CHAPTER – 1

Introduction

The present work deals with the solutions for an immediate problem facing an industrial organization. Hence, it comes under the category of Applied Research. The principal aim of applied research is to discover a solution for some practical problems [1]. The problems arise in the industry day by day with numerous of varieties and diversities. These problems are solved with some concealed approaches to retain secrecy policy.

1.1 Motivation

It is needed to materialize the hidden approaches conducted in industries for the solution of existing problems. There is a need to generalize the structure that can be useful for solving any industrial challenge. The generalization and implementation of various Tailor-Made Solutions are discussed in details with the appropriate outcome in the present work.

The visit and interaction with various industries were conducted at the initial stage. The reviews of concerned persons lead to identifying the need for some firm groundwork. It is concluded to participate with them for in-depth study with technical aspects of day to day activities. There are so many hidden constraints while working on the shop floor of any organization. All those aspects are discussed in details in the present work.

Initially, the approach of management towards the modification found to be challenging. It is obvious that employment of modification becomes challenging at any workstation. The commitment of top management towards continuous improvement imparted lots of encouragement to perform in-depth work and achieve the assigned duty. The management
permitted working with certain conditions as per company policy. The initial success in a minor work becomes the great motivation for further work.

1.2 Background

The significance of modification for the best option has been long recognized as a vital to both competition and survival in the present competitive business world. There are numerous ways to identify improvement potential and implement the same with the highest degree of impact. Various tools used to express the enhancement potential in industries are ISO:9000 (International Standardization for Organization), QS:9000 (Quality Standard), Quality Circles, Zero Defect (ZD), Six Sigma, TQM (Total Quality Management), WCM (World Class Manufacturing), Kaizen (workplace improvement), Lean manufacturing, TPM (Total Productive Maintenance), TQC (Total Quality Control) and much more.

There has been significant research carried out to improve shop floor production activity with due impact. Various aspects are implemented in many organizations to express the improvement. After implementation of these aspects, there are equal chances of success and failure. The success of any action purely depends on the elementary aspects employed for implementation. There should be micro analysis at every step of actions for real impact of success. The area of present work is based on these aspects. The research gap is identified in this field to express the impact of the implemented action.

The present work explains the solutions of ongoing industrial problems in details related to connecting rod manufacturing operations. The solutions of each problem may not be generalized. Every existing problem is having Tailor-Made Solution (TMS). The probably diversified options for the solutions are identified and discussed with statistical measures. The necessary remedial measures are implemented for shop floor activities for an individual case. The impacts of implemented actions for each case are discussed in details. The proposed corrective action plan is justified by feedback of implemented action.

The existing problems are identified from study of Customer Complaints Redressal Form (CE), Rework analysis, Rejection report, In-process Inspection Report (IIR), Final Inspection Report (FIR), Doc Inspection Report (DIR), Patrol Inspection Report (PIR), Process
Boundary Condition

Capability Study Report (PCSR), Pre-Dispatch Inspection (PDI) Report and on-going shop floor production report. Five problems are identified related to connecting rod manufacturing and solutions to be implemented for individual cases.

The solutions for problems raised during shop floor production are derived with various problem-solving techniques. The brainstorming session, Cause and Effect Diagram (CED) (Fishbone Diagram), Pareto Analysis, Failure Mode and Effects Analysis (FMEA), Kaizen, etc, are used for Tailor-Made Solution (TMS) of individual cases. The solutions proposed are implemented to solve the respective production issues.

Various Quality Improvement tools are employed in various industries by many experts in one or another form in manufacturing industries. The gap is identified that there is no generalized methodology to solve the on-going problem. There is a need to generate the general steps to identify the non-conformance potential and to implement the necessary actions.

1.3 Boundary Condition

The boundary conditions represented in Fig. 1.1 represent the justification for selection of present work. Performance Excellence can be employed in Service industries, forging industries, manufacturing industries, designing industries, power generation and transportation industries and in the medical field. The present work is concentrated in manufacturing industries. After visiting many industries, it’s found that there is scope for improvement in manufacturing industries using the conventional machine where more burning issues are found as far as quality and quantity is concerned.

The internal combustion engine parts manufacturer produces many parts of an engine. Main parts are a crankshaft, connecting rod, camshaft, piston, cylinder, piston ring, oil ring, gudgeon pin, etc. The scope is found in manufacturing processes of the connecting rod. The connecting rod of Internal Combustion Engine is one of the most critical components of the mechanism.

The function of the connecting rod is to transmit the reciprocating motion of a piston into rotary motion of the crankshaft. The piston is a reciprocating element; crankshaft is a rotating
element while the connecting rod is an oscillating element of the mechanism. The forging of connecting rod is followed by various machining operations. There are many hidden improvement potentials in connecting rod manufacturing operations, which are solved day by day as and when arisen.

Performance excellence in connecting rod manufacturing includes uses of CNC machines; layout modification of manufacturing line, weight reduction, reduction in wastage, modification in manufacturing processes, reduction in rejection or rework, reduction in the customer complaint, etc.

The present work is performed at manufacturing industries based in Gujarat, dealing with the manufacturing of various auto parts of Internal Combustion Engine. The connecting rod faces few problems like dent marks in the small end after the manual deburring operation, End Float, more rework and rejection at customer end due to the variation in big end bore diameter. All the problems are identified and solved with Tailor-Made Solution (TMS) up to the considerable extent.
FIGURE 1.1: Boundary Conditions
1.4 The Constraints

The implementation of the methodology for a particular solution results in many hurdles for industries as it requires changes in on-going shop floor activities. Change is always rejected at the first time for any normal working environment. It is a great task to convince the people for alteration in their regular work. It’s needed to justify the proposed alteration with many aspects including quality, quantity, cost, comfort and many other aspects. All the hurdles are solved using practical and tailor-made approach for a particular action.

There are few constraints as listed below to be considered while implementing the corrective action of any problem.

- It is not allowed to alter any design parameter of the product as it is the customer requirement. The product is manufactured as per customer drawing, hence it can’t be altered.
- The manufacturing line of the product should not be disturbed, which may result in the reduction in production quantity.
- To implement any alteration, the prior permission should be taken from top management with proper justification.
- The data and documentation of the organization should not be shared anywhere without prior permission of management.
- The confidentiality of the project work to be maintained as per the management policy.

Considering the above constraints in mind, the present work is selected as represented in boundary conditions Fig. 1.1.

There are Twenty Three machining operations to be carried out on a forged connecting rod. Table 1.1 shows the sequence of manufacturing operations needed for the final product. Advanced Product Quality Planning (APQP) for the product was conducted earlier by the company people before starting the production. APQP is a structured method of defining the steps necessary to ensure that a product satisfies the customer requirements.
### TABLE 1.1: Connecting Rod Manufacturing Operations

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Name of Operation</th>
<th>Sr.</th>
<th>Name of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Final Cap Facing</td>
<td>130</td>
<td>Bolt Hole Final Drilling</td>
</tr>
<tr>
<td>20</td>
<td>Rod Face Grinding</td>
<td>140</td>
<td>Bolt Hole Cotation</td>
</tr>
<tr>
<td>30</td>
<td>Small End Drilling</td>
<td>150</td>
<td>Deburring, Washing and Assembly</td>
</tr>
<tr>
<td>40</td>
<td>Small End Final Boring</td>
<td>160</td>
<td>Big End Final Boring</td>
</tr>
<tr>
<td>50</td>
<td>Small End Chamfer</td>
<td>170</td>
<td>Big End Chamfer</td>
</tr>
<tr>
<td>60</td>
<td>Round Rib Turning</td>
<td>180</td>
<td>Opening and Notch Milling</td>
</tr>
<tr>
<td>70</td>
<td>Rough Joint Face (Rod &amp; Cap)</td>
<td>190</td>
<td>Deburring, Washing, Cleaning and Assembly</td>
</tr>
<tr>
<td>80</td>
<td>Final Parting Face (Rod &amp; Cap)</td>
<td>200</td>
<td>Big End Rough Honing</td>
</tr>
<tr>
<td>90</td>
<td>Cap Groove Milling</td>
<td>210</td>
<td>Big End Final Honing</td>
</tr>
<tr>
<td>100</td>
<td>Final Spot Face (Rod &amp; Cap)</td>
<td>220</td>
<td>Small End Bush Pressing and Oil Hole Drilling</td>
</tr>
<tr>
<td>110</td>
<td>Big End Locater Boring</td>
<td>230</td>
<td>Small End Bush Boring</td>
</tr>
<tr>
<td>120</td>
<td>Bolt Hole Pre Drilling</td>
<td></td>
<td>Final Inspection</td>
</tr>
</tbody>
</table>

### 1.5 Contribution by literature

The present work is applied research and not fundamental research. It deals with the solution of the ongoing problem facing an industry. Fundamental research is concerned with generalizations and formulation of a theory. The central aim of applied research is to discover a solution for some practical problem [1].

The cases are discussed and implemented with various aspects of due impact. The impact of implemented action is measured with various parameters. The parameters are rejection quantity per month, rework quantity per month, Customer satisfaction (customer complaint per month).

The solution of case studies represented in present work can be generalized with the following steps. Any shop floor issue related to connecting rod manufacturing can be solved by using these steps.

1. **P-PAP** (Type 1): The first step is to prepare a report of Production Part Approval Process Type 1. Check alignment (straightness) of the fixture with respect to the reference plane. Any deviation more than allowable limit leads to inaccurate output. Take appropriate action to eliminate such deviation.
2. **P-PAP** (Type 2): Prepare a report of Production Part Approval Process Type-2. Measure the spindle axial alignment with respect to the reference surface. Do necessary alteration if the deviation is more than allowable range.

3. **Gauge R & R Study** (MSA): Check the measuring instruments and gauge with a master calibration unit. (Measurement System Analysis, Gauge Repeatability and Reproducibility Study)

4. Interact with Operator and Inspector for the fitness to do work with STAR technique. (Situation, Task, Action and Result) [2] [3]

5. **Reports**: Check the Patrol Inspection and Dock Inspection Reports.

6. Prepare **First Article Inspection Report (FAIR)** and may alter the frequency.

7. **FMEA** : Do Failure Mode and Effects Analysis for the case if needed. Prepare the chart of readings. Try to find out the trend of Non-conformance, e.g. Tool change frequency, coolant temperature, operator, inspector, instrument, etc. (To find the impact of the respective factor responsible for Non-conformance)

### 1.6 Research Objectives

The objectives for present work are

- To identify the improvement potential in manufacturing processes of the connecting rod.
- To maintain customer satisfaction with the implementation of Quality Control tools (Kaizen and Zero Defect).
- To solve shop floor issues related to Connecting Rod manufacturing operations.
- To implement Performance Excellence in Connecting Rod Manufacturing Industries.

### 1.7 Structure of the Thesis
Future Scope

**Chapter 1** gives a brief description of the research work. It includes background and motivation for present work. The boundary conditions are represented along with the predefined constraints for present work. It also covers the research objectives and original contribution by the thesis.

**Chapter 2** covers the Literature review related to present work and research gap identified after rigorous literature survey. The Research methodology employed is also discussed in details in this chapter.

**Chapter 3** presents the method for computation of Overall Equipment Effectiveness (OEE) in connecting rod manufacturing processes. The OEE sheet enables companies to attain a rapid assessment of their operations performance. It highlights the gray area of the shop floor. The OEE sheet discussed is a dominant tool to evaluate the current state and to plan the future state of enterprise operations. This sheet is employed in a connecting rod manufacturing industries to provide decision-makers with adequate input to identify improvement objectives and review the ongoing operations strategy. The use of OEE sheet is demonstrated and some perceptions are extracted and mentioned regarding the sheet’s applicability for different types of manufacturing operations.

**Chapter 4** The purpose of this chapter is to identify and outline the application of Kaizen approach on the shop floor of manufacturer of the connecting rod. After a bush boring operation, in Small End of connecting rod, pillar drill is used to eliminate dent marks and burrs, as a replacement for manual de-burring operation. It reduces manual work with better concentricity of small end and improves the quality of product up to a considerable extent. Assembly of gudgeon pin in the small end of connecting rod becomes easier as compared to the previous method due to chamfered end. The efforts made by teamwork to employ kaizen concept is documented and discussed in details.

**Chapter 5** covers the discussion and solution of a technical problem identified from customer complaint redressal form. The study examines one of the shop floors long-lasting quality issues to maintain the End Float in a connecting rod during the manufacturing process. This study leverages various Six Sigma tools such as “Fishbone diagram, histograms, control charts and brainstorming” to provide the platform for essential actions. The analysis resulted
in a number of findings and recommendations. The corrective actions for the problem are discussed and implemented which improves the customer satisfaction and reduces the rejection quantity. The fixture of one of the manufacturing operations needed to be redesigned and altered. The future scope of present work includes preparation of a model which correlates the interrelationships of the factors affecting the quality of the product as discussed in the brainstorming session and shown in the fishbone diagram.

**Chapter 6** covers the statistical control of customer defined critical parameter i.e. axial alignment (bend and twist) of connecting rod. The connecting rod is one of the most important elements of the internal combustion engine. As it is subjected to alternative stresses, tensile and compressive, it is designed for compressive stress as it is higher at the time of power stroke. Bend and Twist are two-dimensional parameters of connecting rod, which represents the axial misalignment of the axis of both the bores of a connecting rod.

Various methods are used in industry for the inspection of these parameters. Some methods are discussed in details and readings of these two parameters are taken. A program is prepared to assure the dimensional quality in which the process capability index (PCI) is calculated. The value of these indices represents that the process is under statistical control. The Statistical Process Control analysis is conducted for these critical parameters of the connecting rod. The \( \bar{x} \) and R chart is prepared for continuous monitoring of the process. This chart also indicates the trend of the process with the help of which the chance of rejection can be interpreted.

**Chapter 7** discusses the effect of temperature variation at the time of manufacturing of the connecting rod. Temperature variation affects the dimensional quality of the product. The case study for the rejection of a lot from customer end is analyzed. A big lot was rejected from customer end because of the oversize of the various parameters of big end bore. The problem is discussed in detail with the readings of the parameters.

Two methods are described to overcome the problem. The correction factor is found out by taking various readings of the dimension at various temperatures. The other method is suggested to use the masterpiece of the similar material and calibrate the gauge at regular interval. Failure Mode and Effects analysis are conducted to identify the rejection potential.
Future Scope

Chapter 8 identifies the bore diameter variation analysis with a brainstorming sheet. The solution is discussed in details with four iterations. Process Capability Study reports (PCSR) are prepared after iterations and the reason for causes are discussed. The reduction is noticed in big end bore diameter variation after proposed alteration.

Chapter 9 includes about Computation of Performance Excellence, Conclusion and Future Scope of the thesis. The method to compute performance excellence is discussed in details. It represents the impact of implemented action. The performance parameters like rejection quantity, rework quantity and customer complaints per month are considered to compute the performance excellence.

The TMS (Tailor-Made solution) is used to solve the shop floor ongoing issues. The generalization of such TMS is discussed so that it can be used for other chronic issues. Future scope of present work and supplementary improvement potential is stated which is highly significant for the people involved in connecting rod manufacturing. It also encompasses the employability of various quality assurance aspects and their implementation with due impact.