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Applying DMAIC Methodology to Reduce Defects of Sewing Section in RMG: A Case Study

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Abstract

Global competition, crying off profit margin, customer requirement for high quality product at near to the ground cost and other economic factors set in motion the manufacturer to reduce their production cost without concession of quality in order to stand up in business area. Defect or wastages reduction is the initial step to reduce production cost as well as improve the quality. Higher quality comes with the reduced cycle time by reducing alternation. Apprehensive this issue, this work walks around the use of DMAIC methodology of six sigma to lessen the defect rate in sewing section of FCI (BD) LTD. Throughout five phases of DMAIC methodology, named Define, Measure, Analyze, Improve and Control, this approach minimizes defects analytically. In different phases, different types of six sigma tools were exercised. Pareto analysis was acted to identify the top defects and root causes of those defects were sensed. These were done for Ladies' tops and trousers. Brainstorming and literature review helped to endow with some potential solutions to overcome the problem. With the remedial action and implementation in pilot run, the result found is very noteworthy. The defect percentage has been reduced from 11.67 to 9.672 and as a result, the sigma level has been upgraded from 2.69 to 2.8.

Keywords

DMAIC, Sewing Defects, Six Sigma, Sigma Level

1. Introduction and Literature Review

In Bangladesh economy, RMG sector plays a vital role. From the last decade, RMG sector becomes popular in Bangladesh and it contributes to the national economy in considerable rate. It is necessary to focus on quality control of garment industry [1] [2] [3]. Cho & Kang (2001) showed that quality control in the garment industry is a big challenge for existing and it maintained from the initial stage to the stage of final finished garment [4]. In this industry, product quality can be calculated by different kind of scale. These are quality and standard of fibers, fabric construction, yarn, surface designs, color fastness and the final finished garment products [5]. Number of defected occurrence and percentage of defected product are very common way to calculate product quality.

This research has shown that the major departments of a garment manufacturing industry are cutting section, sewing section, finishing section. After finishing of the cutting operation garments components, all the garments parts are joined and sewn as sequentially. In this research, defects of sewing operations for ladies' tops and trousers are discussed. Rahman & Amin and Talapatra & Rahman (2016) have mentioned that defect is the common term in the garment industry. Defect is the loss of time, cost and raw material [6] [7]. So, it is a burning question for manufacturer about how to reduce defects. This research has used DMAIC methodology to reduce defects of RMG that is used which is a problem solving of Six Sigma. The Six Sigma is a philosophy that is used to reduce defects. Nupur, Gandhi, Solanki & Jha (2018) implemented six sigma in cutting process of apparel industry where (DMAIC) approach has been followed to solve the underlying problem of reducing defects and improving sigma level through continuous improvement process [8]. Nagi & Altaraz (2017) also used six sigma DMAIC approach to implement lean tools and facilities layout techniques to reduce the occurrence of different types of nonconformities in the carpeting process [9].

The DMAIC method follows a conductive five-step: Define, Measure, Analyze, Improve and Control necessary to obtain reliable results. According to Brundage, Kulvatunyou, Ademujimi & Rakshith (2017), the DMAIC approach of Six Sigma works as a filter to pass from a complex problem with many uncontrolled variables to a situation where quality is controlled [10].

This research has identified all the defects in the sewing department of FCI (BD) LTD and applies DMAIC methodology to reduce the defects and this analysis is arranged by research methodology in Section 2 by the following steps: Define, Measure, Analyze, Improve and Control Phase and Conclusion is in Section 3.

2. Research Methodology

For garment item, *i.e.* ladies' tops and trousers, data sheets were collected for the length of one month (January). The end line quality inspectors provided the data sheets from their record books from the production lines of the sewing section of FCI (BD) LTD when we visited the garments factory. 15,472 ladies' tops and trousers were examined and we found 1806 defective pieces. Our main purpose was to identify the top most defects, the root cause of the defects, give some suggestions to reduce the percent of defects and improve sigma level. DMAIC methodology is used for this purpose. It can be illustrated with the following.

Define: problem selection and benefit analysis. Identifying and mapping relevant processes, identifying stakeholders, prioritizing customer needs & making a business case for the project.

Measure: translation of the problem into a measurable form, and measurement of the current situation.

Analyze: identification of influence factors and causes, identifying potential influence factors & selecting the vital few influence factors.

Improve: design and implementation of adjustments to the process to improve the performance & conduct pilot test of improvement actions.

Control: empirical verification of the project's results and adjustment of the process management and control system in order that improvements are sustainable, the new process capability & implement control plans.

2.1. Define Phase

The purpose of this phase is to make the defects clear and define the problems. The goal of the project also should be defined very well through this phase and finally here come the processes. Before works begin we must know about all relevant elements of a process improvement. SIPOC (suppliers, inputs, process, outputs, and customers) diagram is the tool to show the process map about this information [11].

Rahman & Amin (2016) identified the problem statement in apparel industries quality is achieved when the defects of the products are decreased [6]. The manufacturers are trying to reduce defects. In Bangladesh garment factory face high rate of rejections due to defects. For this reason they can't meet quality standards. This also increases the number of rework, scrap cost, delay of delivery due to rework [12].

The ultimate goal is to minimize the percentage of defects which results in minimize the production cost, improve quality, reduce wastes and enhance sigma level. SIPOC is the quality of a process that is evaluated by the output of the process. Table 1 shows the SIPOC flow of the FCI (BD) LTD.

Table 1. SIPOC diagram for ladies' tops & trousers.

Suppliers	Inputs	Process	Outputs	Customers
Alex Fabrics Ltd. Fabian Group	Unstitched cloth Machinery Thread Needles Button Zipper Label	Sampling Cutting Sewing Washing Ironing Finishing Packaging	Ladies tops Trousers	NyGard

2.2. Measure Phase

Some of the products are executive ladies' tops and trousers 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. Here the percent of defectives is found 10.30. Defect per opportunity (DPO) is 0.1167 and defect per million opportunities is 116,727. The sigma level is 2.69. Table 2 shows the outcome.

2.3. Analyze Phase

The main goal of the analyze phase is to go through the data to find out the top most defects which are reoccurring as well as the root causes of the problems and seek improvement opportunities. The percentage of defects occurrence has been integrated in Table 3 and also shown in Figure 1.

Brainstorming: It is one of the major problem solving tools. The purpose of this step is to identify, validate and select the root cause for removal. We have analyzed the causes of those defects and constructed Cause-Effect diagrams which are shown in Figure 2.

Table 2. Calculation of DPMO & six sigma.

Total checked items	15,472
No of defectives	1806
% Defectives	11.67
DPU	0.1167
DPMO	116,727
Sigma level	2.69

Table 3. Details of percentage defects occurrence.

Defects	Total Occurrences	Percentage (%) of occurrences	Occurrences percentage (%) cumulative
Puckering	361	20	20
Visible stitch	326	18	38
Out of shape	307	17	55
Skip stitch	199	11	66
Uneven stitch	163	9	75
Broken stitch	144	8	83
Raw edge	90	5	88
Uncut thread	90	5	93
Length stitch	72	4	97
Down stitch	54	3	100

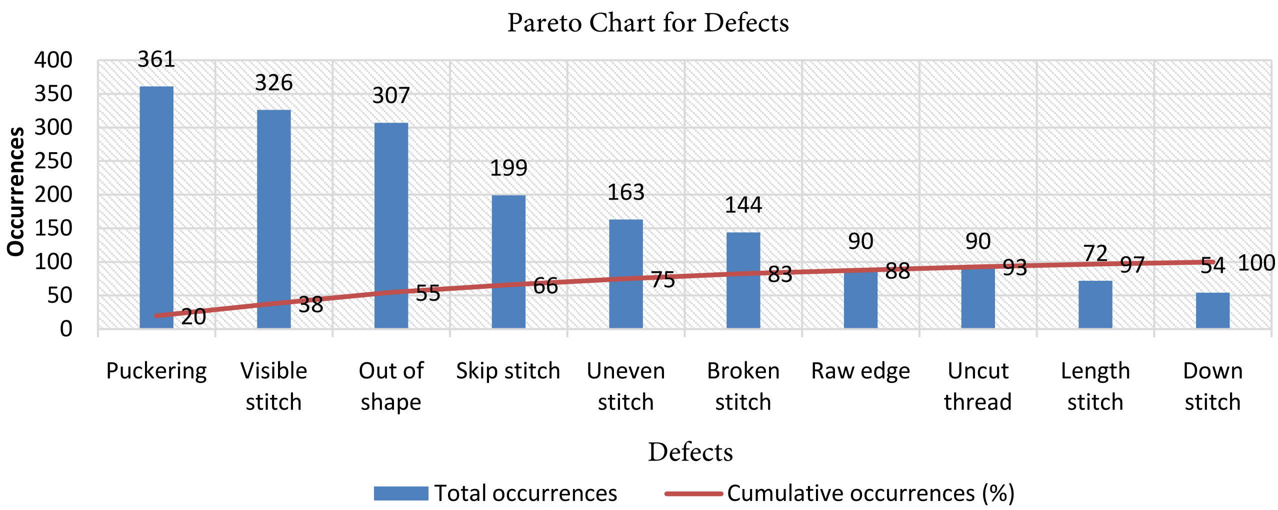


Figure 1. Pareto chart for defects.

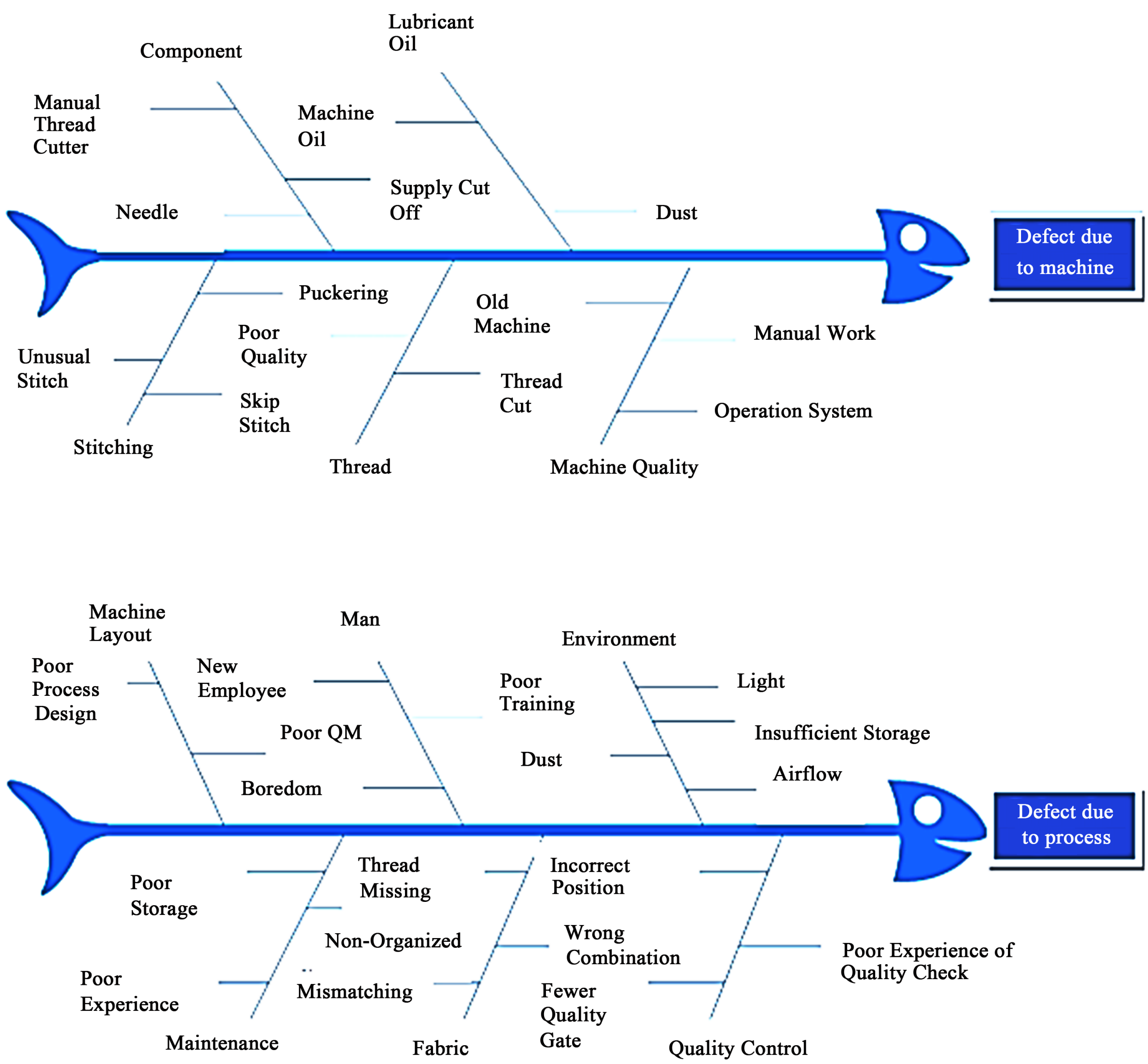


Figure 2. Cause-Effect diagram for all defects due to machine & process.

2.4. Improve Phase

The purpose of this step is to identify, test and implement a solution to the problems in part or in whole. Root causes of different types of defects have been identified and the solutions of these causes have been provided that is shown in this Table 4.

Implementation: The implementation was done into one of their pilot sewing line and details are listed in the Table 5 and Table 6. DPMO and Sigma Level were calculated and reported in Table 7.

2.5. Control Phase

It is possible to reduce by management of an industry the overall occurrence frequency by following some preventive ways by finding out the actual reasons.

Table 4. List of potential root causes and their solutions.

Defect name and place	Potential root causes	Solutions
1) Puckering at Side Seam	Parts handling method	Follow the guide properly, reduce speed at shape changing area
		Hold both parts in asymmetric
	Thread tension mismatched	Readjust thread tension
	There is no mark to hold the parts properly	Put cut mark at edge during cutting the panel
2) Raw edge at side seam	Parts handling method	Follow the guide properly, reduce speed at shape changing area
		Hold both parts in asymmetric
	Excessive Speed	Don't exceed the speed limit 4500rpm
3) Waist band mouth out of shape	Mouth close wrong	Straight sewing at mouth close bottom line
	Waist band top stitch inclined	Use the shape folder for waist band top stitch
4) Uneven stitch at back pocket top stitch	Stitch corner round shaped	Use split bar DNLS machine for ease of operating
		Don't stress the pocket corner during stitching
5) Uncut thread at loop tack	Wiper stopped	Never stop wiper
	Stitch continued over the space	Stop stitch at the parts end
	Bobbin thread loose	Adjust the bobbin thread
6) Broken stitch at cross point	Stitch cut during excess thread cutting.	Cut thread end carefully
	Use of air line during inseam join operation	Stop using air blowing if avoidable
7) Down stitch at waist band top stitch	Waist band attach wrong	Follow block pressing mark
	Waist band width measurement wrong	Keep the allowance same during waist band center tack
	Cut panel width shortage	Follow marker line properly to avoid cutting mistake
	Allowance not even at waist band attach	Keep the allowance even and follow the gauge properly
8) Visible stitch at waist top stitch	Waist band attach wrong	Follow block pressing mark
	Waist band width measurement wrong	Keep the allowance same during waist band center tack
	Cut panel width shortage	Follow marker line properly to avoid cutting mistake
9) Length uneven	Allowance not even at waist band attach	Keep the allowance even and follow the gauge properly
	Size mistake	Use single piece material in sewing line to avoid size mixing up

Table 5. Defects after implementation of DMAIC.

Date	Checked item	Good item	Defective item
Feb 1	431	397	34
Feb 2	570	411	159
Feb 4	805	730	75
Feb 5	843	791	52
Feb 6	743	658	85
Feb 7	887	826	61
Feb 8	832	801	31
Total	5111	4614	497

Table 6. Total defectives in ladies' tops and trousers after inspection.

Defects	Total Occurrences	% of occurrences	% cumulative
Puckering	99	20	20
Visible stitch	89	18	38
Out of shape	85	17	55
Skip stitch	55	11	66
Uneven stitch	45	9	75
Broken stitch	40	8	83
Raw edge	25	5	88
Uncut thread	25	5	93
Length uneven stitch	20	4	97
Down stitch	14	3	100

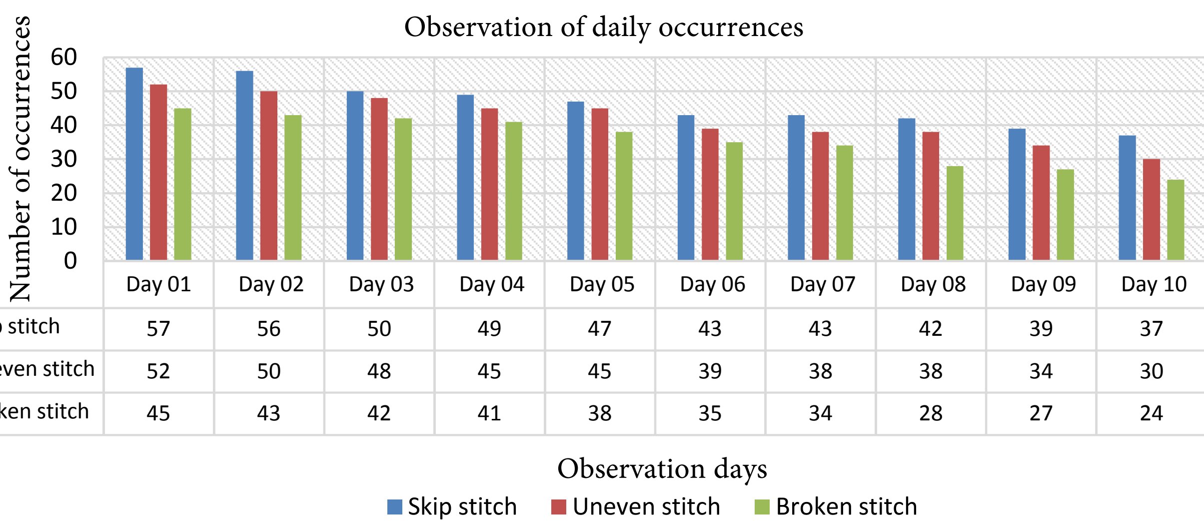
Table 7. Calculation of DPMO & Six Sigma (after implementation of DMAIC).

Total checked items	5111
No of defectives	497
% Defectives	9.72
DPU	0.0972
DPMO	97241
Sigma level	2.8

In this research, one preventive way awareness is used to investigate the result of frequency of defective occurrences. For this purpose awareness has been raised among all the employees, operators even among all the stakeholders of an industry. This awareness is based on how occurrences create and what are the responsibilities on them to minimize the daily percentage of occurrences. Thomas, Barton & Chuke-Okafor (2008), De Mast (2004), George & George (2003), Hahn, Hill, Hoerl & Zinkgraf (1999), Husband & Mandal (1999), Munna, Rahman & Roney (2015), Jostes & Helms (1994) have used different lean tools *i.e.*, 5S implementation, value stream mapping (VSM), systems redesign, application of TPM to control the occurrences frequency [13]-[19]. This research has tried to implement the safety awareness that involves: 1) awareness in setting the needle with the machine 2) awareness in gripping the fabrics for long stitch (more than 10 cm) 3) awareness by showing the video of standard operation for the unskilled operator and 4) awareness among the management to provide the automated machine rather than manually operated machine and observed for 10 days in line no. 17 for the defect of skip stitch, uneven stitch and broken stitch and finally this research has found that the daily defect percentage has decreased day by day after creating the awareness that is showed in the following **Figure 3** and this results in one of the solution to enhance productivity.

3. Conclusion

The aim of this research is to reduce the defect of products and to improve quality. To minimize the defects of garment products DMAIC methodology has been used. In this method, at first problems were identified. We have been focused on sewing section and found out sewing defects. Pareto chart is used to show sewing defects for experimental lot. The percentage of defects from total product is also calculated. Define phase shows that defected piece is 1806 in 15,472 pieces. The percentage of defect was 11.67%. The range is not in tolerable range. For given solution, control phase shows that defect percentage is reduced to 9.72%. To justify the given solution, sigma level is used. In the past, sigma level was 2.69. After Improve phase, it has been upgraded to 2.8. This research has focused some preventive solutions from other researches and also showed that creation of awareness among the stakeholders of a garments industry has decreased the occurrences in a sewing line day by day. This will create a positive effect on the management and will also help to minimize the defective percentage (%) in a



	Day 01	Day 02	Day 03	Day 04	Day 05	Day 06	Day 07	Day 08	Day 09	Day 10
Skip stitch	57	56	50	49	47	43	43	42	39	37
Uneven stitch	52	50	48	45	45	39	38	38	34	30
Broken stitch	45	43	42	41	38	35	34	28	27	24

Figure 3. Observation of defective percentage (%) control.

sewing line of a garment industry. The limitations of this study are that: it was concentrated only on one garment industry and only for sewing section, and only one sewing line was focused, and calculation had been done for two products. But the significance of this research is that this study can help in minimizing the other sections in garments industry. Other researchers can also use this procedure to reduce defect rate in other manufacturing industries. Finally, reduction of defect rate improves quality and apparently, improvement of quality will give a positive impact in RMG sector.

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Nomenclature

Symbol	Meaning	Unit
DPU	Defect Per Unit	Dimensionless
DPMO	Defect Per Million Opportunities	Dimensionless