Applying Six Sigma Methodology Based On "DMAIC" Tools to Reduce Production Defects in Textile Manufacturing

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*Abstract:-*Six Sigma is a systematic methodology for continuous process quality improvement and for achieving operational excellence. Six Sigma methodology is designed to provide for the application of statistical tools in the context of a process improvement structure summarized by the acronym DMAIC–Define, Measure, Analyze, Improve, and Control. The DMAIC model provides a framework to identify and eliminate sources of variation in a process, improve and sustain performance with well-executed control plans, and promote one process improvement language for all members of an organization to employ. This paper deals with the application of Six Sigma based methodology based on "DMAIC" (define-measure-analyze-improve-control) tools to reduce production defects in textile manufacturing. The DMAIC approach has been followed to solve an underlying problem of reducing process variation and the associated high defect rate. This paper explores how to use a systematic and disciplined approach to move towards the goal of Six Sigma quality level. The application of the Six Sigma methodology resulted in a reduction in the overall quality level from 7.7 % to 2%.

Key-words: Six Sigma, DMAIC approach, Production Defects, Textile Manufacturing, Quality, overall quality level

1 Introduction

Quality is one of the most significant performance measures that can considerably influence a manufacturer's competitiveness. High-quality products are influenced by two important factors. One is related to the quality of the product design.

The other factor is the degree of conformance of the manufactured products to the design specifications.

Over the past few decades, Six Sigma has been promoted by many world-class companies. The main advantage of a Six Sigma program is the elimination of subjectivity in decision-making, by creating a system where everyone in the organization collects, analyzes, and displays data in a consistent way [1]. As Six Sigma is a project-driven methodology, it is crucial to prioritize missions which propose the highest financial profit to the organization [2].

The practice of Six Sigma addresses and classifys the sources of “common cause variation” as well as variation due to infrequent causes. Utilizing a long list of preexisting statistical and analytical techniques, Six Sigma permits members of an organization to develop processes and services throughout the organization using a reasonable problem identification technique to meet the organization’s financial objectives and mission statements. There are many offerings for the definition of Six Sigma, each one tackling one of the several aspects of its phenomenon [3]. To be firmly statistical, it involves “operating with only 3.4 defects for every million activities or ‘opportunities’ [3]. Six Sigma puts the customer first and uses facts and data to drive better solutions” [4].

To quote from Jonathan Andell, author of the article, “Benefiting from Six Sigma Quality”, who paraphrased some Motorola pundits, “If we can’t quantify it, we can’t understand it. If we can’t understand it, we can’t control it. If we can’t control it, it controls us” [5]. Six Sigma offers a systematic method to find, quantify and “translate that knowledge into opportunities for business growth,” and well as power over the process [6].

Many Six Sigma consultants proposed the use of the DMAIC model (Define, Measure, Analyze, Improve, and Control) as the structured roadmap to pursue during the course of managing a process improvement effort. At each step of the model, process definition and statistical analysis tools are available as process understanding transitions from intuitive and subjective to defined and objective.

2 Literature Review

Six Sigma has revolutionized the world of business and has offered a new measure of success in customer satisfaction and quality. For companies in the textile industry to compete with others and remain in the market they had to improve quality and minimize defects in their products. Therefore they embraced various quality initiatives such as Six Sigma based on Define–Measure–Analyze–Improve–Control (DMAIC) tools [7].

Six Sigma employs an array of statistical and analytical tools to apply a data-driven, root-cause analysis to existing processes to minimize variation and aim for zero defects. Nowadays, Six Sigma has been generally acknowledged in a variety of industries in the world and it has become one of the most central topics of dispute in quality management. Six Sigma is a well-structured technique that can aid a company accomplish expected target through continuous project improvement [8].

The DMAIC phase comes into play to meet the customer requirements again and again [9]. Su, Chiang, and Chiao have reviewed the exclusive features of the Six Sigma approach consist of (1) sequences and links improvement tools into an overall approach, (2) incorporation of the human and process aspects for improvement using a belt based organization , and (3) consideration to bottom-line results and the supporting of gains over time [10].

3 Case Study

The project selected is reducing production defects in textile manufacturing. The project charter was co-written by top management staff that had overall responsibility for the performance of the production facility studied. The desired outcome from DMAIC roadmap is the identification and implementation of control plans that will serve as the indicator for process capability and control of the critical inputs.

3.1 The case company and problem statement

The case company is Century Standard Textile which is a joint venture company established in October, 1997 for manufacturing a wide rage of textiles apparels. All the manufactured products are pre-sold to Standard Textile for its markets in Europe and United States, specialized in producing medical and workwear garments (pants, short, coverall, jacket, and medical apparels) to coincide with the brand of global standard textile. When implementing Six Sigma, the case company lacks an well-organized way to arrange the business strategic policies to possible projects. To overcome these problems, our proposed approach was accomplished

For the last year, Century Standard Textile achieved an averaged overall quality level (OQL) of 4.7% for cargo pant production line, which is obtained through its customer audits, while the customer calls to have this percentage as 2%. OQL

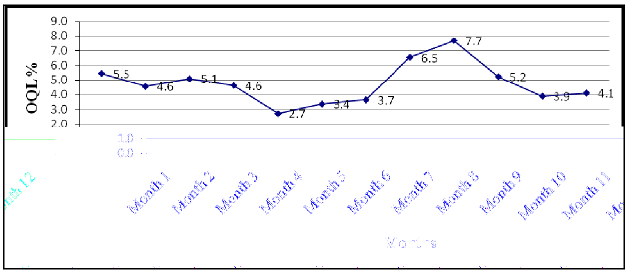

Fig. 1: OQL performance for Century Standard Textile (Cargo Pants Line)

is the percentage of the defects found during the customer audits for the received goods, which can be calculated by dividing the number of defects found by the number of samples audited. Figure 1 shows the performance of the company over the last year.

3.2 Implementation

The DMAIC methodology is fundamental to Six Sigma process improvement projects. The following phases afford a problem-solving procedure in which definite tools are engaged to turn a practical problem into a statistical problem, produce a statistical solution and then translate that back into a convenient solution.

3.2.1 Define phase

The define phase is perhaps the most critical phase within a Six Sigma project. Many aspects need to be analyzed including the voice of customer (VOC), current state of the process, resource availability and the business benefits. During the define phase the use of a cause-and-effect diagram is very useful to determine the critical to quality (CTQ) issues (or improvement areas). The prioritization matrix provides a way of sorting a diverse set of items into an order of importance. Table 1 shows priorities matrix projects presented by the company's management team. Thus an item with a score of 98 is clearly more important than one with a score of 56.

3.2.2 Measure phase

The function of the Measure phase is to fully realize the current performance by categorizing how to best measure current performance and to begin evaluating it. Cause-and-effect diagrams are particularly useful in the measure and improve phases of Six Sigma methodology. To understand the current processes and enable the team to define the hidden causes, process mapping tool would be used, pants production line process has been mapped out as shown in Figure 2. To identify those significant few problems Pareto analysis used, so people can target them for actions. By analyzing cause-and-effect diagram causes, management members weighted all causes, and then results are graphically displayed using Pareto chart. Table 2 shows some number of samples taken and defects breakdown found during finished goods audits for six months.

Table 1: Prioritization matrix

Items to Prioritize	Criteria								Total Scores
	Return on investment weight = 8		Customer satisfaction weight = 8		Link to strategic goals weight = 4		Risk migration weight = 2		
Reducing the OQL for the pants production line to 2%	5	40	5	40	3	12	3	6	98
Increasing pants production line efficiency by 30%	4	32	1	8	3	12	2	4	56
Reducing production damaged pieces (grade B) by 1%	2	16	1	8	1	4	1	2	30

ISBN: 978-1-61804-186-9

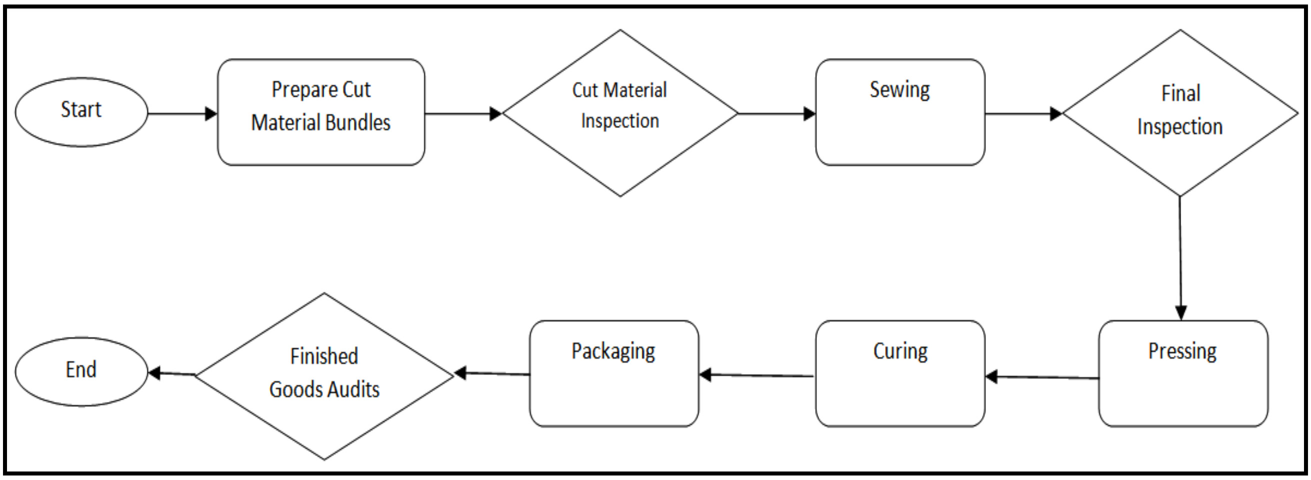

Fig. 2: Pants production line processes flow chart

Table 2: Some of the defects found during six months

Defect	Mon 1		Mon 2		Mon 3		Mon 4		Mon 5		Mon 6	
Bar tack Omitted	10	0.9%	12	1.3%	9	0.7%	6	0.3%	5	0.2%	4	0.2%
Stitches Broken / Incomplete	12	1.1%	9	0.9%	4	0.3%	6	0.3%	4	0.2%	4	0.2%
Wrong Waist Label	19	1.8%	9	0.9%	4	0.3%	4	0.2%	2	0.1%		
Material Flaws	11	1.0%			9	0.7%	6	0.3%	4	0.2%	5	0.3%
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Total number of defects found	90		66		58		54		54		36	
Total number of samples taken	1074		955		1253		1935		2388		1835	

3.2.3 Analyze phase

In the analyze phase, the team identifies the root cause(s) or source(s) of problem or the critical factors which will enable them to achieve a target for improvement. Pareto analysis used to identify those significant few problems, so we can target them for actions. Most occurrence defects found during final inspection and finished goods audits processes are graphically analyzed through Pareto chart. Figure 3 shows graphical analysis of month 01 finished goods results. It is normally easier to reduce a tall bar by half than to reduce a short bar to zero. Pareto chart used like a map to "island hop." Significantly reduce one big problem, and then hop to the next. Leave the smaller problems for "mopping up" later.

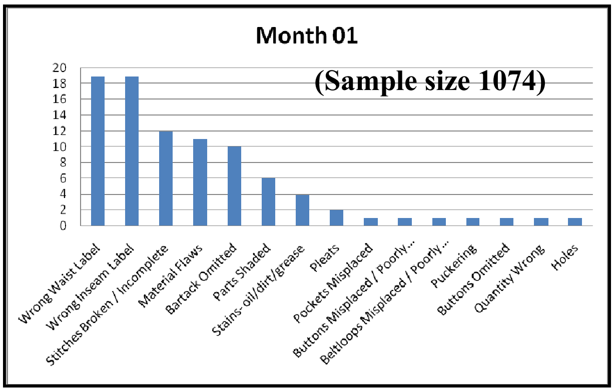

Fig. 3: Finished goods results for month 01

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3.2.4 Improve phase

The improve phase spotlights on developing thoughts to get rid of root causes of variation, testing and standardizing those solutions. In order to solve the poor communication problem between the different departments the following meetings will be held on a daily basis: Finished goods audit meeting and Main daily meeting. In order to solve this problem 5 S's tool will be used for organizing the workstation and to find better design for the final inspection table. In order to solve these problems a graphical work flow for final inspection process must be prepared and then attached on the final inspection tables in a place allow the inspector to see it easily. Figure 4 shows final inspection process flow.

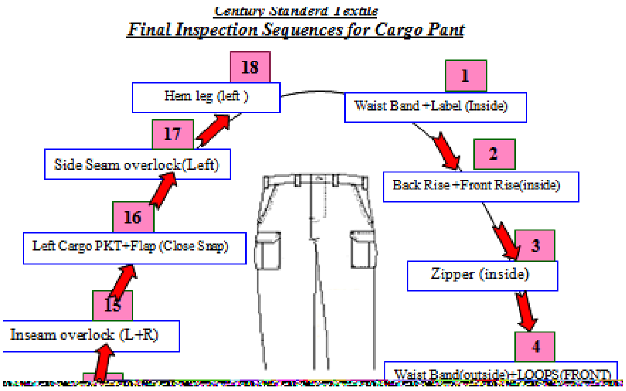

Fig. 4: Final inspection process flow

3.2.5 Control phase

The control phase intends to create standard measures to continue performance and to correct problems as needed, counting problems with the measurement structure. During the improve phase, the solution is piloted, and plans are made for full scale implementation. Putting a solution in place can fix a problem for the moment, but the activities in the control phase are designed to insure that the problem does not reoccur and that the new processes can be further improved over time. Operating flow chart is a single chart or series of charts that visually display the new operating processes. It can be used to track improvements that have been put into place for major defects found during the studied six months. Figure 5 shows operating flow chart for major defects found during ten months (including the six studied months). Percentage of each defect is measured based on the number of sample taken and number of defects found during that month. Overall quality level is our goal target to be followed during this project through SPC charts; these are charts that help to track processes by plotting data over time between lower and upper specification limits with a center line. Upper specification limit is set to be 2% as a request from the customer, accordingly OQL will be controlled. Figure 6 shows OQL over the 12 months (including the six studied months). As a result of applying Six Sigma methodology in our project, averaged OQL of 4.7% obtained through the customer audits for last year reduced to a 1.7%.

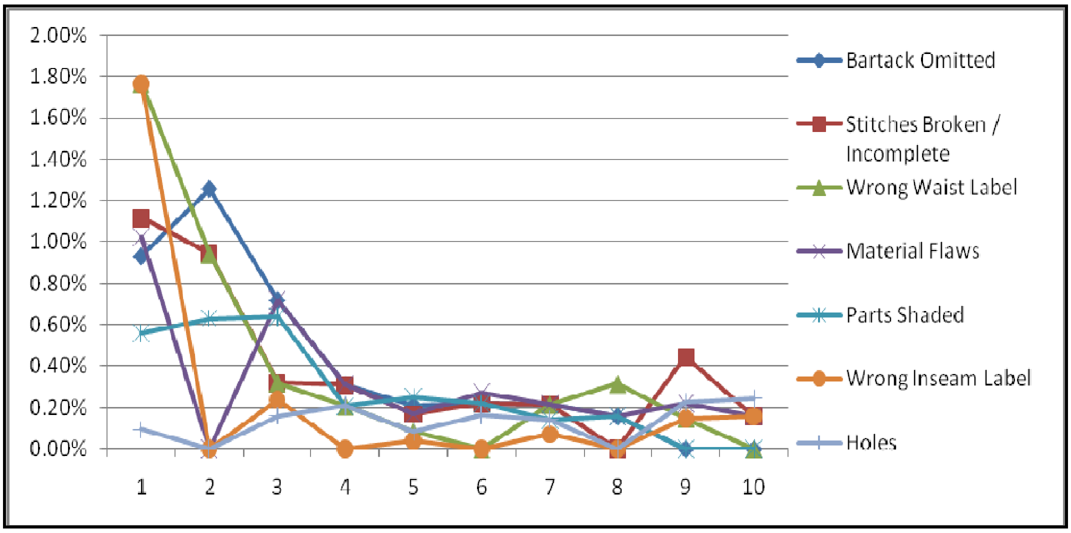

Fig. 5: Operating flow chart for major defects for ten months (including first six studied months)

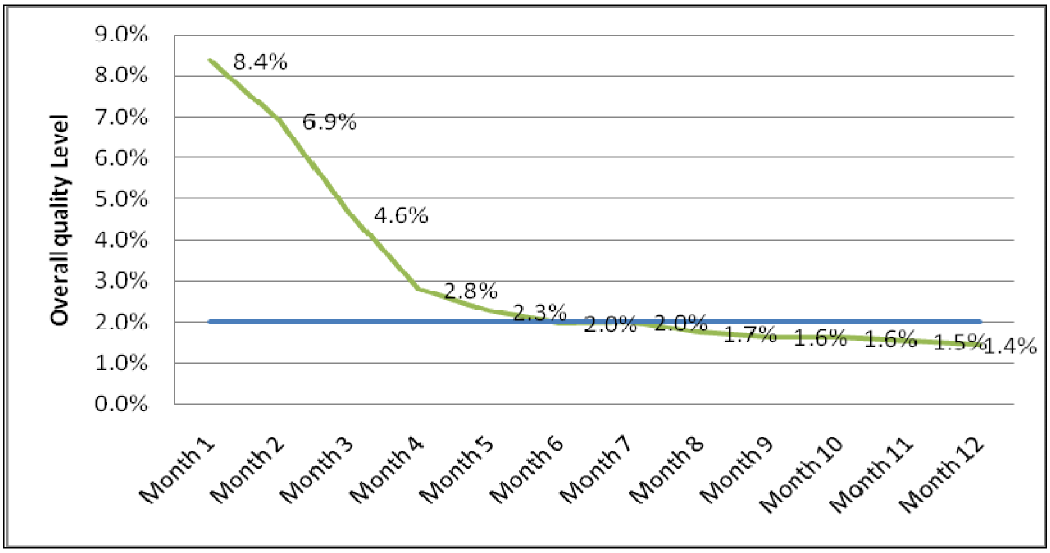

Fig. 6: OQL over the 12 months (including the six studied months)

4. Conclusions

In light of this study, the following conclusions can be reached:

1. DMAIC is methodology that needs to be implemented from top-down management. It is essential that each employee of the company understands the status quo of their work environment as well as all the decisions the company make. Employees should understand the concept for each process improvement and more important, become involved in the company's initiatives.
2. Define phase considered as the main and the most important phase in the DMAIC cycle, since through which the most prioritized project for the company been selected.
3. Pareto chart is suitable tool to visually present and analyze the data collected from measure phase, where solving 80% of defects problems helps in concentrating on only 20% of the causes of these defects in the analyze phase.
4. The application of the Six Sigma methodology resulted in a reduction in the overall quality level from 7.7 % to 2%.

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