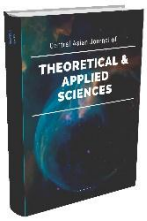

CENTRAL ASIAN JOURNAL OF THEORETICAL AND APPLIED SCIENCES

Volume: 04 Issue: 09 | Sep 2023 ISSN: 2660-5317
https://cajotas.centralasianstudies.org

Influence of Low Temperature Nitrocarburizing Modes on the Structure and Properties of X12ф1 Steel

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Received 28th Jul 2023, Accepted 29th Aug 2023, Online 30th Sep 2023

Abstract: *In the article, the influence of low-temperature nitrocarburizing on the structure and properties of X12Ф1 steel was considered. It was found that for X12Ф1 steel the highest values of micro-hardness are achieved at a saturation temperature of 550 °C and amount to 12,000 MPa at a four-hour saturation.*

Keywords: *wear resistance, heat resistance, tempering, carburizing, nitrocarburizing.*

The essence of combined chemical-thermal treatment in our case is the possibility of combining the processes of saturation of steel with carbon and nitrogen atoms and the process of steel tempering into a single technological cycle. It was found that the most optimal heating temperature for hardening the steel in question, from the point of view of wear resistance and heat resistance of the structure, is the hardening temperature in the range of 1150-1200 °C. At these temperatures, increased doping of the solid solution occurs and the defectiveness of the crystal structure increases. When tempering this steel at temperatures of 550-600 °C, the process of secondary hardening of steels begins due to the release of heat-resistant fine carbides.

It is known that the process of saturation with carbon and nitrogen atoms [1,2,3] with low-temperature cyanidation begins at a temperature of 560 °C, and for intensive saturation of steel with carbon in a short time, the process temperature should be as high as possible. However, with an increase in temperature above 650 °C, processes of decomposition of the steel structure begin, which leads to softening of the steel and a decrease in hardness. Therefore, in our case, to combine the processes of tempering and cyanidation, temperature ranges of 550-620 °C were chosen. It was necessary to establish the optimal time for saturation of steel with nitrogen and carbon atoms to obtain a saturated layer with a depth of 0.2 to 0.4 mm. For the saturation process, we chose a composition from a mixture of urea (urea) and soot; It is known that urea decomposes according to the reaction

$2(NH_2)_2CO=4N+4H_2+C+CO_2$

Highlighting During this decomposition, carbon and nitrogen diffuse into the steel. The use of soot in carburizers for carburization [4-7] makes it possible to intensify the process of carburization of steel. 2 compositions were chosen as a saturating medium:

1. 60% carbon black + 40% urea.
2. 80% carbon black + 20% urea.

This ratio was chosen based on the recommendations [8] for solid cyanidation in a mixture of charcoal and yellow blood salt. In our case, charcoal was replaced by carbon black, and yellow blood salt was replaced by carbamide (urea) as the most technological medium. In addition, urea is produced in the Republic of Uzbekistan at the Navoiazot production association and is not a scarce raw material.

In order to identify the optimal composition, studies were first carried out on saturating a sample of X12F1 steel with two compositions at a temperature of 550-600 °C. Steel containers were prepared into which steel samples were placed with an appropriate filling of a mixture of soot and urea. The lid of the container was covered with refractory clay, and the container was placed in an electric oven heated to a given temperature. The depth of the carbonitride zone in steels was studied at quenching temperatures of 1150 °C, saturation temperatures of 550-600 °C and holding times from 1 to 4 hours (Fig. 1-2). The holding time was chosen according to generally accepted recommendations.

The combined saturation of steels with nitrogen and carbon differs sharply from the process of carburization, nitriding and boriding [9-10]. The activity of nitrogen and carbon during nitrocarburization depends on the partial pressure of nitrogen and carbon, which in turn depends on the temperature of the saturating medium. At lower temperatures, nitrogen is actively generated due to the dissociation of carbamide (urea).

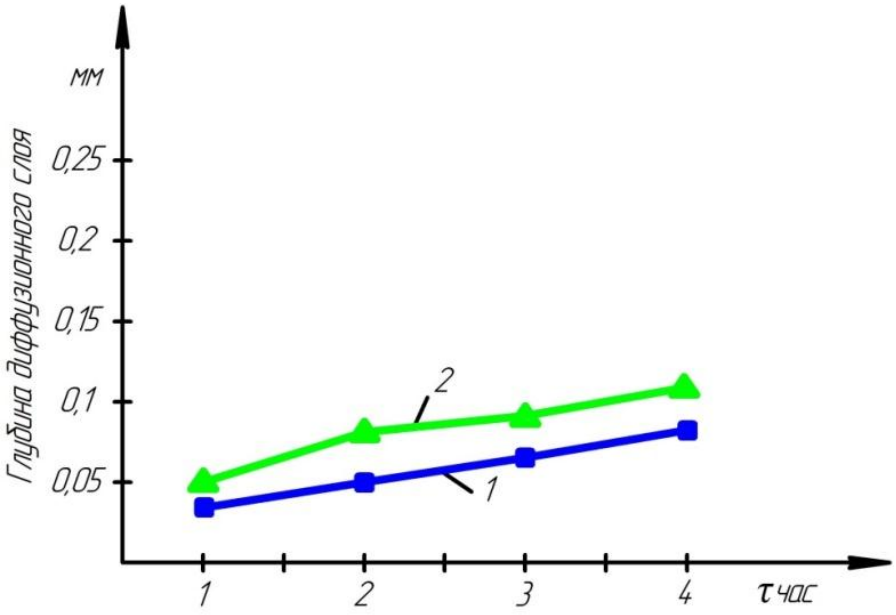

Fig.1. Effect of holding time on the depth of the diffusion layer of X12F1 steel after quenching from 1150°C and the nitrocarburization process at temperatures of 550 °C (curve 1) and 600 °C (curve 2), composition 1.

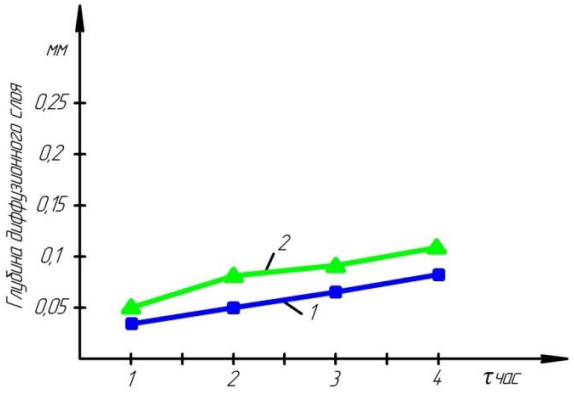

Fig.2. The influence of exposure time on the depth of diffusion layer of X12F1 steel after quenching from 1150 °C and the nitrocarburization process at temperatures of 550 °C (curve 1) and 600 °C (curve 2), composition 2.

As the temperature of the saturating medium increases, carbon begins to be released more actively, which, in the process of diffusion, displaces nitrogen into the deeper layers of the steel. In our case, in the process of combining steel tempering with the process of low-temperature nitrocarburization, the saturated layer is a thin mixture of martensite and the resulting carbonitride phases (Figure 3-4) [11-12].

Figure 3. Cyanidated layer after saturation for 4 hours x500

Figure 4 ε – phase along grain boundaries in the cyanidated layer x500

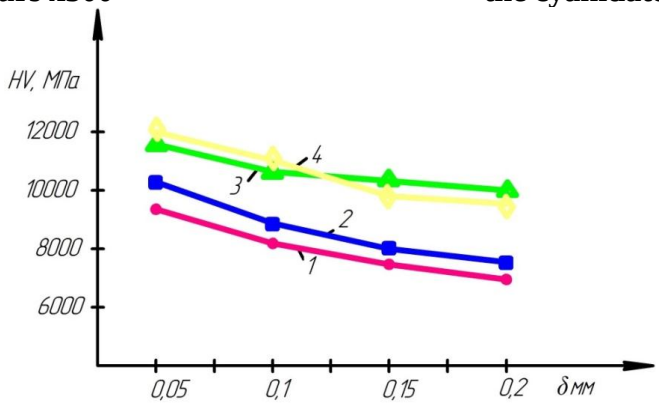

Fig.5. Change in the microhardness of the cyanidated layer according to the depth of saturation of X12F1 steel. Tsaturation=550 °C

Saturation time 1 – 1 hour, 2 – 2 hours, 3 – 3 hours, 4 – 4 hours

A thin, non-etching layer of light carbide crust is formed on the surface of the cyanidated layer. After the crust layer there is a thick, darkly etched zone that does not have a sharp boundary with the main structure. The hardness of the dark-etched zone is HV 10,000 MPa, the hardness of the light crust is HV 8600 MPa. The structure of the dark-etched zone is a mixture of martensite, carbides and carbonitrides of the $M_3(C,N)$ type. The change in micro-hardness of the surface layer of the X12F1 steel sample subjected to low-temperature nitrocarburization is shown in Fig. 6-7 [13-14].

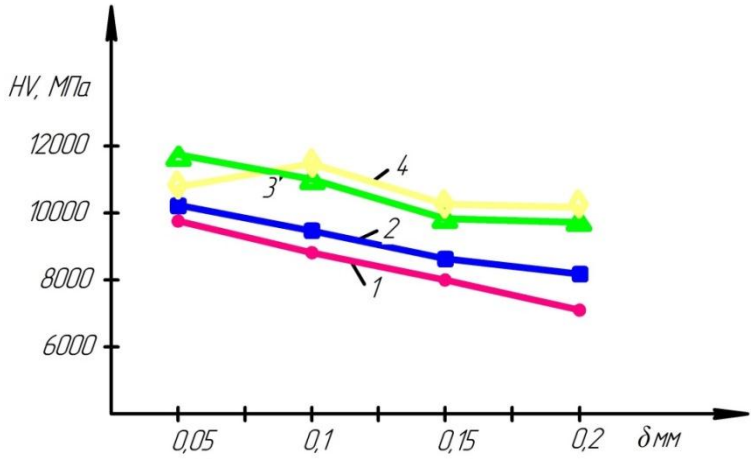

Fig.6. Change in the microhardness of the cyanidated layer according to the depth of saturation of X12F1 steel. Tsaturation=600 °C

Saturation time 1 – 1 hour, 2 – 2 hours, 3 – 3 hours, 4 – 4 hours

For X12F1 steel, the highest microhardness values are achieved at a saturation temperature of 550 °C and amount to 12,000 MPa at four-hour saturation [15].

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