doi.org.10.54473/IJTRET.2023.7403
International Journal of Trendy Research in Engineering and Technology
Volume 7 Issue 4 August 2023
ISSN No. 2582-0958

THE EFFECT OF HEAT TREATMENT ON HARDNESS AND MICROSTRUCTURE OF MILD STEEL

Veligiram Karthik[1], Vignesh Balaji S.V[1], Tirilok K N[1], Dr.T G Loganathan[2],Dr.K. Vinothkumar[2]
[1]Students of III Yr Mechanical Engineering of R.M.K. College of Engineering and Technology, Tamil Nādu, India.
[2]Faculty of Mechanical Engineering, R.M.K. College of Engineering and Technology, Tamil Nādu, India.
Received 0 August 2023 Received in revised form 02 September 2023 Accepted 05 September 2023

ABSTRACT

Mild steel is the most preferred material for domestic and light-load structural applications. Such widely used mild steel materials is considered here to study their response to heat treatment in terms of hardness and microstructure. The heat treatment is done to an annealing temperature (750ºC) with the muffle furnace and then quenched the samples after a fixed incubation period in the furnace say 0.5, 1, 1.5 hr. The hardness and the microstructure of the heat-treated samples are evaluated using the Rockwell Hardness test and a metallurgical microscope. It was observed that heat treatment has contributed to changes in the hardness and microstructure.

Keywords: Mild steel, Heat treatment, Rockwell hardness, treatment, Microstructure.

I. INTRODUCTION

Heat treatment is the process of heating metal without letting it to reach molten state, and then cooling the metal in a controlled way to attain the desired mechanical properties. Heat treatment is used to either make the metal stronger or more malleable, more resistant to abrasion, high hardness or more ductile[1].

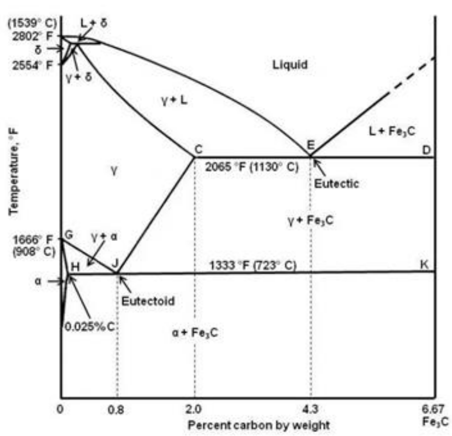

Fig. 1 Iron- iron carbide phase diagram

Steel is an iron alloy with a carbon content that ranges from 0.15 to 1.5%, and plain carbon steel contains between 0.1 and 0.25%. They are subjected to heat treatment procedures with appropriate process parameters to transform their materials properties. Of all heat treatment procedures, annealing and normalizing are the most preferred for enhancing the mechanical properties of mild steel. The steel is heated to the above lower critical temperature line (723^{0}C) as shown in Fig. 1 to attain Austenite transformation, and it is maintained for some time to facilitate the transformation.

II.MATERIALS AND METHODOLOGY

In this full process, we used the BS 970 grade EN 3B (Mild steel) material and also, we used the muffle furnace to heat the material up to the 750^{0}c maximum temperature[2] and also, we used the various emery sheet grades in the finishing process of the mild steel pieces and the Fig 2 shows the mild steel pieces that undergoes into the heat treatment process as well as cooling processes.[3]

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International Journal of Trendy Research in Engineering and Technology
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Fig. 2 Cut samples before heat treatment

Also, different types of cooling medium (quenchant) is used to cool the mild steel pieces after the heat treatment process. The used quenchant are portable water, 5 %NaCl solution and oil 20W40.The varying physical and chemical properties of the quenchant would give some changes in the property as well as microstructure. The Table 1.1 shows the properties of the original material composition.[4]

Table. 1 Properties of MS bar

Elements	Symbol	Specification (max)	Observed values
Carbon(%)	C	0.25	0.217
Silicon (%)	Si	0.35	0.225
Manganese (%)	Mn	1	0.704
Phosphorous (%)	P	0.06	0.048
Sulphur (%)	S	0.06	0.037

III.EXPERIMENTAL PROCEDURE

In this work, mild steel bar was into pieces of size 15mm diameter and 10mm long. Of which one is kept as virgin specimen and others are subjected to heat treatment process. The Fig 3 shows the microstructure of the virgin sample.

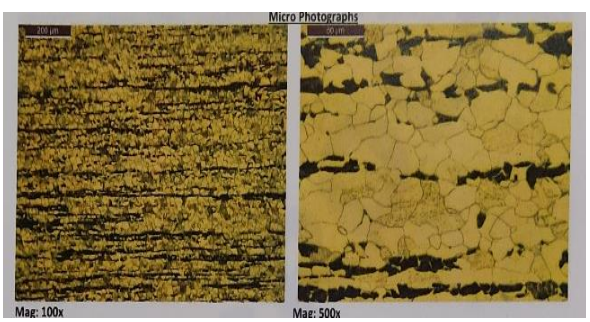

Fig. 3 Microstructure of virgin MS sample

The MS samples are subjected to heat treatment process by heating them in the muffle furnace up to 750^0C. After reaching 750^0C, the samples are retained in the furnace for maximum duration of incubation period of 90 minutes to attain the complete transformation at lower critical temperature[5]. Meanwhile, NaCl solution of 5% concentration is prepared by dissolving calculated mass of salt in the distilled water.

Fig. 4 Removal of heated MS samples from the muffle furnace.

After one and half an hour incubation period in the furnace, the MS samples are transferred to the quenchant medium as shown in Fig. 5. 500 ml of quenchant is taken in a separate container for quenching [6].

Fig. 5 Quenching of MS in Distilled water.

The first set of quenching is done at first 30 minutes after reaching 750^0C . Three MS samples are taken from the furnace and dropped in the containers containing Distilled water, NaCl solution and 20W40 oil.

Fig. 6 Quenching of MS in 5% NaCl Soln.

After the first batch of samples taken from the furnace after 30 min, the second batch is taken after 60 minutes and the third batch is after 90 minutes. Both of the second and third batch samples are separately quenched in all the three quenchants and taken for further studies [7].

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Fig. 7 Quenching of MS in 20W40 Oil.

After quenching processes, the quenched samples are subjected to finishing process as shown in Fig. 7 with different grades of the emery sheets to get the good surface finish to support further examination.

Fig. 8 Surface finishing of the Quenched MS samples.

All heat treated, quenched and surface finished nine MS samples are exposed to hardness and Micro structure examination tests. For hardness, Rockwell hardness tester with diamond indenter and 'C' scale was used as shown in fig 8. 100 Kgf load was the major load on all the test samples to measure the hardness. [8]

Fig. 9 Rockwell Hardness Testing Machine

On completion of the hardness tests, both heat treated – quenched and virgin samples examined for their micro structures at M/S. Micro Labs, Ambattur, Chennai, India – 600053 [9].

IV RESULTS AND DISCUSSIONS.

The Rockwell hardness values of the tested and virgin samples are given in the Table.2 The subsequent microstructure of the samples is also taken and presented in the following sections.

Table 2 HRC Hardness Values of the Test Samples.

Quenchant	**HRC of MS samples**			
	Incubation time after HT			Virgin Samples
	30 min	**60 min**	**90 min**	
Oil	15	13	12	34
Water	17	14	13	
Salt solution	19	12	12	

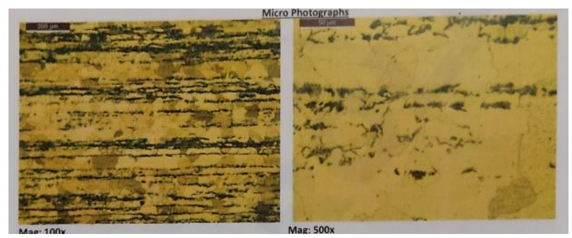

Fig.10 Micro structure of water quenched MS

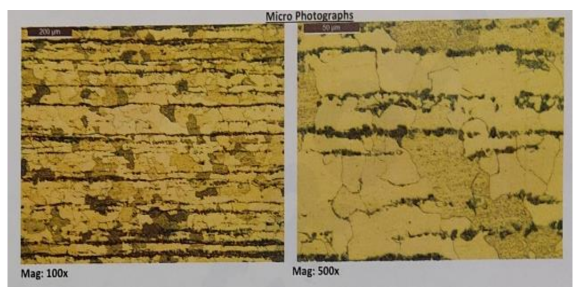

Fig.11 Micro structure of 5% NaCl quenched MS

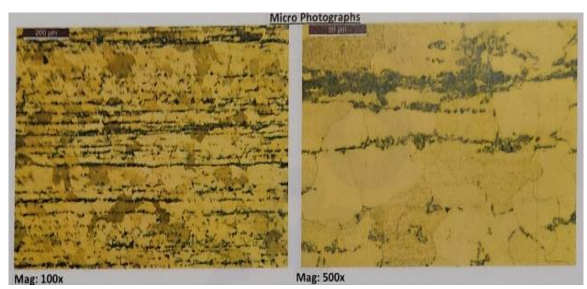

Fig.12 Micro structure of Oil quenched MS

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V.CONCLUSION

The experimental work conducted is to study the behavior pattern of MS on subjected to heat treatment in terms of Rockwell Hardness number and Microstructural pattern. When compared with the Virgin sample (HRC 34), all heat treated and quenched samples exhibit lower hardness attributed corresponding changes in the microstructural constituent of the samples. It can be observed from the microstructure (Fig.3.1, Fig.4.1-4.3) images that, pearlite (black spots) in the ferrite matrix (yellow base) are not identical because of combined effect of incubation period at lower critical temperature and heat transfer ability of the quenchant (Water, NaCl Solna and 20W40 Oil).

Thus, the heating MS to 7500C and quenching with varying incubation time contributes to reduction in the hardness which may have a corresponding improvement in the toughness MS samples.However, the HRC attains consistency irrespective of the quenchant with incubation period of 90 minutes.

REFERENCES

[1] Singh. G, "A review on effect of heat treatment on the properties of mild steel," Materials Today: Proceedings,37 (2020) 2266–2268.

[2] Ibrahim Nasir. N, "The Effect of Heat Treatment on the Mechanical Properties of Stainless-Steel Type 304," International Journal of Scientific and Research 3 (2015)87-93

[3] Srivastava. K, Sinha A. A and Sahani. R, "Effect of heat treatment on hardness and toughness of EN8 steel," Materials Today: Proceedings, 42(2021) 1297–1303.

[4] Ismail. N.M, Khatif. N.A.A, Kecik M.A.K.A, and Shaharudin M.A.H, "The effect of heat treatment on the hardness and impact properties of medium carbon steel," IOP Conference Series: Materials Science and Engineering, (2016).

[5] Bae D.S "Effect of post heat treatment on bonding interfaces in Ti/Mild steel/Ti clad materials", Procedia Engineering,10 (2011), 996–1001.

[6] Kumar Tanwer A, "Effect of Various Heat Treatment Processes on Mechanical Properties of Mild Steel and Stainless Steel", American International Journal of Research in Science, 8(2014)14–722.

[7] Asif M, Ahad M A, Iqbal M F H, and Reyaz. S, "Experimental investigation of thermal properties of tool steel and mild steel with heat treatment", Materials Today: Proceedings, 45(2021) 5511–5517.

[8] Senthil kumar T and Ajboye T. K., "Effect of Heat Treatment processes on the Mechanical Properties of Medium Carbon Steel," Journal of Minerals & Materials Characterization & Engineering, 11(2012)143–152.

[9] Kamal A. R., and Ogunjirin O. A., "Effects of Heat Treatment on the Properties of Mild Steel Using Different Quenchants," Frontiers in Science, 2(2013)153–158.

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