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6 Sigma (σ) in Organization

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***Abstract*: Six Sigma within small and medium sized enterprises (SMEs) is rapidly emerging as the new wave of change in Six Sigma. Here we, reviews the implications of applying Six Sigma methodology over the tractor part manufacturing unit. The study helps in achieving high quality products and services at low cost for every small and medium sized enterprises. The methodology adopted is DMAIC methodology of Six Sigma which had been mostly successful so far in large scale industries. The methodology has been applied to reduce rejection rate of Bull Pinion Shaft by reducing defects inherent in the processes. The statistical techniques such as one sample t-test, process capability analysis have been used to establish the process capability before and after the Six Sigma application.**

***Keywords*: small and medium sized enterprises, Parts Per Million - PPM, Defects Per Million Opportunities'- DPMO, Sigma (σ), DMAIC -Define, Measure, Analyze, Improve, Control, DMADV - Define, Measure, Analyze, Design And Verify, Cause-And-Effect (C&E), CTQ (Critical-To-Quality)**

1. Introduction

Sigma is a Greek letter representing standard deviation or the amount of variation within a given process (McAdam*et al*., 2004) [1]. Six sigma is both a philosophy and a methodology that improves quality by analysing data with statistics to find the root cause of quality problems and to implement controls. Statically, Six Sigma refers to a process in which the range between the mean of a process quality measurement and the nearest specification limit is at least six times the standard deviation of the process (Nilesh*et al*., 2012) [2]. According to Asmita S. Joshi (2012)[3] , Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects and minimising variability in manufacturing and business process . Six Sigma is a powerful breakthrough business improvement strategy that enables companies to use simple and powerful statistical methods for achieving and sustaining operational excellence. It is a business strategy that allows companies to drastically improve their performance by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction (Harry et al.,2000) [4]. Park described that Six Sigma implies three things:

Statistical measurement, management strategy and quality culture. It is a measure of how well a process is performing through statistical measurement of quality level. It is a new management strategy under leadership of the top management that creates quality innovation and total customer satisfaction (Park *et al*., 2002) [5]. It is also a quality culture. It provides the way to do things right at the first time and to work smarter by using data information. It also provides an atmosphere to solve many CTQ (critical-to-quality) problems through team efforts. Statistical representation of Six Sigma describes quantitatively how a process is performing. The goal of Six Sigma is to design processes that do what they are supposed to do with very high reliability, ultimately producing very consistent products and services (Coronado *et al*., 2002) [6]. The numerical goal of Six Sigma is reducing defects less than 3.4 parts per million (PPM) also known as 'Defects Per Million Opportunities' (DPMO), reducing cycle time and reducing costs dramatically which impact the bottom line (Coronedo *et al*., 2002) [7].

Although Six Sigma has been implemented with success in many large corporations, there is still less documented evidence of its implementation in smaller organizations (Behara *et. al*., 1995) [8]. Due to growing importance of supply chain management issues in global market environment, large firms are heavily dependent on small- to medium-sized enterprises for the provision of high quality products and/or services at low costs. The increasing demand for high quality products and highly capable business processes by large organizations has left no choice on the SMEs to consider the introduction of Six Sigma business strategy.

As small companies are more agile, it is much easier to buy-in management support and commitment, as opposed to large organizations. The education and training component is much harder for smaller companies. Moreover, small companies do not have the slack to free up top talented people to engage in training followed by execution of Six Sigma projects as they are crucial to the day-to-day operations and problem solving within the company. Being able to link compensation to Six Sigma implementation is much easier in small companies compared to a large company (Rowlands *et. al*., 2003) [9].

Sigma (σ) is a letter in the Greek alphabet that has become the statistical symbol which is used in mathematical statistical to define standard deviation. The sigma scale of measurement is perfectly correlated to such characteristics as defects-per-unit, parts-per-million defective, and the probability of a failure. 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.

Fundamentally, Six Sigma implies three things: Measure of

quality, Process for continuous improvement and Enabler for culture change. Six sigma is a statistically based quality program. It tells us how good our products, services, and processes really are, through statistical meaning of quality level. It provides a process based approach to continuous improvement. It is independent of the measurement involved and can be used to improve any business process. It is also an enabler for culture change. To be successful, Six Sigma requires a radical change in the way an organization works. Business leadership and Six Sigma can together transform a company.

2. Improvement strategy

Process Improvement refers to a strategy of finding solutions to eliminate the root cause of performance problem in processes that already exist in your company. Its role is to help the management to produce maximum by using minimum input with create improvement programs. Process Improvement also finds the critical Xs (causes) that create the unwanted Ys (defects) produced by the process. If there is an existing process that is not meeting customer specifications, using Six Sigma five phase methodology DMAIC (Define, Measure, Analyze, Improve, Control) as shown in figure 1, that process can be improved and made more effective, more efficient, or both. DMAIC can be explained as:

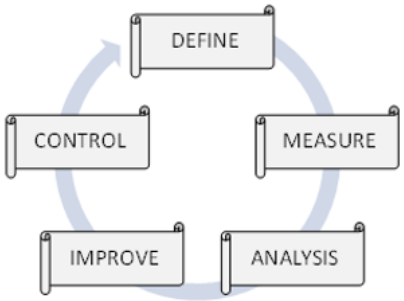

Fig. 1. DMAIC

3. Inter linkage between two Six Sigma Methodology

Six Sigma methodology constitutes two different methodologies for different type of problems. These are DMAIC (Define, Measure, Analyze, Improve and Control) methodology and DMADV (Define, Measure, Analyze, Design and Verify) methodology. If the root cause of the problem is the process, then the methodology which we will use is DMAIC methodology as it is best suited for that and if the root cause of the problem is related to design of the product then the methodology we will use is DMADV methodology as it is best suited for that.

The first three phases of both the methodologies are same i.e. Define, Measure and Analyze. The outcome of the analyze phase determines root cause of the problem and ultimately the demand for a right countermeasure arises. Now the methodology we will follow is justified with the demand of countermeasure irrespective of the methodology we were following. For example, we started a problem using DMADV methodology and after analyze phase we have found that the process is causing the problem not the design then we will switch over to DMAIC methodology from DMADV methodology without any problem. We do not need to redo the first three phases as they common in both the methodology.

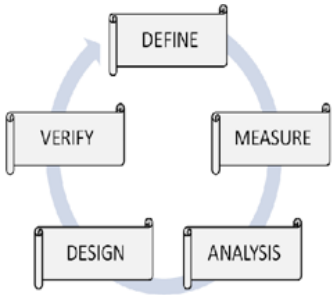

Fig. 2. DMADV

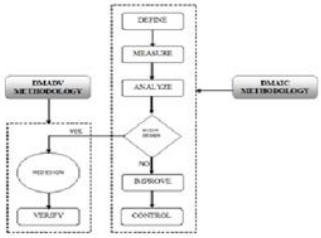

Fig. 3. Inter linkage

4. Research plan

Research plan represents the systematic flow of all the steps or activities taken to achieve the objectives of the present research. This research methodology adopted must cover all possible aspects of the problem for an extensive analysis. If this research methodology is not comprehensive enough, the solution obtained at completion will not be optimum. Figure 3.1 represents a process flow chart prepared to represent sequence of activities under the methodology adopted in completing the research work.

Literature survey is the first step to know the present status of research and application of Six Sigma across various industries. The literature review indicated some poor evidences on Six Sigma implementation in small organizations. It was also observed that Six Sigma has emerged as one of the most effective business improvement strategies among large companies all over the world. So, in the case study, an initiative has been taken to justify the highly useful role of Six Sigma for a small manufacturing industry. The case study is an attempt to justify the usefulness of Six Sigma for small scale industries. After identification of the research gaps, the objectives of the study were formulated. Then problem was formulated, followed by data collection was done over a period of two months in the selected organization at Mohali (Punjab). After the data was collected, as part of DMAIC methodology, an extensive analysis of the data was done using various tools and techniques. This analysis yielded some useful results which

were implemented to improve the existing processes and reduce the defects rate and achieve better productivity levels. The improvement phase helped in computing the new sigma levels and this reflected the improvement in quality achieved and thus impact on productivity was identified. Finally, the conclusions were drawn and scope for further work was identified to continue the research in this field.

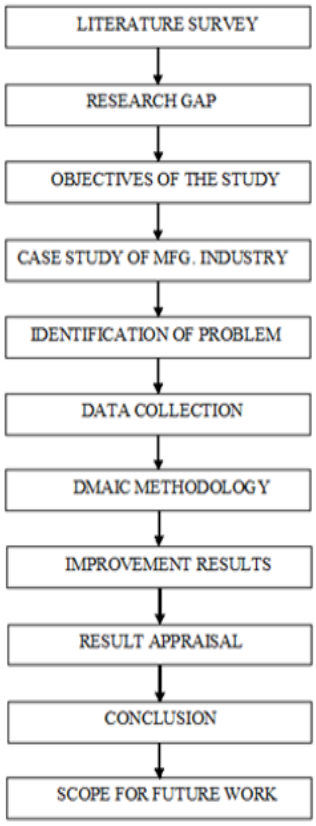

Fig. 4. Research methodology

5. Tools used

A. *Gauge R&R study*

In the measure phase, a measurement system analysis (MSA) is conducted using Gauge R&R studies. The purpose of the Gauge R&R study is to ensure that the measurement system is statistically sound. Gauge repeatability and reproducibility studies determine how much of the observed process variation is due to the measurement system variation. Six Sigma is based on measured data and so the measure phase identifies the defects in the product and gathers valid base line information about the process. There will be unfavorable consequences from analysis using Six Sigma tools if there is problem with measuring system. The observed possible source of variations in a process is the actual process variation and the measurement variation.

B. *Run chart*

A run chart or trend chart is a very simple technique for analyzing the process in the development stage. Plotting a run chart is the first step in data analysis as without a run chart, other data analysis tools- such as the process capability and histogram can lead to erroneous conclusions. Run chart is constructed from a measurement that has been gathered over time and, than plotted with time order. Purpose of this chart is to measure and track a key input, process or output measure over time and helps a team look at whether there are patterns over time in the problem.

C. *Histogram*

Histogram helps to display the large data that is difficult to interpret. It is used to examine the shape and spread of sample data and provides a better view of the center, distribution and shape of data. The data is displayed on a chart on which the horizontal axis is marked off in increasing values (from right to left) and vertical axis shows the frequency. Histogram divides sample values into many intervals called bins. Bars represent the number of observations falling within each bin.

D. *Process capability analysis*

Process capability analysis is done to find out the actual state of the process. The existing DPMO or PPM level which is the way to calculate the sigma level or yield of a process is determined using process capability analysis. Minitab software has been used for analysis of the data in the study and it generates a process capability report, which includes a capability histogram overlaid with normal curve and the complete tables of capability statistics.

E. *Fishbone diagram*

After knowing the DPMO and sigma level of the process using process capability analysis, a fishbone or cause and effect diagram is prepared and it is a structured brainstorming tool. A cause-and-effect (C&E) diagram is a picture composed of lines and symbols designed to represent a meaningful relationship between an effect and its causes. It is used to summarize the problem statement in the ‘head’ of fish, with potential causes arranging in sets of bones link to the head. This graphical tool is used to identify the relationship between a problem and the possible cause of problem. It is created by using an expert’s experiences and critical analysis of process.

F. *Bar chart*

Bar chart is a pictorial representation of a data over a period or under different heads for a given period. Instantly, it gives the areas, which need immediate attention and presents the relative comparison of the data between different heads. It is a simple and effective tool of data presentation, which helps to focus on the components of the problem that have the biggest impact.

6. Conclusions

Six Sigma tool for SMEs is an emerging topic among many academics and Six Sigma practitioners over the last two to three

years. Very few studies have been reported about the successful applications of Six Sigma in SMEs. As small companies are more agile, it is much easier to buy-in management support and commitment, as opposed to large organizations. The education and training component is much harder for smaller companies. Moreover, small companies do not have the slack to free up top talented people to engage in training followed by execution of Six Sigma projects as they are crucial to the day-to-day operations and problem solving within the company. Being able to link compensation to Six Sigma implementation is much easier in small companies compared to a large company.

This research article is an attempt to justify the highly useful role of management techniques like Six Sigma for SME's which are normally presumed to be in the domain of large industries. Pitch variation is found to be a common problem in any manufacturing industry. Application of Six Sigma project recommendations brought up the sigma level to 5.51 from 1.64 and estimated saving from the project after implementation is expected to be around Rs. 0.682millions per annum which is substantial for any small manufacturing industry.

7. Scope for future work

Application of Six Sigma in Indian industries is still in nascent stage and during research review; it was observed that the awareness level on the latest quality tools and statistical techniques is limited among managements of some large Indian organizations only. In this context, the following aspects need attention for future research:

- Apart from manufacturing sector, process sector is highly cost intensive and energy intensive and includes industries like paper mills, sugar mills, fertilizer plants etc, where an attempt can be made to implement Six Sigma over various systems and sub systems to considerably improve the productivity of the whole system.
- Six Sigma can also be implemented over other SME industries such as foundries, power looms, rolling mills etc. to improve the productivity level.
- Six Sigma implications can be studied and explored over different service organizations like healthcare, safety care, transportation, traffic management etc.
- Six Sigma implications can be studied and explored even over organizations like hospitals, schools, colleges, universities etc.

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