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REDUCING THE REJECTION OF FORGED PRODUCTS IN A FORGING INDUSTRY: A CASE STUDY

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ABSTRACT

What really matters in any production industry is the quality of products they deliver. With the aim of quality can't be compromised, the underlying factors that affects the quality of products in a forging industry is studied. Paper discusses the quality issues related to cam shaft gear. Major tool used in the study is root cause analysis. The major contributor to the rejection of finished forged products has been identified and suggestions are given to avoid the problem.

KEYWORDS: Pareto Analysis, Fish Bone Diagram, Decarburisation

1. INTRODUCTION

Every problem has a certain cause for it. To solve a problem one must identify the main cause of the problem and take steps to eliminate the cause. The root cause should be given the treatment otherwise we will be dealing with only the symptoms and the problem will continue to exist. So identifying and eliminating root causes is of utmost importance. A root cause analysis methodology based on the combination of Pareto analysis and fishbone diagram is used. The fishbone diagram is used to sort the potential causes of the failure while organizing the causal relationship. The Pareto analysis is used to identify the major causes. The Pareto analysis is also known as 80–20 rule. The principle states that for many events, roughly 80% of the effects/problems come from 20% of causes. The Pareto analysis helps focusing the attention on the most important causes instead of wasting time and energy on minor ones. The main aim is to have attention on the most important fundamental causes and discover opportunities for sustainability improvement.

A case study is conducted on one of the leading forging industry. Root cause analysis was conducted in the case study. The objective is to identify the major contributor to the increased rejection percentage of forged products and to minimize the effect. The paper is structured as follows. Section 2 gives clear idea of the problem in the industry. Section 3 presents the root cause analysis of the problem. Finally, section 4 concludes the study.

2. PROBLEM DEFINITION

Even after producing 24x7, forging department is not able to meet its demand in the market and it is running under a loss. The monthly production schedule couldn't be achieved due to fact that majority of finished products don't pass the final quality test.

Even though the required number of products are produced in the industry, they cant satisfy the requirement of the customer in terms of quality. It is necessary to reduce the rejection rate of finished products so as to meet the demand and to improve the efficiency of the whole industry. A case study was conducted on the rejection rate of forged products for which the raw material is steel.

3. ROOT CAUSE ANALYSIS

The Root Cause Analysis is a three-step process

- Data collection
- Root cause identification
- Recommendation

3.1 Data Collection

Production data of cam shaft gear was collected for 10 months (from 01/01/2013 to 31/10/2013) from the shift log book of the company and is given in table 1.

Table 1: Production Data

Sl No	Month	Production Details	Jobs Produced	Jobs Accepted	Jobs Rejected
1	January	350	350	330	20
2	February	280	280	265	15
3	March	410	348	325	23
4	April	350	350	336	14
5	May	350	350	333	17
6	June	380	380	374	6
7	July	320	320	309	11
8	August	260	180	171	9
9	September	450	450	441	9
10	October	300	300	289	11

From the table it is clear that the even though the production target was achieved in certain months the rejection rate is present in all the months.

3.1 Root Cause Identification

Cause-and-effect diagrams or Ishikawa diagrams (Fish bone diagram) is one of the seven basic tools of quality, which is used to identify potential factors causing an overall effect. It was used in the study to identify the root cause of the major rejection identified in the previous section. A Pareto chart, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The left vertical axis is the frequency of occurrence, and right vertical axis is the cumulative percentage of the total number of occurrences. The purpose of the Pareto chart is to highlight the most important among a (typically large) set of factors. In quality control, it often represents the most common sources of defects, the highest occurring type of defect.

The production data of cam shaft gear was inspected to find out the root causes of the problem and various possibilities were studied. The quality department staffs were interviewed and a brain storming section was done to find out the possible causes. The possible causes of failure are described with the help of a fishbone diagram.

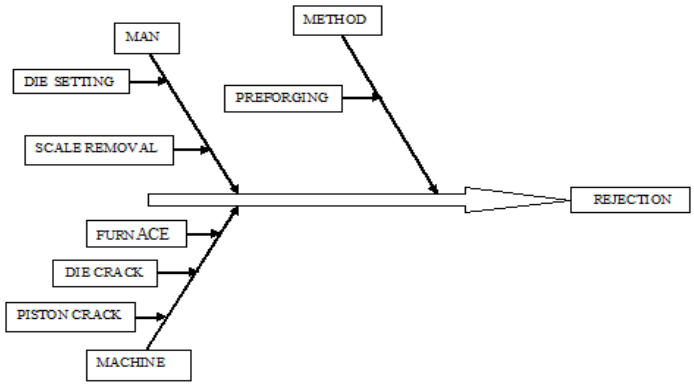

Figure 1: Fish Bone Diagram for Rejection

A Pareto chart (Figure 2) was constructed as per the frequency of occurrences of rejection.

Table 2: Pareto Data

Sl No.	Cause	No of Rejection	Cumulative	Percentage
1	Furnace	73	73	54.07
2	Die crack	24	97	71.85
3	Pre forging	13	110	81.48
4	Die setting	10	120	88.88
5	Piston crack	8	128	94.81
6	Scale removal	7	135	100

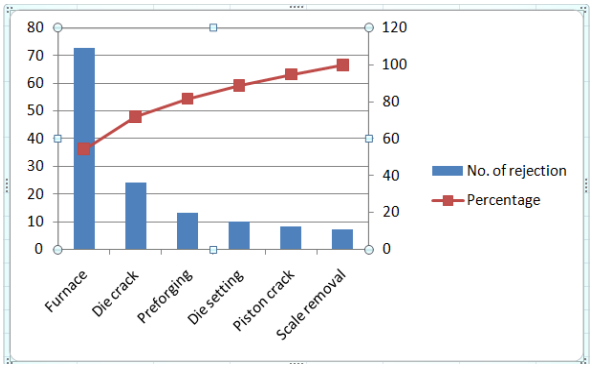

Figure 2: Pareto Chart

From the chart it is clear that majority of rejection is contributed by furnace. A detailed study was conducted based on rejection due to furnace and reasons were identified. It is shown in the figure 3.

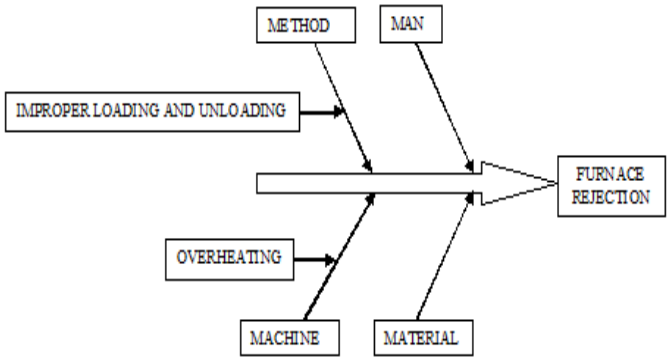

Figure 3: Fish Bone Diagram for Furnace Rejection

A sample of 10 billet was taken. The furnace and forging operation is carried out. When the first billet is unloaded from the furnace the next billet is loaded into it. Finally quality tests were carried out in all the billets. It was found that out of 10 billets 8 of them has surface hardness below the required amount. So it is clear that even though the billets are loaded into the furnace in proper manner the rejection of material still prevails due to overheating of billets in furnace. So the root cause of rejection of forged materials is overheating of furnace.

Carbon is the element that gives strength to steel. From the root cause analysis it is clear that the major cause for the material rejection is overheating. Due to overheating a process called decarburisation occurs. Decarburisation is process of reduction of carbon content due to heating with oxygen or hydrogen containing gases present in the atmosphere. Removal of carbon content from the surface reduces the surface hardness of the material.

Chemistry for steel is given in table 3.

Table 3: Chemistry for Steel

Element	Required Percentage	Percentage Obtained
Carbon	0.38-0.48	.29-.36
Manganese	0.50-0.80	.42-.67
Chromium	0.70-1.10	.66-.98
Nickel	2.75-3.25	2.37-3.13
Molybdenum	0.25-0.45	.17-.42
Sulphur, Phosphorous	.035-.055	.031-.049

Heat treatment process details for crank shaft gear is shown in table 4

Table 4: Heat Treatment Details

Process	Temperature Range	Soaking Time	Cooling Medium
Normalising	870-900^{0}C	2.5 hours	air
Hardening	850-860^{0}C	2.5 hours	oil
Tempering	500-520^{0}C	8 hrs	air

Mechanical property details are shown in table 5

Table 5: Mechanical Property Details

Property	Required	Obtained
Brinnel hardness	277-321 BHN	243-302 BHN
Ultimate tensile strength	165000 psi	153500 psi
Yield point	135000 psi	123230 psi
Elongation	14% psi	12.5% psi

It is clear from the tables that the quality of the final forged products is greatly reduced due to decarburisation.

3.3 Recommendation

From the study it is clear that the surface hardness of the material is greatly influenced by decarburisation due to overheating of the billet. So we should implement some method to reduce the amount of decarburisation level in the furnace. The best alternative is to install sealed quench furnace for heat treatment operation.

The sealed quench is a batch furnace in which the heating and quenching chambers are combined in a single unit.

The two chambers are separated by a refractory-lined door which can be opened to allow the hot charge to be transferred from the heating chamber to the cooling chamber. Sealed quench furnaces usually operate over the temperature range 750°C to 1000°C but can operate from 570oC to 1100°C with suitable modifications.

Sealed quench furnace is shown in figure 4.

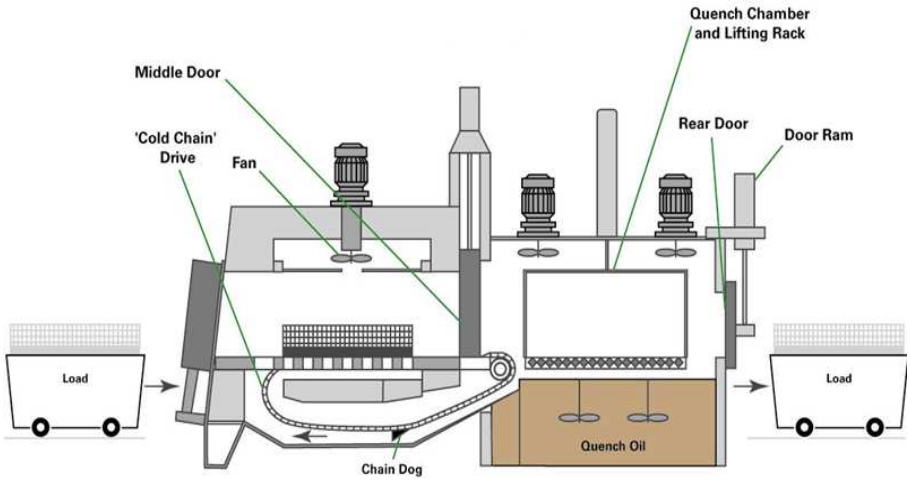

Figure 4: Sealed Quench Furnace

Sealed quench furnaces constitute the most common type of controlled atmosphere furnaces. A sealed quench furnace is a furnace in which the heating chamber is attached to the cooling or quenching chamber, both being enclosed so that the workload is always under the controlled atmosphere and is never exposed to the air whilst at temperature. This means that components are clean and bright and not oxidised when they are removed from the furnace. Since oxidation of the billet from within the furnace can be prevented, overheating is reduced and so decarburisation can be avoided. Advantages of sealed quench furnace are as follows. Better control of the surface carbon content of the component, higher productivity of the equipment, less labour required to run the equipment, easier to automate and control the process, more environmentally friendly - without the serious problems of handling toxic salts or the difficulties of disposing of waste salts and spent pack carburising powders.

3.1.1 Feasibility Study

A study was conducted to check the feasibility.

Name of the item	: Cam Shaft Gear
Cut Weight(Kg)	: 183.5
Gross weight(Kg)	: 198
Net Weight(Kg)	: 140
Price per piece	: Rs 45818.98
Number of Rejection due to Decarburisation	: 73
Total production loss	: 73*45818.98 = Rs 3344785.54

Cost of sealed quench furnace : Rs 2256320

Installation Cost : Rs 85000

Total cost of furnace : Rs 2341320

4. CONCLUSIONS

The main objective of study was to identify the major cause for rejection of final forged products in a forging industry. Root cause analysis was conducted to identify the major cause. Improvement opportunities to reduce the reduction rate is also suggested.

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