 1.05 |
| | 6 | Shoulder placket tack | 0.69 |
| 6 | 9 | Sleeve attach ( Right ) | 0.69 |
| | 10 | Sleeve attach ( Left ) | 1.62 |
| 7 | 12 | Side seam close with wash care label | 1.62 |
| 8 | 11 | Side seam close | 1.35 |
| 9 | 13 | Bottom hemming | 0.60 |
| 10 | 14 | Sleeve tack | 1.59 |
| 11 | 15 | Neck tack | 0.81 |

The manufacturing line is redesigned to form a lean line with an optimum layout which results primarily in the productivity improvement. The area of the current layout was determined and the rearrangement of the machines in the layout so that there is a decrease in the area. 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. Two workers iron the garments and pass to packing section were two workers in front of them who inspects the ironing, attach tags at required places and performs polying and cartooning. The layouts of the current and the proposed lean line are shown in the figure 3.2.4.2.

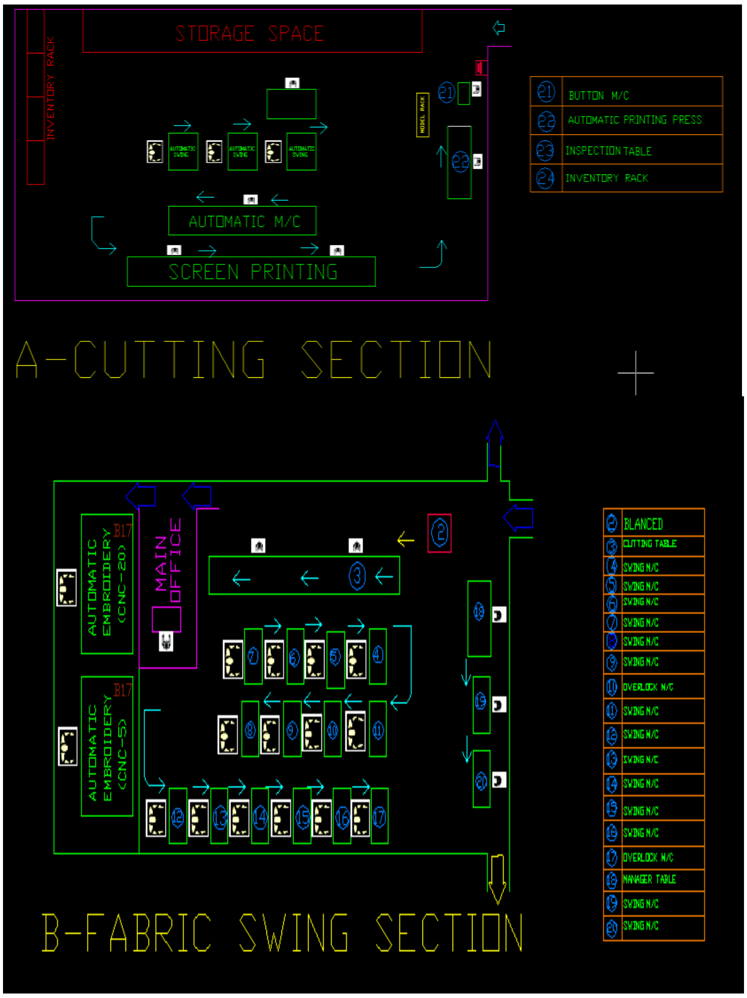



**Fig 3.2.4.2:** Future state layout

### 3.2.5 Control Phase

After implementation of the solutions, the progressive outcomes were shared with owner and managers of the textile industry. The defects are identified and reduced. Now the challenge is to withstand the progresses and refining the system continuously. For this purpose a control plan is prepared.

#### 3.2.5.1 Control Plan

The management needs to take initiative on the following obligatory activities to withstand the progresses after Six Sigma implementation.

- The operators of textile industry must be given training on a continuous basis on the issue of quality.
- The management should give incentives for high quality performance.
- Always use good quality threads, needles and other garment accessories.
- The focus should be on preventing defects rather than correcting defects.
- The organization should develop a proper Quality Management System.

## 4. CONCLUSION

Minimizing defect is very important for ensuring the quality of products. Manufacturing the quality product is mandatory to sustain in this global competitive market. This study follows lean six sigma in order to find out the major defects, their root causes and then suggests logical solutions in order to minimize those defects. This study found that the Textile factory was operating at a defect percentage of 8.25. After implementing the lean six sigma the percentage defective is reduced to 2.63. There is also found a significant improvement of the Sigma level of the industry. It is shifted from 2.9 to 3.1. The problem of batch processing of existing is addressed by using single piece movement of WIP. Thus by converting long assembly line into work cells, 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 rework reduction and online packing. As discussed above the Production time of the garment has been reduced from 5.18 to 3.90 minutes.The same approach can be utilized to other products of the company which will reduce lots of defects. So, this method is very effective to the minimization of defects. As the minimization of defects is a continuous process further implementation of this methodology will help the company enjoying more reduction on defect rate and improvement on productivity. Many medium scale textile industries in India need to enhance the awareness of lean six sigma concepts and this implementation will trigger a positive wave across the textile industries and become more competitive.

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