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THE EFFECTS OF QUENCHING MEDIA ON THE MICRO-STRUCTURAL, HARDNESS AND IMPACT PROPERTIES OF MEDIUM CARBON STEEL

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ABSTRACT
The effect of quenching media on the micro-structural, hardness and impact properties of medium carbon steel has been studied using air, water and engine oil as quenchants. Mild steel was chemically analyzed and observed (micro-structure) as received and when quenched in the respective media. These were carefully subjected to hardness and impact tests accordingly with a view to ascertain its hardness and impact strength. The mild steel had higher hardness of 260 BHN in water and higher impact strength of 86.56 J in engine oil. The mild steel is identified as medium carbon steel.

Keywords:
Hardness, Impact, Quenching media, Medium carbon steel, Micro-structure.

INTRODUCTION

The performance and service requirements of steel are mostly achieve through heat treatment operations. Heat treatment is the controlled heating and cooling of metals to change their physical and mechanical properties without changing the components shape and size. It is really a process utilized to change certain characteristics of metals and alloys in order to make them more suitable for specific applications [1]. Heat treatment involves the application of heat to a metal to obtain desired material properties (e.g. mechanical, corrosion, electrical etc). During this process the material undergoes phase micro-structural and crystallographic changes [2].
The purpose of heat treating carbon steel is to change the mechanical properties of steel e.g. hardness, ductility, yield strength, tensile strength and impact resistance. The standard strengths of steels used in the design of structures are prescribed by their yield strengths. It is necessary for engineers to have a general understanding of the common methods of testing properties of metals from engineering point of view in selecting them for design purpose. Mechanicalproperties and micro-structures of metals describe their behavior under mechanical and physical usage [3].
Plain carbon steels are widely used for many industrial applications and manufacturing on the account of their low cost and ease of fabrication [4]. They are classified on the basis of their carbon content as their major alloying element [1]. Steels with carbon content (0.25-0.65%) are classified as medium carbon steels while those within the range of (0.65-1.5%) are high carbon steels. Steels with less than 0.25% carbon are termed low carbon steels.
The mechanical strength of steel can be improved by quenching in appropriate media [5]. However, the major influencing factors in the choice of quenching medium are the kind of heat treatment, composition of the steel, the size and shape of the parts [6]. Medium like water, ash, brine solution, furnaces are often use as treatment/quenching media.

MATERIALS AND METHODS

The materials used for this study included virgin Mild steel which was purchased at Ibadan iron market, distilled water to eliminate micro-organism activities, uncontaminated engine oil (purchased unused) and dry air.
The chemical composition of the mild steel was determined using a mass spectrographic analyzer (computerized type). The reason for the chemical analysis was to ascertain its type or identification as mild steel. The micro-structure of the mild steel (as received) and when quenched in Air, Water and Engine oil, was observed using digital metallurgical microscope and the results noted.
The mild steel samples were machined to the required standard specified as to conform to hardness and impact test respectively. A 3×4 ×2 experimental design (3 average samples × 4 media including the as received × 2 mechanical properties (hardness and impact)) totaling 24 experimental samples were used to study the effect of

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heat treatment on them respectively. The samples (not inclusive the as received) were slowly heated to the temperature of 850 ^{0}C and allowed to soak for 30 minutes for proper saturation as a standard procedure. The samples were then quickly removed from the furnace and quenched in the media (air, water and engine oil) respectively for another 4 hours as required.
The hardness test was done using the brinel hardness method expressed and computed using (1).

$$BHN = \frac{2p}{\pi D\left(D - \sqrt{D^2 - d^2}\right)} (1)$$

where BHN= Brinel Hardness Number, p = Applied load in Newton (N), D = Diameter of steel ball (mm) and d = diameter of impression/indenter (mm).
The impact test was done using the izod method where a striking hammer suspended as a pendulum on a ball bearing strikes the specimen at the notched face when released from a fallen angle to a fixed position (static vice). The energy absorbed during breaking is given by the difference between the angle through which the pendulum was released and that which it has reached after breaking the specimen. The energy absorbed was noted and recorded.

RESULTS AND DISCUSSION

The result of the chemical composition of the mild steel is presented in Table 1 and the micro-structural observations are presented in Figure 1. The percentage carbon contained in steel is about 0.25 as shown in Table1. This is in agreement with the findings of [4] that the steel is medium carbon steel. The micro-structure of the steel as received, shown in Figure 1(a) shows a recrystallized ferrite structure with "patches"/white phases. When quenched in air, the micro - structure is shown in Figure 1(b). It is a pearlite structure with ridges with a pearlite look. For the sample quenched in water, the micro-structure is shown in of Figure 1(c). It has a martensite look with needle like impression squeezed together (dark spots) pined points. The micro-structure shown in Figure 1(d) represents the observation for the sample quenched in engine oil. It shows a cementite with white country road consisting of noodles of graphite (white balls) retained in dark austenite.

Table 1: Chemical composition of Medium carbon steel

Element	**Average Content**	**Element**	**Average Content**
C	0.253	W	0.001
Si	0.242	As	0.004
S	0.038	Sn	0.010
P	0.031	Co	0.008
Mn	0.697	Al	0.003
Ni	0.057	Pb	0.000
Cr	0.122	Ca	-
Mo	0.012	Zn	0.005
V	0.002	Fe	98.233
Cu	0.104		

The results of the tests for the mechanical properties (hardness and impact tests) of mild steel are presented in Table 2. The results of hardness value and impact strength (Table 2) reveal that the (as received) samples have

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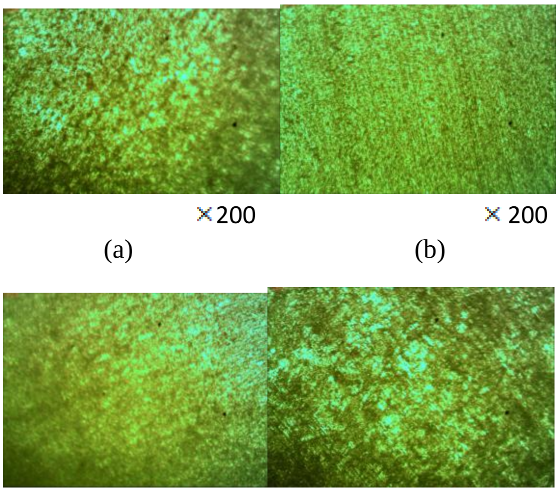
145 BHN and 47.70 J as hardness value and impact strength respectively. As the samples were quenched in air, water and engine oil, the respective average hardness values increases from 121, 131 and down to 260 BHNs. For the average impact strength, these increases steadily from 62.46, 74.12 and 86.56 J accordingly.



×200 ×200
(a) (b)

×200 ×200
(c) (d)

Fig. 1: Micro-structure of mild steel samples (a) as received, (b) quenched in air, (c) quenched in water and (d) quenched in engine oil

Table 2: The Hardness and Impact strengths of the mild steel

Sample/ quenching media	Averaged hardness (BHN)	Averaged impact strength (J)
As received	145	47.70
Air	121	62.46
Water	**260**	74.12
Engine oil	131	**86.56**

CONCLUSION

Based on the experimental results/observations obtained the following conclusions are drawn:

- That the mild steel bar is medium carbon steel.
- The micro-structures of the steel are: as received is ferrite with white patches when quenched in air it is pearlite with ridges like structure, when quenched in water it is martensite with squeezed needle pined dark sports and when quenched in engine oil it is cementite structure with graphite white balls retained in austenite.
- The average hardness and impact strength revealed that water quenched steel are harder (260 BHN) and for the impact strength engine oil quenched steel had the highest strength (86.56 J).

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