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Research Article

A Practical Approach to achieve Six Sigma – Illustration through Case Study

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Abstract

Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects in any process – from manufacturing to transactional and from product to service. Six Sigma is a set of techniques and tools for process improvement. It was developed by Motorola in 1986, Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes. It uses a set of quality management methods, including statistical methods. This paper deals with the procedure to achieve Six Sigma level by means of simple tools viz. Cause and effect diagram, DMAIC methodology. The method is explained with the help of suitable case studies. This paper is dedicated to the deceased of South Korean Ferry Disaster and Manali Dam Tragedy. Lest we improve.

Keywords: *Statistical quality control; Critical to Quality (CTQ), Six Sigma; Defects per million opportunities (DPMO); Voice of Customer; Cause and effect diagram; DMAIC cycle; Key activity, Resource allocation*

1. Introduction

The term "six sigma" comes from statistics and is used in statistical quality control, which evaluates process capability. Originally, it referred to the ability of manufacturing processes to produce a very high proportion of output within specification. Processes that operate with "six sigma quality" over the short term are assumed to produce long-term defect levels below 3.4 defects per million opportunities (DPMO).

Six Sigma is a methodology for pursuing continuous improvement in customer satisfaction and profit. It is a management philosophy attempting to improve effectiveness and efficiency.

The main goal of Six Sigma is to identify, isolate, and eliminate variation or defects / opportunity for improvement.

2. Concept of Six Sigma

The process mean and standard deviation are key to Six Sigma concept. Many processes in nature conform to Normal distribution. In a Normal distribution the proportion of population that fall in the range ($\sigma \pm \mu$) is 68.26%. If the process mean lies at centre of LSL and USL and the ($\mu - \sigma$) and ($\mu + \sigma$) of the process lies at LSL and USL respectively then 68.26% of the components are within specification (success) and number of rejections (failures / defects) is 317,400 per million.

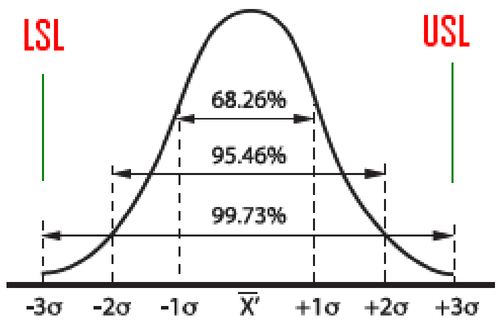

Fig. 1: Areas under a normal distribution

This is also called as defects per million opportunities (DPMO).

Similarly success percentage and DPMO if LSL and USL lie at ($\sigma \pm 2\mu$), ($\sigma \pm 3\mu$), ($\sigma \pm 6\mu$) are given at table no. 1.

Table 1: Success percentage and DPMO

LSL	USL	SUCCESS %	DPMO
(μ - σ)	($\mu + \sigma$)	68.26%	317,400
(μ - 2σ)	(μ + 2σ)	95.46%	45,400
(μ - 3σ)	(μ + 3σ)	99.73%	2,700
(μ - 6σ)	(μ + 6σ)	99.9997%	3.4

We find that as the process is controlled and variability is decreased σ is reduced. As (μ - 6σ) and (μ + 6σ) approaches LSL and USL respectively we achieve 3.4 defects per million opportunities. This is the concept of Six Sigma.

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3. Voice of customer (VOC) and Critical to Quality (CTQ)

Voice of Customer is a term used in business to describe the in-depth process of capturing a customer's expectations, preferences and aversions. Critical to quality is an attribute of a part, assembly, sub-assembly, service or a process that is literally critical to the customer's expectations or aversions. VOC can best be addressed by identifying the CTQ parameters.

4. Cause-and-Effect diagram (Ishikawa diagram)

Cause-and-effect diagrams were developed by Kaoru Ishikawa in 1943 and thus they are often called Ishikawa diagram. These diagrams are used to identify and systematically list the different causes that can be attributed to a problem or effect. Once a CTQ parameter is identified a Cause-and –effect diagram is made to filter the possible cause(s).

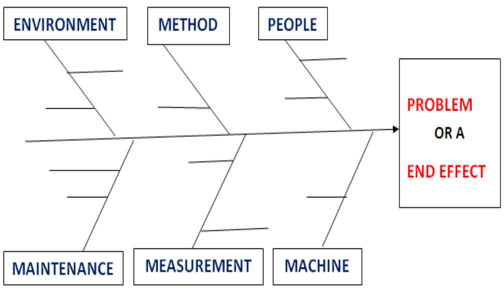

Fig. 2: Cause-and –Effect diagram

At one end of the Cause-and-Effect diagram the problem / desired end effect. A horizontal line is drawn as shown in the figure. All possible causes are mentioned. The cause may be categorised into separate groups.

The categories mentioned in the Cause-and –Effect diagram viz. People, Method, Environment, Maintenance, Measurement and Machine mentioned in the Cause-and-Effect diagram are groups of possible causes. These groupings are suggestions based on past experience. These are not hard and fast rules. The groups and sub-groups will depend upon the case being dealt.

All the possible causes are then studied to find out the actual cause(s).

5. DMAIC cycle

Fig. 3: The DMAIC process / cycle

DMAIC is an improvement methodology. It is an acronym for **D**efine, **M**easure, **A**nalyze. **I**mprove and **C**ontrol. These are the five phases that make up the DMAIC process. (Fig. 3, 4)

- Define the objective viz. problem / improvement activity / opportunity for improvement / the project goals / Customer's requirement
- Measure process performance
- Analyze the process to determine the root causes / additional input required / action required to address
  (i) Variation
  (ii) Poor performance
  (iii) Improvement
  (iv) Meet project goals
  (v) Meet customer requirement
- Improve process performance by addressing and eliminating the root causes / applying additional inputs.
- Control the improved process and future process performance

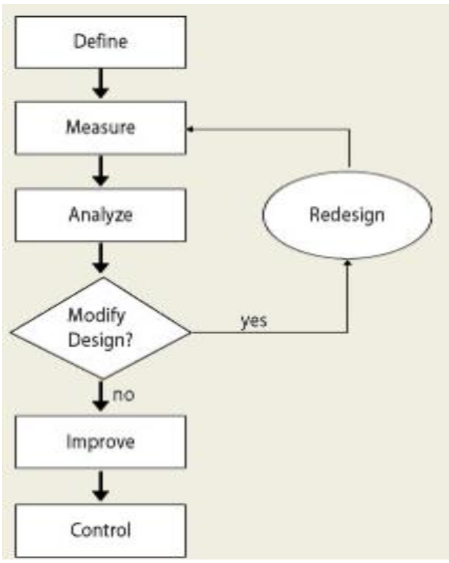

Fig. 4: DMAIC flowchart

6. Case study 1

Statement of the problem: "*Shaft is being manufactured. Its diameter is very critical. It has to be maintained at ϕ10 ± 0.05 mm*"

Here the diameter is the CTQ parameter. This can be very well assumed to be normally distributed. Hence the diameter can be controlled by reducing the standard deviation, σ, which can be done by plugging the sources of variability. Equally important is the centring of the process. Thus for achieving Six Sigma following steps are required.

- Centring of process
- Reduction of process variability

6.1 Process centring

Process mean (μ) should be aligned with midpoint of LSL and USL. (Fig 5)

In the case the Process mean (μ) is not aligned with midpoint of LSL and USL then there are rejections. (Fig 6)

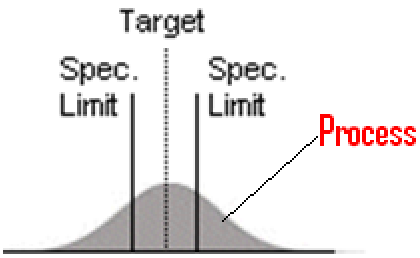

Fig. 5: Process mean is aligned with the midpoint of LSL and USL.

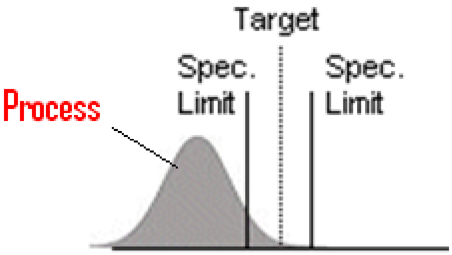

Fig. 6: Process mean is aligned with the midpoint of LSL and USL.

6.2 Reduction of process variability

The process variability can be reduced by identifying the causes of variability and then To identify the sources of variability a Cause-and-Effect diagram is drawn (Fig. 7) mentioning all the possible causes of variability?

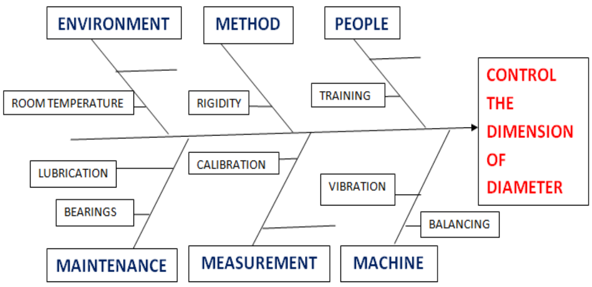

Fig. 7: Cause-and –Effect diagram for Case 1

After that each cause is analysed and the potential cause are identified. After that all the potential causes are plugged. As the process of plugging the potential causes is progresses the variability decreases and the Standard deviation (σ) decreases. (Fig. 8)

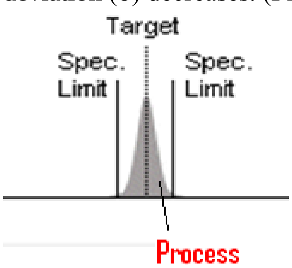

Fig. 8: Process Standard deviation decreases as the causes of variability are plugged

7. Case study 2

Statement of the problem: "*A mouse is found in passenger aircraft. It can damage electrical and electro-mechanical components which can cause a catastrophe.*"
Here protection the aircraft from mouse is the CTQ parameter. But unlike case I, the mathematical modelling is intricate. While it might be possible to find suitable mathematical model for such problems we need not wait till the mathematical model is actually developed. The improvement actions can very well begin to move towards achieving Six sigma.

7.1 Reduction of process variability

To draw the Cause-and-effect diagram the following possible questions may be answered.

- Sources from where mouse can come to the aircraft
- How to block all the paths from where mouse can enter
- What can be done at the sources to get rid from mice
- Even if a mouse enters the aircraft it should not be able to reach the critical systems
- What systems should be installed to keep mice away from the aircraft
- What training be provided to crew members
- What cooperation is required from the passengers (customers)

A Cause-and-effect diagram is drawn (Fig. 9) keeping into consideration the above points.

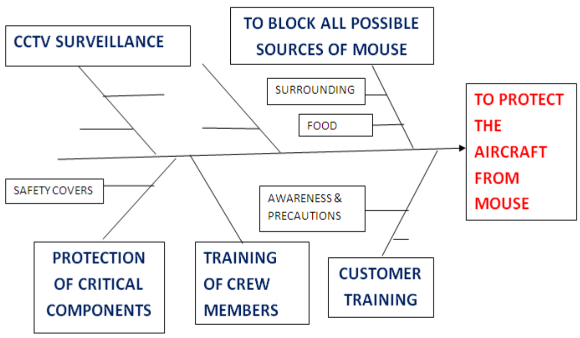

Fig. 9: Cause-and –Effect diagram for Case 2

By drawing, studying and analysing the Cause-and-effect diagram the *potential causes* are identified. After that corrective / improvement actions are taken. As the causes are eliminated one after another the process tends closer to Six Sigma.

7.2 Process centring

The process can be centred by planned allocation of resources. The activities can be classified on the basis of importance / criticality the most important activity being the *Key activity*. The Key activity is allocated the maximum resources for the purpose of process centring.
Table 2 gives the classification of activities on the basis of importance. Activity A is the key activity.

Table 2: Classification of activities

Activity	Description
A	Protection of critical components (Key activity)
B	To block all possible sources of mouse
C	CCTV surveillance
D	Training of crew members
E	Customer training

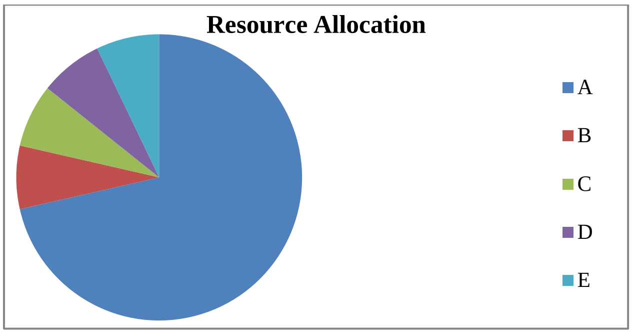

Fig. 10 Allocation of resources to the Key activity and the other activities

Conclusions

This paper explains the mathematical basis of Six Sigma. It also signifies that many problems are difficult to model as mathematics involved is rather intricate. However improvements to achieve Six Sigma level may be initiated by using suitable tools.

Cause-and Effect diagram and DMAIC cycle are introduced for identifying the potential causes and initiating improvement projects. As more and more potential causes are eliminated / incorporated the process moves towards Six Sigma. (Fig. 11)

Process centring is also explained. In case 1 the process centring is achieved by aligning the Process mean (μ) with midpoint of LSL and USL.

In case 2 the process centring is done by planned allocation of resources.

The method is explained by using most relevant and representative case studies.

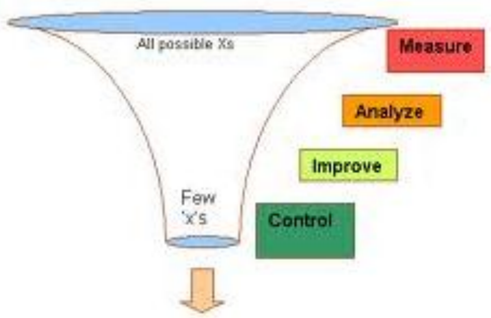

Fig. 11: Elimination of potential Cause / Incorporation of improvements

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