Serbian Tribology Society

SERBIATRIB '13

13th International Conference on Tribology

Faculty of Engineering in Kragujevac

Kragujevac, Serbia, 15 – 17 May 2013

WEAR BEHAVIOUR OF COMPOSITES BASED ON ZA27 ALLOY REINFORCED WITH GRAPHITE PARTICLES

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Abstract: *It is well known that reinforcing the matrix with graphite particles effects on friction properties, while reinforcing the matrix with hard particles (Al_2O_3, SiC, Garnet...) increases wear resistance of the matrix material, in this case ZA27 alloy.Reinforcing the matrix by adding the graphite also effects on mechanical properties of material. In this study authors made an attempt to investigate the effect of small amount of graphite reinforcement on wear behaviour of composites and in order to preserve the mechanical properties of the material. The composites with 1 and 2wt% of graphite particles were produced by compocasting procedure. Wear behaviour of unreinforced ZA27 alloy and composites were studied using, computer aided block-on-disc tribometer, under dry sliding conditions at different sliding speeds (0.25, 0.5 and 1m/s) and normal loads (10N, 30N and 50N). The obtained results revealed that composites exhibited better wear resistance in comparison to unreinforced ZA27 alloy. Better wear properties of composites in comparison to the unreinforced matrix alloy are a result of creation of graphite rich film on the contact surfaces.*

Keywords: *Composite, ZA27, Graphite, Wear.*

1. INTRODUCTION

Due to wide potential applications, composite materials have been investigated very intensively over the recent decades [1]. Metal matrix composites have emerged as an important class of engineering materials because they provide opportunity to manage the material mechanical and tribological properties [2].

Zinc-aluminium (ZA) alloys are important bearing materials, especially suitable for high-load and low-speed applications [3, 4]. ZA alloys are characterized by good tribological and mechanical properties, low weight excellent foundry castability and fluidity, good machining properties, low initial cost, and environmentally friendly technology. However, major limitations of ZA alloys are its inferior mechanical and wear properties on elevated properties. Also, this alloy exhibits dimensional instability at temperatures above 120°C [5].

Various authors have reported that the incorporation of hard particles (SiC, Al_2O_3, zircon, garnet and glass) [6-17] improves wear resistance of base alloy. Also, many researchers have reported that MMCs reinforced with graphite particles exhibits low friction and low wear rate, and suggested that such behaviour is the result of self-lubricating graphite-rich film formation on the contact surface [4, 18-20]. Mechanical properties of ZA27 alloy graphite reinforced are significantly changed by varying the amount of graphite [21]. The increase of the graphite content within the ZA27 matrix results in increase of ductility, compressive strength, corrosion resistance, but in a decrease of hardness. In spite of the significant decrease in hardness, tribological tests showed that addition of graphite particles to ZA27 alloy matrix improved wear resistance of composites [22].

Based on presented literature review small amount of graphite will not degrade mechanical properties so An attempt has been made to evaluate the drysliding wear behaviour of the ZA-27/graphite composites over a range of applied loads and slidingspeeds. The unreinforced ZA-27 alloy was tested as a referencematerial.The role of graphite in dry was discussed.

2. EXPERIMENTAL TESTING

2.1 Material

The ZA-27 alloy (27.5% Al, 2.5% Cu, 0.012% Mg, and balance Zn) was used as the base matrix alloy. The graphite particles of mean size 30 μm were used as the reinforcement. The percentage of graphite was 1 and 2 by weight. The composite specimens were obtained by the compocasting procedure, which was executed by mixing in the isothermal regime.More detailed process of the compocating procedure could be found elsewhere [4].

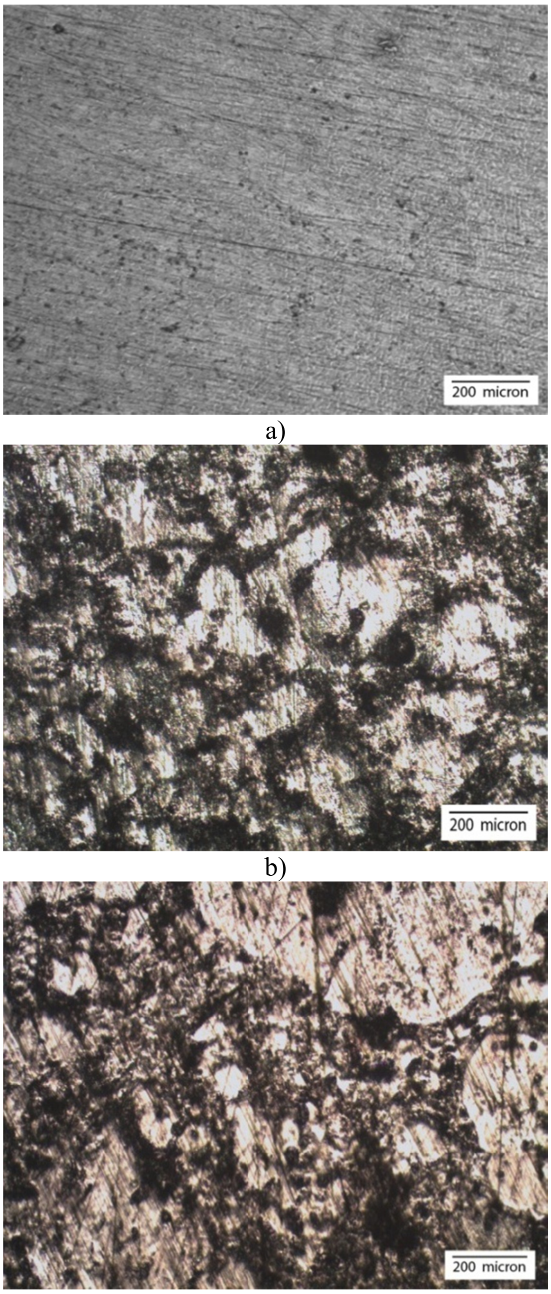


Figure 1. Optical microscopy of tested specimens: a) unreinforced matrix alloy ZA27; b) composite with 1 wt% of graphite particles; c) composite with 2 wt% of graphite particles

After obtaining the composite materials samples, it was necessary to perform the hot pressing to reduce porosity. The samples (blocks) for the tribological investigations were then made from the ZA-27 as-cast alloy and pressed pieces.

Microstructural characterization of the alloys was carriedout using the optical microscopy on samples, similar tothose used for wear testing. The typical OM micrographs ofthe matrix alloy and composite are shown in Fig. 1.

Bulk hardness of all the samples was measured using a Brinell hardness tester with a 2.5-mm diameter steel ballindenter and at an applied load of 625 N. The load application time was 60 s. The mean values of at least fivemeasurements, conducted in different areas of each sample, show that the composite attained lower hardness (115 HB) than that of the matrix ZA-27 alloy (124 HB). Hardness of the matrix alloy was 124HB, while hardness for composites reinforced with 1 wt% and 2 wt% of graphite particles were 119 HB and 115 HB, respectively. In his investigation of mechanical properties of the cast ZA-27/ graphite particulate composites Seah found that with graphite content increase hardness monotonically decreases significantly [23]. In fact, as the graphite content is increased from 0 to 5% the hardness decreases for about 27%.

2.2 Wear tests

Samples for tribological testing were made by cutting. Cutting was realised by machine saw with intensive cooling in order to avoid changes of surface layers, due to high temperature.

Wear test were carried out in a computer aided block-on-disk sliding wear testing machine with the contact pair geometry in accordance with ASTM G 77–05. More detailed description of the tribometer is available elsewhere [4].

The test blocks (6.35x15.75x10.16 mm) were prepared from ZA27 unreinforced alloy and from composite with 1% and 2% of graphite particles. All samples prior to wear testare polished. The counter face (disc of 35 mm diameter and 6.35 mm thickness) was made of EN: HS 18-1-1-5 tool steel of 62HRC hardness. The tests were performed under dry sliding conditions at different sliding speeds (0.25 m/s, 0.5 m/s, 1 m/s) and applied loads (10 N, 30 N, 50 N). The duration of sliding was 10 min. Each experiment was repeated five times.

The tests were performed at room temperature. The wear behavior of the block was monitored in terms of the wear scar width (Figure 2). Using the wear scar width and geometry of the contact pair the wear volume (expressed in mm^3) was calculated.

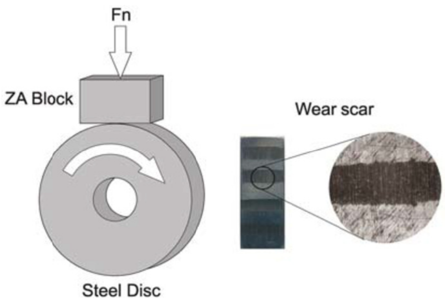
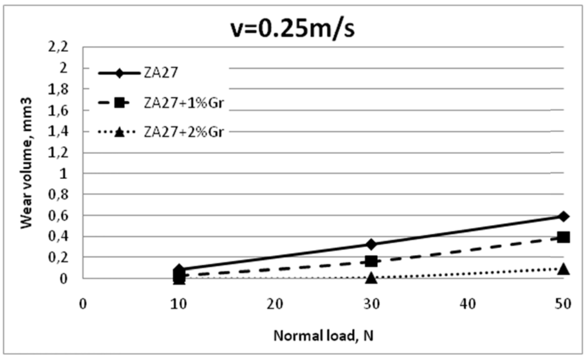


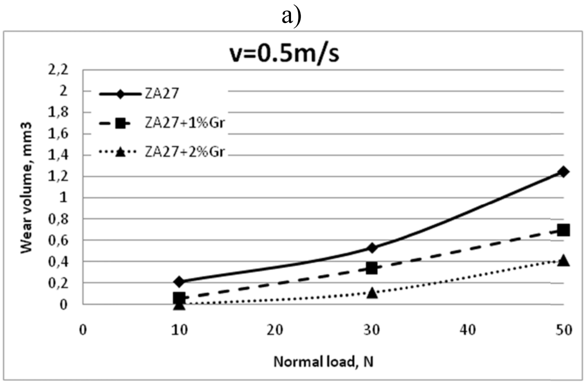
Figure 2. The scheme of contact pair geometry

3. RESULTS AND DISCUSSION

Wear volume of tested ZA27/graphite composites, as well as unreinforced ZA27 alloy, as a function of sliding speed and normal load in dry sliding conditions is illustrated on figures presented down below.



a)



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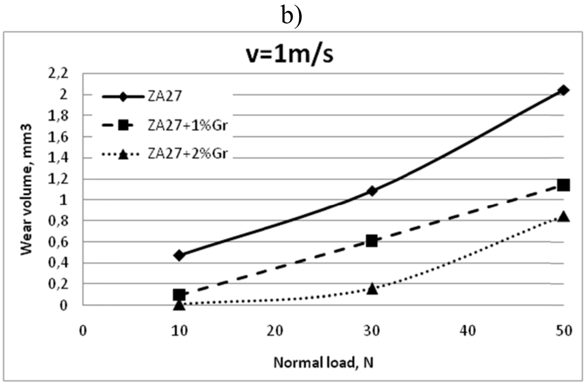
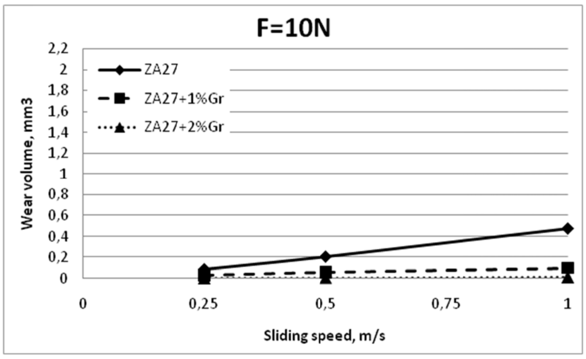


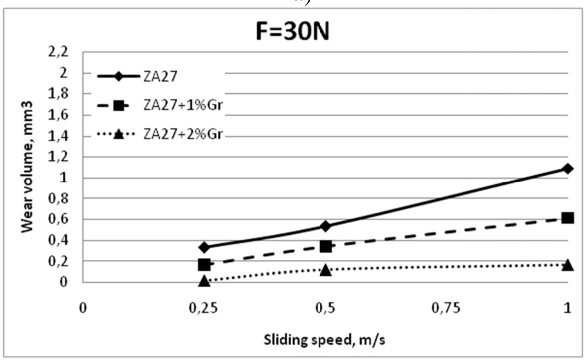
c)

Figure 3. Wear volume of tested samples versus normal load for different sliding speeds in dry sliding conditions

The effect of normal load on wear volume of tested composites, as well as the matrix alloy specimens at different values of applied normal load is presented on Fig.3. Presented plots suggest that wear volume of all tested samples increases with normal load increase, at all values of sliding speed. Increase in wear volume with increasing of normal load is more pronounced at higher sliding speed (1 m/s), as could be clearly seen if we compare plots on Fig. 3a with plots on Fig. 3c. This phenomenon is more pronounced for unreinforced matrix alloy. According to Seah et al. [24] wear rate increases monotonically with normal load increase.



a)



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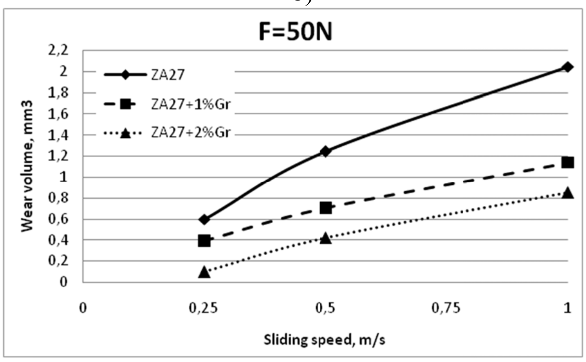
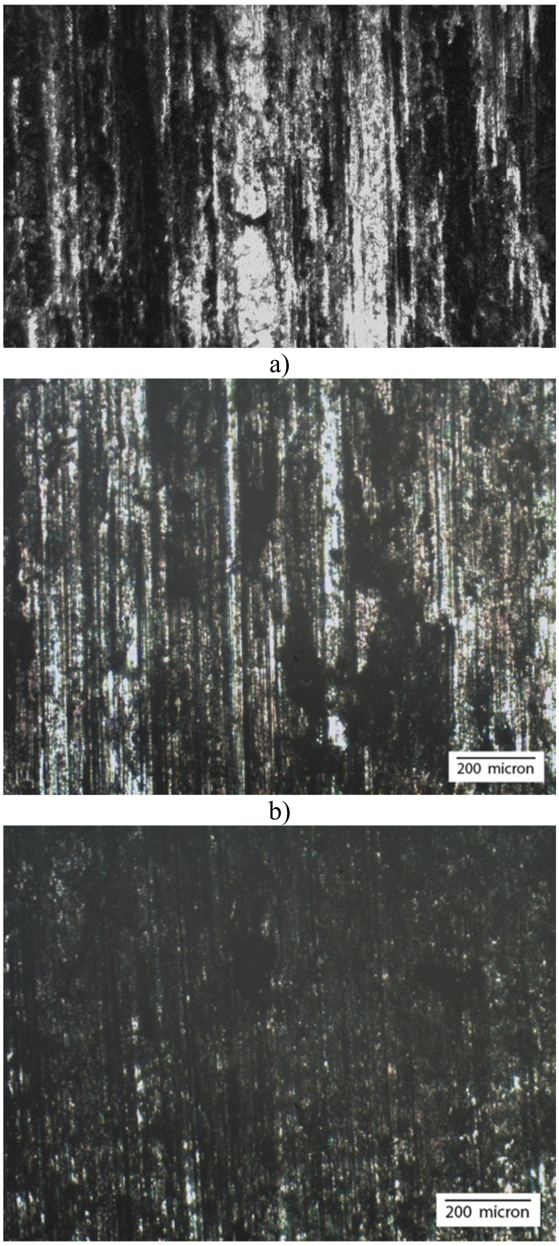


c)

Figure 4. Wear volume of tested samples versus sliding speed under different applied normal loads in dry sliding conditions

The influence of sliding speed on wear volume of tested composites, as well as matrix alloy specimens at constant values of applied normal load is presented on Fig. 4. From presented plots it could be clearly seen that with increase of sliding speed wear volume of all tested specimens increases. Wear volume increase is more pronounced at applied load of 50N, and for unreinforced matrix alloy in comparison to the composites. Also, on the figure 3a it could be seen that the wear of the composite with 2 wt% of graphite is almost negligible under applied load of 10N.

Seah et al. [24] have confirmed that the wear rate of as-cast ZA-27/graphite particulate decreases monotonically with an increase in sliding speed, but in our case it is inversely because of different contact geometry.



a)

b)

c)

Figure 5. Wear scars of tested specimens: a) unreinforced matrix alloy; b) and c) composites with 1 and 2 wt% of graphite particles, respectively.

Figure 5 presents wear scars of all tested specimens Based on the wear scars it could be concluded that the dominant wear mechanism was abrasive wear, because of this parallel tracks within the wear scars of all tested materials. One can clearly notice that on the worn surface the black graphite film is smeared and it covers the large portion of the contact surface. Presence of the graphite film in contact zone reduces the metal-to-metal contact between the sliding pairs.

Many researchers have reported that during dry sliding, themetal/graphite composites tribo-influenced the graphitefilm forming on the contact surface of elements [18–20], whichacts as solid lubricant that reduces metal-to-metal contactbetween the sliding surfaces. The formation of graphiterichlubricant film between the sliding surfaces has beenexplained as a result of the soft second phase (graphite)squeezing-out from the subsurface toward the mating surfacedue to extensive plastic deformation [18].

4. CONCLUSION

Based on the results presented in this paper it could be concluded:

- Generally wear volume of the composites are lesser in comparison to the unreinforced matrix alloy.
- Higher content of graphite particles within the matrix alloy results in higher wear resistance of material, composite with 2 wt% of graphite particles has lesser values of wear volumes in comparison to the composite with 1wt% of graphite particles, under the same contact conditions.
- Wear volume of all tested specimens increases with sliding speed and normal load increase.
- Higher wear resistance of ZA27/graphite composites in comparison to the unreinforced matrix alloy is a result of graphite film forming on the surface of contact elements.

ACKNOWLEDGEMENT

The study was financed by Ministry of Education, Science and Technological Development, Serbia, project No.35021.

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