TRIBOLOGICAL CHARACTERISTICS OF AOC MODIFIED WITH CARBON PARTICLES AND NANO-PIPES

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Summary

The paper represents the results of investigations conducted on the tribological tester T-01 on pin-on-disk pair for the conditions of the friction of technically dry. Analysis stereological counter-specimen was subjected from AOC and AOC modified with carbon particles and nano-pipes, that is composites coats. The values of the coefficient of the friction and the parameters of the roughness are presented, to four groups of samples.

Keywords: anodic hards layer, nanomaterials, friction, wear, tribological properties.

WŁAŚCIWOŚCI TRIBOLOGICZNE ANODOWYCH WARSTW TLENKOWYCH MODYFIKOWANYCH CZĄSTKAMI WĘGLA I NANORURKAMI

Streszczenie

Artykuł przedstawia wyniki badań przeprowadzone na stanowisku tribologicznym T-01 w skojarzeniu trzpień-tarcza w warunkach tarcia technicznie suchego. Poddano analizie stereologicznej przeciwpróbki wykonane z czystego APT i APT modyfikowanej cząstkami węgla i nanorurkami czyli powłokami kompozytowymi. Zestawiono wartości współczynnika tarcia oraz parametry chropowatości, dla czterech grup próbek.

Słowa kluczowe: anodowa warstwa tlenkowa, nanomateriały, tarcie, zużycie, właściwości tribologiczne.

1. OXIDE CERAMIC LAYER

Modifications of an oxide coating maintain all its advantages and improve operating properties of a composite material formed in such a way (e.g. a decrease in the friction coefficient or intensity of wear of co-partners). Anodic oxide coatings (AOC), which were obtained on the EN AW-5251 aluminum alloy in the ternary electrolyte, were examined in the work. The following types of the oxide coating modifications were used: in a form of an addition of graphite powder into the electrolyte during production; by vacuum sublimation by a graphite electrode and modifying the base coating with nano-particles. For comparison purposes a non-modified oxide coating was used as a reference.

The ternary electrolyte composition consisted of a water solution of the sulfric acid, oxalic acid and phthalic acid (SFS), being an organic addition to protect the aluminum oxide formed against an aggressive influence of the electrolyte (dissolution of the oxide coating) [1]. This electrolyte composition was used to anodize four groups of specimens, additionally while hard anodizing counter-specimens modified by a simplex method there was a graphite powder with a grain diameter of <1 micrometer in the amount of 20 g/l (PE) in the electrolyte. Other two groups of specimens were modified by duplex methods.

The anodic oxide surface was made by a direct current method at the same current and temperature conditions. Anodizing time for all counter-specimens was the same and was 60 min (Fig. 1). The current intensity was 3 A/dm2, the electrolyte temperature was 20 ºC (PB). Then, the oxide coatings formed in such a way were modified [2,3]:

1. Method 1 – the counter-specimen marked as PG –the carbon was injected into pores and on the surface of the pure oxide by vacuum sublimation,
2. Method 2 – the counter-specimen marked as PN –carbon nano-pipes were formed in the pores of the aluminum oxide.

The oxide coatings formed as a result of anodic oxidation are often subjected to removing of electrolyte residues, humidity and other impurities in the vacuum sprayer.

A Jeol IEE-4B vacuum sprayer was used for this purpose (Fig. 1). The carbon nano-pipes obtained by the α-CNT method were added to the oxide coating.

A mandrel made of the PEEK/BG high grade polymer composite was a tribological partner [4]. The material used is a thermo-material medium-crystalline linear aromatic polymer. The PEEK/BG composite PEEK- based contains dispersions of additions in a form of PTFE, graphite and short carbon fibers.

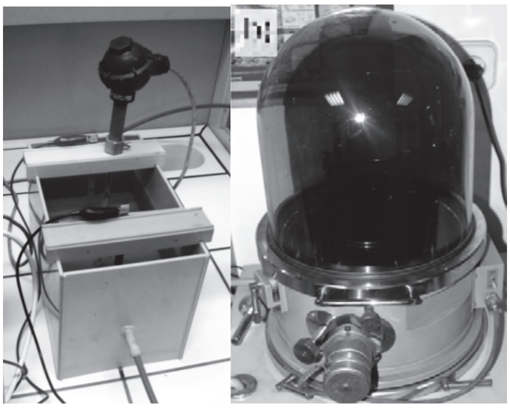

Fig. 1. Place for anodizing and Jeol IEE-4B vaccum evaporator

2. EXPERIMENTAL STUDIES

The tribological tests were performed for all types of specimens with coupling with the PEEK/BG material in the conditions of the technically dry friction on the T-01 M tribological test apparatus (Fig. 2 and 3) [5,6]. Other parameters of tribological tests:

- Friction path - 1500 m
- Load - 10 N
- Linear velocity - 0,2 m/s
- Friction diameter - Ø 25 mm
- Pin diameter - Ø 5mm
- Ambient temp - 21±1 ºC
- Air humidity - 40%±5%

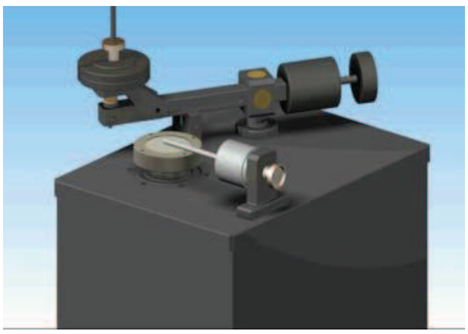

Fig. 2. 3D visualization model of tester T-01M

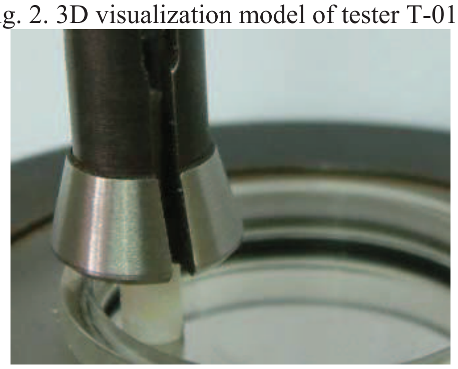

Fig. 3. Tribological pair pin on disk

Measurement results of the friction coefficient, linear displacements and the stabilized temperature of co-operation are showed in Fig. 4,5,6.

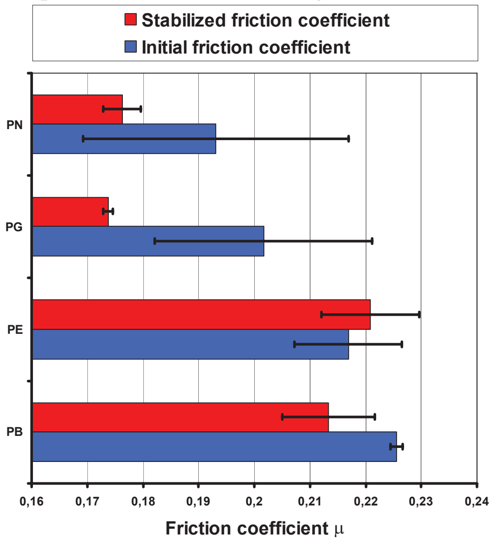

Fig. 4. Presentation of the initial and stabilized friction coefficient

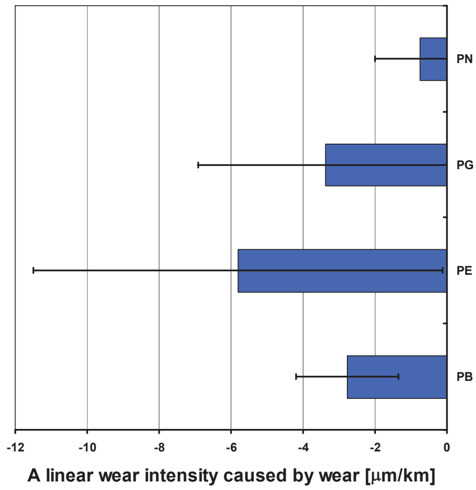

Fig. 5. A linear wear intensity caused by wear

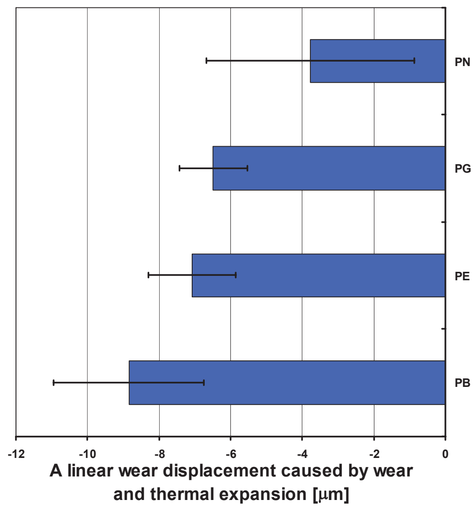

Fig. 6. A linear wear displacement caused by wear and thermal expansion

Measurement results of the friction coefficient, linear displacements and the stabilized temperature of co-operation are presented in table 1, 2.

Table 1. Initial and stabilized friction coefficient

	Initial friction coefficient	Stabilized friction coefficient
PN	0,193 ± 0,024	0,176 ± 0,003
PG	0,202 ± 0,020	0,174 ± 0,001
PE	0,217 ± 0,010	0,221 ± 0,009
PB	0,226 ± 0,001	0,213 ± 0,008

Table 2. Intensity of linear wear

	PN	PG	PE	PB
Intensity of linear wear	-0,748 ±1,242	-3,362 ±3,542	-5,804 ±5,679	-2,775 ±1,419

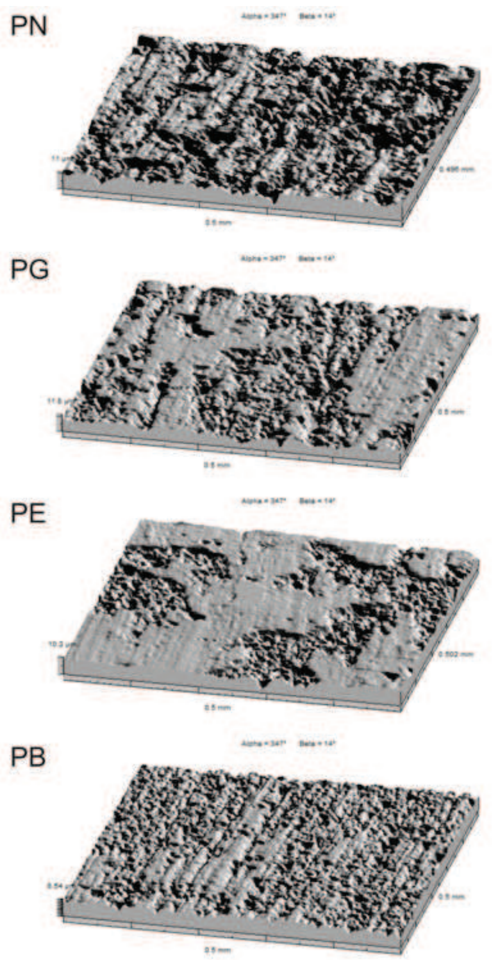

Fig. 7. The geometrical surface structure obtained as the result of profilometer measurements by a contact method

The geometrical surface structure obtained as the result of profilometer measurements by a contact method (TALYSURF 3D Taylor Hobson) is presented in figures 7. Results Abbott curve were introduced together with the graphic interpretation of functional parameters showed on figure 8. Amplitude parameters (Sa, Sq, Sp, St), spatial parameter (Sds) and functional parameter (Sci) are presented in table 3.

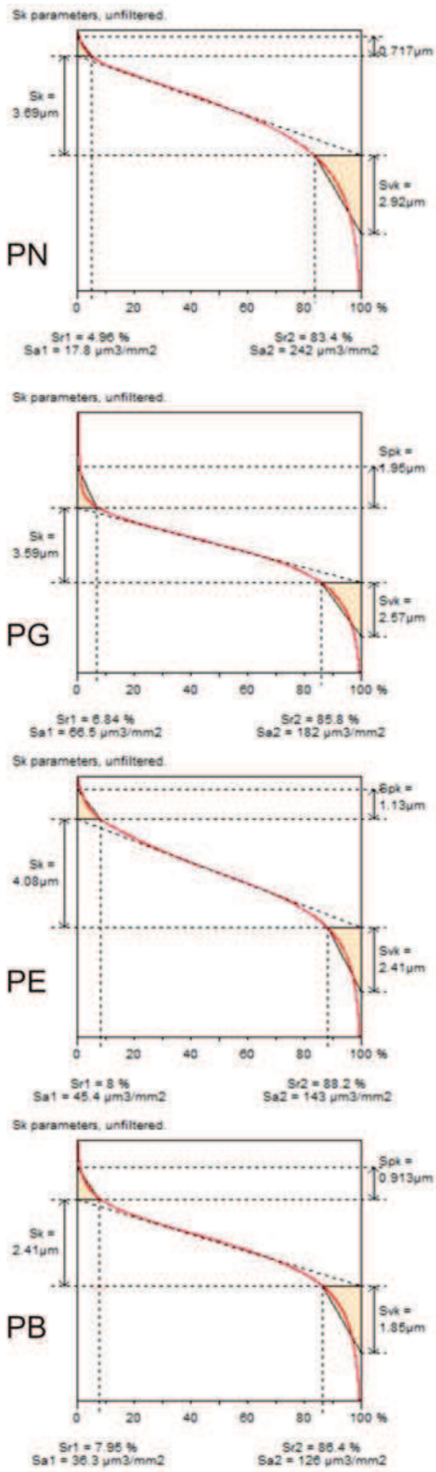

Fig. 8. Graphical study of Sk parameters

Table 3. Parameters calculated on the surface PN, PG, PE, PB

	PN	PG	PE	PB
Sa [μm]	1,32	1,23	1,21	0,84
Sq [μm]	1,73	1,78	1,58	1,14
Sp [μm]	3,22	18,6	3,76	7,66
St [μm]	11,5	26,1	11,6	13,4
Ssk	-1,27	0,82	-0,86	-0,76
Sku	5,27	16,1	4,91	7,05
Sds [pks/mm^2]	48,92	5550	58,82	7727
Sci	1,03	1,01	1,29	1,15

Analysing the parameters of the roughness of the surface from the amplitude group significant differences of the influence on profiles tribological were not affirmed. Decrease of the value coefficient friction is the most probably connected with the morphology of the surface layer.

3. SUMMARY

The AOC base modifications regardless of a way of their realization have an advantageous influence on the tribological characteristic in coupling with the PEEK/BG material. The lowest values of the initial and stabilized friction coefficient were obtained for couplings where the oxide coatings were modified by the vacuum sublimation of the PG carbon and the PN nanomaterial. It is also confirmed by the 3D surface topography of the variants analyzed.

During the tests a continuous slip film from the PEEK/BG material was formed and after setting it up led to the PEEK/BG material-PEEK-BG co-operation. In spite of such a system the substrate on which such a layer was formed, has a significant influence on the temperatures recorded near the friction zone and on a change of the linear dimensions of the specimen. Further stereometric, tribological examinations and numerical experiments will be performed for the coating modified with nanomaterials and obtained by sublimation.

4. REFERENCES

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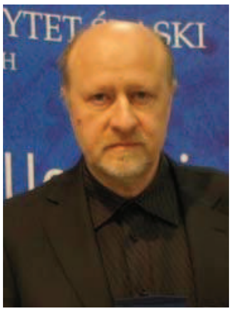

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