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JOURNAL OF THE BALKAN TRIBOLOGICAL ASSOCIATION

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Journal of the Balkan Tribological Association is an International Journal edited by the Balkan Tribological Association for rapid scientific and other information, covering all aspects of the processes included in overall tribology, tribomechanics, tribochemistry and tribology.
The Journal is referring in Chem. Abstr. and RJCH (Russia).

Aims and Scope

The decision for editing and printing of the current journal was taken on Balkantrib'93, Sofia, October, 1993 during the Round Table discussion of the representatives of the Balkan countries: Bulgaria, Greece, Former Yugoslavian Republic of Macedonia, Romania, Turkey and Yugoslavia. The Journal of the Balkan Tribological Assosiation is dedicated to the fundamental and technological research of the third principle in nature – the contacts.

The journal will act as international focus for contacts between the specialists working in fundamental and practical areas of tribology.

The main topics and examples of the scientific areas of interest to the Journal are:

(a) overall tribology, fundamentals of friction and wear, interdisciplinary aspects of tribology;
(b) tribotechnics and tribomechanics; friction, abrasive wear, adhesion, cavitation, corrosion, computer simulation, design and calculation of tribosystems, vibration phenomena, mechanical contacts in gaseous, liquid and solid phase, technological tribological processes, coating tribology, nano- and micro-tribology;
(c) tribochemistry – defects in solid bodies, tribochemical emissions, triboluminescence, tribochemiluminescence, technological tribochemistry; composite materials, polymeric materials in mechanics and tribology; special materials in military and space technologies, kinetics, thermodynamics and mechanism of tribochemical processes;
(d) sealing tribology;
(e) biotribology – biological tribology, tribophysiotherapy, tribological wear, biological tribotechnology, etc.;
(f) lubrication – solid, semi-liquid lubricants, additives for oils and lubricants, surface phenomena, wear in the presence of lubricants; lubricity of fuels; boundary lubrication;
(g) ecological tribology; the role of tribology in the sustainable development of technology; tribology of manufacturing processes; of machine elements; in transportation engineering;
(h) management and organisation of the production; machinery breakdown; oil monitoring;
(j) European legislation in the field of tribotechnics and lubricating oils; tribotesting and tribosystem monitoring;
(k) educational problems in tribology, lubricating oils and fuels.

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Compiled by S. K. Ivanov, Zh. D. Kalitchin, J. P. Ivanova, M. I. Boneva, N. Evtimova and E. Tosheva.

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Abstract must be on a separate page. It should not exceed 200 words and should give the subjects and conclusions of the article and all results of general interest.

The rest of the manuscript should be arranged in the following order:

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Journal of the Balkan Tribological Association

CONTENTS

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TRIBOLOGICAL BEHAVIOUR OF ZA27/10SiC/1Gr HYBRID COMPOSITE

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ABSTRACT

The paper describes the tribological behaviour of a hybrid composite based on zinc–aluminium ZA27 alloy, reinforced with silicon–carbide (SiC) and graphite (Gr) particles. The composite specimen was prepared by compocasting technique. The tested sample contains 10 vol.% of SiC and 1 vol.% Gr particles. The experiments were done on a block-on-disc tribometer under conditions of dry sliding. The wear volumes of the alloy and the composite were determined under different test conditions, by varying the normal loads and sliding speeds. The wear surface of the composite material was examined using a scanning electronic microscope (SEM) and energy dispersive spectrometry (EDS). Conclusions were drawn based on the observed impact of the sliding speed, normal load and sliding distance on tribological behaviour of the observed composite.

Keywords: ZA27 alloy, hybrid composites, tribological behaviour.

AIMS AND BACKGROUND

The composite material represents the solid connection of two or more constituents, which are joined into the unbreakable connection, for obtaining the better mechanical, tribological and other characteristics.

Metal matrix composites (MMCs) have attracted considerable attention recently because of their potential advantages over monolithic alloys[1–3].

The zinc alloy with increased content of aluminium is one of the alloys, which can be used for manufacturing the metal matrix composites. The ZA27 alloy is considered as the most prospective for obtaining the composites, since it is convenient as a substrate for several methods of composites manufacturing.

* For correspondence.

Besides, it is also convenient for the heat treatment and plastic forming, thus it is possible to a posterior influence the mechanical properties of the final products[4–7].

Zinc-based alloys have been used to a number of engineering and particular tribological applications for many years because of their low density, excellent cast ability, fluidity, lower energy requirement for shaping and superior wear properties. Various methods and techniques were used to substantially improve wear behaviour of Zn–Al (zinc–aluminium) alloys without lowering significantly the mechanical properties of materials[6–8].

The ZA27 alloys have high strength, hardness and wear resistance, as well as other favourable physical properties. The properties make it an attractive alternative to aluminium, brass, bronze or iron for the design of structures and machine parts that can be cast. Good characteristics of zinc–aluminium alloys have inspired researchers to reinforce them with different dispersed reinforcement materials (SiC, Al_2O_3, graphite and garnet) in order to obtain much more enhanced mechanical and tribological properties[8–16].

Considering the above, ZA27/SiC/graphite composites may be a good alternative to zinc–aluminium alloys in many industrial applications.

EXPERIMENTAL

The composite material with the ZA27 metal matrix reinforced by 10% SiC and 1% Gr particles (ZA27/10%SiC/1%Gr) was obtained by a compocasting procedure. The tests of the ZA27/SiC/Gr composite tribological characteristics were performed on a computer-supported tribometer with block-on-disc contact geometry (Fig. 1) at the Centre for tribology of the Faculty of Engineering, University of Kragujevac[13–15]. Tribometer provides variation of contact conditions in terms of shape, dimension and material of contact elements, normal contact load and sliding speed.

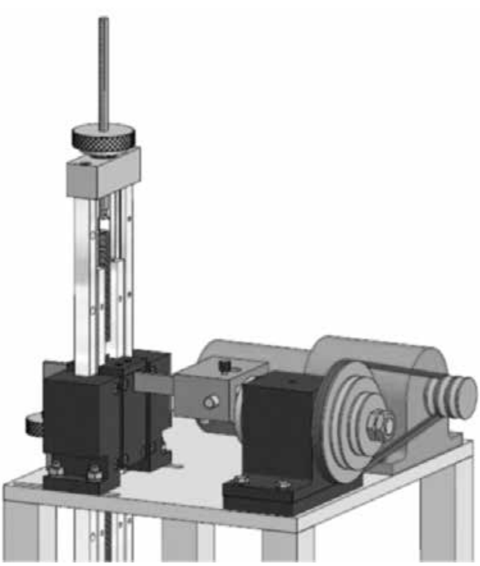

Fig. 1. The block-on-disc tribometer

Based on the mesasured wear scar width on the contact surface, obtained by variation of normal loads and sliding speeds, the material wear volume was calculated. The tests were performed in dry sliding conditions, with variation of sliding speed levels (0.25, 0.5 and 1 m/s) and contact load levels (10, 20 and 30 N). The observed sliding distances during tests were: 30, 60, 90, 150 and 300 m, respectively.

The test contact pair meets the requirements of the ASTM G77-05 standard. It consists of a rotational disc with a diameter of $D_d = 35$ mm and width of $b_d = 6.35$ mm and of stationary block of width of $b_b = 6.35$ mm, length of $l_b = 15.75$ mm and height of $h_b = 10.16$ mm. The discs were made of 90MnV8 steel with hardness of 62–64 HRC and surfaces roughness of $R_a = 0.40$ µm. The blocks were made of the tested ZA27/10%SiC/1%Gr.

RESULTS AND DISCUSSION

The variations of dry sliding wear volume loss are presented in corresponding diagrams in the paper, depending on the sliding distance and for different values of sliding speeds and contact loads. The results of wear for a given hybrid composite and for ZA27 alloy were presented in the same diagrams in order to understand the wear process evolution during tests and to make corresponding comparisons. Solid lines on the diagrams refer to the wear scar widths of the composite, while the wear scar widths of the ZA27 alloy are denoted by dashed lines.

The variation of dry sliding wear volume loss with the sliding distance for different applied loads and for a sliding speed of 0.25 m/s is presented in Fig. 2. All diagrams are given for a sliding distance of 300 m.

The variation of wear volume loss of ZA27 alloy and ZA27/10%SiC/1%Gr composite depending on the sliding distance and for different applied contact loads and sliding speed of 0.5 m/s may be seen in Fig. 3.

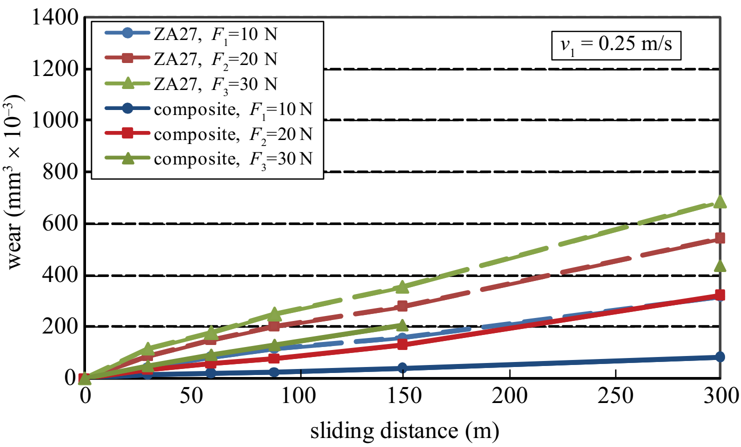

Fig. 2. Variation of wear volume of ZA27 alloy and ZA27/10%SiC/1%Gr composite against sliding distance for different contact loads and for sliding speed of $v = 0.25$ m/s

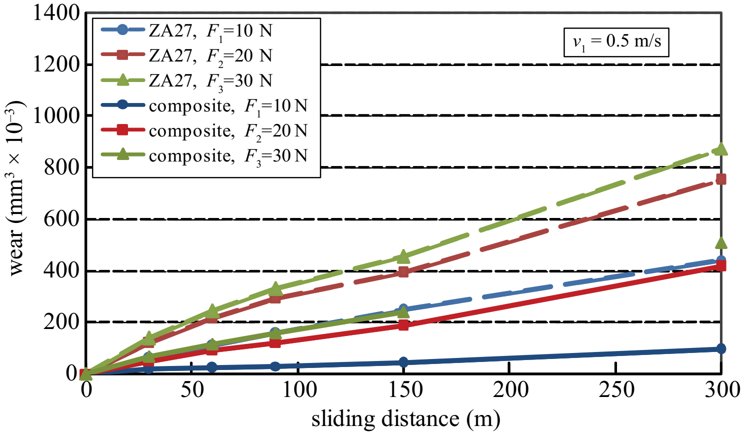

Fig. 3. Variation of wear volume of ZA27 alloy and ZA27/10%SiC/1%Gr composite against sliding distance for different contact loads and for sliding speed of v = 0.5 m/s

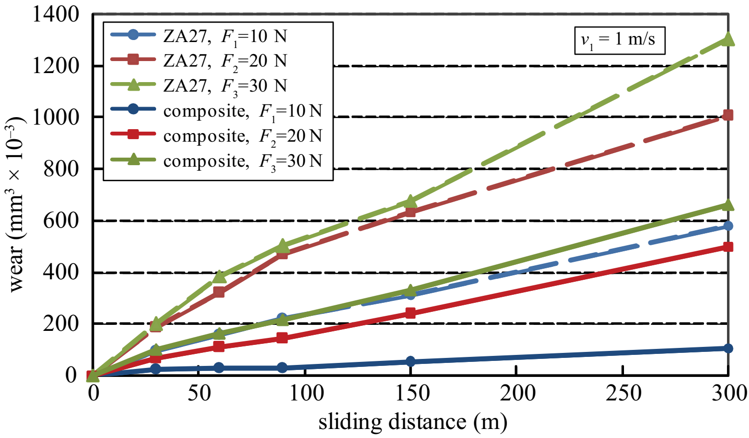

Fig. 4. Variation of wear volume of ZA27 alloy and ZA27/10%SiC/1%Gr composite against sliding distance for different contact loads and for sliding speed of v = 1 m/s

The diagram in Fig. 4 presents the variation of wear volume loss of ZA27 alloy and ZA27/10%SiC/1%Gr composite depending on the sliding distance and for different applied contact loads and sliding speed of 1 m/s.

The wear volume losses of the alloy and the composite grow with the increase of the sliding distance. The wear volume loss curves have the same character both for alloy and for the observed composite material – the only difference is seen in level of wear. At the beginning of the tests, a larger slope of the curves is noticeable, so there is an intensive initial wear of the composite material. A rapid increase of wear volume loss is characteristic for sliding distance of approximately

30 m. After reaching the zone of constant wear, the wear volume loss has only slight, almost linear increase.

Generally, the wear behaviour of the tested materials is characterised by very intensive wear during initial period, after which there is a period of stabilisation. It could be noticed that wear of the composites was always significantly lower when compared to wear of the matrix ZA27 alloy.

The influence of the sliding speed on wear volume, for different values of normal loads is shown in Fig. 5, for both materials.

The effects of the normal load on wear volume both of composite and alloy is presented in Fig. 6, for different values of sliding speeds and for sliding distance of 300 m.

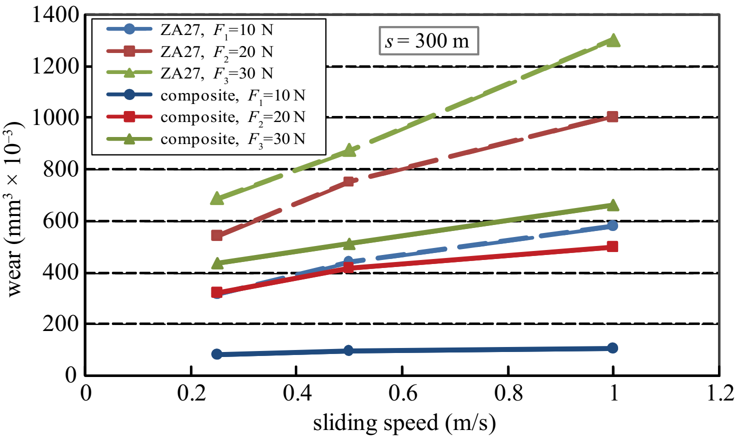

Fig. 5. Wear volume of ZA27/10%SiC/1%Gr composite and ZA27 alloy depending on sliding speeds, for different contact loads and for sliding distance of 300 m

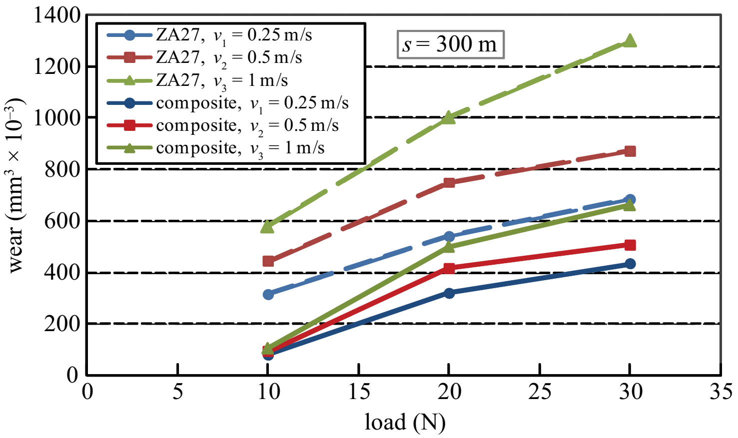

Fig. 6. Wear volume of ZA27/10%SiC/1%Gr composite and ZA27 alloy depending on contact loads, for different sliding speeds and for sliding distance of 300 m

As it may be seen from the diagrams, both tested materials have basically the same nature of wear process development in all contact conditions. The observed composite material has better wear resistance, under the same test conditions.

The comparative histograms of the wear volume formed after 300 m of sliding distance, depending on the contact conditions (the sliding speed and the normal force) for the basic, ZA27 alloy and ZA27/10%SiC/1%Gr composite materials are shown in Fig. 7.

Analysis of histograms in Fig. 7 shows that a trend of increase of wear with the increase of normal load be observed. The increase of sliding speed induces also the increase of wear. This observation is valid for both tested materials. It may be noticed that the wear of the tested ZA27 alloy is always significantly higher compared to wear of the composite with addition of the SiC and graphite particles.

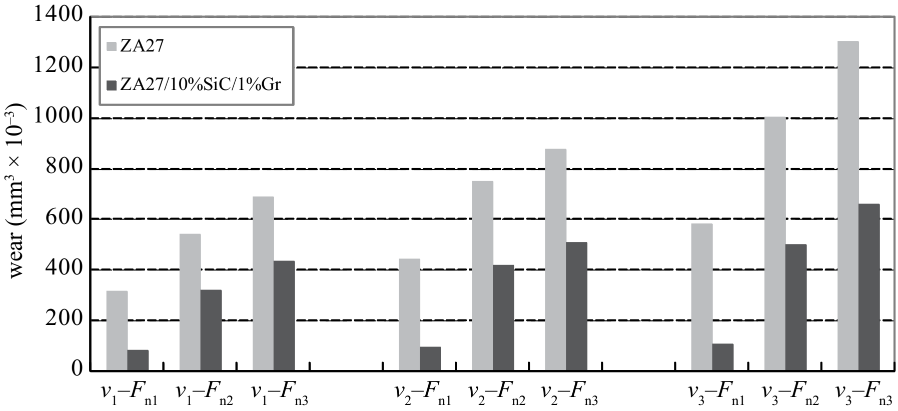

Fig. 7. Comparative histograms of wear volume of ZA27 alloy and ZA27/10%SiC/1%Gr composite

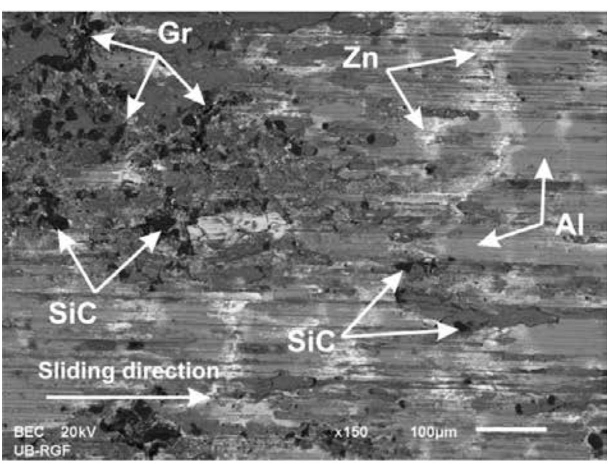

Fig. 8. SEM micrographs of worn surfaces of the ZA27/10%SiC/1%Gr composite

From the figure, one can clearly notice the influence of the normal load and sliding speed on the wear magnitude. The wear intensity increases with increase of the normal force, and increases with increase of the sliding speed. The largest value of wear corresponds to the highest sliding speed (v_3 = 1 m/s) and to the highest value of the normal contact load (F_3 = 30 N). For the lowest sliding speed (v_1 = 0.25 m/s) and the lowest load (F_1 = 10 N), the smallest wear values were recorded.

Characterisation of the microstructure of wear surface for metal matrix composites is more complex than that of the metals or alloys and an understanding of wear mechanisms is far from complete. The SEM analysis may contribute to better understanding of this mechanism.

The SEM micrograph of the worn surface at a load of 10 N and at a speed of 0.25 m/s for a sliding distance of 300 m is presented in Fig. 8 for the tested composite material. Directions of sliding and the cooresponding constituents of the composite material are marked in the figure.

Qualitative and quantitative chemical examination of microconstituents was performed using energy dispersive spectrometry (EDS) (Fig. 9).

Given analyses confirm the presence of constituent elements like: Zn, Al, SiC, Gr (C), as well as the presence of Fe as a consequence of material transfer from the counterpart to the composit block.

In analysis of the tribological response of the composite at higher sliding speed/loads, besides effects of the suppressed micro-cracking tendency, one needs to include the crucial role of the mechanically mixed layers (MML) on the contact surfaces during the wear process. Generally, sliding wear of alloys and metals is characterised by forming a MML over the mating surface, which strongly dictates wear mechanism, i.e. the wear behaviour of the material.

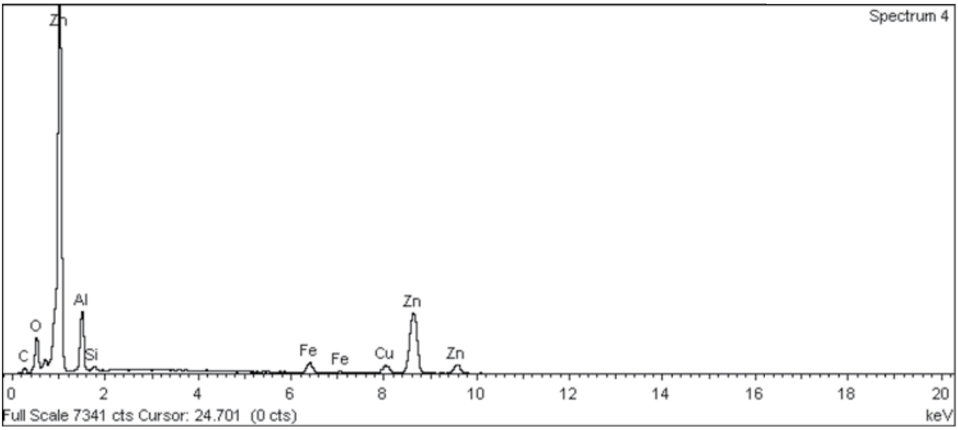

Fig. 9. EDS analysis of worn surface on the ZA27/10%SiC/1%Gr composite

CONCLUSIONS

This research serves to complete the tribological knowledge on developed composite materials with ZA27 alloy reinforced by the SiC and graphite particles. The goal was to confirm further possibilities for broader application of composites as advanced tribo-materials in different technical systems.

By monitoring the wear process through observation of wear volume in dry sliding conditions, the following conclusions can be made:

- Wear of the tested composite is smaller than wear of ZA27 alloy for all applied sliding speeds and normal loads.
- Wear process evolution has the same character for both tested materials (basic ZA27 alloy and ZA27/10%SiC/1%Gr composite).
- Values of the wear volume of the observed composite material increase with the increase of normal loads.
- Wear volume also increases with the increase of the sliding speed.

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