STRUCTURE AND PROPERTIES OF SURFACE LAYERS OBTAINED DUE TO TITANIUM SURFACE ALLOYING BY YTTRIUM VIA COMBINED ELECTRON-ION-PLASMA TREATMENT

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The performed investigations indicate that the microhardness of the alloying surface is barely dependent on the electron beam treatment mode and exceeds the initial material microhardness by a factor of 3–3.5. Analysis of the microhardness profiles revealed the formation of an extended strengthened layer. Under the condition that the base microhard ness is exceeded by a factor of 2.5, the layer thickness reaches 60 μm if the electronbeam energy density is 50 J/cm^2. It is established that, in this treatment mode, titanium modification is accompanied by more than seven and threefold decreases in the friction coefficient and wear rate, respectively.

In compliance with the mechanical and tribological test results, a sample irradiated by the electron beam under the aforementioned conditions was chosen to examine the elemental and phase compositions and defect substructure of the modified layer. X-ray diffraction analysis demonstrated that a structure based on αyttrium with a volume fraction of 73% is generated in the surface layer and that the volume fractions of other surface phases are much smaller (10% of α-titanium, 14% of TiC and TiO_2, and 3% of Y_2O_3).

Typical surface layer images illustrating the formation of a multilayer structure are presented. As is seen from the microelectron diffraction pattern, the surface layer 500 nm thick is amorphous. The next sublayer 1.0–1.5 μm thick has a columnar structure, under which an extended layer (30–40 μm) with a dendritic (globular) crystal structure is identified.

The study of the element distributions over the surface layer, the results of which were obtained viamicro-X-ray diffraction analysis at the given points, signifies that the amorphous layer is enriched with titanium, the next sublayer having a columnar structure is enriched with yttrium, and the subjacent layer is again enriched with titanium. The elemental composition maps shown in Fig. 3 agree well with the point-by-point analysis of the elements and enable us to define the elementdistribution regions more precisely. Indeed, it is plainly seen that the layer with the columnar structure has columns that are alternately enriched with titanium and yttrium. This is evidence of phase decomposition in the material of the given layer.

The detailed structure of the layer with the columnar structure is illustrated in Fig. 4. It is clearly seen that the columns enriched with titanium have a block structure and the columns enriched with yttrium have no block structure.

Thus, the surface layer of commercially pure titanium has been modified using a combined technique uniting irradiation by plasma formed in the electric explosion of titanium foils with added yttrium powder and subsequent treatment by a pulsed high-intensity electron beam.

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