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Experimental Analysis and Statistical Optimization of Effect of Heat Treatment Distortion in DIP Variation in an Idler Gear

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Abstract – *"Experimental Analysis And statistical Optimization of Effect Of heat Treatment Distortion on DIP Variation in an Idler Gear"*

The Objective of the Project is to reduce the rejection in gear having internal teeth and also reduce the scrap cost. This problem identified in Heat Treatment after the complete analysis of processes carried in both Before Heat Treatment and After Heat Treatment. Conducted the experiment and measured the variation in DIP. This is done by analyzing the Effect on Heat Treatment Distortion on DIP. Using the DIP readings, checking the effect and response design of experiment plan is introduce. Statistically analyzing responses of changed parameters are observed and depending on it, optimized changes in parameters are introduced.

Key Words: Process Capability, Gemba Observation, Stress Relieving, Change in Time and Temperature.

1.0 INTRODUCTION

A Reverse Drive Gear, as shown in fig, of material 20MnCr5 alloy steel, has to undergo Heat Treatment of carburizing, the effective case depth required is minimum 0.35mm and maximum 0.5mm and surface hardness of 680-780 HV. The heating treatment process in conducted in seal quenched furnace, where both heating and quenching is done. This component detected distortion in DIP after Heat treatment crosses the permissible limit. This experiment is conducted to know the amount of distortion, to find out the probable causes and to take corrective action to control distortion.

Fig 1.0 Idler Gear.

1.1 Problem Definition

During final inspection it is found that some parts on reverse idler gear are distorted in DIP. Distortion is measure cause of rejection. It was also found that distortion problem mainly occurs in specific lot. As the cost of one part is approximately Rs. 178, it is essential to find out the root cause and eliminate it. On analyzing the last six months data it is observed that 32% of rejection of this part is due to variation in DIP beyond its specification

1.2 Cost Of Poor Quality (COPQ)

Cost Of Poor Quality per year considering maximum rejection in September is Rs. 1,62,336

2.0 Current Procedure:

The actual parameters to be maintained during the heat treatment process, various controlling and checking parameters are mentioned in detail.

Table -1: Process Cycle

Processes with temperature, time and Carbon percentage			
Process Cycle	Temperature (^{0}C)	Time (Minutes)	Carbon Percent
Carburizing	930	100	1.00%
Diffusion	930	50	0.90%
Hardening	840	30	0.75%
Tempering	160	120	-
Oil Quenching	100	30	-

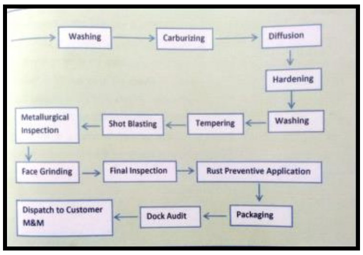
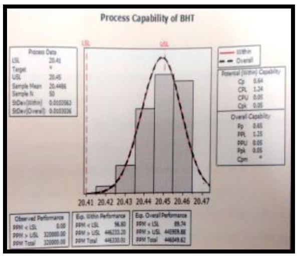


Fig 2.0 Process Cycle **Fig 2.1** PFC

2.1 Process Capability Chart:



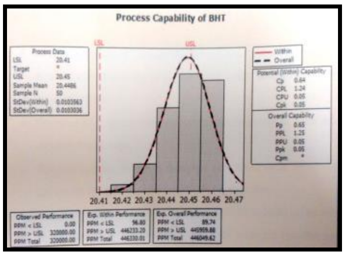


Chart 1: Process Capability Before and After HT.

2.0 Gemba Observation:

As per the data collected the it is clear that DIP variation in shaping process does not exceed the limit as all the 50 samples were within its range i.e. 40 micron as per control plan. These 50 samples, after heat treatment were found varied in DIP i.e. 100 micron which is more than specification i.e. 60 microns. As per the observation the DIP variation is exceeding the limit up to 100 microns which brings concerns about it.

3.1 Action Implemented

Table-2 Process Cycle After Action Implemented.

Processes with temperature, time and Carbon percentage			
Process Cycle	Temperature (^{0}C)	Time (Minutes)	Carbon Percent
Stress Relieving	485	60	-
Carburizing	915	130	1.00%
Diffusion	915	40	0.90%
Hardening	835	35	0.75%
Tempering	160	120	-
Oil Quenching	130	45	-

4.0 Modification:

4.1 Why Stress Relieving?

Stress relieving is the process , in which part is heated at a temperature at 480 ^{0}C i.e. below its recrystallization temperature. These parts are kept at room temperature for 1 hr and cooled to room temperature. Due to this internal stresses are relieved which are developed in forging and machining operation without loss of strength and hardness i.e. without change in microstructure. This reduces the risk of distortion.

To overcome distortion in DIP, changes in time and temperature is done in order to reduce the temperature gradient that prevents part from distortion. The new temperature to carburize charge is reduced from 930 ^{0}C to 915 ^{0}C whereas time is increased by 30 min to equalize the temperature in furnace i.e. 130 min. In addition to it, hardening temperature is reduce from 840 ^{0}C to 835 ^{0}C and operation is carried out for 30 min. Quenching oil temperature is increase from 100 ^{0}C to 130 ^{0}C. this reduces thermal gradient from 740 ^{0}C to & 705 ^{0}C that enable charge to sustain the thermal shock and avoid distortion in DIP. Above are the changes in temperature and time made during experimentation and found successful in reducing the distortion in microns in DIP.

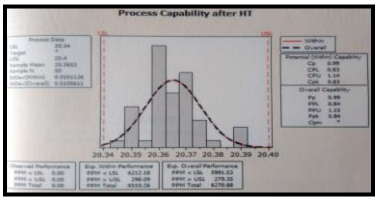


Chart 2: Process Capability After Action Implemented.

4.2 Results:-

Benefits			
	Before Project	After Project	Cost Saving in Rs. Per Annum
Scrap per Month	50(AVG)	5 (AVG)	-
Scrap Cost per Month	8,900	890	-
Scrap Cost per Annum	1,06,800	10,680	-
Saving in Scrap cost per Month	-	8,010	-
Cost per Annum	-	**96,120**	**96,120**

5.0 CONCLUSIONS

After studying defect, readings of 50 samples for variation in DIP were taken in soft as well as hard stage. By this, it was found that DIP in soft stage is within the range as per specification but DIP after Heat Treatment was not within specification. Some necessary action are taken to avoid distortion in DIP. A new process, Stress relieving, is added to Heat Treatment processes. In addition changes in time and temperature are done to reduce the temperature gradient that results in reduce in DIP distortion.

These changes are implemented and again the 50 readings are taken and observed all parts were within range of given specification. Therefore, distortion is controlled by implementing above necessary actions. This experiment saved Rs. 96,120 per year.

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[2] 2015 ThyssenKrupp Steel Preheating furnace for hybrid material LITECOR K. Elissa, "Title of paper if known," unpublished.

[3] 2001 Alex Heavy Industries, Taiwan Heat treatment plant with roller hearth furnace (RHF) and water quench (HHT) for aluminum rods, bars, and plates

[4] 1999 KM Europa Metal, Osnabrück, Germany Strip floatation annealing furnace for copper strips (strip width 600 – 1300 mm, thickness 0,2 – 1,5 mm)

[5] Production Carburising in LPG/C02 Atmospheres for Energy and Cost Savings P. GHORPADE (Hightemp Furnaces Ltd, India) and K. BENNETT(KMBMetallurgical, UK)