Effect of Various Heat Treatment Processes on Mechanical Properties of Mild Steel and Cast Iron

[1]Vishal Singh, [2]Amresh Mishra, [3]Km. Sonam, [4]Rupma Gautam, [5]Aamir Alam Azmi
[1,2,3,4,5]Dept. of Mechanical Engineering, Buddha Institute of Technology Gida, Gorakhpur, UP, India

Abstract
In this paper, we studied about the mechanical properties like Toughness strength, hardness and microstructure for different steels such as low carbon steel and stainless steel and find out the effect of various heat treatment like annealing, quenching and normalizing on material properties through testing on samples using CHARPY Test.
First of all, we take metal rods are machined on shaper machine as per drawing of samples. Drawing is based for testing of samples on CHARPY Test then Heat treatments processes are done in muffle furnace on at temp 8000C and holding time is 1/2 hrs. Than we cooled as per different heat treatment. After that heat treated samples are used for testing of different material properties and different process. Result shows which heat treatment will be better for improving material properties of mild steel and cast iron.

Keywords
Mild Steel; Cast Iron; Annealing; Quenching; Normalizing; Toughness Strength; Hardness; Microstructure; CHARPY Test

I. Introduction

The heat treatment includes heating and cooling operations applied to any material in such ways as to produce desired mechanical properties (toughness strength, hardness, microstructure). Annealing, normalizing and quenching are the most important heat treatments often used to modify the mechanical properties of engineering materials particularly ferrous metal. Annealing is the type of heat treatment most frequently applied in order to soften iron or steel materials and refines its grains due toferrite-pearlite microstructure; it is used where elongations and appreciable level of tensile strength are required in engineering materials [3].
In normalizing, the material is heated to the austenitic temperature range and this is followed by air cooling.
This treatment is usually carried out to obtain a mainly pearlite matrix, which results into strength and hardness higher than in as received condition. It is also used to remove undesirable free carbide present in the as-received sample [1].
Steels are normally hardened and tempered to improve their mechanical properties, particularly their strength and wear resistance. In quenching, the steel or its alloy is heated to a temperature high enough to promote the formation of austenite, held at that temperature until the desired amount of carbon has been dissolved and then quench in oil or water at a suitable rate. Also, in the harden condition, the steel should have 100% martensite to attain maximum yield strength, but it is very brittle too and thus, as quenched steels are used for very few engineering applications.
By tempering, the properties of quenched steel could be modified to decrease hardness and increase ductility and impact strength gradually. The resulting microstructures are bainite or carbide precipitate in a matrix of ferrite depending on the tempering temperature. Steel is an alloy of iron with definite percentage of carbon ranges from 0.15-1.5%, plain carbon steels are those containing 0.1-0.25%. There are two main reasons for the popular use of mild steel and cast iron: It is abundant in the earth's crust in form of Fe_2O_3 and little energy is required to convert it to Fe. It can be made to exhibit great variety of microstructures and thus a wide range of mechanical properties. Although the number of steel specifications runs into thousands, plain carbon steel accounts for more than 90% of the total steel output. The reason for its importance is that it is a tough, ductile and cheap material with reasonable casting, working and machining properties, which is also simple heat treatments to produce a wide range of properties [3].
They are found in applications such as train railroads, beams for building support structures, reinforcing rods in concrete, ship construction, tubes for boilers in power generating plants, oil and gas pipelines, car radiators, cutting tools etc.
The objective of the present study is to investigate the effect of heat treatment (annealing, normalizing and quenching) on the mechanical properties of mild steel and stainless steel
The hardness of heat treated and untreated samples are determined using Rockwell Hardness testing machine using C scale (HRC). The purpose of this test is to make comparison of the hardness properties between the specimen
Microstructure examination of used metals is an important analysis to be carried out; it is very useful since it can provide important information about grain size, material properties and reliability

II. Experiment

A. Material Specifications

The first and foremost job for the experiment is the specimen preparation. The specimen size should be compatible to the Testing machine specifications. We purchased the First steel samples from local steel trader. The sample was Mild steel rod Grade Fe 415D (IS 1786:2008). It is one of the Indian standard specifications of the mild steel or soft steel. The second material purchased from market was Cast iron. The cast iron rod is made by molded cast iron metal.

B. Material Processing

The test sample is prepared for different type test of different dimensions. The steps adopted in specimen preparation are as follows-

1. Cutting aspecimen
2. Rough Grinding
3. IntermediatePolishing
4. Fine Polishing
5. Etching

Fig. 1: Charpy Test Specimen Preparation

C. Heat Treatment

The properties of metal and alloy can be changed by heating followed by cooling under definite condition to make them suitable for specific purpose or application. Steel can be hardened to resist cutting action and prevent abrasion. the rate of cooling and the manner of cooling are the controlling factor in heat treatment process. heat treatment not only increases the hardness but also increases the tensile strength and toughness. Different heat treatment processes are carried out in temperature controlled furnaces and oven here we use Electric Muffle furnace having higher heating temp. up to1200^{0}C as shown in fig. 3. There are various heat treatment processes, which we have adopted for testing, annealing, normalizing and quenching.

1. Annealing

The specimens were heated to a temperature of 750^{0}C. At 750^{0}C the specimens were held for 2 hours in furnace. Then the furnace was switched off so that the specimens' temperature will decrease with the same rate as that of the furnace. The objective of keeping the specimens at 750^{0}C for 2 hrs is to homogenize the specimen. The temperature 750^{0}C lies above recrystallization temperature. So that the specimens at that temperature gets sufficient time to get properly homogenized. The specimens were taken out of the furnace after 24 hrs. when the furnace temperature had already reached the room temperature.

Fig. 2: Electric Muffle Furnace

2. Normalizing

At the very beginning the specimen was heated around temperature of 790^{0}C. There the specimen was kept for 2 hours. Then the furnace was switched off and the specimen was taken out. 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 is called normalizing.

3. Quenching

The specimen was heated to the temp of around 800^{0}C and was allowed to homogenize at that temp for 2 hours. An water and oil bath was maintained at a constant temperature in which the specimen had to be put. After 2 hours the specimen was taken out of the furnace and directly quenched in the bath. 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.

Charpy Impact Testing: -

Charpy impact is practical for the assessment of brittle fracture of metals. An impact test signifies toughness of material that is ability of material to absorb energy during the plastic deformation. The Charpy test sample has 10x10x55mm^3 dimensions, a450 V notch of 2 mm depth and a 0.25 mm root radius will be hit by a pendulum attach opposite end of the notch as shown in

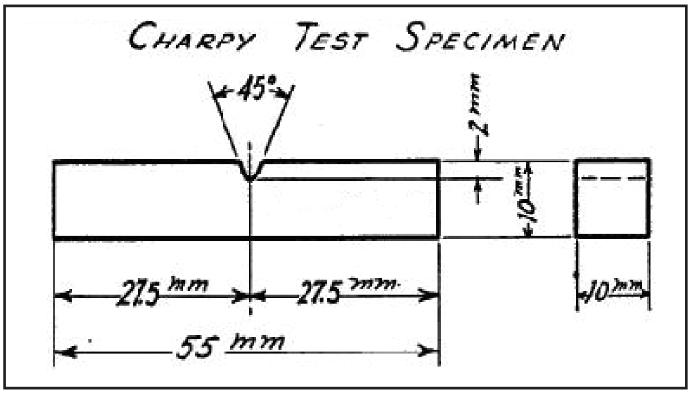

Fig. 3: Charpy Test Specimen Dimensions

III. Result and Discussion

The result indicates that the specimen hardness and toughness are proportional to amount of martensite and amount of martensite depends on intercritical annealing temperature Result shows that Toughness of mild steel for Normalizing heat treated specimen is larger than other heat treated or without heat treated specimens. Toughness for cast iron specimen is more in without heat treated than heat treated specimen. Result shows that hardness of mild steel for Normalizing heat treated specimen is larger than other heat treated or without heat treated specimens. Hardness for cast iron specimen is more in without heat treated than heat treated specimen.

IV. Conclusion

Following points have been pointed out in research:

- Toughness and hardness have best results in
- normalized heat treated mild steelspecimen than all other specimens of mild steel
- In cast iron specimens, Annealing heat treatment gives better results than other heat treatment process.
- In Mild Steel specimens, Normalizing heat treatment gives better results than other heat treatment process.
- Normalizing treatment produces a homogeneous structure of fine pearlite of cast iron.
- Oil is preferred as a quenching medium to minimize stresses and quench cracking, butwater or brine may be used for simple shapes

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Vishal Singh received my B.Tech. degree in Mechanical Engineering from Buddha Institute of technology Gida Gorakhpur Uttar Pradesh India, affiliated to Dr. A.P.J. Abdul Kalam Technical University, Lucknow2016. I am student in Buddha Institute of Technology Gida Gorakhpur Uttar Pradesh India in 2012 to 2016 respectively. My research interests include material science, manufacturing science.