MINIMIZATION OF DEFECTS IN THE FABRIC SECTION THROUGH APPLYING DMAIC METHODOLOGY OF SIX SIGMA: A CASE STUDY

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ABSTRACT

Global competition which is the crying off the gross margin is now escalated in daily basis. The customer demand for a high quality product at close to ground cost whereas other economic factors set the manufacturer in motion to reduce their cost of production without minimization of quality to stand up in the business area. Because of this global competition, now for the manufacturer, the main concern is productivity or profit. Productivity is dynamic indicator of financial performance of any manufacturing or service-based enterprises. To achieve this, an important phase of productivity improvement is the enhancement of productivity of these industries by reducing its waste or defect while maintaining quality. This paper demonstrates the application of Six Sigma approach and shows how to minimize the defect percentage by using the DMAIC methodology in the fabric section of a firm. Pareto analysis was performed to detect the major defects and to find out the root cause of the defects. Cause and Effect Analysis was also done, by the help of brainstorming. Furthermore, some salient solutions are also suggested to surmount the problems. Finally, with remedial action and implementation of Six Sigma DMAIC approach, the result found is very noteworthy in the pilot run. The defect percentage had been reduced from 10.07% to 7.87%, and the sigma level had been upgraded from 2.78 to 2.91 which are noticeable. In a firm, the lesser defect is produced the greater profit is ensured, which forleads a company to be more competitive in the global competition than any other firms.

Keywords: Six Sigma, DMAIC, Defects, Ready Made Garment (RMG), Sigma level

INTRODUCTION

The Ready-Made Garment (RMG) sector since its inception in the early '80s, it has established itself as Bangladesh's major source of export revenue. Bangladesh is the world's second-largest exporter of Ready-Made Garment (RMG) products for the past three decades, exporting over 132 countries worldwide. RMG is one of Bangladesh's most important sectors in terms of foreign export earnings, economic growth, jobs, and its contribution to the gross domestic product (GDP). The total export of Bangladesh, for the first time in history, crossed the USD 30.18 billion marks, which is 13.83 percent growth over the last fiscal year [1].

In this competitive global market, quality is the main priorityof these RMG sectors. Wastage or defective product is the obstacle to achieve targeted quality product as well as gaining more profit.Nowadays, organizations strive for an improved level of quality products and a reduced level of cost.A concerted process of continuous improvement can lessen the proportion of defects and boost productivity [2]. One of the sustainable ways to boost up quality is a project-based approach based on the Six Sigma DMAIC methodology [3]. It is a part of a strategy by Six Sigma, which includes five steps define, measure, analyze, improve,

and control (DMAIC) is a data-driven quality strategy by which quality is improved [4].Six Sigma DMAIC methodologies also utilized to improve previously existing procedures and had been demonstrated to be effective in decreasing costs, improving process durations, disposing of deformities, raising consumer satisfaction, and essentially expandingproductivity in each industry and numerous organizations around the world [5].There are myriad studies that show the successful application of Six Sigma DMAIC methodology in the small-scale enterprises [6][7]; manufacturing processes [8][9][10]and services such as healthcare[11] [12]; automotive industry [13]; and retail stores [14].

Within a garment factory, defects typically come from the fabric section, cutting section, sewing section, or finishing section. Meanwhile, fabric defects are a frequent and recurring problem in clothing manufacturing mostly nowadays. Thomas studied the economic effect of defects in woven structures and found that second-quality fabric prices are just 45-65 percent of those of first-quality fabrics [15]. Patel discusses 235 fabric defects and their possible causes [16].

In this context, defects of the fabric section for gentgarments, i.e., T-shirt, Polo shirt, Trousers, are discussed by applying DMAIC methodology. In different phases of this study, different types of six sigma tools were also exercised and few suggestions are also suggested through brainstorming. The defective product mainly increases the production cost. So it is necessary to reduce the defects; as a result, the cost will be minimized.

METHODOLOGY

DMAIC is one of the Six Sigma's distinctive approaches for processing and improving quality [17]. The case study had been conducted on a garment factory in Dhaka, Bangladesh. We have collected Primary data of the fabric section from the management of the factory. Datasheets were collected for the length of three months (November, December, January). A total of 647207 items were examined throughout this period, and 65200 defected items were found. We've used two Six Sigma tools (Pareto Analysis and Cause-Effect Diagram) to find out the major defects in the fabric section and the root cause behind these defects, and based on brainstorming, give some suggestions. DMAIC methodology is used to remedy these defects so that the percentage of the defective product is reduced.

DATA ANALYSIS AND CALCULATIONS

The data collection and analysis go through five phases:

Define Phase

Define is the first step of the DMAIC technique of Six Sigma.

Table 1.SIPOC flow of SQUARE Fashion Ltd

Suppliers	Inputs	Processes	Outputs	Customers
X Fabric	Unstitched Cloth	Knitting	T-shirts	Y
	Machinary			
	Thread	Dying	Polo shirts	Z
	Needles	Cutting	Trousers	
	Button	Sewing	Hoodies	
	Zipper	Ironing		
	Label	Finishing		
		Packing		

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The main objectives of this step are to identify the problem, project target, and the process that needs to be improved to achieve a higher sigma level. In this phase, SIPOC, too, is used.

A SIPOC diagram is a method used by a team to describe all important facets of a process improvement project before starting work. It helps to define a complex project that may not be well conducted and is traditionally used during the Six Sigma DMAIC measuring phase[18]. Above table 1 depicts the SIPOC flow of the selected factory.

Measure Phase

At this stage, the percentage of defects, existing DPO (Defect per Opportunity), DPMO (Defect per Million Opportunity), and Sigma Level of the selected factory were calculated, which is shown in table 2. The variation of the percentage of defects is also calculated and demonstrated in table 3.

Table 2.DPMO and Sigma level of existing process

Total checked pieces	**647207**
No. of Defectives	65200
% Defectives	10.07
DPO	0.1007
DPMO	100740
Sigma Level	2.78

Analyze Phase

The main objective of the review process is to go through the data and figure out the topmost recurring defects as well as the root causes of the problems and to find out the opportunities for improvement. At this stage, we had found six major problems. Two problem solving Six Sigma tools were used at the analyzing phase, and these were: Brainstorming and cause and effect diagram.

Table 3.Frequency of defects of the inspected shirt

Defect name	**Total Occurrence**	**Percentage(%) of Occurrence**
Hole	20697	32
D. Needle	8773	13
Cut	7115	11
Dirty Spot	4918	8
Knot/Slub	4353	7
Join	3604	8
T. Thin	3331	5
Yarn	3099	5
Conta	2191	3
C. Mark	1963	3
L. Mark	1428	2
Dia less	1297	2
Others	2431	4
Total	65200	100

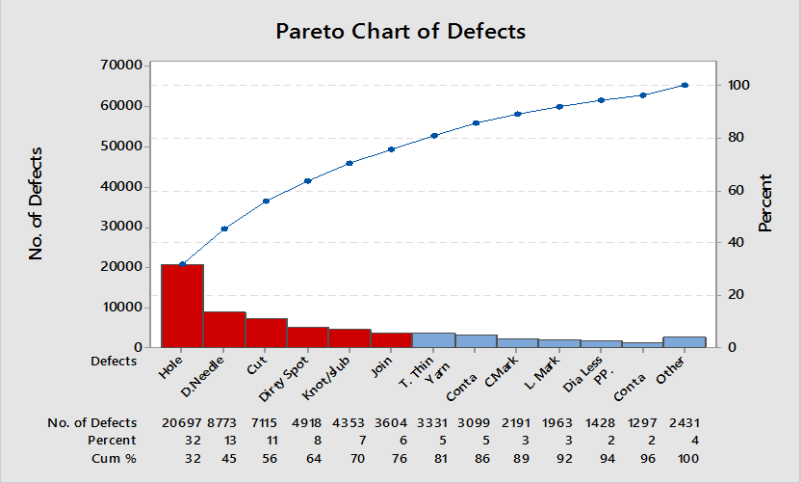

Figure 1.Pareto chart for identifying major defects

Brainstorming

Brainstorming is a method of collective creativity. The main purpose of this team is to identify, validate, and solving the root problems by sharing spontaneous ideas. All the ideas are noted down and appreciated without criticism. We've analyzed the causes of the problems and constructed a Cause-Effect diagram, which is shown in Fig-2.

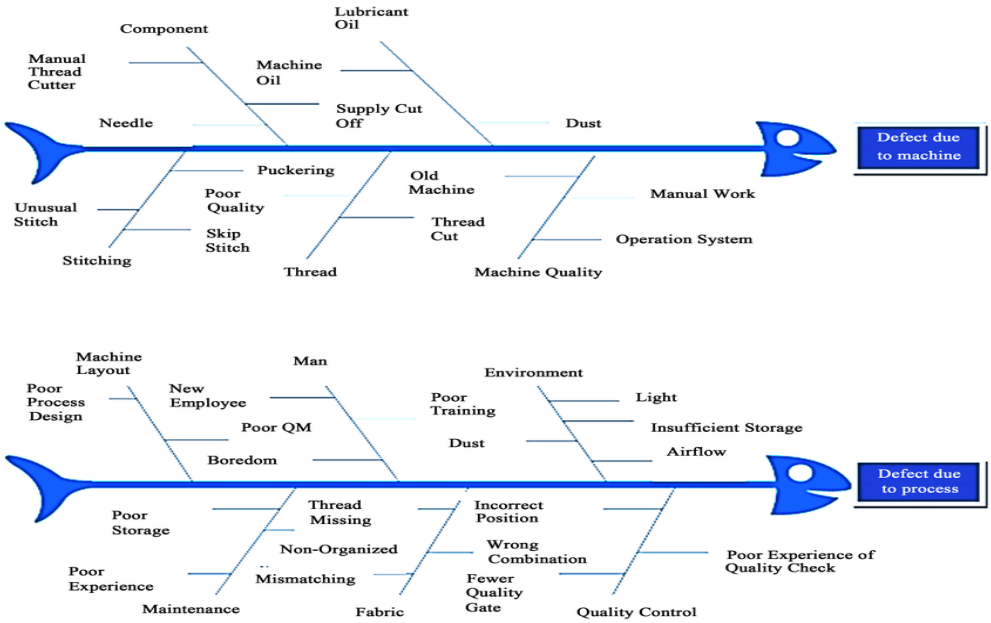

Figure 2. Cause-effect diagram for all defects due to machine and process

Improve

This step focuses on using experiments and statistical techniques to generate potential changes in improvements to reduce problems or defects [19]. It includes brainstorming of possible solutions, collection of solutions for testing, and review of the outcomes of the solutions implemented.

Implementation Phase

After discussing with the management, they agreed to implement some of the suggested solutions.

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Suggested Solutions

From the Pareto chart, we've detected six major defects. We've tried to suggest some possible solutions to remove the causes of defects. The solutions with their corresponding causes are given in below Table 4.

Table 4(part-i). Suggested solutions for all major defects with corresponding causes

Defect Name	Cause	Solution
Holes	1. Because of yarn tension is high 2. Yarn overfeed or underfeed 3. Due to take-down tension is high 4. Eyelets, yarn guides, wax, etc. caused barriers in the yarn paths.	1. Eyelets & Yarn Guides shouldn't contain any fibers, fluff & wax. 2. The yarn feed rate, as per the required Stitch Length , should be strictly regulated. 3. As per the size of the knitted loop, the gap between the Cylinder & the Dial should be adjusted. 4. The tube of fabric should be just like a fully inflated balloon, not too dense or too extent. 5. Provide uniform yarn tension with a Tension Meter on all feeders.
D.Needle	1. High Yarn Tension 2. Count Variation 3. Mixing of the yarn lots 4. Bend Needle	1. Provide equal Yarn Tension. 2. The mean variation of the lot count should not exceed (+-) 0.3. 3. Make sure the knitting yarn is of the same Lot / Merge no. 4. Ensure all yarn packages are uniform in hardness, by using a hardness tester. 5. Ensure all the needles Should be Straight.
Cut	1. Excess amount of Fabric cuts during Dyeing Operations. 2. Excess amount of Fabric cuts during GSM Test & Shrinkage Test. 3. Workers are careless.	1. Need more counseling 2. Avoid unnecessary fabric cuts. 3. Management Level Should emphasize on Gamba Practice.

Table 4(part-ii). Suggested solutions for all major defects with corresponding causes

Defect Name	Cause	Solution
Dirty Spot	1. Unclean Knitting Machine bed. 2. Unclean Stentor Machine 3. Poor Chemical use in dyeing and Finishing. 4. Uncover Fabric batch after each operation finished	1. Clean Knitting Machine bed before operations Starts. 2. Clean Stentor Machine before Fabric finishing. 3. Select High-quality Chemicals. 4. Cover Fabric batch.
Knot/Slub	1. By tying spools of yarn altogether. 2. High Yarn Tension 3. Count Variation 4. Package hardness variation	1. Equal Yarn Tension on all the feeders. 2. Average Count of variation in the lot, should not surpass (+-) 0.3. 3. Yarn should be used for Knitting is of the same Lot / Merge no. 4. Assure that the hardness of, all the yarn packages, is uniform, using a hardness tester.
Join	1. High Rate of Yarn Lot. 2. Batch mixing by overlock sewing for fabric slitting	1. Decrease the change of Yarn lot as more as can. 2. Cuts join during the final fabric inspection.

RESULTS AND DISCUSSION

Percentage of defectives**,** DPMO, Sigma Level were measured and listed on table 5 after the implementation of some suggested solutions.

Table 5.DPMO and sigma level after Implementation

Variables	Quantity
Total Number of Checked Pieces	614658
No. of Defectives	48395
% of Defectives	7.87
DPO	0.0787
DPMO	78735
Sigma Level	2.91

Control Phase

Eventually, this last stage in the DMAIC process ensures that the changes are continued and that the output is tracked continuously. Improvements to the method are often recorded and institutionalized [20]. The management needs to act on the following necessary tasks to withstand the success after the adoption of Six Sigma:

1. They should provide proper training to the operators on the quality issues.

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2. To motivate the workers and for high-quality results, a sound reward scheme should be considered.
3. Preventing defects is given greater importance than fixing defects.
4. When the issue is quality then there should be zero compromisation.
5. The organization should develop a proper system of Quality Management.

CONCLUSION

The main aim of this study is to minimize the defects of the fabric section and increase overall efficiency. The DMAIC technique of SIX SIGMA had been employed to reduce these defects. In this study, the Pareto chart identified six major defects (Hole, D. Needle, Cut, Dirty Spot, Knot/Slub, Join). Furthermore, the root causes of this problem are investigated, and through brainstorming, some possible solutions are finally offered to reduce the major defects. From this study, we found that the defect rate was 10.07%, which is very high for any industry. After the implementation of the DMAIC technique, the percentage of defects was reduced to 7.87%, which is more convenient. The sigma level had also represented a sharp increase; with considerably shifted from 2.78 to 2.91. Finally, as minimizing defects is a continuous method, further implementation of this technique would enable the organization to achieve more defect rate reduction and productivity increament.

REFERENCES

[1]. Export Promotion Bureau (2020). Export Data, viewed 29 march 2020, *http://www.epb.gov.bd/index.php.*

[2]. Tennant, and Geoff, (2001). *Six sigma: spc and tqm in manufacturing and services*, Gower publishing ltd.

[3]. Kumar, S., & Sosnoski, M. (2009). Using dmaic six sigma to systematically improve shopfloor production quality and costs. *International journal of productivity and performance management.*

[4]. Sokovic, M., Pavletic, D., & Pipan, K. K. (2010). Quality improvement methodologies–PDCA cycle, RADAR matrix, DMAIC and DFSS. *Journal of achievements in materials and manufacturing engineering*, 43(1), 476-483.

[5]. Tong, J. P. C., tsung, F., & Yen, B. P. C. (2004). A dmaic approach to printed circuit board quality improvement. *The international journal of advanced manufacturing technology, 23*(7-8), 523-531.

[6]. Sinthavalai, R. (2006, August). *A methodology to support six sigma implementation in smes as elearning.* In proceedings of the third international conference on elearning for knowledge-based society, August (pp. 3-4).

[7]. Desai, D. A. (2006). Improving customer delivery commitments the six sigma way: case study of an indian small scale industry. *International journal of six sigma and competitive advantage, 2*(1), 23-47.

[8]. Kumar, M., Antony, J., Antony, F. J., & Madu, C. N. (2007). Winning customer loyalty in an automotive company through six sigma: a case study. *Quality and reliability engineering international, 23*(7), 849-866.

[9]. Li, M. H. C., Al-refaie, A., & Yang, C. Y. (2008). Dmaicapproach to improve the capability of smt solder printing process. *IEEE transactions on electronics packaging manufacturing, 31*(2), 126-133.

[10]. Kumar, S., & Sosnoski, M. (2009). Using dmaic six sigma to systematically improve shopfloor production quality and costs. *International journal of productivity and performance management.*

[11]. Dreachslin, J. L., & Lee, P. D. (2007). Applying six sigma and dmaic to diversity initiatives. *Journal of healthcare management, 52*(6), 361.

[12]. Taner, M. T., Sezen, B., & Antony, J. (2007). An overview of six sigma applications in healthcare industry. *International journal of health care quality assurance.*

[13]. Chen, S. C., Chen, K. S., & Hsia, T. C. (2005). Promoting customer satisfactions by applying six sigma: an example from the automobile industry. *Quality management journal, 12*(4), 21-33.

[14]. Kumar, S., Strandlund, E., & Thomas, D. (2008). Improved service system design using six sigma dmaic for a major us consumer electronics and appliance retailer. *International journal of retail & distribution management.*

[15]. Thomas, H. L. (1987). *Analysis of defects in woven structures: development of the knowledge base*, Doctoral dissertation, ms thesis. Georgia institute of technology.

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[16]. Srinivasan, K., Dastoor, P. H., Radhakrishnaiah, P., & Jayaraman, S. (1992). Fdas: a knowledge-based framework for analysis of defects in woven textile structures. *Journal of the textile institute, 83*(3), 431-448.

[17]. Garza-reyes, J. A.; oraifige, I.; Soriano-Meier, H.; Harmanto D.; Rocha-Lona, L. (2010). *An empirical application of six sigma and dmaic methodology for business process improvement*, Proceedings of the 20th international conference on flexible automation and intelligent manufacturing (faim), July 12-14, California, US, 92-100.

[18]. Poytipjirasukprasert, Arturogarza-reyes, Vikaskumar, Ming K. Lim,(2014). A six sigma and dmaic application for the reduction of defects in a rubber gloves manufacturing process. *International Journal of Lean Six Sigma, 5*(1), pp.2 – 21.

[19]. Omachonu, V. K.; Ross, J. E. (2004). *Principles of total quality*, 3rd edition. Florida: CRC Press LLC.

[20]. Stamatis, D. H. (2004). *Six sigma fundamentals: a complete guide to the system, methods and tools.* New York: Productivity Press.