

Implementation of Six Sigma Methodology for Piston Rod Manufacturing

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Abstract

This research paper deals with a case study of Piston Rod. Rejection of Piston Rod was the main problem in company due to defects of pitting; porosity etc. DMAIC approach (Six Sigma Methodology) was used to reduce the defects and increase the productivity. Plasma Nitriding of AISI 4140 Alloy Steel was carried out at plasma nitration technology. The effect of temperature on the surface hardness and microstructure was investigated along with their corrosion resistance. The Plasma (Ion) Nitriding technology shows a clear orientation towards future developments. Hence, it ideally satisfies current and future industrial demands for economical and efficient solutions to the treatment of surfaces. It is also an answer to social demands for improved environmental protection. In the second phase the collected data was validated by collecting sampling during production hours, which helped in representing a true picture of defects, occurred after Plasma Nitriding. Finally an analysis was done using Six Sigma technique. Then, the cause and effect diagram was used to explore possible causes of defects through a brainstorming session and to determine the causes which had major effect. Some corrective measures are also suggested to overcome these defects. Six-Sigma, mainly based on customer needs & expectation with the use of facts & statistics, analysis & responsible approach to managing & improving current business, manufacturing capacity & services is applicable to such cases. Tools of six sigma methodology are used to improve the process by enhancing the quality of product. This paper draws attention towards adoption of six sigma methodology in manufacturing organization with the case study. This is successfully achieved by implementing DMAIC Methodology.

Keywords- DMAIC, Six Sigma, Plasma Nitriding, Defects, Fishbone diagram

I. INTRODUCTION

Six sigma as a business strategy has been well recognized as an imperative for operations and business excellence. Customer satisfaction is a key for any successful business. Production methodology is changed from push type to pull type. In such case customer plays role of king who demands for the satisfaction of every aspect. One of the most important aspects of customer is achieved through high quality product, which means low defect product. For countries, it is about creating more from available resources such as labour, raw materials, land, skills, capital equipment, intellectual property, managerial capability and financial capital. Higher value, higher incomes and higher production can be achieved with the right choices for every hour worked. According to V.K.R Menon "Productivity implies development of an attitude of mind and a constant range to find better, cheaper easier, quicker and safer means of doing a job, manufacturing a product and providing service". The purpose of nitriding is to improve wear, corrosion and fatigue resistance of constructional parts. These improvements can be understood when looking at the surface microstructure and hardness after treatment. Six Sigma is a communal approach, which uses various techniques and tools for productivity improvement. There are DMAIC methodology used to achieve Six Sigma goals; Define, Measure, Analyze, Improve and Control. DMAIC a five phase closed-loop problem solving pattern that eliminates unproductive steps and applies technology for continuous improvement. Business process that fails to meet customer requirements is generally used Six Sigma Methodology. The objective of the research paper is to investigate how six sigma methodologies can be successfully implemented in manufacturing projects through case study. Six-sigma uses statistical methods to achieve almost defect free process. This improvement procedure is generally known under acronym DMAIC. This stands for Define, Measure, Analyze,

Improve and Control. Originally this was described as method for variation reduction. DMAIC is applied in practice as generic problem solving & for improvement approach. Success of six sigma basically depends upon the understanding of customer.

A. Problem Statement

After visiting piston rod manufacturing company our project is decided on topic “Piston Rod Defect Analysis and Actions to Overcome Defect”. After Plasma Nitriding Process on piston rod there are small pits and pores occurred on Nitriding surface of rod. This project is aim to overcome this defect & make piston rod defect free. By “Implementing Six Sigma Technology” we are reducing defects in piston rod and also improving efficiency of piston rod.

B. Objective

Our main aim of this project is to find new changes in material composition such that cracks & pits gets reduced and improve efficiency. To find different techniques to overcome defects & make significant improvement in throughout process average lead time reduce and increase product quality.

C. Scope

Plasma Nitriding imparts a hard ware resistant surface without brittleness, galling. This eliminates costly cleaning or grinding to remove the brittle white layer associated with traditional Nitriding. A glow discharge envelops the entire surface with consistent hardness and case depth. Due to uniformity, complex geometry shapes can also nitride. Plasma Nitriding least affects the surface finish of the product. After doing plasma Nitriding higher surface hardness maintained due to which materials core properties doesn't gets affected. By this process material surface gets excellent wear resistance. It produces a compound zone which is dense, nonporous, very hard, and non-brittle and has low coefficient of friction. This process has least process gas consumption & clean emissions (usually hydrogen and nitrogen). This process has shorter cycle time and good friction, wear and fatigue properties. Due to this factors and many advantages this process is generally preferred by industries.

D. Methodology

For Piston Rod manufacturing AISI 4140 steel is used. The base material is taken through the dealers which is untreated, then supplier's converts' material into required length. Then the samples are machined with following operations

- 1) Centering (Pre Turn) 3-4mm allowance
- 2) Heat Treatment - Oil Quenching
- 3) Lab Checking - Tensile/Chemical Properties Checking
- 4) Mechanical Testing
- 5) Finish Turning
- 6) Grinding (20micro meter tolerance)
- 7) Thread Rolling (use 3rollers)
- 8) Plasma Nitriding

II. LITERATURE REVIEW

Miroslav Rusko (2011) presents “Application of Six Sigma Methodology”. This paper is based mainly on understanding the customer needs and expectation, disciplined use of facts and statistics analysis, and responsible approach to managing, improving and establishing new business, manufacturing and service processes. The fundamental idea of Six Sigma is that if performance is improved, quality, capacity, cycle time, inventory levels, and other key factors as reduction waste, energy sources and environment will also improve. Thus, when these factors are improved, both the provider and the customer experience greater satisfaction in performing business transactions.

U. N. Puntambekar (2013) Presents “Effect of Plasma Nitriding Treatment on Fatigue Life of En-24 steel”. This paper discusses the effect of plasma nitriding and the thickness of compound layer in particular, for the En-24 steel. The experiments were carried-out on steel rod samples which were plasma nitrided with formation of varying amount of thickness of compound white layer and maintaining diffusion layer depth the same. The characterization of samples was done in respect of chemical composition, microstructure & micro-hardness. The rotating bending fatigue tests on plasma nitrided samples were conducted at various stress levels to plot S-N curves. Based on the fatigue test results, modification factors for stress & life-cycles were established. The data indicate that the fatigue life of samples increases up to a certain thickness of compound layer and then decreases.

Pawan Jaglan (2015) presents “DMAIC: A Tool for Productivity Enhancement”. This paper provides the study of Successful implementation and growing organizations interesting Six Sigma methods have been blowing up in the last few years. However there is still the need for more research into Six Sigma to test new theories or models that have been proposed to strength in the methodology. Implementation of Six Sigma is directly related with financial result of company because it targets the customer satisfaction and new innovative ways to exceed the customer hope. Six Sigma is an important advance in quality management and process improvement in the last two decades. Six Sigma is a communal approach, which uses various techniques and tools for productivity improvement. The fundamental idea of Six Sigma is that if performance is improved, quality, capacity, cycle time, inventory levels, and other key factors as reduction waste, energy sources and environment will

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III. CASE STUDY

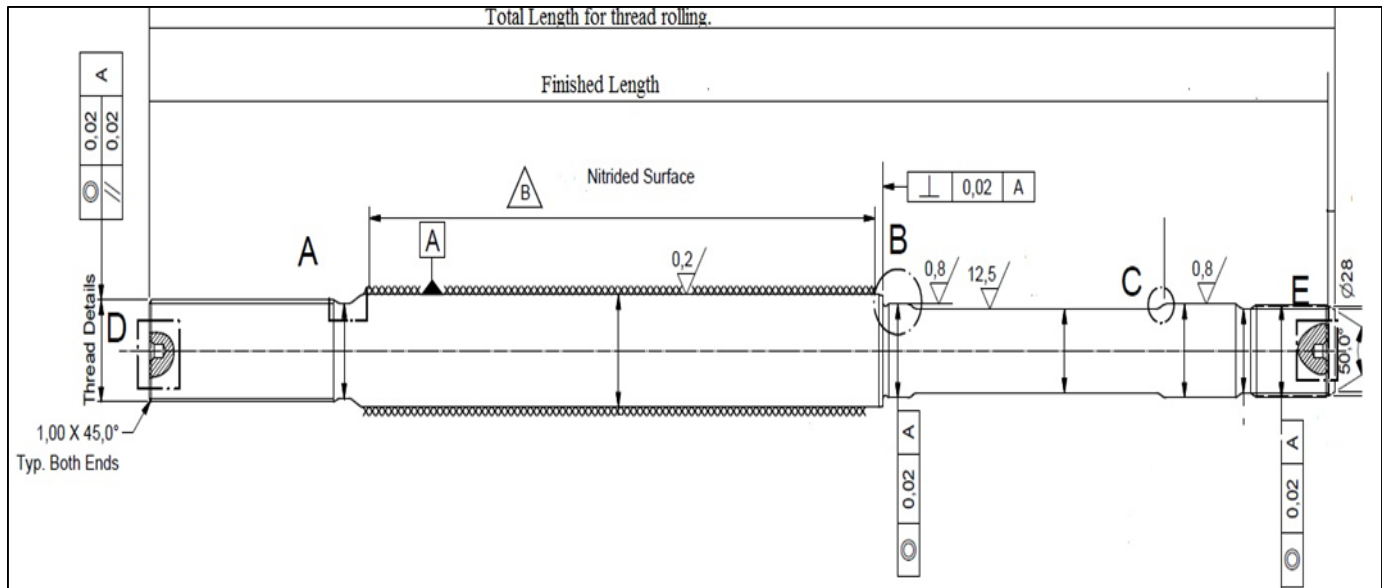


Fig. 1: 2-D Drawing of Piston Rod

In company rejection of piston rod is take place due to some defects (pits). The sigma level is below the 3 sigma. So there is a need to reduce the defects from the rod which arises during the process. DMAIC Approach (Six Sigma Methodology) was used to solve piston rod rejection problem to achieve the productivity level greater than three sigma from the present level. DMAIC is five phase closed-loop problem solving pattern that eliminates unproductive steps, and applies technology for continuous improvement. DMAIC is generally used on business process that fails to meet customer requirements.

Table 1: Lean Six Sigma DMAIC Model

Lean BB DMAIC	Define	Measure	Analyze	Improve	Control
Purpose	Define Business metrics Identify Project For Process improvement Select resources for project improvement	Establish baseline performance Validate measurements for each projects	Set performance objectives Identify sources of variation	Prioritize the vital few causes of variation Establish relation between output and input variables	Implement solutions Ensure solutions are sustained Document case studies
Primary Tools	1) Voice of the customer 2) Business metrics 3) Trend charts 4) Process mapping 5) Value stream map 6) Value stream requirements	1) Data collection 2) Six Sigma Metrics 3) Measurement System analysis basic SPC 4) Process capability analysis 5) Process cycle time	1) Control charts 2) Hypothesis Testing 3) Cause & effect diagram 4) Affinity Diagrams 5) FMEA 6) Root cause Verification 7) ANOVA	1) FMEA 2) Planning tools 3) TPM 4) 5S 5) SMED 6) Kaizen 7) Solution Selection metrics	1) Mistake proofing 2) SPC Implementation 3) Control plans 4) Process standards 5) Evaluate process improvement Results 7) Dashboard
Key outputs	1) Project team 2) Project selection and measurement 3) Project plan 4) Management commitment	1) Product performance baseline 2) Measures for Evaluating performance of the product	1) Defined list of potential sources of variation 2) Cost benefit Analyze	1) Select appropriate solution 2) Proposed process settings	1) Process in control 2) Project Documentation 3) Opportunities for transfer of learning

A. Define Phase

1) Selection of Improvement Opportunity

Company PQR is supplier of Piston Rod to the company XYZ. PQR has received severe customer complaint regarding Piston Rod Defects. Before define the problem, Process Map and High Level Process Map- a SIPOC (Supplier, Input, Process, Output, and Customer) the piston rod defect photograph was shown in figure 2).



Fig. 2: piston rod defect photograph

B. Measure Phase

1) Translating VOC to CTQ

Understand & analyses VOC and converting to CTQ is important for proper defining of the project. Determine how well our process is performing compared to others through benchmarking exercise and identify the strengths and weaknesses and determine the gaps for improvement.

C. Analysis Phase

Fishbone Diagram is used to show the causes due to which defects come in the rod and from all the following suspected sources of variation of the problem are considered for the further study.

- 1) Temperature and current maintain during plasma Nitriding
- 2) Cleaning of Work piece before the plasma Nitriding
- 3) Chemical composition and fixture of plasma Nitriding.

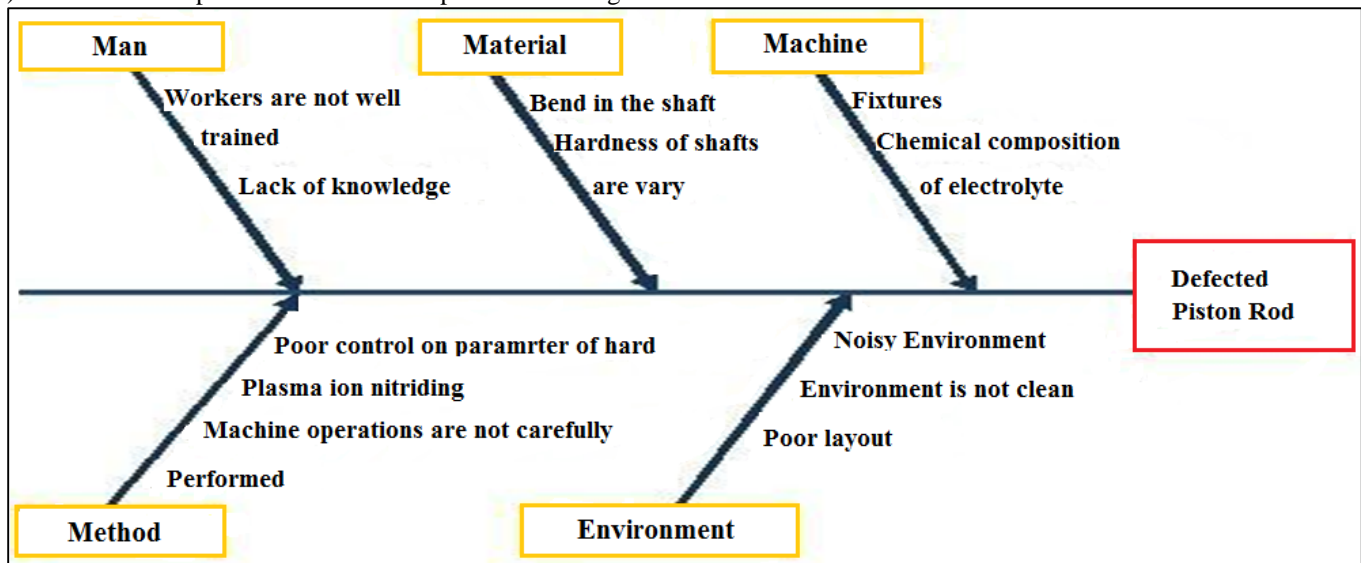


Fig. 3: Fishbone Diagram

D. Improve Phase

In improve phase, Design of Experiments was done to find out the most favorable conditions. These experiments were conducted to optimize the value of the parameters like Temperature and current. Improve is the fourth phase in Six-Sigma methodology. It is most important phase in the methodology. The purpose of this step is to identify, test and implement a solution to the problem; in part or in whole. Identify creative solutions to eliminate the key root causes in order to fix and prevent process problems.

Table 2: Action and Control

Sr No.	Recommend action Proposed	Status
1	Inspection and the cleaning of Piston Rod properly before Plasma Nitriding	Implemented Instruction passed
2	Before the Plasma Nitriding process of Piston Rod all the electrical connection of equipment to be check if they are loose than tight up.	Implemented Instruction passed
3	Check pressure test is OK, start the cycle otherwise look for leak, Rectify it and again leak test.	Implemented Instruction passed
4	Plasma Nitriding operation to be performed by a well-trained person.	To be Implemented
5	Maintains of fixture to be done time to time and proper fixture to be used for different rods.	Implemented Instruction passed
6	Control all the parameters viz. temperature, pressure and gas ration throughout the nitriding process.	To be Implemented

E. Control Phase

In this phase all the steps and variable are implemented and controlled which is improved in the improve phase. Action Plan (as show in Table 2) was made to improve the process.

IV. RESULT AND CONCLUSION

Successful implementation and growing organizations interesting Six Sigma methods have been blowing up in the last few years. However there is still the need for more research into Six Sigma to test new theories or models that have been proposed to strength in the methodology. Implementation of Six Sigma is directly related with financial result of company because it targets the customer satisfaction and new innovative ways to exceed the customer hope. DMAIC Methodology is a very systematic approach that provides a pathway to go to the roots of the problems gives opportunities for improvement & moreover helps us to monitor improved performance through controlling mechanism. On Surface everything appears smooth & fine but we dig down deep, then only problem areas tend to surface out. The tools like Fishbone Diagram, Cause & Effect Matrix, FDC, and Qualitative Analysis are really informative that explore the possible causes of failure to a great extent.

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