INFLUENCE OF MACHINING ON QUALITY PARAMETERS OF OPTICAL METAL PRODUCTS

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Abstract: *The article gives recommendations about the technological support of the given optical characteristics of metal products. The main task at providing light reflectance of surfaces is smoothing of roughnesses on a surface and providing surface cleanliness. The criterion of surface roughness and the work function of electrons have the greatest connection with the performance characteristics of optical metal products. The surface properties are determined by the double electric layer at the surface. Each subsequent stage of abrasive polishing should be carried out with a smaller grain size of an abrasive of not more than Rmax roughness, obtained in the previous stage.*

Keywords: surface, processing, method, roughness criterion, electron work function.

1. INTRODUCTION

Technological support of the optical characteristics of parts working in the conditions of direct exposure to solar radiation is realized by the finishing processes. Among finishing machining processes there is a specific area of abrasive polishing of materials [1], which is the only effective way of forming a surface layer with minimal values of the height parameters of the surface roughness.

The main task when polishing is to smooth the roughness on the surface.

2. ANALYTICAL RESEARCH

However, a number of details have operating requirements where the estimation of the height parameters of the surface roughness is insufficient. This particularly applies to the details of aircraft. Among them are the ones that should have high reflective ability of surfaces, high light-absorbing and emissive capacity (details of outer shells of aircraft, details of thermoregulating devices, etc.). Control over the processing of such surfaces is carried out through parameters of the geometric and physico-chemical state of the surface layers (criterion for surface roughness and work function of electrons).

Recently in connection with the increase in the tactical and technical characteristics of aircraft, especially military applications, more and more find application of a product with special properties of surface layers in their constructions.

Manufacturing of parts and assembly units of aircraft with specified optical characteristics of their surface layers allows to solve the problem of minimizing their mass, temperature deformation of structural elements while simultaneously increasing their dimensional stability. details of aircraft Typical examples are the details of aircraft in thermal control systems for compartments with on-board equipment, reflectors for laser mirrors, retractable rods, antennas, etc. The properties of the surface layers of such parts will be determined by the geometric characteristics and the physico-chemical state of these layers.

Nanotechnologies open up great opportunities. The use of nanotechnologies is especially important in the production of precision parts of machines such as metal mirrors for laser technology which are widely used in sections of the working path of the laser beam.

They should have a high reflectivity, for example, over 99 % for copper mirrors, and the height of surface irregularities should be 5 - 3 nanometers. Working surfaces of aluminum substrates of electronic devices, details of adaptive optics, gyroscopic devices should have nanometric dimensions of unevenness. Therefore the application of nanotechnology processing, which provides the necessary parameters of the surface layer of parts, is very relevant for engineering.

Thus the study of the influence of processing methods and in particular abrasive polishing on the quality parameters of optical surfaces as well as the creation of new technological processes for the manufacture of articles with special properties of surface layers are very urgent tasks.

Thus the goal of the work is the development of technological recommendations for abrasive polishing of optical surfaces.

Research objectives. The work is based on the following formulated research objectives:
- systematization of structural and technological solutions for precision machining of metal surfaces;
- highlight the parameters of the machined surfaces of metal products, which have the greatest connection with the operational optical characteristics of the details;
- to develop a theoretical approach to determining the technological conditions for providing quality parameters for abrasive polishing of parts based on surface quality parameters (surface roughness and its physico-chemical state);
- to develop recommendations for smoothing out surface irregularities, for minimizing the altitude parameters of surface roughness on the basis of the method of complex evaluation of the surface quality of optical metal products.

Results of the research. Classification of processing methods by technological impact showed that abrasive polishing can be attributed to technological systems associated with a slight change in the substance in the surface layers of the parts (Fig. 1) and the classification of processing methods by the nature of the impact on the subject of labor (Fig. 2) shows that the implementation of the polishing process by the high-speed movement of the working medium relative to the surface being processed is poorly studied.

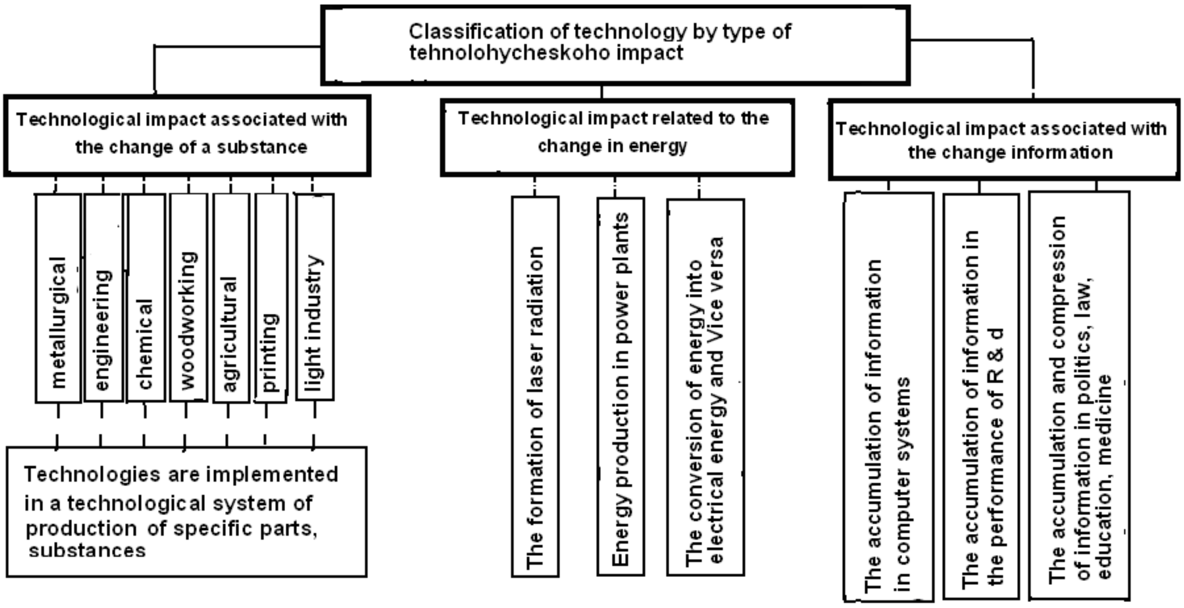

Fig. 1. *Classification of technology by the nature of the impact on the subject of labor.*

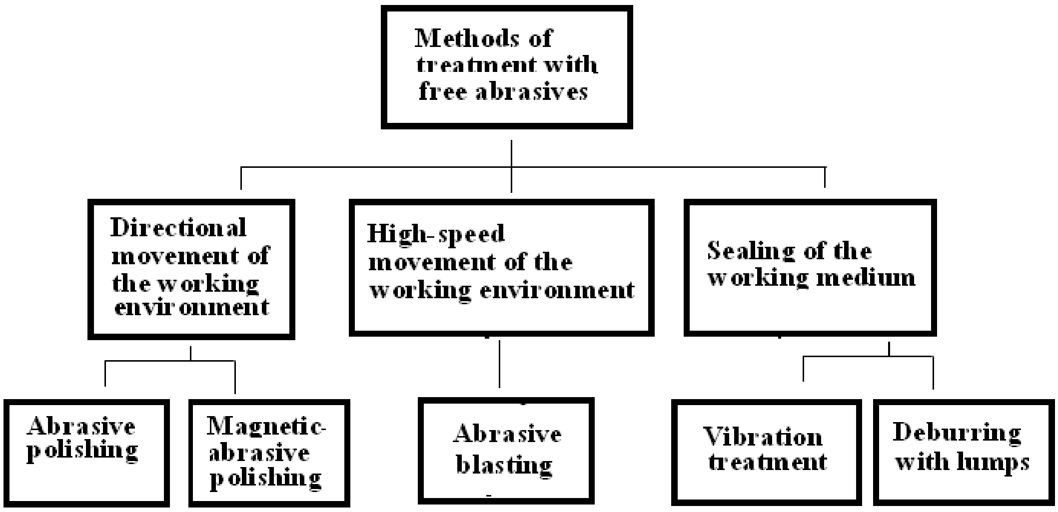

Fig. 2. *Classification of methods of treatment with free abrasives by the nature of the impact of an abrasive particle.*

The processing methods determine the limits of the change in optical characteristics, and this makes it possible to choose a method for processing the surfaces of aircraft parts. Fig. 3 shows the change in the maximum reflectivity of the surfaces for the aluminum alloy AMg6 after processing by various methods. In this case, the nature of the change in the ratio of absorption to radiation will also be determined by the methods of processing.

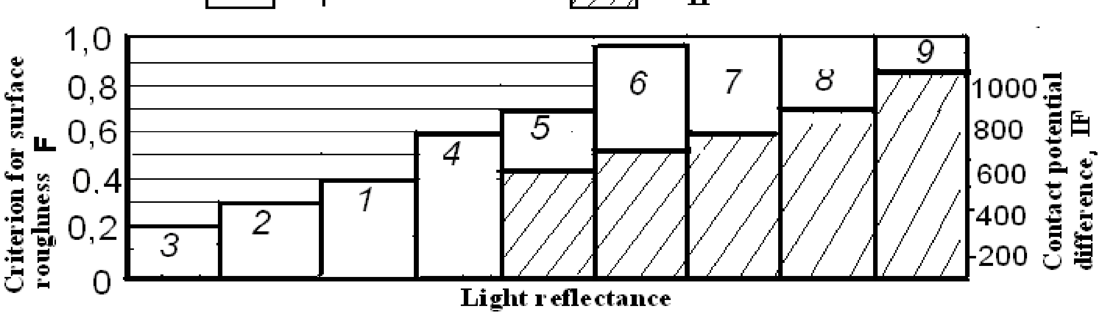

Fig. 3. The nature of the change in the light reflectance and surface parameters from the processing methods of AMG-6 alloy parts: 1 - rolling; 2 - hydroabrasive treatment; 3 - processing with metal shot; 4 - milling with carbide cutter; 5 - milling with a milling cutter from an electromotive bushing; 6 - turning a carbide-tipped tool; 7 - diamond polishing; 8 - smoothing; 9 - diamond turning.

We have established the character of the change in the ratio of the optical characteristics and geometric parameters of the surface from the methods for processing details from the AMg6 alloy (Fig. 4).

For aircraft parts for the thermal regulation of compartments of onboard equipment, the ratio of absorption to radiation should approach unity, i.e. The absorbed energy must be radiated and in this case the surface should not be heated.

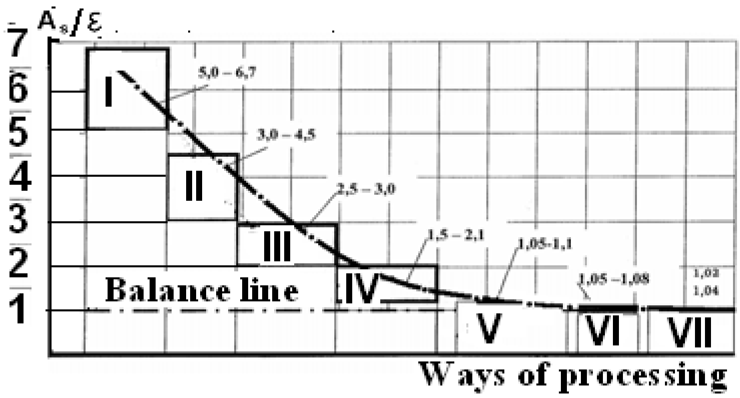

***Fig. 4.** Dependence of the ratio of absorption to radiation from surface treatment methods: I - milling; II - hire; III - turning, ironing; IV - diamond turning; V - enamels AK-512, EF-1118; VI black chrome; VII chemical milling + anodizing.*

And what happens with the geometric and physico-chemical state of the surface?

The processing of super-smooth, precise metal surfaces has its own specific features related to its electronic structure. Free electrons in violation of the crystal lattice in the boundary layer exit the surface and form a so-called double electric layer, which determines the properties (conductivity) of the upper boundary layer. Moreover, the presence of a double electric layer also determines the oxidation processes on the metal surface, that is, the formation of nonmetallic conductivity membranes, on which the properties of the upper boundary layer of the metallic surface depend. They can be much larger in thickness than the roughness of the treated surface.

In connection with the foregoing, the formation of a double electric layer on a metal surface determines the degree of disruption in the crystal lattice of the metal and can be a measure of its defectiveness. These changes on the surface can be quantified by measuring the work function of the electron, which determines the amount of work on the movement of electrons on the surface of the metal.

Taking into account this circumstance, we proposed to control the state of the surface layer after cutting by estimating the surface parameters from the work function of the electron (WFE), since it is sensitive to changes in the physical and chemical state of the surface.

The theoretical positions developed by us, in contrast to the existing ones, consist in establishing the relationships between performance characteristics and technological parameters with the help of integral parameters of the surface layer: the roughness factor and the work function of the electron. When establishing the relationships, the surface roughness parameters and the roughness factor F [2] were chosen as geometric parameters, and the parameters of the physical-chemical state of the surface were taken to be: structure, phase state, chemical composition of phases and thickness of the non-metallic membrane.

The roughness factor F and the value of the work function of the electron respectively for geometric and physicochemical characteristics were chosen as the integral parameters of the mismatch.

To clarify the procedures for the use of integral parameters mismatch F and consider the edge layer. Roughness factor indicates the ratio of the square smooth trailing part of hollows to square rough part of basin $F = Fg / Fw$ It takes into account not only the height of roughness, the height of submicrocavity, but the shape and completeness of the depressions (protrusions) of the roughness [2]. In practice, this factor is determined from the profile diagrams being analyzed and electronic images. Analysis of roughness factor values on surfaces of parts after different treatment showed that at the height of the roughness $Rz \leq 100$ nm its magnitude is almost equal to 1. So it can be used as an integral parameter in obtaining roughness height at least 100 nm. At the same time reducing the roughness height less than 100 nm integral parameter mismatch adopted value of RWE, which in practice is measured through the amount of contact potential difference (Fig. 3, Fig. 5).

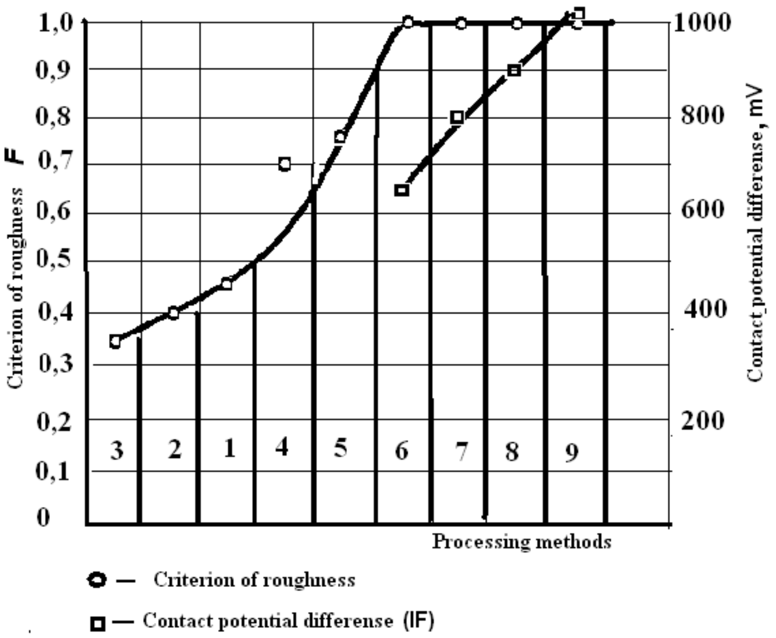

Fig. 5. *Dependence criterion of surface roughness and the KRG from alloy machining methods AMg6: 1 - rolling; 2 - processing with metal shot; 3 - hydroabrasive treatment; 4 - milling with carbide cutter; 5 - milling with a milling cutter from an electromotive bushing; 6 - turning a carbide-tipped tool; 7 - polishing diamond; 8 - smoothing; 9 - microcurrents with a diamond cutter.*

Studies have shown that the value of RWE can evaluate any change in physical and chemical status of surface processing.

In practice, in nanotechnology processing of machine parts, both abrasive and blade processing are used [3].

Technological media based on ultradisperse alumina abrasives (UDD), which are obtained by gas-dispersed synthesis (GDS), are developed for nanoscale treatment. The essence of this is the synthesis of UDD in the combustion zone of a laminar two-phase torch of gas suspensions of metal powders in oxygen-containing gas. At the same time, the capabilities of the metal-oxygen system are fully realized and high temperatures are obtained, which are necessary for the synthesis of metal oxides due to heat release from intrinsic chemical reactions.

UDD parts are spherical in shape with a diameter of about 100 nm. Smoothing effect that provides abrasive slurry with the presence of spherical abrasive allows to reduce cutting-scratching the surface and go to the micro-roll effect and so ensures tall 5 - 3 roughness nm.

To assess the impact of processing methods on the surface layer, we assessed the criterion of surface roughness (*F*) and the electron work function (if) for details of the alloy AMg6 (Fig. 5). It is established that when surface surfaces are pretreated in order to achieve minimum values of the height parameters of the surface roughness, the control of the treated surface must be carried out by evaluating the roughness criterion of the surface, and after the final processing methods, the control of the treated surface must also be carried out by estimating the work function of the electrons (estimates of the values of the contact potential difference - PSC).

One of the drawbacks of abrasive processing is the effect of currently used abrasive compounds on the physicochemical properties of the treated metal surface associated with oxidation processes. This is explained by the fact that at this type of treatment free electrons appear, leading to oxidation of the surface layer. The thickness of the resulting oxide film, as a rule, is much larger than the height of the irregularities on the real metal surface.

Therefore the main task at providing light reflectance of surfaces is smoothing of roughnesses on a surface and maintenance of cleanliness of a surface from pollution. The change in the height parameter of the surface roughness during polishing is shown in Fig. 6.

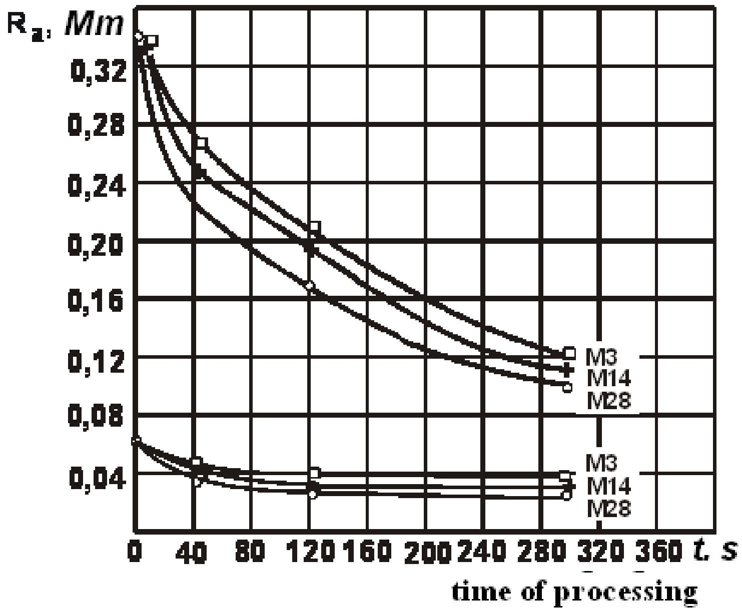

Fig. 6. *Dependence of the height parameter of the surface roughness on the time of polishing with abrasive materials of different granularity*

Dependency analysis (see fig. 6) shows that:

- the time of stabilization of the process of formation of the altitude parameter of the surface roughness depends little on the grain size of the abrasive (from M3 to M28);
- the time of stabilization of the process of formation of the altitude parameter of the surface roughness decreases substantially with a decrease in the height parameter of the initial roughness of the surface before processing;
- for each granularity of the abrasive material, there is a limit to stabilizing the values of the altitude parameter of the surface roughness, and this is very important when assigning a sequence of use of working media when smoothing the surface layer of the parts.

3. CONCLUSION

1. Industrial abrasive processes and practical recommendations for their effective use do not provide the required smoothing of surface irregularities and very small values of the height parameters of the surface roughness of parts with optical characteristics.

2. Promising directions for the further development of abrasive processing in order to achieve super-smooth surfaces of parts with optical characteristics should be considered metrological assurance of quality control of processing, selection of appropriate technological environment and development of a control system for the process of shaping the surface layers of parts.

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