

FORGING DEFECTS ANALYSIS IN AXLE SHAFT USING TAGUCHI METHOD

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ABSTRACT

Forging process commonly used in industry and affected by the process temperature. A study has been conducted to understand the effect of forging process parameters of the axle shaft. The axle shaft is made of different material. The four significant parameters such as billet weight, billet temperature, forging time and the die temperature were used to optimize and reduce the rejections due to various forging defects. Forging defects of axle shaft under different manufacturing conditions successfully analyzed using Taguchi's experimental design method. Taguchi's method provides a simple, systematic and efficient methodology for the optimization of the control factors. Forging time is the most significant factor followed by weight of billet and initial die temperature while the forging temperature has the least or almost no significance on defects of the forged gear whereas, forging temperature is the most significant factor followed by weight of billet and initial die temperature while the forging time has the least or almost no significance on defects of the forged axle shaft.

Keywords: Axle shaft, billet temperature, Forging temperature.

I. INTRODUCTION

Forging is a manufacturing process where metal is pressed, pounded or squeezed under great pressure into high strength parts known as forgings. The process is normally (but not always) performed hot by preheating the metal to a desired temperature before it is worked. The forging process can create parts that are stronger than those manufactured by any other metalworking process. This is why forgings are almost always used where reliability and human safety are critical. The Figure 1.2 shows the various processes at the different location point such as the die, die and work interface, plastic deformation etc.

- Forging process set up

The forging set up consist of the various operation such as shearing/cutting of the billet to the proper weight as provided in standard operating procedure (SOP), heating of the billet in an controlled environment to the forging temperature, pre-form and placing the pre-form in the finisher die to forge the component of the desired shape,

heat treatment, cleaning and inspection as per laid down procedure in SOP. The sub systems used are:

- Raw material identification and inspection
- Gear billet cutting process
- Gear billet heating process
- Forging die
- Forging hammers
- Heat treatment process
- Cleaning process

II. EXPERIMENTAL METHODOLOGY

2.1 Introduction

This chapter presents the detailed description of the raw materials and methodology used in this research work. The forging defects are generally characterized by weight of the billet, billet temperature, time during forging, friction and initial temperature of die. In this work, the forging defects of axle shaft studied. Parts under study in a lot size of 150 parts in each lot, then parts are inspected for forging defects as per standard operating procedure (SOP) and the rejection in each set of trail is recorded for statistical analysis. The process parameters under different combinations are selected and applied during the actual forgings of the parts.

2.2 Research Outline

The steps followed in experimentation are as shown in Figure 1.1. The billet is heated in the induction furnace and then hot billet is preformed and forged to final shape. The forged specimens were prepared by varying the process parameter levels. The rejection percentage is recorded.

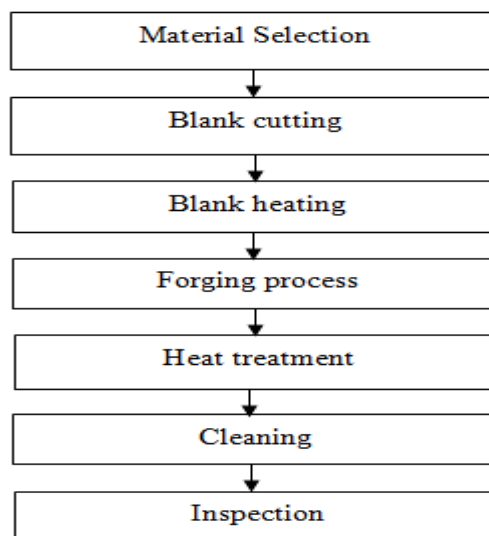


Figure 1.1: Steps for experimentation.

2.3 Experimental Setup

The schematic diagram of experimental setup is shown in the Figure 1.2 .The billet from the raw material rod was first cut by the shearing machine and then cut to the final size and weight by the band saw. The billet is the heated in the induction furnace up to the forging temperature. The hot billet is then placed on the blocker die to remove the scaling and make the pre-form; the pre-form is then placed on the finish die to make the forging of the desired shape and size. The hot forging is the cooled and heat treated to relieve the stresses induced during forging. The oil fired heat treatment furnaces are used for annealing and normalizing. The forged components are the cleaned by the shot blast cleaning machine by using the metal ball blast and the air blast.

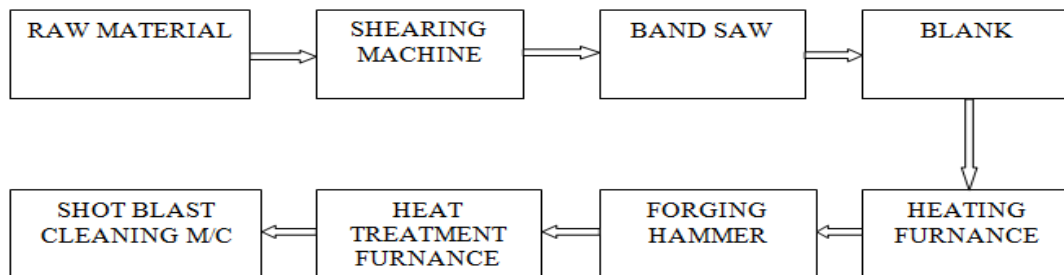


Figure 1.2: Forging process set up.

To check the quality of the forging parts the parts are inspected hundred percent visually for the forging defects and ten percent with the help of vernier caliper and height gauge for dimensional accuracy. In this study the percentage of rejections due to the forging defects are the quality characteristics of the forgings. To increase the quality of the forging the forged parts should be defect free.

III. TAGUCHI ANALYSIS OF DEFECTS FOR AXLE SHAFT

Table 1.1: Experimental design (L₉ orthogonal array) with output and S/N ratio for forging defects in axle shaft.

S.No	Weight of bille (A) (kg)	Temperature (B) (°C)	Forging time (C) (sec.)	Initial die temperature (D) (°C)	Defect (%)	S/N Ratio (db)
1.	2.7	1190	15	200	5	-13.9794
2.	2.7	1200	20	220	4	-12.0412
3.	2.7	1210	25	240	6	-15.5630
4.	2.8	1190	20	240	8	-18.0618
5.	2.8	1200	25	200	5	-13.9794
6.	2.8	1210	15	220	9	-19.0849
7.	2.9	1190	25	220	6	-15.5630
8.	2.9	1200	15	240	5	-13.9794
9.	2.9	1210	20	200	7	-16.9020

The experimental results were also analyzed using Taguchi method and the significant parameters affecting material wear, identified. The results of the Taguchi analysis are as follows:

In Table 1.1, each column provides a test parameter and each row gives a test condition which is a combination of parameter levels. Table 1.1 also presents the defect % and S/N ratio of the Taguchi's factorial experiment design. Figure 1.3 shows the effect of the four control factors on defect %. The possible interactions between the control factors must be considered, before any attempt is made to use this simple model as a predictor for the measurement of performance. Thus factorial design incorporates a simple means of testing for the presence of the interaction effects.

The S/N ratio response are given in Table 1.2, from which it can be concluded that among all the factors, forging temperature is the most significant factor followed by weight of billet and initial die temperature while the forging time has the least or almost no significance on defects of the forged axle shaft. Analysis of these results leads to the conclusion that combination of factors A₁ (2.7 kg weight of billet), B₂ (1200 °C of forging temperature), C₃ (25 s forging time) and D₁ (200 °C of initial die temperature) gives minimum defect as shown in Figure 5.6.

Table1.2: Response table for signal to noise ratios.

Level	Weight of billet (A)	Temperature (B)	Forging time (C)	Initial die temperature (D)
I	-13.86	-15.87	-15.68	-14.95
II	-17.04	-13.33	-15.67	-15.56
III	-15.48	-17.18	-15.04	-15.87
Delta	3.18	3.85	0.65	0.91
Rank	2	1	4	3

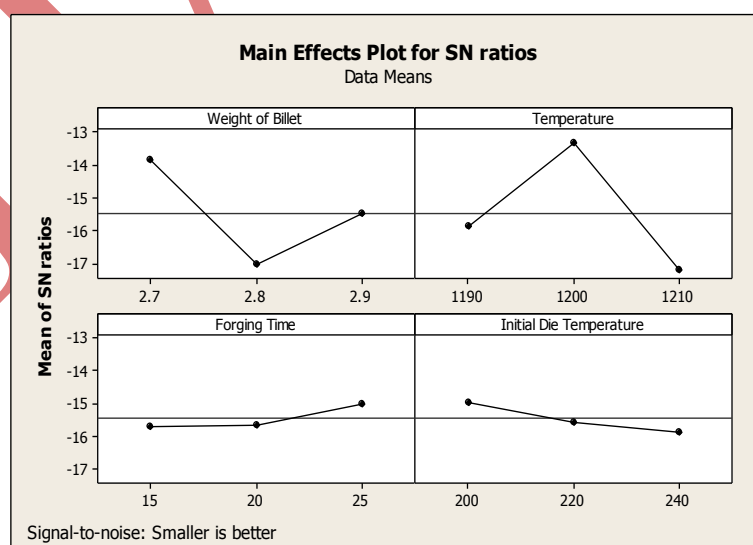


Figure1.3: Effect of control factors on defects during forging of axle shaft.

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