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THE INFLUENCE OF LUBRICANT ON FRICTION COEFFICIENT OF HYBRID AL-SIC-GR COMPOSITES

Miroslav BABIĆ, Blaža STOJANOVIĆ, Slobodan MITROVIĆ, Ilija BOBIĆ, Nenad MILORADOVIĆ, Marko PANTIĆ

Abstract: *In the paper were shown the test results of tribological characteristics of hybrid composites with alloy base A356 reinforced by SiC and graphite. Hybrid composites are obtained by compo casting procedure. Tribological tests are realized on tribometer with block on disc compact pair in Tribological Center of Faculty of Engineering in Kragujevac. The tests were done for different normal load values, sliding speeds, sliding distance, with and without lubrication. Hybrid composite with 10% SiC and 1% graphite was used as a material. The main parameter analyzed in the paper is coefficient of friction obtained in the conditions with and without lubrication.*

Key Words: *Hybrid composites, coefficient of friction, tribometer, wear, friction.*

1.INTRODUCTION

Composite materials are made by unifying two or more different materials. Initial materials have mutually different properties, and their compound gives completely new material. It has unique, completely new and different features in comparison to components. The aim is to improve structural, tribological, thermal, chemical, and some other characteristics of individual material. Components do not mix with each other or dissolve so that two or more phases are clearly differed inside the composite [1,2].

Essentially, components are made of the base (matrix), whose content is significantly higher in comparison to other materials and reinforcement i.e. material by adding of which the desired features of composites are obtained.

When talking about composites with metal matrix, aluminum and its alloys are mostly used as a base. Aluminum and its alloys may accept various reinforcements and improvers. Aluminum composites have a number of positive features such as: small density, good thermal conductivity, and corrosion resistance. However, aluminum alloys have a certain disadvantages, as well, in form of higher coefficient of thermal expansion and inadequate tribological characteristic. The increase of stiffness, hardness, resistance to fatigue, as well as improvement of tribological characteristics is achieved by adding certain reinforcements and improvers and by forming aluminum composites. SiC, Al_2O_3, and graphiteare mostly used as reinforcements [3-11].

The influence of SiC, Al_2O_3, and graphite on tribological and mechanical characteristics is different. By increasing weight or volume percent of SiC and Al_2O_3, mechanical characteristics are improving, and by increasing weight or volume percent of graphite, thibological characteristics of composites are improving. Optimal values of tribological and mechanical characteristics of material are obtained by combining certain percent of these two materials [12-26].

2.PROCEDURE OF OBTAINING HYBRID COMPOSITES

Sub-eutectic Al-Si alloy EN AlSi7Mg0,3 (A356 alloy) of chemical composition (given in Table 1) is used as a base for obtaining composites.

Table 1. Chemical composition of (weight %) A356 alloy

Element	**Si**	**Cu**	**Mg**	**Mn**	**Fe**	**Zn**	**Ni**	**Ti**	**Al**
Percentage	7,20	0,02	0,29	0,01	0,18	0,01	0,02	0,11	residue

A356 alloy is aluminum alloy with silicon with addition of small amount of magnesium, intended for casting. It is widely applied in automotive and aviation industry. It is characterized as excellent castability and corrosion resistance. Its mechanical characteristics are significantly improved by heat treatment, especially by T6 regime of heat treatment.

Considering given task and chosen technological procedure of obtaining composites in Laboratory for materials of Institute of Nuclear Sciences "Vinča", hybrid composites with aluminum matrix of A356 alloy and reinforcements SiC and graphite are developed.

The composites are obtained by compo-casting procedure (infiltration of reinforcement particles in semi-solidified cast of A356 alloy) and by applying laboratory equipment, consisting of processing part and part for measuring and regulating temperature. Ceramic pot is made of alumina with multiple layers [11,21,22].

3.TRIBOLOGICAL TESTS

Tribological characteristics tests of hybrid composites with aluminum base are of model type and are done on advanced and computer supported tribometer with block-on-disc contact geometry in Tribology Center of Faculty of Engineering in Kragujevac.

Tribometer provides variation of contact conditions in terms of shape, dimension and material of contact elements, normal contact load and sliding speed (Figure 1). The tests may be done in conditions with lubrication and without lubrication [1,2,4,5].

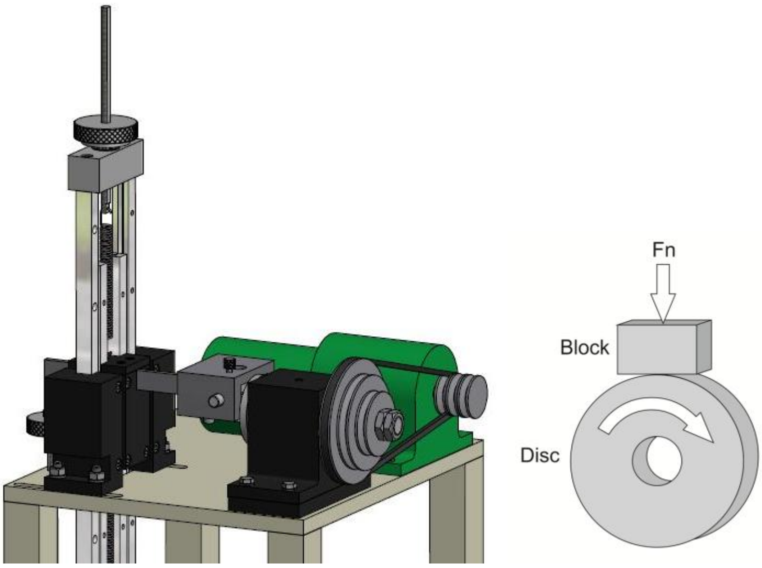

Fig. 1.Tribometer with block-on-disc contact pair

Tribological characteristics tests of hybrid composites is done on tribometer with block-on-disc contact pair for different normal loads, sliding speeds, sliding distance with and without lubrication. Namely, plan of tribological tests is based on variation of three different normal loads from 10 N, 20 N, and 30 N, three different speeds from 0.25 m/s, 0.5 m/s, and 1 m/s. Thereby, the measuring of coefficient of friction and broadness of wear track is being done for different sliding distances (30, 60, 90, 150, 300, 600, and 900m) without lubrication.

When it comes to lubrication, the tests are also done for three different loads (40 N, 80N, and 120N) and three sliding speeds (0.25 m/s, 0.5 m/s, and 1 m/s). Determining coefficient of friction and broadness of wear track is done for the crossed distance from 1200 m and 2400 m.

Hydraulic oil of HL type with advanced characteristics against wear, viscosity VG46 is used for lubrication. The lubrication of contact pair is realized by immersing the lower part of the disc up to the depth of 3 mm into the reservoir with oil of volume 30 ml, and at rotation it continually brings oil into the contact zone and it is doing the border lubrication of contact pair.

Tested contact pair meets demands of ASTM G 95 standard. Contact pair comprises rotating disc of diameter D_d=35 mm and broadness b_d=6.35 mm and stationary block of broadness b_b=6.35 mm, length l_b=15.75 mm, and height h_b=10.16 mm. The discs are made of steel 90MnCrV8 with hardness 62 – 64 HRC with grinded surfaces, roughness Ra=0.40 μm, and blocks of tested hybrid composite material A356-10SiC-1Gr.

4.RESULTS OF TRIBOLOGICAL TESTS

Tribological tests of hybrid composites with Al base is done for sample with 1% of graphite and 10% of SiC, as a comparative material is used A356 alloy.

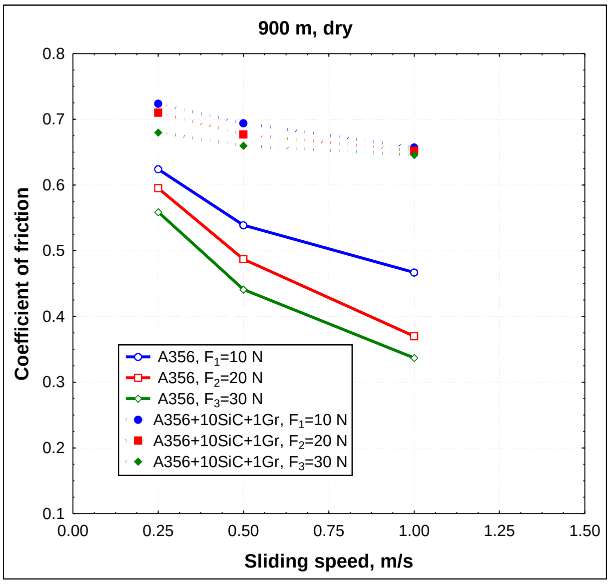

Fig. 2. Coefficient of friction dependence of sliding speed for different normal load valuess in conditions of dry friction

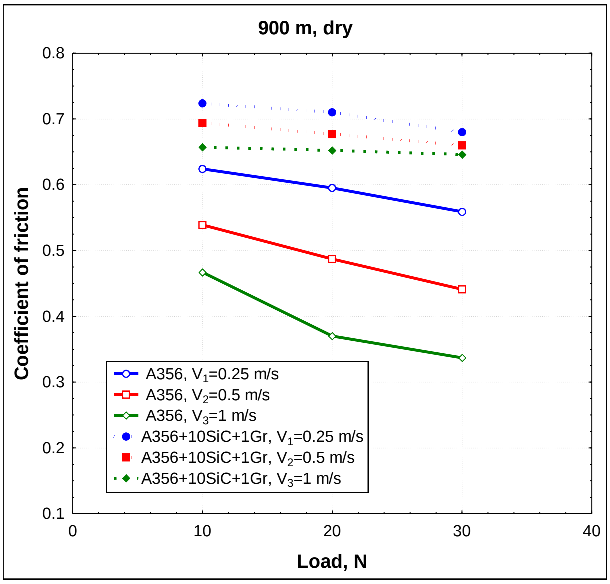

Fig. 3. Coefficient of friction dependence of load for different sliding speeds in conditions of dry friction

Figure 2 shows coefficient of friction dependence of sliding speed for all three loads. Figure 3 shows coefficient of friction dependence of load for all three sliding speeds (0.25 m/s, 0.5 m/s и 1 m/s). The results in Figs. 2 and 3 are obtained in condition of dry friction for sliding distance of 900 m.

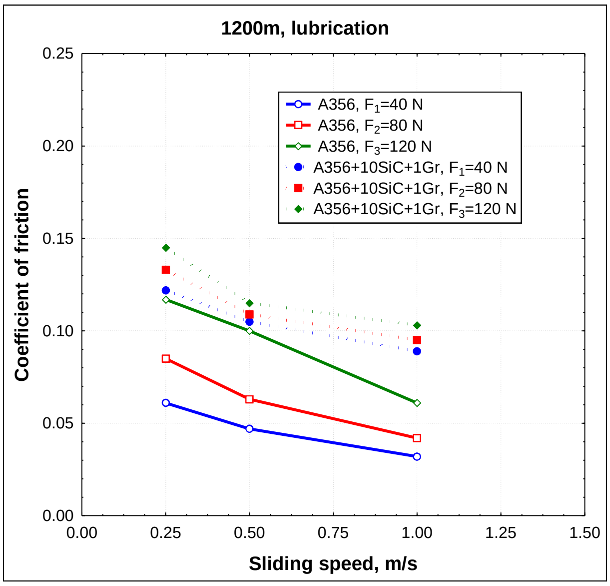

Fig. 4. Coefficient of friction dependence of sliding speed for different normal load values with lubrication

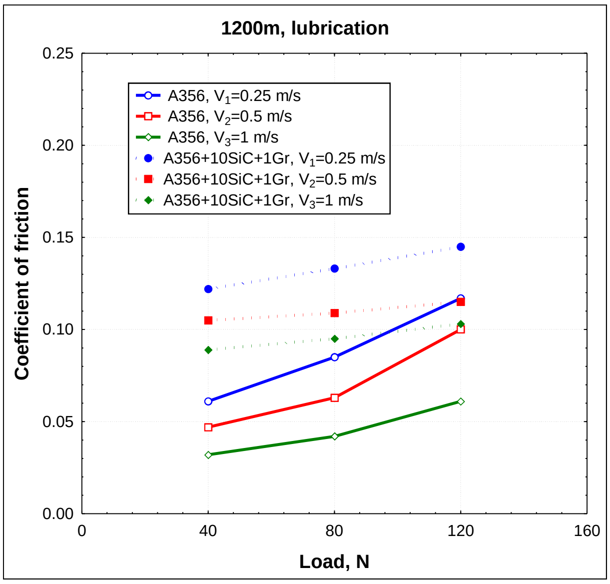

Fig. 5. Coefficient of friction dependence of load for different sliding speeds with lubrication

Figure 4 and 5 show coefficient of friction dependence of sliding speed and load. Loads vary from 40 N, 80 N and 120 N for three sliding speeds (0.25 m/s, 0.5 m/s и 1 m/s), sliding distance of 1200 m in conditions of lubrication.

5. ANALYSES OF OBTAINED RESULTS

Figure 6 and 7 at the same time show obtained values of coefficient of friction depending on sliding speed and load. Figure 6 shows the change of coefficient of friction in conditions without lubrication and Figure 7 in case with lubrication.

In case of dry friction (without lubrication) coefficient of friction decreases with increase of sliding speed. The highest values of coefficient of friction are at lowest loads of 10 N, while with increase of load, coefficient of friction decreases. The values of coefficient of friction for dry friction A356+10SiC+1Gr of hybrid composites are within the boundaries of 0.64÷0.72 (Fig. 6) [11,22,23,24], and the values are higher than the friction coefficient of base material A356 alloy.

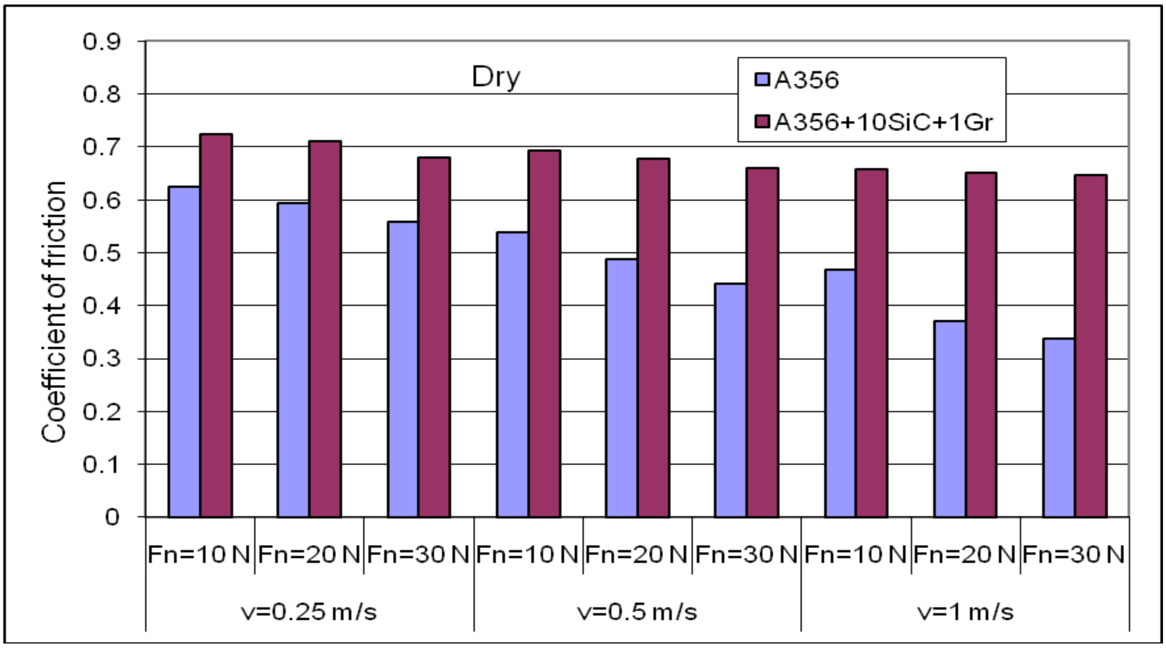

Fig. 6. Histogram representation of friction coefficient two tested materials (A356 and A356+10SiC+1Gr) for different normal load values (10N, 20N, 30N) with dry

Coefficient of friction decreases with increase of sliding speed in conditions with lubrication of contact pairs. At the same time with increase of load, coefficient of friction increases. Coefficient of friction of hybrid composites A356+10SiC+1Gr in condition with lubrication is 0.085÷0.145 (Fig. 7), and the values are higher than the friction coefficient of base material A356 alloy.

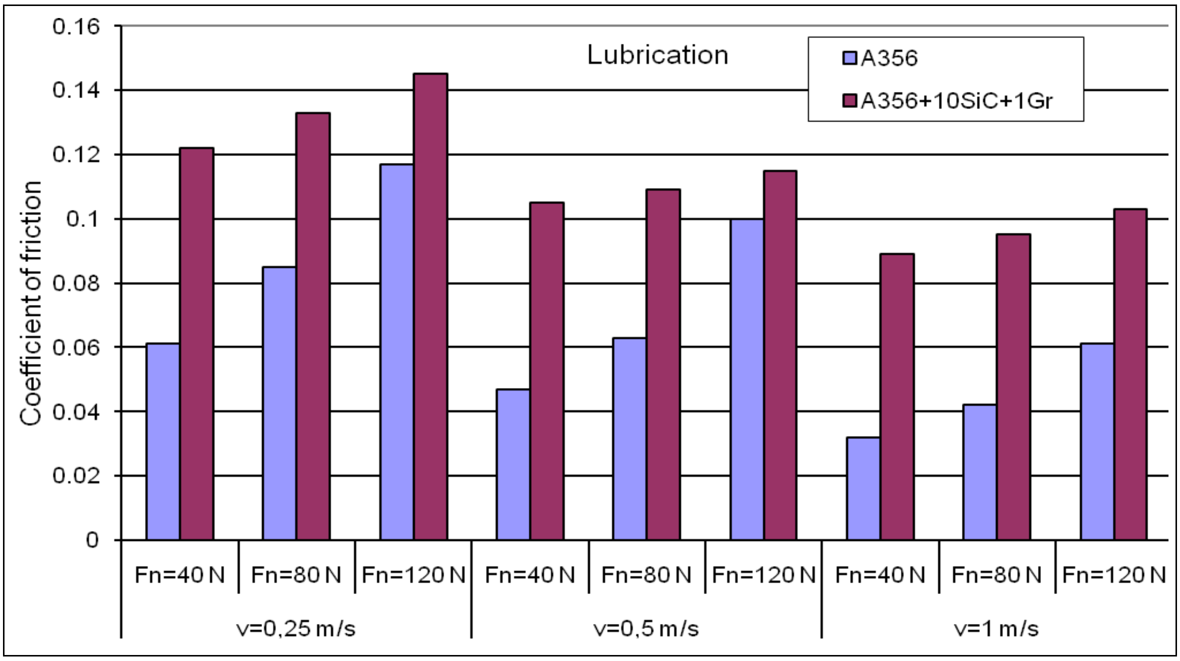

Fig. 7. Histogram representation of friction coefficient two tested materials (A356 and A356+10SiC+1Gr) for different normal load values (40N, 80N, 120N) with lubrication

Al-SiC-Gr hybrid composites are very much used in automotive industry. When composites are used for manufacture of braking discs, obtained values of coefficient of friction μ~0.7 are excellent, considering sliding distance and used materials.

However, if hybrid aluminum composites are used for manufacture of motor parts, pistons, cylinders or cardan shaft, then the use of lubrication is necessary.

6. CONCLUSION

Tests of friction characteristics of hybrid composites A356+10%SiC+1%Gr without lubrication show that:

- Hybrid aluminum composite in condition of dry friction has very high and pretty constant friction coefficient (μ~0.7).
- Due to presence of SiC, friction coefficient of hybrid aluminum composite is higher than the friction coefficient of base material.
- The changes of coefficient of friction are small with change of load and sliding speed.
- Coefficient of friction decreases with increase of load.
- Coefficient of friction decreases as well with increase of sliding speed.
- Decrease of coefficient of friction with increase of speed and load is conditioned by presence of graphite in contact.

Tribological characteristics of hybrid composite in conditions with lubrication show following:

- Coefficient of friction decreases with increase of sliding speed.
- The presence of SiC leading to an increase friction coefficient of hybrid composites as compared with the base material.
- Coefficient of friction increases with increase of load.
- The values of coefficient of friction are 5÷8 times lower values than in case of dry friction.
- Temperature in the contact is much lower.
- Intensity and size of wear are 3÷5 lower than without lubrication.
- Sliding distance increases with decrease of wear at the same time.

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CORRESPONDENCE

BABIĆ MIROSLAV
Faculty of Engineering, University of Kragujevac, Sestre Janjić 6, 34000 Kragujevac, Serbia
e-mail: babic@kg.ac.rs

STOJANOVIĆ BLAŽA
Faculty of Engineering, University of Kragujevac, Sestre Janjić 6, 34000 Kragujevac, Serbia
e-mail: blaza@kg.ac.rs

MITROVIĆ SLOBODAN
Faculty of Engineering, University of Kragujevac, Sestre Janjić 6, 34000 Kragujevac, Serbia
e-mail: boban@kg.ac.rs

BOBIĆ ILIJA
Institute of Nuclear Sciences “Vinca”, University of Belgrade, PO Box 522, 11001 Belgrade,Serbia
e-mail: ilijab@vinca.rs

MILORADOVIĆ NENAD
Faculty of Engineering, University of Kragujevac, Sestre Janjić 6, 34000 Kragujevac, Serbia
e-mail: mnenad@kg.ac.rs

PANTIĆ MARKO
Faculty of Engineering, University of Kragujevac, Sestre Janjić 6, 34000 Kragujevac, Serbia
e-mail: pantic@kg.ac.rs