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Effect of Hardness and Wear Resistance on En 353 Steel by Heat Treatment

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Abstract: *En 353 steel is an easily available and cheap material that is acceptable for heavy duty applications. Heat treatment on En 353 steel is improved the ductility, toughness, strength, hardness and relive internal stress in the material. Spectrographic method is used to analyze the composition of the alloy material. The experimental results of hardness and dry wear testing on pin-on-disc are done to get idea about heat treated En 353 steel. It is found that the hardness and wear resistance of the En 353 steel is improved after the heat treatment and the microstructure is changed from ferrite to martensite.*

Keywords: *En 353 steel, Heat treatment, Hardness, Wear resistance, Pin-on-disc.*

I. INTRODUCTION

En 353 steel has carbon content of 0.17% and the most common form of steel as it's provides material properties that are acceptable for many automobile applications such as heavy duty gear, shaft, pinion, cam shafts, gudgeon pins. It is neither externally brittle nor ductile due to its lower carbon content and lower hardness. As the carbon content increases, the metal becomes harder and stronger. The process of heat treatment is carried out first by heating the metal and then cooling it in water or oil or air. The purpose of heat treatment is, to enhances the transformation of austenite to martensite i.e. (soft material to hard material), to change the grain size, to modify the structure of the material and relive the stress set up in the material. It is a one-time permanent treatment process and it is change the entire cross section of the material. The martensitic phase transformation is usually used to increase the hardness of the steels. The various heat treatment processes are annealing, normalizing, hardening, quenching and tempering.

According to this work basically focus on carburizing; it is a process of improving carbon on case. These are done by exposing the part to carbon rich atmosphere at the high temperature (close to melting point) and allow diffusion to transfer the carbon atoms into the steel. So, these work concentrations go through gas carburizing which is widely used in mass production. The carburizing process does not harden the steel it only increases the carbon content. In heat treatments, both chemical composition and microstructure properties of a case can be changed.

The aim of this paper is to examine the hardness, wear resistance and effect of microstructure of before and after heat treatment on En 353 steel. In heat treatment, the machined specimens are loaded in the gas carburizing chamber . Carburizing takes places at 920°C for 120 minutes then it is cooled by air and relaxing time is 75 minutes. The purpose of the relaxing time is to arrest the in and out of the carbon and it is followed by oil quenching at 820°C for 30 minutes, oil temperature is below 80°C then by tempering at 250°C for 90 minutes. In general, the untempered material structure has the high hardness and also more brittle. Hence the tempering process should be done to reduce the brittleness, to relieve the internal stress and to increase the toughness and ductility of the material.

Nomenclature:

AHT - After Heat Treatment
BHT - Before Heat Treatment
CHT - Conventional Heat Treatment
HV - Vickers Hardness test

II. Methodology

After heat treatment, the specimens for structure investigations are conventionally prepared and etched using nital. The specimen with a diameter of 10 mm and a length of 50 mm are subjected to the Hardness test using the MH6 machine. The specimen with same size are subjected to wear testing using Pin-on-disc apparatus. The Leica DM 2500 M microscope is used to the observations of obtained structures before and after the heat treatment.

III. Results And Discussion

3.1 Chemical Analysis

In order to ensure the material of the specimen is done with help of the optical emission spectroscope (OES). The result is obtain from the chemical analysis, carbon - 0.169 %, silicon - 0.234 %, manganese - 0.712 %, phosphorus - 0.015 %, sulphur - 0.030 %, Chromium – 1.617 %, Nickel - 1.574 %, molybdenum - 0.265 %, copper - 0.243%, Aluminum -0.034% and remaining percentage is iron respectively. A sample of ϕ 20 × 10 mm is polished using 60 grit papers and two sparks is introduced on the surface to find the chemical composition of the material. After ensuring the chemical composition, the raw material is machined according to the dimension for various tests.

3.2 Hardness

Vickers hardness measurement is done on the specimen as per the IS 1501-2008 procedures by using Vickers hardness tester (MH6). Hardness measurement is made with 100 g loads, dwell time of 10 seconds and diamond indenter is used for test. The impression is done on the circular faces at the centre of the specimen. The hardness values are taken corresponding to the diagonal length of the indentation. Two samples (i.e. BHT and AHT) and four readings are taken from the each sample from case to core. The average value is calculated from four readings. The hardness values of BHT (case and core) samples are, 244.25 and 244.77 HV respectively. The hardness values of AHT (case and core) samples are 671 and 417.2 HV respectively. It is clearly noticed that the base material (BHT) has the low hardness. The AHT specimen has high hardness when compared to the BHT sample as shown in Fig. 1.

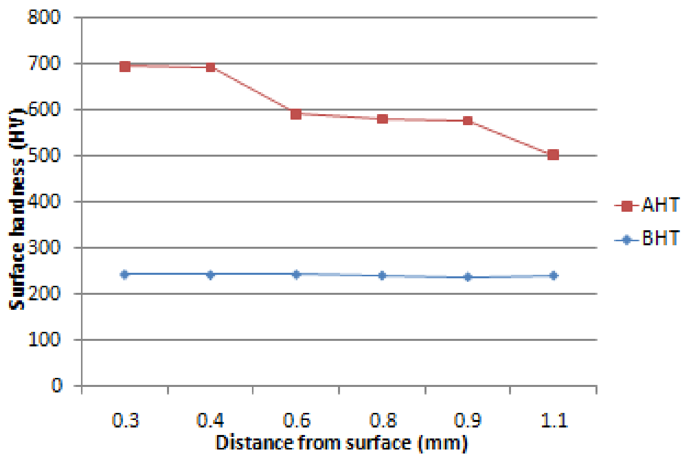

Fig.1: Hardness Profile of En353 steel BHT and AHT

3.3 Wear Resistance

wear resistance measurement is done on specimen by using dry wear on pin-on-disc testing in accordance with the ASIM G99-95standrds.the experimental results of wear carried out in laboratory gives values of initial and final weight, before and after wear of specimen. wear test carried out with the 40N load, 400rpm velocity, 40mm track radius, 1000m sliding distance for 10 minutes. the experimental result of wear test are analyzed by the Archad's (Hutchings,1995)or Rabinowicz's equation (rabinowicz,1965) that assess the wear rate and wear coefficient, relating the cumulative lost volume per sliding distance with the wear resistance through the linear equation as follows.

$Q(\frac{mm^3}{m}) = \frac{V}{S} = K\frac{F_N}{H}$ ....(equation 1)

where,

Q - wear rate

V - cumulative lost volume

S - sliding distance

F_N - normal load

H - hardness (HRC)

from Eq.(1), wear coefficient is given by,

$K = \frac{QH}{F_N}$ ....(equation2)

and in general wear coefficient is defined as 1/K.

Readings are taken from two samples average value calculated from readings. results obtain are shown in following tables.

Sr. no.	Specimen	wear rate Q=V/S(mm^3/m) (*10^{-3})	mean value Q	wear coefficient(K) (*10^{-3})	mean value(K)	wear resistance(1/K)	mean value(1/K)
1	BHT	8.81	8.81*10^{-3}	5.1	5.1*10^{-3}	196.1	196.1
2		8.81		5.1		196.1	
1	AHT	1.23	1.23*10^{-3}	9.04	9.04*10^{-4}	1106.2	1106.2
2		1.23		9.04		1106.2	

Table 1: results of wear resistance BHT and AHT

3.4 Microstructure

The change of microstructure in the material due to conventional heat treatment (CHT) is the main reason for the improved mechanical properties. Hence the microstructure examination is carried out to find the structure of BHT and AHT. The samples are polished using SiC emery paper of grit 280 and velvet cloth using white kerosene as coolant. These samples are etched with nital and dried in air. Finally, microstructure examination is carried out using optical microscope.

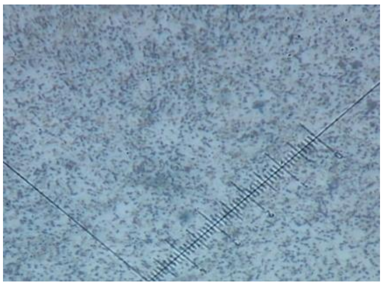

Fig. 2: spheroidized annealed structure at Mag. 1000X BHT

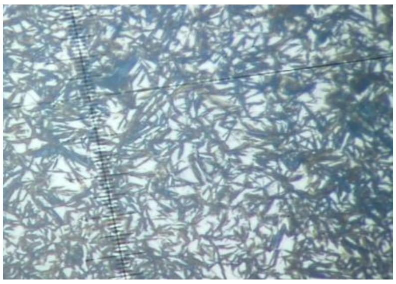

Fig. 3: about 45% retained austenite in the matrix of martensite at Mag. 1000X AHT

Fig. 2 show the microstructure of BHT is ferrite and spheroidized annealed structure with at the grain boundaries distributed throughout the structure and Fig. 3 show the microstructure of AHT is fine martensite, with retained austenite and traces of ferrite distributed throughout the structure.

IV. Conclusion

Before and after the heat treatment process the mechanical properties of the En 353 steel are examined. The results obtain under the experimental conditions of this work the following conclusion are drawn.

1. High hardness is obtained in carburizing 120 minutes at 920°C for En 353 steel.
2. Micro hardness values of AHT are found to be higher than BHT.
3. Wear resistance values AHT are found to be higher than BHT.
4. The specimen is having greater hardness on case sample than the core sample.
5. Pictorial view of case/core microstructure indicates that the heat treated specimen is martensite.
6. Thus life of material can be enhanced by the conventional heat treatment process.

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