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Study of Potential Applications of Lean Six Sigma in Job Order Production System

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Abstract: *There is a growing need for operation management in today's manufacturing sector. It is no wonder why more and more companies are now establishing a completely separate department called 'operational excellence', which envisages potentials for implementation of techniques like lean manufacturing, six sigma, TPM(Total Preventive Maintenance), TQM(Total Quality Management), and many more. The six sigma has now become inevitable in manufacturing industries which targets quality and customer satisfaction. Six sigma concept, which took birth in Motorola back in 1980's has now forayed into numerous sectors including manufacturing, finance, logistics, healthcare etc. Implementation of six sigma in mass production is comparatively easy because of less or no product variability, however equally abstruse for job order production system. Our paper focuses on potential applications of six sigma in job order production, and we have taken up study of a turbine machining factory unit, wherein quality and precision play a pivotal role. We have also explored the prospects of combing lean manufacturing with six sigma.*

Keywords: *Job order production, Lean Six Sigma (LSS), Operation management.*

I. Introduction

The Six sigma has variegated definitions and applications, changing from company to company and from professional to professional. However, it can be defined as a data-driven approach which struggles or strives toward achieving customer specified quality,embarking a near perfect system of production. Six sigma was incubated in Motorola in 1987. Motorola management decided to take up the quality issue more seriously, Bob Galvin became Motorola's CEO in 1981, challenged his company to achieve a multifold improvement in performance over a tenure of five years, and thus this challenge marked the onset of six sigma.

In six sigma, customer is the top priority. The customer defines the quality standards, precision levels, closeness of tolerances and other parameters. Six sigma aims at achieving near perfect process, by reducing process variability and ensuring process can achieve the specifications laid down by designer or customer. LSS has a five phased approach towards improving and changing a process. It is called as DMAIC, namely Define, Measure, Analyze, Improve and Control. These phases are followed in above stated order only, which tackle the specified problem.[1]

II. Methodology Of Literature Review

- **Six Sigma:**

Six sigma involves statistical techniques to monitor a process and to comprehend whether given process is under control or not. It encompasses varies phases to achieve a completely under control process. Phases are 1- Define, 2- Measure, 3- Analyse, 4- Improve, 5- Control.

The DEFINE phase involves defining the given problem, in a way which is description and clear. It also involves defining customer need and quality standards required to be achieved. The define phases is the foundation of six sigma project.

The MEASURE phases involve collecting relevant date from authentic sources. It measures various process parameters, for example for turning operation, at given feed and depth of cut, achieve surface finish value is Ra 3.2, which should be Ra 0.8 as per specification. Thus, measure phases measures the parameters of a process. The ANALYSE phase involves analyses of obtained data. This analyse might be statistical or technical, or may be combined analysis. It involves finding the root causes of a problem. For example if Ra 0.8 is not achieved then it might be due to improper nose radius of tool or incorrect feed, etc.

The IMROVE phase involves rectification. In this, all the parameters are reset to another value so that required performance is achieved. In our discussed example, potential improvement could be increase nose radius and feed. The CONTROL phase emphasises on efforts made to sustain the changes which has been made to improve the process. This is important phase because the rewards of improvement are achieved only after sustained efforts.

- **Lean Manufacturing:**

The lean manufacturing emphasises on elimination of 7 Wasters encountered in a manufacturing process. These 7 wastes are WORMPIT; Namely, Over Processing, Motion of Employees, Inventories, Transportation, Rejection, Underutilized man power and human talent etc. It also has various tools like 5S, Kanban, Kaizen, TPM, etc. which are applicable.

Six Sigma Techniques: Six Sigma concepts can be better understood and explained using mathematical term Sigma and Normal Distribution. Sigma is a Greek symbol represented by "σ". The bell shape curve shown in Fig. 1 is called "normal distribution" in statistical terms. In real life, a lot of frequency distributions follow normal distribution, as in the case of delivery times in Pizza Business. Natural variations cause such a distribution or deviation. One of the characteristics of this distribution is that 68% of area (i.e. the data points) falls within the area of -1σ and +1σ on either side of the mean. Similarly, 2σ on either side will cover approximately 95.5% area. 3σ on either side from mean covers almost 99.7% area. A more peaked curve (e.g. more and more deliveries were made on target) indicates lower variation or more mature and capable process. Whereas a flatter bell curve indicates higher variation or less mature or capable process. To summarize, the Sigma performance levels – 0ne to Six Sigma are arrived at in the following way[2]

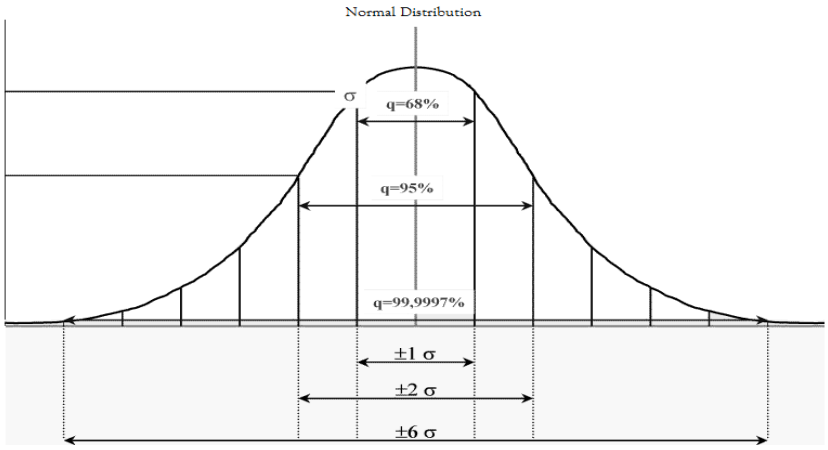

Figure 1

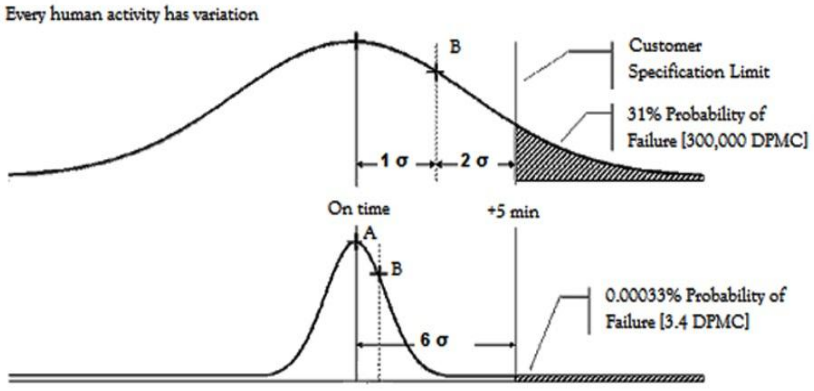

Figure 2

Various charts are used in Six sigma for example;

1- X-Bar R chart.(Variables)
2- U Bar, P, nP, C chart.(Attributes)
3- Gage R&R. etc.

Procedure: As discussed earlier regarding various phases in Six Sigma, the first deployment phase is 'define' phase. Define phase involves defining the CTQ's and VOC and VOBs. CTQ is Critical to quality, it describes parameters which are critical to quality of product, VOC is voice of customer, that is what does the customer demand, it may either be quality, delivery on time, economic machining, etc. VOB is voice of business, which includes all parameters which can cause an impact on business, for example, company policies, HR policies,

Wages and Incentives etc. One has to define the function Y=f(x), Where Y is dependent variable and x is independent variable. For example, Surface finish is a function 'Y', and feed and spindle speed is independent variable 'x', that is feed is dependent only on feed and speed.

Tools in Define phase;

- Project Charter
- Process Flowchart
- SIPOC Diagram
- Stakeholder Analysis
- DMAIC Work Breakdown Structure
- CTQ Definitions
- Voice of the Customer Gathering[4]

We shall define a problem statement, forpotential processes and problems which need to be addressed at LAXMI ENGINEERING WORKS, which performs machining of key turbine elements.

List of problem(Problem Statement) which need to be addressed are as under:

1- Thermal expansion of the work piece during machining, leading to faulty measurements during inspection.
2- Effect of selection of feeds and depth of cuts for close tolerances, on machining time and economy.
3- Variation in measurements, due to 'human bias error'.
4- Reducing tool breakage and increasing tool life.
5- Reducing down time of machine to increase productivity of unit.

Measure Phase: In this phase we measure key parameters for define problem. For list of problems listed before, possible measurable quantities could be as under

1- Measuring temperature and thermal expansion co-efficient of material.
2- Obtain data for various feed and depths of cut performed on machine and tolerances obtained,
3- Measure values as measured by all the quality inspectors.
4- Measure tool strength and hardness at prescribed temperature, and frequency of tool breakage, due to various reasons like thermal cracking, mechanical impact, crater crack, etc. Use to temperature measuring instruments to keep check on tool temperature.
5- Measure which time for which a machine remains idle during single shift of working.

Tools in measure phase;

- Process Flowchart
- Data Collection Plan/Example
- Benchmarking
- Measurement System Analysis/Gage R&R
- Voice of the Customer Gathering
- Process Sigma Calculation[4]

Analyse Phase:

In this phase the key parameters are analyzed using past experience and statistical control charts. This is an important phase, because it holds key to improvements of process or system. This phase has to be performed meticulously or else all efforts put in previous phase would go futile. Moreover, since this phase is solely data driven it is very important that the data is collected from an authentic source which is devoid of any bias. The outputs of analyze leads to inputs of IMPROVE Phase. The cause and effect diagram is a useful tool; it is also called as the Fish Bone diagram.

Data analysis has to be precise and improper analysis may lead to wrong conclusion, hence experience is need in this phase to point out the correct from incorrect.

Tools which are used in this phase are as under;

- Histogram
- Pareto Chart
- Time Series/Run Chart
- Scatter Plot
- Regression Analysis
- Cause and Effect/Fishbone Diagram
- Whys
- Process Map Review and Analysis

- Statistical Analysis
- Hypothesis Testing (Continuous and Discrete)[4]
- Non-Normal Data Analysis.

Improve Phase:

This includes counter measures to be taken to tackle the problem. Solution is found out to given problem and implement in the process. This phase marks the fruits of six sigma implementation because as improvements are made, better results can be expected.

The tools used in this phase are;

- Brainstorming
- Mistake Proofing
- Design of Experiments
- Pugh Matrix
- QFD/House of Quality
- Failure Modes and Effects Analysis (FMEA)
- Simulation Software

Control Phase:

This phase ensures that all the changes which are made during the previous phase are sustain and continued until next improvement is made. To yield results it is very important that the improvements are not only but also sustained. Tools used in this phase are;

- Process Sigma Calculation
- Control Charts (Variable and Attribute)
- Cost Savings Calculations
- Control Plan[4]

Limitations Of Six Sigma[3]

The biggest hurdle in implementation of Six Sigma is the company itself. The management plays a central role in successful implementation of LSS. It is not an individual initiative; it demands company wide support and actions. If the management is not motivated or is indifferent towards the benefits of implementation of LSS, then no good can be done, and LSS can only remain on paper a mere theoretical concept. The management has to reward the employees who take active participation in implementation of such techniques. Thus we can say that management has to play pivotal role in successful implementation of LSS, without their motivation it is very difficult to implement LSS.

III. Conclusion

After detailed study, we conclude that six sigma can be applied in job order production system as well. Though it is recondite but after detailed analysis one can find many ways in which Six Sigma can be implemented in Job order production system. We intend to conduct all the five phases of six sigma and improve a process at mentioned factory, in near future.

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