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Wear Behavior of Metal Matrix Composites by Recycling Metal Chips

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ABSTRACT

In this study, the wear properties of metal matrix composites by isostatic hot pressing were investigated. The metal matrix composites were produced with bronze (CuSn10) and spheroid cast iron (GGG40) metal chips. It is contain %10, %20, %30, %40 spheroid cast iron chips The hot isostatic pressing was realized under 820 MPa and 450°C. The wear test has been assessed using pin-on-disc dry wear test. The test specimens have 8 mm diameter and 10 mm length. In addition to test specimen rubbed against rotating steel disc (SAE1050) throughout 1000 m with 0.5 ms-1 speed and 10 N loads. The results showed that the amount of wear and surface roughness depending on spheroid cast iron percentage.

INTRODUCTION

Metallic chips are created during machining of metals. These chips are considered as waste materials. However, some recycling methods are introduced. Recently, the most common recycling method is melting and casting process whereas, this process requires very high energy due to oxidized surfaces of chips and very low heat and electrical conduction. (Gunes, A., *et al*., 2015) So, melting/casting process becomes costly. On the other hand, very harmful gasses released during melting process of chips and results in environmental pollution. As a result of above mentioned situation, the melted chips converted to 10% of slag, 8% of casting scrap, 10% of melting losses and 18% of other losses and the overall process efficiency can be as low as 54% (Gunes, A., *et al*., 2015; Aslan, A., *et al*., 2015; Aslan, A., 2014; Gronostajski, J.Z., *et al*., 1997). Recycling of metallic chips was investigated by some authors. But most of these studies were focused on melting/casting and sintering processes. (Gunes, A., *et al*., 2015; Aslan, A., *et al*., 2015; Aslan, A., 2014; Gronostajski, J.Z., *et al*., 1997; Mindivan, H., *et al*., 2008)

Copper consents for fast heat dissipation due to its high thermal conductivity properties, which prevents the degradation of the sliding couple's mechanical properties. It has easy deformability, low modules and low strength. Conversely, alloys such as bronze and brass are widely used in the sliding parts of machines, e.g., bearings and bushings. (Kovalchenko, A.M., *et al*., 2012; Marui, E., H. Endo, 2001; Iglesias, P., *et al*., 2013).

In this study, the wear properties of metal matrix composites by isostatic hot pressing were studied. It is contain different percentage spheroid cast iron chips. The hot isostatic pressing was realized under 820 MPa and 450°C. The wear test has been assessed using pin-on-disc dry wear test. Besides to test specimen rubbed against rotating steel disc.

Experimental Procedure:

In this study, bronze and spheroid cast iron chips were used. The used materials were prepared by casting for compatible of chemical composition and the materials were machined and changed into metallic chips. The chemical compositions of specimens are showed in table 1. (Gunes, A., *et al*., 2015)

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Table 1: Chemical composition of specimens

GGG-40	Fe	C	Si	Mn	P	S	Cr	Mo
	93,4	3,45	2,43	0,277	0,0218	0,0216	0,0374	0,0063
CuSn10	Cu	Sn	Zn					
	88,94	9,11	0,82					

The metal matrix composites were produced by isostatic hot pressing and production parameters was chosen 450°C and 820 MPa. Mechanical properties of specimens are showed in table 2 (Aslan, A., *et al*., 2015).

Table 2: Mechanical properties of specimens

Mixing Rate (CuSn10/GGG40)	Density (gr/cm^3)	Porosity(%)	Brinell Hrd.	Microvickers Hrd.
90/10	8,332	2,549	140	162
80/20	8,033	4,37	147	319
70/30	7,923	3,963	144	273
60/40	7,745	4,383	159	216

These specimens were formed into pin shape by turning lathe. The wear behaviors of the produced materials were investigated using a pin on disc test stand (ASTM G99-05) shown in figure 1. The disc is made of SAE 1050 steel and the specimens have 8 mm diameter and 10 mm length. Wear test were executed at 0.5 ms-1 sliding velocities under a fixed load of 10 N over 1.000 m distance. Test specimens were cleaned and measured using a scale with 10-4 g precision for determine to wear losses. The test stand also allowed us to measure friction forces during testing. In this way, changes in the friction coefficient during wear testing could be acquired.

Fig. 1: Pin on disc machine and specimen

RESULTS AND DISCUSSION

The change in frictions coefficient has been saved during pin on disc testing and figure 2 shows the change in friction coefficient of composite specimens under sliding. Table 3 shows to wear loss of composite materials with different mixing rates. When the spheroid cast iron increasing in composite materials, wear losing decrease on wear tests. Figure 3 and figure 4 show that the microstructure images of steel disc and composite materials. As seen in these images, the abrasive wear increases with increasing spheroid cast iron in mixing rate.

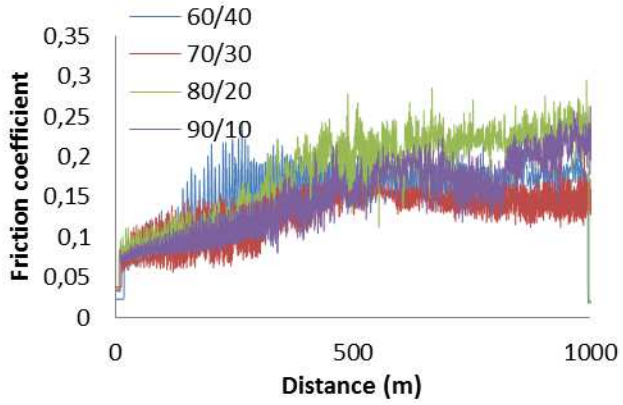

Fig. 2: Change of friction coefficient with different mixing rate

Table 3: Changes wear loss with the mixing ratio

Mixing Rate CuSn10/GGG40	Velocity (m/sn)	Load (N)	Loss (mg)
90/10	0,5	10	32,7
80/20			31,6
70/30			28,9
60/40			23,5

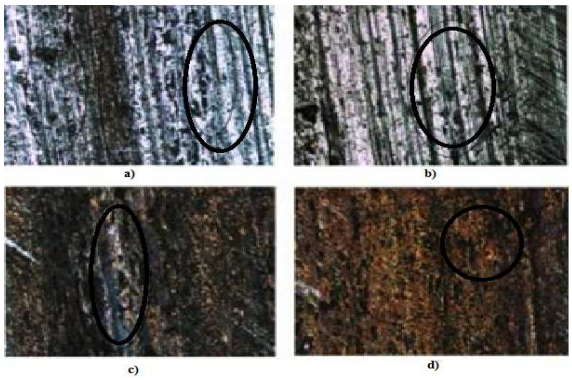

Fig. 3: Optical images of SAE1050 steel disc after wear test-50x (CuSn10/GGG40) a)90/10 b)80/20 c)70/30 d)60/40

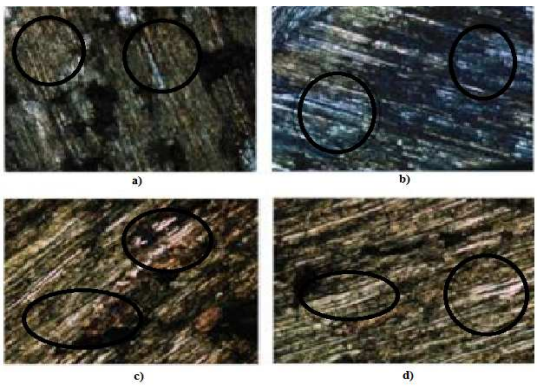

Fig. 4: Optical images of metal matrix composites after wear test-50x (CuSn10/GGG40) a)90/10 b)80/20 c)70/30 d)60/40

Conclusions:

In this study, wear behavior of metal matrix composite materials by recycling metal chips has been investigated. It is demonstrate that metal chips can be successfully recycled to porous material without melting. On the other hand, the wear behaviors of composite materials are changing with percentage of spheroid cast iron. The wear characteristics of metal matrix composite materials change with mixing rate.

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