Journal of Science and Technology
ISSN: 2456-5660 Volume 06, Issue 04, July-August 2021

www.jst.org.in *DOI: https://doi.org/10.46243/jst.2021.v6.i04.pp145-149*

Implementation of Six sigma for improvement in Product quality

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To Cite this Article

Prafulla c. Kulkarni, "Implementation of Six sigma for improvement in Product quality", Journal of Science and Technology, Vol. 06, Issue 04, July-August 2021, pp145-149.

Article Info

Received: 23-08-2021 *Revised: 25-08-2021* *Accepted: 28-08-2021* *Published: 31-08-2021*

Abstract: *Companies business objective is to provide high quality products and services to customer at a lower cost and as quickly as possible. Earlier various quality control techniques were introduced. Aim of six sigma is to reduce cost by reducing the number of defects as much as possible or by streamlining the process to its perfection. Six sigma is variance reduction technique. Six sigma is a quality philosophy, a tool, a concept, a process, a measurement and a performance target. In a well known industry, there were a lot of complaints in its product from their customers. The customer complaints were analyzed. A detailed study of the process was performed by six sigma methodology. The improvements and corrective actions were taken. Six sigma has been a widely accepted tool for improving product quality.*

Key Word*: Process capability, Product quality, six sigma, Taguchi method, Pareto diagram, YX diagram*

I. Introduction

Customer focus, customer orientation, customer satisfaction are the buzzwords today in the industry, but a few companies actually know how to go about it. The business objectives are to provide a high quality product or service to a customer at a lower cost and as quickly as possible so as to increase the sales, revenue and profits. However, the question is how to achieve customer satisfaction? It can be achieved by lower price, fast delivery and high quality. Various quality management tools and quality control techniques are available and applied but all these tools aim at one common objective i.e. increase profits through enhanced quality [1].

However, the means adopted to achieve this end are different for different tools. Kaizen and TQM adopt the method of gradual and continuous improvement whereas BPR (Business Process Reengineering) goes for radical redesign. The aim of six sigma methodology is to reduce cost by reducing the number of defects as much as possible or by streamlining the process so that the given product or service nears perfection. Six sigma allows for no defects at all but in the long run every process shifts from its mean and because of it failure rate will exists. Six sigma is essentially variance reduction technique, which tries to reduce the variation by decreasing the number of defects in the product. Six sigma is also a quality philosophy, a tool, a concept, a process, and a measurement and performance target. It is a philosophy that talks about attainable short term goals while striving for long term objectives. Six sigma is a statistical and problem solving tool. Six sigma provides its inputs in the form of measurements of the company's existing set standards, working on them to get the desired output. Six sigma uses two methodologies namely, DMAIC (Define, Measure, Analysis, Improve, and Control) and DMADV (Define, Measure, Analysis, Design and Verify) methodologies that have a sequence of steps that are tailor made for improvement in existing as well as new processes respectively in any organization. DMAIC methodology is used for improving the existing processes while DMADV is used for creating new processes. Since they are meant for different purposes, they have different parameters. Six sigma is a process quality goal. As such, it falls into the category of process capability (Cp) technique. The traditional quality paradigm defined a process as capable if the process as capable if the process's natural spread was less than the engineering tolerance. Under the assumption of normality, this translates to a process yield of 99.73%. A later refinement considered the process location as well as its spread (Cpk) and tightened the minimum acceptable from the nearest engineering requirement. [2]

Taguchi methodology is one of the six sigma technique. The method combines the experimental design with quality loss function. Engineering optimization of a process is the key step. It considers three steps. System design, parameter design and tolerance design. Amongst these, parameter design is the key step for achieving high quality. Table 1 gives Sigma level and its competitive level. [3]

Table no 1: Sigma level and Competitive level

Sigma level (σ)	Defect Rate (DPMO)	Yield in %	Cost of poor quality (% of sales)	Competitive Level
6σ	3.4	99.999666	< 10%	
5σ	233	99.9767	10 to 15%	World class
4σ	6210	99.37	15 to 20%	
3σ	66807	93.3193	20 to 30%	Industry average
2σ	308537	69.1462	30 to 40%	
1σ	690000	--	74%	Non competitive

II. Six sigma Implementation

In the initial phase, the historical data was collected from the feedback given by the customers and the area problems are selected after analyzing the measurements of the company's existing set standards, working on them to get the desired output. The historical data is collected from the feedback given by the customers and the areas of critical problems are selected after analyzing the historical data.

The problems which form the major portions of the complaints are selected and then the phases are applied of DMAIC six sigma methodologies in stages. These stages are tailor made for improvement in existing processes and redesigning any process in an organization. [4] The five phases of the six sigma strategies are applied in the sequence as given in Table 2.

Table no 2: Six sigma steps

Six sigma Steps	**Process Improvement**	**Process design/ Redesign**
Define	• Identify problem • Define requirements • Set goals	• Identify specific or broadproblem • Define goal / change vision • Clarify scope & customerrequirements
Measure	• Validate problem/process • Refine problem/goal • Measure key steps/inputs	• Measure performancerequirements • Gather process efficiency data
Analyze	• Develop casual hypothesis • Identify vital few root causes • Validate hypothesis	• Identify best practices • Assess process designs • Refine requirements
Improve	• Develop ideas to remove root causes • Test solutions • Standardize solution/ measureresults	• Design new process • Implement new process,structure systems
Control	• Establish standard measure tomaintain performance • Correct problems as needed	• Establish measures and reviewsto maintain performance • Correct problems as needed

III. Comparison of various methods

For identifying the causes of the defects, in the analysis phase, it is essential to conduct some investigative experiments by methods. A designed experiment is a test of series of tests in which purposeful changes are made into the input variables of a process or system so that reasons for the changes in the output responses can be observed and identified. The investigation sets several factors in these experiments simultaneously and changes the factor setting from experiment to experiment in a specified manner. The procedure yields the maximum amount of information about the effect of input variable on the output response. Some special statistical experiments require mere simple arithmetic calculations to yield sufficiently precise and reliable information. Each such special design has a rational relationship to the purpose of experimentation, the needs of the investigator and the physical limitations of the experiments. All such designs with the statement of investigator objective and the identification of the factors have the greatest potential influence upon the response. Some common statistical approach designs are described below which gives precise and reliable information. [5]

1. Regression analysis: - It is used to find out the mathematical relationship between the cause (independent input variable) and the effect (performance parameter). Both should be quantitative variables. This is a major limitation for its use.
2. Statistical methods:- A statistical experiment consists of several well planned individual experiments conducted together. It is also known as Design of Experiments. It is a simple and systematic approach by identifying various independent factors and levels and conducting experiments by varying one variable at a time. In order to reduce the noise effect or error due to the order, sequence in which the experiments are conducted in randomization of the sequence of experiments and variables is done. Following are different types of design of experiments. Randomized block, Balanced incomplete block design, Latin square, Factorial design and Full factorial design.
3. Taguchi method: - Most engineers focus on system design and tolerance design to achieve performance. Common practice is to base on initial prototype on system design. Relying on tolerance design makes a product expensive and relying on improved concept design requires technological breakthrough. Taguchi mainly focuses on the parameter design. It aims at achieving best parameters so that process becomes insensitive to noise variables. The lack of quality should be measured as a function of deviation from the normal value of the quality characteristics. Thus, quality is best achieved by minimizing the deviation from target. The product should be designed such that it is immune to cause of variation. The quality of a product is the loss imparted by the product to the society from the time product is shipped. This economic loss is associated with losses due to rework, cost of resources during manufacturing, warranty costs, customer complaints and dissatisfaction, time and money spent by the customer on failing products and eventual loss of market share. When a critical quality characteristics deviates from the target value, it causes a loss.

The quality means no variability or very less variations from the target performance. Continuously pursuing variability reduction from target value is critical quality characteristics key to achieve high quality and reduced cost. Taguchi quadratic loss function is the first operational joining of cost and reduced cost. Variability of product that allows design engineers to actually calculate the optimum design based on cost analysis and allows experimentation with the design. The simplest loss function is

$L(y) = \frac{M \times (y-t)^2}{D^3}$ Where L(y) is the loss to society of a unit output at value x and t is ideal state target at L=0, M is producer's loss while D is the customer's tolerance.

The Taguchi method utilizes orthogonal array from design of experiment to study a large number of variables with a small number of experiments. These are available at different levels. The numbers of levels with associated test values for the test parameters define the experimental region. Choice of the number of levels depends on how the response is related to the values of the factor. If the response function is linear then the two levels will suffice but for quadratic function three levels could be adequate. Standard arrays are available for experiments. Taguchi method is effectively used for identifying the individual variables contribution and their intricate interrelationship in many processes. Thus it is utilized for identifying the best parameter for optimum performance.

IV. Application of Six sigma methodology

In a well known electrical circuit breaker manufacturing company in Nashik, Six sigma concepts were methodically implemented in following phases for year duration. [6]

4.1 Phase 1: Define Phase

The circuit breaker is one of the most important units in the electrical power system. The protection, stability and continuity of the system depend on the circuit breakers ability to switch line, load and exiting current and to

interrupt fault currents. There were lots of complaints from the customer. The complaint rate was average fifty complaints per month.

4.2 Phase 2: Measure Phase

After analyzing the customer complaints, there were some major causes of gas leakage in the gas pipe assembly for circuit breakers. The causes and data analysis is shown in Table 3. The Pareto diagram is drawn and is as shown in Figure 1. After analyzing the TBR for two months some of the major causes were found. After analyzing the TBR results in Table 3 and Pareto diagram in Figure 1, it is found that brazing was one of the main constituents responsible for gas leakage. The brazing process is studied in detail for further analysis and implementation of six sigma methodology for reducing gas leakage. In accordance to it, as shown in Table 4, YX diagram and process map for the brazing process so as to find out all the possible parameters that caused the gas leakage. Weight of 10 was given each output variable. After analyzing the YX diagram and Table 4, the input variable "clearances" was selected as a major input variable which was aimed at. A detailed study of clearances is done in analyze phase.

4.3 Phase 3: Analyze Phase

A study of tolerances from the drawings is done. The process capability chart is drawn. From the chart, the process capability is 1.25. It is below the six sigma level. The required Cp and Cpk for six sigma quality level is 2.0. Therefore an improvement in the current process has to be done.

4.4 Phase 4: Improve Phase

To minimize gas leakages, following few changes were made and implemented. Silver content was increased from 35% to 50%. Use of fixtures was made compulsory which provided a smooth and flawless brazing. Proper clearances were maintained at brazed joints. Proper knowledge and training was provided to workers who were also made to do inspection themselves rather than separate inspector. Changes in the pipe design were made to impart more flexibility. Now, after these corrections, process capability chart was drawn. The Cp and Cpk values were improved and increased to 2.02. Thus, improvements in the quality of brazed components were made by corrective actions.

4.5 Phase 5: Control Phase

Control of the improvement done in brazing is done on continuous basis with regards to the corrective actions. Thus Six sigma methodology is implemented.

Table no 3: Data Analysis, Causes and Count

Causes	January	February	Count (Total)	% of Total	Cumulative %
No. of defects reported	46	30	76	--	--
Assembly O -Ring	17	7	24	31.6	31.6
Brazing leak	14	13	27	35.5	67.1
Feed valve	13	4	17	22.4	89.5
Compound gauge	-	6	6	7.9	97.4
Pole O -Ring	2	0	2	2.6	100

Table no 4: YX Diagram

No.	Input variable (X's)	Gas Leakage Weight age (10)	Dimension Weight age (10)	Pipe length Weight age (10)	Ranking
1	Silver content	6	6	0	120
2	Use of fixtures	5	7	6	180
3	Clearances	8	8	6	220
4	Design	6	8	7	210
5	Operator skill	7	7	6	200

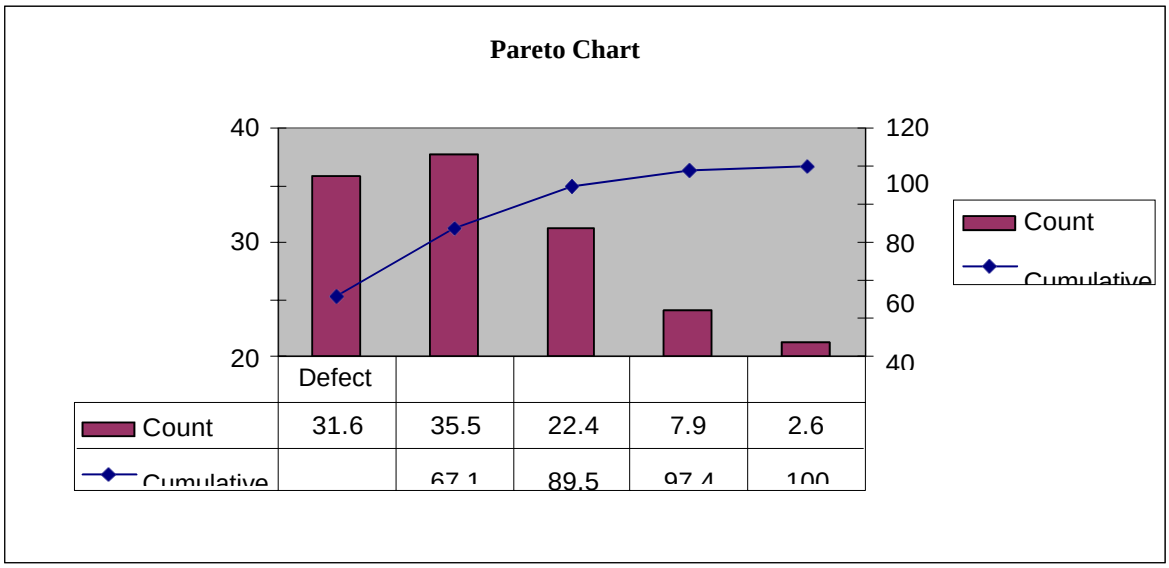

Figure 1: Pareto Diagram

V. Conclusion

In this paper, aim was to understand how implementation of concept of Six sigma methodology used aptly for solving a small industrial problem. The problem was to minimize customer complaints of gas leakage in the gas pipe assembly used in circuit breaker assembly. After application of Six sigma methodology, the gas leakage was considerably reduced. It was also confirmed by Pareto and process charts. Thus, six sigma is a value added approach.

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