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Evaluation of Surface Hardness Behavior of Heat-treated 35Mn6Mo3 and C35MN75 Steel

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Abstract— The mechanical properties of medium carbon steel (35Mn6Mo3) were investigated. The hardness was tested by Rockwell hardness tester. Samples of medium carbon steel were examined after heating between 900^{0}C-980^{0}C in a vertical force air-circulating furnace and the tempering temperature was 250^{0}C. The hardness values of the quenched samples were relatively higher than those of the as-cast samples. Samples quenched in oil displayed better properties compared with that of water-quenched samples. Water quenched steel produced its best properties in hardness; while oil quenched steel arrived lower hardness compared to water quenching.

Keywords— Medium carbon steel, quenching, hardness, Rockwell method, tempering.

I. INTRODUCTION

The engineering materials are classified as metallic and non-metallic, Metallic is grouped into ferrous and non-Ferrous materials [1]. For Ferrous alloys, iron is the principal constituent, include steel and cast iron. To obtain required metal properties like brittleness, hardness, strength, toughness it is subjected to heat treatment processes. The steel grades are usually required for the production of body parts of vehicles, trucks, and machineries [2]. Steel is an alloy of iron with definite percentage of carbon ranges from 0.15-1.5%, plain carbon steels are those containing. Although the number of steel specifications runs into thousand, 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 cheep material with reasonable [3] casting, working and machining properties , which is also amenable to simple heat treatments to produce a wide range of properties. Hardness and other mechanical properties of plain carbon steels increase with the rise in concentration [4] of carbon dissolved in austenite prior to quenching during hardening heat treatment which may be due to transformation of austenite in to martensite. Quenching in water resulted in higher tensile strength and hardness possibly due to the formation of martensitic structure after quenching. Martenitic structure, which has an experimental effect on toughness, is also produced during continuous [5] water quenching. The steel developed by quenching followed by tempering process at a desired temperature [6] has the highest ultimate tensile strength with excellent combination of impact strength, ductility and hardness which is very attractive for structural use.

II. MEDIUM CARBON STEELS

Plain carbon steels are changed on the basis of their carbon content as their major alloying element in carbon. Steels with carbon content varying from 0.25% to 0.65% are classified as medium carbon, while those with carbon content less than 0.25% are termed low carbon. The carbon content of high carbon steels usually ranges within 0.65 – 1.5%.Medium carbon steels are used in mining equipment, and tractors. In addition, machined parts such as bolts, and concrete reinforcing bars are made of this class of carbon steel. Gears, wire rods, seamless tubing, hot-rolled/cold-finished bars and forging products are more objects constructed from medium carbon steel [7]. Medium carbon steel is made up of between 0.3% to 0.6% carbons. Steels with enough carbon and alloy content will direct harden [8]. They can be heated to the austenitizing temperature and quenched to form hard martensite. There is a family of processes that can be used for direct hardening. If steel does not have sufficient carbon and alloy content to allow direct hardening, another family of hardening processes applies diffusion treatments. These processes add chemical species (elements) to the steel so that the surface will harden. They may or may not require a quench to complete the hardening. An in increasing the carbon concentration to 0.55% in TRIP-type steels makes possible to obtain very high strength properties without a deterioration of the ductility, compared to most often used steels containing about 0.2%.

III. HEAT TREATMENT PROCESSES, QUENCHING AND TEMPERING PROCESS

Heat treatment involves the application of heat, to a material to obtain desired material properties [9]. During the heat treatment process, the material usually undergoes phase microstructural 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 [10] are prescribed from their yield strength. Most engineering calculations for structure are based on yield strength. 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 [11] 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 [12] machining effect, to improve metals and make them to versatile.

The prepared samples were heated from 860 to 900^{0}C and soaked for 60 minutes using a vertical-force-air-circulating furnace. The test samples were quickly taken out of the furnace after each of the heat treatment temperatures and quenched in air, water and oil separately. Surface morphologies of the quenched samples were examined and hardness test were also carried out on each of the samples

The desired properties and structures depend on tempering temperature and time .The tempering of the quenched specimens was also carried out in a muffle furnace for 1 hour. The following four stages define the strength, hardness and toughness required in service application. First stage of tempering: 250^{0}C, Second stage of tempering: 350^{0}C, Third stage of tempering: 450^{0}C, Fourth stage of tempering: 550^{0}C.

IV. TEST SPECIMEN PREPARATION

A set of specimens was prepared for hardness test. The specimens were prepared for 20 mm diameter using machining operations. The chemical composition of medium carbon steel samples used for this investigation is given in the following Table.

Table 1. Chemical composition of the Medium carbon steel sample

Chemical Elements	C	Si	Mn	P	S
35Mn6Mo3 Steel	0.30	0.10	1.30	0.035	0.03 5
C 35 MN 75 Steel	0.35	0.15	0.75	0.035	0.03 5

V. HARDNESS TEST AND HARDNESS VALUE

The hardness of the specimen is indicated by the depth of penetration of the indenter on the steel specimen. Rockwell hardness method was used for the determination of the hardness of the quenched samples. Each of the test specimens was flatten after the different heating and quenching regimes and then mounted on the anvil. The specimens were brought in contact with the indenter and allowed to rest for a dwell time. The hardness of a specimen is indicated by the penetration of the indenter on the said specimen and displayed by the machine. Hardness was read directly from the calibrated dial gauge of the machine. Average values were recorded after repeating the test for each one of the test specimens.

Following figure shows the mechanical properties of the quenched steel samples compared with the un-quenched samples at different heat treatment temperatures. The hardness measurements presented in Table:3 show that water quenched samples had higher Rockwell hardness number compared to oil quenched samples. This may be due to the faster cooling rate of water resulting in highest free carbon in martensite. Furthermore, the presence of fine dispersion of small particles in the pro-eutectoid ferrite and pearlitic ferrite, which will hinder the dislocation movement, may have also contributed to the higher Rockwell hardness number of the water quenched sample.

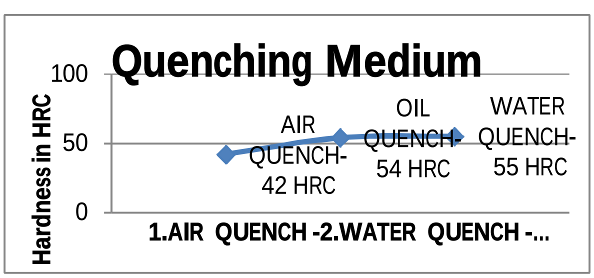

Figure: Effect of Hardening Rates on – All Quenched Media

The results of hardness testing of the specimens who were hardened with air quenched and then tempered at 250^{0}C, 350^{0}C, 450^{0}C and 550^{0}C are given in the above figure. The data clearly show an improvement of hardness after the hardening; where as a decrease in hardness is observed with increase in tempering temperature.

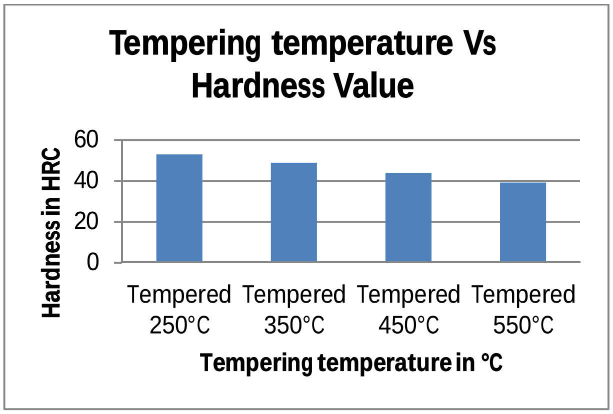

Figure: Hardness Vs Tempering temperatures of 250^{0}C to 550^{0}C

The mechanical properties of tempering samples (tempered at 250^{0}C, 350^{0}C, 450^{0}C and 550^{0}C) showed that the hardness value in HRC is noted as 53, 49, 44, and 39 respectively. The results of the specimens which were hardened with oil quenched and then tempered at 250^{0}C, 350^{0}C, 450^{0}C and 550^{0}C are expressed graphically in the above Figure.

VI. CONCLUSION

The properties of the heat-treated medium carbon steel have excellent values in terms of hardness when quenched and tempered. Quenching in water resulted in higher hardness. In the hardness point of view ,more the hardness in water quenching steel which is compare to oil quenching steel. It has been established that oil can also be used as a quenching medium for medium carbon steel because, oil cooling improves the ductility of the steel because of its lower cooling rate compared with water. Also the hardness is more in the case of oil Quenching compare with air quenching steel. In all the quenching steel, the rate of tempering temperatures start from 250 ^{0}C, 350 ^{0}C, 450 ^{0}C and 550 ^{0}C. With reference to increase the tempering temperature tends to decrease the hardness simultaneously. In the above tempering temperature range, toughness of the steel gradually increased with increase in temperature. The tempered samples gave an increase in tensile strength and hardness. Comparing the mechanical properties of tempering sample with hardened sample, it was found that there was decrease in toughness and percentage of elongation.

REFERENCES

[1]. W.D.Cellister, JV adapted by R.Balasubramaniam, Material Science and Engineering, 2007, Wiley India Pvt.Ltd publication, New Delhi, India.

[2] B.Gajda, A.K.Lis, Intercritical Annealing with Isothermal Holding of Trip CMn AlSI steel, Journal of Achievements in materials and manufacturing, Vol.20, Issues 1-2, Pp439-442.

[3] Dell, K.A., 1989, Metallurgy Theory and practical Text book, American Technical Society , Chicago , pp.351-353.

[4] Thelning, E.E. 1984. Steel and Its Heat Treatment. 2nd ed. Butterworth, London, England, U.K.

[5] Madariaga, I.; Gutierrez, I.; Garcia de Andras, C. ; and Capdevila , C. . 1999. Acicular ferrite formation in medium carbon steel with a two stage continuous cooling. Scripta Materialia 41 (3); 229-235.

[6] Daramola O.O Adewuyi B.O, Oladele I.O "Effects of Heat Treatment on the Mechanical Properties of Rolled Medium Carbon Steel." Journal of Minerals & Materials Characterization & Engineering, Vol.9, N0.8, pp.693-708, 2010

[7] Material Selection- Jacob Klinginsmith, Russ Glass- Naomi Sanders, Becky Moffitt."The Science and Engineering of Materials "(Fourth Edition): Donald R.Askland and Pradeep P.Phule: Brooks/Cole copyright 2003.

[8]Kenneth G.Budinski, Michael .K.Budinski, "Engineering Materials- Properties and Selection", PHI Learning Private Limited, New Delhi, 2009, pp398

[9] Mamoru, o. Yukito, T; Hitoshi, k ; and Yuji ; F (1990).Development of New steel plates for building structural use , Nippon Steel Technical Report , No 44 pp.8-15.

[10] Adnan, calik. Effect of cooling rate on Hardness and Micro structure of AISI 1020, AISI 1040 and AISI 1060 steels. Int .J. of Physics Sciences, Vol. 4(9), pp. 514-518, 2009.

[11] Rao. P.N 2011. "Manufacturing Technology, "Vol.1, the McGraw Hill Companies –New Delhi, 2011, pp.11-53.

[12] Lakhtin.Y,'Engineering Physical Metallurgy, "MIR Publishers, Mascow, 1998, pp.14-55