PLASMA-ELECTROLYTE POLISHING OF TITANIUM ALLOYS IN LOW CONCENTRATED SALT SOLUTION BASED ELECTROLYTE

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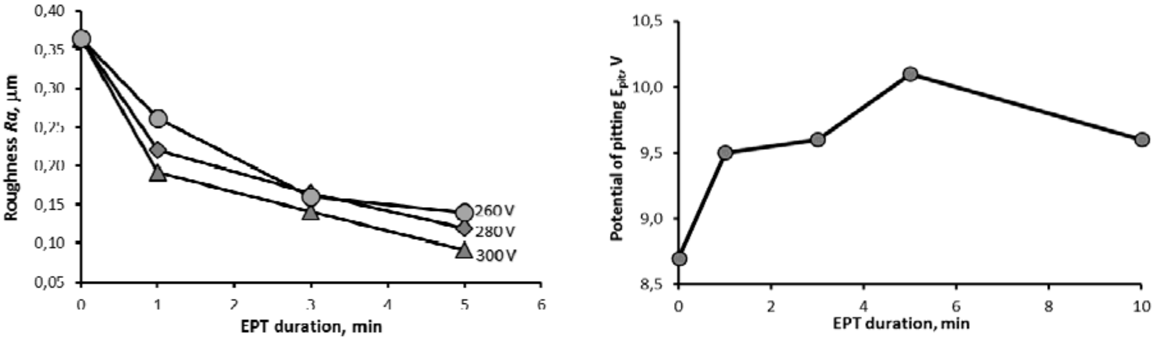
Titanium alloys are widely used at present in aircraft, nuclear energy, space technology, microwave technology, ultrasonic technology as well as in the manufacture of medical products. In most cases the production technology of such products involves the implementation of a quality polishing surface.

The disadvantages of mechanical methods are low productivity, susceptibility to the introduction of foreign particles, difficulties in processing complex geometric shapes. These materials are hard-to-machine for electrochemical technologies and processes of their polishing require the usage of toxic electrolytes. Traditionally, electrochemical polishing of titanium and alloys is carried out in acid electrolytes consisting of toxic hydrofluoric (20–25%), sulfuric nitric and perchloric acids. The disadvantage of such solutions is their high aggressiveness and harm to production personnel and the environment.

In order to reduce the environmental load, plasma-electrolyte polishing (PEP) is possible to use as an alternative to the existing methods of electrochemical polishing. The PEP technology is developed for polishing, deburring and cleaning of metal products and also for improvement chemical, mechanical and physical properties of the surface. In addition, PEP can be used for electrolytic heating and electrochemical-thermal hardening of the surface. The PEP is performed at a voltage above 200V.

This paper presents results of experimental study of new modes developed by us for plasma polishing and cleaning products of titanium alloys with the use of simple electrolyte composition based on an aqueous 4% ammonium fluoride solution, providing a significant increase in surface quality ensuring high reflectivity. Due to the use of aqueous electrolyte, the technology has a high ecological safety in comparison with traditional electrochemical polishing.

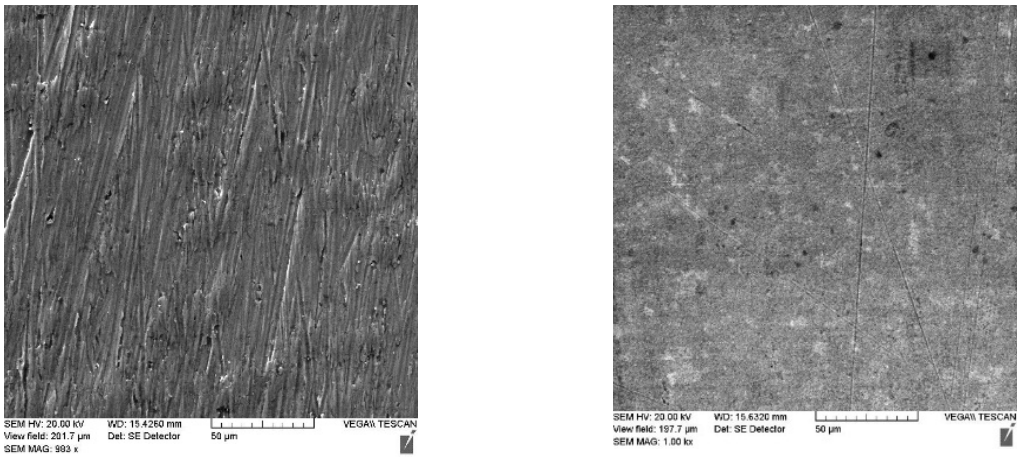
Fig. 1a shows experimental dependences demonstrating the dynamics in the surface roughness *Ra* changes while the titanium samples processing. From the obtained dependences, it appears that with the increase in operating voltage in the analyzed range (from 260 to 300V), reduction of the achievable values of the surface roughness parameter *Ra* is provided. According to the results of corrosion testing of titanium samples it was found that PEP has a significant effect on the change in their stationary potential and pitting formation potential in a 0,9% solution of sodium chloride. PEP with duration more than 3 minutes results in the transfer of a stationary potential from a region of partial passivity (the E_{st} of the initial sample is –16,8 mV) to the region of complete passivation (the E_{st} value is above 0,0 mV). PEP enhances the potential of pitting E_{pit} by 9–16%. The maximum value of the pitting potential E_{pit} = 10,1 V is reached at voltage of 300V, an electrolyte temperature of 90°C and duration of 5 minutes (Fig. 1b).



a *b*

Fig. 1 – Effect of PEP duration on the surface properties:
a – roughness at different voltage; *b* – potential of pitting

Microphotographs of the surface of titanium samples before and after treatment are shown in Fig. 2. The surface of titanium before the PEP (Fig. 1a) is characterized by the presence of longitudinal stripes formed as a result of preliminary grinding of the samples. After the PEP the surface is smoothed out, only traces from the deepest scratches are observed (Fig. 2b).



a *b*

Fig. 2 – Microphotographs of the surface of titanium samples before and after PEP:
a – before the PEP; *b* –after the PEP

Based on the results obtained, processes of electrolytic-plasma polishing of a number of products made of titanium alloy Grade 5, used in medicine, have been worked out (Fig. 3).

Fig. 3 – Examples of the PEP medical products made of titanium alloy Grade 5