WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979 (Volume 2, Issue 12, Dec., 2021

# EFFECT OF LOW-TEMPERATURE NITROCEMENTATION ON THE PROPERTIES OF 4XMFC STEEL

Begatov Jakhongir Mukhammadjonovich
Doctor of Philosophy in Technical Sciences (Ph.D.), Joint Belarusian-Uzbek Intersectoral Institute of Applied Technical Qualifications in Tashkent

Djalilova Malika Mirkamalovna
Teacher, Joint Belarusian-Uzbek Intersectoral
Institute of Applied Technical Qualifications in Tashkent

**Abstract**
This article presents the results of studies of the influence of low-temperature nitrocementation modes on the structure and properties of 4HMFC steels. The possibilities of carrying out a combined technology with nitrocementation are shown.

**Keywords:** nitrocementation, cyanidation, austenite, martensite, hardness, tempering.

## Introduction

The essence of combined chemical and thermal treatment in our case consists in the possibility of combining the processes of saturation of steels with carbon, nitrogen atoms and the process of tempering steels into a single technological cycle. It was found that the most optimal heating temperature for quenching the steels in question, from the point of view of wear resistance, heat resistance of the structure, are the quenching temperatures of 1150-1200$^0$C. At these temperatures, there is an increased alloying of the solid solution, the defectiveness of the crystal structure increases. When tempering for these steels 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 during 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.[1] However, with an increase in temperature above 650 °C, the processes of disintegration of the steel structure begin, which leads to softening of the steel and a decrease in hardness. Therefore, in our case, temperature ranges of 550-620 °C were chosen to combine the tempering and cyanidation processes. It was necessary to establish the optimal time of saturation of steels with nitrogen and

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carbon atoms to obtain a saturated layer with a depth of 0.2 to 0.4 mm.

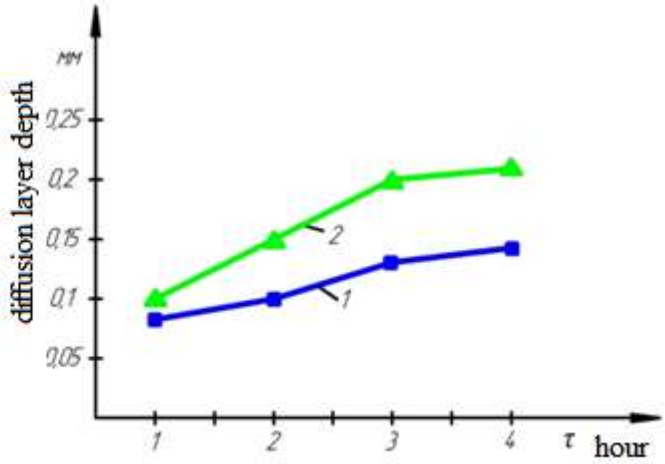


Fig.1.1. The effect of the holding time on the depth of the diffusion layer of 4XMFC steel after quenching from 1150 °C and the nitrocementation process at temperatures of 550 °C (curve 1) and 600 °C (curve 2), composition 1.

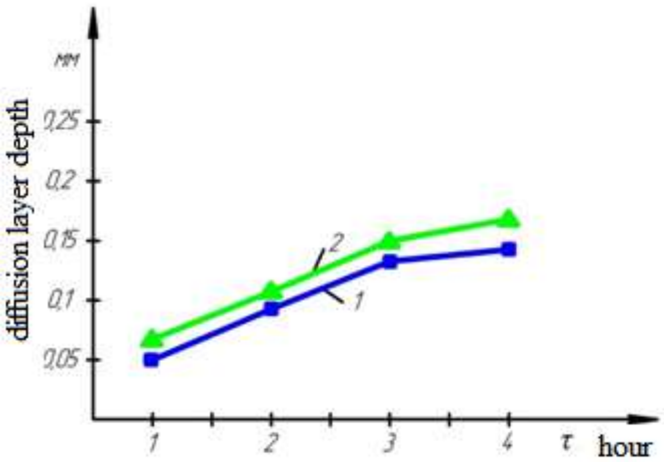


Fig.1.2. The effect of the holding time on the depth of the diffusion layer of 4XMFC steel after quenching from 1150 °C and the nitrocementation process at temperatures of 550 °C (curve 1) and 600 °C (curve 2), composition 2.

For the saturation process, we selected a composition from a mixture of urea (urea) and carbon black; it is known that urea decomposes according to the reaction
$2(NH_2)_2CO=4N+4H_2+C+CO_2$
The carbon and nitrogen released during this decomposition diffuse into the steel. The use of soot in the carburetor for cementation makes it possible to intensify the process of carburization of steel.[2]

2 compositions were selected as the saturating medium:

1. 60% soot + 40% carbamide.
2. 80% soot + 20% carbamide.

This ratio was chosen based on the recommendations for solid cyanidation in a mixture of charcoal and yellow blood salt. In our case, charcoal was replaced with carbon black, and yellow blood salt was replaced with carbamide (urea) as the most technological environment.[3]

In addition, carbamide is produced in the Republic of Uzbekistan in the production association "Navoiazot" and is not a scarce raw material. To identify the optimal composition, studies were first carried out on the saturation of 4XMFC, 4X5MF1C steel samples with two compositions at a temperature of 550-600$^0$C. Steel containers were prepared, where steel samples were placed with the appropriate filling of a mixture of soot and carbamide.

The lid of the container was covered with refractory clay and the container was placed in an electric furnace heated to a predetermined temperature. The depth of the carbonitride zone in steels was studied at quenching temperatures of 1150 °C, saturation temperature of 550-600 °C, and holding time from 1 to 4 hours (fig. 1.1-1.2). The exposure time was selected according to generally accepted recommendations.

The joint saturation of steels with nitrogen and carbon is sharply different from the process of cementation, nitriding, and boration.5 The activity of nitrogen and carbon in the nitrocementation process 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). With an increase in the temperature of the saturating medium, carbon begins to be released more actively, which in the process of diffusion displaces nitrogen into deeper layers of steel. In our case, in the process of combining the tempering of steels with the process of low-temperature nitrocementation, the saturated layer is a thin mixture of martensite and the resulting carbonitride phases.

A thin, non-etching layer of light carbide crust forms on the surface of the cyanized layer. After the crust layer, there is a thick dark-etching zone that does not have a sharp border with the main structure. The hardness of the dark etching zone HV 10000 MPa, the hardness of the light crust HV 8600 Mpa. The structure of the dark etching zone is a mixture of martensite, carbides, and carbonitrides of the $M_3$(C, N) type.

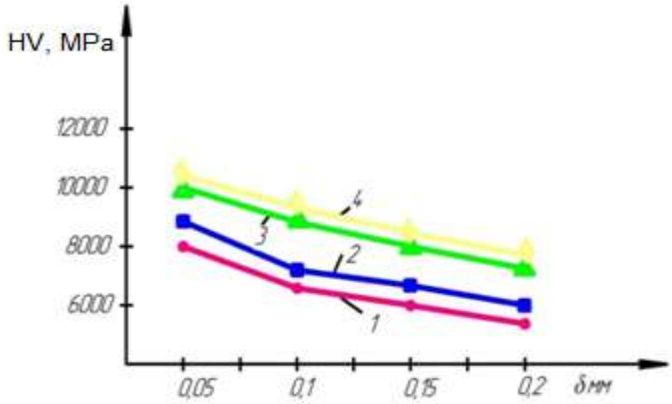


Fig.1.3. Change in the microhardness of the cyanized layer by the saturation depth of steel 4XMFC. $T_{satur}$=550°C
Saturation time 1 – 1 hour, 2 – 2 hours, 3 – 3 hours, 4 – 4 hours

## Conclusion

The change in the microhardness of the surface layer of 4XMFC steel samples subjected to low-temperature nitrocementation is shown in figure 1.3.
For 4XMFC steels, the microhardness of the surface zone reaches values of 8000 MPa within one hour, to obtain microhardness values of 10000MPa, the minimum saturation time should be three hours. The analysis of the presented data shows that the saturation temperatures of 5500 °C and 600 °C practically give one value of microhardness.

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