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Effect of Heat Treatment in Low Carbon Steel

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ABSTRACT

Low carbon steel is easily available and cheap having all material properties that are acceptable for many applications. Heat treatment on low carbon steel is to improve ductility, to improve toughness, strength, hardness and tensile strength and to relive internal stress developed in the material. Here basically the experiment of harness and ultimate tensile strength is done to get idea about heat treated low carbon steel, which has extensive uses in all industrial and scientific fields.

***Keywords*—** Carbon steel, Heat Treatment

I. INTRODUCTION

As we know there is a little bit of steel in everybody life. Steel has many practical applications in every aspects of life. Steel with favorable properties are the best among the goods. The steel is being divided as low carbon steel, high carbon steel, medium carbon steel, high carbon steel on the basis of carbon content. Low carbon steel has carbon content of 0.15% to 0.45%. Low carbon steel is the most common form of steel as its provides material properties that are acceptable for many applications. It is neither externally brittle nor ductile due to its lower carbon content. It has lower tensile strength and malleable. Steel with low carbon steel has properties similar to iron. As the carbon content increases, the metal becomes harder and stronger but less ductile and more difficult to weld.

The process heat treatment is carried out first by heating the metal and then cooling it in water, oil and brine water. The purpose of heat treatment is to soften the metal, to change the grain size, to modify the structure of the material and relive the stress set up in the material. The various heat treatment process are annealing, normalizing, hardening, austempering, mar tempering, tempering and surface hardening.

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, ball bearings, railway wheels.

As my project concerned it is basically concentrate on carburizing which is a case hardening process. It is a process of adding carbon to surface. These are done by exposing the part to carbon rich atmosphere at the elevated temperature (near melting point) and allow diffusion to transfer the carbon atoms into the steel. This diffusion work on the principle of differential concentration. But it is not easy to go through all the carburizing process like gas carburizing, vacuum carburizing, plasma carburizing and salt bath carburizing.

II. METHODOLOGY

Stress relieving - a low-temperature treatment, to reduce or relieve Internal stresses remaining after casting Annealing - to improve ductility and toughness, to reduce hardness and to remove carbides. Normalizing - to improve strength with some ductility Hardening and tempering - to increase hardness or to give improved Strength and higher proof stress ratio. Austempering - to yield bainitic structures of high strength, with significant ductility and good wear resistance. Surface hardening - by induction, flame, or laser to produce a local wear resistant hard surface

III. LITRETUTRE REVIEW

Carbon steel (plain carbon steel) is steel which contain main alloying element is carbon. Here we find maximum up to 1.5% carbon and other alloying elements like copper, manganese, silicon. Most of the steel produced now-a-days is plain carbon steel. It is divided into the following types depending upon the carbon content.

Steel with low carbon content has properties similar to iron. As the carbon content increases the metal becomes harder and stronger but less ductile and more difficult to weld. Higher carbon content lowers the melting point and its temperature resistance carbon content cannot alter yield strength of material. instruction set.

3.1 Low Carbon Steel.

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 its 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.

3.2. 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 various heat treatment processes commonly employed in engineering practice as follows:-

3.1.1. Annealing

Spherodite forms when carbon steel is heated to approximately 700 for over 30 hours. The purpose is to soften higher carbon steel and allow more formability. This is the softest and most ductile form of steel. Here cementite is present.

Full annealing: Carbon steel is heated to approximately above the upper critical temperature (550650) for 1 hour. Here all the ferrite transforms into austenite. The steel must then cooled in the realm of 38 per hour. This results in a coarse pearlite structure. Full annealed steel is soft and ductile with no internal stress.

Process annealing: The steel is heated to a temperature below or close to the lower critical temperature (550-650), held at this temperature for some time and then cooled slowly. The purpose is to relive stress in a cold worked carbon steel with less than 0.3%wt c.

Diffusion annealing: The process consists of heating the steel to high temperature (1100- 1200). It is held at this temperature for 3 hours to 20 hours and then cooled to 800-850 inside the furnace for a period of about 6 to 8 hours. It is further cooled in the air to room temperature. This process is mainly used for ingots and large casting. It is also called isothermal annealing.

The process of normalizing consist of heating the metal to a temperature of 30 to 50 c above the upper critical temperature for hypo-eutectoid steels and by the same temperature above the lower critical temperature for hyper-eutectoid steel. It is held at this temperature for a considerable time and then quenched in suitable cooling medium. The purpose of normalizing is to refine grain structure, improve machinibility and improve tensile strength, to remove strain and to remove dislocation It is a hardening process. it is also known as isothermal quenching. In this process, the steel is heated above the upper critical temperature at about 875 c where the structure consists entirely of austenite. It is then suddenly cooled by quenching it in a salt bath maintained at a temperature of about 250 c to 525 c.

IV. LITERATURE SURVEY

Basak and chakroborty (1983) developed Cr-Mn-Cu white cast iron for application in mining, farm machinery; etcrequiringerosive and corrosive wear resistance properties. They found that the addition of Cu improves the corrosion resistance of Cr-Mn iron and hence reduced the rate of corrosive wear of high copper, chromium and manganese cast iron.

Kuma and Gupta(1990) studied the abrasive wear behavior of mild, medium carbon, leaf and high carbon, low Cr. Steel by means of a dry stand rubber wheel abrasion apparatus. They found that the heat treated high carbon low Cr. Steel and mild steel carburized by their own technique to be the best abrasion resistance materials. The abrasive wear resistance values of the two materials wear found to be very much comparable with each other.
They also studied the abrasive wear of carburized mild steel. They investigated the influence of carburization conditions (e.g., temperature, time, properties of carbonaceous material etc.) on the abrasive wear loss. During the study, Kumar developed a cheaper method of carburizing producing better wear resistance. In this technique, mild steel samples are carburized under two conditions such as;

1. Carburization in as received charcoal granules +BaCO3 mixtures with a thick coating (2mm approx.) of a coal tar pitch on steel sample.
2. Carburization in used charcoal +BaCO3 mixture with cold tar pitches coating on the steel sample.

In both the cases carburization was carried out at a temperature 930c for two hours (optimum).All the quenched carburized steel samples were tempered at 150c for 15min. As outlined by them, the nature and reactivity of carbon used greatly affect the mechanical properties and abrasion resistance of carburized mild steel specimens. The result obtained by their carburization technique was found to be much superior to those obtained by conventional technique. The tribological properties of carbon graphite have been widely documented in the literature. This carbonization technique not only gives very high hardness and abrasion resistance (equivalent to those of high carbon steel) but also result in the following other advantages.

1) Reduction in the requirements of charcoal and BaCO3.

2) Saving of carburization time and elimination of rehardening elements. 3) Utilization of waste material. 4) Saving in the composition of electricity.

V. EXPERIMENTAL PROCEDURE

5.1 Specimen Preparation

The first and foremost job for the experiment is the specimen preparation. The specimen size should be compatible to the machine specifications: We got the sample from mild steel trader. The sample that we got was Mild steel. AISI8620. It is one of the American standard specifications of the mild steel having the pearlitic matrix (up to70%) with relatively less amount of ferrite (30-40%). And so it has high hardness with moderate ductility and high strength as specified below. So we can also say that it is basically a pearlitic/ferritic matrix.

5.2. Heat Treatment

Low Carbon 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. 4.2.1. Annealing a) The specimen was heated to a temperature of 900 deg Celsius b) At 900 deg Celsius the specimen was held for 2 hour c) Then the furnace was switched off so that the specimen temperature will decrease with the same rate as that of the furnace. The objective of keeping the specimen at 900 deg Celsius for 2 hrs is to homogenize the specimen. The temperature 900 deg Celsius lies above Ac1 temperature. So that the specimen at that temperature gets sufficient time to get properly homogenized .The specimen was taken out of the furnace after 2 days when the furnace temperature had already reached the room temperature.

5.3 Normalizing

a) At the very beginning the specimen was heated to the temperature of 900 deg Celsius.
b) There the specimen was kept for 2 hour.
c) Then the furnace was switched off and the specimen was taken out.
d) Now the specimen is allowed to cool in the ordinary environment. i.e. the specimen is air cooled to room temperature. The process of air cooling of specimen heated above Ac1 is called normalizing.

5.4 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 900 deg Celsius and were 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.
e) Now the specimen attains the liquid bath temp within few minutes. But the rate of cooling is very fast because the liquid doesnot release heat readily.

5.5 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 4" specimen were heated to 900 deg Celsius for 2 hour and then quenched in the oil bath maintained at room temp.
b) Among the 4 specimen 2 were heated to 250 deg Celsius. 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 hour 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.

5.6 Austempering

This is the most important experiment carried out for the project work. The objective was to develop all round property in the material. a) The specimen was heated to the temperature of 900 degree Celsius and sufficient time was allowed at that temperature, so that the specimen got properly homogenized. b) A salt bath was prepared by taking 50% NaN03 and 50 % KnO3 salt mixture. The objective behind using NaNO3 and KNO3 is though the individual melting points are high the mixture of them in the bath with 1:1 properties from an eutectic mixture this eutectic reaction brings down the melting point of the mixture to 290 deg Celsius. The salt remains in the liquid state in the temp range of 290-550 deg Celsius whereas the salt bath needed for the experiment should be at molten state at 350 deg Celsius. c) After the specimen getting properly homogenized it was taken out of the furnace and put in another furnace where the container with the salt mixture was kept at 350 deg Celsius. d) At that temp of 350 degree the specimen was held for 2 hrs in this time the austenite gets converted to bainite. The objective behind choosing the temperature of 350 deg Celsius is that at this temperature will give upper bainite which has fine grains so that the properties developed in the materials are excellent. e) An oil bath also maintained so that the specimen can be quenched. f) So after sufficient time of 2 hr the salt bath was taken out of the furnace and the specimen were quenched in the oil bath. g) An oil bath is also maintained so that specimen can be quenched. Now the specimens of each heat treatment are ready at room temperature. But during quenching in a salt bath, or oil bath or cooling due to slight oxidation of the surface of cast iron, there are every possibility of scale formation on this surface if the specimens are sent for testing with the scales in the surface then the hardness value will vary and the specimen will also not be gripped properly in the UTS. To avoid this difficulties the specimens were ground with the help of belt grinder to remove the scales from the surface. After the scale removal the Specimens are ready for the further experimentations.

5.7 Study of Mechanical Properties

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.

5.8 Hardness Testing

The heat treated specimens hardness were measured by means of Rockwell hardness tester. The procedure adopted can be listed as follows: 1. First the bale indenter was inserted in the machine; the load is adjusted to100 kg. 2. The minor load of a 10 kg was first applied to seat of the specimen. 3. Now the major load applied and the depth of indentation is automatically recorded on a dial gage in terms of arbitrary hardness numbers. The dial contains 100 divisions. Each division corresponds to a penetration of .002 mm. The dial is reversed so that a high hardness, which results in small penetration, results in a high hardness number. The hardness value thus obtained was converted into C scale by using the standard converter chart.

VI. DISCUSSION

From the various experiments carried out following observations and inferences were made. It was seen that the various tensile properties followed a particular sequence:

1) More is the tempering temperature, less is the hardness or more is the softness (ductility) induced in the quenched specimen. Ductility induced in the quenched specimen.

2) Microstructure photographs taken by SEM and metallurgical inspections indicated that the surfaces of heat treated samples are martensitic.

3) Case depth can be increased by longer cycle of carburization. Case depth can be increased exponentially by increasing carburization temperature.

4) The samples having greater case depth and surface hardness are more wear resistant than that with low case depth and low surface hardness.

5) More is the tempering time (keeping the tempering temperature constant), more is the ductility induced in the specimen.

6) This clearly implies that the UTS and also to some extent the yield strength decreases with increase in tempering time whereas the ductility (% elongation) increases.

7) For a given tempering time, an increase in the tempering temperature decreases the UTS value and the yield strength of the specimen whereas on the other hand increasing the % elongation and hence the ductility..

VII. CONCLUSION

From the various results obtained during the project work it can be concluded that the mechanical properties vary depending upon the various heat treatment processes. Hence depending upon the properties and applications required we should go for a suitable heat treatment processes. When ductility is the only criteria tempering at high temperature for 2 hours gives the best result among all tempering experiments however it is simply the hardness of the low carbon steel that is desired than we should go for low temperature tempering for 1 hour or so. However if strength is also desired along with hardness, this should not be done. It is seen that annealing causes a tremendous increase in % elongation (ductility). It can be clearly seen comparing all the heat treatment processes, optimum Combination of UTS, Yield Strength, % Elongation as well as hardness can be Obtained through austempering only.

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