Study on Six Sigma an Approach to Improve Productivity in Manufacturing Industry

Abhinav V. Tingne
Department of Mechanical Engineering
K.D.K. College of Engineering
Nagpur, India
avtingne@gmail.com

Abstract -- Six Sigma is smarter way to manage business or department of any field. It is a vision of quality that equates with only 3.4 for million opportunities for each product or service transactions. Strives for perfection. We believe that defects free product can be in any organization implementing six sigma. In this we presented an overview of the process which explains how six sigma increase overall quality improvement task into a series of project management stages. We will describe dependence of six sigma on Normal Distribution theory and process capability. It gives a small note on assumptions made in six sigma methodology of problem solving and the key elements involved This paper describes the application of the Six Sigma methodology comprising the five phases – Define, Measure, Analyse, Improve and Control

Keywords – six sigma, phases, lean, manufacturing, lean six sigma, DMAIC, DMADV

I. INTRODUCTION

A term (Greek) used in statistics to represent standard deviation from mean value, an indicator of the degree of variation in a set of a process. Sigma measures how far a given process deviates from perfection. Higher sigma capability, better performance. Six Sigma a highly disciplined process that enables organizations deliver nearly perfect products and services. The figure of six arrived statistically from current average maturity of most business enterprises. The main objective of any business is to make profit. For increasing the profit, the selling price should increase and/or the manufacturing cost should come down. Since the price is decided by the competition in the market, hence the only the way to increase profit is to cut down the manufacturing cost which can be achieved only through continuous improvement in the company's operation. Six sigma quality programs provide an overall framework for continuous improvement in the process of an organization. Six sigma uses facts, data and root cause to solve problems.

Sigma is a letter from the Greek alphabet used in statistics as shorthand for the Standard Deviation, one metric that describes the variability in a set of data. In Six Sigma, the focus is on the reduction of defects in a product or process. The measure is derived from the concept of a process predictably producing output that is about twice as good as that specified by the customer. Six Sigma is the powerful force by which leading corporations such as GE, Motorola and Ford are delivering staggering results to their bottom line and customer satisfaction through fundamental changes in the way they operate and an overall improvement in the products and services they deliver. These leading companies believe so much in Six Sigma that they are willing to invest 100's of millions of dollars in Six Sigma with the expectation to receive billions of dollars in return. Six Sigma places the emphasis on financial results that can be achieved through the virtual elimination of product and process defects. Gone are the days of quality at any cost.

II. WHAT IS SIX SIGMA AND WHY ?

A Vision and Philosophical commitment to our consumers to offer the highest quality, lowest cost products. A Metric that demonstrates quality levels at 99.999997% performance for products and process. A Benchmark of our product and process capability for comparison to 'best in class'. A practical application of statistical Tools and Methods to help us measure, analyze, improve, and control our process. Measure how many "defects" are in a process then systematically figure out how to eliminate them and get as close to "zero defects" as possible.

When we say that a process is at six sigma level, such a process is normally yield two instances of non - conformances out of every million opportunities for non-conformances, provided there is no shift in the process average. The same will yield 3.4 instances of non –

conformances out of every million opportunities with an expected of 1.5 sigma in the process average. This is considered to be best-in-class quality.

Six Sigma emerged as a natural evolution in business to increase profit by eliminating defects. The Current business environment now demands and rewards innovation more than ever before due to:

- Customer Expectation
- Technological Change
- Global Competition
- Market Fragmentation

III. CONCEPT OF SIX SIGMA

Six sigma is defined a customer oriented, structured, systematic, proactive and quantitative companywide approach for continuous improvement of manufacturing, services, engineering, suppliers and other business process. It is a statistical measure of performance of a process or a product. It measures the degree to which the process deviates from the goals and then takes efforts to improve the process to achieve total customer satisfaction.

Six sigma efforts target three main areas:

- Improving customer satisfaction.
- Reducing cycle time.
- Reducing defects.

Three key characteristics separates six sigma from quality programs of the past:

1. Six Sigma is a customer focused.
2. Six sigma projects produce major returns on investments.
3. Six sigma changes how management operates.

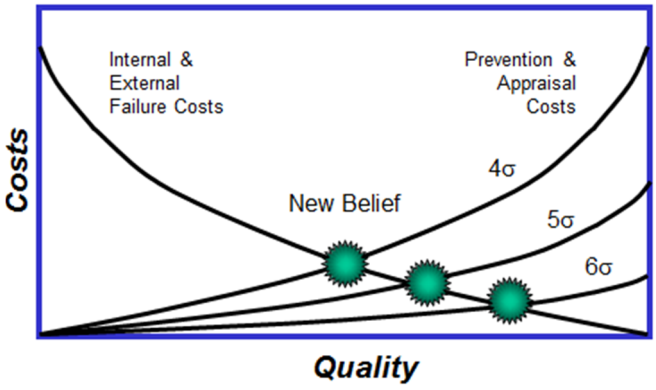

Fig 1. *Cost v/s quality graph*

IV. LEAN SIX SIGMA

Lean is a philosophy and set of management techniques focused on continuous "eliminating waste" so that every process, task or work action is made "value adding" (the real output customer pays for!!) as viewed from customer perspective. Lean "waste elimination" targets the "Seven Wastes" namely: 1) Excess production and early production 2) Delays 3) Movement and transport 4) Poor process design 5) Inventory 6) Inefficient performance of a process 7) Making defective items. If six sigma ideas combined with lean, then it is called as "Lean Six Sigma".

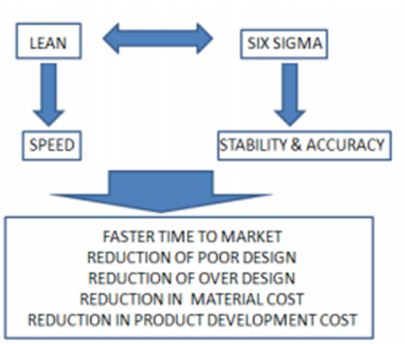

Fig 2

V. DEFECT PER MILLION OPPORTUNITIES ANALYSIS (DPMO)

In practice, most of the delivered products or services will have multiple parts and /or process steps, which represent opportunities for nonconformities or defects. For example, which a watch has numerous parts and assembly steps. In such cases it is important to ask questions such as what is the distribution of defects, how many units can be expected to have zero defect, one defect, two defect, and so on for a given ppm, what will be the defect rates and sigma levels for individual parts and process steps that contributes to the total unit with a given defect rate.

If the number of observed nonconformities as "d" out of the total number of units produced "u".

Defects Per Unit (DPU) = d/u

If each unit manufactured has got "m" number of opportunities for non-conformance, we can compute the Defects Per Opportunity (DPO) as

Defect Per Opportunity (DPO)= DPU/m

In the calculation of DPO, we are taking into consideration only the active opportunities (those which are getting measured) and not the passive opportunities (which are not getting measured) with in each unit.

From this, the DPMO can be computed as

Defects Per Million Opportunities (DPMO) = DPO x10^6

The sigma level can be found out from the DPMO value using statistical tables. If the DPMO and the number of defect opportunities are known for each contributing step, the total DPMO for the completed unit can be computed as follows.

Expected Defects (ppm for each step) = DPMO x Number of opportunity (for each)

Expected defects (ppm for completed unit) = Sum of expected defects of each steps

DPMO for completed unit = (Expected defects)/(Total number of Opportunities)

The process yield represents the proportion of defect-free units before testing or repair. The Poisson distribution can be used to calculate the

Yield for a unit if the DPU value is known.

YIELD= e^(-DPU)

If the yield is known for each part or process step, the overall yield for the process (ROLLED THROUGHPUT YIELD [YRT]) can be computed as the product of yields of individual process steps. This value will be less than smallest individual yield since these are all in fractions. This clearly shows that for improving the YRT, the individual yields shall be improved. In other words, for minimizing the overall defect rate, the overall defect rate, the individual defect rates of each part or process step shall be minimized. Hence, only with six sigma parts and process steps will an organization experience high YRT for complex products with numerous parts and process steps.

Fig 3

VI. SIX SIGMA METHODOLGY AND LEVELS

Following are the methods for implementing to any processes:

- ❑ BPMS
  - ➢ BUSINESS PROCESS MANAGEMENT SYSTEM
- ❑ DMAIC
  - ➢ SIX SIGMA IMPROVEMENT METHODOLOGY
- ❑ DMADV
  - ➢ CREATING NEW PROCESS WHICH WILL PERFORM AT SIX SIGMA

Sigma levels (process capability)	*Defects per million opportunities*	*Our yield in percentage*
1.	690,005	30.9%
2.	308,537	62.9
3.	66,807	93.3
4.	6,210	99.4
5.	320	99.98
6.	3.4	99.999997

Table 1. Six sigma levels with DPMO and yield value

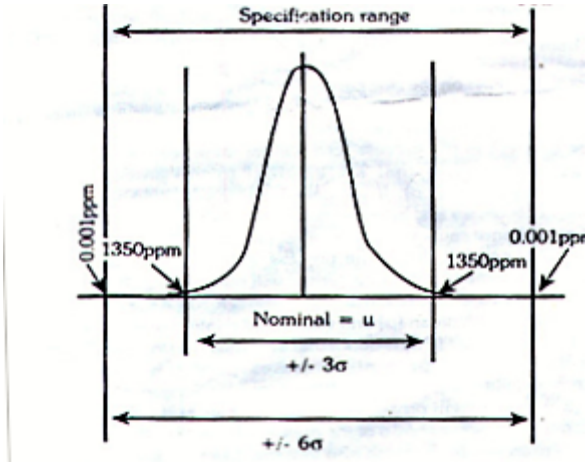

Fig 4. Six sigma process with mean centred at nominal

VII. SIX SIGMA- PROBLEM SOLVING PROCESS

The sigma of the process, which tells us how capable the process is, can be used to compare similar or dissimilar process. Such comparison, known as Benchmarking, will uncover what we do well. Method used in Six Sigma innovation is described as follows:

A. BUSINESS PROCESS MANAGEMENT SYSTEM (BPMS)

a) BPM strategies emphasize on process improvement and automation to derive performance
b) Combining BPM strategies with sigma six is most powerful way to improve performance
c) Both strategies are not mutually exclusive but some companies produced dramatic results by combining them.

B. DEFINE, MEASURE, ANALYSE, IMPROVE, CONTROL

MAIC, DMAIC or DMAIIC are all acronyms used to identify six sigma methodologies by different 6 sigma service providers. The DMAIIC acronym, which is the "most hybridized" form used by Six Sigma Innovation.

a) A logical and structured approach to problem solving and process improvement.

b) An iterative process (continuous improvement)

c) A quality tool which focus on change management style.

- ✓ **DEFINE** the problem and the scope of the six sigma project in detail.
- ✓ **MEASURE** and collect data on the problem and its potential root causes.
- ✓ **ANALYSE** the data selected determine the real root cause (s).
- ✓ **INNOVATE** – to identify the "best" solutions to the problem.
- ✓ **IMPROVE** the process, and then pilot the proposed solution.
- ✓ **CONTROL** the new process to ensure that the improvements are sustained.

C. DEFINE, MEASURE, ANALYSIS, DESIGN, VERIFY

- ✓ **Define** the project
- ✓ **Measure** the opportunity
- ✓ **Analyze** the process options
- ✓ **Design** the process
- ✓ **Verify** the performance

DEFINE: identify purpose, identify and set measurable goals from the perspective of both the organization and stakeholder, develop schedule and guidelines for review, identify and assess risks.

MEASURE: define requirements, define market segments, identify critical parameters for design, design scorecards to evaluate design components that are critical to quality (CTQ), reassess risks assess production process capability and product capability.

ANALYZE: develop design alternatives, identify the best combination of requirements to provide value within constraints, develop conceptual designs, evaluate, select the best components and develop the best available design.

DESIGN: develop a high level design, develop exact specifications, develop detailed component designs, develop related processes, and optimize design.

VERIFY: validate that the design is acceptable to all stakeholders, complete pilot test, confirm expectations, expand deployment, document lessons learned.

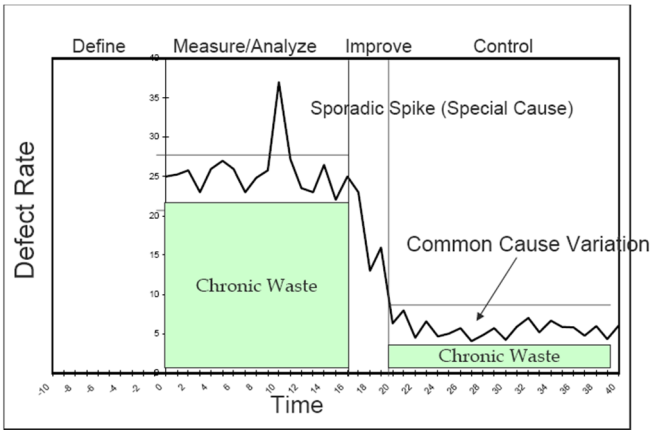

Fig 5. Defect rate v/s time graph

VIII. KEY ROLE AND KEY ELEMENTS FOR SIX SIGMA

A. KEY ROLE

Six Sigma identifies several key roles for its successful implementation in top to bottom way:

- Executive leadership
- Champions
- Master Black Belts (Identify projects& functions)
- Black Belts (Identify non value added activities)
- Green Belts (works on small projects)

B. KEY ELEMENTS

1. Management initiatives

- Customer focus
- Participative management
- Benchmarking
- Design for manufacture
- Statistical process control
- Supplier qualification

2. Improvement process

- Define your product or service
- Identify your customers (both internal and external) and their needs.
- Identify your suppliers and what you need from them to satisfy your customers.
- Define your process
- Error-proof the process to avoid operator controllable errors.
- Ensure continuous improvement through measurement, analysis and control.

3. Improvement Tools

- Histogram
- Process mapping
- Quality function deployment
- Design of experiments

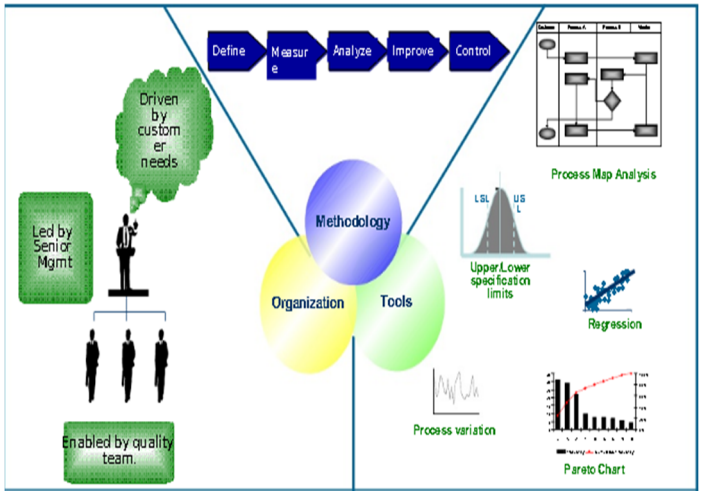

Fig 6. Implementation of six sigma

IX. APPLICATIONS

Six sigma can be applied at following places:

- ✓ Service
- ✓ Management
- ✓ Design
- ✓ Purchase
- ✓ Production
- ✓ IT
- ✓ M&S
- ✓ HRM
- ✓ Quality Depart
- ✓ Administration..etc.

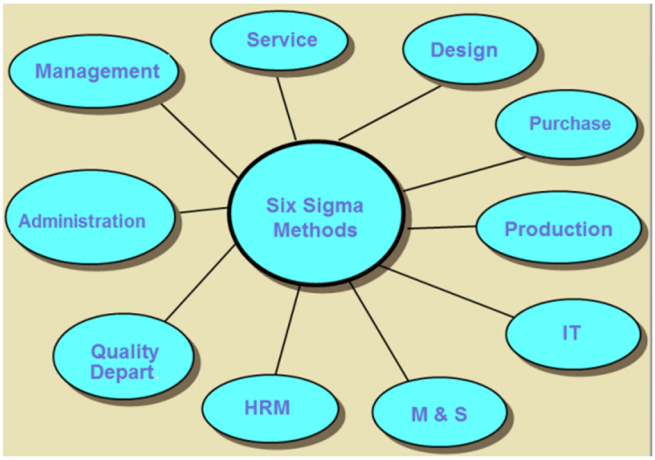

Fig 7. Application of six sigma

X. STATISTICAL TOOL FOR SIX SIGMA

Following graph shows that how the distribution of sigma over the entire graph.

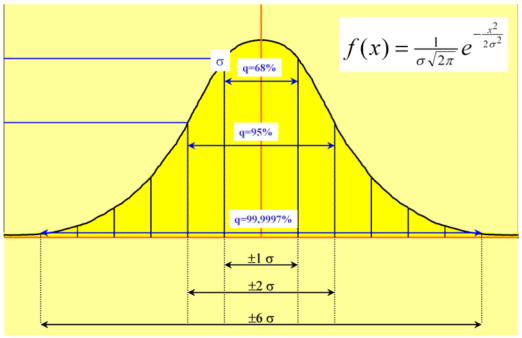

Fig 8. Statistical tool for six sigma

XI. EXPECTED OUTCOMES OF SIX SIGMA METHODOLOGY

A. Six Sigma

• minimize future problems
• minimize variability
• maximize satisfaction
• deliver what is desired in a timely fashion

B. Lean

• Reduces the time to deliver the design
• Reduces the weight of the material, so cost reduction takes place

C. Facts

• Customers are important
• Speed, agility, quality and low cost are linked
• Eliminate variation and defects; focus on process flow to deliver quality, speed and low cost
• Data is critical to making sound technical decisions
• People have to work together to make improvements that customers will notice

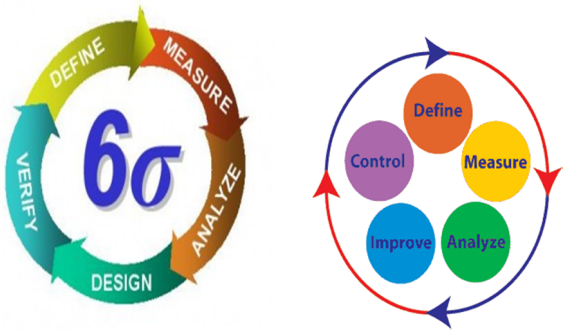

Fig 9. Tool for six sigma

XII. ADVANTAGES

- Generates sustained success
- Sets performance goal for everyone
- Enhances value for customers
- Accelerates rate of improvement
- Promotes learning across boundaries
- Executes strategic change

XIII. DISADVANTAGES

- Long term process
- Large amount of data required
- Not very much suitable for small scale industries

XIV. COMPANIES USING SIX SIGMA

Six Sigma is in use in virtually all industries around the world. Some of companies can be listed as:

- Motorola
- Sony
- Ericsson
- Citi bank
- Ford
- IBM
- Whirlpool
- Department of defence, USA
- John deere and many more companies which are using six sigma.

Fig 10. Companies using six sigma

XV. CONCLUSION

The goal of this research was to improve the target company's manufacturing lead time. This was to be done using the Lean Six Sigma improvement process DMAIC, in order to illustrate the use of this methodology and related tools. In addition, the system evaluation and solution formulation were to be done based on data analyzes of the process data. Thus, illustrating how to base the decision making on actual data rather than intuition and guesswork.

The term "sigma" is used to designate the distribution or the spread about the mean of any process. Sigma measures the capability of the process to perform defect - free work. A defect is anything that results in customer dissatisfaction. For a business process, the sigma value is a metric that indicates how well that process is performing. Higher sigma level indicates less likelihood of producing defects and hence better performance.

Six sigma is a performance standard to achieve operational excellence. With six sigma, the common measurement index is “defects-per-unit” where a unit can be virtually anything – a component, piece of material, administrative form etc. Conceptually, six sigma is defined as achieving a defect level of 3.4 ppm or better. Operationally, six sigma is defined a staying within half the expected range around the target. The approach aims at continuous improvement in all the process within the organisation.. This works on the belief that quality is free, in that the more we work towards zero-defect production, the more return on investment we will have. The advantages of six sigma approaches are reduction in defects / rejections, cycle time, work in progress etc. and increase in product Quality & Reliability, customer satisfaction, productivity etc. leading ultimately to excellent business results.

XVI. REFERENCE

1. Chowdhary, S. The Power of Six Sigma. Chicago: Dearborn Trade, 2001
2. Pande, P. S., Neuman, R. P., Cavanaugh, R. R. The Six Sigma Way How GE, Motorola, and Other Top Companies Are Honing Their Performance. New York: McGraw-Hill, 2000
3. Normal Distribution Bell Curve:
4. Six Sigma IT Concepts Kurt Haubner Home Page:
5. http://www.sixsigma.de/english/images/sixsigma/gauss_kurve.gif
6. http://www.isixsigma.com/me/six_sigma/
7. http://www.ge.com/sixsigma/
8. http://eng-ed.ucsd.edu/six-sigma.html
9. References Andrea Chiarini (2011). Japanese total quality control, TQM, Deming’s system of profound knowledge, BPR, Lean and Six Sigma. pp. 332355.
10. Berhman, B. & Klefsjo B. (2001). Kvalitet fran behov till anvandning (3rd ed.) Lund: Student litteratur. International Journal of Library Sciences and Research, ISBN: 9144-01917-3. Vol.1
11. Harry Mikel, Schroeder Richard; “Six Sigma-The Breakthrough Management Strategy Revolutionizing The World’s Top Corporations” (ISBN0385494386); 1998
12. Brue Greg; “Six Sigma For Managers 1st Edition”; Tata McGraw Hill Publishing Company Limited (ISBN 0070486395); 2003