THE EFFECT OF WEAR TEST PARAMETERS ON TRIBOLOGICAL CHARACTERISTICS OF ALUMINUM BASED COMPOSITES

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Abstract: *In this paper we examined the effect of contact pressure (applied load) and relative speed in braking points on the coefficient of friction and wear of aluminum composites, sintered at 620°C for one hour in hydrogen atmosphere and after that solution treated at 515±5o C for 6 hours, quenched in water and artificial aging at 170° C for respectively 8 and 4 hours. The obtained values of tribological characteristics for studied composites (Al-4Cu/10% and Al-4Cu/15% SiC)compared with Al-4Cu alloy material and with another import sintered friction material, tested under the same conditions, shows that if the applied load increases, wear increases for all materials and friction coefficient decreases. It is noted that we obtained the lowest wear for Al-4Cu/10% SiC material, tested with a load of 0.35 MPa at a speed of 3.8 m/s, and the highest values of wear we are recorded for unreinforced aluminum alloy. The measured fiction coefficient values are in the range of 0.4-0.5 for composite materials and the same friction coefficient values for the imported material and for unreiinforced aluminum alloy has a tendency of gripping.*

Keywords*: sintered friction material, aluminum-based composites, tribological characteristics*

1. INTRODUCTION

The first friction material used in automotive industry was based on synthetic resins reinforced with oxides and asbestos as frictional material, graphite, lead and other elements as lubricant components. After development of researches in the field, they produced an improved frictional material with metallic matrix from cast iron or copperby classical metallurgy. The frictional materials with resin as based material presented the following disadvantages: have low operating temperatures 250-280°C respectively 370-400°C [1,3] and also had toxic elements in composition (lead, asbestos, etc.) and for that reasons were replaced with copper or cast iron based ones. These metallic based composites for braking pads are advantageous because worked safely at higher temperatures of 500-700°C and at a speed of 20-40 m/s, but them present the tendency of gripping and welding at high temperatures of the frictional material, intensive wear and low coefficient of friction, as disadvantages.

Currently, the performance friction materials for automotive braking systems consist of composites made by Powder Metallurgy with metallic matrix from copper, iron or aluminum reinforced with i) friction components (as oxides: Al2O3, SiO2, ZrO2, nitrides: TiN, Si3N4, carbide: SiC, TiC, B4C) with role of friction and improving of the wear resistance and ii) lubrication components (graphite, molybdenum disulfide, etc.), with the role of increasing material resistance to gripping and for wear reduction of disc (rotor) brake. Among these metallic matrix for automotive braking systems, aluminum or aluminum alloys provide new possibilities in the production of friction materials due to high thermal conductivity (60% of the copper) and low specific density. These characteristics of the alloy matrix correlated with improved wear characteristics data by adding of hard ceramic reinforcement components (Al2O3, TiC, SiC, ZrO2, etc.) and /or soft (graphite, mica, MoS2, etc.) recommend them that new solutions materials for the brake pads. As a result of using these lightweight materials with frictional characteristics, we determine a low consumption of fuel and implicit the decreasing of costs in exploitation of the cars and also the decreasing of the burn gases results in process, leading at increasing of environmental protection [1 -10].

2. EXPERIMENTAL RESEARCHES

For testing, the chosen materials were aluminum based composite with 10 and 15wt. %SiC as reinforcement, and for comparison the unreinforced aluminum alloy obtained by P/M. Aluminum based composites were gravimetric dosed, and the elemental powder of the matrix and composite mixtures was dry blended using the Double Cone Blender (10kg capacity) at a rotation speed of 20 r.p.m, between 7 and 8 hours. For all mixtures Al+4wt.% Cu with (0, 10 and 15 %) SiC was added 2 wt. % zinc stearat powder lubricant and after that, homogeny blended (at macroscopically level) to reduce the friction between the powder mass and the surface of the die and obtain a good compaction.

The mixed homogenous powders were compacted at room temperature at 450 MPa in a double action hardened steel die with an automate hydraulic press of 30 tone force, Meyer Type, and after that, the compacts were dewaxed for 30 min, degassing during heating up from 420oC to 520oC during 30 min and sintered at 620oC, maintaining for 60 min in presintered-sintered furnace (Siemens-Plania type) in a protective atmosphere (hydrogen), furnace cooled.

And finally, the sintered aluminum based composites and sintered unreinforced matrix were solution treated at 515±5oC for 6 hours, quenched in water and artificial aging at 170°C for respectively 8 and 4 hours.
We determined the wear rate and average friction coefficien for all types of composites and unreinforced matrix in cast state. The composites were compared with a ferrous sintered material tribological tested in the same condition.
The tribological tests were performed on the pin-on-disc type wear machine (Fig. 1) at Mettalurgical Research Institut, in Bucharest, under following condition: contact pressure (applied load) 0.35, 0.70 and 1.15 MPa, relative sliding speed of 3.8 m/s at constant temperature. All tests were run under dry sliding conditions. The dimensions of all samples was 10x10x7 mm. The disc was polished before each tribological test. The time of wear test was kept constant in all cases at 30 min.
Wear was measured as the loss in weight of the pin (sample) after the test, with an accuracy of 0.1 mg, using a single analytical balance, type SAUTER with a precision of 10-3g. The test machine consists of a balanced pendulum in which is mountedthe sample into a box (Figure 1).
The sample rubs on a cast iron disc (300 Brinell Hardness) and the disc is acted through the main body of a transmission belt by an electric motor of 1.4 kW power. The peripheral speed of the discat the sample level is variable through the possibility to fixed the sample box at different distances to the driving axle and helped by the variable transmission. The frictional force was determined by measuring the angular movement (α) of pendulum from the vertical position.

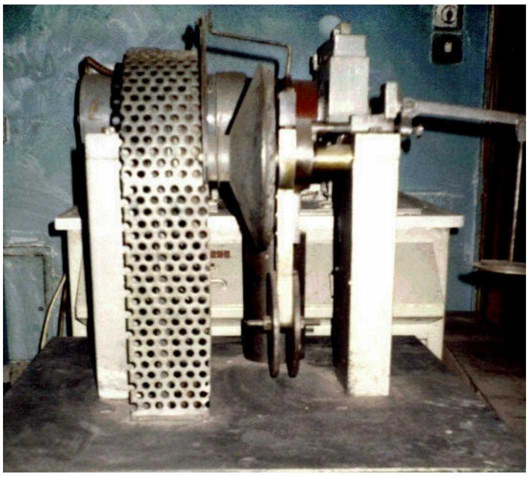

Figure 1. **The pin-on-disc type wear machine from Metallurgical Research Institute –Bucharest**

The friction force was determined by measuring the angular displacement of the pendulum from the vertical position. The normal force N is applied to the sample through a pusher at a desired value (Figure 2).

The correlation between applied pendulum weight (G) in Kg, total length (L), in mm and the distance from the spindle axis to pendulum test box (e), in mm is given by the relation:

$$F = L \cdot G \cdot \sin\alpha / e \quad (1)$$

We knows that:

$$\mu = F/N \quad (2)$$

And FROM Eq. (1) and (2) result that the coefficient of friction is determined by the relationship:

$$\mu = L \cdot G \cdot \sin\alpha / Ne \quad (3)$$

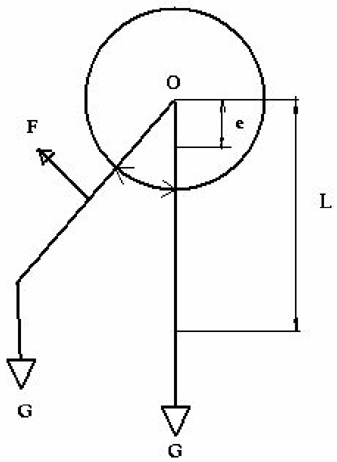

Figure 2. **Schematic diagram of the forces (the friction force in correlation with the weight force) which activate during the wearing of samples (pin)-on-disc**

The wear of the materials was determined by measurement of respectively weight loss and height loss of the tested samples.

3. EXPERIMENTAL RESULTS

The obtained values of the coefficients of friction and wear are calculated as an average of three determinations. In Table 1 and Figure 3 are presented the values of tribological characteristics (wear and friction coefficient of composite materials Al-4Cu reinforced with 10% and 15% SiC) of the material studied in comparison with imported sintered friction material, tested under the same conditions.
As we see from the table below, the lowest wear of the material presents the composites Al-4Cu 15wt.% SiC, tested with a load of 0.35 MPa at a speed of 3.8 m/s and the highest valuesof wear presents the aluminum alloy.
It is noted that as the applied load increases, wear increases for all materials and friction coefficient decreases.

Table 1 - The average values of wear and the frictional coefficients of studied material in comparison with unreinforced aluminum matrix and reference material RM

Material type	Applied load, MPa	Dry sliding speed m/s	Wear. mm/h	Wear. g/cm3·h	Frictional coefficient. μ
Al-4Cu	0.35	3.8	1.82	0.138	0.29
	0.70		1.83	0.151	0.28
	1.15		-	-	gripping
Al-4Cu/ 10% SiC	0.35	3.8	0.26	0.044	0.56
	0.70		0.32	0.093	0.487
	1.15		0.44	0.125	0.43
Al-4Cu/ 15% SiC	0.35	3.8	0.1	0.068	0.49
	0.70		0.24	0.084	0.478
	1.15		0.3	0.165	0.378
RM	0.35	3.8	0.29	0.139	0.51
	0.70		0.33	0.146	0.4
	1.15		0.37	0.164	0.38

Tribological characteristics of studied materials

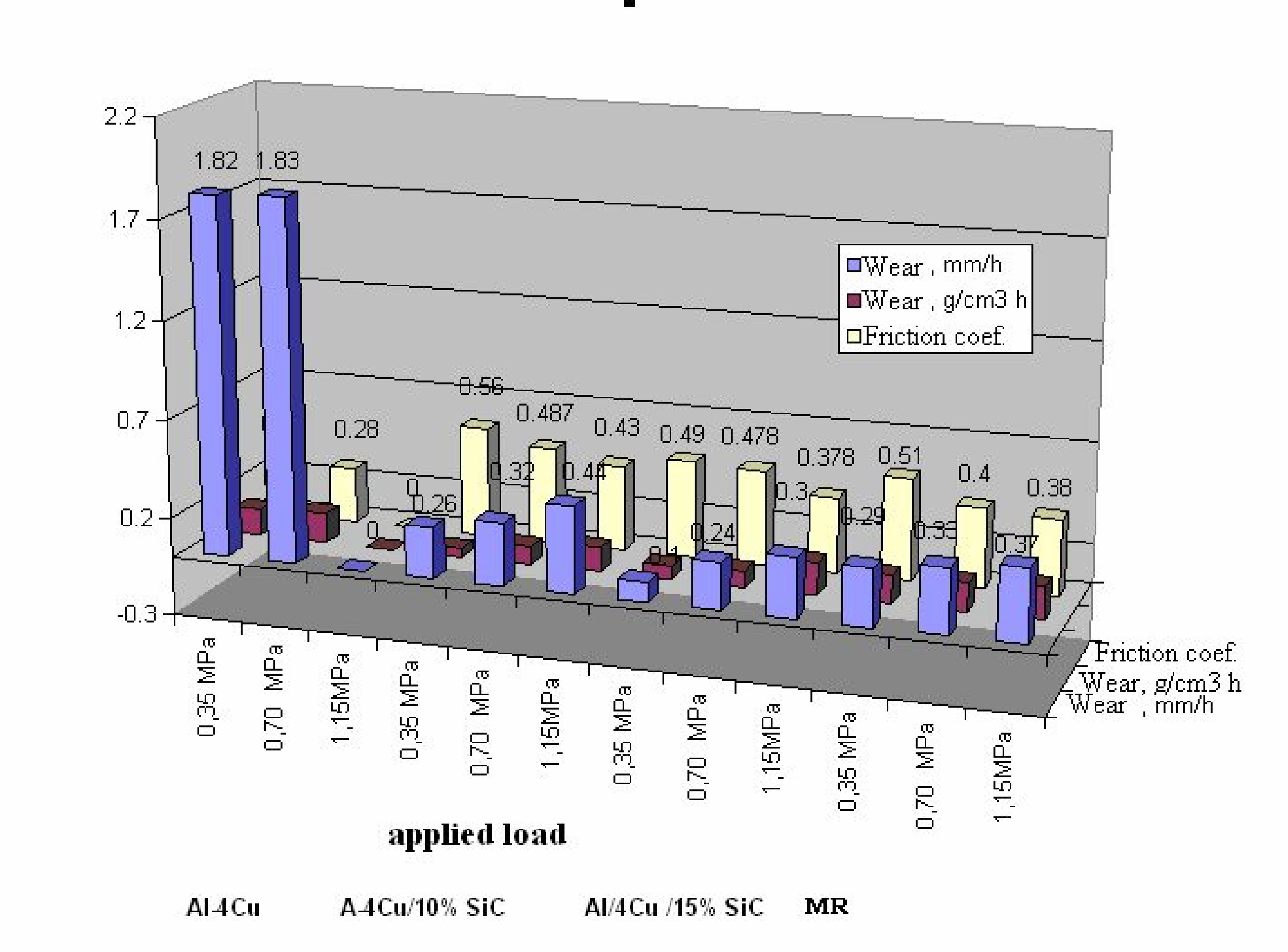

Figure 3. **The average values of wear and the frictional coefficients of Al-4Cu/10% and A-4Cu/15% SiC in comparison with unreinforced aluminum matrix and reference material RM, tested in the same conditions**

4. CONCLUSIONS

The selected materials for tribological testing were aluminium based composites reinforced with 10 and 15wt.% SiC sintered at 620° C/60'/ hydrogen atmosphere. The tribological tests were performed on the “pin-on-disc” type wear machine under following condition: contact pressure (applied load) 0.35, 0.70 and 1.15 MPa, relative sliding speed of 3.8 m/s at constant temperature. All tests were run under dry sliding conditions. The dimensions of all samples was 10x10x7 mm. The obtained wear values of the composites materials determined in the same conditions by measurement of respectively weight loss and height loss of the tested samples, in comparison with unreinforced aluminum matrix and reference material RM, shows that as the applied load increases, the wear increase for all materials and friction coefficient decreases. The values of friction coefficients, as shown in the Table 1 and Figure 3 are majority located in the 0.4 to 0.5 area, the amounts recommended to brake safely. The tribological characteristics of Al-4Cu/10wt.%SiC composite are compared to the reference material, which recommended them as the wear-resistant materials for friction couplings, except that situation when the coefficient of friction at applied load of 0.35 MPa, slightly exceeds the values of friction coefficients for frictional materials. The unreinforced aluminium alloy presents severe wear (1,82 - 1,83mm/h), very low friction coefficients, respectively at a load of 1.15 MPa and speed of 3.8 m/s and a tendency of gripping.
These differences in tribological behavior are explained by the presence of hard particles in aluminum matrix which protect the soft Al-4Cu surface and, at the same time, ensure a very good coefficient of friction. The role of the soft aluminum alloy matrix is to retain particles in the material (provides lift).

5. REFERENCES

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