HEAT TREATMENT TECHNOLOGIES FOR BEARING COMPONENTS

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Abstract: This article explores modern heat treatment technologies applied to bearing components. Key thermal processes such as quenching, tempering, surface hardening, and carburizing are described. Their effects on the microstructure and mechanical properties are discussed. Using experimental data, graphs, and tables, the influence of thermal treatment on bearing steel is presented, with an emphasis on reducing structural defects and extending service life.

Keywords:
Bearing, heat treatment, quenching, tempering, metallographic analysis, hardness.

1. Introduction

Bearings are critical components widely used in mechanical engineering systems. Their durability and operational reliability depend greatly on the material used and the type of heat treatment applied. Thermal processing alters the microstructure of bearing steels to achieve desired mechanical properties such as hardness, wear resistance, and fatigue strength. Optimized heat treatment contributes to minimizing defects such as deformation, cracking, or uneven hardness distribution[1].

2. Methods

This study analyzed the heat treatment processes for high-carbon chromium steel (e.g., grade ШХ15). The following procedures were examined:

Quenching: Heating to 820–850°C followed by rapid cooling in oil, water, or air.

Tempering: Reheating to 150–200°C to relieve stresses and adjust hardness.

Surface hardening: Includes induction or flame hardening.

Carburizing: Increasing carbon content on the surface prior to quenching.

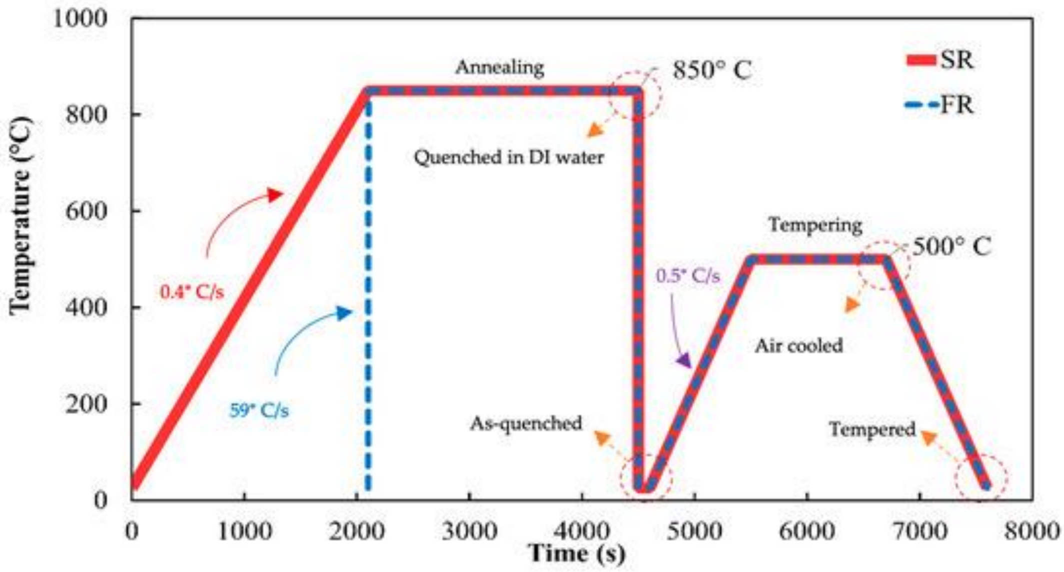

Figure 1. Heat treatment cycles: The process began with varying heating rates (0.4 °C/s for slow and 59 °C/s for fast), followed by identical annealing and quenching in DI water. After electrochemical testing and SEM micrography, both the slow- and fast-rate samples underwent tempering under identical conditions.

The samples were mechanically sanded from 120 to 1200 grit, cleaned with ethanol, and then air dried at room temperature. The specimen surfaces were further mirror polished using a polishing cloth with 3 µm to 1 µm diamond suspension and etched with a 2% Nital solution (ES Laboratory, Glendora, CA, USA) for the purpose of revealing their grain boundaries. Through trial and error, the best etching time was determined to be between 4 and 7 s per sample, with specimens with lower ferrites requiring a longer etching time than those containing martensitic phases. Microstructural analyses were performed using the Hitachi S-3400-II (Hitachi High-Tech Corporation, Tokyo, Japan) Scanning Electron Microscope (SEM). The

Cascade Microtech M150 (FormFactor, Livermore, CA, USA) Optical Microscope (OM) was used to examine the quality of the etching process[2].

Figure 2. Transmission bearings for new energy passenger cars

In order to improve the bearing life of new energy vehicle gearboxes, in addition to using computer simulation software to simulate the design of the bearing structure, the bearing raceways are optimized for low friction design and microscopic shaping to reduce early failure due to stress concentration. In addition to simulating the internal stress graph of the bearing, calculating the maximum contact stress, friction torque and technical parameters such as stiffness, efficiency and preload, it is necessary to control the key factors that determine the life of the bearing such as materials and heat treatment processing technology[2].

Near net forming technology is a combination of forging and cold rolling technology for the production of high-end metal ring parts, is an advanced blank manufacturing technology, rolling expansion at room temperature, not only high dimensional accuracy, saving raw materials, material saving rate can reach 15% ~ 30%, and the product quality intrinsic quality, raceway streamline distribution is reasonable, grain refinement as shown in Figure 1, bearing fatigue life increase in, the world's leading bearing manufacturers have adopted this technology, while cold rolling technology has also been the focus of domestic bearing enterprises[2-3-4].

A metallographic microscope and Rockwell hardness tester were used to assess the microstructure and mechanical properties. Parameters like heating rate, soak time, and cooling media were varied to analyze their influence on final properties.

3. Results and Discussion

Table 1 presents hardness results for bearing steel quenched at different temperatures and cooling media:

Quenching Temperature (°C)	Cooling Medium	Hardness (HRC)
820	Water	64
820	Oil	62
850	Water	65
850	Oil	63
850	Air	58

The results indicate that water quenching yields the highest hardness, but at the risk of cracking. Oil quenching provides a balance between hardness and reduced internal stress. Carburized samples exhibited increased surface hardness with a tougher core, suitable for rolling contact applications.

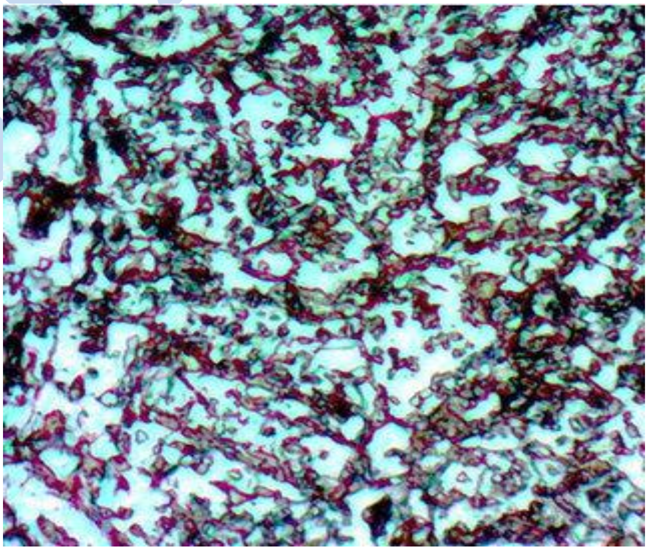

Figure 3. Microstructure of quenched and tempered ШХ15 steel (Insert metallographic image here).

4. Conclusion

The study investigated the impact of heating rate on the microstructural changes, mechanical characteristics, and electrochemical responses of cold-rolled wrought 8620 low-carbon alloy steel, with a particular emphasis on the results of electrochemical tests. The investigation revealed important differences in microstructure and mechanical properties between samples subjected to slow and fast heating rates after quenching and tempering heat treatment[5].

- The formation of martensite significantly increased the hardness, with SR samples showing a hardness 8 HRC higher compared to FR. This was consistent with the higher martensite phase fraction observed, confirming the impact of phase transformation on mechanical properties.
- Following the tempering process, the hardness decreased from 44.77 to 33.65 HRC for SR and from 36.88 to 30.37 HRC for FR. It may be inferred that moderate tempering yields nearly identical effects on both martensite and the dual-phase of ferrite and martensite.

Heat treatment plays a pivotal role in defining the quality of bearing rings. Quenching and tempering are essential for achieving high hardness and resistance to fatigue. Carburizing and surface hardening further enhance the surface characteristics required in rolling element applications. Proper process control minimizes casting or microstructural defects, ensuring long service life of bearings made from recycled or foundry-sourced steel.

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