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Footwear Industry in Bangladesh: Implementation of Six Sigma Methodology

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Abstract

The increasing economic growth in Bangladesh encourages the growth of Leather sector. This condition results in an intense competition among the leather products industries particularly footwear industries which encourages companies to produce quality products in order to meet customers' satisfaction. One of the methods to control the quality is by using Six Sigma (SS). SS is a method of improving the quality towards the target of 3.4 defects per million opportunities for each production of goods and services. SS is divided into two methods, namely DMAIC (Define, Measure, Analyse, Improve, and Control) and DMADV (Define, Measure, Analyse, Design, and Verify). It can be implemented not only for big companies but also for SMEs. This study was conducted to determine the application of quality control aspect of SS in leading export oriented footwear industry in Bangladesh using DMAIC method. By using this tool, it can be seen that the sigma value in the different production line like court shoe and oxford shoe production line are 6324 and 6300 with the possibility of error products contained are 32938 and 32814 per million opportunities respectively. In the application of SS in this study, there are various causes of defective products, namely toe lasting problems, inefficient ironing, insufficient chilling, etc.

Keywords: Waste; Six sigma; Pareto chart; Shoe production line; Footwear industry; Bangladesh

Abbreviations:

SS: Six Sigma; D/T: Down Time; C/T: Cycle Time; U/T: Up Time; VD: Value Added Time; NVD: Non Value Added Time

Introduction

Footwear industry is a booming and one of the largest manufacturing sectors in Bangladesh. In the World, it is one of the leading manufacturing industries based on raw material, geographical condition and work force and is highly favourable for the growth of footwear industry. The demand of processed footwear is rapidly increasing in the busy World and consequently it seems a rapid expansion of footwear industry in Bangladesh as like as other countries. It needs several production steps to produce the finished goods from raw materials. Today Higher Productivity achievement is very important factor for the production field. With the Higher productivity other various factors must be taken in to consideration in manufacturing industries such as global competition, lead time and customer need in terms of quality and quantity. A new technique SS has been developed for dealing with all these needs. SS vision is to improve the quality output of a process and product by identifying the causes in the process and removing the causes of defects and minimizing the variability in manufacturing process. Since Motorola gave birth to SS in the late 1980s, these concepts have been implemented worldwide in firms striving for quality improvement in their processes. This concept was brought in by engineer Bill Smith while working at Motorola in 1986; it is a continuous quality improvement process and created from the concepts of Total Quality Management (TQM) [1,2]. In this study the SS role has been examined through the case study of footwear manufacturing industry [3]. It is also expected that with the implementation of SS methodologies, footwear Industry will entail with the increased global competitiveness.

Six Sigma (SS)

From many aspects of quality of any product or service SS is a very promising way of branding and packaging. Over the time, SS brings the different meanings from different corners in case of defect free production of manufacturing World and still now it is evolving with new dimension with its meanings and application. By SS it is refers to the philosophy, tools and methods used to seek, find and eliminate the causes of defects or mistakes in business processes by focusing on the outputs that are important to the customers[4,5]. It is not a single thing rather a set of tools and strategies for process improvement [6]. It represents a highly disciplined and statistically based approach to quality. The Department of Trade and Industry, UK (June, 2005) says SS is a data-driven method for achieving near perfect quality. SS analyses can focus on any element of production or service and has a strong emphasis on statistical analysis in design, manufacturing and customer-oriented activities. The SS as a well-structured continuous improvement methodology to reduce process variability and remove waste within the business processes [6-8]. It is defined as a set of statistical tools adopted within the quality management to construct a framework for process improvement [9]. It is also as an operational philosophy of management which can be shared beneficially by customers, shareholders, employees and suppliers [10,11]. SS methodically analyses underlying data and identifies the root causes of

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problems as opposed to using subjective opinions. Hence, every step in a process represents an opportunity for a defect to occur; SS seeks to reduce the variation in these steps which results in the occurrence of fewer defects and the production of higher quality goods and services. By controlling this variation, SS prevents defects from occurring rather than simply detecting and correcting them. SS intends to help companies to survive in a competitive environment by creating cost savings, improving customer satisfaction and improving organizational competence for innovation and continuous improvement. The term sigma is often used as a scale for level of goodness or quality (Table 1). SS is the set of tools & techniques for process improvement. The comparison of different sigma values [12]:

Sigma level	Defects per million opportunities (DPMO)	Percentage yield	Capability
1	690000	30.9%	Non competitive
2	308537	69.1%	
3	66807	93.3%	Industrial average
4	6210	99.4%	
5	233	99.98%	
6	3.4	99.99966%	World class

Table 1: The comparison of different sigma values.

Tools and techniques of six sigma

Over the years, companies have developed a number of tools into the approach of SS to make them more effective and to eliminate possible gaps after its application. This tool sets includes the statistical and analytical tools both from industrial engineering and operations research fields [13]. Different tools and techniques of SS are used for different aspect so it is important to apply the right tool in the right situation in order to achieve successful results [14,15]. The output of technology depends on the proper implementation of tools and techniques of SS [16]. Inspired by Deming's Plan-Do-Check-Act cycle SS projects follow two project methodologies. These methodologies composed of five phases each assume the acronyms DMAIC and DMADV. DMAIC is used for projects aimed at improving an existing business process while DMADV is used for projects aimed at creating new product or process designs [17]. The DMAIC project methodology has five phases [18]:

- Define the problem specifically identify the voice of the customer and the project goals;
- Measure key aspects of the current process and collect relevant data;
- Analyse the data to investigate and verify cause-and-effect relationships. Determine what the relationships are responsible for the problem and attempt to ensure that all factors have been considered. Seek out root cause of the defect under investigation;
- Improve or optimize the current process based upon data analysis using techniques such as design of experiments, poka yoke or mistake proofing and standard work to create a new and future state process. Set up pilot runs to establish process capability;
- Control the future state process to ensure that any deviations from target are corrected before they result in defects. Implement control systems such as statistical process control, production boards, and visual workplaces and continuously monitor the process.

Research Methodology

Population

In this study, Footwear industry was the population where its two types of shoe production lines were the samples.

Primary data collection

The primary data was documented from personal observations of researcher of court and oxford shoe production lines at different production stages from a leading export oriented footwear industry in Bangladesh. The observations data were setup time, change over time, machine function, material and labour flow at each and every production stages of the production line. The regarding data collection tools were prepared by following the principles of different tools and strategies of Six Sigma methodology.

Secondary data collection

The secondary data was taken through the internet, books, journals, related studies and other sources of information.

Statistical analysis

Each type of data was collected for at least three times where mean and standard error of mean of these collected data were analysed by using the statistical software tool of SPSS for windows (version 17.0) (Figure 1).

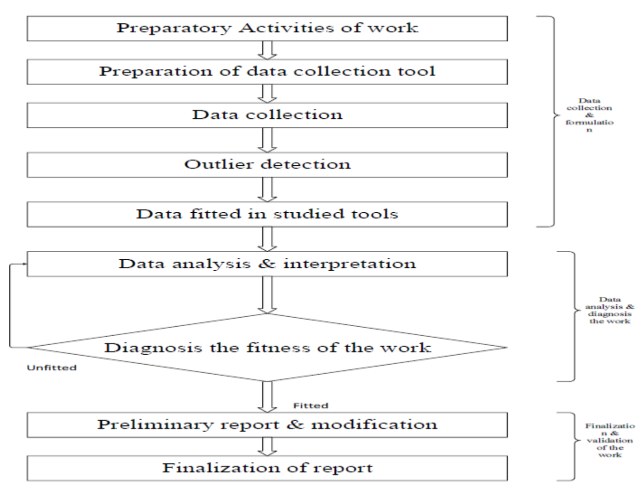

Figure 1: Complete methodology for the study.

Manufacturing waste of different shoe production line

There are different types of manufacturing wastes like over production, defect, waiting, unnecessary processing, unnecessary inventory, unnecessary transportation between work sites and unnecessary motion in the work place. In a single production line all types of wastes could not be seen (Tables 2-5). Based on the nature of

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production the manufacturing wastes are varied. Among these manufacturing wastes, defective productions were very common in the different shoe production line [19,20]. In this production line defect shoe was considered as the defect production.

Step	Causes for D/T	D/T (Sec)	Average D/T	C/T	% D/T
Sewing	Needle thread breakage	302		2760	
		308	303		17.55
		298			
	Bobbin or looped thread breakage	55			
		51	53		3.07
		48			
	Skipped stitches	34			
		32	35		2.02
		40			
	Seam pucker	83			
		96	89		5.15
		88			
Lasting	Improper setting during toe lasting	534		2400	
		524	526		5.96
		520			
	Improper setting during seat lasting	97			
		109	103		
		103			
	Inappropriate scouring	93			
		102	97		5.62
		96			
	Side lasting problems due to feather edge stitching	48			
		39	43		2.49
		41			
	Inappropriate chilling	90			
		95	91		5.27
		89			
Finishing	Inefficient ironing	176		1620	
		170	171		9.90
		167			
	Improper polishing	90			
		87	91		5.27
		95			
	Inefficient spraying	39			

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		45	42		2.43
		42			
	Long mark defects	38			
		45	41		2.37
		41			
	Bumps or hollows	41			
		38	41		2.37
		43			
Total			1726		

Table 2: Down Time (D/T) of court shoe production line.

In court shoe production line, the most important production stages were sewing, lasting and finishing where the most frequent D/T was observed due to different causes that were documented in Table 2.

Name of stages	**No of observation**	**Rejected shoes per batch**	**Average rejected shoe per batch**	**Average rejected shoe per batch (per day 12 batch)**	**Rejected shoe per million opportunity**	**Gap at Six Sigma level**	**Remarks**
Sewing	1	14					Contains at three sigma level
	2	11					
	3	10	11	132	688	685	
	4	13					
	5	9					
Pre-lasting	1	260					
	2	258					
	3	269	258	3096	16125	16122	
	4	253					
	5	248					
Post-lasting	1	193					
	2	180					
	3	199	186	2232	11625	11622	
	4	170					
	5	189					
Finishing	1	4					
	2	3					
	3	3	3 × 24=72	864	4500	4497	
	4	3					
	5	3					

Total			527	6324	32938		

Table 3: Wasted product calculation of Court Shoe Production Line.

From Table 3, it seems that the total defect products of court shoe production line were 32938 per million products of production which was considered as the three Sigma productions.

Steps	Causes for D/T	D/T (sec)	Average D/T	C/T	%D/T
Sewing	Needle thread breakage	314		2760	
		310	311		19.09
		308			
	Bobbin or looped breakage	73			
		82	78		4.78
		80			
	Seam pucker	29			
		31	32		1.96
		37			
	Skipped stitches	87			
		89	87		5.34
		90			
Lasting	Improper setting during toe lasting	312		2400	
		318	313		19.12
		310			
	Improper setting during seat lasting	112			
		104	103		6.32
		93			
	Inappropriate scouring	93			
		96	92		5.64
		88			
	Side lasting problems due to feather edge stitching	84			
		81	81		4.97
		78			
	Inefficient chilling	50			
		47	49		3.01
		52			
Finishing	Inefficient ironing	293		1620	
		281	286		17.55
		284			

	Improper polishing	83			
		78	83		5.09
		87			
	Inefficient spraying	46			
		41	41		2.51
		37			
	Long mark defects	41			
		32	37		2.27
		43			
	Bumps or hollows	38			
		30	36		2.20
		41			
Total			1629		

Table 4: Down time (D/T) of oxford shoe production line.

In oxford shoe production line, the most important production stages were sewing, lasting and finishing where the most frequent D/T was observed due to different causes that were documented in Table 4.

Name of stages	No of observation	Rejected shoes per batch	Average rejected shoe per batch	Average rejected shoe per batch (per day 12 batch)	Rejected shoe per million opportunity	Gap at Six Sigma level	Remarks
Sewing	1	10					Contains at three sigma level
	2	11					
	3	9	11	132	688	685	
	4	13					
	5	12					
Pre-lasting	1	266					
	2	253					
	3	260	257	3084	16063	16060	
	4	254					
	5	250					
Post-lasting	1	186					
	2	180					
	3	192	185	2220	11563	11560	
	4	176					
	5	189					
Finishing	1	3					

	2	3					
	3	2	3 × 24=72	864	4500	4497	
	4	3					
	5	3					
Total			525	6300	32814		

Table 5: Wasted products of oxford shoe production line.

Based on Six Sigma concept it seems that if the amount of defect product was more than 6,210 but less than 66,807 per million products of production then it was considered as the three (03) Sigma productions. From Table 5, it seems that the total defect product of oxford shoe production line was 32814 per million product of production which was considered as the three Sigma productions. But the prime target of any manufacturing industry should be Six Sigma production where the amount of defect products should not be more than 3.4 per million products of production. Throughout this study it was expected that 80% of the present manufacturing waste could be reduced after the implementation of Six Sigma methodology.

Pareto Analysis

It is a statistical technique in decision making that is used for selection of a limited number of tasks that produce significant overall effect. It uses the Pareto principle – the idea that by doing 20% of work, 80% of the advantage of doing the entire job can be generated [21]. The Pareto Principle also known as the "80/20 Rule" which is the idea that 20% of causes generate 80% of results [22-24]. In this study, by using this tool it was tried to find out the 20% of causes that is generating 80% NVD (Non value added time) activities. This tool focuses on the most damaging causes on a project (Figures 2 and 3). In this essence, the application of the Pareto chart consisting of causes for downtime or NVD activities along the X axis while the Y axis represents the cumulative percentage of downtime. Most of the NVD activities were documented on sewing, pre-lasting, post-lasting and finishing steps where these were frequently observed due to different causes. The highest frequency of NVD activities that derived the down time were found for mainly toe lasting problems while the lowest frequency was varied.

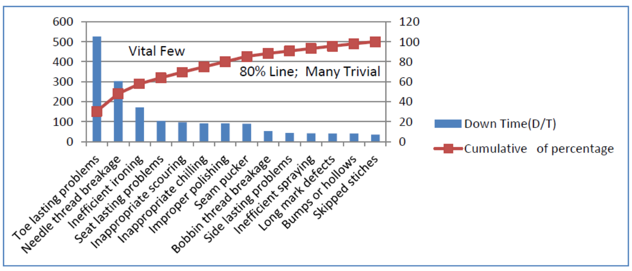

Figure 2: Pareto chart of court shoe production line.

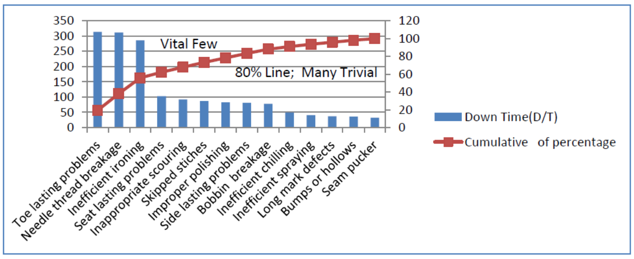

Figure 3: Pareto chart of Oxford shoe production line.

Conclusion

The Six Sigma method is a project-driven management approach based on the theories and procedures to reduce the defects for a specified process. This paper presents the step-by-step application of the Six Sigma methodology for identifying and reducing the rejection level of shoe production line and examines the products quality level. Several statistical tools and techniques were effectively utilized to make inferences during the project.

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