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Effect of Tensile Properties on Heat Treated 0.38% Medium Carbon Steel

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Abstract

The experiment was conducted using 0.38% carbon in steel it was quenched in oil after austenizing and then tempered from 250oC. The experiment was conducted it was hardened at 900oC followed by tempering. The steel exhibited the highest strength when oil quenched and tempered. The steel acquired toughness and strength in oil quenched conditions. The steel acquired tensile stress increased where as elongation decreased.

Keywords: Oil quenching, Mechanical Properties, Tensile Properties, Toughness, Ductility.

Introduction

This document is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website. The heat treatment processes is to modify the microstructure and consequently change the properties (1) of the work piece throughout. It is possible to alter the properties of steel by heating and cooling steel under controlled condition. The term heat treatment is used to indicate the process in which the heating and cooling of steel is involved to change the mechanical properties of steel [2]. Heat treatment techniques include annealing, hardening, tempering, [3] case hardening, normalizing and so on. But this paper concentrates on hardening and tempering. A metal must be heated into austenitic crystal phase and then quickly cooled in the quenching media such as water, quenching oil etc. The ultimate tensile strengths are steadily decreased by increasing tempering time and temperature. The ductility of the samples is measured by the tensile test. The percent of elongation is an upward trend in the increment of tempering time and [4] temperature. This brittleness is therefore removed by tempering. Tempering results in a desired combination of hardness, ductility, toughness, strength and structural stability. The strength of the steel may be improved by quenching followed by tempering [5] with some compromise on toughness. The faster cooling rate of water resulting in highest free carbon in martensite [6]. Furthermore, the presence of fine dispersion of small particles in the pro-eutectoid ferrite and pearlitic ferrite, which hinder the dislocation movement, may have also contributed to the higher Rockwell hardness number of the water quenched sample. Heat treatment involves the application of heat to a material to obtain desired material properties .During the heat treatment process; the material usually undergoes phase microstructure and cryptographic changes. The purpose of heat treating carbon steel is to change the mechanical properties of steel, usually ductility, hardness, Yield strength, tensile strength and impact resistance. The standard strengths of steels used in the structural design [7] are prescribed from their yield strength. Most engineering calculations for structure are based on yield strength. Heat treatment operation is a means of controlled heating and cooling of materials in order to effect changes [8] in their mechanical properties.

Heat treatment is also used to increase the strength of materials by altering some certain manufacturability objectives especially after the materials might have undergone major stresses like forging and welding. Heat treatment is a combination of timed heating and cooling applied to a particular metal or alloy in the solid state in such ways as to produce certain microstructure and desired mechanical properties (hardness, toughness, yield strength, ultimate tensile strength, Young's modulus, percentage of elongation and percentage of reduction). Annealing, normalizing, hardening and tempering are the most important heat treatments often used to modify the microstructure [9] and mechanical properties of engineering materials steels. The heat treatment improves the mechanical properties (such as tensile strength, yield strength, ductility, corrosion resistance and creep rupture). These processes are also help to improve [10] machining effect, to improve metals and make them to versatile. At the time of quenching, the thermal and transformational stresses were arrived. In general, the greater stresses result in distortion and risk of cracking. Also , the carbon steel will exhibit a much lower susceptibility to quenching cracking increases progressively with increasing carbon content. The alloying elements in quenching[11] is to permit slower rates of cooling for a given section, thereby generally decreasing the thermal gradient end, in turn, the cooling stress. In general, the use of a less drastic quench results in lower distortion and greater freedom from cracking.

The transformation of austenite to martensite by diffusion less shear type transformation in quenching is also responsible for higher hardness obtained and this properly is attributed to the effectiveness of the interstitial carbon in hindering the dislocation motion. The hardness of the steel increases with cooling rate and also with increasing pearlite percentage which increased as the percentage martensite increases. The reason being that martensite is one of the strengthening phases in steel. The increase in the hardness was due to the delay in the formation of pearlite and martensite at a higher cooling rate. Kempster stated in 1976 that water should be used as quenching if plain carbon steel is to have a high value of hardness [12].

The effective mechanical properties such as tensile strength, yield strength, toughness, elongation, which is suited to manufacturing of parts to the different applications. Mechanical properties of these steel can further be improved by different heat treatment procedures which include normalizing, hardening and tempering. The attainment of the hardness to the metals is due to the different types of quenching medium such air, water, oil, etc. the heat treatments of these steels have been carried out Aim of the present work is to improve the mechanical properties by various quenching medium in heat treatment in order to improve the tensile behaviour in a steel and then to compare the properties with the others

Material And Experimental Techniques

A. Specimen Preparation

The material studied in the work was a 0.38% plain carbon steel. The specimens for heat treatments were obtained from a 20 mm diameter bar and the height of the specimens was approximately 600 mm [As per ASTM STD.] The specimen for heat treatment was first austenite at 900^{o}C in a Vertical force air-circulating furnace for one hour and then quenched in air, water, oil at room temperature range of 250^{o}C.

B. Heat Treatment Processes

After preparation of the specimen samples from the low carbon steel, it was taken to the furnace for the heat treatment operations. To commence the operation, the furnace was initially calibrated to determine the furnace operating temperature based on the pre-set furnace temperature. Representative samples of low carbon steel were subjected to heat treatment processes. The various forms of the heat treatment processes were stated below.

C. Hardening Process

The specimens to be hardened were placed inside the furnace and heated to a temperature of 900^{0}C.At this temperature; there is transformation of the steel to austenite. The total heating time should be just enough to attain uniform temperature through the section of the part to enable not only the completion of phase transformation, but also to obtain homogeneous austenite.

D. Tempering Process

After the hardening of the hardened specimen is follow by the tempering. The tempering of the quenched specimens was also carried out in a muffle furnace for 1 hour. The selective steel is tempered in the temperature range of 250^{0}C.The tempering involves under the temperature of 250^{0}C for tempering time of 60 minutes respectively.

Determination of Mechanical Properties

The mechanical property depends largely upon the various forms of heat treatment operations and cooling rate [13]. Mechanical Properties of the treated and untreated samples were determined using standard methods. After the specimens had been heat treated, the specimens were loaded into a 2000-Kg Auto instrument Universal Testing Machine. The tensile test is widely used for measuring the stiffness, strength and ductility of a material [14]. The tensile test were carried out on them to determine the mechanical properties of the steel and compare it with the non heat treated specimen which was also subjected to the same tensile test. Yield strength, tensile strength, and % of elongation were determined. The various heat treated samples were taken for the tensile test in the universal testing machine. The tensile test was carried out on them to determine the mechanical properties of the steel.

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A. Tensile Strength Testing

After the successful heat treatment operation, the various heat treated samples were taken for the tensile test. The tensile tests were conducted by using an Auto instrument Universal Testing Machine. Each of the specimens was inserted one after the other into the machine jaws and having fastened the specimen properly at both ends, tensile test up to the fracture limit was carried out. The heat treated specimens were checked and to obtain the elongation, ultimate tensile strength, yield strength.

Result And Discussions

TABLE: I CHEMICAL COMPOSITION OF 0.38% MEDIUM CARBON STEEL

C	Mn	Si	P	S	Mo
0.38	0.76	0.24	0.016	0.029	0.17

Tensile properties of 0.38% carbon steel austenized at 900c and then quenching in oil media. The results of tensile testing of the received oil quenched specimens of the same material are reported below.

TABLE: II TENSILE PROPERTIES OF 0.38% STEEL AUSTENIZED AT 900^{O}C

Hardening Temperature	Quenching medium	Soaking time	Yield stress (Mpa)
As received			295.463
900^{0}C	Oil quench	1 hr	310.463

Tensile properties of 0.38% of carbon steel austenite at 900^{o}C, oil quenched and tempered. The results on yield strength of the specimen which were oil quenched and then tempered at 250^{o}C are given in the figure below:

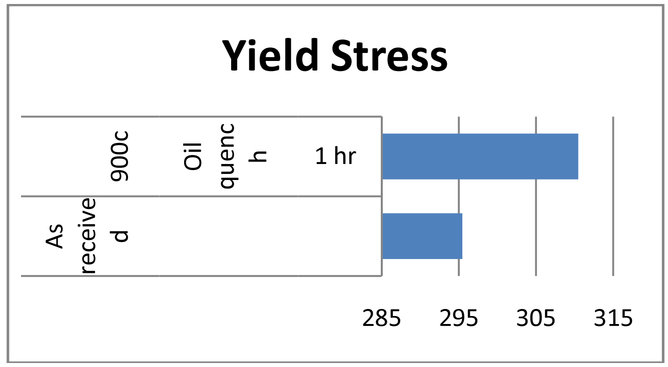

Figure 1: Yield properties (Mpa)of 0.38% steel austenized at 900^{o}C

TABLE: III TENSILE PROPERTIES OF 0.38% STEEL AUSTENIZED AT 900^{O}C

Hardening Temperature	Quenching medium	Soaking time	Tensile stress(Mpa)
As received			378.227
900^{0}C	Oil quench	1 hr	397.86

Tensile properties of 0.38% of carbon steel austenite at 900^{o}C, oil quenched and tempered. The results on tensile testing of the specimen which were oil quenched and then tempered at 250^{o}C are given in the figure below:

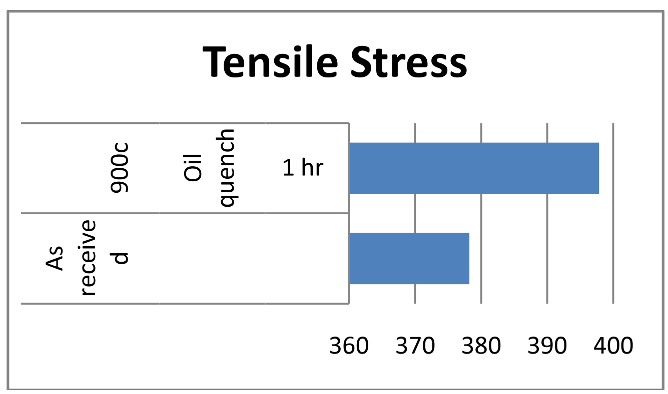

Figure 2 :Tensile properties(Mpa) of 0.38% steel austenized at 900^{o}C

TABLE: IV TENSILE PROPERTIES OF 0.38% STEEL AUSTENIZED AT 900^{O}C .

Hardening Temperature	Quenching medium	Soaking time	Elongation %)
As received			39.96%

900^{0}C	Oil quench	1 hr	31.57%

Tensile properties of 0.38% of carbon steel austenite at 900^{o}C, oil quenched and tempered. The results on elongation of the specimen which were oil quenched and then tempered at 250^{o}C are given in the figure below:

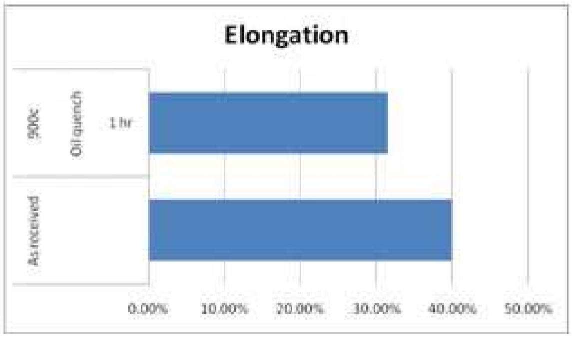

Figure 3 : Elongation properties (%) of 0.38% steel austenized at 900^{o}C.

TABLE: V TENSILE PROPERTIES OF 0.38% STEEL AUSTENIZED AT 900^{O}C

Hardening Temperature	Quenching medium	Soaking time	Toughness (J)
As received			60.7812
900^{0}C	Oil quench	1 hr	57.2558

Tensile properties of 0.38% of carbon steel austenite at 900^{o}C, oil quenched and tempered. The results on toughness of the specimen which were oil quenched and then tempered at 250^{o}C are given in the figure below:

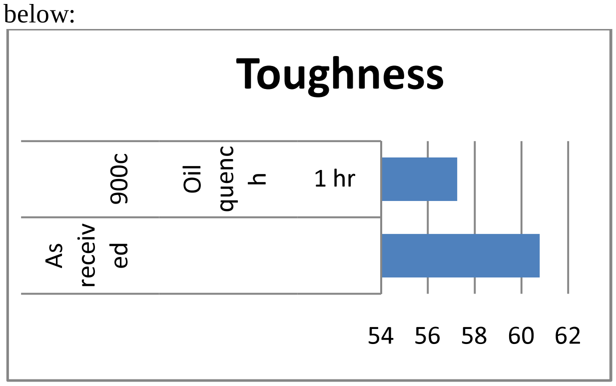

Figure 4: Elongation properties (J) of 0.38% steel austenized at 900^{o}C.

The data clearly shows an improvement in percentage elongation and toughness. A decrease in yield strength and tensile strength is observed.

Conclusion

From the various experiments carried out, the following observations were made.

1. The mechanical properties vary depending upon the various heat treatment processes.
2. Hence depending upon the properties and application required we should go for a suitable heat treatment process.
3. In the oil quenched condition, the steel exhibited higher yield strength and tensile, as compared to the as received properties.

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