

UDC 621.785.532:621.78.669.17

EFFECT OF ION NITRIDING ON THE WEAR RESISTANCE OF ALLOYS

V. P. Artem'ev¹

Translated from *Metallovedenie i Termicheskaya Obrabotka Metallov*, No. 4, pp. 10–11, April, 2001.

INTRODUCTION

Small fitment parts are produced from corrosion-resistant steels that are known to possess low tribological properties. This problem can be solved by nitriding. Nitriding increases the strength, hardness, wear resistance, and score resistance of steels with a nitrided layer. The traditional nitriding process possesses substantial disadvantages, i.e., a high duration of diffusion saturation, brittleness of the hardened surface layer, difficulties in saturation of easily passivating materials, and the impossibility of fabricating a layer of the same thickness over the whole of the treated surface of a part with complex configuration [1]. In addition, successful nitriding of corrosion-resistant steels requires additional depassivation of the surface, because the dense oxide film lying on the surface of these metals hampers the penetration of nitrogen into them.

The method of nitriding in low-temperature plasma of a glow discharge, i.e., ion nitriding, provides diffusion layers with specified structure and properties on steels and alloys of nonferrous metals. The advantages of this method are the increased productivity of labor, the possibility of controlling the saturation process with optimization of the structure and properties of the diffusion zone and the zone of the junction with allowance for the service conditions of specific parts, decreasing the brittleness of the nitrided layer, decreasing the deformation of the parts during the treatment, and preservation of the high purity of the surface.

In the present paper we describe the results of ion nitriding of corrosion-resistant steels 16Kh-VI and 14Kh17N2 and alloy 36NKhTYu (Table 1).

¹ Kuban State Technological University, Krasnodar, Russia.

METHODS OF STUDY

We performed the ion nitriding in two stages, namely, (1) cleaned the surface by cathode sputtering and (2) saturated the surface with nitrogen. In the first stage of the process the surface of the metal was activated and the oxide films were depassivated; in the second stage there occurred processes providing diffusion of nitrogen into the near-surface layers, i.e., heating of the surface to the saturation temperature, activation of the gas medium, provision of the requisite gradient of concentration of the saturating element, and control of the phase composition.

The nitrided parts were placed into the chamber and connected to the negative electrode. Then the chamber was sealed, and the atmosphere in it rarefied to 0.532 Pa. After evacuating the air the chamber was blown with the working gas. The cathode sputtering was performed at a voltage of 1600 V and a current of 0.1 A. The parts were heated to at most 250°C. The duration of the cathode sputtering was 0.3 h. After it the surfaces of the parts were depassivated and thus prepared for nitrogen saturation. The saturation of the parts with nitrogen was performed by an optimum regime, i.e., at a voltage of 650–900 V and a pressure in the chamber of 798–1064 Pa. The working temperature of the process (530–580°C) was provided in 15–30 min. The heating rate was determined by the proportion of the area of the surface of the parts to their mass. The nitriding was performed in a nitrogen-hydrogen mixture (95% N + 5% H). The nitrided parts had the final sizes.

The microhardness of the parts was measured by a PMT-3 device under a load of 0.5 N.

TABLE 1

Grade of alloy	Content of elements, %									
	C	Cr	Ni	Ti	Cu	Al	Si	Mn	S	P
16Kh-VI	0.015	–	0.3	–	–	5.5	0.2	0.3	0.015	0.015
36NKhTYu	0.05	11.5–13.0	34.5–36.5	2.7–3.2	–	0.9–1.2	0.5	0.8–1.2	–	–
14Kh17N2	0.11–0.17	16–18	1.5–2.5	0.2	0.3	–	0.8	0.8	0.025	0.03

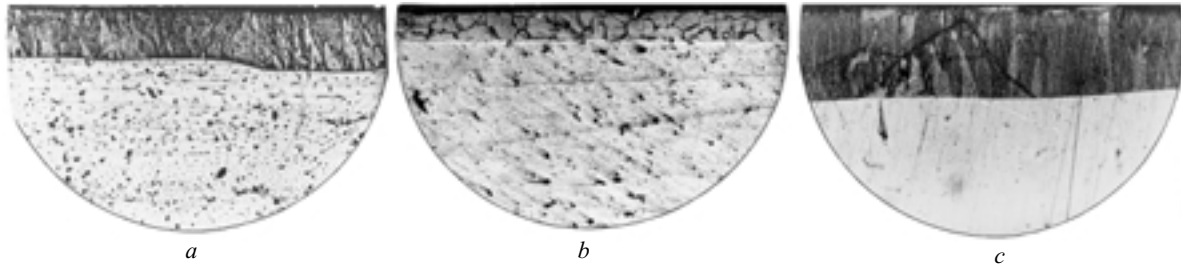


Fig. 1. Microstructure of the studied alloys after ion nitriding ($\times 200$): a) steel 16Kh-VI, $t_{nit} = 550^\circ\text{C}$, $\tau_{nit} = 6$ h; b) alloy 36NKhTYu, $t_{nit} = 530^\circ\text{C}$, $\tau_{nit} = 7$ h; c) steel 14Kh17N2, $t_{nit} = 550^\circ\text{C}$, $\tau_{nit} = 7$ h.

The wear resistance of the nitrided layer was studied in a friction machine with shuttle motion by the method described in [2]. The load on the indenter was 10 N; the path was 6 mm. The linear wear was determined by transverse profilography of the wear traces. The profilograms were taken by a 201 profilograph-profilometer under the following regimes: the speed of the gauge was 1 mm/min, the speed of the ribbon was 80 mm/min; the vertical magnification was $\times 10,000$. The cross section of the profilograms was rather accurately describable by simple geometrical figures, trapeziums in the given case. We calculated the areas of these trapeziums S and determined the relative linear wear I by the formula

$$I = \frac{S}{b},$$

where b is the maximum width of the wear furrow.

RESULTS AND THEIR DISCUSSION

The microhardness (HV) and the thickness of the hardened layer (h) of the studied alloys after nitriding by different regimes are given in Table 2 and the microstructure is presented in Fig. 1.

It can be seen that with increase in the nitriding temperature the thickness of the hardened layer increases. A layer of maximum thickness is formed on steel 16Kh-VI saturated for 6 h at 580°C .

The thickness of the diffusion layer on alloy 36NKhTYu is lower than on steel 16Kh-VI and amounts to 60 – 100 μm depending on the saturation regime. The high hardness is preserved over the entire cross section of the diffusion layer, decreasing gradually at the interface of the layer and the substrate (Fig. 2), which indicates a strong cohesion between the coating and the substrate metal. The high hardness of the nitrided layer is determined by the formation of γ' -phase in the nitrogen plasma.

The initial sizes and the roughness of the surface of the parts after ion nitriding do not change.

Figure 3 shows the variation of the wear of the nitrided layer on steel 16Kh-VI and alloy 36NKhTYu in air after dif-

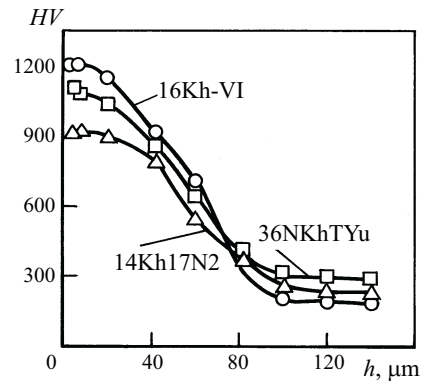


Fig. 2. Variation of the microhardness over the thickness of the nitrided layer of the studied alloys after saturation by different regimes (h is the distance from the surface): 1) steel 16Kh-VI, $t_{nit} = 550^\circ\text{C}$, $\tau_{nit} = 6$ h; 2) alloy 36NKhTYu, $t_{nit} = 550^\circ\text{C}$, $\tau_{nit} = 7$ h; 3) steel 14Kh17N2, $t_{nit} = 550^\circ\text{C}$, $\tau_{nit} = 7$ h.

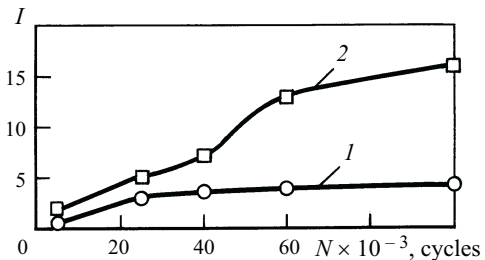


Fig. 3. Relative wear I of steel 16Kh-VI (1) and alloy 36NkhTYu (2) as a function of the number of run cycles.

TABLE 2

Grade of alloy	$t_{nit}, ^\circ\text{C}$	τ_{nit}, h	HV	$h, \mu\text{m}$
16Kh-VI	550	6	1050	80
	580	6	1200	120
36NKhTYu	530	7	1025	60
	550	7	1085	80
14Kh17N2	580	7	1200	100
	530	7	1000	70

ferent saturation regimes after a run of 100,000 cycles. At such a run the linear wear of the nitrated layer of the steels does not reach the substrate metal.

CONCLUSIONS

We used the results of our tests for choosing regimes of ion nitriding for the studied alloys which provide elevated anti-friction properties and a high wear resistance of the friction surfaces of small fitment parts. For steel 16Kh-VI the

optimum regime is 580°C, 6 h; for steel 14Kh17N2 and alloy 36NKhTYu it is 550°C, 7 h.

REFERENCES

1. B. N. Arzamasov, A. G. Bratukhin, Yu. S. Eliseev, and T. A. Panaioti, *Ion Chemicothermal Treatment of Alloys* [in Russian], Izd. MGTU im. N. É. Baumana, Moscow (1999).
2. Yu. L. Lohvitskii and V. M. Kolesnikov, "On the evaluation of shuttle wear in corrosion-active media," in: *Strength of Materials in Aggressive Media* [in Russian], Izd. KPI, Krasnodar (1976), pp. 62 – 65.