Review on Defects Reduction in Multiple Sector by Using Six Sigma DMAIC Methodology

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Abstract: This paper presents a review on reducing defects in various areas by Six sigma DMAIC Methodology. In modern era, the Six Sigma tools and techniques have been implemented in various sectors, which strive to ameliorate continuous improvement in achieving less variation, cost and high quality of end products.Six Sigma emerged as a natural evolution in business to increase profit by eliminating defects. Six Sigma is a powerful world class improvement business strategy that enables companies to use simple but powerful statistical methods to define, measure, analyze, improve and control (DMAIC) processes for achieving operational excellence. In this paper, how DMAIC approach is carried out that has been reviewed from different research papers.

Keywords: *Six sigma, DMAIC, Quality tool, etc.*

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1. INTRODUCTION

The Six Sigma is a business strategy that enables organizations to increase their profits by optimizing operations, improving quality and eliminating the defects. The Six Sigma methodology is one of the most successful quality management initiatives. Six sigma has been adopted as a major initiative by some of the leading companies throughout the world[2].Six sigma is very powerful approach to achieve financial goals for organization and improving the company's value by Data driven, Project based, Disciplined and systematic, Customers focused (internal & external) for process improvement [13].

Six sigma has gained wide acceptance as an improvement methodology to enhance an organization's competitiveness.If there are processes that generate lot of negative customer feedback, whether that customer is internal or external, components of Six Sigma should be considered as a means to study and rectify the problem [3].

The Six Sigma implementation uses five step DMAIC (Define, Measure, Analyze, Improve and Control) methodology, somewhat similar to Plan-Do-Check-Act problem solving methodology defined by Deming. DMADV (Define, Measure, Analyze, Design and Verify) methodology is adopted for new product developments [13].

1.1 History Of Six Sigma

The Six Sigma is a set of techniques and tools for process improvement. It was introduced by engineer Bill Smith while working at Motorola in 1986. Jack Welch made it central to his business strategy at General Electric in 1995. Today, it is used in many industrial sectors. Six sigma has been exploited by many world class organizations such as GE, Motorola, Honeywell, Bombardier, ABB and Sony to name but a few, and has resulted bottom-line savings in millions.

2. METHODOLOGY

Six is the number of sigma measured in a process, when the variation around the target is such that only 3.4 outputs out of one million are defects under the assumption that the process average may drift over the long term by as much as 1.5 standard deviations. Six sigma has two key methodologies DMAIC Methodology and DMADV Methodology, both inspired by Deming's Plan-Do-Check-Act Cycle.

2.1 DMAIC Methodology

The DMAIC means Define, Measure, Analyze, Improve and Control. These all work together to create the DMAIC process. 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 [7]. This process is incredibly important in six sigma process because it is what helps bring a diverse team together. In Six Sigma DMAIC Define (Process Improvement Problem), Measure, Analyze, Improve and Control as a methodology is relevant for growing the process from maturity level 2 to maturity level

3, 4 and 5 [14]. First we have discussed all problems that can occur in the process, then at the same time we have also given a preventive action for those problems and then after we have also highlighted the critical success factors of every department that can cause more dangerous in quality point of view and improvement of process[11].

Fig-1: DMAIC Six sigma methodology

Define

The purpose of this step is to clearly articulate the business problem, goal, potential resources, project scope and high-level project timeline. This information is typically captured within project charter document. Write down what you currently know. Seek to clarify facts, set objectives and form the project team. Define a problem, The customer, Voice of the customer and Critical to Quality. If complex problems in industry the first thing is to construct a well-structured problem formulation a good representation and different types of problem formulation like "What" "Why" "How", to solve the problems from different actions and implementation some rules in the process [11].

The aim of Define phase is to define the project with all the possible details including project title, objective, scope, project team, risk involve, expected benefits and schedule for the project in terms of the customer requirements and identify the process delivering these requirements [18].To identify customer's requirements, the critical to quality tree is one of the most effective tool and very useful. This will help to understand the critical quality requirements of the product. To improve the quality of the product, these CTQ need to be addressed [19,4].Process mapping is a tool which takes into account and acquires a visualization of current operating processes and particularizing possible potential solutions. So, process mapping is applied in design, inspection, mould design and tools and molding process [16].

Measure

The purpose of this step is to objectively establish current baselines as the basis for improvement. In data collection step, the purpose of which is to establish process performance baselines. The team decides on what should be measured and how to measure it [12].Good data is at the heart of the DMAIC process. Basically a data collection phase in which current situation data are collected and then current sigma level is calculated for the process in question. Sigma level can be calculated by different methods the selection of method depends upon the type of data [4].

The existing process capability is expressed in terms of sigma quality level for the purpose of comparing the improvement after the case study. Sigma quality level of each batch is calculated through the below steps.

- calculating defects per unit of the batch (DPU)
- calculating defects per opportunities (DPO)
- calculating defects per million opportunities (DPMO)
- determining the sigma level to corresponding DPMO level using the empirical equation [2]

For discrete data defects per million opportunities (DPMO) number is calculated and then sigma level is calculated from the DPMO sigma level table.DPMO is a relatively simple concept and is applied using a simple approach for the manufacturing industry engaged in producing tangible products [14].

$$DPMO = \frac{(\text{Number of defects} \times 10^6)}{(\text{Number of Oppurtunities} \times \text{Number of units})}$$

Where
Number of defects = number of rejections
Number of opportunities = number of CTQs.
Number of units = number of units produced [9,8].

Analyze

This phase is intended to analyse the data to determine the direction of process improvement.it is important to identify the possible sources of variation.[20]The objective of Analyze phase in a six sigma project is to identify the root causes that are responsible for high variation in the selected CTQs. Brainstorming sessions are planned and conducted by the team with the involvement of all the concerned personnel of the process, and a list of potential causes for variation in CTQ has to be generated. A cause and effect study is conducted and parameters, thought to contribute to defects.[20] A cause-and-effect diagram was drawn based on these causes [17,5]. The analysis phase deals with identifying the root causes of the process whether it can be improved or redesigned and to understand the defects

studies & charts are produced to analyze this problem from different angles [14]. It is at this stage that practical are turned into statistical problems and analyzed as statistical problems. The relevant outputs and all the potential inputs (x) that might impact each output are connected to each other. So, the vital inputs (x) are appraised using graphical analysis [16].

In analyse phase, the identification of the root cause, makes an impact on the effectiveness of the shell and tube heat exchanger. In this regard, various subcritical factors were illustrated by cause and effect diagram. Consequently, the brainstorming sessions were conducted to identify the major critical factor that makes an impacton the shell and heat exchanger effectiveness. [1]

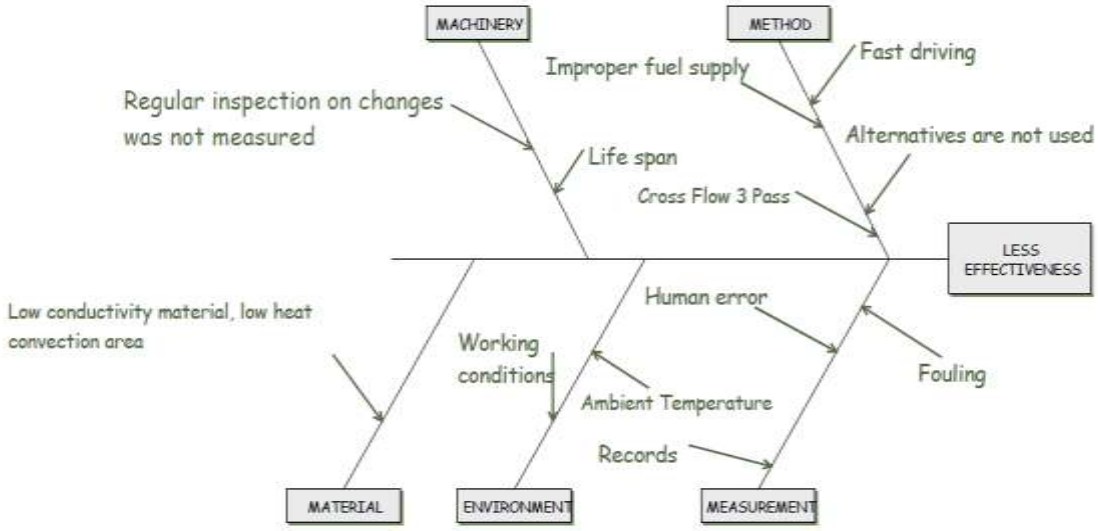

Fig-2: Cause and effect diagram

Improve

The purpose of this step is to identify, test and implement a solution to the problem; in part or in whole. This depends on the situation. Identify creative solutions to eliminate the key root causes in order to fix and prevent process problems. Explained in improvement phase possible solutions for the validated root causes are to be identified and should be actually implemented to observe the results [5]. As per the brainstorming sessions carried out by the team in the analyze phase, the improve phase spotlights on developing thoughts to get rid of root causes of variation, testing and standardizing those solutions.[4] The improvement of process is calculated by the help of Design of Experiment. In order to improve the process, some settings are changed which have severe effect on the defects of final product [13]. Industries point of view if inputs affect the outputs then, there is need to run trials to find and confirm the changes in old processes or procedure of these vital inputs and start implementing new processes according to Defects per Millions Opportunities (DPMO) to be reduce which can be called as Design of Experiments (DOE). DOE can be employed as a tool to pin point the influencing factors which affects on process outputs and could effectively troubleshoot problem [16].

Control

The real challenge of Six Sigma methodology is not in making improvements to the process but in providing a sustained improvement to the optimisation. This requires standardisation and constant monitoring and control of the optimised process. [2]The purpose of this step is to sustain the gains. Monitor the improvements to ensure continued and sustainable success. Create a control plan. Update documents, business process and training records as required. In control phase, tools are put in place to ensure that the key variables remain within acceptable ranges over time so that process improvement is maintained. A Control chart can be useful during the Control stage to assess the stability of the improvements over time by serving as a guide to continue monitoring the process and provide a response plan for each of the measures being monitored in case the process becomes unstable [19]. 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. [7]The improved production process was observed for a month, relevant data collected and control charts (X, R and p charts) were drawn to detect any deviation.[4]

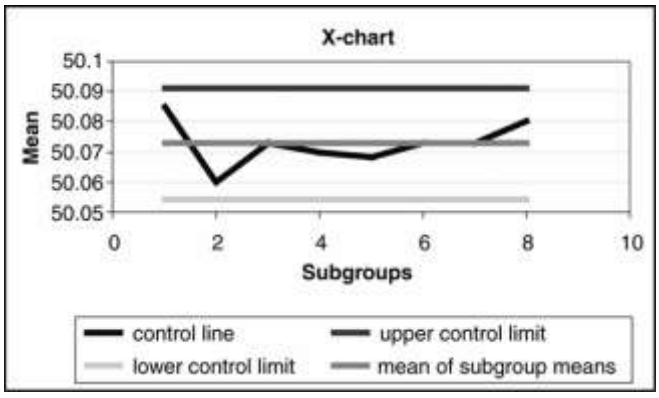

Fig-3: X-chart for outer diameter

2.2 Tools and Techniques

Different types of tools and techniques are used related to quality in various phases of six sigma. The first and best way to analyze measures of a process is to create a picture of the data. Charts and graphs are really nothing more than visual displays (pictures) of data. Charts and graphs are of various types, each offering a bit different picture of the data [6]. Taguchi DoE is conducted with the five process parameters identified from the analysis phase[2].A Black Belt will usually use at least a couple of these in one project. The most commonly used types of charts and graphs like Control Chart, Pareto Diagram, Cause-and-Effect or Fishbone Diagram, SIPOC Diagram, Tree Diagram, Run Chart, Check sheets and Spreadsheets, Matrix Diagram, Flow Chart, Scatter Diagram, Histogram [9].

3. CRITICAL SUCCESS FACTORS OF SIX SIGMA

The following elements are absolutely essential to successful implementation of Six Sigma:

- Commitment and involvement of top management
- Proper understanding of six sigma methodology, tools and techniques.
- Linking six sigma project to business strategy.
- Linking six sigma project to customer needs.
- Correct project selection, project reviews and project tracking.
- Sufficient organizational infrastructure.
- Cultural change.
- Project management skills for the middle level managers.
- Liking six sigma project to suppliers.
- Providing training to workers as well as managers.
- Linking six sigma project to human resources [17,5]

Useful implementation tips for successful six sigma applications as:

- Sustained and visible management commitment.
- Continuing Education and training of managers and participants.
- Setting clear expectations and selecting project leaders carefully for leadership skills.
- Picking and selecting strategically important projects [10]

3.1 Application

Six sigma has since been successfully applied in other manufacturing organizations such as General Electric, Boeing, DuPont, Toshiba, Seagate, Allied Signal, Kodak, Honeywell, Texas Instruments, Sony, etc [5]. The reported benefits and savings are composed and presented from investigating various literatures in six sigma [12].The healthcare sector are very well matched because of the healthcare nature of zero tolerance for mistakes and potential for reducing medical errors. The radiology film library at the University of Texas MD Anderson Cancer Centre also adopted six sigma and improved service activities greatly. Finance and credit department are pressured to reduce cash collection cycle time and variation in collection performance to remain competitive [19]. Six sigma projects in financial institutions include improving accuracy of allocation of cash to reduce bank charges, automatic payments, improving accuracy of reporting, reducing documentary credits defects, reducing check collection defects. The largest engineering and construction companies in the world, reported savings of $200 million with an investment of $30 million in its six sigma program to identify and prevent rework and defects in everything from design to construction to on-time delivery of employee payroll [7]. By implementing six sigma in R&D organizations Cost has been reduced, R&D process have been improved. One survey noted that as of 2003, 37% of the respondents had formally implemented six sigma principles in their R&D organization [6]. Six Sigma is the most fervent managerial methodology not only in manufacturing area but also in the services industry. Many investigations have indicated that Six Sigma can increase organization's competitive capability and enhance the quality of products or services by conducting the projects. This study aims to develop a systematic methodology to generate the project on the basis of the company's strategic policies and VOCs and determine the benefits and risk priorities of each project [15]. In the case study where Taguchi's Beta correction technique was integrated in the Control phase of Six Sigma methodology to have proper monitoring of the process. It has helped the process to reduce the variability [17]. In service sector six sigma DMAIC project to improve the warranty billing process paid by Car Brands. It shows that the project allowed car dealers managers to understand that financial metrics in use did not control compliance standards for Car Brands, in warranty

services, or assure a good cash-flow for the car dealers. It is helpful to understand why money was being lost or missing [18].The application of DMAIC approach in the foundry shop results were obtained by applying DMAIC approach the rejection percentages has reduced and saving of cost [9].

3.2 Limitations

The right selection and prioritization of projects is one of the critical success factors of a six sigma program. But most of the time the project selection and prioritization is completely based on the pure subjective judgment. Very few powerful tools are available for prioritizing projects and no standard method available for the project selection [10]. Due to dynamic market demands, the critical-to-quality characteristics (CTQs) of today would not necessarily be meaningful tomorrow. All CTQs should be critically examined at all times and refined as necessary [19]. 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 [5,10].

4. CONCLUSION

By review of these papers it was observed that six sigma methodology is implemented by use of project charter, SIPOC diagram and process map in define phase. It is observed that use of any quality control tools like cause and effect diagram, Pareto diagram, Brain storming, Multi-voting & cause validation ,Why-why analysis etc. in the measure phase and analysis phases. Six sigma strategy should start with measurement of initial sigma level and after implementation phase once again sigma level should be evaluated, and net improvement in sigma level can be achieved to use applicable method. By review of these papers it was observed that Six sigma is highly flexible strategy for any problem by appropriate tools and techniques to achieve significant results. This review indicates that the six sigma strategy is used to reduce rejection, to improve design, to reduce cycle time and to improve quality of the products. Six sigma methodology is useful for various objectives in different sectors. This strategic tool and technique can be used according to preset objectives and need of industry. A correct methodology and correct tools and technique must be used. Proper implementation of six sigma methodology can lead to great benefits.

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