PriMera Scientific Engineering
Volume 3 Issue 1 July 2023
ISSN: 2834-2550

PriMera Scientific Publications

The Mechanism of Hardening of High-Speed Steel During Nitriding

Type: Editorial
Received: May 26, 2023
Published: June 06, 2023

Citation:
FR Norkhudjayev., et al. "The Mechanism of Hardening of High-Speed Steel During Nitriding". PriMera Scientific Engineering 3.1 (2023): 01-02.

FR Norkhudjayev*, AA Mukhammedov, ShT Shukurov and BR Egamberdiev

Materials Science department, Tashkent State Technical University, Uzbekistan

***Corresponding Author:** FR Norkhudjayev, Materials Science department, Tashkent State Technical University, Uzbekistan.

Abstract

This article presents the results of a study of the processes of nitriding of alloyed steels. It is shown that to obtain a high hardness of the surface layer of steel, it is necessary to obtain dispersed nitrides of alloying elements in the surface layer of steel. The resulting nitrides have high hardness and are an obstacle to the movement of dislocations in the steel, thereby strengthening the surface layer of the steel.

Keywords: nitriding; nitrides; hardness; temperature; alloyed steels

It is known that phases are formed in the Fe-N system: α-phases (nitrogenous austenite with a face-centered cubic lattice) [1, 2]. At a temperature of 590°C, the α-phase represents the eutectoid decomposition γ→α+ γ'. When supercooling the γ-phase by the shear mechanism, it represents a martensitic transformation. Nitrogenous martensite (α ' - phase) has a tetragonal body-centered lattice [2, 3]. A separate γ'-phase is a solid solution of Fe and N nitride, the ε-phase is also formed during nitriding and is a solid solution of Fe3N. In the Fe-C-N system in steel, the main strengthening phase is ε-carbonitride Fe2-3(N-C) formed during nitriding, the carbonitride phase obtained by simultaneous diffusion of carbon and nitrogen into steel has high hardness and high wear resistance. In the γ-phase, carbon practically does not dissolve, and the γ-phase is a solution of nitrogen and carbon intercalation. According to [4]. The introduction of nitrogen into the cementite lattice facilitates the formation of the carbonitride phase. Carbonitride with a cementite lattice is formed in the process of nitrocarburizing at a temperature of 680°C. When steel is nitrided, cementite, after saturation with nitrogen atoms, turns into ε-carbonitride. It has been established in the studies that during the nitriding of alloyed steels, phase points are formed, which are also formed during the nitriding of iron, only during alloying does the composition of the phases and the temperature intervals of their formation change. Studies have shown that in alloyed steel, due to the nitrogen content in the ε-phase, the hardness is increased to HRC 63.

Following the nitride zone during nitriding in steels, there is a layer of the α-phase, which is the main part of the diffusion layer. Refractory alloying elements increase the solubility of nitrogen in the α-phase. During nitriding, the mosaic blocks are also refined and the α-phase lattice is distorted. The overall change in the defectiveness of the crystal structure of the α-phase depends on the nitriding temperature. When nitriding in the region of 500-600°C, the α-phase zone provides ferrite grains, and at a higher temperature of more than 600°C, a darkly etched zone is formed, also consisting of ferrite grains. Moreover, the darkening of ferrite grains increases with an increase in the content of alloying elements. During slow cooling after nitriding in steel, a γ'-phase of an acicular character is released from the α-phase. All alloying elements to some extent reduce the diffusion coefficient of nitrogen in the α-phase and, accordingly, reduce its depth.

The structure of the nitrided layer is formed not only at saturation temperature but also during subsequent cooling. During cooling of the nitrided layer, the α-solid solution decomposes. This decay is strongly influenced by the rate of cooling. If there is a slow cooling, then simultaneously granular needle-like nitrides are formed that are released from the α-phase. The properties of the nitrided layer are determined by the structure that was formed during the saturation of the steel with nitrogen and subsequent transformations occurring during cooling. Two phases have high hardness: γ'-phase and nitrogenous martensite α'-phase. All alloying elements reduce the thickness of the nitrided layer but significantly increase the hardness of the steel surface. It was found that the high hardness of the nitrided layer is obtained by separating dispersed nitride alloying elements from solid solutions, which distort the α-phase lattice and serve as an obstacle to the movement of dislocations.

Moreover, the greatest increase in hardness corresponds to the nitriding temperatures at which nitrides are actively formed. The nitride layer forms strong elastic distortions of the crystal lattice of the α-phase. These distortions prevent the movement of dislocations and contribute to the hardening mechanism of the steel. By changing the temperature and time of nitriding, it is possible to fix various stages of nitride precipitation in the diffusion zone and thus control the degree of steel hardening. When alloying steel with several elements, the degree of distortion of the diffusion layer is much higher than that of steel alloyed with one element. Therefore, complex alloy steels tend to have higher hardness than low alloy steels.

References

1. Lakhtin YuM and Kozlovsky IS. “Fundamentals of chemical heat treatment technology”. M. Mashinostroeniya (1985): 256.
2. Guriev AM., et al. “Improving the technology of chemical-thermal processing of tool steels and metal processing”. 6.1 (2009): 19-21.
3. Dolzhenkov VN. Cyanidation of improved steels in pastes: Cand. tech. Sciences. - Kursk (2001): 127.
4. Lakhtin YuM and Kogan YaD. “Nitriding of steel”. M.: Engineering (2005): 254.
5. Norkhudjayev FR., et al. “Influence of nitrocementation modes on the change in the hardness of the surface layer of structural steels”. Journal NX- A Multidisciplinary Peer Reviewed Journal 7.11 (2021): 75-77.
6. Alimbabaeva ZL and Bektemirov BSh. “Composite materials production technology for machining materials”. Lityo i metallurgiya 2020: sbornik nauchnih rabot III Mejdunarodnoy nauchno-prakticheskoy internet konferenciy studentsov i magistrantov, 18-19 noyabrya 2020 g./sost. AP Bejok. Minsk: BNTU (2021): 92-93.
7. Tilavov Yunus Suvonovich., et al. “Research of Technological Modes of Production of Small Diameter Rods from Niobium”. In: Ciobotă, D.D. (eds) International Conference on Reliable Systems Engineering (ICoRSE) - 2022. ICoRSE 2022. Lecture Notes in Networks and Systems, Springer 534 (2022).
8. Alimbabaeva ZL., et al. “Physical and technological basis for formation of coatings by electric contact sintering”. Casting and metallurgy 2022: collection of scientific papers of the International Scientific and Practical Internet Conference of Students and Undergraduates. Minsk: BNTU (2022): 175-176.