ENHANCING THE OPERATIONAL EFFECTIVENESS OF SEWING SEGMENT IN GARMENT INDUSTRY BY DMAIC APPROACH.

Varun[1], S.Appaiah[2], Chethan kumar.C.S [3]

[1] *PG Scholar, IEM Department, MSRIT Bangaluru, Karnataka, India*
[2] *Associate professor, IEM Department, MSRIT Bangaluru, Karnataka, India*
[3] *Associate professor, IEM Department, MSRIT Bangaluru, Karnataka, India*

---***---

Abstract - *For any industry the production and quality management or wastages reductions have major impingement on overall factory economy. This work discusses the quality improvement of garment industry by applying Pareto analysis and cause and effect diagram. The main purpose of the work is to reduce the defects, which will also minimize the rejection and reworks rate .This work provides the guidelines for the betterment and control of wastes in garment industry for shorts and pants by using six sigma methodology. The DMAIC methodology is introduced and implemented in the Karle garment industry, by that major factor for the defects are determined, along with that the corrective actions are performed, and the defective % is compared before and after the implementation of corrective actions, where the sigma level has been increased from 2.8 to 3.38.*

Key Words: Defects, DMAIC, Garment industry, Rework, etc...

1. INTRODUCTION

The worldwide economic condition changing in a rapid motion, generally in an industries more attention is given on a profit margin, customer demand for high quality products and improved productivity. In garment manufacturing, it is regular to watch lots of rejected garments after shipment. These non-repairable defects may occurs due to the low quality raw materials or incorrect process or operators casual behaviors'. In this modern day of manufacturing, due to high competition nature of the market, different companies have started to seek about different approaches and practices to reduce the defect percentage. Pareto Analysis helps to identify different defects and classify them according to their implication. These defects often lead to the rejection of raw materials. To identify the possible root causes for rejection, Cause-Effect Diagram is also a very useful tool. It helps to sort, and display causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome and thus to spot the attainable root causes.

2. LITERATURE REVIEW

Pratima Mishra and Rajiv Kumar Sharma [1] in their study proposed a hybrid framework (suppliers, inputs, process, output and customers define, measure, analyze, improve and control (SIPOC+DMAIC)) aimed to improving supply chain management (SCM) process dimensions in a supply chain (SC) network. Although process dimensions related to SCM are critical to organization competitiveness, research so far has tended to focus on supply chain operations and reference model, balanced scorecard, total quality management, activity-based costing, just in time, etc., but in literature hardly any description of the SIPOC-DMAIC model to improve SCM process performance is provided. The use of statistics in DMAIC provides better insight into the process performance, and process control. Based upon the critical review of literature, process dimensions (average outgoing quality limit (AOQL), average outgoing quality (AOQ), process Z, defect per million opportunity) critical to SCM performance were identified.
A framework consisting of three phases, i.e., design, implementation and results has been conceptualized and a case from paint industry is investigated. Implementation framework makes use of SIPOC model and Six Sigma DMAIC methodology. It was observed from the results that selection of appropriate strategies for improving process performance based upon experiences and use of statistical tools by cross functional teams with an effective coordination, guarantees success. Metrics such as AOQL shows the maximum worst possible defective or defect rate for the AOQ. Process Z helps to know about sigma capability of the process.

Chethan Kumar.C.S, N.V.R Naidu, k.Ravindranath advocated the significance of implementing DMAIC methodology to control defects in garments industry.[2]

Chethan Kumar.C.S, N.V.R Naidu, k.Ravindranath illustrated the importance of using the lean principles to eliminate non value added wastes in garment industry.[5]

Ploytip Jirasukprasert et.al [3] used six sigma and DMAIC application for the reduction of defects in a rubber gloves manufacturing process. The Six Sigma's problem-solving

Methodology DMAIC has been one of the several techniques used by organizations to improve the quality of their products and services. This paper aims to demonstrate the empirical applications of Six Sigma and DMAIC to reduce product defects within a rubber gloves manufacturing organization. The paper follows the DMAIC methodology to systematically identify the root cause of defects and provide a solution to reduce/eliminate them. In particular, the design of experiments, hypothesis testing and two-way analysis of variance techniques were combined to statistically determine whether two key process variables, oven's temperature and conveyor's speed, had an impact on the number of defects produced, as well as to define their optimum values needed to reduce/eliminate the defects. This study presents an industrial case which demonstrates how the application of Six Sigma and DMAIC can help the manufacturing organizations to achieve quality improvements in their processes and thus provide to their search for process excellence.
The analysis from employing Six Sigma and DMAIC indicated that the oven's temperature and conveyor's speed influenced the amount of defective gloves produced. After optimizing these two process variables, a reduction of about 50 per cent in the “leaking” gloves defect was achieved, which helped the organization studied to reduce its defects per million opportunities from 195,095 to 83,750 and thus improve its sigma level from 2.4 to 2.9.

3. DMAIC METHODOLOGY

3.1 Data collection

The Data sheets were gathered for garment item i.e. shorts and pants for the duration of three months. These data had been taken by the end line quality inspectors’ record books from different production lines of sewing section of the garments. A total of 7870 Shorts and pants were checked and 1218 pieces were found defective. The Studies have recognized that how quality management can be employed in lean manufacturing to enhance the performance of various issues within the whole business processes of varied industries. This project work adds to an application guideline for the assessment, improvement, and control of wastes in garment industry using six-sigma improvement methodology. Improvements in the quality of processes lead to cost reductions as well as service enhancements. An endeavor is made to introduce and implement DMAIC methodology in garment industry.

3.2 Six sigma based DMAIC methodology

DMAIC (an abbreviation for Define, Measure, Analyze, Improve and Control) refers to the data-driven improvement cycle used for improving, optimizing and stabilizing the business processes and designs. The DMAIC improvement cycle is the core tool used to drive Six Sigma projects. The steps adopted in DMAIC are as follows:

1) Define phase:
The principle motivation behind this stride is to plainly explain the business issue, goal, potential resources, project scope and high-level project timeline. This information is typically captured within project charter document. Seek to clarify facts, set objectives and form the project team.
The following are to be defined:
Study Case: The quality assumes a critical part in all parts of the life; whereas decreasing the quantity of defectives in piece of clothing industry is an essential function. Garment industries in India are facing stiff competition from Sri Lanka, Bangladesh and China. At this critical juncture, it is a paramount for the manufacturers to reduce defects in their products and become competitive.
The problem statement- The garment industries are suffering from high rate of rejections of their products.
Goal statement- To reduce the total defect% to minimum level and there by improve quality reduce the wastes and to increase the productivity.
Team-1 member

Voice of the customer (VOC) and Critical to Quality (CTQs) - what are the most essential process outputs? - Defective % of shorts and pants.

SIPOC: It is the process map that includes Suppliers, Inputs, Process, Outputs and Customers. Quality is judged based on the output of a process. The SIPOC Table is developed to identify the requirements of the customers and other processes used for the manufacturing of garments. Table shows the SIPOC flow of the selected factory.

Suppliers	Inputs	
	Description	Requirements
TIRUPPUR	MATERIALS	MACHINERY
BANGALURU		THREADS
MADURAI		BUTTONS
		NEEDLES
		UNSTITCHED CLOTH
		FABRICS IN ROLL FORM
		ZIPPERS,HANGRERS,SNAPS, ETC.

Process
RECEIVING MATERIALS
STORING AND SORTING
INSPECTION
CUTTING
SEWING
WASHING
PRESSING
PACKAGING

Outputs		Customers
Description	Requirements	
ORDER FORM BUYERS	SHORTS	ANN TAYLOR
	PANTS	POLO
	SHIRTS	EDDIE BAUER
		CWC

Fig -1: SIPOC flow at garment industry.

2) Measure phase:

The purpose of this step is to objectively establish current baselines as the basis for improvement. This is a data collection step, the purpose of which is to establish process performance baselines. The performance metric baselines (s) from the Measure phase will be compared to the performance metric at the conclusion of the project to determine objectively whether significant improvement has been made. Good data is at the heart of the DMAIC process:
-Identify the gap between current and required performance.

-Collect data to create a process performance capability baseline for the project metric, that is, the process Y(s) (there may be more than one output).
-Assess the measurement system.
-Establish a high level process flow baseline.
During this phase, after discussions with the section manager and line supervisors' data is collected individually.
1. Data collection period:

Table -1: Data collection period

Duration	Variables (CTQ)	responsibility
November 2014 -April 2015	Total checked defectives	Individual

2.The company manufactures variety of garment products like shirts, shorts, pants and Jackets, skirts etc. some of the products are Executive Shorts and pants are inspected for defects since this was the critical product for the company as they had lot of demand and the profit margin for these particular products are high. Table. Indicates the total number of shorts and pants checked and the number of defectives.

Table -2: Details of the checked pieces and defectives

Sl. no	Batch number	Checked pieces	Defectives
1	1	800	83
2	2	750	79
3	3	375	50
4	4	375	51
5	5	425	47
6	6	600	98
7	7	160	39
8	8	210	35
9	9	350	53
10	10	573	74
11	11	615	69
12	12	872	138
13	13	590	95
14	14	650	156
15	15	900	151
	Total	7870	1218

3. Capability study
The capability of a process should be constantly measured and analyzed. Capability analysis can help you answer following questions:
-Is the process meeting customer specifications?
-How will the process perform in the future?
-Are improvements needed in the process?
-Have you sustained these improvements, or has the process regressed to its previous unimproved state?
Analyze process capability with capability indices such as Cp, Pp, Cpk, and Ppk.
This analysis is carried out by using Minitab Software. The results are evident from the Figure.

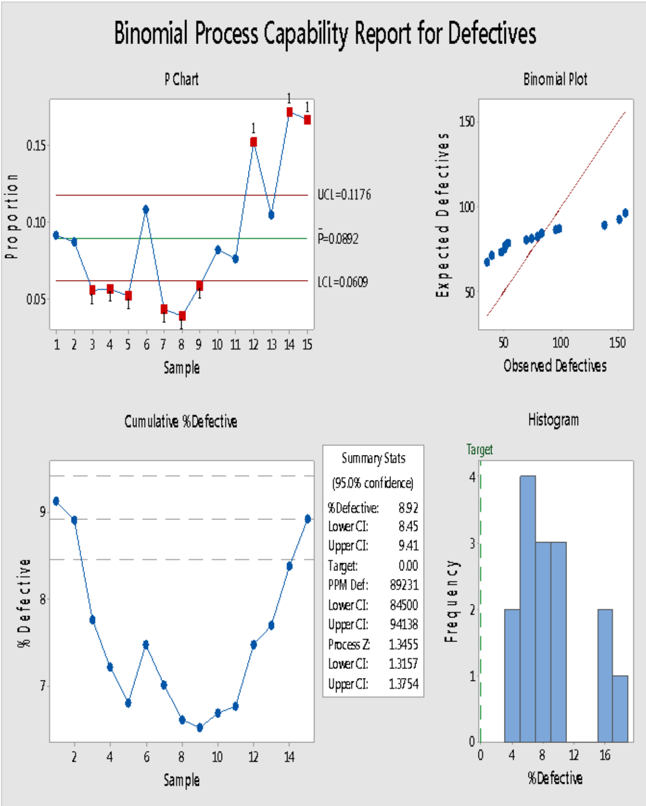

Chart -1: Capability study.

Analysis-The outcome is given in the table and showing %defectives is 8.92%

Table -3: Calculation of Dpmo

Sl. no	Total checked	7870
1	No. of defectives	1218
2	% defectives	8.92%
3	Dpmo	89231.0023
4	sigma	2.8
5	Dpo	0.08923

3) Analyze Phase:
The main goal of the analyze phase is to go through the data to find out the root causes of the problems and seek improvement opportunities.

Table -4: Details of percentage occurrence

Sl. No	Defects	Occurrence	Percentage (%) occurrence
1	W/B Raw Edge	176	14.3%
2	Side Seam Raw Edge	57	4.67%
3	Pkt Raw Edge	285	23.3%
4	Back Raw Edge	354	29.07%
5	Bar Tack Missing	159	13.05%
6	Side Seam Kacha Ulta	123	10.09%
7	Btm Stitch Missing	34	2.79%
8	Others	30	2.46%
	total	1218	

Pareto Chart: This Pareto Chart is used to graphically summarize and also display the contribution of each type of defects. It is a bar graph, the lengths of the bars represent occurrence and they are organized with longest bars on the left side and the shortest to the right Side. In this way the chart visually shows which defects are more significant. By using this Pareto Chart major types of defects were identified which is as shown in the figure.

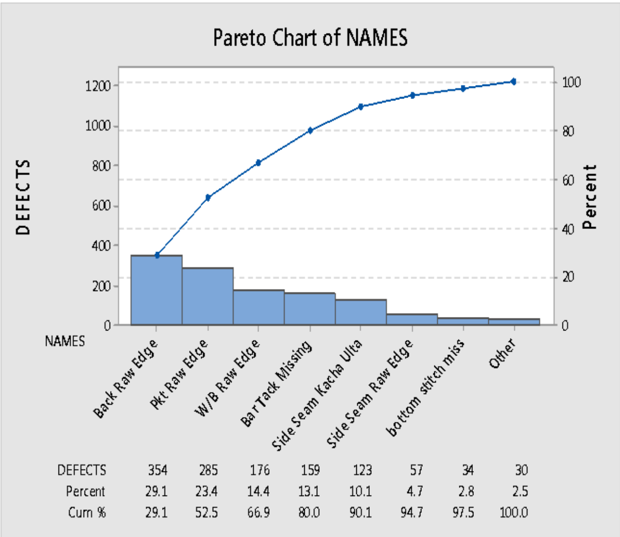

Chart -2: Pareto analysis

The Observations made from Pareto Analysis for Top Defect Positions

1. Back raw edge is the most frequent defect with as much as 29.1% of the total.
2. Pocket raw edge is the second most frequent defect with 23.40% of the total.
3. Among the other defects contribution of Bar tack missing is 13.10%, w/b raw edge is 14.4%, Side Seam is 4.70% and bottom Stitch open is 3.0%.
4. These five top defect positions are the "vital few" where 90.0% of total defects occur.
5. We need to perform further Pareto Analysis on those top defect positions to identify the vital few defect types that are responsible for maximum amount of defect at the measure phase five noteworthy sorts of defects were recognized and the objective of this phase is to find out all the potential causes of those defects. Two problems solving six sigma tools were used at analyse stage and these were: Brainstorming and cause and effect diagram.

Brainstorming-It is one of the major problem solving tools. The goal of this tool is to identify the issues, solutions and opportunities. In order to identify the potential causes of the defects and their respective solutions. The purpose of this step is to identify, validate and select the root cause for elimination. A large number of potential root causes (process inputs, X) of the project problem are identified via root cause analysis. The top 3-4 potential root causes are selected using multi-voting or other consensus tool for further validation. A data collection plan is created and data are collected to establish the relative contribution of each root causes to the project metric, Y. this process is repeated until "valid" root causes can be identified. Within Six Sigma, often complex analysis tools are used. All or some can be

-Listing and prioritizing the potential causes of any problem

-Prioritizing the root causes (key process inputs) to pursue in the Improve step

-Identify how the process inputs (Xs) affect the process outputs (Ys). Data is analyzed to understand the magnitude of contribution of each root cause, X, to the project metric, Y. Statistical tests using p-values accompanied by Histograms, Pareto charts, and line plots are often used to do this.

-Detailed process maps can be produced to help pin-point where in the process the root causes reside, and what be contributing to the occurrence.

Hierarchy of causes and cause and effect diagram

From Pareto Analysis I have distinguished top defect positions and by further analyzing I have likewise identified top seven defect types in those positions. Those defect types are Skipped Stitch, Broken Stitch, Uneven Stitch, Raw Edge, Uncut Thread, Spot and Visible Top Stitch. These types of defect occur because of some particular reasons. By the own observation and data provided by 05 QC supervisors from different production lines through questionnaires I have identified the causes for each specific defect types. Then these causes are ordered in a hierarchy according to the frequency of the feedback provided by QC supervisors.

Cause and effect diagram for rejection due to machines

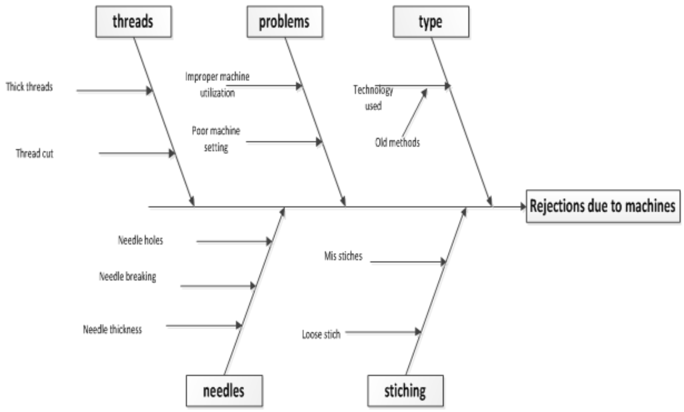

Fig -2: Fishbone diagram for rejections due to machines.

Cause and effect diagram for rejection due to process

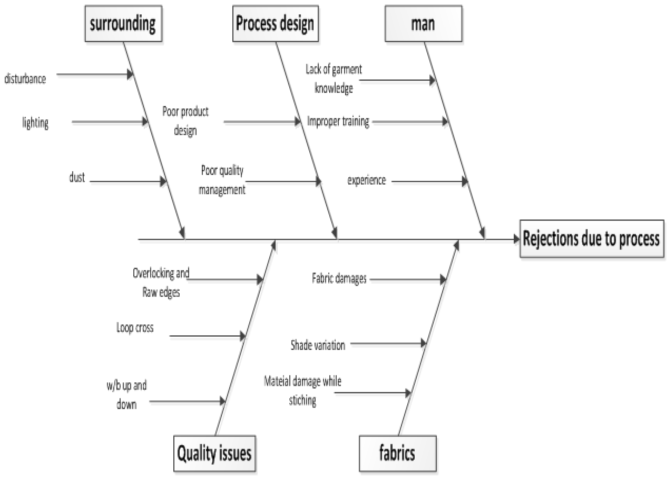

Fig -3: Fishbone diagram for rejections due to Process.

Findings and Data Analysis –

In the previous section I have discussed about the study of some repetitive defects exists in the sewing section of a particular product i.e. shorts, pant. From own observation and data given by the management level, I have observed that there are different types of defects occurred in the production lines. These defects cause reworks and rejection which leads to time waste and decrease in productivity. By concentrating on those few repetitive defects in particular positions, most of the defects can be minimized. So with this respect, I have tried to identify those particular defects and positions using Pareto Analysis. Then I have analyzed the causes of those defects and constructed Cause-Effect diagrams. And finally I have provided some suggestions in relation to those causes that will ultimately reduce those defects.

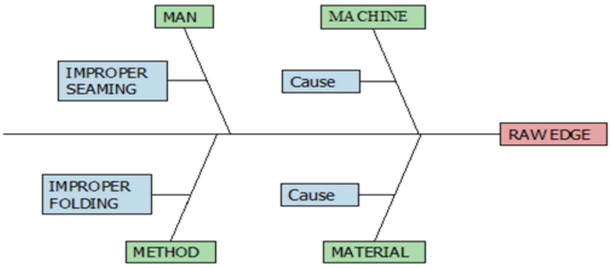

Fig -4: Fish bone diagram for Raw Edge

4) Improve phase: The purpose of this step is to identify, test and implement a solution to the problems in part or in whole. Identify creative solutions to eliminate the key root causes in order to fix and prevent Process problems. Some project can utilize complex analysis tools like DOE (Design of Experiments),-Create innovative solutions
-Focusing on the simplest and easiest solutions
-Testing solutions using Plan-Do-Check-Act (PDCA) cycle
-Creating a detailed implementation plan

Table -5: Remedial actions

Defects	Remedial Action
Thread cut	The broken threads are mainly due to the fabric and the initial swatch test is tightened so that wrong fabric does not roll out.
W/b stitch open	The stitches are extended than required and the operators are trained to control the speed of the machine
Bar tack missing	The operators are compelled to refer to the drawings whenever they are stitching.
Bottom down stitch	The operators are trained to check for unevenness by using a sample fabric pattern
Raw edges	proper trimming is done where ever it is necessary and folding is done
Run down	The stitches are extended than the required and the workers are trained to control the speed of the machine
Uneven(cross)	The operators are trained to check for unevenness by using a sample fabric specimen of a cloth.

Suggested Solutions: This study is tried to suggest some potential solutions to minimize the causes of defects through Brainstorming, direct observation and by literature review. The solutions with their corresponding causes are given in the table.

Table -6: Suggested solutions for different types of problems (defects occurring)

Cause types	causes	Suggestions
Machine	Hook, lopper or needle is not able to hold the thread loop in proper time	Timing of lopper with needle is to be adjusted properly
		Repair damage machine parts
		Use needle which design to facilitate loop formation
	Needle deflection	Adjust the needle height and testing before bulk sewing
	Improper finishing	To cut thread properly, start regularly checking and use auto trimming machine and it is functioning properly or not
	Defective machine	Regular checkup and cleaning machine
	Inappropriate thread tension	Tension of thread is properly adjusted
	Tension variation in lopper	Select good quality threads which are free from flaws Adjust tension properly

Cause types	causes	Suggestions
	Operator inefficiency	Provide adequate training to operators
	Operator carelessness	Improve supervision
	Improper trimming	Teaching them the method by providing training
	Improper seaming/working	Teach operator to work
	Mishandling	Establishing preventive maintenance
	Operator increases the speed of the machine rapidly	Control the speed of machine, use correct feed control
	Holding or pulling the fabric	Provide standard quality specifications, never pull on the fabric while sewing

Implementation-Based on the Cause and Effect diagram, the operators are trained well in all situations of their jobs and after the remedial actions are taken, the products are checked for defects. The details are listed in the table below.

Table -7: Defects after implementation

Sl no.	Batch number	Checked pieces	Defectives
1	1	558	29
2	2	1830	32
3	3	855	41
4	4	1380	51
5	5	240	44
6	6	3260	379
7	7	2168	221
8	8	670	102
9	9	258	26
10	10	430	21
11	11	615	69
12	12	1779	139
13	13	100	10
14	14	640	156
15	15	900	151
	Total	15683	1471

After soon the remedial actions are taken to reduce the different types of defects, then results are supporting as shown in the table below.

Table -8: Total defectives in shorts and pants after inspection.

Sl. No	Defects	Occurrence	Percrntage (%) occurence
1	Side Seam Raw Edge	12	9.6%
2	Pkt Raw Edge	15	12.09%
3	Back Raw Edge	21	16.93%
4	Bar Tack Missing	16	12.0%
5	Side Seam Kacha Ulta	20	16.12%
6	Btm Stitch Missing	18	14.51%
7	Others	22	17.7%
	Total	124	

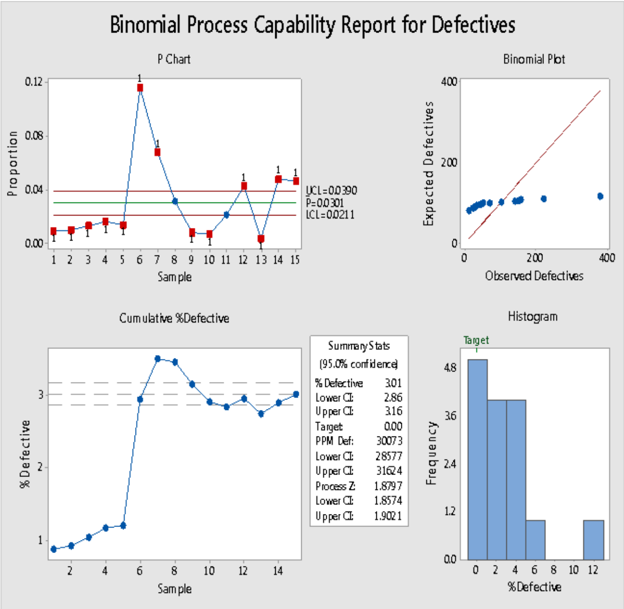

Chart -3: capability study after accomplishment

Table -9: Dpmo calculation

Sl. no	Total checked	15683
1	No.of defectives	1471
2	% defectives	3.01%
3	Dpmo	30073.0023
4	sigma	3.38
5	Dpo	0.030073

5) Control phase:
The main purpose of this step is to obtain the gains, monitoring the improvements to ensure continued and sustainable success. Create a control plan. Update documents, business processes and training records wherever it is as required. After implementation of the solutions, the positive results are discussed with the managers and the progressive outcomes were shared with the management. The main defects were recognized and partially reduced in amount. Now the challenge is to withstand the progresses and to sustain the improvements made in improving the processes refining the system continuously.
Control Plan: The following are the mandatory actions that have to be taken by the management to maintain the results after lean six sigma implementation in the garment industry.
1. The operators of garment industry must be given training on a continuous basis on the issue of quality.
2. Always use of the good quality needles, threads, and the other garment accessories
3. Tight quality controls should be enforced on those products coming from subcontractors
4. The drawings of the product must be made available at all the machines. The final garment pattern should be referred by all the operators.
5. The administration ought to give the incentives for high quality performance.
6. The focus should be on preventing defects rather than correcting defects.
7. Training the subcontractors on the importance of quality on continuous basis.
8. The organization should develop a proper quality management system.
Deploy improvements Control -Engineers and production managers always search for an approach to enhance processing factory's labor productivity. But they look-over things that lower labor productivity. "Higher line setting time" as it is one of the most visible reasons at present the factory's overall productivity. When it sets aside longer time for setting a line, most of the operators sit idle. That means operators are not utilized in producing garment and operator productivity falls resulting high labor cost.

4. CONCLUSION

The Minimization of defects is very important for guaranteeing the quality of products. This study found that the sewing section of selected garment factory was operating at a defect percentage of 8.92%. This rate is very high at this present business context. Subsequent to presenting the DMAIC Methodology of Six Sigma the percentage of defects is reduced to 3.01% there also found a significant improvement of the sigma level of the industry. It is shifted from 2.8 to 3.38. So, this method is very extremely compelling the minimization of defects. As the minimization of defects is the continuous process for further implementation of this methodology, it will help the company to identify the more reduction on defects rate and increases productivity and change on profitability.

ACKNOWLEDGEMENT

The guidance provided by Dr.Chethan Kumar.C.S, Associate Professor, IEM Department, MSRIT, Sri.S.Appaiah Associate Professor, IEM Department, MSRIT and Shankregowda, Manager karle-1, Bangaluru are thankfully acknowledged.

REFERENCES

[1] ploytip Jirasukprasert, Arturo Garza-Reyes, Vikas Kumar, Ming K. Lim, "A Six Sigma and DMAIC application for the reduction of defects in a rubber gloves manufacturing Process", International Journal of Lean Six Sigma, Vol. 5 Iss: 1,2014, pp.2 – 21
[2] Chethan Kumar C S, Dr. N V R Naidu, Dr. K Ravindranath/ IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org Vol. 1, Issue 1, pp. 001-009
[3] Pratima Mishra, Rajiv Kumar Sharma "A hybrid framework based on SIPOC and Six Sigma DMAIC for improving process dimensions in supply chain network",

International Journal of Quality & Reliability Management, Vol. 31 Issue: 5, 2014, pp.522 – 546.
[4] Barnes, R.M., 1980. Motion and Time Study; Design and Measurement of Work, seventh ed. John Wiley, New York, USA
[5] Chethan Kumar C S, Dr. N V R Naidu, Minimizing the eighth waste of lean- Absenteeism through Six sigma methodology, International journal for Quality Research, Vol. X No. X, pp.505-512, 2011.
[6] Frank Bunker Gilbreth, Lillian Moller Gilbreth (1921) Process Charts. American Society of Mechanical Engineers.
[7] Graham, Ben B. (2004). Detail process charting: speaking the language of process ([Online-Ausg.] ed.). Hoboken, N.J.: Wiley. p. 2. ISBN 9780471653943.
[8] American Society of Mechanical Engineers (1947) ASME standard; operation and flow process charts. New York, 1947.
[9]Kapuge, A.M. & Smith, M. (2007). Management Practices and Performance Reporting in the Sri Lankan Apparel sector. Managerial Auditing Journal, 22 (3), 303-318
[10]Hoffman, J. and Mehra, S.,(1999), "Management Leadership and Productivity Improvement Programs", International Journal of Applied Quality Management, vol 2, no. 2, pp. 221-232.
[11] M.Mahajan, "Statistical Quality Control", Dhanpat Rai & Co. (P) LTD. pp.186-206,

