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WEAR BEHAVIOUR OF HYBRID ZA27/SIC/GRAPHITE COMPOSITES UNDER DRY SLIDING CONDITIONS

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Abstract: *The paper deals with tribological behaviour of hybrid composites based on ZA27 alloy reinforced with silicon-carbide (SiC) and graphite (Gr) particles. The tested sample contains 5% of SiC and 1% Gr particles. The experimental tests were performed on a "block-on-disc" tribometer. The main tribological parameter in the analysis was wear scar width, obtained by variation of normal loads and sliding speeds, under dry sliding conditions. Through observation of the changes in wear scar widths in dry sliding conditions, corresponding conclusions were made.*
Key Words: *ZA27 alloy, hybrid composites, tribological behaviour*

1.INTRODUCTION

Zinc–aluminium (ZA) alloys are important materials for tribological applications. They are especially suitable for high-load and low-speed applications. Their main advantages are good tribo-mechanical properties, low weight, excellent foundry castability and fluidity, good machining properties, low initial costs and environmental-friendly technology. Metal matrix composites (MMCs) have recently attracted considerable attention because of their potential advantages over monolithic alloys. Metal matrix composites based on ZA matrix are being increasingly applied as light-weight and wear resistant materials. Good characteristics of ZA alloys have inspired researchers to reinforce them with different dispersed reinforcement materials (SiC, Al_2O_3, glass fibres, graphite) in order to obtain better mechanical and tribological properties [1-3].

One of the major limitations of conventional ZA alloys is deterioration of their mechanical and wear resistance properties at higher temperatures (above 100°C) and their dimensional instability [4-6]. Recent investigations have focused attention to modification and improvement of the ZA27 alloy.

The mechanical properties of the ZA27 graphite reinforced composites are significantly changed by varying the amount of graphite [7-11]. Tribological tests show that addition of graphite particles to the ZA27 alloy matrix improves the wear resistance of the composite, despite of significant decrease in hardness. Graphite is a good choice for reinforcement of MMCs that need to have a good wear resistance, like: engine bearings, pistons, piston rings and cylinder liners.

The silicon-carbide reinforced composites exhibit reduced wear rate when compared to unreinforced ZA27 alloy specimens under the dry sliding conditions. The wear rate decreases with the increase of SiC content. The positive effects of SiC in improvement of the tribological behaviour of the ZA27 alloys are confirmed in [12-20].

The use of multiple reinforcements in zinc matrix hybrid composites provides better tribological properties than in composites with single reinforcement. Literature review shows that many researchers have considered partial influences of SiC and Gr reinforcements on the ZA27 alloys, while combined influence of SiC and Gr reinforcements is rarely investigated. This paper is an attempt to contribute to investigations of this combined influence on tribological behaviour of ZA27/SiC/Gr hybrid composites. The influence of sliding speed, loads and sliding distance on the tribological behaviour of ZA27/SiC/Gr hybrid composite is considered.

2.EXPERIMENTAL INVESTIGATIONS

The composite material with the ZA27 metal matrix reinforced by 5% SiC and 1% Gr particles (ZA27+5%SiC+1%Gr) was obtained by the compocasting procedure at the Laboratory for materials of Institute of Nuclear Sciences "Vinča".

The tests of the ZA-27/SiC/Gr composite's tribological characteristics were performed on the computer supported tribometer (Fig. 1) with "block-on-disc" contact geometry (Fig. 2) at the Centre for tribology at the Faculty of Engineering, University of Kragujevac. The main tribological parameter in the analysis was the wear scar width on the contact surface, obtained by variation of normal loads and sliding speeds. The tests were performed without lubrication, with variation of sliding speed levels (0.25 m/s, 0.5 m/s and 1 m/s) and contact load levels (10 N, 20 N and 30 N). The observed sliding distances during tests were: 30 m, 60 m, 90 m, 150 m and 300 m.

Fig. 1. The "block-on-disc" tribometer

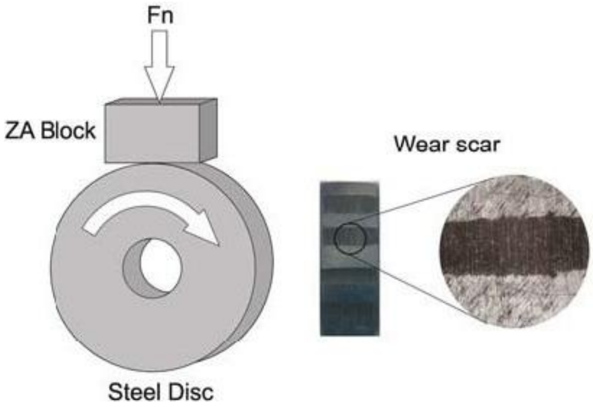


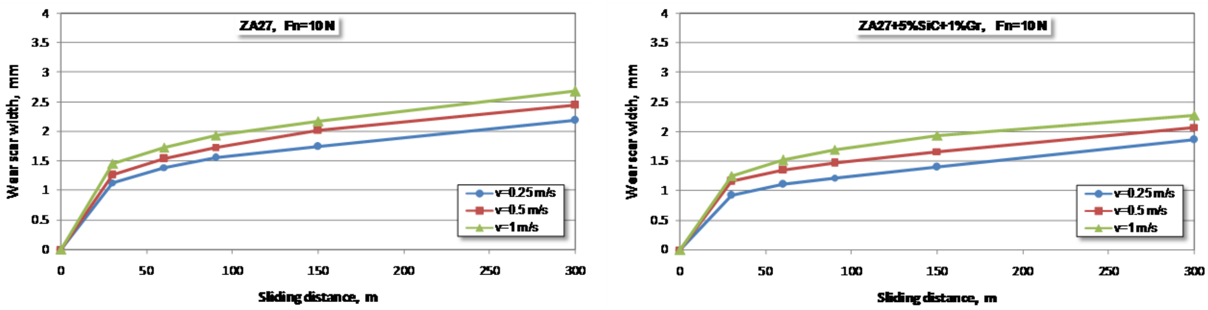
Fig. 2. The scheme of contact pair geometry

The test contact pair meets the requirements of the ASTM G77-05 standard. It consists of the rotational disc with diameter D_d=35 mm and width b_d=6.35 mm and of the stationary block of the width b_b=6.35 mm, length l_b=15.75 mm and height h_b=10.16 mm. The discs were made of steel 90MnV8 with hardness of 62 HRC and ground surfaces with roughness of R_a=0.42 mm, while the blocks were made of the tested ZA27+5%SiC+1%Gr composite.

3.THE RESULTS OF TRIBOLOGICAL INVESTIGATIONS

The curves of wear scar widths are presented in corresponding diagrams in the paper, depending on the sliding distance and for different values of sliding speeds and contact loads. Wear curves of ZA27 alloy and given hybrid composite are presented side-by-side in order to see the trends and values of respective wear scar widths.

Fig. 3 presents the wear scar width values depending on the sliding distance, for different selected values of the sliding speeds and for the applied load of F_n=10 N.

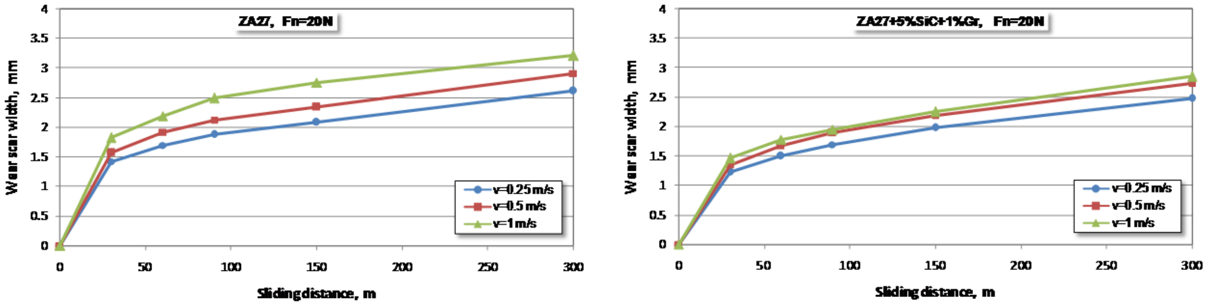


a) *b)*

Fig. 3. Wear curves of: a) ZA27 alloy and b) ZA27+5%SIC+1%Gr composite for different sliding speeds and for the applied load of F_n=10 N

Generally, the wear behavior of the tested materials is characterized by very intensive wear during initial period, after which there is a period of stabilization. It could be noticed that wear of the composites was always significantly lower when compared to wear of the matrix ZA-27 alloy.

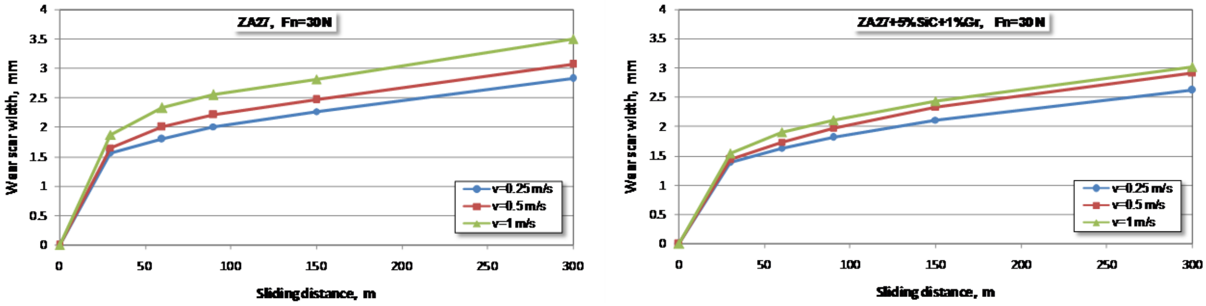
Fig. 4 shows the wear scar widths of the tested materials depending on the sliding distance, as functions of the applied load of F_n=20 N and different sliding speeds.



a) *b)*

Fig. 4. Wear curves of: a) ZA27 alloy and b) ZA27+5%SIC+1%Gr composite for different sliding speeds and for the applied load of F_n=20 N

The curves of wear scar widths of the both tested materials for different sliding speeds and for the applied load of F_n=30 N are given in Fig. 5.



a) *b)*

Fig. 5. Wear curves of: a) ZA27 alloy and b) ZA27+5%SIC+1%Gr composite for different sliding speeds and for the applied load of F_n=30 N

Obtained wear curves have the shapes that are consistent with theoretical models of the process of wear. From the presentations of the wear curves in Figs. 3 to 5, a zone of initial (intensive) wear is noticed that corresponds to a period of contact surfaces break-in and a zone of stationary (moderate) wear where uniform wear occurs. A rapid increase of wear scar width is characteristic for initial wear period for approximately 30 m of the sliding distance. After that, the increase of wear scar width is smaller and almost linear. For all given test conditions, wear curves have identical character. It may be noticed that the wear scar width in dry sliding conditions is the biggest for the highest sliding speed.

The shape and the outlook of the wear curves depend on achieved contact conditions, the intensity of the external load and the sliding speed, but also on the tribological characteristics of the tested materials. In order to comprehend the process of wear of the hybrid composite, as well as to be able to compare the wear scar widths of both tested materials, these values are presented together in Figs. 6 and 7. Solid lines on the diagrams refer to the wear scar width of the composite, while the wear scar width of the ZA27 alloy are denoted by dashed lines.

From the comparative presentations in Figs. 6 and 7, the nature of the normal load and sliding speed influences on the wear process in dry sliding conditions may be clearly noticed. With the increase of normal load and sliding speed, the wear scar width also increases, thus the largest values are noticed at highest sliding speeds and the largest contact loads.

Fig. 6 shows the influence of the sliding speed on both materials, for different values of normal loads.

Fig. 7 shows the effects of the normal load on wear scar widths of both given composite and alloy, for different values of sliding speeds and for sliding distance of 300 m.

By analysis of the obtained diagrams, it may be concluded that both tested materials have common nature of the wear process development for all contact conditions. Under the same test conditions, the observed composite material exhibits the better wear resistance.

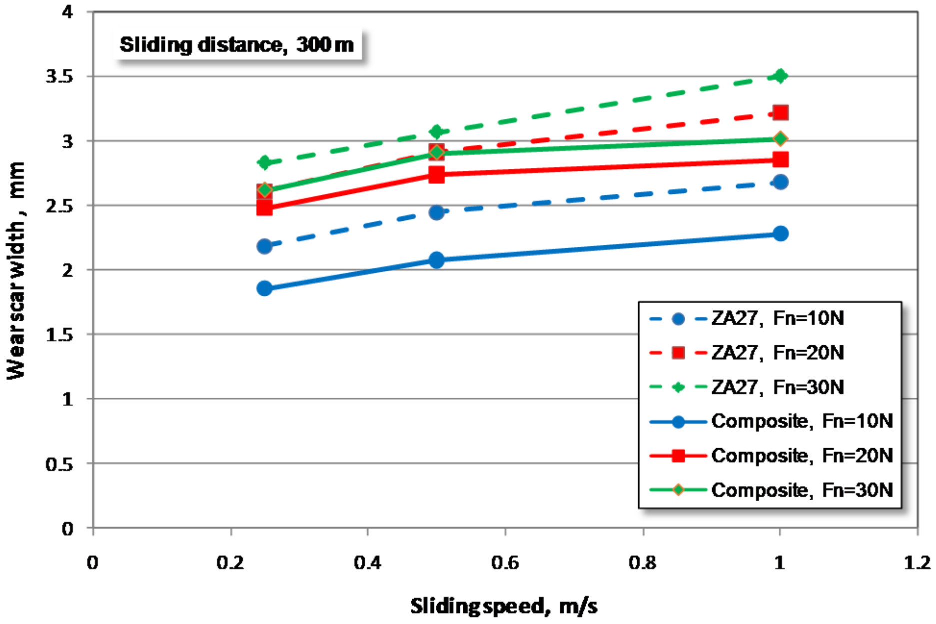


Fig. 6. Wear scar widths of ZA27+5%SIC+1%Gr composite and ZA27 alloy depending on sliding speeds, for different contact loads and for sliding distance of 300 m

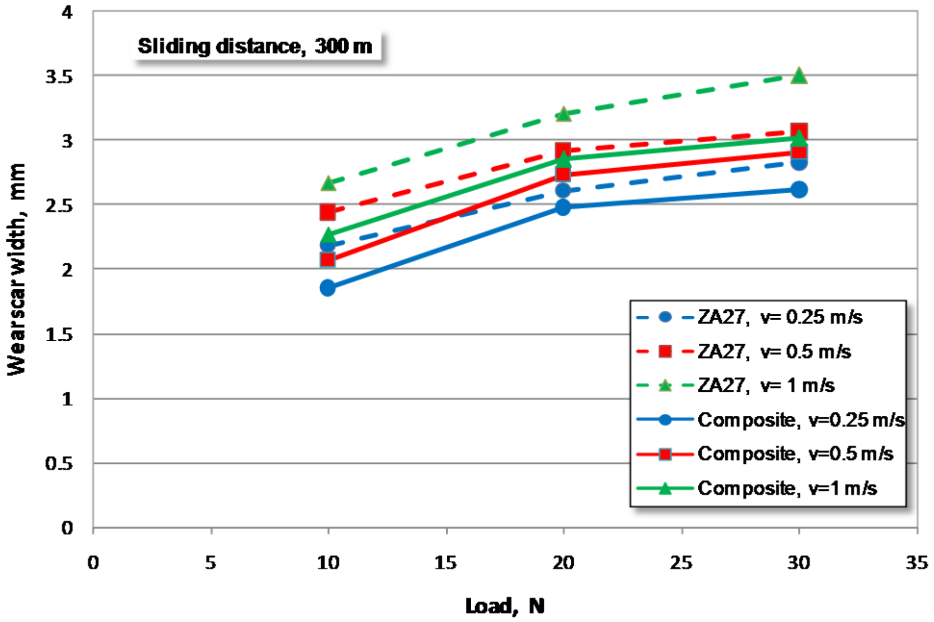


Fig. 7. Wear scar width of ZA27+5%SIC+1%Gr composite and ZA27 alloy depending on contact loads, for different sliding speeds and for sliding distance of 300 m

The comparative histogram representations of the wear scar widths were formed after 300 m of sliding distance, depending on the contact conditions (the sliding speed and the normal force) for the basic, ZA27, and composite ZA27+5%SiC+1%Gr materials (Fig. 8).

By analysis of histograms in Fig. 8, a trend is observed that the wear scar width increases with the increase of normal load. Also, the wear scar width increases with the increase of the sliding speed. This trend is valid for both observed materials. It is noticeable that the wear of the tested composites with addition of the SiC and graphite particles is always significantly lower compared to the wear of ZA27 alloy.`

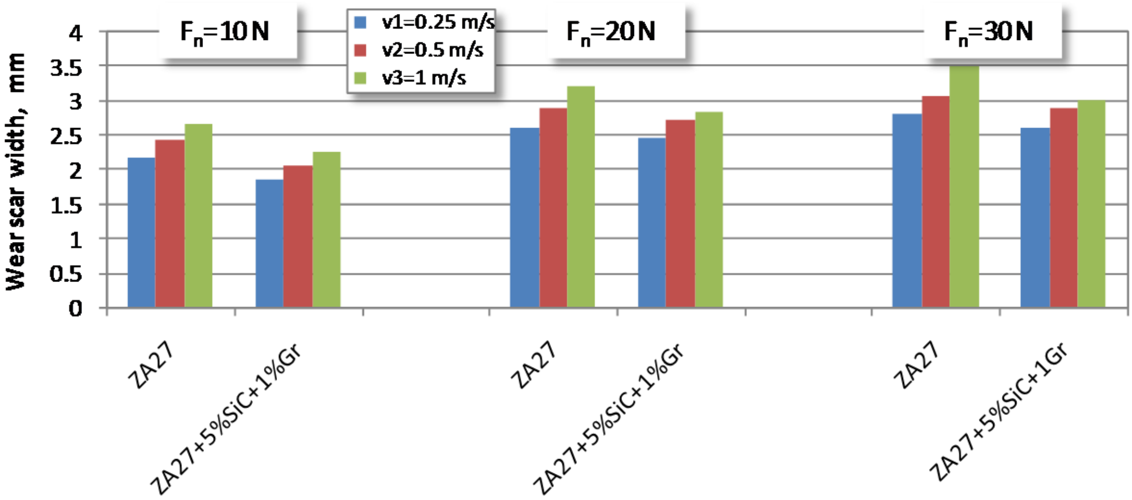


Fig. 8 Comparative histograms of wear scar widths of ZA27+5%SIC+1%Gr composite and ZA27 alloy

4.CONCLUSIONS

This paper presents an attempt to complete the tribological knowledge regarding developed composite materials with the ZA27 substrate alloy reinforced by the SiC and graphite particles. The goal is to further research the possibilities for broader application of the composites as the advanced tribo-materials in technical systems.

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

- Wear process evolution has the same character for both tested materials (basic ZA27 alloy and ZA27+5%SiC+1%Gr composite).
- Wear of the tested composite is smaller than wear of ZA27 alloy for all applied sliding speeds and normal loads.
- Values of the wear scar width of the observed composite increase with the increase of normal loads.
- Wear scar width also increases with the increase of the sliding speed.

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