SIX SIGMA IN MANUFACTURING INDUSTRIES

Vivek Singh
Quality Manager, India.

Abstract: *Six Sigma is a management technique for advance business practices by approaching zero defects in the system. It is a data driven approach and a methodology that drives towards eliminating errors. Six Sigma strategy is adopted by organization all over the world including Indianindustries for reducing process variations thereby improving the process and business performances. This concept was derived and introduced back in 1986 and gained universal applicability, many industries still lag in implementing this methodology in their systems. The purpose of this paper is to understand the requirements and methodology of six sigma.*
Key Word*: DMAIC Process, Critical Process, Black Belts, Repeatability and Reproducibility Gauge Study*

I. INTRODUCTION

Every organization having aims to increase profit and growth. Growth and profits are directly related to the level of satisfaction that is imparted by the product or the services to the customers. Customer wants value for money. Customer needs the best quality in the given cost. So how does organizations achieve this quality? Now a days Quality is a subjective constraint. Every customer has a different requirement of quality. So, it is the responsibility of the organization to provide everything in terms of quality that every customer requirement. From where does this quality start? It starts from the moment the manufacturer purchases the raw material from the supplier. This quality is percolated in the product through right set of processes, activities with the use of right resources in terms of human and technology and ultimately right quality is achieved by reduction in defect in the product. Lesser is the tolerance limit for defect, better is the quality. This concept drives the organization towards the concept of least deviation in the products that are manufactured. This drives the organization towards Six Sigma.

II. WHAT IS SIX SIGMA?

Six Sigma is the degree of quality that strives for near excellence and perfection. Six Sigma strategies seek to improve manufacturing quality by identifying and removing the causes of defects and minimizing variability in manufacturing and business processes. It is a methodology for eliminating defects (driving towards six standard deviations between the mean and the nearest specification limit) in any process. The application Six Sigma is spread from manufacturing to transactional and from product to service. When a process produces not more than 3.4 defects per million opportunities (DPMO), six sigma is said to be achieved. A Six Sigma defect is defined as anything beyond and outside of customer specifications and requirements. Thus, anything that does not satisfy the customer is called a defect. The role of Six Sigma professional is to identify defect, reduce it and confirm that the defect does not repeat or occur.
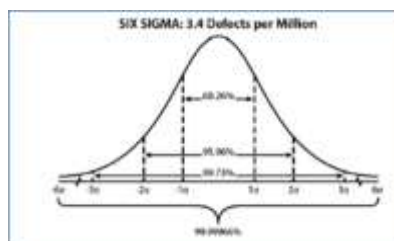

Fig -1: Six Sigma Curve (Approaching Perfection)

Figure 1 shows the bell shape curve which also signifies the six sigma. The central peak of the curve is where the variable attributes are supposed to lie. The deviation from the center shows the increasing defects in the process. One sigma indicates 68% of the process in control. Two sigma means 95.96% products lie in the specification limits. Thus, Six Sigma means 99.00066% of the products lie in the specification limits. Thus, the defect rates on each side of the curve are 0.00017%. This accounts to 3.4 defects in per million opportunities. Less is the standard deviation, more is the accuracy. Six Sigma encompasses the complete 'professionalizing' of quality management functions. Before the introduction of Six

Sigma, quality management in practice was largely consigned to the production floor and to statisticians in a separate quality department. Then a formal program that ranked the professional based on their knowledge and experience to organize projects on quality improvement was introduced. This is known as Six Sigma belts. Professionals are ranked in the role they play in Six Sigma Projects.

III.LEVELS OF SIX SIGMA

Today's many of leading organizations synthesize Six Sigma standardization practices with Lean manufacturing methods that cut waste to make their organizations as efficient as possible. But what do Six Sigma belt levels mean? There are 6 levels in six sigma.
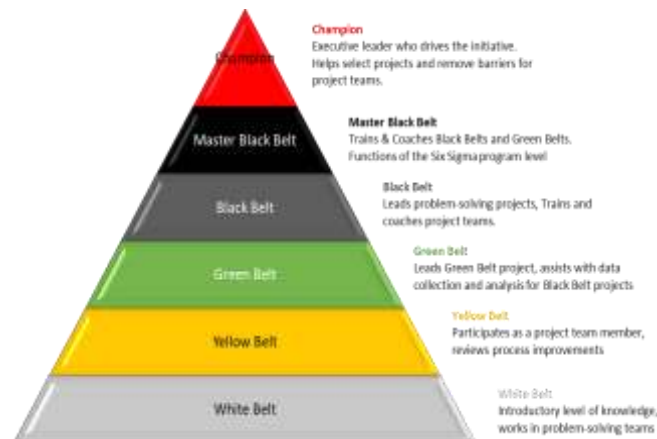

Fig -2: Level of Six Sigma

White Belt:- White belt person having a single session with an overview of relevant methods and vocabulary for LSS (Lean Six Sigma) shows workers at all levels of an organization how they contribute to efficient, reliable outcomes. With this basic grounding, White Belts participate in projects and problem-solving tasks related to quality management and waste reduction.

Yellow Belt:- A Yellow Belt designation indicates an exposure to Six Sigma concepts that goes beyond the fundamentals provided for a White Belt. Yellow Belts may have attended training sessions over a day or two, developing the knowledge they need be assigned to a project as fully contributing team members. They may guide limited-scope projects and assist managers at higher belt levels.

Green Belt:- A Lean Six Sigma Green Belt certification requires professionals to attend a full course that introduces themto Six Sigma methods for developing and improving products, services and processes. They learn to apply problem-solving frameworks such as DMAIC: Define, Measure, Analyze, Improve and Control. This improvement cycle lays out a series of steps to understand the problems in a business process, set useful metrics for measuring changes, examine relevant data, implement solutions and then sustain the results over time.

Black Belt:- After completing their Green Belt courses, leaders may take their skills to next level by pursuing Six Sigma Black Belt certification. This advanced training requires previous knowledge of LSS strategies as professionals master the skills they need to plan, lead and explain more complex and expansive projects or organizational changes.

Master Black Belt:- A seasoned Black Belt with strong leadership and problem-solving skills can go on to become a Master Black Belt in LSS (Lean Six Sigma). This designation indicates that an expert takes a broad view of strategy throughout a business, coordinating teams across.

Champion:- A Champion is an upper-level manager who leads LSS strategy and deployment. Based on the objectives set by executive leadership, Champions ensure that all initiatives to lower waste and remove defects come together in alignment with a company's needs for growth. Aided by Master Black Belts, these managers mentor the leaders involved in LSS implementation and track their progress.

IV.METHODOLOGY

The Six Sigma methodology is defined by five DMAIC steps and a preceding "step zero" known as Six Sigma Leadership.

Fig -3: Six Sigma Methodology

Phase 1:- Define

Define the problem and explain the scope of the project for the team working on it. Usually teams just look at the problem from their perspective, but it has to be the other way around. The problem should include the pain points felt by the customer and how long the issue has been left unattended. There could be various problems that arise at once such as employees, services, or advertising and marketing. Irrespective of the problem, the problem has to be an existing one which is in a steady-state of process and not a one-time event and has been causing trouble over many cycles.

Goals of Define phase:-
- Understand the project, including its purpose and scope.
- Determine whether the process is a good candidate for DMAIC.
- Map the current process.
- Detail customer expectations.
- Estimate timelines and costs using project management tools

Deliverables of Define phase:-
- Identify problem statement
- Determine the project scope
- Conduct financial impact
- Establish project goals and form team
- Determine project deliverables and milestones
- Project charter acceptance from management
- Define phase tollgate review

Phase 2:- Measure

Measure the current process / performance. Six Sigma is all about data-driven decisions, and to improve processes, one has to identify what kind of data is available and from where. Initially create a plan to gather the info and then summarize to describe the problem at hand. Make use of graphical tools to ensure better understanding of the problem.

Goals of Measure phase:-
- Establish baseline performance of the process
- Identification of process performance indicators
- Develop a data collection plan and then collect data.
- Validating the measurement system

- Determine the process capability

Deliverables of Measure phase:-
- Detailed process map
- Data collection plan and collected data
- Results of Measurement system analysis
- Graphical analysis of data
- Process capability and sigma baseline

Phase 3:- Analyze

   Analyse current performance to isolate and act on the problem. Through both statistical and qualitative analysis, you canformulate and run test hypotheses towards the root cause of the problem.

Goals of Analyze phase:-
- Use measure data to identify the probable causes of the problem
- Identify the actual root cause using brainstorming, 5 why, and other techniques
- Find the critical root cause that has the highest impact on CTQ
- Verify the root causes using appropriate statistical tools and techniques like hypothesis testing

Deliverables of Analyze phase:-
- Detailed process map
- Identify value and non-value activities
- List of potential causes
- Data Analysis and results
- "Vital few" x's

Phase 4:- Improve

   Improve the process by selecting a solution for a problem. Depending upon the particular root cause, address the cause with an improvement initiative. It's better to brainstorm potential solutions towards the problems and prioritize accordingto the customers' requirements, and do a test run to see if it gives a perfect solution for the problem.

Goals of Analyze phase:-
- Identify the feasible solutions for the identified root cause(s)
- Select the best solution using statistical tools
- Perform cost-benefit analysis
- Test the solution
- Assess the effectiveness of the solution to ensure measurable improvements in the process

Deliverables of Analyze phase:-
- Identify potential solutions
- Finalize the preferred solution
- Pilot test the solution
- Implement the solution
- Ensure the implemented solution results in eliminating the root cause(s)

Phase 5:- Control

Control the improved process to ensure the customer requirements or goals are met. Once a consensus has been reached towards the improvement, it must be standardized across the organization for similar problems in the future. Even the standard operating procedures (SOPs) may need a relook to track ongoing performance of processes. The project teams implement the standardized improvements over a period to control processes and ensure the projects are being completed successfully.

Goals of Control phase:-
- Develop Control Plan
- Validate the solution
- Statistical process control
- Implementation plan
- Cost benefit analysis
- Formal project closure
- Celebrate success and recognize the team

Deliverables of Control phase:-
- Process monitoring (Control charts)
- Control plan
- Work Instructions/SOPs
- Training Plan
- Financial savings
- Update the Lessons Learnt database
- Project closure
- Celebrate the success and recognize the team

DMAIC acts as the foundation of Six Sigma and is much more effective when used in an iterative manner to solve the problems. Quality practitioners and process improvement specialists often start by learning the DMAIC approach as most of the other methodologies obtain its fundamental structure and concepts.

V.LIST OF SIX SIGMA TOOLS

Six Sigma tools are defined as the problem-solving tools used to support Six Sigma and other process improvement efforts. The Six Sigma expert uses qualitative and quantitative techniques to drive process improvement. Although the tools themselves are not unique, the way they are applied and integrated as part of a system is. There are 10 most powerful statistical and graphical tools commonly used in improvement projects are:

1) DMAIC and DMADV Tools:-

DMAIC is a 5-step process, and it is the first and most used method/tool in Six Sigma.The 5 steps are
- Define
- Measure
- Analyze
- Improve
- Control

The DMAIC process helps in creating continuous improvement in your manufacturing methods by using data and measured objectives. Also, there is a process known as DMADV, which is used to develop a new process, product, or service, whereas DMAIC which is useful for improving current processes.
DMADV Stands For
- Define
- Measure
- Analyze

- Design
- Verify

The DMADV process helps in developing a high-quality product and service by creating an efficient process doing thorough analyses and using data.

2) The 5 Why:-

To determine the root cause of problems in your organization, the tool of 5 Whys is used, which is frequently deployedas part of the Analyze phase in DMAIC.

The 5 Whys works like this:

- Write down the problem you are having so that every member of your team can focus on it specifically.
- Ask why the problem took place.
- If your first answer is not the main reason for your problem, ask why again.

- Repeat this questioning at least 5 times to find the true reason for the problem.
- Whys do not mean that it has to be restricted to 5 times only, you can ask more than 5 times, but basically, after 5 times, you will get the clarity on the root cause of the problem.

3) The 5S System:-

For quicker access and better management, workplace materials are organized following a tool known as the 5S System.The waste that is produced by poor conditions and poor workstations are eliminated with the help of this system.

The 5S are:

- Seiri (Sort) – Leaving only necessary items, all extra items are removed from current production.
- Seiton (Set in order) – Organize all items and label them according to being clutter-free.
- Seiso (Shine) – Keep your work area clean and inspect everything in it regularly.
- Seiketsu (Standardize) – Write the standards that you have set, sort them, set them in order, and shine stepsabove.
- Shitsuke (Sustain) – Apply and execute the standards that you have set for your company and make everyonefollow it as a habit regularly.

4) Value Stream Mapping:-

Value Stream Mapping is a tool used in the Analyze phase of DMAIC and also in Lean Manufacturing, making it perfect for Lean Six Sigma. To help you improve and optimize flow throughout your organization, a value stream map was developed to show the flow of materials and information in one of your processes.

Value Stream mapping helps you identify 3 things:

- **Value Enabling Activities:** Identifying the activities which when enabled, adds value to your processes.
- **Value-Adding Activities:** Identifying the activities that add value to your processes.
- **Non-value adding activities:** Identifying and eliminating the activities that do not add any value to your processes.

In order to make your processes more compact, swift, and precise, you have to eliminate wait time between consecutive steps in your processes and eliminate all your non-value-adding activities with the help of Value Stream Mapping.

5) Regression Analysis:-

A Regression Analysis which is used to define the mathematical relationship between an input variable and an output variable is a statistical process for estimating and understanding the relationship between variables. It helps you visualize patterns or deviance from desired patterns in your workflow by graphing these inputs and outputs.

You have to be cautious when performing a regression analysis. In Layman's language, Regression analysis is a statistical method which helps in determining the extent to which a relationship exists between two variables. One can accurately identify the values of one variable based on the values of another variable using a simple linear formula if the relationship is strong enough.
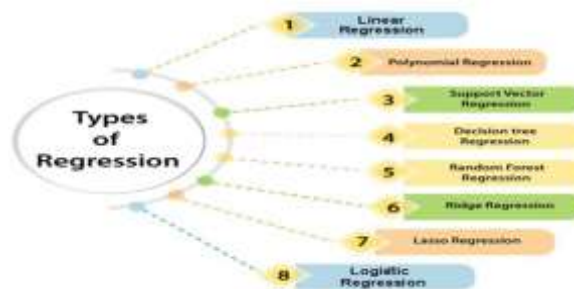
6) Pareto Chart:-

Pareto Chart is a graphic representation that visualizes what part of the process influences output the most. You first have to figure out components of the process along with how to measure them to create such a chart. It allows Six Sigma teams to identify the largest issues facing the process by displaying differences between groups of data.

It is considered as the most important tool of Six Sigma as it helps the team identify 20% of resources that causes 80% of problems in their processes. In short, it will give you a clear idea that which component requires your immediate attention.
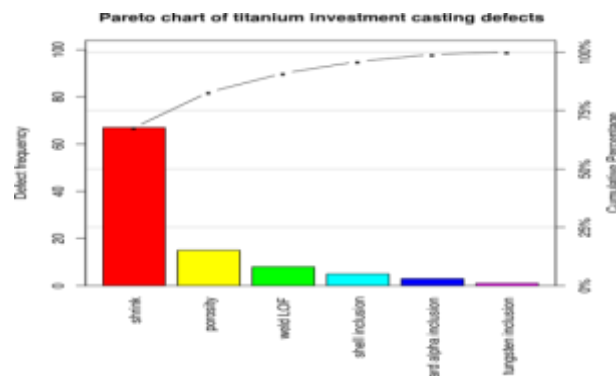
7) FMEA:-

The full form of FMEA is Failure Modes and Effects Analysis (FMEA). Developed in the 1950s, FMEA helps businesses in identifying and eliminating weak points by reviewing the causes and effects of components, assemblies, and subsystems. It helps Six Sigma Practitioners detect and fix problems before it occurs, resulting in improved quality of their processes, services, and products.

8) Kaizen:-

Kaizen means continuous improvement. It is a practice that continuously involves observing, identifying, and implementing incremental improvement in your manufacturing process by involving all employees and managers and encouraging them in the process of manufacturing improvements.

It ensures to rectify the smallest inefficiencies every day through the collective talents and knowledge of everyone working in the company. It also ensures the reduction of waste in production.

9) Poka-Yoke:-

Poka-yoke is a Japanese term meaning mistake-proofing. It helps in identifying and rectifying human errors by employees that occur throughout the production and manufacturing processes.

10) Kanban System:-

Kanban is a Japanese word meaning billboard. The Kanban System being a supply chain control system focuses on cost reduction by implementing a just-in-time inventory control system. It is very easy to use and has many benefits, for which it is also one of the most popular six sigma tools. Kanban system increases efficiency and brings more focus to the business as it works on a simple and elegant idea by only activating the supply chain when the demand requires it, by feeling additional resources and allowing to use them better. This system helps all the current business processes by setting limits for the inventory- holding.

VI.CONCLUSION

As the market is changing rapidly, the customer's definition of quality is changing. It is thus a challenging time for the manufacturers as they must bring the best in quality through zero defects. This has prioritized the application of Six Sigma. And for the organization to implement Six Sigma, the involvement of top management is of utmost importance.

In recent years there has been a lot of interest in the application of Six Sigma principles. Numerous papers have been presented on this subject substantiating the importance of adopting Six Sigma to improve process performance. This research is carried out to identify the latest trends, various approaches, tools and techniques, benefits and combinations of Six Sigma with other concepts by carrying out a systematic, thematic literature review.

References

1. Berenson M. y Levine D. (1996). Estadística Básica en Administración: Conceptos y Aplicaciones. Segunda Edición. Prentice Hall Hispano-American S.A. Edo. México, México.

2. Besterfield D. (1994). Control de Calidad. Cuarta Edición. Prentice Hall Hispanoamericana S.A. Edo. México, México.

3. Brue G. y Howes R. (2006). Six Sigma. Mc Graw Hill, New York, N.Y.USA.

4. Automotive Industry Action Group (2002). Measurement System Analysis: Reference Manual. Tercera Edición.

5. Automotive Industry Action Group (1995). Statistical Process Control SPC: Reference Manual. Segunda Edición.

6. Automotive Industry Action Group (2001). FMEA-Potential Failure Mode and Effect Analysis: Reference Manual. 3rd. Ed.

7. Eckes G. (2001) Making Six Sigma Last: Managing the Balance between Cultural and Technical Change. John Wiley & Sons, Inc. New Cork, N.Y. USA.

8. Evans J. y Lindsay W. (2002). The Management and Control of Quality. South Western a division of Thomson Learning. Quinta Edición. Cincinnati, Ohio, USA.

9. Gutiérrez H.y De la Vara R. (2004). Control Estadístico de Calidad y Seis Sigma. Mc Graw Hill Interamericana Editores, S.A. de C.V. México, D.F.

10. Howard S. GItlow y Levine D. (2005). Six Sigma for Green Belts and Champions. Prentice Hall. USA.

11. Lamprecht, J. (2004) El Six Sigma Desmitificado. Panorama. México, D.F.

12. Levin R. y Rubin D. (1996). Estadística para Administradores. Sexta Edición. Prentice Hall Hispanoamericana S.A. Edo. México, México.

13. Montgomery D. (2002). Diseño y Análisis de Experimentos. Segunda Edición. Limusa, S.A. de C.V. México D.F.

14. Montgomery D. y Runger G. (1996). Probabilidad y Estadística: Aplicadas a la Ingeniería. Mc Graw Hill Interamericana Editores, S.A. de C.V. México D.F.

15. Pande P. Neuman R. y Cavanagh R. (2000). The Six Sigma Way: How GE, Motorola and Other Top Companies are Honing Their Performance. Mc Graw Hill. USA.