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WEAR OF ZA27/10SIC/1GR HYBRID COMPOSITE

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Summary: *Metal matrix composites are extensively researched due to their potential advantages over monolithic alloys. The paper presents the wear characteristics of a hybrid composite based on zinc-aluminium ZA27 alloy, reinforced with silicon-carbide (SiC) and graphite (Gr) particles. The tested sample contains 10 vol.% of SiC and 1 vol.% Gr particles. The experiments on the ZA27/SiC/Gr composite were performed on a computer supported tribometer with "block-on-disc" contact geometry under conditions of dry sliding. The paper contains the procedure for preparation of sample composites and presents the microstructure of the composite material and the base ZA27 alloy observed by metallurgy microscope. The wear behaviour of the alloy and the composite were determined under different test conditions, by varying normal loads and sliding speeds.*

Key words: ZA27 alloy, hybrid composite, wear

1. INTRODUCTION

Composite materials are formed by mixing the two or more materials or phases of the same material. The composite has completely new, different and better characteristics in comparison to its constituents.

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 in order to obtain better mechanical and tribological properties [1].

The addition of graphite particles to the ZA27 alloy matrix improves the wear resistance of the composite, despite of significant decrease in hardness [2]. The results of tribological investigations confirm that ZA-27 alloy composites reinforced with SiC particles have reduced wear rate with respect to that of the base ZA-27 alloy in conditions of dry sliding [3, 4].

The use of multiple reinforcements in ZA matrix hybrid composites provides better tribological properties than in composites with single reinforcement. Literature

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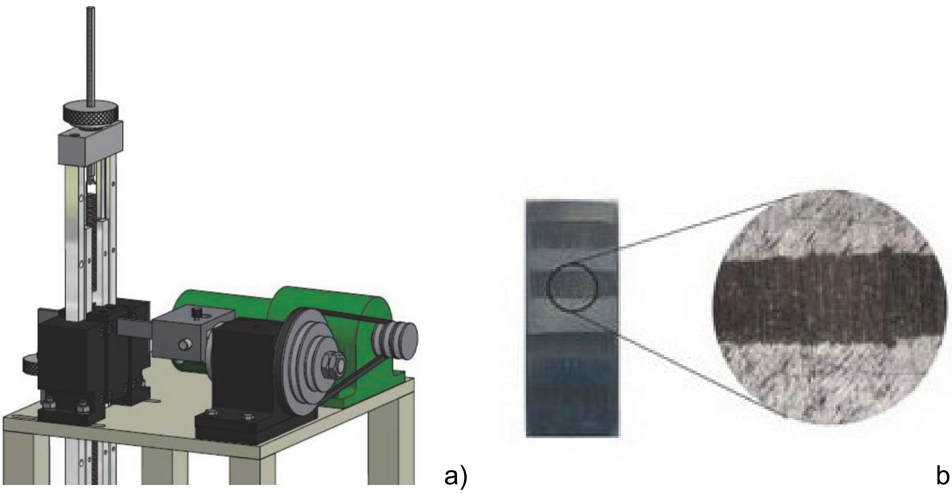
review shows that many researchers have considered partial influences of SiC and Gr reinforcements on the ZA27 alloys, while combined influence of SiC and Gr reinforcements is rarely investigated [5 - 9].

2. EXPERIMENTAL INVESTIGATIONS

The composite material with the ZA27 metal matrix reinforced by 10% SiC and 1% Gr particles (ZA27/10%SiC/1%Gr) was obtained by the compocasting procedure at the Laboratory for materials of Institute of Nuclear Sciences "Vinča". The applied compocasting procedure consisted of two phases. During the first phase, infiltration of the particles from the secondary phases into the semisolid melt of the basic alloy was conducted with constant mechanical blending. Obtained composite casts were then subjected to hot pressing during the second phase. This was done in order to decrease porosity and get better connection between the matrix and the reinforcement particles. At the same time, better mechanical characteristic of the composite material were obtained.

The specimens were tested using a computer aided block-on-disk sliding wear testing machine (Fig. 1) with the contact pair geometry in accordance with ASTM G 77-98 standard.

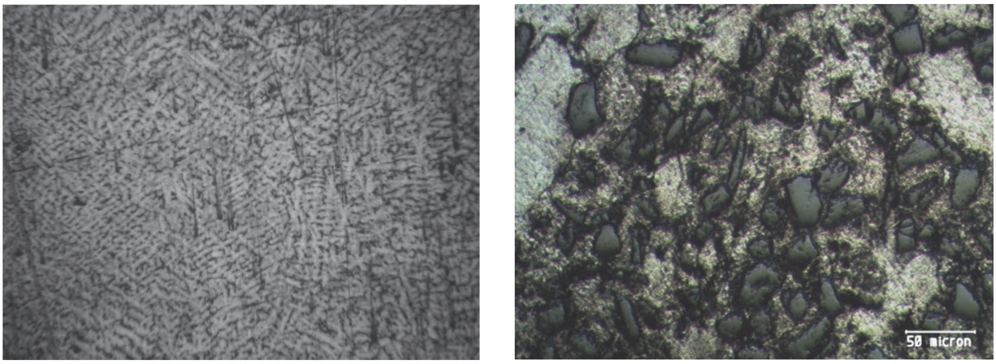


a) b)

Fig. 1 *a)The "block-on-disc" tribometer b) wear scar*

The test blocks were prepared from the composites and as-cast ZA-27 alloy. Their contact surfaces were polished to a roughness level of R_a=0.4 mm. 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) with a sliding distance of 300 m.

Microstructure of ZA27 alloy and hybrid composite were observed by metallurgy microscope and presented in Fig. 2. Structure of the sample of ZA27 alloy is mainly dendrite. Distinct uniformity of the structure was present, which indicates a favourable ratio of mechanical properties of the tested materials. Microstructure of ZA27 alloy is given in Fig. 2a) and of ZA27/10%SiC/1%Gr composite in Fig. 2b)



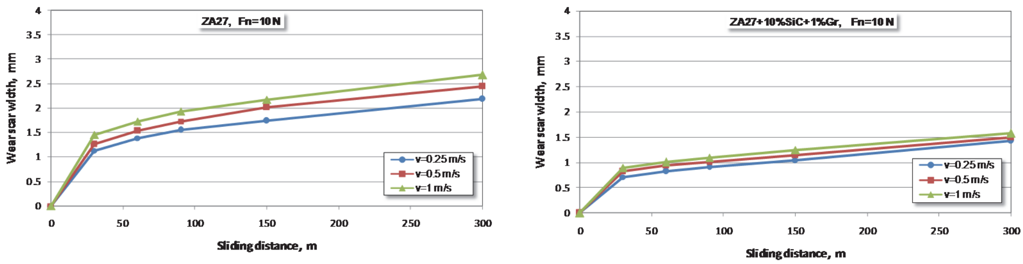
a) b)

Fig. 2 *Microstructure of the sample materials:*
a) base material, ZA27 alloy, b) hybrid composite ZA27/10%SiC/1%Gr

3. RESULTS AND DISCUSSION

The curves of wear scar widths are presented in the paper, depending on 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.



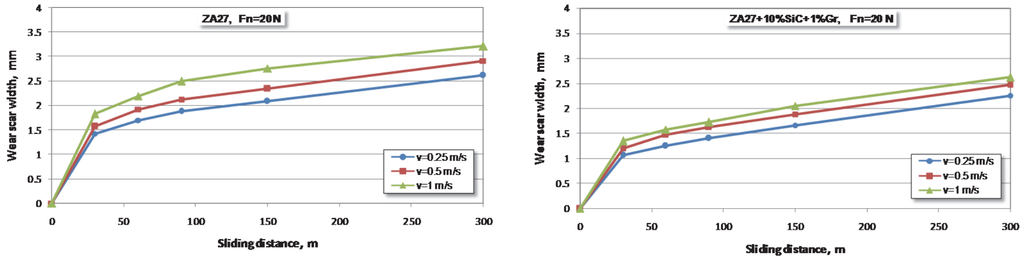
a) b)

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

Generally, the wear behaviour of the tested materials is characterized by very intensive wear during initial period, after which, there is a period of stabilization. Wear of the composites was always significantly lower wear of the matrix ZA-27 alloy.

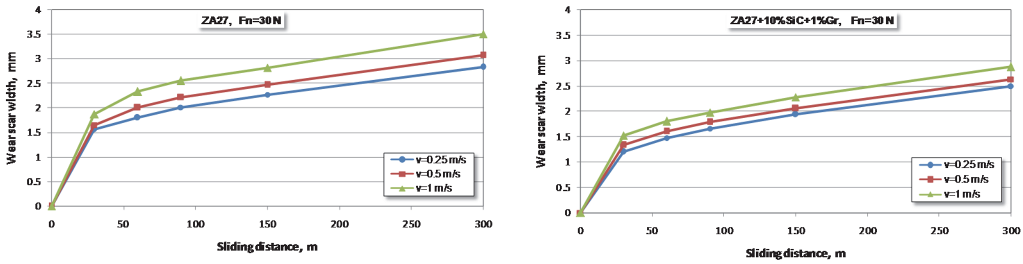
Fig. 4 shows the wear scar widths of the tested materials depending on the sliding distance, as functions of the applied load of F_n=20 N and different sliding speeds.

The curves of wear scar widths of 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. 4 *Wear curves of: a) ZA27 alloy and b) ZA27+10%SIC+1%Gr composite for different sliding speeds and for the applied load of F_n=20 N*



a) b)

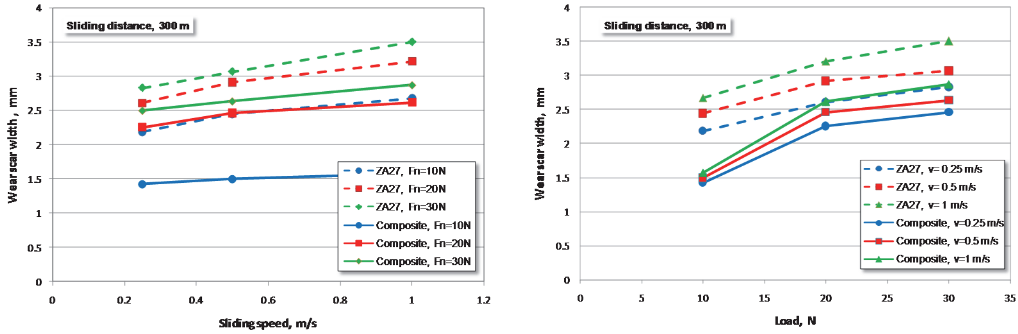
Fig. 5 *Wear curves of: a) ZA27 alloy and b) ZA27+10%SIC+1%Gr composite for different sliding speeds and for the applied load of F_n=30 N*

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. For all given test conditions, wear curves have identical character.

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 Fig. 6. Solid lines on the diagrams refer to the wear scar width of the composite, while the wear scar widths of the ZA27 alloy are denoted by dashed lines.

The effect of normal load and sliding speed on the wear rate of the tested materials at different sliding speeds is presented in Figs. 6. Fig. 6a) shows the influence of the sliding speed on both materials, for different values of normal loads. Fig. 6b) shows the effects of the normal load on wear scar widths on both given composite and alloy, for different values of sliding speeds.

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 typical worn surface of the tested composite material is presented in Fig. 7. Directions of sliding and the corresponding constituents of the composite material are marked in the figure.



a) b)

Fig. 6 *Wear scar widths of ZA27/10%SIC/1%Gr composite and ZA27 alloy for sliding distance of 300 m*
a) depending on sliding speeds, for different contact loads
b) depending on contact loads, for different sliding speeds

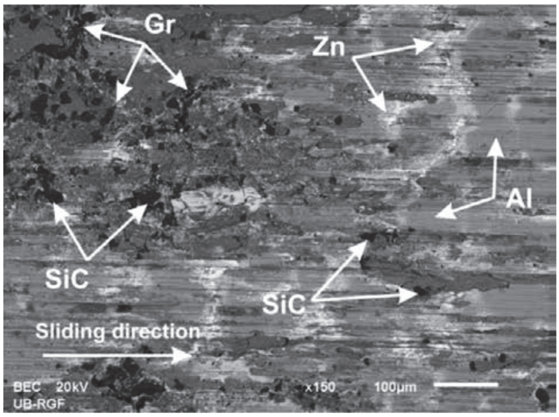


Fig. 7 *SEM micrographs of worn surfaces of the ZA27/10%SiC/1%Gr composite*

From the comparative presentations in Fig. 6, 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. Composite specimens exhibited significantly better wear properties than ZA-27 matrix alloy specimens in almost all combinations of applied loads and sliding speeds. The wear scar width in dry sliding conditions is the biggest for the highest sliding speed.

4. CONCLUSION

Tribological knowledge regarding developed composite materials with the ZA27 substrate alloy reinforced by the SiC and graphite particles may be used for future research of possibilities for broader application of the composites as advanced tribomaterials in technical systems.

Investigations of the wear process by observing the wear scar widths in dry sliding conditions, lead to the following conclusions:

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

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REFERENCES

[1] Prasad, B. K. (2002). Abrasive Wear Characteristics of a Zinc-based Alloy and Zinc-alloy/SiC Composite. *Wear,* vol. 252 no 3-4, p. 250–263.

[2] Sharma, S. C., Girish, B. M., Kramath, R., Satish, B. M. (1998). Graphite Particles Reinforced ZA27 alloy Composite Materials for Journal Bearing Applications. *Wear,* vol. 219, p. 162-168.

[3] Prasad, B. K. (2007). Investigation into Sliding Wear Performance of Zinc based Alloy Reinforced with SiC Particles in Dry and Lubricated Conditions. *Wear,* vol. 262, p. 262-273.

[4] Sharma S. C., Girish B. M., Kramath R. Satish B. M. (1997). Effect of SiC Particle Reinforcement on the Unlubricated Sliding Wear Behaviour of ZA-27 alloy Composites. *Wear,* vol. 213, p. 33-40.

[5] Miloradović, N., Stojanović, B. (2013). Tribological Behaviour of ZA27/10SiC/1Gr Hybrid Composite. *Journal of the Balkan Tribological Association*, vol. 19, no. 1, p. 97-105.

[6] Mitrović, S., Babić, M., Stojanović, B., Miloradović, N., Pantić, M., Džunić, D. (2012). Tribological Potential of Hybrid Composites Based on Zinc and Aluminium Alloys Reinforced with SiC and Graphite Particles. *Tribology in industry*, vol. 34, no. 4, pp. 177-185.

[7] Mitrović, S., Babić, M., Miloradović, N., Bobić, I., Stojanović, B., Džunić, D., Pantić, M. (2014). Wear Characteristics of Hybrid Composites Based on ZA27 Alloy Reinforced With Silicon Carbide and Graphite Particles. *Tribology in Industry*, vol. 36, no. 2, p. 204-210, p. 422-427.

[8] Mitrović, S., Miloradović, N., Babić, M., Bobić, I., Stojanović, B., Džunić, D. (2013). Wear Behaviour of Hybrid ZA27/SIC/Graphite Composites Under Dry Sliding Conditions. *Tribological Journal Bultrib*, vol. 3, no. 1, pp. 142-147.

[9] Babić, M., Mitrović, S., Džunić, D., Jeremić, B., Bobić, I. (2010). Tribological Behaviour of Composites Based on Za27 Alloy Reinforced with Graphite Particles. *Tribology Letters*, vol. 37, no. 2, p. 401-410.