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Structure of the surface and wear products of titanium against a cobalt alloy*

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The paper contains results of investigations on titanium wear, performed with the „pin on disk" method and a reference specimen made of the cobalt alloy Co28Cr5W5Fe3Ni. It has been shown that in wear products there are particles of both materials of the pair. While wearing, we can observe abrasion with the successive oxidation as well as grinding on the reference specimen surface. The reference specimen is also subjected to abrasive wear and local microcutting. We can also observe transfer of the reference specimen material and its smearing over the specimen.

1. THE TESTS

The tests were performed by the „pin on disc" method under the rotational speed of the specimen V = 0.20 m/s and loading 60 N. In the frictional pair, titanium Grade 1 (according to ASTM) was the specimen and the cobalt alloy Co28Cr5W5Fe3Ni was used as a reference specimen. Structure of that alloy is multiphase, compound of fine grains of a solid solution, 16 μm in the main diameter, and phases located on the grain boundaries (Fig.1). From X-ray microanalysis (Philips XL20, analyser Oxford Microspec WDX400) it appears that in the phases located on the grain boundaries it is possible to distinguish a phase plenteous in chromium (dark areas in Fig.1) and a phase containing a lot of tungsten (light areas). The macroscopic hardness of the reference specimen was 52 HRC.

2. THE TEST RESULTS

Titanium wear determined during tribological tests versus time is big and linear. As a consequence, we obtain the wear products of different chemical compositions and quantities. They are a result of processes proceeding in the space where surfaces of the pair are in contact. They were recognised during tests of both surfaces and the product as well. On the titanium surface, wear proceeds according to some overlapping mechanisms. From observations of the specimen surface it appears that small particles separate from the ground (Figs. 2a and b) by cyclic action of loading, probably leading to fatigue. The microareas remaining in the gaps (Fig. 2c) have structures typical for a slide occurring in the hexagonal phase Tiα, and before separation in the particles there are many microcracks (Fig. 2d). At the same time, on the specimen surface there are some regions where we can observe transfer of the reference specimen material (Figs 2a, e). From the X-ray microanalysis done in some

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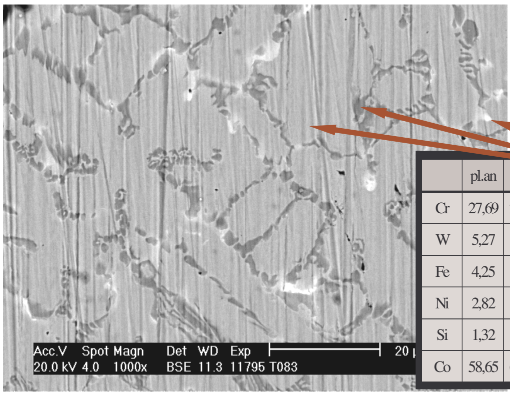
chosen points it appears that there are some places with the cobalt alloy smeared over the titanium ground. They are arranged in an irregular way (Fig. 2f). Presence of the cobalt alloy can be joined with formation of local adhesion couples of titanium and the alloy. They cause instantaneous increase of friction forces and smearing takes place.

The reference specimen made of the cobalt alloy has many scratches on the wear path. On their ends we can observe fine particles. From the particles analysis it results that they are oxidized – in the surface or completely – titanium (Figs. 3a, b, c), probably rutile. High hardness of rutile remaining in the area of the pair contact intensifies abrasive wear. The specimen material (titanium) is also deposited on the reference specimen. Titanium is smeared over the surface and under local increase of temperature and in the area of atmospheric oxygen action it is subjected to surfacial or total oxidation (Figs. 3d, e, f).

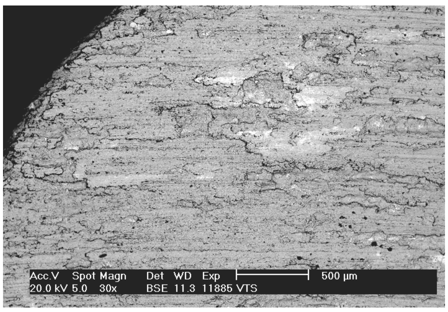


	pl.an	p1	p2	p3
Cr	27,69	22,14	66,33	18,38
W	5,27	6,21	5,29	27,39
Fe	4,25	5,09	3,16	3,05
Ni	2,82	3,31	—	—
Si	1,32	1,36	—	—
Co	58,65	61,90	25,22	51,18

Fig. 1. Structure of the reference specimen (cobalt alloy) and its chemical composition in microareas

Such wear course in the cooperating surfaces (including oxidation of the titanium particles) causes that wearing products contain both particles plenteous in the specimen material and particles plenteous in the reference specimen material (Fig.4). Products from the reference specimens form as a result of abrasive wearing and microcutting (Fig. 4a) and products from the specimens – as a result of abrasion and fatigue-corrossive processes.

a)



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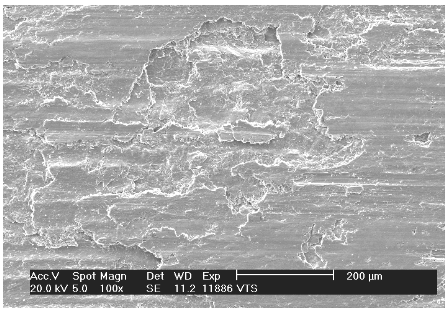

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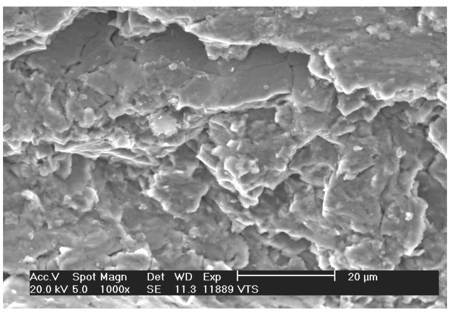

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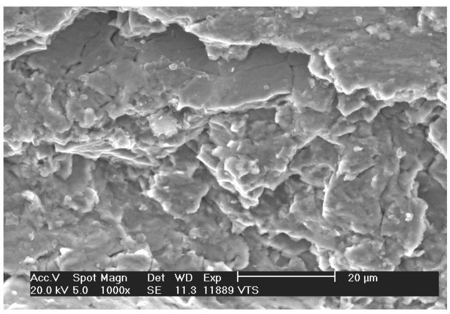
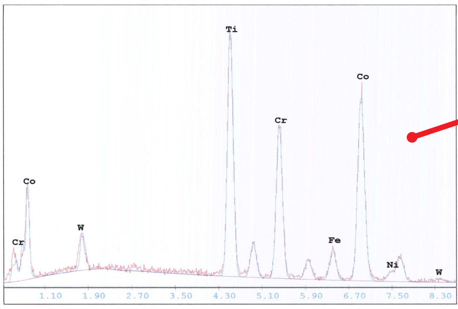


e)



f)

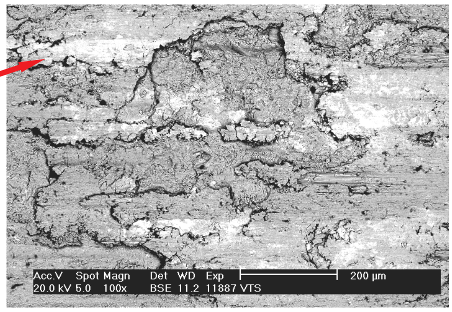
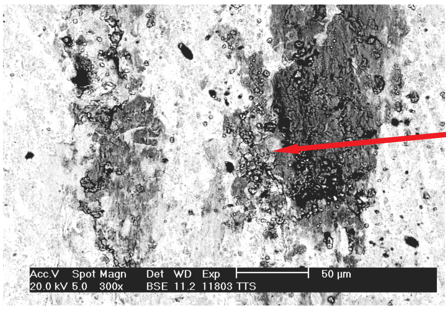


Fig. 2. Titanium specimen wear: a) macrophotography of the boundary area, b,f) surface pictures, c) microstructure of pits, d) microcracks in a particle, e) spectrum near smearing in 2f

a)



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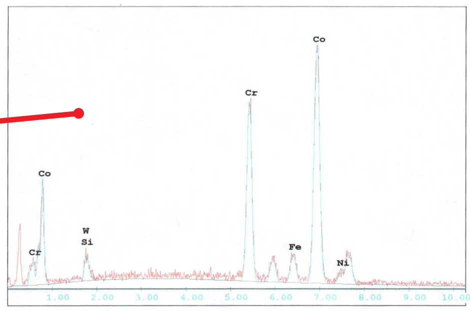
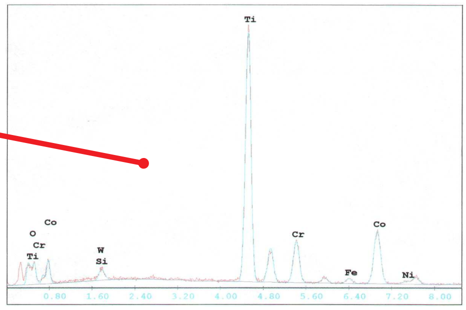
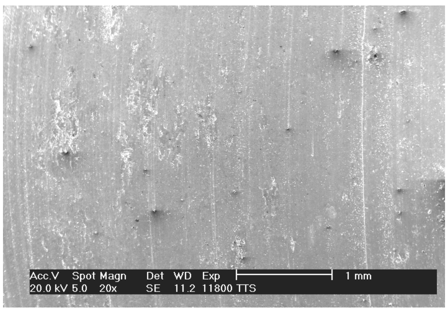


c)

d)



e)



f)

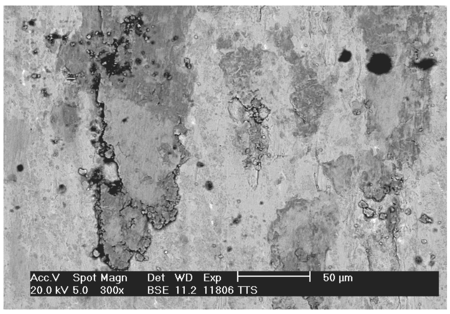


Fig. 3. Titanium specimen wear: a) particle of oxidized titanium, b) spectrum from Fig. 3a, c) smeared titanium, d) spectrum from Fig. 3c, e) macrophotographs of the wear path, f) smeared and oxidized titanium

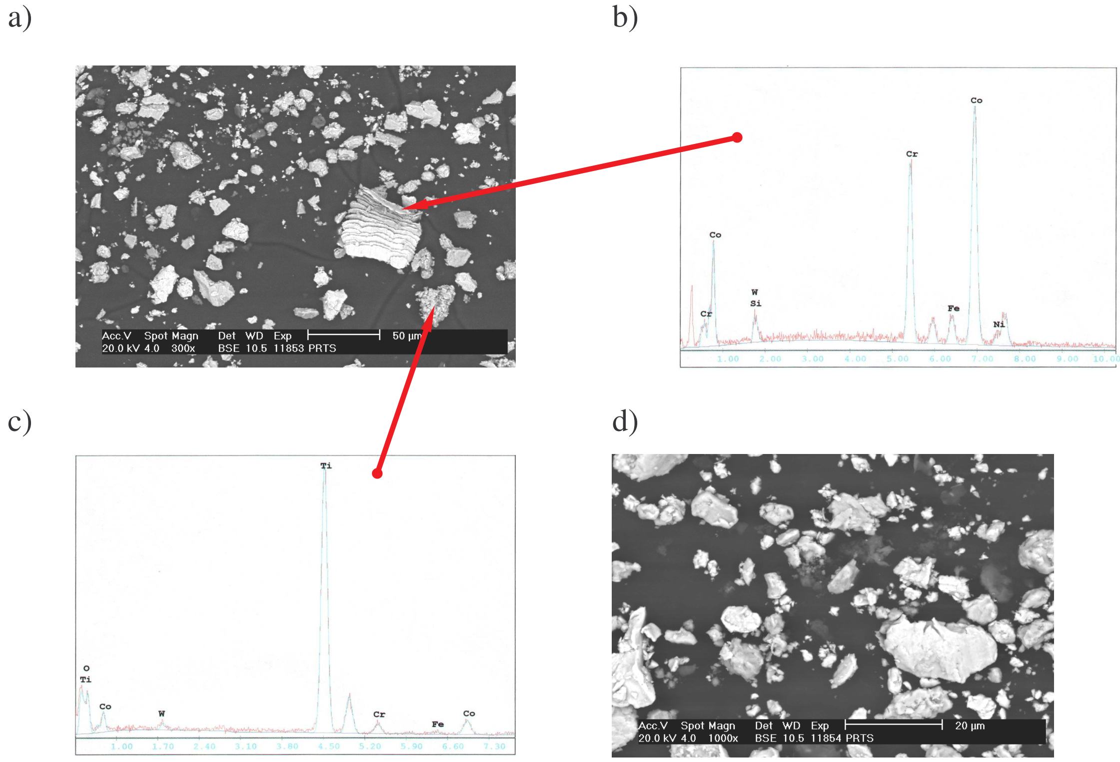


Fig. 4. Wear products of a pair titanium - cobalt alloy a) products of different quantities and shapes, b, c) spectrum from Fig. 4a, d) product microparticles

3. CONCLUSIONS

1. In a tribological pair Ti – Co28Cr5W5Fe3Ni, both the specimen and the reference specimen are subjected to wear (under 0.2 m/s, 60 N).
2. Titanium wear is a result of abrasion and corrosive processes.
3. Titanium oxides remaining in the friction zone intensify abrasion wearing.
4. Wear of the reference specimen made of the cobalt alloy is a result of abrasion, microcutting, its transfer and smearing over titanium

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