THERMAL TREATMENT REQUIREMENTS FOR STEELS AND CASTING DEFECT ELIMINATION

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Abstract

Thermal treatment plays an essential role in achieving required mechanical properties of steels. Proper control of heating temperature, cooling rate, holding time, and selected cooling media determines the resulting microstructure and performance characteristics. Meanwhile, casting processes often introduce defects such as porosity, shrinkage cavities, cracks, and inclusions. These defects reduce the reliability and durability of steel components. This study examines requirements applied to steels during thermal treatment and presents effective methods for identifying and eliminating casting defects. The results show that optimized heat treatment combined with controlled casting conditions significantly enhances steel quality and operational performance.

Keywords: Heat treatment**,** steel thermal processing**,** austenitizing, quenching and tempering, cooling rate, microstructural transformation, martensite, pearlite, sorbite, casting process, casting defects.

1. Introduction

Steel is one of the most widely used engineering materials due to its strength, durability, and adaptability to thermal and mechanical processing. To obtain desired properties such as hardness, toughness, and wear resistance, steels undergo various thermal treatments including annealing, normalizing, quenching, and tempering. Each method requires strict control of temperature, time, and cooling rate.

However, steel components manufactured by casting may contain defects such as gas porosity, shrinkage cavities, non-metallic inclusions, cold shuts, and cracks. These defects can severely diminish mechanical performance. Therefore, understanding both thermal treatment requirements and casting defects is essential for producing high-quality steel products.

2. Materials and Methods

2.1 Materials

Medium-carbon steels (40, 45, 50 steel grades) Low-alloy steels (20Cr, 40Cr, 30Mn2) Sand-mold cast steel samples

2.2 Methods

Heat treatment conducted in STA-1700 furnace. Microstructure observed under metallographic microscope (100–1000×). Hardness measured using Rockwell C and Brinell methods. Casting defects identified using radiographic, ultrasonic, and dye-penetrant testing.

2.3 Procedure

Samples were heated to 800–900°C, held for 20–40 minutes, quenched in water or oil, and tempered at 200–600°C. Cast samples were inspected before and after treatment to study defect behavior.

3. Results and Discussion

3.1 Requirements for Steels During Thermal Treatment

During thermal treatment, strict requirements must be met to ensure proper structural transformation:

• Heating temperature must be controlled within transformation limits.
• Holding time must ensure full austenitization without decarburization.

• Cooling rate determines martensite, bainite, or pearlite formation.
• Final microstructure must be uniform and fine-grained.

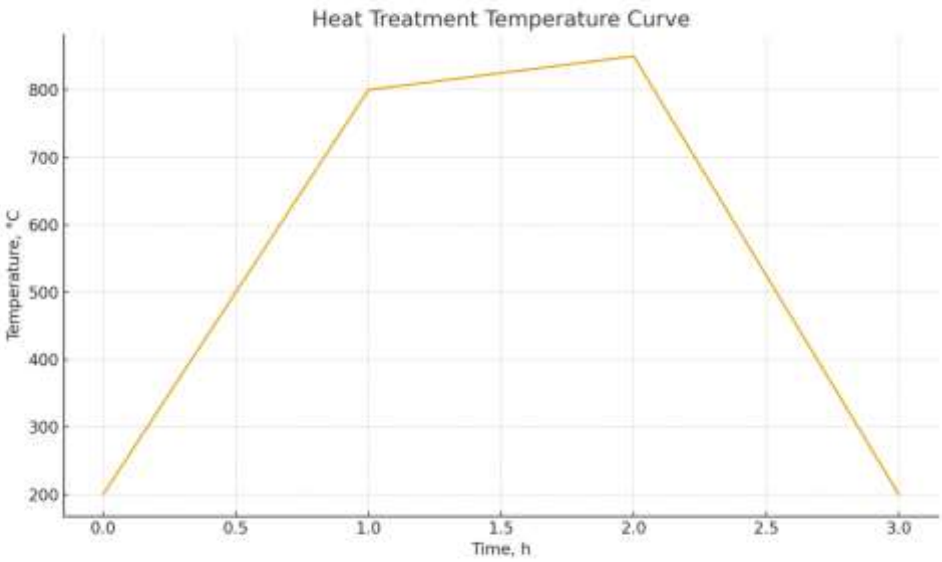

Figure 1. Heat treatment temperature curve.

3.2 Common Casting Defects

Common casting defects include: Porosity (gas entrapment) Shrinkage cavities Cold shuts. Non-metallic inclusions. Hot and cold cracks Misruns due to insufficient filling

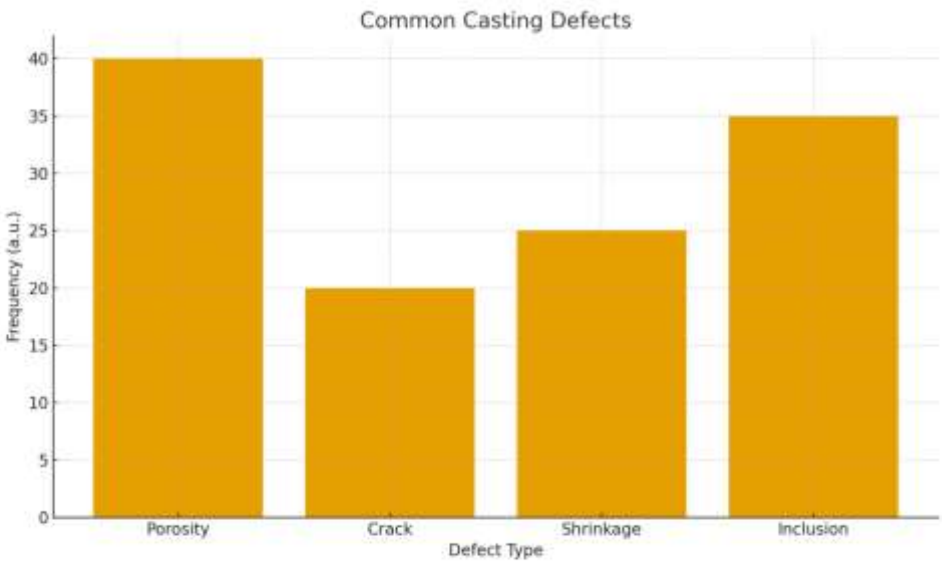

Figure 2. Frequency of common casting defects.

3.3 Methods of Eliminating Casting Defects

Defects can be reduced or eliminated by: Using deoxidizers such as Al, Ti, FeSi Improving gating and riser design. Controlling pouring temperature (1500–1580°C) Applying ceramic filtration Vacuum degassing to remove gases. Repair welding for shrinkage and crack defects.

3.4 Effect of Heat Treatment on Defect Reduction

Heat treatment reduces microstructural stress concentration and increases resistance to crack formation. Tempering after quenching stabilizes the martensitic structure and improves toughness.

4. Conclusion

Properly controlled heat treatment procedures significantly enhance the microstructure and mechanical properties of steels. At the same time, identifying and eliminating casting defects ensures the production of durable and reliable steel components. Combining optimized casting technologies with precise thermal treatment results in high-performance materials suitable for industrial applications.

References

1.Totten, G.E., Steel Heat Treatment Handbook. CRC Press, 2014.

2. Davis, J.R., ASM Metals Handbook: Heat Treating, ASM International, 1991.

3. Campbell, J., Castings Practice. Butterworth-Heinemann, 2004.

4. Lisboa, H. M., Pasquali, M. B., dos Anjos, A. I., Sarinho, A. M., de Melo, E. D., Andrade, R., ... & Barros, A. (2024). Innovative and sustainable food preservation techniques: Enhancing food quality, safety, and environmental sustainability. *Sustainability*, *16*(18), 8223.

5. Dossett, J. L., & Totten, G. E. (Eds.). (2013). *Steel heat treating fundamentals and processes*. Asm International.

6. Papaefthymiou, S., Tzevelekou, T., Antonopoulos, A., & Gypakis, A. (2016). Typical defects in plate and long steel products. *International Journal of Structural Integrity*, *7*(5), 645-655.
7. Becker, W. T., & Shipley, R. J. (Eds.). (2002). *Failure analysis and prevention*. ASM International.
8. Patwari, A. U., Bhuiyan, S. A., Noman, K., & Ul Navid, W. (2024). Defects and remedies in casting processes: a combinatorial approach between manual and digital optimization technique for enhanced quality casting. *Discover Mechanical Engineering*, *3*(1), 39.
9. Bullens, D. K. (1918). *Steel and its heat treatment*. John Wiley & Sons, Incorporated.
10. Liu, A. F. (2005). *Mechanics and mechanisms of fracture: an introduction*. ASM International.