EFFECTS OF HEAT TREATMENT ON THE HARDNESS OF MILD STEEL USING DIFFERENT QUENCHANTS

Durvesh M. Jadhav
Department of Mechatronics
Government Polytechnic Karad, India
Email: jadhavdurvesh70@gmail.com
Guided By:- Dr A. A. Gadhikar Sir

***Abstract*—This research investigates the effect of different cooling media on the hardness of mild steel after heat treatment. Mild steel samples were heated in a furnace at 900 °C for 45 minutes and quenched in water, brine, oil, air, and furnace cooled. Rockwell hardness tests were conducted, with three readings per sample, and the averages were reported. Results show that water and brine quenching produced the highest hardness values, while furnace cooling produced the lowest hardness. These findings confirm that the cooling rate significantly affects the hardness of mild steel.**

Index Terms—Heat treatment, Mild steel, Hardness, Quenching, Mechanical properties

I. Introduction

Heat treatment is a controlled process of heating and cooling metals to alter their physical and mechanical properties without changing the product shape[4]. It is widely used to improve hardness, strength, toughness, and wear resistance. The cooling medium and heating temperature during heat treatment play a critical role in determining the final hardness of a material[4]. Mild steel, with low carbon content, is widely used in structural and engineering applications. This study aims to investigate how different cooling methods affect the hardness of mild steel samples heated at 900 °C for 45 minutes.

II. Materials and Methods

- Material Used: Mild Steel
- Heat Treatment: Samples were heated in a furnace at 900 °C and soaked for 45 minutes.
- Quenching Media: Water, brine, oil, air, and furnace (slow cooling).
- Hardness Testing: Rockwell hardness test. Three readings per sample were taken, and the average was calculated.

III. Results

Table I shows the hardness values under different quenching conditions.

Figures 1-7 show the experimental graphs.

TABLE I
Hardness values of mild steel under different cooling conditions

Cooling Medium	Readings (HRB)	Average (HRB)
Original	59.9, 64.6, 62.3	62.27
Water	86.2, 85.6, 87.2	86.33
Brine	85.9, 86.1, 84.5	85.50
Oil	81.2, 85.6, 84.7	83.83
Air	81.8, 82.6, 82.6	82.33
Furnace	66.1, 63.0, 64.9	64.67

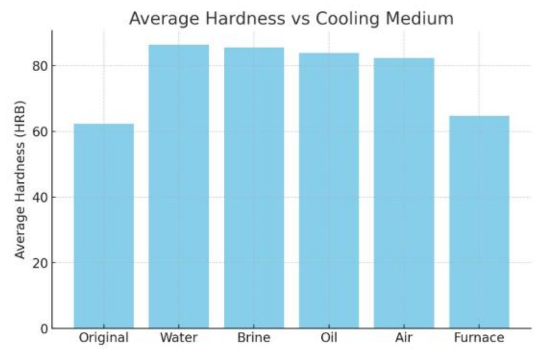

Fig. 1. Average Hardness vs Cooling Medium

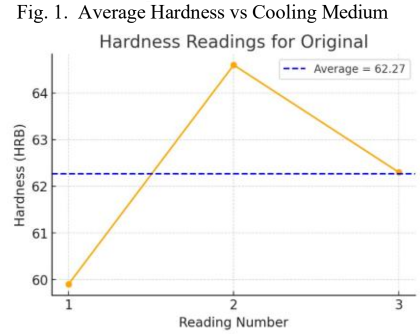

Fig. 2. Hardness readings for Original (Unheated) sample

IV. Discussion

The results indicate that the cooling rate has a direct influence on the hardness of mild steel. Brine and water, being the fastest quenching media, produced the highest hardness values (86 HRB), due to rapid transformation into martensite. Oil quenching, with a slower cooling rate, resulted in slightly lower hardness (84 HRB), while air cooling showed further reduction (82 HRB). Furnace cooling, which is the slowest, yielded hardness values close to the original mild steel sample (65 HRB), indicating minimal phase transformation. These findings confirm the relationship between cooling rate and the formation of harder microstructures in steel.

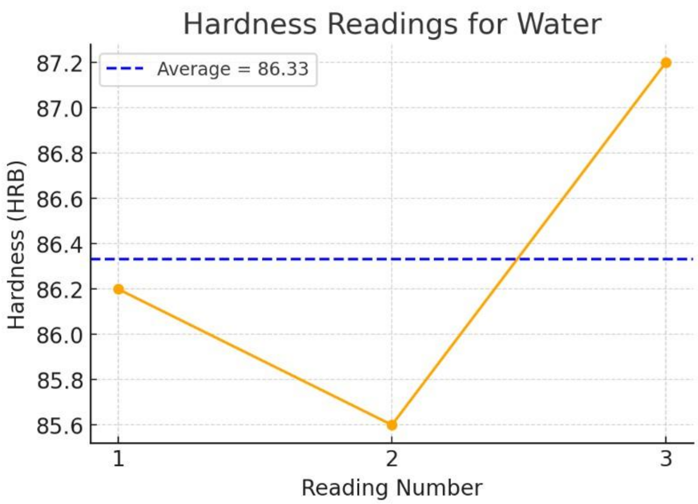

Fig. 3. Hardness readings for Water quenched sample

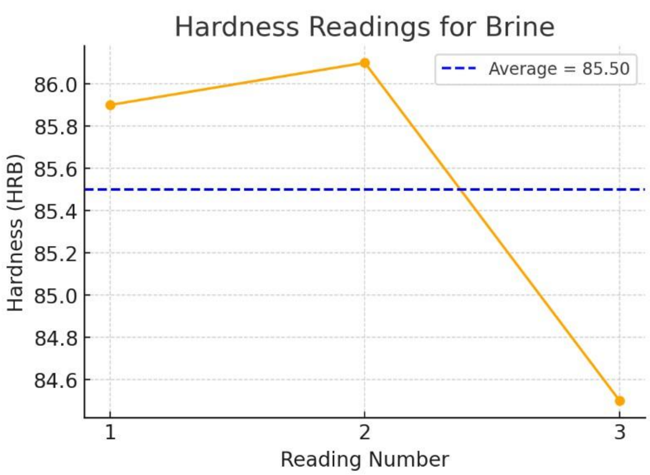

Fig. 4. Hardness readings for Brine quenched sample

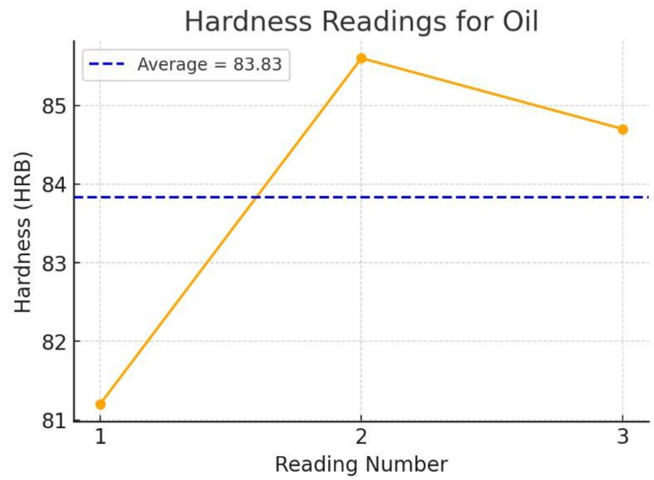

Fig. 5. Hardness readings for Oil quenched sample

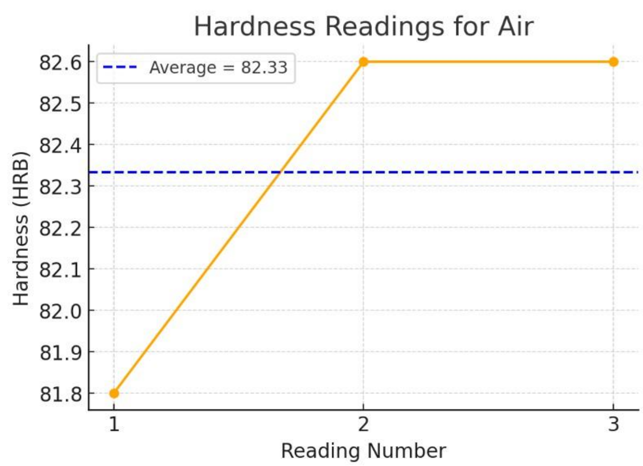

Fig. 6. Hardness readings for Air cooled sample

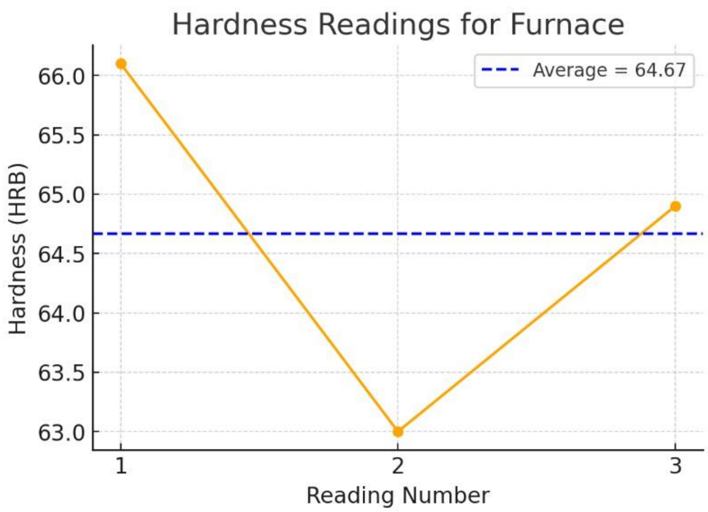

Fig. 7.Hardness readings for Furnace cooled sample

V. CONCLUSION

This study concludes that the hardness of mild steel after heat treatment is highly dependent on the cooling medium. Water and brine quenching significantly increase hardness due to rapid cooling and martensitic transformation. Oil and air quenching produce moderate hardness, while furnace cooling leads to minimal improvement. These results highlight the importance of selecting the appropriate cooling medium to achieve desired mechanical properties in mild steel components

References

[1]W. D. Callister and D. G. Rethwisch, *Materials Science and Engineering: An Introduction*. Wiley, 2018.

[2]S. H. Avner, *Introduction to Physical Metallurgy*. McGraw-Hill Educa-tion, 1997.

[3]G. E. Totten, *Steel Heat Treatment Handbook*. CRC Press, 1997.

[4]I. E. Ahaneku, A. R. Kamal, and O. A. Ogunjirin, "Effects of Heat Treatment on the Properties of Mild Steel Using Different Quenchants," *Frontiers in Science*, vol. 2, no. 6, pp. 153–158, 2012.