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# INFLUENCE OF NITROCEMENTATION MODES ON THE CHANGE IN THE HARDNESS OF THE SURFACE LAYER OF STRUCTURAL STEELS

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**ABSTRACT:**

**This article provides research on the influence of technological modes of nitrocarburizing carried out in a paste-like carburized on the change in the hardness of the surface layer of steels of grades 40 and 40X. These steel grades are the most used in the manufacture of machine parts in which surface hardness is the determining factor in the wear resistance of steel.**

**Keywords: steel, nitrocarburizing, temperature, hardness, microhardness.**

## I. INTRODUCTION:

A feature of nitrocarburizing and cyanidation processes is the ability to use a wide range of temperatures for saturation, depending on the requirements for the processed products. If it is necessary to obtain high hardness on the surface of parts (HRC 58-63) at a layer depth of 0.2-0.8 mm and, if required, ensure the hardness of the core (HRC - 30-43) within the specified limits, then nitrocarburizing (or cyanidation) is recommended at 840-870 $^0$C followed by conventional cold oil quenching; if the deformation should be minimal, then step-by-step quenching withholding in hot oil (180-200 $^0$C) is carried out.

When products, according to the conditions of their operation (small gears, bushings, ball bushings, piston pins), require a much smaller layer depth (0.025-0.15 mm), it is advisable to use nitrocarburizing or cyanidation at low temperatures (540-670 $^0$C) [1] followed by cooling in calm air, as well as blowing with air or gas. Due to the high nitrogen content on the surface, the critical quenching rate is significantly reduced, and even when cooling in air, a real possibility of obtaining a high hardness of the nitrocarburized layer and minimal deformation is created due to the absence of sharp cooling after saturation.

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For the joint saturation of steel with nitrogen and carbon in the industry, such technological processes as high-temperature and medium-temperature cyanidation, nitrocarburizing, as well as low-temperature saturation processes have been developed [2,3].

## II. RESEARCH METHODS:

For the study, steels were selected that are widely used for the manufacture of machine parts, which require increased fatigue strength, impact toughness, and increased wear resistance. These requirements are met by medium-carbon tempering steels.

Quality improved carbon and low-alloy structural steels are used for medium-sized parts of a simple configuration, operating at low speeds and medium-specific loads. Improved steels with the addition of 1–2% alloying elements (mainly chromium and manganese) have an increased hardenability and are therefore used for parts operating with increased loads, in particular in the presence of small shock loads. Considering the above, two steel grades were chosen: 40 and 40X. The chemical composition of these steels is shown in table 2.1.

Table 2.1. Chemical composition of the studied steels

| Steel grade | Content of elements, % | | | |
|---|---|---|---|---|
| | C | Si | Mn | Cr |
| 40 | 0,41 | 0,27 | 0,65 | - |
| 40X | 0,40 | 0,21 | 0,67 | 0,95 |

To study the effect of nitrocarburizing modes on the strength and other characteristics of the surface layers of 40-40X sheets of steel, nitrocarburizing of these steels was carried out at various temperatures in the range 450-650 $^0$C.

Nitrocarburizing was carried out in a paste-like carburized consisting of urea - 70% (nitrogen-containing component) and soot - 20% $Na_2CO_3$ - 10%. After nitrocarburizing, the samples were cooled either in water or in calm air.

The hardness of the samples after nitrocarburizing was measured on a TK-2 hardness tester on the "A" scale (load 60 kgf), taking into account the small depth of the hardened layer, or the microhardness was determined on a PMT-3 device with a load of 50 g.

## III. RESULTS:

The results of the experiment are shown in Figures 1-3. Experiments show that with an increase in the temperature of nitrocarburizing from 450 to 550 – 570 $^0$C, the hardness of the nitrocarburized layer increases. This coincides with an increase in the thickness of the carbonitride crust, which also increases with an increase in the nitrocarburizing temperature to the indicated values (see Fig. 3). With a further increase in the temperature of the nitrocarburizing process, the hardness of the surface layers decreases, although the total depth of the diffusion layer, as shown above, increases.

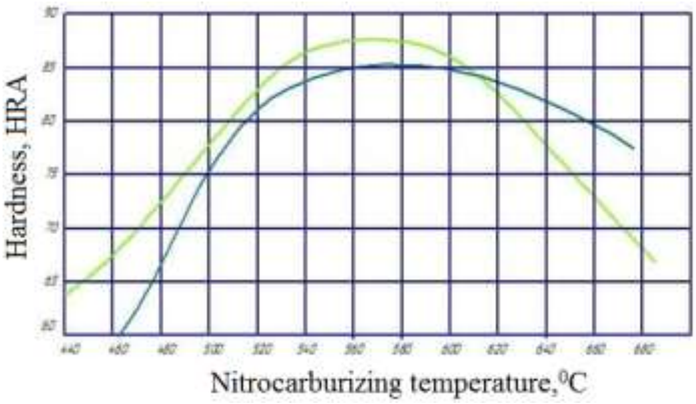


Fig. 1. Influence of the temperature of nitrocarburizing (duration 3 h) of steels 40X (curve 1) and 40 (curve 2) on the hardness of the surface layers

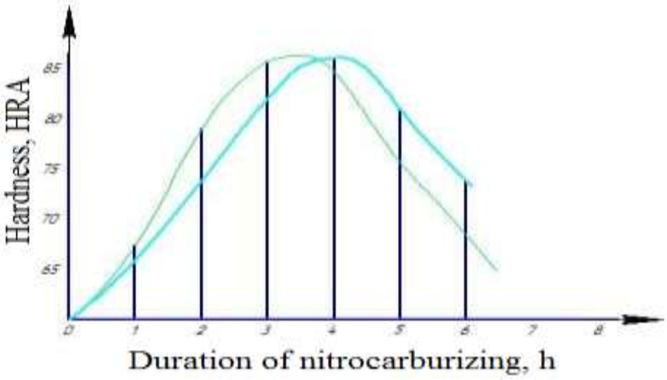


Fig. 2. Influence of the duration of nitrocarburizing (at 5500C) of steels 40X (curve 1) and 40 (curve 2) on the hardness of the surface layers

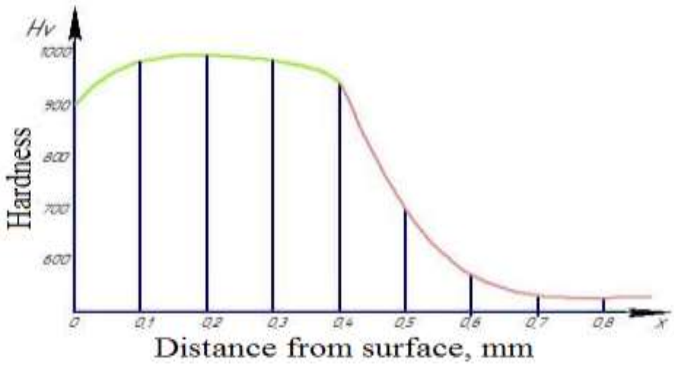


Fig. 3. Distribution of microhardness over the cross-section of a nitrocarburized steel sample of 40X, τ = 550 $^0$C, τ = 3 h.

The microhardness of the nitrocarburized layer is unevenly distributed along with its depth (see Fig. 3). On the surface itself, its thickness reaches, ~ 800Nμ, at a depth of 0.01 ... 0.05 mm, an increase in the value of microhardness to ~ 1000Nμ is observed and this value remains at a considerable depth (up to 0.3 ... 0.4 mm). Then a sharp decrease in microhardness is observed, which coincides with the end of the carbonitride layer. At a depth of 0.6 ... 0.7 mm, the microhardness value stabilizes at a relatively low level (~ 500Nμ).

This distribution of microhardness over the cross-section of the nitrocarburized layer of the sample suggests its high wear resistance for various types of wear, both without abrasive and in the presence of abrasive particles in the friction zone. The hardness of the most common natural abrasive, quartz sand, is about 1000Nμ. This value is the same as the hardness of the nitrocarburized layer, so the sand will not have an abrasive effect on the nitrocarburized layer.

At nitrocarburizing temperatures above 550-570 $^0$C, the decrease in hardness of alloy steel 40X occurs more intensively than that of ordinary carbon steel 40. So if at 550 $^0$C the hardness of steel 40X is more than 85HRA, and steel 40-84HRA, then at 650 $^0$C the hardness of steel 40X is much lower and is about 70HRA, while the hardness of 40 steel only drops to 80HRA.

## IV. CONCLUSION:

1. Technologically, it is possible to use nitrocarburizing steels 40 and 40X combined with high tempering after quenching.
2. An optimal nitrocementizing medium has been established – a paste-like coating consisting of urea and soot with a bonding agent.

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