Technology of ionic-plasmic nitriding of teeths of disc saw of the knot of saw cylinder

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Abstract. The technology of obtaining a deep-nitrided layer on the teeth of disc saw of the saw cylinder for a short period of time (0.5–2 hours) and subsequent standard heat treatment is considered. The results of testing of resistant characteristics of circular saws, made of U8G steel and processed using deep nitriding technology, are presented.

The saw cylinder of the fiber separation machine is designed to grapple the fibers of feathers with the teeth of the saw blades, tear it off from the seeds and carry it out through the slotted gaps in the flat grate to the air intake apparatus. In addition, at the same time as the fiber is torn off, the saw cylinder, making contact with the raw roller on the fiber grapple arc into the working chamber, rotates it, which creates conditions for the constant supply of fresh fibers of feathers to the saw blades.

The following technological requirements for the saw cylinder are determined: the saw cylinder must have a high exciting ability to ensure a given performance and continuous rotation of the raw roller; saw blades must be rigidly fixed to the shaft of the saw cylinder, do not change their position during operation. When the cylinder rotates, the saws pass strictly in the center of the gap between the grates [1].

According to the number of saw blades on the shaft, the saw cylinders are divided into cylinders with 80, 90 and 130 saw and cylinders with even more saws. Moreover, an increase in the number of saws over 90 requires a change in the dimensions of the fiber separation machine.

The task of increasing the efficiency of a disc saw of a saw cylinder knot of a fiber separation machine by increasing tooth resistance can be solved by using ionic-plasmic nitriding. This technology allows significantly accelerating the process of saturation of the surface of the teeth of the saw with nitrogen, compared with traditional furnace nitriding. So, during nitriding of a saw blade of a saw cylinder knot of a U8G carbon steel fiber separation machine in a two-stage vacuum-arc discharge plasma (DDR), a layer with an effective thickness of up to 200 μm and a hardness of up to 0.05 kgt/mm² is formed within one hour. The resistance of the teeth of a circular saw that was under such processing increases by 1.5 times compared with a non-nitrided circular saw [2].

Ionic-plasmic nitriding is a multifactorial process of chemical-thermal treatment. A number of technological factors determines the structure, phase composition and characteristics of the diffusion layer formed under the conditions of a glow discharge. By controlling them, it is possible to adjust the
thickness of the nitrided layer and its structural state, which determines the complex of necessary properties of hardened parts, taking into account the conditions of their operation. In addition to the usual technological factors affecting the efficiency of ion nitriding (temperature and duration of saturation, composition of the gaseous medium), it has additional factors due to the specifics of processing in a glow discharge (working gas pressure, electrical characteristics, interelectrode distance; configuration of parts and their location in the charge). Most of these factors are in a complex and yet insufficiently studied relationship. Therefore, currently used processes of ion nitriding are based on empirical data and experimental selection of rational regimes of surface hardening of various alloys [3].

With ion nitriding of any current-conductive materials, there are practically no restrictions on the size and weight of the workpieces.

One of the disadvantages of the existing ionic nitriding method is the impossibility of accelerating the process by increasing the ionic current density, since surface hardness decreases because of overheating of parts.

Studies have shown the promise of using the ionic nitriding method in a glow discharge to improve the properties of metal alloys.

Nitriding in the glow discharge is a fairly simple and reliable process, however, because of ion bombardment, the substrate surface cleanliness is significantly impaired, and the process requires the obligatory presence of hydrogen, which introduces certain difficulties.

The proposed technology compares favorably with other known methods of hardening a circular saw in that a relatively deep diffusion layer with a high nitrogen concentration is created in the steel. During the subsequent hardening of the circular saw, nitrogen diffuses deep into the product, increasing the hardness and heat resistance of steel to a depth of 0.7–1 mm.

The method of ionic-plasmic nitriding according to the DVDR method allows for purification, heating, and a high rate of nitrogen diffusion deep into the metal due to the high emission ability of the plasma [4]. Because to this solution, a high nitrogen concentration can be achieved in a short time (0.5–2 hours) in a thin (up to 200 μm) surface layer.

The technology of deep ionic-plasmic nitriding was implemented using the STANKIN-APP-1 installation (figure 1). A U8G steel saw was chosen as an object of study, and samples of the same steel were used for subsequent microhardness measurements and phase analysis. In order to avoid deformation of the circular saw, a rig was developed, since the thickness of the circular saw is 0.95 mm (figure 2).

![Figure 1. “STANKIN-APP-1” vacuum installation.](image1)

![Figure 2. Circular saw with the rig, placed in the vacuum chamber of the “STANKIN-APP-1” installation.](image2)
The disc saw and samples, after mechanical treatment of the annealed steel billet, were placed in the vacuum chamber of the STANKIN-APP-1 installation. Then heating was carried out to 650 °C in argon atmosphere at a pressure of 0.4 Pa with simultaneous ionic cleaning of the surface. I onic-plasmic nitriding was carried out at 650 °C in pure nitrogen for 1 hour at an arc current of \( I_d = 80 \) A and anode current of \( I_{an} = 75 \) A, and a bias voltage of \( U = 700 \) V was applied to the table with the work piece. After nitriding the saw and samples are slowly cooled in the chamber to room temperature [5].

To measure microhardness and establish the phase composition microsections were manufactured using equipment “Struers” (Denmark). Microhardness was measured using a “Micro-duromat 4000” attachment to a Polyvar-Met microscope (Austria) at a load of 0.294 N and a test time of 10 seconds. Imprints on the surface of the microsection were applied in the form of a “track” from the edge to the center in increments of 10 to 500 μm (depending on hardness and distance from the surface of the sample). The number of imprints at each depth ranged from three to eight, depending on the magnitude of the scatter of values. The relative error of the average microhardness with a probability of 0.95 did not exceed 4%.

X-ray phase analysis (XPA) was carried out on a PANalytical Empyrean diffractometer (Holland) using CuKα radiation. The shooting was carried out under conditions of symmetric focusing according to Bragg-Brentano, using a beta filter.

The results of microhardness measurements after ionic-plasmic nitriding are shown in Fig. 3 and allow to get a picture of the high concentration of nitrogen in a thin surface layer.

The high microhardness of the surface layer confirms this: at a depth of up to 200 μm, the microhardness is from 600 to 700 HV. High hardness is due to the presence in the steel structure of complex iron nitrides and alloying components of the Me₄N type, which contain up to 6% nitrogen by mass, while the nitrogen content in ferrite is significantly lower (at 590 °C no more than 0.12%) [6, 7]. The created high concentration of nitrogen in a thin surface layer is necessary for further diffusion of nitrogen deep into the steel during subsequent quenching.

**Figure 3.** The distribution of microhardness in depth in U8G steel, after ionic-plasmic nitriding at 650 °C for 1 h.
The high hardness and heat resistance of U8G steel after processing, as well as the large depth of the hardened layer, determine the increased resistance of the teeth of a disc saw (Fig. 4). Thus, for example, tooth resistance after deep nitriding is 1.5 time higher, comparing to non-nitrided.

**Figure 4.** Disc saw after nitriding.

Based on the foregoing, we can draw the following conclusion:

The more suitable deep ionic-plasmic nitriding technology was selected, and its practical implementation on disc saw blades made of U8G steel was carried out. The technology of deep nitriding makes it possible to obtain a depth of the diffusion layer of more than 1 mm with increased hardness and heat resistance, while the process of saturation with nitrogen does not exceed 1 hour.

The results of testing of resistant characteristics show the feasibility of using this technology for disc saws. The total durability of the teeth of a disc saw made of U8G steel increased by two times compared to a disc saw without nitriding.

**References**

[1] 2007 *Technological regulations for the processing of raw cotton* (Paxtasanoat-ilm)

[2] Berlin E V, Koval N N and Seydman L A 2012 *Plasmic chemical-thermal surface treatment of steel parts* (RIC "Technosphera") p 462

[3] Fuchs-Rabinovich G S, Moiseev V F, Brostrem V A, et al. 1995 Resistance of a nitrided tool made of high-speed steels *Friction and Wear* 4 780-6

[4] Bogachev I I, Klimov V N and Aleshin S V 2016 Technology of deep ionic-plasmic nitriding of a cutting tool *Machine tool construction and tool production* 5 30-2

[5] Fedorovich V A and Supov A V 1990 Nitriding and carbonitriding *Metallurgy* pp 14-7

[6] Lakhtin Yu M and Kogan Ya D 1976 Steel nitriding *Mechanical engineering* p 257