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The Condition of Machined Surface of Titanium Alloy in Dry Grinding

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Abstract

The Versa 3D twin-beam electron microscope was used to study the relief and chemical composition of the VT3-1 titanium alloy surface after grinding with the ceramic bonded silicon-carbide wheel without grinding fluid. The results show that the process of infeed grinding of titanium alloy is associated with adhesive and cohesive processes which lead to the formation of a multi-layer structure of the machined surface. The thickness of the multi-layer structure without adhered material amounts to 2-4 μm. The X-ray spectral microanalysis elicited the modification of the chemical composition. The experimental result indicated that the mass concentration of oxygen, nitrogen, and carbon atoms increases by more than 20 times. The concentration of carbon, nitrogen and silicon becomes lower as the analyzed layer thickness increases.

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Keywords: grinding; titanium alloy; surface structure; chemical composition; electron microscopy; X-ray spectral microanalysis.

1. Introduction

Titanium alloys are used for making critical parts. Therefore, research of surface quality of such parts is always in the center of attention of Russian and foreign scientists. Special attention is paid to the quality of finishing operations, which include abrasive treatment and grinding.

There are numerous articles addressing the issue of titanium alloy surface quality [1-9]. They describe the special characteristics of surface structure and submicrostructure formation, temperature, residual stresses, hardness, and

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chemical composition. But since the surface quality control methods are permanently enhanced, our knowledge about the object of research must permanently increase due to the use of more advanced monitoring methods.

The purpose of this article is to research the relief and chemical composition of titanium alloy surface after it has been subjected to grinding without grinding fluid, using the latest world achievements in the field of quality control.

2. Experimental material and procedure

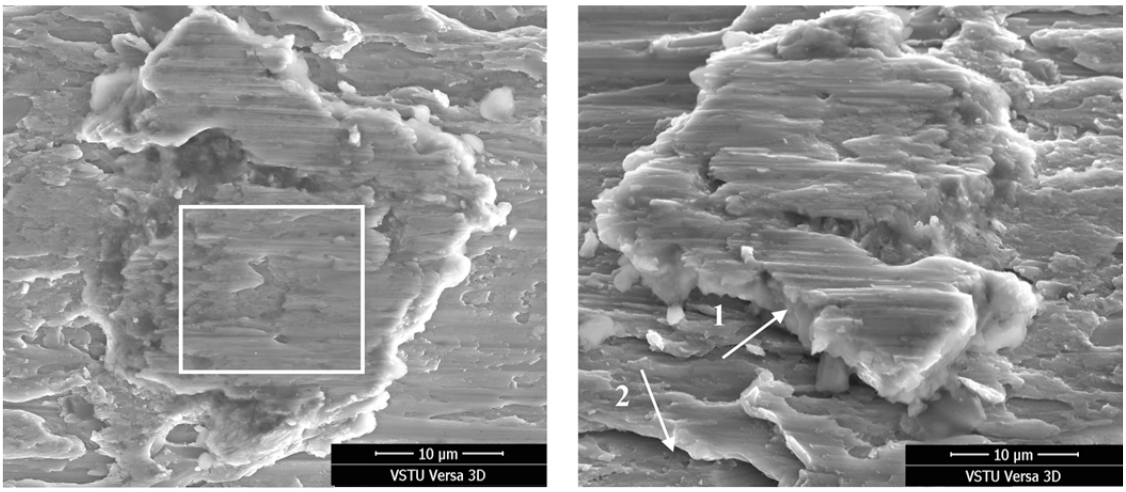
The VT3-1 titanium alloy was chosen as the object of this research. It was obtained by infeed grinding with a 63CF60K7V silicon-carbide wheel without grinding fluid. The machining conditions were as follows: the grinding speed was 25 m/s; the grinding depth was 0.005 mm/pass; the speed of table supply was 12 m/min. The research was carried out with the Versa 3D twin-beam electron microscope.

The high adhesive activity of titanium alloys towards abrasive materials is known to be the main reason of bad workability. Most adhesive activity of titanium-based alloys takes place in the process of grinding without grinding fluid. In such conditions of treatment, metal intensively sticks to peaks of grains. Therefore, in grinding without grinding fluid, the abrasive tool loses its cutting capacity not because of peaks of grains going blunt, but because of metal sticking to them [10-14].

Titanium, which is used as the alloy basis, belongs to d-transition elements. Titanium exhibits the greatest adhesive activity towards abrasive materials out 12 VI-VI d-transition metals of the periods, as shown in articles [3, 15]. VT3-1 alloy titanium content is 85.7-91.4% by mass. Therefore, the properties of the alloy, including its high adhesive activity towards abrasive materials, are determined by the alloy basis.

3. Experimental results and discussion

In case of subsequent contacts of grains with the treated material, the metal which has stuck to peaks of grains is transferred to the treated surfaces. The adhered metal is given to plastic deformation and cutting in case of contact with other peaks of grains. As a result, a very developed relief of the treated titanium alloy surface is formed with rough grinding. This was confirmed by X-ray spectral microanalysis. One of the treated surface sections with adhered metal is shown in Fig. 1a (6500-fold magnification). The electronic picture was taken at an accelerating voltage of U=10 kV. The maximum size of adhered metal was 32 μm on the abscissa axis and 39 μm on the ordinate axis.



a) b)

Fig. 1. Electronic photographs of adhered metal: (a) 6500-fold magnification, U=15 kV, α=0°; (b) 6500-fold magnification, U=20 kV, α=45°.