Balkan Tribological Association

Serbian Tribology Society

University of Belgrade, Faculty of Mechanical Engineering

10th International Conference on Tribology – BALKANTRIB '20
Belgrade, Serbia, 20 – 22 May 2021

TRIBOLOGICAL INVESTIGATION OF ZA-27 ALLOY BASED MICRO/NANO MIXED COMPOSITES

Dragan DŽUNIĆ[1,*], Slobodan MITROVIĆ[1], Darko PEŠIĆ[1], Vladimir KOČOVIĆ[1], Marko PANTIĆ[2], Aleksandra KOKIĆ ARSIĆ[2]

[1]University of Kragujevac, Faculty of Engineering, Kragujevac, Serbia
[2]Kosovo and Metohija Academy of Applied Studies, Zvečan, Serbia
*Corresponding author: dzuna@kg.ac.rs

Mixed micro/nano ZA-27 based composites were obtained by compocasting technique. Structural, mechanical and tribological properties were investigated. Structural and mechanical tests indicated on presence of structural irregularities in form of non-uniform distribution of reinforcement and their agglomeration as well. Despite deterioration of structural and mechanical properties in comparison to the pure base ZA-27 alloy, tribological tests were positive, due to absence of material transfer that occurs during counter-body steel ball against the base alloy. Material transfer from the ZA-27 alloy to the steel ball surface results in higher values of coefficient of friction and wear rates in comparison to the tested composites.

Keywords: *ZA-27 alloy, mixed micro/nano composites, wear, friction, material transfer.*

1. INTRODUCTION

In the last few decades composites are the one most attractive method for material improvement, in mechanical and tribological manner. ZA-27 alloy has been already known as tribological alloy suitable for various types of reinforcements, SiC [1], Al_2O_3 [2], zircon, garnet and graphite. With addition of mentioned reinforcements ZA-27 properties drastically changes, spreading their application as light-weight alloy.

Based on the positive results obtained from mechanical and tribological testing of ZA-27 and Al alloys reinforced with micro particles, next phase of investigation was their reinforcement with nano particles. In the case of nano reinforcement two main problems occurred: non-uniform distribution of ceramic reinforcing particles and agglomeration and clustering of nanoparticles [3]. Those problems were especially related in composites obtained by compocasting technique without any prior preparation of reinforcement.

In order to overcome structural irregularities in nanocomposites, an attempt to micro particles along with nano particles was made, an attempt to use addition of micro particles to solve previously mentioned problems in nanocomposites. Mixed micro/nano composites were obtained by compocasting technique and prepared for structural, mechanical and tribological investigation.

2. MATERIAL

Investigated materials were obtained by compocasting technique. Nano Al_2O_3 and micro SiC particles were used as reinforcement, with average size of 20 – 30 nm and 40 µm, respectively. For these tests four different materials were prepared with the following composition: base ZA-27 alloy as a referent material, nanocomposite ZA-27 + 0.5 vol. % Al_2O_3, mixed nano/micro composites ZA-27 + 0.5 vol. % Al_2O_3 + 3 wt. % SiC and ZA-27 + 0.5 vol. % Al_2O_3 + 5 wt. % SiC.

3. EXPERIMENT

Structural, mechanical and tribological test were performed on previously prepared samples that were grinded and polished. Structural test were performed using Phenom SEM with EDS, which is used for wear track characterization as well. Density measurement was performed in order to obtain information related to structural irregularities, such as agglomeration and porosity witch is very common in nanocomposites (Fig. 1).

Tribological test were performed using ball-on-plate CSM nanotribometer in rotational motion. Normal force was maintained constant (800 mN) and sliding speed (20 mm/s) as well. For each material three samples were prepared and on each sample test were performed three times with different sliding radius 2, 2.5 and 3 mm.

4. RESULTS AND DISCUSSION

Density (Fig. 1) of obtained composites is lower than base ZA-27 alloy as a result of the structural irregularities within the material volume.

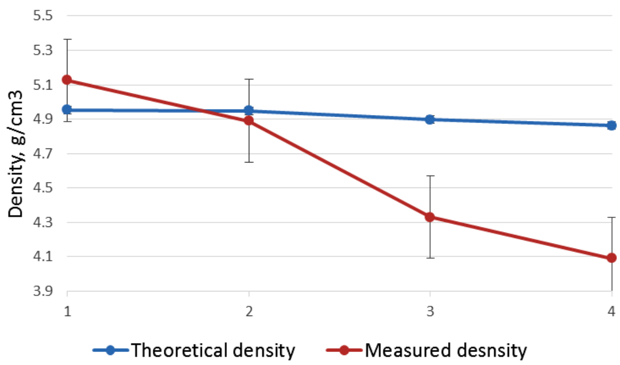

Figure 1. Theoretical and measured density

Measured coefficient of friction (Fig. 2) of composites is much lower than base ZA-27 alloy, due to absence of material transfer to the counter-body steel ball. In the case of material transfer, there is only one material in the contact zone, ZA-27 alloy, since the significant amount of it is firmly attached to the counter-body surface. Also, due to material transfer wear of ZA-27 alloy is much higher than wear of tested composites (Fig. 3).

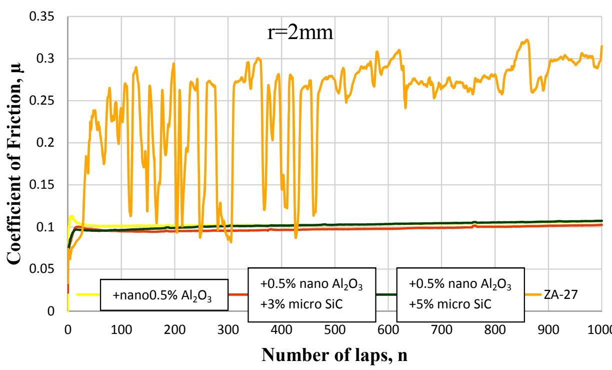

Figure 2. Coefficient of friction for tested materials, averaged values for radius *r* = 2 mm

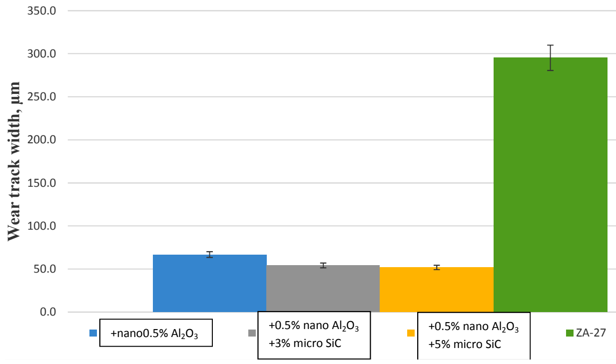

Figure 3. Wear track width, averaged values for radius *r* = 2 mm

5. CONCLUSIONS

Structural analysis of obtained nano and mixed nano/micro composites indicates on presence of structural irregularities such agglomeration and porosity as a result of trapped air bubbles within the material. Structural irregularities results in deterioration of mechanical properties density and hardness. Porosity level increases with increase of reinforcement content, no matter nano or micro particles.

Despite of structural irregularities, obtained composites performed better tribological properties in comparison to the base ZA-27 alloy, due to absence of material transfer on the counter-body surface that occurs in each ZA-27 tribological test.

ACKNOWLEDGEMENT

The results of this paper are realized through the national project TR-35021 supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

REFERENCES

[1] S.C. Sharma, B.M. Girish, R. Kamath, B.M. Satish: Effect of SiC particle reinforcement on the unlubricated sliding wear behaviour of ZA-27 alloy composites, Wear, Vol. 213, No. 1-2, pp. 33-40, 1997.

[2] O.P. Modi, R.P. Yadav, D.P. Mondal, R. Dasgupta, S. Das, A.H. Yegneswaran: Abrasive wear behaviour of zinc-aluminium alloy – 10% Al_2O_3 composite through factorial design of experiment, Journal of Materials Science, Vol. 36, No. 7, pp. 1601-1607, 2001.

[3] M. Babic, B. Stojanovic, D. Dzunic, M. Pantic: Micro/nanoscale structural, mechanical and tribological characterization of ZA-27/SiC nanocomposites, Journal of Composite Materials, Vol. 54, No. 16, pp. 2113-2129, 2020.