A Review on Implementation of Six Sigma in Manufacturing Industries

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Abstract- This paper discusses the implementation of Six Sigma Methodology in Manufacturing Industries. The DMAIC (define- measure- analyze- improve- control) approach of Six Sigma has been used in implementing Six Sigma in Manufacturing Industries for improving process quality level. This has resulted in improving Sigma level by implementing this methodology, without any huge capital investment. Implementation of Six Sigma methodology has resulted in large financial savings for different Manufacturing Industries.

***Keywords*- Six Sigma, Manufacturing Industries, DMAIC**

I. INTRODUCTION

A. Six Sigma: Historical Background

Six Sigma began in 1986 as a statistically based method to reduce variation in electronic manufacturing processes in Motorola Inc. in the USA. It is developed by Bill Smith at Motorola, later it was adopted by General Electrics and Allied Signals, where it was initiated by Jack Welch [20]. There are two important contributions from GE's way of implementation to the evolution of Six Sigma. First, Jack Welch demonstrated the great paradigm of leadership. Second, he backed the Six Sigma program up with a strong rewards system. GE changed its incentive compensation plan for the entire company so that 60 percent of the bonus was based on financials and 40 percent on Six Sigma results. The new system successfully attracted GE employees' attentions to Six Sigma. Moreover, Six Sigma training had become a prerequisite for advancement up GE's corporate ladder. Welch insisted that no one would be considered for a management job without at least Green Belt training by the end of 1998.

Further, Six Sigma has undergone many changes and improvement with the passage of time, also its implementation from manufacturing industries to service industries as well. Six Sigma can be applicable to any product, process or transactions. It can also be applied business operations such as Research & Development (R&D), sales and marketing, on time delivery process, administration and other areas that directly affects the customers. It is a project-by-project improvement approach, which consists of analysis of quantitative data by using statistical tools and techniques. It is a highly data driven approach. Because breakthrough improvements and profits are associated with it, it has taken an attention from academics and practitioners worldwide.

B. *Six Sigma: Definition*

Being highly disciplined, systematic, customer-centric and profit-driven or organization-wide strategic business improvement initiative, which helps to focus on developing and delivering very close to perfect solutions, products or services [1]. In a different way Six Sigma seek to reduce variation in the processes that lead to the defects [1]. Six Sigma is considered a strategic corporate initiative to boost profitability, increase market share and improve customer satisfaction through statistical tools and techniques that can lead to breakthrough quantum gains in quality. Six Sigma blends management, financial and methodological elements to make improvement to process and products concurrently.

To become globally compatible and to gain business as well operational excellence industries are implementing various quality improvement initiatives like Lean manufacturing, ISO certification, Total Quality Management, Quality Circle, etc.[8,10]. But results explored by these initiatives are timely constrained and not that much profitable. So methodology, which can provide breakthrough improvement in a short time, is required to be introduced and implemented. Six Sigma is the same methodology which can provide breakthrough improvements in short time period, so it is very essential to explore it application for gaining quantum gains and profit in terms of quality, market share and customer satisfaction.

Six Sigma methodology has two approaches: 1. DMAIC (D-Define, M-Measure, A-Analyze, I-Improve, C-Control). 2. DMADV (D-Define, M-Measure, A-Analyze, D-Design, V-verify). DMAIC methodology is applicable to existing product or

process, which is to be improved, and DMADV is applicable to new product or process, which is to be designed and implemented in such a way that it provides Six Sigma performance.

II. SIX SIGMA METHODOLOGY APPLICATION IN MANUFACTURING INDUSTRIES

The application of Six Sigma methodology is a statistical analysis approach to quality management and hence the DMAIC methodology can be used for improving the product quality during the injection molding as follows:

A. Define Phase and Tool

Define (D) is the first step of the Six Sigma methodology. In this phase selection of projects, initial goals and targets are set and develop a project charter or statement of work is carried out. Cost of quality related to existing process is being calculated. Analysis of SIPOC (Supplier, Input, Process, Output, Customer) and CTQ (Critical To Quality) are listed. Improvements target and goals are set in terms of sigma level and cost associated. This phase includes identification of the key problem areas and defining quality characteristics.

B. Measure Phase and Tool

Measure (M) phase is the second step of Six Sigma methodology. In this phase collection and observation of data is carried out and based on that DPMO (Defects Per Million Opportunity) or Process Capability Analysis is estimated based on the features of data (Attribute or Variable).

C. Analyze Phase and Tool

The third step is Analyze (A). Here identification of possible causes due to which variation or defects are occurring and which are affecting the output of the process is identified. Most frequently step in Analyze phase is cause and effect diagram. A Six Sigma team explores possible causes that might originate from sources, such as man, material, machine, method and environment. Another technique is "Why-Why" analysis. In this procedure team explores at least five possible reasons for influence of particular cause, so that root cause of particular problem can be evaluated. In order to make each member understand about effect of particular cause, each suggestion may need clarification. The resulting list should be reduced to the most probable root causes. Causes validation may be carried out by new or existing data and by statistical tools, such as scatter plots, ANOVA, regression, hypothesis testing and Design Of Experiment (DOE). By validating root cause, implementing ineffective improvements and wastage of resources can be prevented.

D. Improve Phase and Tool

The forth step is Improve (I). After collecting and analyzing the data suggestion is recommended to reduce the defect or non-conformity, which is critical for customer. In this phase counter measures for root causes are listed out which can be implemented to reduce defects. Affinity diagram can be used in which issue is presented and ideas or solutions for that are discussed. The list should be narrowed to one or two potential improvements that should be selected based on probability of success, time of execution, impact on resources and cost. A pilot project is carried out based on the ideas or solutions selected for implementation and data collection is carried out. If small-scale implementation provides drastic success, team should proceed to full-scale implementation.

E. Control Phase and Tool

Fifth and last stage of DMAIC methodology is Control (C). In this stage control of improved implementation is done. If process is heading towards out of control, indication of that should be carried out by early signals. Team may develop poka-yoke or mistake proof devices that utilize light, sound, logic programming or no-go design to help control a process. The basic goal of this step is to reduce variation by controlling inputs and monitoring the outputs. The real challenge of Six Sigma implementation is not in making improvements in the process but sustaining the achieved results.

In brief Six Sigma improvement framework and tool kit can be shown as below (Sivity 2008)

DEFINE	MEASURE	ANALYZE	IMPROVE	CONTROL
Benchmark	7 basic tools	Cause & Effect diagram	Design of Experiments (DOE)	Control charts
Baseline	Defect metrics	Failure modes & effect analysis (FMEA)	Modeling	Time series methods
Charter	Data collection forms, plan, logistics	Decision & risk analysis	Tolerancing	Procedural adherence
Kano model	Sampling techniques	Statistical inference	Robust design	Performance management
Voice of the customer		Control charts		Preventive activities
Quality function deployment		Capability		
Process flow map		Reliability analysis		
Project management		Root cause analysis (5 why's)		
"Management by fact"		Systems thinking		

III. CONCLUSION

Due to remarkable improvements in various organizations, Six Sigma can be applicable to varieties of sectors that want to improve business excellence and operating excellence. Being a breakthrough improvement methodology, quantum gains in quality, productivity and profitability can be achieved. Due to its wide area of application, it can be used to improve any product, process or transaction. Six Sigma is a customer-oriented approach so an organization can also satisfy their customers also by providing quality products/services. By using Six Sigma we can reduce defects from any processes and can deliver close to target products. Improvement in quality, productivity, profitability, market share and customer satisfaction can be achieved by using this methodology.

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