

Influence on Mild Steel Mechanical Properties by Soaking Time

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Abstract

The findings of an examination into the influence of soaking time on the mechanical characteristics (hardness, tensile strength, and yield strength) of mild steel are presented in this work. The mild steel samples were annealed at 910°C for varying soaking times of 20 minutes, 40 minutes, 60 minutes, and 90 minutes. To investigate the characteristics of annealed mild steel with increasing soaking time, hardness, tensile, and yield tests were performed. The hardness indicated about the same value and a rapid dip in value after 40 minutes of soaking time, but afterwards increased in value after 60-90 minutes. While the tensile strength and yield strength increased in value as the soaking duration increased. For varying soaking times, there was a linear connection between the material's tensile strength and yield strength.

Keywords: *Heat Treatment, Mechanical Test, Soaking Time, Tensile Test, Annealing*

INTRODUCTION

Heat treatment is the application of timed heating and cooling to a specific metal or alloy in the solid state in order to create desired mechanical qualities such as hardness, tensile strength, and yield strength (Wadhwa et al., 2008). The most common heat treatments used to affect the

mechanical characteristics of engineering materials, notably steels, are annealing, normalising, quenching, and tempering (Higgins, RA 2004). Heat treatment and alloying materials such as fly ash can change the properties of materials (Sharma et al., 2019). Annealing is the most common method of heat treatment used to

soften iron or steel products. It is utilised in engineering materials when elongation and a significant amount of tensile strength are required. Normalizing involves heating the material to the austenitic temperature range and then cooling it with air.

This treatment is often used to generate a mostly pearlite matrix, which leads in greater strength and hardness than the as-received state. It is also used to eliminate unwanted free carbide from as-received samples. Steels are often hardened and tempered to increase mechanical qualities like as strength and wear resistance (Smith WF, 1981).

In hardening, the steel or alloy is heated to a high enough temperature to encourage the production of austenite, kept at that temperature until the necessary quantity of carbon has been dissolved, and then quenched at a reasonable rate in oil or water. In addition, to get optimum yield strength, the steel should contain 100% martensite in the hardened phase, but it is also exceedingly brittle, hence quenched steels are employed for relatively few technical applications. Tempering may progressively change the characteristics of quenched steel, reducing hardness while increasing ductility and impact strength (Sharma et al., 2014). Whereas carbon

steel alloy, steel alloy, and stainless steel gained prominence, it is one of the few engineering alloys that are thermally treated to take advantage of the change in mechanical characteristics caused by changes in the internal structure that occurs in the solid-state (Arora et al., 2015). Heat treatments can be used on stainless steel to enhance not just its hardness but also its durability, flexibility, and ductility (Wadhwa et al., 2014).

Mechanical properties are affected by phase transitions and changes that occur during heat treatments, and the carbon ratio has a large influence on mechanical properties as well as the heat treatments that can be used. Heat treatments are classified as annealing, quenching, normalising, and tempering.

Experimental Procedures

For this investigation, mild steel samples were received from the Olusegun Obasanjo Centre for Engineering Innovation at The Federal Polytechnic, Ado-Ekiti, Ekiti State, Nigeria.

The angle iron mild steel was cut with a cutting disc to a dimension of 2 mm by 4 mm and a thickness of 0.5 mm. Following that, the steel samples were submitted to an annealing heat treatment procedure with

varying soaking times of 20 minutes, 40 minutes, 60 minutes, and 90 minutes, respectively, before being subjected to various mechanical testing such as tensile, hardness, and yield tests.

The spectrometric analysis of the metal was carried out and is presented in Table 1.

Table 1. Chemical Composition of mild steel

Parameter (%)	Result
Carbon	0.128
Sulphur	0.030
Phosphorous	0.010
Manganese	0.292
Nickel	1.500
Chromium	0.820
Arsenic	1.420
Lead	0.096
Zinc	3.414
Copper	0.072
Nitrogen	0.066
Iron	Rest

Table 2. Heat treatment conditions

Condition	Annealed			
Temperature (°C)	910	910	910	910
Holding time (minutes)	20	40	60	90
Cooling medium	Furnace			

Annealing Procedure

The specimen (i.e. mild steel) was loaded into the furnace and heated to 910°C. The

sample was soaked (held in the furnace) at 910°C for 20, 40, 60, and 90 minutes, respectively. The furnace was then turned off and left to cool at the same temperature rate within the furnace (Table 2).

Annealing is the process of heating steel to a high temperature and then gently cooling it to room temperature, resulting in steel with great ductility and toughness but low hardness. Annealing is accomplished by heating a component to the desired temperature, soaking it at that temperature, and then turning off the furnace while the component is still in it. Steel is annealed before cold forming to minimise load and energy needs and to allow the metal to withstand significant stresses without failing.

Hardness Test Procedure

After the sample was put on the table, the lever was moved to the centre position. The dial reading as a tiny pointer at 0 and a long pointer at 50 was crudely adjusted. The handle wheel for raising the specimen was cranked, making contact with the penetrator and continuing to revolve until the dial gauge's long pointer had done two and a half turns and finally stepped at 0. Turn the lever A to B to apply the complete load to the specimen. When the dial gauge's long pointer reached a stable

position, the lever was gently returned to its original position. The figure was read against the long pointer. For diamond indenters, use black graduation, while for ball indenters, use red graduation. To remove the sample, the handle wheel was rotated back.

Tensile Test Procedure

The specimen's original length and diameter were measured. The specimen

was placed in the grips of the test machine, and a strain measurement device was attached to it. The load was applied, and data on load versus elongation was recorded. As the yield point neared, readings were taken increasingly regularly. The values of elongation were recorded. Repeat the test until a fracture occurs. The specimen's ultimate length and diameter were measured (Figure 1).

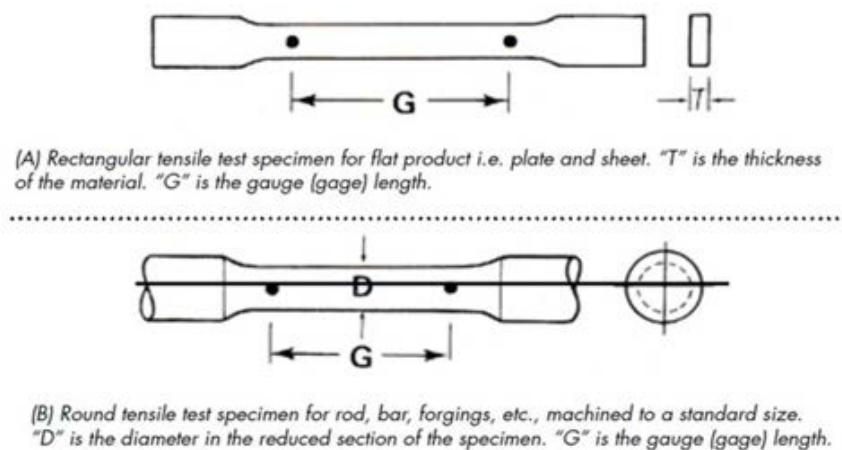


**Figure 1. Schematic illustration of rectangular and round tensile test specimens
(Standard Tensile Test Diagram)**

RESULT

Table 3. Results of mechanical tests of heat treated and untreated mild steel

Specimen	Yield Strength (N/mm ²)	Tensile Strength (N/mm ²)	Hardness BHN (KgF/mm)	Heat Treatment Temp (°C)	Holding Time (min)	Cooling Medium	Heat Treatment Process
Control	132.142857	142.857143	1.21951874	—	0	—	Untreated
A	146.285714	161.907143	1.219352136	910	20	Furnace	Annealed
B	150.714286	169.05	1.191195301	910	40	Furnace	Annealed
C	157.142857	176.192857	1.219352007	910	60	Furnace	Annealed
D	167.857143	183.335714	1.219352007	910	90	Furnace	Annealed

The mechanical test results of heat-treated and untreated mild steel are shown in Table 3. Heat treatment (annealing) effects on the mechanical properties of treated and untreated mild steel samples (tensile strength, hardness, and yield strength).

Discussion

Figure 2 depicts the influence of soaking time on the hardness property of mild steel after annealing at 910°C. The hardness of the samples increases with soaking time, with the exception of 40 (minutes), which displays a rapid decline in hardness. When compared to the untreated sample, the treated sample with a soaking duration of 40 minutes had the lowest hardness

(1.21951874). Figure 3 shows the effect of soaking time on the tensile strength of mild steel after 910°C annealing. With increasing soaking time, it displays a growing tensile strength trend. The untreated sample has the lowest tensile strength (142.857143 N/mm²).

Figure 4 shows the effect of soaking time on mild steel yield strength after annealing heat treatment at 910°C. With increasing soaking time, it displays a growing yield strength tendency. The untreated sample has the lowest yield strength (132.142857 N/mm²).

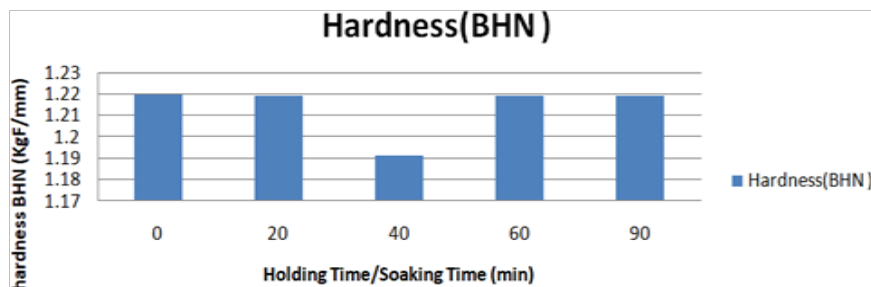


Figure 2. Hardness of treated and untreated samples of mild steel

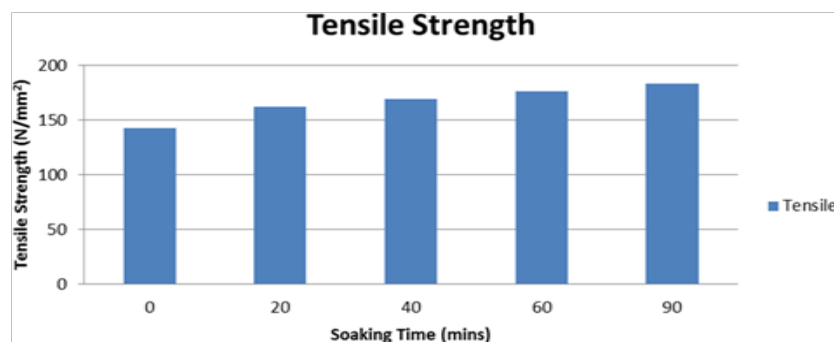


Figure 3. Tensile Strength of treated and untreated samples of mild steel

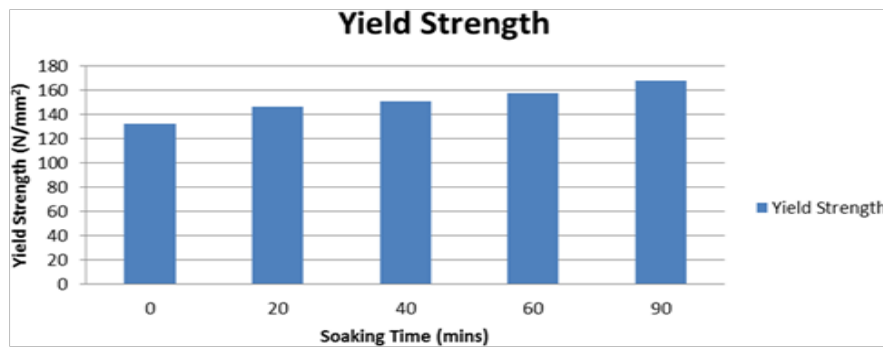


Figure 4.Yield strength of treated and untreated samples of mild steel

CONCLUSION

The following conclusions were reached from the investigation into the effect of soaking time on the mechanical properties of mild steel:

- As the soaking duration lengthened, the tensile and yield strength of (annealed) mild steel increased (20 minutes, 40 minutes, 60 minutes, 80 minutes and 90 minutes)
- The greater the tensile and yield strength, the greater the plastic deformation and, hence, the likelihood of residual stresses accumulating.

Recommendation

The following recommendations are made:

- Future research should investigate other heat treatment methods like as quenching, normalising, and tempering to broaden the scope of this study.

- In addition to the hardness, tensile strength, and yield strength parameters studied in this study, future research should look at other mechanical properties such as ductility, toughness, and impact resistance.

REFERENCES

1. Smith WF. Structure and Properties of Engineering Alloys. 1981: (47): 72-81.
2. Joseph ER, Rundman, KB, Alexander, B. Abrasive wear characteristic of carbon and low alloy steel for better performance of farm implements. J. Material Science Technologies, 2014, (11): 91-96
3. Wadhwa AS & Dhaliwal HS. A Textbook of Engineering Material and Metallurgy. Firewall Media, 2008.

4. Alberg GT. Effect of heat treatment on mechanical properties of low carbon steel, J. Material Science Technologies. 2003, (9): 23-29.
5. Dell KA. Effect of carburization time and temperature on the mechanical properties of carburized mild steel, using activated carbon as carburizer. Journal of Materials Research. 2009, 12(4): 483-487.
6. Kempstar HA. First result on the effect of direct quenching on mechanical properties and an elastic relaxation in CLAM steel fusion. Engineering and Design, 1984, (85): 1556-1561.
7. Sharma V & Akhai S. Mechanical behaviour of fly ash reinforced aluminum composite prepared by casting. Journal of Advanced Research in Mechanical Engineering and Technology 2019; 6(1&2): 23-26.
8. John VB. Introduction to Material Science and Engineering, 2nd ed. 1980, 34-38.
9. Higgins RA. Engineering Metallurgy: Applied Physical Metallurgy, 6th ed. New Delhi: Viva Books. 2004, 69-75.
10. Indentec RA. Study the effect of hardening among polymer on some properties of the alloy stainless steel type (316L). Journal of Engineering and Technology. 2007, 27(10).
11. Dosset NA, Donald B, Wagner RA. Effect of alloying elements on heat treatment behavior of steel. 2006, (8): 46-58.
12. Arora N & Akhai S. Reclaiming EN14B steel grade implements by hardfacing. International Journal of Scientific Research. 2015, 4(10): 14-16.