

**INTERACTIVE METHODS FOR INCREASING WEAR RESISTANCE OF CUTTING
TOOL BLADES**

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Abstract: In the scientific work, the features of the structure of the near-surface layer of high-speed steel R6M5, complex processing modified by the methods of the first ion-nitriding, ion alloying of the surface, and wear-resistant coating, its effect on the wear resistance of the tool during dry cutting of hard-to-cut chromium and its alloys are considered. Among the methods for such surface modification is a special process based on the use of high-intensity pulsed beams of charged particles. Ion-nitriding treatment was carried out on the APP-2 unit, ion-alloying treatment was carried out on the unit, the latter with low friction coating. The advantage of this device is that it coats the Nb and Hf elements on the surface of the cutting tool, heats up to 10 6 deg/s in 5 μ s, causing the two elements to diffuse into the cutting tool. The last treatment on the basis of reinforced cutting tools is coated with PLATIT π 311 (TiAl)N. As a result, the stability of the cutting tool has increased by 3-4 times. The study was conducted at the Navoi Machine-Building Plant and conclusions were drawn.

1 Introduction

Today, high demands are placed on carbide and high-speed cutting tools when working with them. For example, solid carbide end mills have characteristics such as high wear resistance, but over time or technological root causes, they are subject to wear and breakage. But it should be borne in mind that up to 80% of failures occur due to chipping, mowing and malfunctions that cut the wedge. The quality of the cutting tool, in this case, largely determines the productivity of the processing process and is the determining factor for obtaining parts of the required shape and size. Therefore, improving the quality of the cutting tool is the most important task [1, 2].

A cutting tool designed for machining heat-resistant, difficult-to-cut materials requires special characteristics. In this case, it is advisable to apply several successive treatments to the surface of the cutting tools. The use of a single chemical-thermal treatment or coating of a metal-cutting tool under heavy load conditions does not give good results.

The introduction of elements such as N₂ and C affects the mechanical surface properties of cutting tools. In this case, the crystal lattice is distorted and the microhardness increases. The grain boundaries of oxides and the boundaries of dislocation blocks are fast diffusion channels for implanted atoms. Ion implantation - when oxidation occurs simultaneously in the material and stresses appear. This study presents some complex compositions that can be used to obtain modified surface layers in the manner discussed here to improve the wear resistance of cutting tools made of relatively high speed steel with medium heat resistance in horizontal milling of a resistant, difficult to machine 34KhN1MA chromium alloy [3, 4].

2 Materials and methods

In the study of the durability of the cutting tool for milling, specially designed cutting end mills with various options for combined ion-plasma surface treatment were used (Fig. 1). The end

mills were made of high speed steel and subjected to standard heat treatment. Ion-nitriding of machined and sharpened cutting end mills was carried out on an APP-2 type installation using a two-stage vacuum-arc gas discharge. This treatment was carried out at a temperature of 490°C for 45 min, which made it possible to create a thermochemically hardened layer on the surface with a thickness of up to 60–80 μm and a microhardness of up to HV₆₀ = 120 MPa. The final resistant coating (TiAl)N, (TiAl)N + ion-nitriding, (TiAl)N + ion-nitriding + ion-alloying (NbHf), with microhardness HV₆₀ = 350 MPa was applied on a Platin π311 installation. This processing is a combination of the adhesive layer of the composition with a (TiAl)N gradient coating [5, 6].



Fig.1. High-speed R6M5 cutters.

Two- and three-phase coating layer with grain size (TiAl)N, (TiAl)N + ion-nitriding, (TiAl)N + ion-nitriding + ion-doping(NbHf) up to 5 nm, on the boundary of which the amorphous phase Si₃N₄ is located suppresses the coagulation of grains of the main phase both during the coating process and during tool operation. The area of a single treatment is about 50-100 cm². As a result of exposure of the sintered high-speed alloy to beams of charged particles by plasma flows, we obtain heating of the surface layer of the alloy at a high rate (up to 10⁶ deg / s) to temperatures exceeding the melting temperature of the remaining ones, followed by cooling at an extremely high rate (10⁴ -10⁹ deg/s) [7, 8]. The extreme temperature here should be understood as the equivalent of the thermal energy corresponding to the energy of the ions incident on the surface.

$$KT = E_{ion}$$

If here $T = 1 \cdot 10^6$ K if we put the value

$$E_{ion} = 1.38 \cdot 10^{-23} \cdot 1 \cdot 10^6 = 1.38 \cdot 10^{-17} \text{ Ж} = \frac{1.38}{1.6 \cdot 10^{-19}} \cdot 10^{-17} \approx 8.625 \cdot 10 \text{ eV} \approx 86 \text{ eV}$$

As can be seen from the last cipher, it corresponds to an energy of 86 eV.

A multiphase structure using doping in the process of an exothermic chemical reaction occurring between the metal of the film and nitrogen was obtained by depositing a thin layer of nitride-forming elements (targets from the Nb₇₂Hf₂₈ alloy were used) on the tool surface before its treatment with an electron beam [9, 10].

A wide range of wear-resistant coatings has been developed that are resistant to various types of wear (abrasive, adhesive, oxidative, fatigue, dust and cavitation erosion, etc.). All of them have high hardness (25–35 GPa and more) and lower coefficients of friction than steels. However, all these coatings, which have excellent service characteristics, are intensively destroyed during plastic deformation of the base under high load. It has been established that, in most cases, the destruction of the coating-substrate system begins with plastic deformation of the substrate near the interface, when this system is subjected to relatively high loading. Thus, the load resistance in the coating-substrate system also depends on the properties of the substrate. It is clear that a sufficiently thick layer with high hardness, heat resistance and crack resistance will increase the load resistance. Creating such a layer with subsequent application of a harder coating is one of the options for combined surface treatment[11, 12].

3 Results and discussion

The device allows the deposition of films of different materials on the surface of the desired cutting tool and subsequent liquid-phase mixing of the materials of the film and the NSEP substrate in a single vacuum cycle.

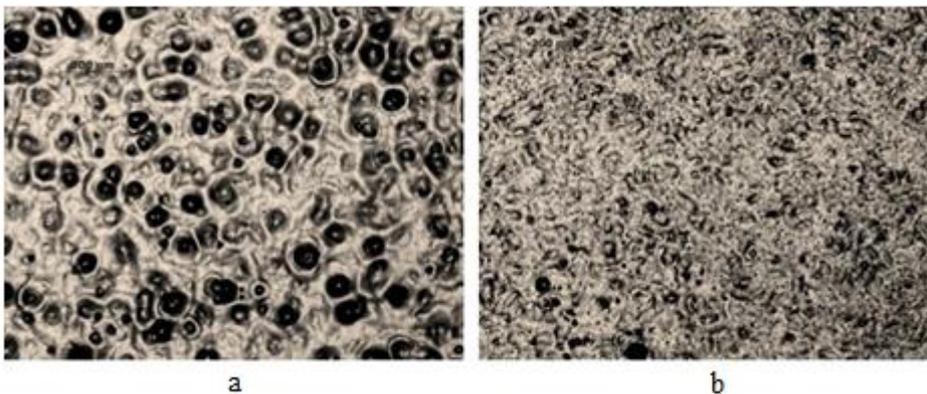


Fig. 2. Surface structure of the cutting tool. a) The structure of the surface of nitride high-speed steel R6M5 after exposure to NESP, b) The same after electron-beam doping with.

Irradiation with NSEB causes dissociation of iron nitrides, especially the ϵ -phase; a large amount of residual austenite is formed on the surface (Fig. 3b). After applying a thin film with a thickness of about $0.2 \mu\text{m}$ to the samples using a magnetron sputterer and subsequent exposure to an electron beam, exothermic chemical reactions of the formation of the nitride phase can be initiated [13, 14].

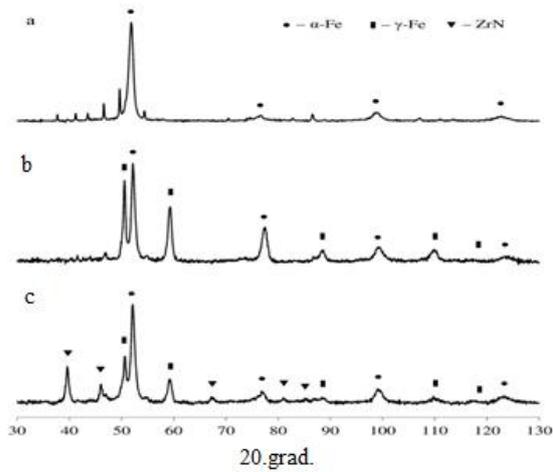
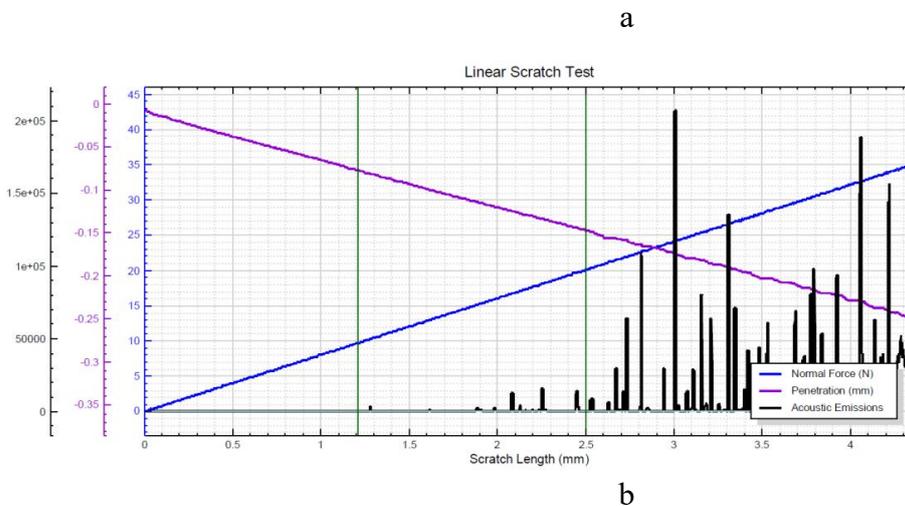
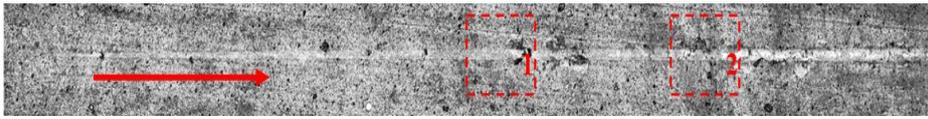


Fig.3. Diffraction appearance of the alloy surface a) Diffraction (CoK α) from the surface of a sample of nitride steel R6M5, b) the same after exposure to NESP, c) the same after applying NbHf film to the surface before irradiation.

Due to the formation of a refractory nitride film on the surface, the evaporation of the metal is significantly reduced, and the structure becomes finely dispersed (Fig. 2b). The formation of the nitride phase is confirmed by the data of X-ray diffraction analysis (Fig. 3c). It should be noted that in the latter case, the content of retained austenite in the near-surface layer is much lower. At the same time, in our case, we are dealing with strain hardening caused by the passage of an elastic wave that occurs under pulsed electron beam action [15, 16]. However, due to the short process time and thermal inertia, the heating caused by compression and internal friction is not likely to be a physical factor that determines the material's behavior under such conditions. In this case, the mechanical activation of high-speed physicochemical processes, which inevitably occur in both liquid and solid phases, should play a key role. Figures 4. show the test results of cutting tool samples with different (TiAl)N coatings, respectively. Numerical values of adhesive strength values are presented. Each of the figures shows load and acoustic emission graphs, a panorama of a scratch, the beginning of the destruction of the coating $\times 1500$ and the complete destruction of the coating $\times 1500$.





c

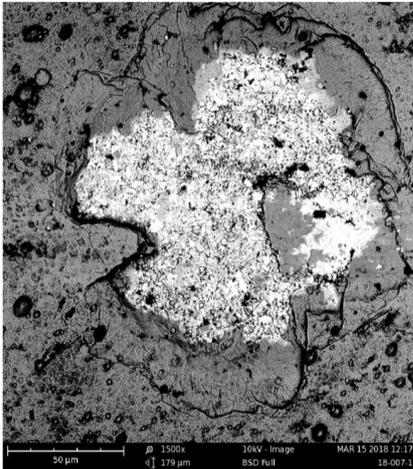


Fig .4. Results of testing the cutting tool of the sample coated with ion-nitriding +(TiCr)N-(TiAl)N-(CrAlSi)N): 1-graphs of the load and acoustic emission on the cutting tool; b – scratch panorama; c – complete destruction of the coating ×1500

4 Results and discussions

Multiple starts of the process practically do not change the initial microstructure. As a rule, a series of five or six LHEP pulses is sufficient to complete the microalloying process. The rational thickness of the wear-resistant layer of a multicomponent composite coating is determined for end milling of titanium-aluminum alloys under given cutting conditions. It was found that the coating with a wear layer of 4 μm showed the best value in terms of wear resistance period. The conducted studies showed that the cracks formed did not completely cut through the structure of this coating and did not damage the surface layer, in contrast to coatings with a wear-resistant layer of greater or lesser thickness [17, 18].

pass number	Coated cutter (Platit)
37	84.626 μm.
37+35	91.774 μm

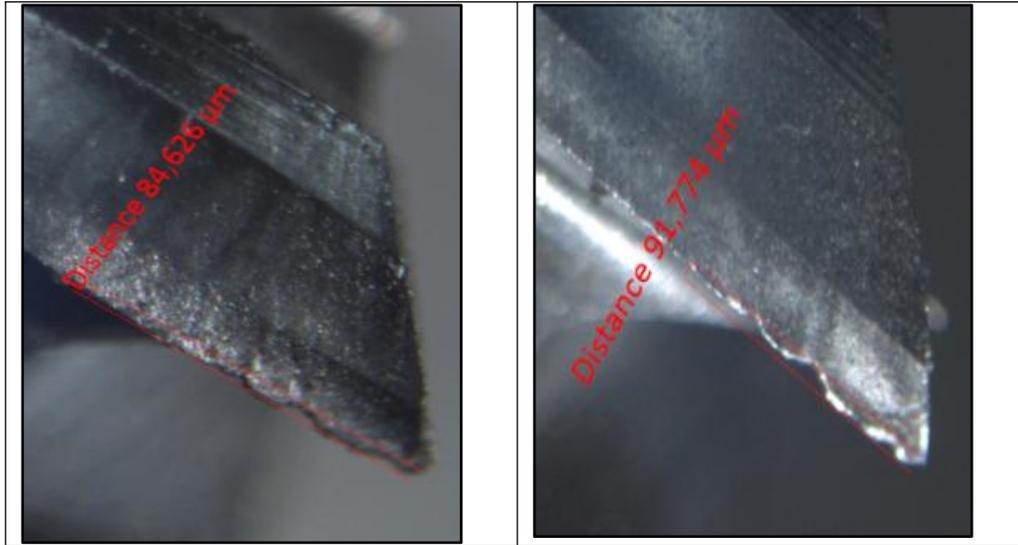


Fig.5. Wear is visible on the tool after machining.

Carried out at NMMC PO "NMZ" for wear resistance tests were carried out when turning a forged, heat-resistant alloy 34XH1MA at a cutting speed $n=10000$ rp/m, $S_z=0.037$ mm/tooth, $S_m=1500$ m/min, $B=5$ mm, $t=0.6$ mm. The rate of wear of the rear and front surfaces of 0.4 mm was chosen as the failure criterion [19, 22].



Fig.5. Machined by milling machine.

Changing the geometry of the results of the partial results tool after processing the results of calculations of the results of measurements ρ of rounding the results of the edges with the calculation of values with the value of the initial radius of action, which are the result of the results of processing the results of cutting. The results obtained are presented in the table below. Forged ingot brand 34HN1MA, hardness HB375 workpiece processing was carried out on a milling machine FUS-32.

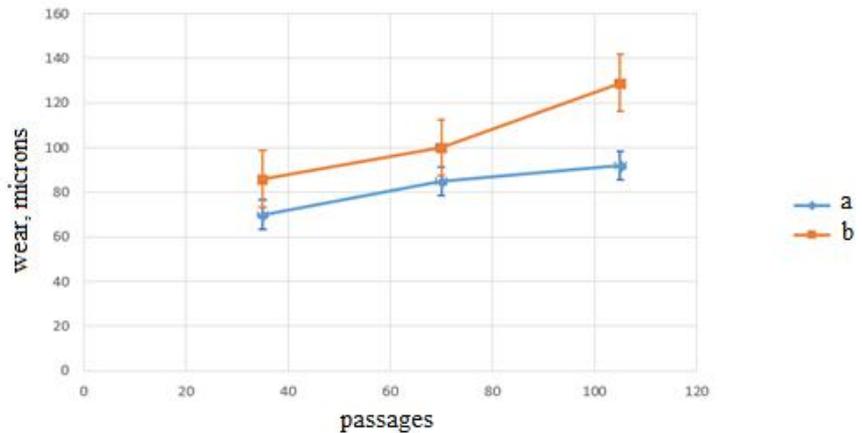


Fig. 6. Graph of tool flank wear versus number of passes (250 mm) (a) with a coating applied by New Plasma Technologies using vacuum-arc technology.(b) uncoated.

When cutting with a raw tool, the characteristic point of wear was the tip of the end mill.

5 conclusions

The results of the experiments indicate the possibility of obtaining layers modified by surface alloying on the surface of the tool's high-speed steel. Such layers were obtained due to the initiation of exothermic chemical reactions between the substrate and the thin film deposited on it.

The experience of using a cutting tool that has undergone complex surface treatment in production conditions shows an average increase in tool life by 1.5-2.5 times.

In a scientific study, the actual scientific and practical problem of increasing the wear resistance of a cutting tool during milling of a chromium-titanium hard-to-machine alloy through the use of multicomponent composite nanostructured coatings was solved. This structure of the coating makes it possible to effectively resist cyclic force and thermal loads, which are typical for intermittent processes, and in particular for the milling process;

You can also use microalloying. such treatment, which is recommended to be carried out before applying a wear-resistant coating, allows you to influence the wear processes of not only high-speed, but also high-speed tools, which makes it possible to increase tool life (2-3 times) once.

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