ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT025

# Effect of Different Tempering Media on Fracture Toughness and Mechanical Properties of Carbon Steel

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**Abstract:- In this study, the effect of different thermal carbons on the impact resistance of heavy carbon, which contains 0.4% of. The focus was on how the resulting biochemistry affects the microstructure of the steel, and thus its mechanical properties. Steps: Impact test before heat treatment: Charpy impact test was performed on pre-impact specimens before any specimen was made. This test helps to determine the original impact of the steel without any modification in its microstructure. Tempering procedure: After that, it was further investigated by exposing it to high temperatures and then cooling it rapidly. This method is for market formation, which is a must. It was retested after tempering. The results showed a significant increase in the shock cases after tempering due to the formation of the texture which increased the strength of the specimen. Flame tempering (surface heat treatment): In this type of treatment, only the surface is heated with a flame and cooled rapidly, which results in the formation of a strong martensite texture on the surface, while the core of the specimen remains softer. When tested, it did get shock, but the amount of increase that occurred with full shock was not reduced. The reason for this is that the hardening in God is only on the surface while the core of the eye remains flexible, which leads to a reduction in contrast. Carburizing (surface heat treatment): Carburizing treatment is performed on some samples, which is a method that involves adding carbon to the outer surface of the fulminate and cooling it rapidly, resulting in a solid, hard material. When performing the shock test, it did get a shock that improved, but a case like flame hardening, you did not have very many shocks in full hardening.**

***Keywords:-*** *Hardening , Impact, Cast, Heat Treatment, Fracture Toughness.*

## I. INTRODUCTION

The industrial importance of iron and its alloys is due to many factors, including the availability of iron ores in the form of: In addition to the ease of extracting iron and its ores, there is also the possibility of controlling the physical and chemical properties of iron alloys by adding alloying elements to them. Iron alloys are characterized by with good formability, workability and castability, in addition to the ability to control properties. Mechanical, especially by thermal treatments [1]. Pure iron has no industrial application, so it is mixed with carbon to form what is called Steel, which has high mechanical, thermal, physical and chemical properties, has become a necessity in today's industry. Depending on the percentage of carbon added to iron, a large number of types of steel are formed, such as carbon steel, cast iron and steel. Alloy and other types of steel [2]. Carbon steel consists of two basic elements, iron and carbon, in addition to some impurities such as sulfur, phosphorus, silicon and manganese, which are natural impurities in it and not added alloying elements. Carbon steel is divided into three types according to the percentage of carbon there are these types: Carbon steel is a type of steel that contains iron and carbon as the basis of its composition, while the rest of the other elements are in the form of impurities that exist within the structure of the steel. The percentage of carbon affects the hardness, [3] resistance, and ductility of the steel, as the higher the percentage of carbon, the higher the hardness and resistance and the lower the ductility, and the opposite occurs when the percentage of carbon decreases (2). Carbon steel can be classified into three types according to the carbon content structure, it is: Low carbon steel It is steel containing a carbon content of (0.05-0.3%) and a manganese content of (0.4%). Many products are made from this steel, such as plates, strips, and wires (3). medium carbon steel These types of steel are similar to low carbon steel except that the carbon content is (0.3% - 0.6%) and manganese is around (0.6-1.6%). [4] Shafts, gear axles, and crankshafts are made from this steel (3). High carbon steel It contains a carbon percentage of (0.6%1%) with manganese percentage ranges of (0.3-0.9%). This type of steel is used in the manufacture of high-resistance wires.

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## II. MATERIALS USED IN THE RESEARCH

In this project, medium carbon steel was used, which contains a carbon content of (0.4%) and its chemical composition is shown in Table No. (1-1), which was obtained through the X-Ray Fluorescent test.

Table 1 Chemical Composition of Medium Carbon Steel

| Element | C | Fe | Si | Mn | S | P |
|---|---|---|---|---|---|---|
| Percentage % | 0.5 | 97.78 | 0.24 | 0.59 | 0.019 | 0.18 |

➢ *Preparing Test Models*

Four specimens suitable for Charpy impact test were prepared. The specimens are rectangular pieces with a length of (55mm), a height of (7.5mm) and a width of (10mm), while the groove is in the shape of the letter (V) with an angle of (45) and a depth of (2mm) and a groove radius of (0.25mm). Figure No. (1) Shows the shape of the Charpy impact test specimens

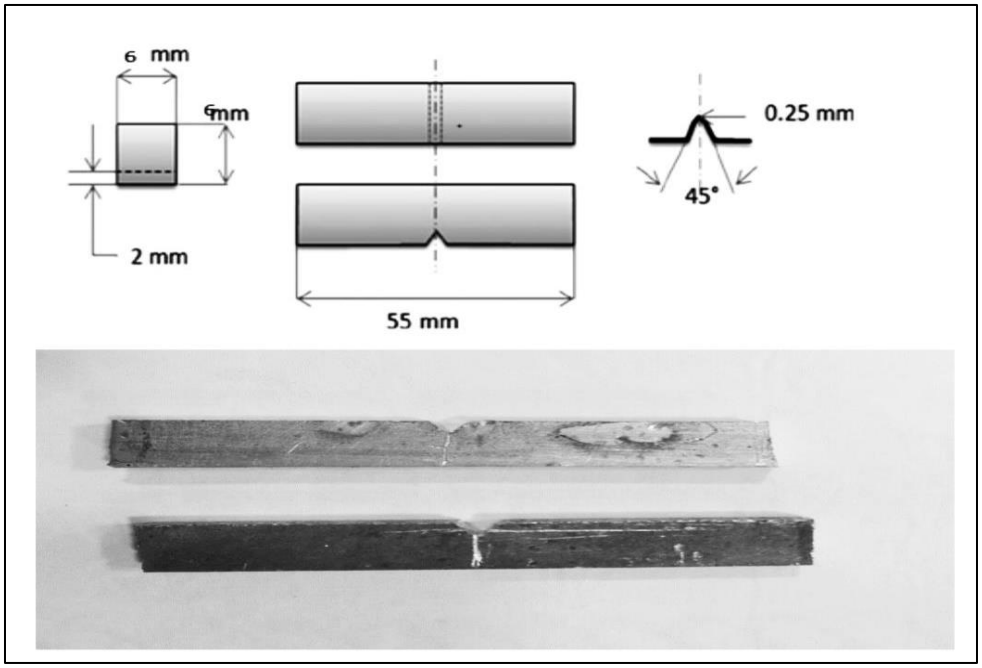


Fig 1 Shows the Shape of the Charpy Impact Test Specimens

➢ *Heat Treatments*

In this project, a number of thermal treatments were used for the hardening or tempering process of medium carbon steel. The aim is to identify the extent to which shock resistance is affected by the type of hardening applied to the test specimens. These treatments are:[5]

- *Hardening Treatment*

The sample made of medium carbon steel was heated in the oven to a temperature of (870°C) and remained at this temperature for one hour. One, after which the model is taken out of the oven and quenched with water.

- *Surface Heat Treatments:*

Two types of surface heat treatments were used that aim to harden the steel surface only. These treatments are:

➢ *The Practical Side*

Flame Hardening: For this purpose, an oxyacetylene flame was used, which was directed at the surface of the model in order to heat it, then water was sprayed on it to cool it. Carburizing. The model was placed in a box and covered with black powder. Carbon and put it in the oven and heat it to a temperature of (900°C) and leave it at this temperature For (4) hours until the carbon atoms penetrate the model to the required thickness. Then the model was heated to a temperature of (870°C) and kept for one hour in This temperature is then cooled in water in order to obtain a more flexible structure of the crust. The surface of the model is heated to a temperature of (760°C) and left for one hour. At this temperature it is followed by cooling in water to obtain a less brittle structure. Figure (2) shows the furnace in which the thermal treatments were carried out.

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Fig 2 Shows the Furnace in which the Thermal Treatments were Carried Out.

➢ *(Impact Test)*

The Charpy Impact Instrument, shown in Figure (2), was used to perform the impact test on the notched specimens made of low-alloy steel. Carbon and shock resistance can be calculated from the following equation:

$$R = \frac{E}{A}$$

where : R Shock resistance (kj/m). Work or energy. Cross-sectional area of test specimen (mm). The value of work or energy can be calculated from the following equation:

$$E = W \times L(\cos\alpha - \cos\beta)$$

where : W Test pattern width (mm). Length of test specimen (mm). Load angle. The angle after the load is applied. Figure (3) shows the installation of the Charpy shock test device.

Fig 3 Shows the Installation of the Charpy Shock Test Device.

## III. RESULTS AND DISCUSSION

Heat treatment is one of the important processes that are applied to metals and alloys during or after manufacturing them, the aim of which is to improve the properties of these materials, the most important of which are the properties Mechanical. Carbon steel has the ability to change its mechanical properties effectively when Heat treatment is performed on it due to the changes that occur in its structure during the cooling and heating processes of this type of steel. One of the most important mechanical properties that must be taken into account when choosing such materials that are exposed to dynamic loads is the shock resistance property and the extent to which it is affected by heat treatment, the results obtained from the Charpy shock test on specimens that underwent thermal treatment of hardening, flame hardening, Carbonization

➢ *Hardening*

The impact resistance value of the grooved model made of medium carbon steel before heat treatment is (Kj/m 23.25) and this value is relatively low due to the ductile structure of this type of steel (a) + FC). The impact resistance of this steel will improve significantly when treated with a hardening treatment as shown in Figure (4 ) which represents the effect of the hardening treatment on the impact resistance. The reason for this increase is due to the formation of the martensite phase after quenching from the hardening temperature, which is considered a very hard phase, which causes the impact resistance value to increase.

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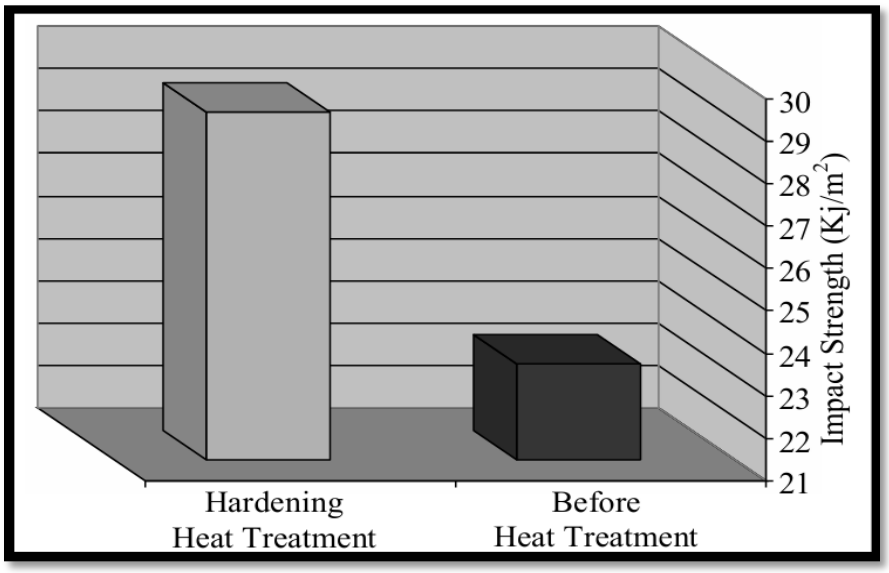


Fig 4 Which Represents the Effect of the Hardening Treatment on the Impact Resistance

➢ *Flame Hardening*

Flame hardening is considered one of the surface thermal treatments. We notice from Figure (5) the effect of oxyacetylene flame hardening on shock resistance, with an increase in the resistance value.

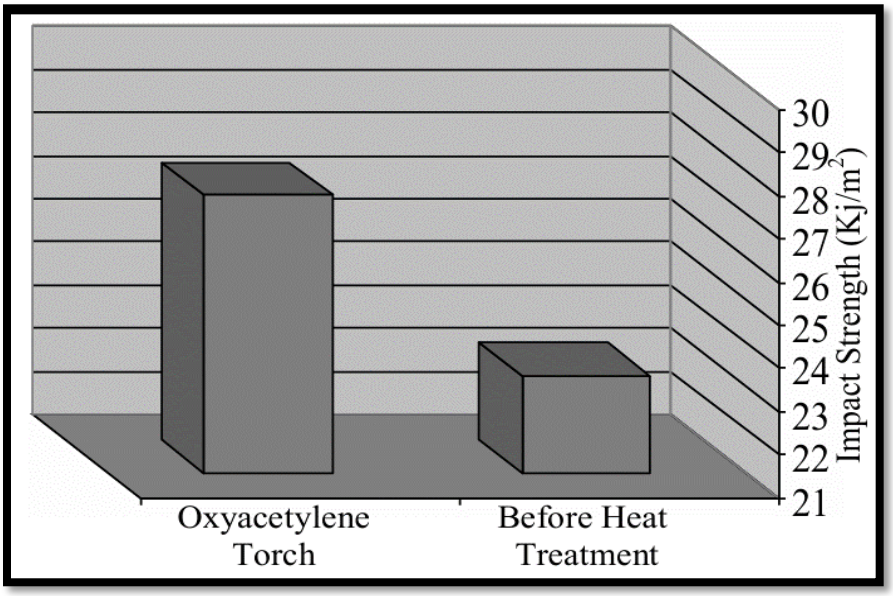


Fig 5 The Effect of Oxyacetylene Flame Hardening on Shock Resistance

➢ *Carburizing*

It is also one of the surface heat treatments where the shock resistance value is higher than it is without heat treatment as shown in Figure (6) which represents the effect of carburizing hardening on shock resistance. The reason for this increase in resistance is due to the formation of the martensite phase on the surface despite the core still having an appropriate degree of ductility. The shock resistance value here is also less than the hardening treatment and the reason, as we mentioned, is that hardening is limited to the surface layer only. And as shown in figure (7) the fracture of thermal treatment of hardening, flame hardening, Carbonization .

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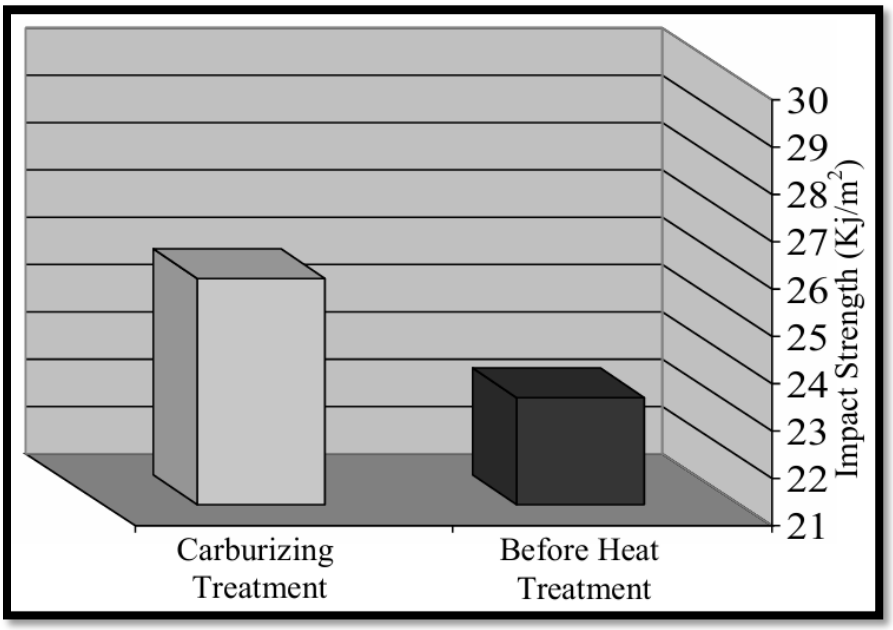


Fig 6 Which Represents the Effect of Carburizing Hardening on Shock Resistance.

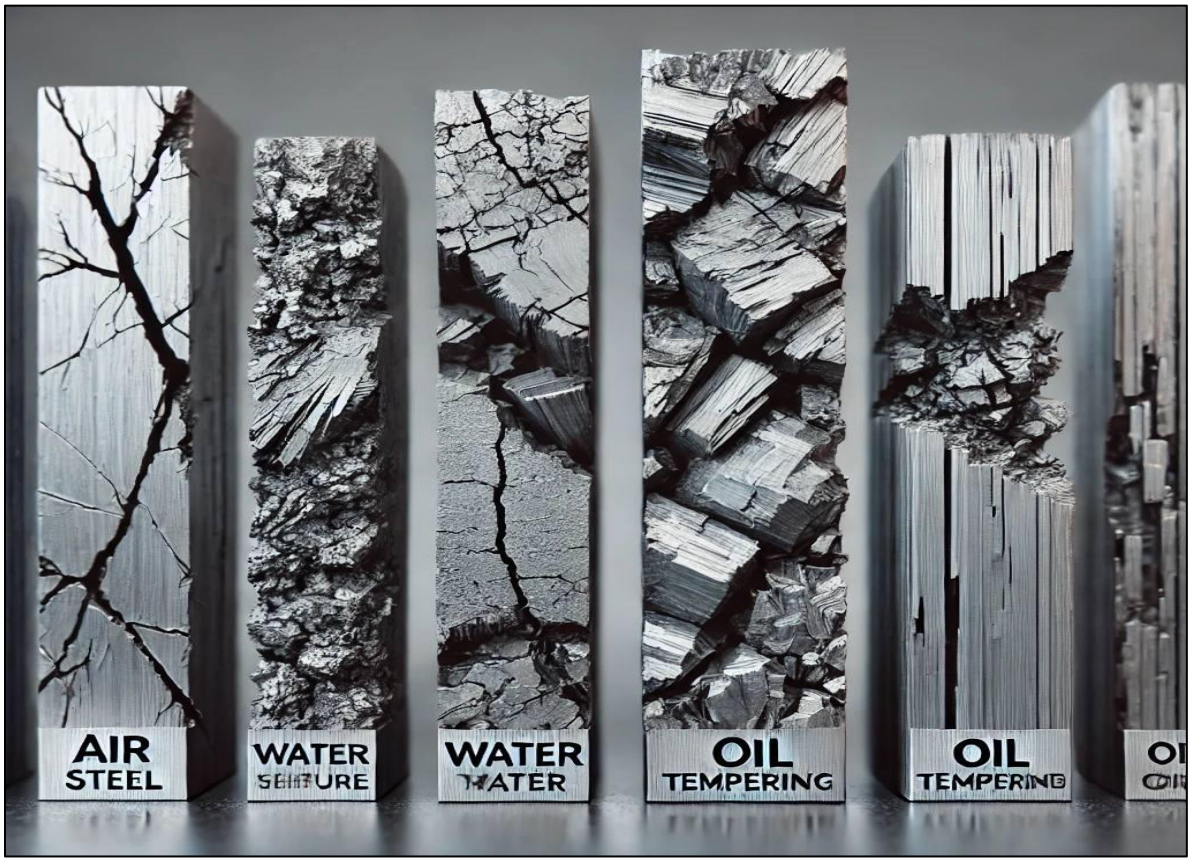


Fig 7 the Fracture of Thermal Treatment of Hardening, Flame Hardening, Carbonization

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## IV. CONCLUSIONS

From the results obtained from the shock resistance test, we conclude the following:

- Low impact resistance of medium carbon steel due to its ductile structure (a + FeC).
- The shock resistance of this type of steel improves after undergoing heat treatments as a result of the formation of the hard martensite phase.
- The shock resistance value is higher in the case of hardening treatment than in the case of flame hardening and carburizing hardening treatment, due to the fact that all the steel structure turns into martensite in the hardening treatment, while in the last two treatments, hardening is limited to The surface with the core remaining has a degree of ductility.

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