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Effect of quenching medium on hardness of three grades of steel - AISI 1040, 1050 and 4340

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Abstract - Medium carbon steel contains higher percentage of carbon and thus gives better response to the heat treatment processes. Also the hardness of medium carbon steel can be improved by quenching through different quenching mediums. The present investigation emphasizes on improving the hardness property of three different types of steel AISI 1040, 1050 and 4340 having varying carbon content. Hardening was carried out for the selected steels through different quenching mediums like water, oil, brine and air for different soaking time of 30, 60 and 90 minutes at 850°C. The hardness values under all the processes have been measured to show the comparison in this investigation.

Keywords – Carbon Steel, Hardness, Mechanical property, Medium Carbon Steel, Quenching media

I. INTRODUCTION

Carbon steel also called plain carbon steel which is an alloy of iron and carbon, formed by adding small amount of carbon content (0.2% and 2.1% by weight) to iron depending upon the type where other elements are present in too small quantities to affect the properties. Many properties like hardness, ductility, tensile strength, malleability and microstructure of steel can be adjusted by different amounts of carbon content.

Heat treatment is defined as the process of heating and cooling of metals at a certain rate for specific time to alter their physical and mechanical properties. Generally, all the heat treatment processes consist of three stages: heating of the material, holding at that temperature for sufficient time and then cooling, usually to the room temperature. The conditions of heat treatment can modify the microstructure, mechanical and physical properties of steel within a wide range. Various types of heat treatment processes are used to modify the surface and structural properties of steel and carbon content of steel plays an important role for controlling the properties of steel. Practically, all steel respond to one or more type of heat treatment. This is the only reason steel have been so extensively used in manufacturing sector in twentieth century.

II. EXPERIMENTAL PROCEDURE

From the family of plain carbon steel, three different grades of steel i.e. AISI 1040, AISI 1050 and AISI 4340 were collected and around twenty five test specimens were prepared from each grade by different machining processes. The chemical composition of all samples was tested by spectroscopic analysis according to ASTM E 415-99a and the results are as follows:-

Table I Composition of Steels

| Steel Grade | C | Si | Mn | Cr | Mo | Ni | Cu | Al | P | S | V | Fe |
|-------------|------|------|------|-------|------|------|----|----|-------|-------|---|---------|
| AISI - 1040 | 0.40 | 0.23 | 0.65 | 0.054 | - | 0.13 | - | - | 0.09 | 0.030 | - | Balance |
| AISI - 1050 | 0.48 | 0.25 | 0.61 | 0.455 | - | | - | - | 0.040 | 0.050 | - | Balance |
| AISI - 4340 | 0.38 | 0.20 | 0.73 | 0.70 | 0.25 | 1.87 | - | - | 0.035 | 0.040 | - | Balance |

A. Preparation of test specimens

The test specimens for hardness measurement were prepared as per ASTM standard is given below.

Length – 25 mm

Width – 10 mm

Thickness – 10 mm

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Fig. 1 Prepared steel samples

B. Heat Treatment of AISI 1040, 1050 and 4340 samples

Eight samples from each grade were taken in a batch. The samples were kept inside the muffle furnace for three different durations 30 min, 60 min and 90 min at 850°C. Two of each sample was quenched in four different quenching mediums i.e. water, oil (Quenching oil-11), brine (ratio of 125 gm salt + 500 ml water) and air. After 15 minutes, the steel samples were taken out from quenching bath and cleaned by cloth. Then the hardness of those samples were measured at five different locations and average of them was taken. Finally the comparison was shown between the hardness values of all quenching mediums.



Fig. 2 quenching mediums

III. RESULTS AND DISCUSSION

A. Hardness of quenched steel

The hardness of the three types of steel i.e. AISI 1040, 1050 and 4340 increases after quenching through different mediums due to transformation of martensite from austenite. The comparison between the hardness has been shown in Table II.

Table II Hardness values in RHB

| Material | Initial Hardness (RHB) | Hardness after soaking for different time intervals (RHB) | | | | | | | | | | | |
|-----------|------------------------|---|-------|-----|-----|------------------|-------|-----|-----|------------------|-------|-----|-----|
| | | 30 min | | | | 60 min | | | | 90min | | | |
| | | Quenching Medium | | | | Quenching Medium | | | | Quenching Medium | | | |
| | | Water | Brine | Oil | Air | Water | Brine | Oil | Air | Water | Brine | Oil | Air |
| AISI 1040 | 79 | 117 | 118 | 101 | 98 | 113 | 114 | 100 | 94 | 111 | 111 | 98 | 93 |
| AISI 1050 | 83 | 101 | 102 | 89 | 87 | 101 | 101 | 84 | 80 | 98 | 99 | 79 | 72 |
| AISI 4340 | 89 | 106 | 108 | 100 | 91 | 100 | 103 | 95 | 87 | 93 | 84 | 81 | 75 |

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Table III Effect of Temperature and time on hardness of steel samples after quenching

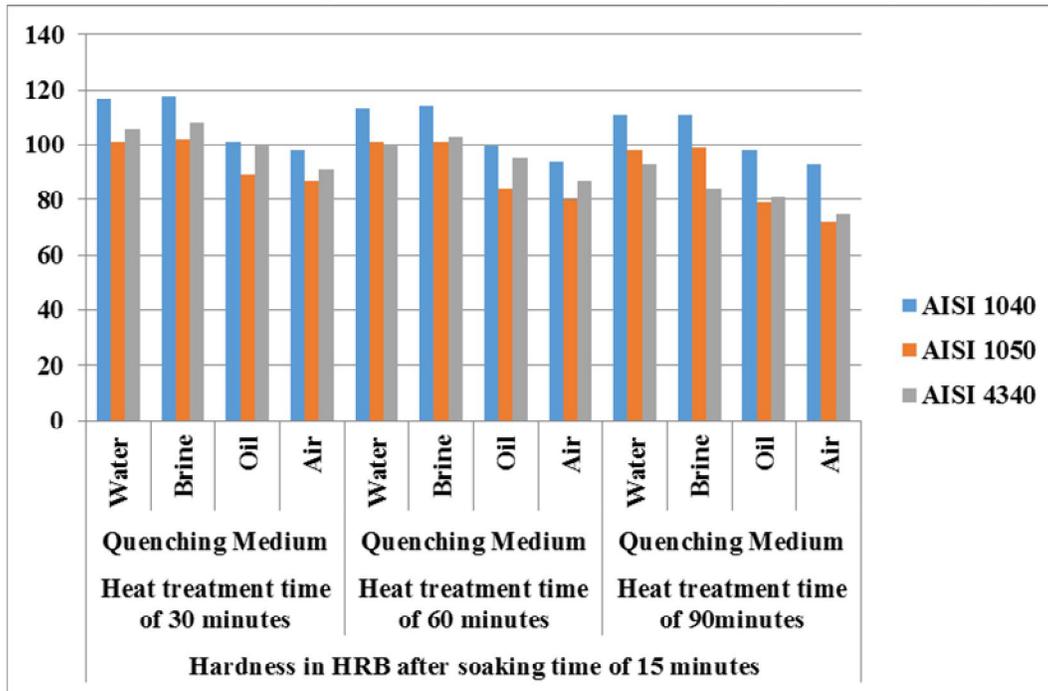


Fig. 3 Graph of Hardness in different quenching mediums

IV. CONCLUSION

Based on the results obtained the following conclusions have been drawn:

- A. For all steels, higher hardness values have been obtained when quenched in salt water (Brine) after 30 minutes of heat treatment at 750°C.
- B. The lowest hardness values have been obtained under normalizing condition.
- C. The value of hardness decreases with retention of sample in the furnace for longer period.

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