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Six Sigma Approach to increase the Original equipment percentage in hinoline

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ABSTRACT

Rejection Analysis is a process of identification of quality and productivity related problems which are the key factors in manufacturing process. It provides effective suggestion to the problem encountered in manufacturing process. It was apparent that production line was having more defect and rework and had rejection percentage rate. In this project we examine the cylinder liners, analysis and study was conducting to observe the process going in the production line, to increase the OE percentage of cylinder liners by tracing the root causes and by providing suggestion. It is also a process of continuous improvement that gives better results every time when implemented properly. In this project we are approaching six sigma to reduce the rejections. This paper discusses the implementation of Six-sigma methodology in reducing defectives in a cylinder liner manufacturing industry. The Six- sigma DMAIC (define– measure– analyze –improve – control) approach has been used to achieve this result. This paper explains the step-by-step approach of Six-sigma implementation in this manufacturing process for improving quality level.

KEYWORDS: Six sigma, DMAIC, Process Capability, Fish bone Diagram, SIPOC Diagram, Pareto Chart, Process Yield, Original Equipment

1. INTRODUCTION

Six Sigma (6σ) is a set of techniques and tools for process improvement. It was introduced by American engineer Bill Smith while working at Motorola in 1986. Six Sigma strategies seek to improve manufacturing quality by identifying and removing the causes of defects and minimizing variability in manufacturing and business processes. This is done by using empirical and statistical quality management methods and by hiring people who serve as Six Sigma experts. Each Six Sigma project follows a defined methodology and has specific value targets, such as reducing pollution or increasing customer satisfaction.

The term Six Sigma originates from statistical modeling of manufacturing processes. The maturity of a manufacturing process can be described by a sigma rating indicating its yield or the percentage of defect-free products it creates—specifically, to within how many standard deviations of a normal distribution the fraction of defect-free outcomes corresponds. Six Sigma has played an important role by improving the accuracy of allocation of cash to reduce bank charges, automatic payments, improving the accuracy of reporting, reducing documentary credit defects, reducing check collection defects, and reducing variation in collect or performance. For example, Bank of America announced in 2004 that Six Sigma had helped it increase customer satisfaction by 10.4% and decrease customer issues by 24%; similarly, American Express eliminated non-received renewal credit cards. Other financial institutions that have adopted Six Sigma include GE Capital and JP Morgan Chase, where customer satisfaction was the main objective.

2. LITERATURE REVIEW

It describes about the literature review of Six sigma Technique based on different applications. In this we considered few journals to apply the six sigma technique, the few journals are explained as follows:

Mohan Babu et.al [1] are proposed the SIX Sigma has been characterized as the latest management fad to repackage old quality management principles, practices, and tools/techniques. At first glance Six Sigma looks strikingly similar to prior quality management approaches. However, leading organizations with a track record in quality have adopted Six Sigma and claimed that it has transformed their organization .**J.P. Costa et.al [2]** are proposed the Six Sigma concept emerged in the 1980s on the initiative of Motorola Inc. in the USA. Due to competition from the Japanese electronics manufacturing industries, Motorola was forced to reduce defect levels while simultaneously reducing costs and increasing productivity and customer satisfaction. **S. Pratiksha Shinde et.al [3]** are proposed Construction industry plays a major role in economic growth of nation. It is the most booming industry in the whole world. Construction sector is viewed as a service industry which generates substantial employment and provides growth afflatus to other manufacturing sectors. **Anand K. Bewoor et.al [4]** are proposed the Six Sigma is new, emerging, approach to quality assurance and quality management with emphasis on continuous quality improvements. The main goal of this approach is reaching level of quality and reliability that will satisfy and even exceed demands and expectations of today's demanding customer. **Pallawi B Sangode et.al [5]** are proposed while studying the existing literature on the barriers to the implementation of Six Sigma practices, many review studies were identified that list vivid barriers. Few of which are listed as follows. while reviewing the issues in implementation of Six Sigma in small and medium enterprises documented that the lack of resources is critical barrier to Six Sigma implementation in SMEs and lack of knowledge is the most important barrier for implementation of Six Sigma programmed but the leadership issue is also crucial for the failure or success of implementation of Six Sigma. **Sujit Kumar Pttanayak et.al [6]** are proposed the "Six-sigma is a disciplined, systematic, data-driven approach to process improvement adopted by organizations world over. Motorola introduced the concept of six-sigma in the mid-1980s as a powerful business strategy to improve quality. Six-sigma continues to be the best-known approach for process improvement. Implementation of Six-sigma methodology has a significant impact on profitability and customer satisfaction, if successfully deployed. It takes users away from 'intuition-based' decisions to 'fact-based' decisions. This paper discusses a case study conducted in a welding electrode manufacturing industry with the aim of reducing rejection, and thereby increasing its sigma level, using Six-Sigma methodology. The application of the Six-sigma problem solving methodology, DMAIC, reduced the rejection and thereby improved productivity. Various statistical techniques were applied to analyze the data and to identify solutions at different stages. **Nilamani Sahu et.al [7]** are proposed the Six Sigma is recognized as a strategy that can be used by organizations, with the objective of increasing the profitability of the business, by focusing on improving the effectiveness and efficiency of internal and external operations, in order to meet customer needs .To improve processes, products and services, organizations should, according to the context, adopt the most appropriate approach to apply the Six Sigma methodology. Thus, if the goal is to raise the performance of an existing process to a Six Sigma level, the organization must adopt the DMAIC approach. **M. Sokovic et.al [8]** are proposed the result of six sigma will be an increased efficiency, improvement in performance and control the problems to minimizing defects, risks and deviation. Six sigma is a quantitative and qualitative approach for improvement with the goal of limiting defects from any process, especially a numerical goal of 3.4 defects per million opportunities

(DPMO). Six sigma is easier to apply than many other quality management techniques because it is provided information about what change needand the programs to execute the change. The six sigma is a statistics-based methodology and depends on the scientific method to make significant reductions in customer defined defect rates in an effort to eliminate defects from every product, process and transaction.**Subhav Singh et.al [9]** are proposed the Six-Sigma DMAIC-Methodology: Six sigma today has evolved from merely a measurement of quality to an overall business improvement strategy for a large number of companies around the world. The concept of six sigma was introduced by Bill Smith in 1986, a senior engineer and scientist within Motorola's communication Division, in response to problems associated with high warranty claims.

Susmy Michael et.al [10] are proposed the fast changing economic conditions such as global competition, declining profit margin, customer demand for high quality product, product variety and reliable deliveries had a major impact on manufacturing industries. To respond to these needs various industrial engineering and quality management strategies such as Total Productive maintenance (TPM), Total Quality Management, Kaizen, JIT manufacturing, Enterprise Resource Planning, Business Process Reengineering, Lean manufacturing have been developed. A new paradigm in this area of manufacturing strategies is Six Sigma. The Six Sigma approach has been increasingly adopted worldwide in the manufacturing sector in order to enhance productivity and quality performance and to make the process robust to quality variations.

By considering all these journals we conclude that detailed analysis has been performed to rectify the problems of rejection of cylinder liners due to the variations in Quality characteristics of the manufactured units. TPM is implemented to improve the utilization of machines. Analysis is carried out with the help of tools like Pareto analysis, process capability analysis and fish-bone diagram. This Six Sigma improvement methodology viz. DMAIC project shows that the performance of the firm is increased to a better level as regards to: enhancement in customers satisfaction, adherence of delivery schedules, development of specific methods to redesign and reorganize a process with a view to reduce or eliminate errors, defects; development of more efficient, capable, reliable and consistent manufacturing process and more better overall process performance, creation of continuous improvement.

3. METHODOLOGY

The DMAIC methodology follows the phases: define measure analyze improve and control. Although PDCA could be used for process improvement, to give a new thrust Six Sigma was introduced with a modified model i.e., DMAIC. The methodology is revealed phase wise as shown in Figure 1 which is depicted in A, B, C, D and E and is implemented for this Project.

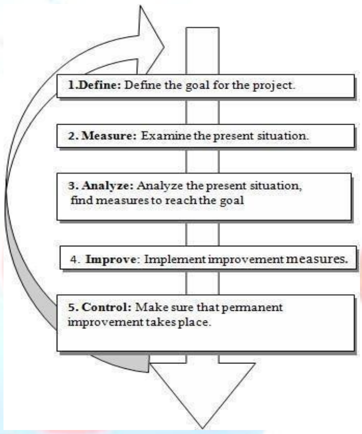

Figure 1: The DMAIC Methodology

Define:

The purpose of this step is to clearly pronounce the business problem, goal, potential resources, project scope and high-level project timeline.

Measure:

The purpose of this step is to measure the specification of problem/goal. This is a data collection step, the purpose of which is to establish process performance baselines. The performance metric baselines from the Measure phase will be compared to the performance metric at the conclusion of the project to determine objectively whether significant improvement has been made.

Analyze:

The purpose of this step is to identify, validate and select root cause for elimination. A large number of potential root causes (process inputs, X) of the project problem are identified via root cause analysis (for example, a fishbone diagram). The top three to four potential root causes are selected using multi-voting or other consensus tool for further validation.

Improve:

The purpose of this step is to identify, test and implement a solution to the problem; in part or in free of all whole. This depends on the situation. Identify creative solutions to eliminate the key root causes in order to fix and prevent process problems.

Control:

The purpose of this step is to embed the changes and ensure sustainability, this is sometimes referred to as making the change 'stick'. Control is the final stage within the DMAIC improvement method. In this step, the following processes are undertaken: amend ways of working, quantify and sign-off benefits, track improvement, officially close the project, and gain approval to release resources.

4. EXPERIMENTATION

Define Phase:

This phase determines the objectives & scope of the project, collect information on the process and the customers, and specify the deliverable to customers.

Problem Description:

The operational process concerned is machining operations. The problem encountered in the manufacture of cylinder liners is the large number of rejections of the units after manufacturing. The occurrence of rejection of cylinder liners was due to non-conformance of inner diameter, outer diameter, collar width, Groove Diameter, Shoulder Ovality with respect to the required standard specifications. Due to improper maintenance percentage of machines availability and utilization are low. Cylinder liners process yield is low because of poor utilization of the machine and poor Quality. It was decided to improve this process yield. Here Table 1 shows the specifications of the cylinder.

Process Mapping:

The process mapping with SIPOC (Supply-Input-Process-Output-Customer) provides a picture of the steps needed to create the output of the process. Figure 2 shows the SIPOC diagram.

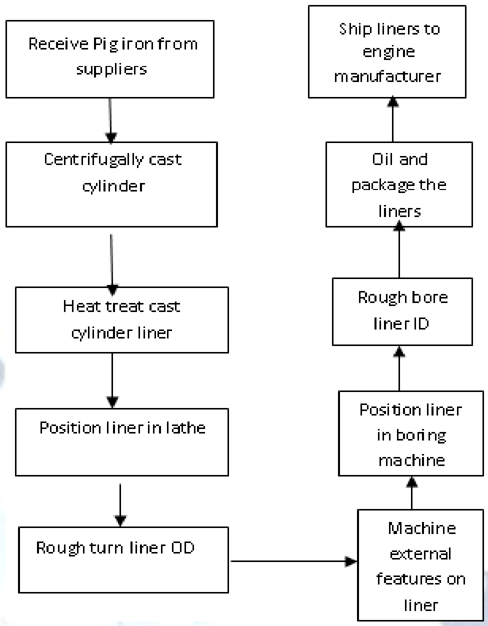

Figure 2: SIPOC Diagram

Table 1: Specifications of Cylinder Liner

Parameter	Upper Specification Limit	Lower Specification Limit
Inner diameter	104.048	104.016
Outer diameter	107.024	107.000
Collar width	8.055	8.035
Under cut diameter	106.990	106.890
Collar diameter	112.00	111.90
Length	200.20	199.80

Table 2: Operations in the Process and Measuring Parameters

Operation	Description	Measuring Parameters	Gauges Used
1	1B & 1C Operation	ID & OD Turning	Vernier calipers
2	2DR Operation or CNC	Finish OD, U/C Diameter, Facing, Collar Width	Bore gauge, Micrometer, Flange micrometer
3	Rough grinding	Outer diameter	Flange micrometer
4	Fine boring	Inner diameter	Bore gauge
5	Rough honing	Outer diameter	Micrometer
6	Plateau honing	Collar diameter	Micrometer
7	OD Polish	Outer Diameter	Micrometer

Table 3: Percentage Utilization of the Machines, Quality Rating and Original Equipment Effectiveness

Parameter	Value
Machines Availability time in percentage	79
Machines idle time in Percentage	32
Percentage utilization of the machines (Performance)	68
Quantity planed (units)	20000
Quantity produced (units)	18598
Quantity rejected (units)	1941
Qty accepted (units)	16657
Quality Rating	0.85
Original Equipment Effectiveness	0.79x0.68x0.85 =0.45

Measure Phase:

This phase is concerned with selecting appropriate product characteristics, studying the measurement system, making necessary measurements, recording the data, and establishing a baseline of the process capability or sigma level for the process. Table 2 shows Operations in the process, measuring parameters and gauges used.

Current Process Capability:

A vital part of an original quality improving program is process capability analysis by which the capability of a process can be measured and assessed. The process capability index CP enjoys a broad base of acceptance in the industry.CP value greater than 1 means that the process uses up less than 100 percent of the specification band, i.e., relatively less non-conforming points will be observed. Whereas, CP value less than 1, means the process uses up more than the specification band. CPK value is less than CP value, means that the process is off centered, but capable, and has to be confirmed with more no. of samples. Whereas, CPK value less than zero means that the entire process mean lies outside the specifications, hence, the process is incapable. As per calculation, the values obtained are CP = 0. 011, CPL = 0. 024, CPU = 0.0919, and CPK = 0. 0919. The process uses up more than the specification band. It can also be deciphered that the process is off-centered, but capable. From the measurement phase it is observed that Current Sigma Level is 2.51 and defects per million are 67900.

Original Equipment Effectiveness:

Table 3 shows computation of original Equipment Effectiveness. The findings are showing the need for implementing Total Productive Maintenance's to improve Overall Equipment Effectiveness.

Analyze Phase:

The objective of analyze phase in this study is to identify the root causes that creates the dimensional variation of the cylinder liners. This phase describes the potential causes identified which have the maximum impact on the low process yield, causes for low original Equipment Effectiveness.

Pareto Chart Analysis:

Data analysis was carried out in this phase to find the reasons for rejection and reworking of cylinder liners. It arises due to defects viz., diameter variation, poor surface finish, eccentricity, and variation in collar width. Pareto analysis on the various types of defects. In the diagram X-axis represents causes and Y-axis represents percentage of occurrence. It is found that inner diameter variation caused the major portion in rejection of the cylinder liners. Due to poor quality and low utilization of the machines Overall Equipment Effectiveness is not satisfactory. Figure 3 shows Pareto diagram illustrating the reasons for low utilization of the machines.

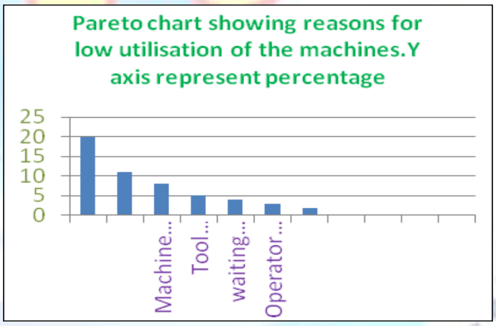

Figure 3: Pareto Diagram Illustrating the Reasons for Low Utilization of the Machines

Fishbone (Ishikawa) Diagram Analysis:

The tool that is used for the analysis of the causes of variation in the specifications of the cylinder liners is the Cause-and-Effect diagram or fishbone diagram. A cause-and-effect diagram for process yield presents a chain of causes & effects, sorts out causes & organizes relationship between variables. The cause-and-effect diagram prepared for the initial probable causes identified can be viewed in Figure 4.

This phase aims at adjusting the process mean on target. Process mean can be adjusted on target by improving the factors that have significant effects on the mean. The DPMO of the process was found to be 5950 and the corresponding sigma level was calculated to be 4.1. The process capability of the key Quality characteristics is shown in the Table 4.

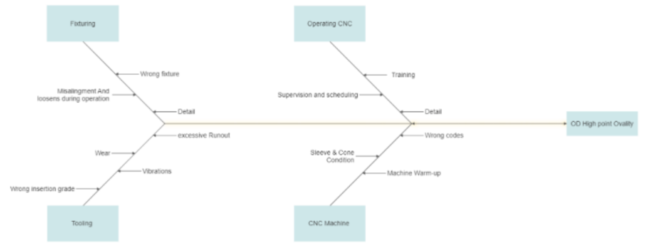

Figure 4: Cause and Effect Diagram for Out of Specifications of Cylinder Liner Quality Concern

Table 4: Process Capability of the Key Quality Characteristics

Process Capability	Groove Diameter	Shoulder Ovality	Collar Width
σ	0.006	0.008	0.002
Cp	1.578	1.34	1.66

IMPROVE PHASE:

Improve Process

During improvement phase statistical process control (SPC) is used as a monitoring tool. The objective of SPC was to control the variations in the process reduce the rejections and improve the process capability.

Process Capability after Improvement

This phase aims at adjusting the process mean on target. Process mean can be adjusted on target by improving the factors that have significant effects on the mean. The DPMO of the process was found to be 5950 and the corresponding sigma level was calculated to be 4.1. The process capability of the key Quality characteristics is shown in the Table 4.

Pareto Chart after Improvement

After implementation of the solutions, the reasons for rejection were analyzed with the Pareto chart. The Pareto chart after improvement is shown in Figure 5.

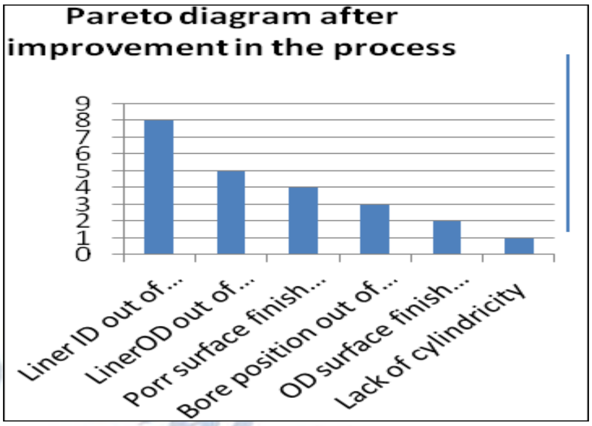

Figure 5: Pareto Chart after Improvement in the Process

Improvement in Original Equipment Effectiveness

As shown in the Pareto chart figure 5, the reasons for low machine utilization were analyzed and Total Productive Maintenance was initiated to improve Overall Equipment Effectiveness. The improvement in availability, utilization, Quality Rating and Overall Equipment Effectiveness (OEE) are given in Table 5.

Table 5: Results after Implementation of TPM

Parameter	Value
Total unavailable time in Percentage	11
Availability of the machine in Percentage	89
Percentage of the machine idle Time	24
Percentage utilization of the machine (Performance)	76
Quantity planed (units)	20000
Quantity produced (units)	19583
Quantity rejected (units)	1773
Qty accepted (units)	17810
Quality Rating	0.94
Original Equipment Effectiveness (OEE)	0.89x0.76x0.90 =0.63

Control Phase:

This is about holding the gains which have been achieved by the project team. Implementing all improvement measures during the improve phase, periodic reviews of various solutions and strict adherence on the process yield is carried out The real challenge of Six Sigma implementation is not in making improvements in the process but in sustaining the achieved results. In this phase, the process control charts and Pareto charts are regularly utilized for monitoring diameter readings.

5. RESULTS

The implementation of the various tools and sessions has resulted in the improvement of the manufacturing process, and also on the firm as a whole. Table 6 shows results after improvement and control. The comparison of sigma level before and after undertaking the study is depicted in Figure 6.

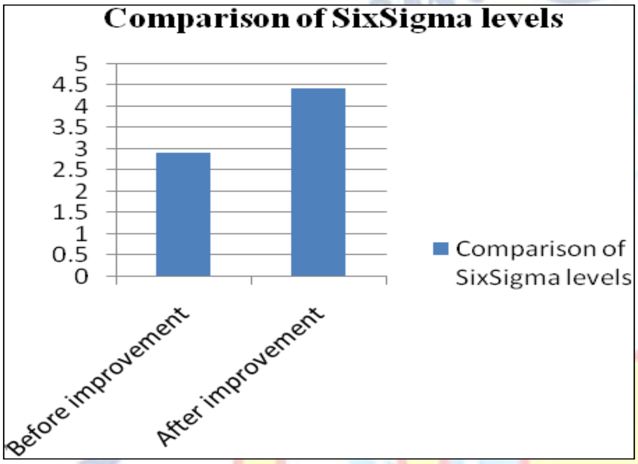

Figure 6: Comparison of Sigma Level before and after Undertaking the study

Table 6: Results after Improvement and Control

Parameter	Before Improvement	After Improvement
Process yield	45.3%	87%
Original Equipment Effectiveness (OEE)	42%	63%
Six-sigma Level	2.51	4.1
Defects per million	67900	5950
Process capability Index	0.45	1.34

6. CONCLUSION

Detailed analysis has been performed to rectify the problems of rejection of cylinder liners due to the variations in Quality characteristics of the manufactured units. TPM is implemented to improve the utilization of machines. Analysis is carried out with the help of tools like Pareto analysis, process capability analysis and fish-bone diagram. The process Sigma level through Six Sigma DMAIC methodology was found to be approaching 4.1 Sigma from 2.51,while the process yield was increased to 87% from a very low figure of 45.3%. This Six Sigma improvement methodology viz. DMAIC project shows that the performance of the firm is increased to a better level as regards to: enhancement in customers satisfaction, adherence of delivery schedules, development of specific methods to redesign and reorganize a process with a view to reduce or eliminate errors, defects; development of more efficient, capable, reliable and consistent manufacturing process and more better overall process performance, creation of continuous improvement.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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