Application of SIX-SIGMA In Four Wheeler Platform Truck With Quality Tools and Techniques

[1]Abhishek Kishor Sardeshpande, [2]Prof. H.P.Khairnar
[1]M-Tech (Machine Design) PG Scholar, [2]Assistant Professor (Mechanical Engineering).
[1,2]Dept of Mechanical Engineering, Veermata Jijabai Technological Institute, Mumbai, Maharashtra, India-400019
[1]abhishek.sardeshpande@yahoo.com, [2]hpkhairnar@vjti.org.in

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Abstract— The six sigma method is a project-driven management approach to improve the organization's products, services, and processes by continually reducing defects in the organization.

This paper examines the evolution, benefits, and challenges of six sigma practices and identifies the key factors influencing successful six sigma project implementations. It integrates the lessons learned from successful six sigma projects and considers further improvements to the six sigma approach. Effective six sigma principles and practices will succeed by refining the organizational culture continuously.

The purpose of this paper is the survey of six sigma process and its impact on the total productivity and final quality of the four wheeler platform truck in leading manufacturing of material handling equipments. So I have studied key concepts, problem solving process of six-sigma as well as the survey of important fields such as: DMAIC, six sigma and productivity applied program, and other advantages of six-sigma.

After successful implementation of this concept, the total sigma level for four wheeler platform truck will be improved from 1.2 to 3.2.

Index Terms—Six-Sigma, DMAIC, Cause and Effect Diagram, Pareto Chart & CASE STUDY.

I. INTRODUCTION

The six sigma method is a project-driven management approach to improve the organization's products, services, and processes by continually reducing defects in the organization. It is a business strategy that focuses on improving customer requirements understanding, business systems, productivity, and financial performance. Dating back to the mid 1980s, applications of the six sigma methods allowed many organizations to sustain their competitive advantage by integrating their knowledge of the process with statistics, engineering, and project management.

The six sigma approach was first applied in manufacturing operations and rapidly expanded to different functional areas such as marketing, engineering, purchasing, servicing, and administrative support, once organizations realized the benefits. Particularly, the widespread applications of six-sigma were possible due to the fact that organizations were able to articulate the benefits of six-sigma presented in financial returns by linking process improvement with cost savings.

Statistical viewpoint

Six sigma methods have two major perspectives. The origin of six-sigma comes from statistics and statisticians. From the statistical point of view, the term six sigma is defined as having less than 3.4 defects per million opportunities or a success rate of 99.9997% where sigma is a term used to represent the variation about the process average. If an organization is operating at three sigma levels for quality control, this is interpreted as achieving a success rate of 93% or 66,800 defects per million opportunities. Therefore, the six sigma method is a very rigorous quality control concept where many organizations still performs at three sigma level.

Business viewpoint

In the business world, six-sigma is defined as a 'business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations.

Definition of Six-Sigma

Six-Sigma is a statistic quantity about performance of products or service. Sigma, transliteration of Greek letter σ, means standard deviation in Statistics and reflects the degree of deviation. In the process of production or management, Six Sigma is used to describe quality fluctuation and indicates the amount of data that is within the extension of quality demands and customer needs. From the view of statistics, Six-Sigma means Six-time standard deviation between the average and the lower or upper limit; in the meanwhile, the fluctuation is reduced and only 3.4 defective parts per million opportunities (namely 3.4 ppm) is produced. Therefore, the larger the σ is, the more disperse the data is; and the smaller the σ is, the more centralized the data is. Six-Sigma Management measures performance using "σ yardstick", and the smaller the σ is, the higher the quality is. We usually use the following formula to express the value of

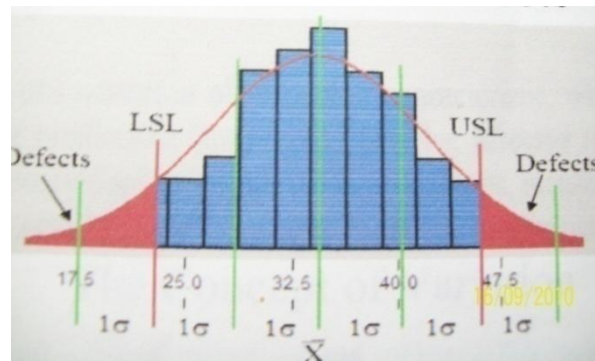$$\sigma = \sqrt{\frac{\sum_{i}^{n}\left(Xi - \overline{X}\right)^2}{n-1}}$$

Figure 1: - Standard Deviation

Xi- observation data of samples
X- Average level of samples.
n- Capability of samples.


II. METHODOLOGY

Six sigma process

Six sigma strategies, tools, techniques, and principles are a systematic, data-driven approach using define, measure, analysis, improve, and control (DMAIC) process.

DMAIC is a closed-loop process that eliminates unproductive steps, often focuses on new measurements, and applies technology for continuous improvement.

DMAIC – Defining, Measuring, Analysis, Improving and controlling which is the general way of Six-Sigma implementation.

- ✓ **Define**: Find out problems establish improved target and make plans for programs.
- ✓ **Measure**: Quality the customers' CTQ, collect the data, and know about the current quality level.
- ✓ **Analyze**: Analyze data and find out the vital factors affecting quality.
- ✓ **Improve**: Establish the best method to improve quality based on the vital factors.
- ✓ **Control**: Take measures to keep the improved results.

DMAIC begins with investigating and understanding the customers' needs, and then finding out the factors which affect the key products or services and improving the quality. DMAIC is the key to application of Six Sigma.
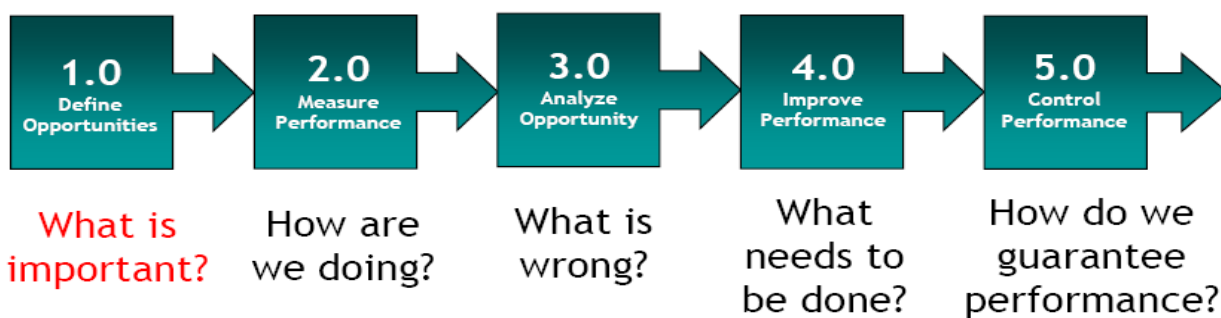
III. Quality Management Tools & Methods Used In Six-Sigma

1. Process Mapping
2. Cause & effect diagram.
3. Control chart.
4. Cost-Benefit Analysis.
5. CTQ tree.
6. Histograms.
7. Quality Function Development.
8. Pareto Chart.
9. Process capability.
10. Regeneration analysis.
11. Root cause analysis.
12. SIPOC analysis. (Supplier, Input, Process, Output, Customers.)

**Terms and definitions: -**

Project charter:

The project charter is a document that evolves over the course of a Six Sigma project. It names the project, lists the people involved and delineates the responsibilities of each, identifies the project objectives, links them to the organization's strategic goals, and establishes the reasons for the project. The charter has its roots in your project-selection efforts. The project and objective statements you created in Chapter 5 represent the early stages of your project charter. Essentially, the charter documents a Six Sigma project and provides all relevant information about it. Anyone who reads this document should be able to understand all of the elements of a project. Choose a descriptive title: it should make the subject and purpose of your project immediately recognizable.

Cause-and-effect diagram

CE is a tool to solve problems through finding the cause of their occurrence. It helps to find all possible causes, to split causes into categories and organize their relationships and impact on output, and to identify opportunities for improvement. In general, these categories are commonly known as 7M causes:
• Man - people, job;
• Methods and mechanics, process;
• Machine – machines, equipment;
• Measurement;
• Management - system of organization and management;
• Material;
• Mother Nature - Environment.
Figure 2 is a more detailed analysis of each factor gives a diagram that resembles a fish bone as seen in
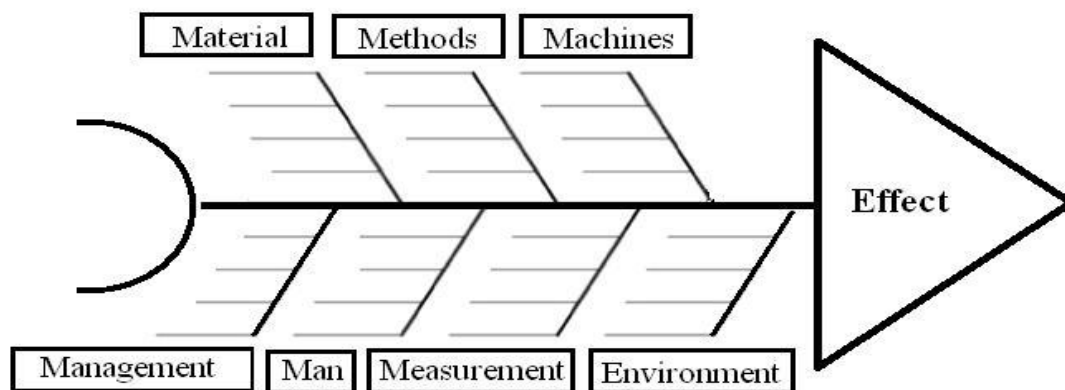
Figure 2: -

Fish-bone Diagram (Cause and effect diagram)

SIPOC`

A SIPOC diagram helps us understand what is upstream and downstream from our process. The elements of the diagram are: the Suppliers (S) to our process and their Inputs (I), our Process (P), and the Outputs (O) we provide to our process's Customers (C). A SIPOC can be drawn quickly and can help us better understand the context of our process and explain it to others.

Check sheet

A Check sheet is a tally sheet that is used to collect data. It is a simple manual method that operators can use with a minimum of instruction

Pareto chart

Pareto diagrams are special types of histograms. The bars in pareto diagrams are rearranged in descending order of their heights, showing individual contribution of each factor as well as cumulative contributions. The purpose of pareto diagram is to identify high priority items separating the vital few from the trivial many or as they known as useful many.

Standard Sigma level chart: -

Sigma level	DPMO	Percentage defective
1	691,462	69%
2	308,538	31%
3	66,807	6.7%
4	6,210	0.62%
5	233	0.023%
6	3.4	0.00034%

Table 1: - Sigma levels

IV. CASE STUDY
Quality Improvement in Four Wheeler Platform Trucks (Moving Towards ZERO DEFECTS)

Product: - Four Wheeler Platform Truck.

PURPOSE: -
 To improve the work and quality level within a company and at customers level in given schedule time at minimum expenses with maximum operational feasibility.

SCOPE: -
 This project applies to all departments that are currently participating in the company. Specifically quality and service departments for development of six sigma standard.
This project also improves the quality of the product within six sigma level for customer's satisfaction and for the growth of company.

ANALYSIS: -   1. Analysis of major quality issues during warranty period.

2. Root cause analysis using QA techniques.
3. Corrective solutions for the root cause.
4. Feedback on implementation.
5. Study and improvement of processes for six-sigma level.

Need of Study: -

The problem and scope for work effort of the project. The description of the problem should include the pain felt by the customer and/or business as well as how long the issue has existed. Hence, identify the customer(s), the project goals, and timeframe for completion.

The appropriate types of problems have unlimited scope and scale, from employee problems to issues with the production process or advertising. Regardless of the type of problem, it should be systemic part of an existing, steady-state process where in the problem not a one-time event is, but has caused pain for a couple of cycles

- Define customers and their requirements.

- Define project boundaries (project scope).

- Create a Process Map (e.g., flow chart) of the process to be improved.

- Identify project support people (operators, engineers, supervisors, finance)

PROBLEM STATEMENT

After detail study and as per available data I have got current sigma level calculation.
Now final aim is to increase the level of quality for each four wheeler platform truck for the customer's satisfaction with improvement of six-sigma level as a reduction in cost and process time.
For better quality of trucks, I am trying to nullify all possible problems which are directly or indirectly affect the quality of product with every possible changes and modifications in design and in SOP.
 Final aim is to nullify all present complaints from final inspection and all complaints from customers end per sample which directly increase sigma level of the product and company.

Application of SIX-SIGMA standards

Source of data:-
- Total Quality Department- Complaints received from final inspection.

- Service Department- Complaints received from customers end.

Period of review: -
- Quality Dept.: - Jan 2013 to Sep 2013.
- Service Dept.: - Jan 2013 to Sep 2013.

Summary: -   Total Trucks = 264

| Sr. No.	CATEGORY	No. Of Problems
1	Brake and hand brake	286
2	Differential & Gearbox- Oil Leakage	170
3	Rear axle shaft	116
4	Fuse terminal & F/R switch	97
5	Steering	89
		TOTAL = 858

Table 2: - Data Table

Pareto chart:-

Sr. No.	Category	No. Of Problems	Cumulative frequency	% cumulative frequency

1	Brake and hand brake	386	386	44.98%
2	Differential & Gearbox- Oil Leakage	170	556	64.80%
3	Rear axle shaft	116	672	78.32%
4	Fuse terminal & F/R switch	97	769	89.62%
5	Steering	89	858	100%
		TOTAL = 858		

Table 3: - Frequency Data Table
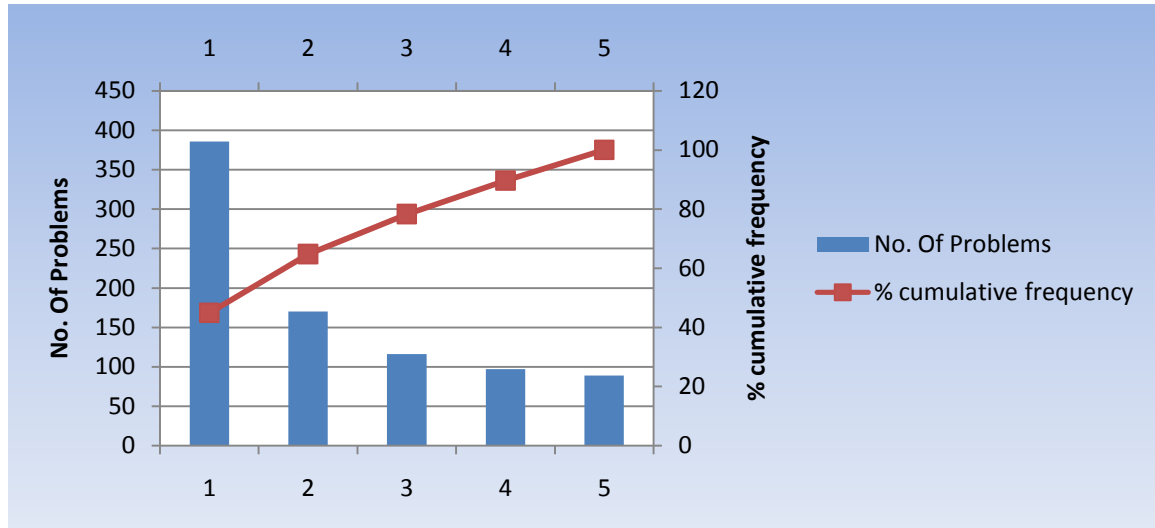
Graph 1: - Pareto Chart (Graphical Representation)

V. SIX-SIGMA LEVEL CALCULATION: - Defects Per Million Opportunity (D.P.M.O.)
   D P M O calculation:

- Number of opportunity (Sample Size)   264
- Number of opportunity   05

(Total defects / sample)

- Number of defects   858

(Total defects for total sample of Trucks i.e. 264)

$$DPMO = \frac{Defects \times 1000000}{Defects\ Opportunity\ Per\ Unit \times No\ of\ Opportunity}$$

$$DPMO = \frac{858 \times 1000000}{05 \times 264} = 6,50,000$$

DPMO = 6, 50, 000

As per Sigma Chart with respect to DPMO

CURRENT SIGMA LEVEL IS 1.2 TO 1.4

VI. RESULT & DISCUSSION

Problems, Root Causes and Its Solutions: -

1)   Brakes: -

Total No. Of complaints: - 222 + 94 + 36 out of 264 Trucks.

Problems	1. Brake shoe liner crack. 2. Brake light continuously on. 3. Brake Noise after brake pedal released. 4. Oil leakage from 3-way junction. 5. Improper assembly of Service and parking brake.
Root Causes	1. Poor quality of liner material. 2. Thickness of liner is not standardised. 3. Variation in Brake plate and brake drum alignment. 4. Difference in inner diameter of brake drum and outer diameter brake plate. 5. Ferruling problem in 3 way junction.
Corrective actions	1. Use brake shoe liner of ASBESTOS MATERIAL as per standard brake plate. 2. Procure Brake plate and Brake drum as a one unit 3. New braking system for service and parking brakes individually. 4. Use all brake plates and brake drums of 11 inch for all four wheels. 5. Use hydraulic braking system for service brake. 6. Mechanical brake (Wire braking) arrangement for parking brake. 7. Use limit switch arrangement for brake lights.

2)   Oil Leakage:-

a)   Gearbox: -

b)   Differential: -

Total No. Of complaints: - 170 out of 264 Trucks.

Problems	1. Oil leakage from drain plug. 2. Oil leakage from two gearbox casing. 3. Oil leakage from threading of bolts. 4. Less / Excess oil.
Root Causes	1. Uneven facing. 2. Improper threading of bolts. 3. No gasket provision. 4. Loose tightening of drain plug. 5. Loose tightening of nut and bolts. 6. No oil measuring instrument.
Corrective actions	1. Facing of two meeting surfaces should be proper. 2. Provide Gasket in between two meeting surfaces. 3. Use CELLAC solution with gasket. 4. Use of Lock-tight solution for drain plug. 5. Teflon tape should be use for drain plug. 6. Oil should be fill as per measured quantity, For Gearbox- 450 ml & for Differential – 1250 ml.

3)   Rear Axle Shaft:-

Total No. Of complaints: - 116 out of 264 Trucks.

Problems	1. Key comes out. 2. Shaft damage.
Root Causes	1. Key way depth is small / large. 2. Key size is not as per key way depth. 3. Key hole on brake drum is smaller / bigger. 4. Key material is not good.
Corrective Actions	1. Use of three different sizes of key as per key way size. 2. Sample inspection of keys as per drawing. 3. Proper assembly of key on key way with press fitting.

4)   Electrical Department: -

Total No. Of complaints: - 97 out of 264 Trucks.

Problems	1. Short life of F/R switch. 2. Loose Fuse terminal. 3. Loose head light wiring.

	4. Battery discharge buzzer open.
Root causes	1. Bad quality of F/R switch. 2. Rough handling of switch over its cycle of rotation. 3. Fuse terminal pins are loose. 4. No screw arrangements on fuse terminal. 5. Loose wiring. 6. Not proper routing of wires. 7. Random wiring assembly. 8. Buzzer body gets open. 9. High vibrations.
Corrective Actions	1. Provide two way switches. 2. Fix cycle of operation. 3. Use screw tightening for fuse terminals. 4. Proper screw arrangements on fuse terminal on control panel. 5. Routing of wires with standard process. 6. Avoid random assembly of wires. 7. Provide electric tape on buzzer body.

5)   Steering: -

Total No. Of complaints: - 89 out of 264 Trucks.

Problems	1. Hard Steering 2. Play in steering rod. 3. Steering lock.
Root Causes	1. No Universal joint for steering rod. 2. Problem with new design of steering assembly. 3. Threads of steering rod & wheel are not matching (Serration). 4. Crowning is not available on steering gears.
Corrective Actions	5. Provide one universal joint in between steering rod and gears 6. Crowning and serration on teeth of the gears. 7. Threads should be properly matched during incoming inspection. 8. Assembly of new design as per standard procedure.

Final Implemented Results: - Total Trucks = 264

Sr. No.	Category	No. Of Problems	After Implementation
1	Brake and hand brake	386	0
2	Differential & Gearbox- Oil Leakage	170	< 25
3	Rear axle shaft	116	< 25
4	Fuse terminal & F/R switch	97	< 15
5	Steering	89	< 15
		TOTAL = 858	**80**

Table 4: - Implemented Results Table

After achievement of these target values, total no. of complaints will directly minimize by huge margin.
And customer complaints will be minimizing by 90%.
Then, product new sigma level will be: -

$$\text{DPMO} \quad = \quad \frac{80 \times 1000000}{05 \times 264}$$

$$= \ 60,606.0606$$

Therefore for Four Wheeler Platform Trucks Sigma level as per DPMO will be 3.0 to 3.2.

From above solutions we are heading towards good quality of trucks without any further major problems from customers end and from final quality inspection also. Applications of all best possible solutions will improve current Six-Sigma level of four wheeler platform truck.
For smooth and continuous flow of good quality product company has to improve all standard operating procedure with all good resources and techniques with full dedication toward individual working plan and working procedure in each and every stage of production.

With implementation of all new and current solutions in final check sheets will increase the way of inspection and process of operations.

Prepared three new check sheets with all improved solutions:
1.   Check list for Incoming Inspection
2.   New Production Check list.
3.   Final inspection Check list.

Prepared a new SOP for further production of Four Wheeler Platform Trucks.

FINAL OUTPUT – Improved Sigma level is from 1.6 to 3.2

VII. CONCLUSIONS

1- Six-sigma is a business improvement approach that seeks to find and eliminate causes of mistakes or defects in business processes by focusing on outputs that are of critical importance to customers.

2- The four phase improvement process; define, measure, analyze, improve, control (DMAIC).

3- Six-sigma has both management and technical components.

4- Six-sigma is designed to dramatically upgrade an organizations performance, improving quality and productivity.

5- The program of six sigma and productivity is designed for quality service managers and administratively/ professional staff, who are seeking to learn and apply six sigma language and concept at their respective work places and increasing their productivity.

6- Direct and positive relation is between six sigma and productivity.

7- It works and it can be important to both the success of your organization and your career. Six Sigma is arguably the most important business and industry initiative that has involved statistical thinking and methods.

8- "Good things don't come easy". This is certainly the case for Six Sigma.

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