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Research Paper

HEAT TREATMENT ON EN 8 & EN 353 FOR HEAVY DUTY GEARS

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As our project concerned it is basically concentrate on "To study the heat treatment on the structure and properties of automobile gears, which consist of hardening and carburizing process which is a case hardening process". Case hardening is the process of hardening the surface of metal, often low carbon steel by infusing elements into the metal surface forming a hard, wear resistance skin but preserving a tough and ductile applied to gears. The hardening treatment for most steels consists of heating the steel to a set temperature and then cooling it rapidly by plunging it into oil, water. EN 8 and EN 353 steel is an easily available and cheap material that is acceptable for heavy duty applications. Heat treatment on EN 8 and EN 353 steel is improved the hardness and relive internal stress in the material. The experimental results of hardness and microstructure are done to get idea about heat treated materials. It is found that the hardness of the materials are improved after the heat treatment and the microstructure is changed from austenite to martensite.

Keywords: EN 8 and EN 353 steel, Heat treatment, Hardness, Microstructure

INTRODUCTION

EN 8 and EN 353 steel has carbon content of 0.35% and 0.18% the most common form of steel as it's provides material properties that are acceptable for the manufacture of parts such as general purpose axles and shafts, gears, bolts and studs. It is neither externally brittle due to its higher carbon content and higher hardness. As the carbon content increases, the metal becomes harder and stronger.

The Steel (0.15%-0.45% carbon) is primarily heat treated to create matrix microstructures. As cast matrix microstructures usually consist of ferrite or pearlite or combinations of both, depending on cast section size and/or alloy composition. The principle objective is to carry out the heat treatment of Low carbon steel and then to compare the mechanical properties. Heat treatment temperatures, including rate of heating, cooling and soaking times will vary due to factors such as the shape and size of each steel component.

The process of heat treatment is carried out first by heating the metal and then cooling

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it in water or oil or air. The purpose of heat treatment is, to enhances the transformation of soft material to hard material, 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 marten site 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 and through hardening; it is a process of improving carbon on cases. 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. 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.

Nomenclature

AHT - After Heat Treatment

BHT - Before Heat Treatment

CHT - Conventional Heat Treatment

BHN - Brinell hardness test

METHODOLOGY

After heat treatment, the specimens for structure investigations are conventionally prepared. The microscope is used to the observations of obtained structures before and after the heat treatment. The specimen with a diameter and length are subjected to the Hardness test using the BHT machine.

EXPERIMENTAL WORK

The experimental procedure for the project work can be listed as:

1. Specimen preparation
2. Heat treatment
3. Harden measurement
4. Chemical analysis
5. Microstructure study

Specimen Preparation

The first and foremost job for the experiment is the specimen preparation. The specimen size should be compatible (diameter 15mm and length 150mm) to the machine specifications. Low carbon steel has carbon content of 1.5% to 4.5%. Low carbon steel is the most common type of steel as its price is relatively low while it provides material properties that are acceptable for many applications. It is neither externally brittle nor ductile due to its low carbon content. It has lower tensile strength and malleable.

EN 8 - 2 rod

EN 353 - 2 rod

Heat Treatment

The process of heat treatment is carried out first by heating the material and then cooling it in the brine, water and oil. The purpose of heat treatment is to soften the metal, to change the grain size, to modify the structure of the material and to relieve the stress set up in the material after hot and cold working.

The Steel are primarily heat treated to create matrix microstructures and associated mechanical properties not readily obtained in the as-cast condition. As-cast matrix microstructures usually consist of ferrite or pearlite or combinations of both, depending on cast section size and/or alloy composition

The principle objective of the project is to carry out the heat treatment of Low carbon steel and then to compare the mechanical properties. There are various types of heat treatment processes we had adopted.

Case Hardening

In many applications, it is desirable that the surface of the components should have high hardness, while inside or core should be soft. The treatments given to steels to achieve this are called surface heat treatment or surface hardening. We know that the principle reason for hardening steel is to retard wear on bearing and rubbing surfaces, but hard steel is brittle and not fatigue and shock resistant.

In heat treatment, the machined specimens are loaded in the chamber at below 800°C. 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 Therefore, for high strength along with durability it is desirable to harden selected outer surfaces of many machine parts for wear and leave their cores soft and ductile for shock resistance. This can be achieved by the process known as surface or case hardening.

Carburizing is the type of case hardening. It is the process in which carbon atoms are introduced onto the surface of low carbon steels to produce a hard case of surface, while the interior or core remains soft. Steels for carburizing should have carbon from 0.10 to 0.20%. In carburization, when a piece of low carbon steel is placed in a carbon saturated temperature, then the carbon will diffuse or penetrate into the steel and carburizing it.

Through Hardening

Hardening refers to the heat treatment of steel which increases its hardness by quenching. Hardening normally implies heat-treating operations which produce microstructures which are entirely or predominantly martensite.

The steel to be heat treated is heated slowly in a furnace to a temperature 300c to 500c above the upper critical temperature. The heated steel is held at this temperature for considerable length of time to allow complete austination. The steel is cooled by quenching to the room temperature. The cooling rate should be higher than the critical cooling rate in order to get the completely martensite structure.

Quenching

This experiment was performed to harden the cast iron. The process involved putting the red hot cast iron directly in to a liquid medium.

a) The specimen was heated to the temp of around 900oc and was allowed to homogenize at that temp for 2 hour.

b) An oil bath was maintained at a constant temperature in which the specimen had to be put.

c) After 2 hour the specimen was taken out of the furnace and directly quenched in the oil bath.

d) After around half an hour the specimen was taken out of the bath and cleaned properly.

Now the specimen attains the liquid bath temp within few minutes. But the rate of cooling is very fast because the liquid doesn't release heat readily.

Tempering

This is the one of the important experiment carried out with the objective of the experiment being to induce some amount of softness in the material by heating to a moderate temperature range.

a) First the specimen were heated to 900 deg Celsius for 2 hour and then quenched in the oil bath maintained at room temp.

b) Among the specimen were heated to 250oc. But for different time period of 1 hour, 1and half hour and 2 hour respectively.

c) Now 3 more specimens were heated to 450 deg Celsius and for the time period of 1 hour, 1and a half hour and 2 hour respectively.

d) The remaining specimens were heated to 650 deg Celsius for same time interval of 1 hour. 1 and half and 2 hours respectively. After the specimens got heated to a particular temperature for a particular time period, they were air cooled. The heat treatment of tempering at different temp for different time periods develops variety of properties within them.

Harden Measurement

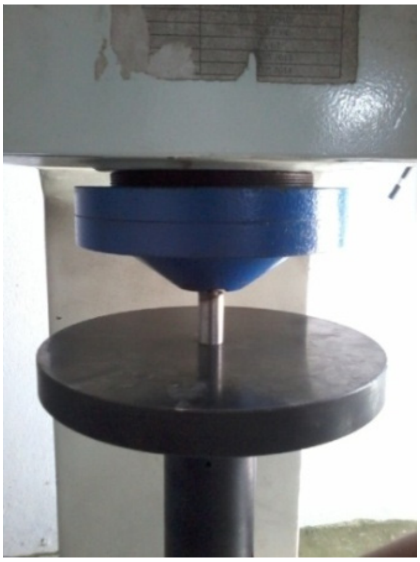
As the objective of the project is to compare the mechanical properties of various heat treated cast iron specimens, now the specimens were sent to hardness testing and tensile testing.

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

Brinell Hardness Test

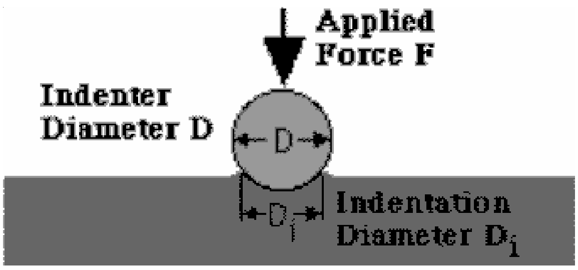
It consists of pressing a hardened steel ball into a test specimen. In this usually a steel ball of Diameter D under a load “P is forced in to the test piece and the mean diameter” d of the indentation left in the surface after removal of load is measured. According to ASTM specifications a 10 mm diameter ball is used for the purpose. Lower loads are used for measuring hardness of soft materials and vice versa. The Brinell hardness is obtained by dividing the test load “P by curved surface area of indentation. This curved surface is assumed to be portion of the sphere of diameter” D .

Figure 1: Brinell Hardness Testing



Specimen is placed on the anvil. The hand wheel is rotated so that the specimen along with the anvil moves up and contact with the ball. The desired load is applied mechanically (by gear driven screw) and the ball presses into the specimen. The diameter of the indentation made in the specimen by the pressed ball is measured by the use of a micrometer microscope, having transparent engraved scale in the field of view. The indentation diameter is measured at two places at right angles to each other, and the average of two readings is taken. The Brinell Hardness Number (BHN) which is the pressure per unit surface area of the indentation is noted down.

Figure 2: Indenter, Indentation Diameter



Brinell Hardness Number

(BHN) = 2P/ {D [D- (D2- d2)]}

Where,

P = Load applied in Kgf.

D = Diameter of the indenter in mm.

D = Diameter of the indentation in mm.

EN 8 (BHT) = 179 BHN

EN 8 (AHT) = 233 BHN

EN 353 (BHT) = 355 BHN

EN 353 (AHT) = 380 BHN

Chemical Analysis

In order to ensure the material of the specimen is done with help of the Spectro Maxx. A sample of 15 × 35 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.

Figure 3: Spectro Maxx Equipment

Table 1: Chemical Analysis of En 8 (BHT)

C	Mn	Si	P	S	Cr
0.364	0.720	0.173	0.0194	0.0166	0.0073

Table 2: Chemical Analysis of En 8 (AHT)

C	Mn	Si	P	S	Cr
0.586	0.720	0.185	0.0180	0.0204	0.0136

Table 3: Chemical Analysis of En 353 (BHT)

C	Mn	Si	P	S	Cr
0.348	0.702	0.290	0.0275	0.0351	1.55

Table 4: Chemical Analysis of En 353 (AHT)

C	Mn	Si	P	S	Cr
0.392	0.703	0.312	0.0315	0.0469	1.56

Microstructure of Materials

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.

Microstructure is defined as the structure of a prepared surface or thin foil of material. The microstructure of a material can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior, wear resistance

Figure 4: EN 8 (BHT) Ferrite or Pearlite

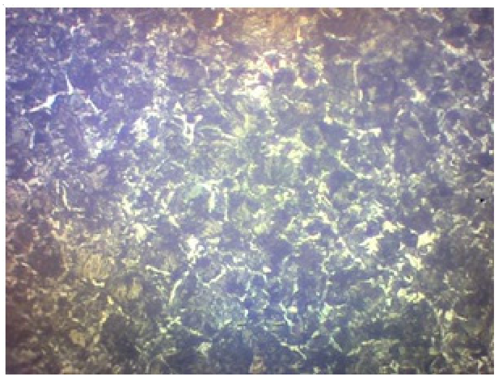


Figure 5: EN 8 (AHT) Martensite

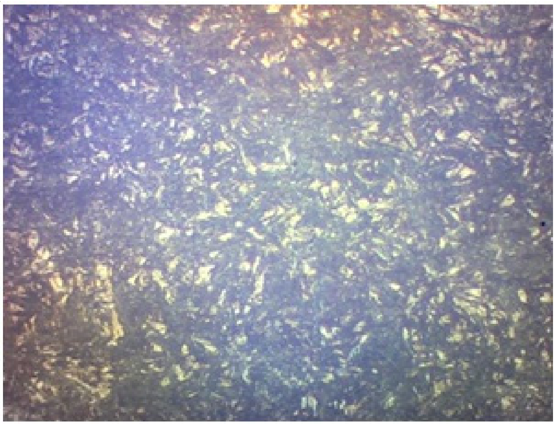


Figure 6: EN 353 (BHT) Ferrite or Pearlite

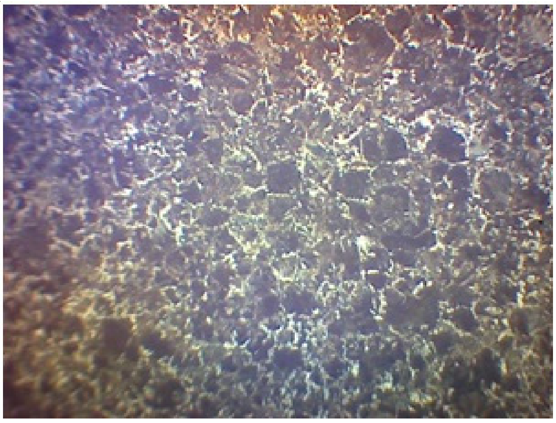
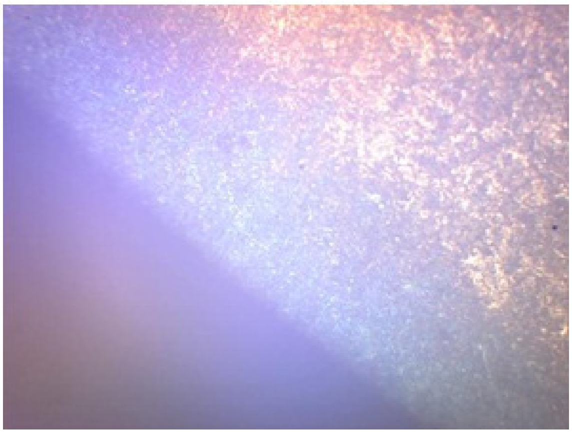


Figure 7: EN 353 (AHT) Martensite



RESULTS AND DISCUSSION

From the various experiments carried out following observations and inferences were made. Before and after the heat treatment process the hardness, carbon content, micro hardness of the En 8 and 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 for En 8 and En 353 steel through case hardening and through hardening process.
2. Micro hardness values of AHT are found to be higher than BHT.
3. The specimen is having greater hardness on case sample than the core sample.
4. Thus life of material can be enhanced by the conventional heat treatment process.

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