EFFECT OF PRIOR SURFACE PLASTIC DEFORMATION
ON THE STRUCTURE AND CONTACT DURABILITY
OF NITRIDED STEEL 16Kh2N3MFAYu-Sh (VKS-7)

S. A. Gerasimov, É. A. Eliseev, V. I. Kucheryavyi,
S. D. Karpukhin, and V. K. Nekrasov

The state of the surface layer is of special importance in connection with the use of nitriding as the final
operation in the manufacturing cycle for the preparation of reliable heavily loaded components. In this work
the effect of surface plastic deformation (SPD) on the structure and contact durability of nitrided steel
16Kh2N3MFAYu-Sh (VKS-7) was investigated.

It is known that the use of surface plastic deformation as the final operation in the manufacturing cycle increases the
contact durability of ground carburized and nitrided components [1, 2] due to the creation of a favorable stressed state in the
surface layer. In addition, the effect of machining on the structural state of the surface layer prior to nitriding is important for
nitrided components which are not ground. For example, the operation of tooth cutting forms a work-hardened layer 120-150
μm thick on the surface of machined parts [3].

In this work* the structure and properties of steel 16Kh2N3mFBAYu-Sh (0.18% C, 1.85% Cr, 2.9% Ni, 0.44% Mo,
0.13% V, 0.14% Nb, 0.2% Cu, 0.49% Mn, 0.33% Si, 0.01% Ti, 0.01% W, 0.04% Al, 0.014% Ce, 0.018% N, 0.07% S,
0.011% P) after SPD, and also after SPD subsequent ion-nitriding, were investigated.

The SPD of specimens for microstructural analysis was carried out using a hard-alloy cutting tool with a blunt cutting
edge (radius of the cutting edge = 1.5 mm) without removing a cutting (Fig. 1). In this operation the following working
conditions were simulated: cutting speed \( n = 250 \text{ rpm} \), depth of cut \( t = 0.3 \text{ mm} \), feed rate \( S_f = 0.02 \text{ mm/turn} \). Subsequent
ion nitriding of specimens for structural investigation was carried out in chemically pure nitrogen in a one-step process at
500°C for 24 h.

Specimens for the contact durability tests were hydrojet shot blasted before nitriding. The shot material was ball-bearing
steel, particle diameter 0.8-1.2 mm, exit velocity 8 m/sec, shot consumption 10 ± 1 kg/min, conveying medium - transformer
oil, pressure 0.45 ± 0.05 N/mm². The kinetic energy of the shot arriving on a unit of treated surface area was calculated
according to the equation:

\[ E = E_{sp} \tau \]

where \( E_{sp} \) is the specific kinetic energy imparted by the shot to a unit of surface per unit time and \( \tau \) is time for hardening a
unit of surface on which the shot falls under the effective angles 45-90°. The energy \( E \) was varied from 50 to 100 kJ/m², \( T \)
from 2 to 4 min.

Specimens for the contact durability tests were nitrided by a two-step process: (1) 500°C for 24 h; (2) 540°C for 48
h.

* D. L. Korobov participated in the work.

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Contact durability was determined on roller specimens by the method of point contact without sliding (GOST 25.501) on the machine MKV-K at a maximum normal stress of 5000 N/mm².

Metallographic and durometric analysis of the specimens was carried out. The structure of steel 16Kh2N3MFBAYu-Sh before and after nitriding was studied by x-ray diffraction analysis and electron microscopy. The widths of the (110) and (220) diffraction lines of the α-phase were determined on the x-ray diffractometer DRON-3 in cobalt K-radiation. Diffractograms were taken on work-hardened and unworked portions of one and the same specimen before and after nitriding, 3-5 times on each. The electron microscope studies were carried out using the thin-film technique on the electron microscope Testa BS-540 at an accelerating voltage of 120 kV. The foils were prepared using the following sequence of operations: (1) Cut a 0.5 mm sheet from the work-hardened side of the specimen for structural analysis; (2) Hand-grind the sheet on the side opposite the work-hardened surface to a thickness of 50 ± 10 μm; (3) Electrolytically etch the ground sheet. Since electrolytic etching occurs to the same degree on both sides of the foil, we assume that the image on the screen of the electron microscope reflects the structure of the material at a distance of 25 ± 5 μm from the surface.