Estimation the surface roughness after mineralceramic smoothing of electrophysical coating

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Estimation the surface roughness after mineralceramic smoothing of electrophysical coating

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Abstract. Roughness is an important factor in the working properties of instruments. Roughness determines such working properties as durability, wear resistance from dettritions, density of combinations, chemical fortitude and appearance. A method for evaluating the roughness of wear–resistant electric-spark coatings on a metal cutting instrument and a specimen of fast-cutting steel is a complex parameter of roughness (Δ). Complex parameter of roughness (Δ) allows more accurately estimating the surface roughness after smoothing the mineral ceramics of an electrophysical coating and others types of surface treatment.

1. Introduction
The development of modern mechanical engineering is connected with wear-resistance of cutting instruments to increase the efficiency of treatment processes. The surface layer of a detail exposes the strongest mechanical, thermal, chemical and some other types of impacts in the process of operation. The deprivation of the detail working capacity takes place, as a rule, from the surface as a result of wear, erosion, corrosion, thermal effect and etc. A significant resource for increasing efficiency consisted in the material from which the elements of constructions are made, as well as and the surface roughness of this material.

The aggregation of surface irregularities with relatively small steps on base length is the surface roughness (figure 1). Roughness concerns to microgeometry of a solid and determines its most important exploitative qualities. Wear resistance from dettritions, durability, density of combinations, chemical resistance and appearance are the most important exploiting properties. There is also a connection between the ultimate deviation of the size and roughness [1, 3-5].

The altitudes parameters are as follows: $Ra$ is the arithmetic mean deviation of the profile. $Ra = \frac{1}{n} \sum_{i=1}^{n} y_i$. $Rz$ is the height of irregularities in the profile of 10 points. The step parameters are as follows: $t_p$ is the relative support length of the profile, where $p$ is the sectional values of the profile from the row: 10; 15; 20; 30; 40; 50; 60; 70; 80; 90%. $t_p = \frac{1}{7} \sum_{i=1}^{7} b_i$. $Ra$, $Rz$ and $Rmax$ are determined on base length $l$, which can accept values from the row: 0.01; 0.03; 0.08; 0.25; 0.80; 2.5; 8; 25 mm. The parameter $Ra$ is preferred [2].
2. Methods and procedure

Effective opportunities have been discovered to increase the operational capacity of the friction surface in connection with the development of new methods of the surface treatment of materials that provide a specified set of surface density and roughness.

Now, there are modern methods to increase the performance of blade metal cutting instrument due to changes in the physicochemical and operational properties of the working edges of metal surfaces in a given direction. These include: technological, thermal, chemical, chemicothermal, thermomechanical, electrophysical and mechanical methods.

Electric-spark coating has a row of advantages as compared to some other methods. There are several advantages of the electrospark coating:

1. The highest durability strength of the applied material with warp (due to mechanical mixing and the relative diffusion penetration of electrode materials in the formed layer);
2. The locality of the process;
3. The possibility of using pure metals and many alloys, metal-ceramic composition, refractory compound and etc. as alloying materials;
4. Lack of heating or minor heating of the detail in the treatment process, which may notice changes in its physical and mechanical attributes and geometry;
5. The technological process is simple, the equipment is compact and transportable;
6. Restoring the size of machine parts and instrument, decrease in inclination to grasp of surface in friction, holding of micro metallurgical process on the treatment surface for forming necessary connections.

3. Results

Hardening working surfaces of the metal cutting instrument made of powder fast-cutting steel of increased heat resistance R12M3K8F2-MP consist of the RF Specification TU 14-1-3647-83: C-1.0%; W-12.0%; Mo-3.1%; Cr-4.0%; V-2.1%; Co-8% realized on installation of «EIF-541» by local the electric spark method (LENP). Disk milling cutters, spiral drills, passing cutter, hard cutter, cutting cutter were subjected to the LENP method [3]. Cylindrical rods from self-fluxing powder alloy of the Ni-Cr-B-Si-C system on nickel chrome basis (%): Ni 80; Cr 15; B 2-3; Si 3-2 и C 0.1-0.7 with a

![Figure 1. Normal profile and parameters of the surface roughness][1]

[1]: https://example.com/image.png
diameter of 1…1.5 mm used as electrodes. This material was developed in the USA and was called «Colmonoy».

Local electric-spark coating on the working surfaces of the cutting instrument in places of intensive wear and tear on the rear and front surfaces is accompanied by the education of microrelief with rounded projections and hollows. Herewith, in contrast to mechanical treatment, the microrelief has not acute a scallop. However the quality of the instrument surface often does not match the technical conditions after LENP (figure 2). Ra roughness of instrument cutting edge after LENP is 4…6 µm under optimal conditions, but 0.2…0.4 µm is required. This significant drawback is decided by applying a combined treatment. This treatment consists of: LENP, adamantine and mineral–ceramic smoothing, LENP plus laser treatment.

Figure 2. Photos of the drill: (a) with electric-spark coating, (b) with a surface of wear-resistant coating.

Significant contrast stress arises from the process of smoothing the surface in the place of contact of the deforming element and the workpiece. Plastic deforming of the surface layer occurs at a certain effort of smoothing, as a result of which microroughnesses crumble and the physic-mechanical properties of the surface layer change. Significant residual stress of compaction arises on the ironed surface. Details with a surface treated with smoothing have increased operating properties (high wear resistance and fatigue strength).

The technology of smoothing was realized on crew-cutting 1K62 lathe with the device described in works [4, 5]. Smother from mineral-ceramic BOK-60, belonging to the class of oxide-carbonate cutting ceramics of composition: Al₂O₃ – 76; TiC – 20; (WCo) C – 3…5; Mg<1 (at%) with a square cross-section 2×2 mm, a length of up to 15…20 mm and a working surface radius of 4.5…6.6 mm was used as an instrument. Optimal modes of processing conditions for smoothing with metal-ceramics were installed by an experiment with a target for ensuring maximum fortitude of smoother from metal-ceramic BOK-60 and the required parameter of roughness. The roughness of processed surface depends on the moods of smoothing (effort of smoothing and innings). The number of approaches and the speed of smoothing to a lesser extent affect the roughness and microhardness of the processed surface.

The roughness was measured by an Outline-67 profilograph-protilometer by means of the complex parameter of roughness (Δ), proposed by the authors in work [6].

\[
\Delta = \frac{R_{\text{max}}}{r \cdot b^\nu},
\]

where \(R_{\text{max}}\) is the largest height of the profile; \(r\) is the middle radius of curvature of the vertices of the projection; \(b\) and \(\nu\) are the parameters of the initial section of the reference curve, which is built in absolute coordinates. These coordinates are determined by formulas (2) and (3) respectively.
\[ b = t_{R_p} \left( \frac{R_{\text{max}}}{R_p} \right)^{\nu}, \]  
(2)  
\[ \nu = 2 \cdot t_{R_p} \left( \frac{R_p}{R_a} \right) - 1, \]  
(3)

where \( R_a \) is the arithmetic mean deviation of the profile; \( t_{R_p} \) is the relative support length of the profile on the level \( R_p \); \( R_p \) is the deviation from the line of prominences to the line, which cuts the square into two equal parts.

4. Conclusions
The value of \( R_a \) amounted to 0.28…1.28 \( \mu \)m after smoothing the coatings with cermet. The complex parameter of roughness, which is defined by formula (1), was 1.55 before smoothing, but after smoothing it became 0.08…0.14.

The durability tests of the instrument were realized according to GOST 2034-80 «Twist drills. Specifications», 2M55 radial-drilling machine, workpiece material - steel 45GOST1050-88.

As a result of the tests, it is established: 1) Drill No. 1 with electric-spark alloying has wearing on the front surface no more than 0.3 mm; 2) DDrl No. 2 without electric-spark alloying has wearing on the front surface no more than 1.3 mm; 3) The actual persistence of the drill with electric-spark coating is 17.4 minutes to the first regrinding; 4) The actual persistence of the drill without electric-spark coating is 4.3 minutes to the first regrinding; 5) Industrial tests of hardened cutting instrument showed an increase in their persistence in 4 times.

Analysis of the obtained results shows that quality of the surface, which was formed after LENP, is insufficient by the roughness parameters \( R_a \) and \( R_{\text{max}} \). The complex roughness parameter (\( \Delta \)) an order of magnitude more accurately to measure the roughness of surface after adamantine and cermet smoothing of electrophysical coatings, in particular LENP and some other surface treatment [7-9].

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