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Research Article

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Investigation of Dry Sliding Wear Behavior of Mg-SiC Alloys Produced by Powder Metallurgy Method

Toz Metalurjisi Yöntemiyle Üretilen Mg-SiC Alaşımlarının Kuru Kayma Aşınma Davranışının İncelenmesi

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ABSTRACT

In recent years, Mg alloys have great promise for weight-saving applications, because of their superior properties over monolithic metals, in the field of automotive and aerospace industries. In this study, the dry sliding wear behavior of Mg- SiC alloys with different sintering temperatures (375°C, 400°C, 425°C) were investigated. Mg with %10 weight SiC powders were mechanically mixed and alloyed and then fabricated successfully via fast heating under vacuumed argon atmosphere. The friction coefficient, hardness value, and wear resistance of the alloys were higher than those of the pure Mg. The increase in the sintering temperature of the Mg-SiC alloys up to 425°C caused an increase in the friction coefficient and a decrease in the wear mass loss respectively.

Key Words

Magnesium, mechanical alloying, powder metallurgy, dry sliding.

ÖZ

Son yıllarda, Mg alaşımları, otomotiv ve havacılık endüstrileri alanında, monolitik metallere göre üstün özellikleri nedeniyle, ağırlık tasarrufu sağlayan uygulamalar için büyük umut vaat etmektedir. Bu çalışmada, farklı sinterleme sıcaklıklarına (375°C, 400°C, 425°C, 450°C) sahip Mg-SiC alaşımlarının aşınma davranışları incelenmiştir. Ağırlıkça %10 SiC içeren Mg-SiC tozları mekanik olarak karıştırılıp alaşımlanmış ve ardından vakumlu argon atmosferi altında FAST ile sinterlenmiştir. Alaşımların sürtünme katsayısı, sertlik değeri ve aşınma direnci saf Mg'den daha yüksektir. Sinterleme sıcaklığının 425°C'ye kadar artması, Mg-SiC alaşımlarının sürtünme katsayısının artmasına ve aşınma kütlesi kaybının azalmasına neden olmuştur.

Anahtar Kelimeler

Magnezyum, mekanik alaşımlama, toz metalurjisi, aşınma.

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INTRODUCTION

Magnesium (Mg) has a density of 1.738 g / cm^3 and is the world's lightest structural metal. Because of this property, Mg alloys hold great promise for weight-saving applications in the automotive and aerospace industries. Recently, Mg alloys have been studied by many researchers to improve mechanical properties [1]. Despite all these advantages, Magnesium has traditionally been difficult to process efficiently. Therefore, the powder metallurgy method has been used by many researchers recently.

Powder metallurgy (PM) technique has been a revolutionary method for manufacturing metal matrix composite (MMC) materials and components. Producing high quality complex parts with near end shape with a relatively economic model is possible with PM. The basic PM operation converts a metal powder with specific characteristics of size, shape, and density into a strong, high-performance part body. PM steps include the compaction of the powder and sintering respectfully or simultaneously [2]. One of the common reinforcement particles used in magnesium matrix composites is SiC [3-4]. Mechanically alloyed(MA) powders are subjected to repeated micro welding and fracturing which causes micro alloying of the matrix with the reinforcement. In the beginning this method is used to disperse oxide layers to strengthen metallic materials. [5]. MA is basically mixing powders of different materials together and putting them in the grinding container with milling agents(generally ceramic or stainless steel balls with high hardness values). . Then this mixture is millet for a certain length of time until a steady state or desired conditions are met [6].

FAST is a low voltage, direct current (DC) pulsed current activated, pressure-assisted sintering technique, which has been widely applied for materials processing [7]. The main purpose of this study is to investigate the effects of mechanical alloying of Mg with SiC for 5 hours and sintering at various temperatures. The effect of reinforcement and different temperatures on wear was observed. In addition, the effects of different sintering temperatures on density and hardness were also investigated.

Figure 1. FAST machine.

MATERIALS and METHODS

Mg powders (purity: ≥99.3%, size ≤220 µm, Kumas Manyezit Sanayi A.S., Turkey) were used as matrix materials. Commercially available SiC powders (particle size 40-70 µm) were used as reinforce materials. Zinc Stearate (C36H70O4Zn), (weighing 1% of magnesium powders) was used as a process control agent.

Mg and SiC powders were alloyed by high energy ball milling (DECO-PBM-V-2L) under argon protective atmosphere for 5 hours. The mixed powders were ball milled using 10 mm diameter stainless steel balls with a planetary ball mill. The powder to ball ratio was 1:20 and ball milling was carried out at rotation speed of 160 rpm.

Mechanical alloyed powders were put into the graphite die and pressed under pressure of 45 MPa in argon atmosphere by using a FAST machine (Figure 1).

Sintering temperatures were 375 ^{o}C, 400 ^{o}C, 425 ^{o}C and the sintering time was 15 min. The density calculation is based on Archimedes' principles. Brinell hardness measurements were made in accordance with TS EN ISO 6501-1 standard, with a 2,5 mm diameter ball. In the measurements, a load of 31.25 kgf and a waiting time of 15 seconds were applied. Samples with hardness measurements are shown in Figure 2.

Wear tests were performed on a pin on disk configuration against SAE1040 steel counter body under constant load and sliding speed. In tests, sliding speed was 5cm/s, pre-load speed was 10 mm/min and wear load was 5 N.

Figure 2. Samples with hardness measurement.

Table 1. Density and hardness values of samples produced in Mg and Mg-SiC alloys.

Temperature (°C)	Mg Density (g/cm^3)	Mg-SiC Density (g/cm^3)	Mg Hardness (HB)	Mg-SiC Hardness (HB)
375	96	92	64	68
400	97.7	93.1	65	73
425	91	89	52	66

RESULTS and DISCUSSION

Brinell hardness and density values of the samples are given in Table 1.

The highest hardness value was obtained with 400°C Mg-SiC alloys. The order of hardness values for the produced alloys are as follows: Mg-SiC (375°C), Mg-SiC (425°C), and Mg (unreinforced). SiC reinforcement particle addition increased the hardness when compared to the unreinforced Magnesium.

In pure Mg samples, the temperature increased, and the density increased up to 400°C and then decreased. The densities of the sintered Mg-SiC samples likewise increased up to 400°C and then decreased.

The graph of the coefficient of friction-sliding distance is given in Figure 3.

The wear behaviors of Mg-SiC alloys were evaluated as a function of different sintering temperatures. The wear resistances of the alloys were higher than those of the pure Mg (425°C). Wear surfaces of the worn samples are shown in Figure 4.

CONCLUSION

In the current study, Mg-SiC alloys were fabricated by the PM process. By the addition of SiC into the Mg matrix, the hardnesses of alloys were found to be higher when compared to unreinforced Mg. It was detected that the wear loss of the samples increased with increase in sliding distance.As shown in Table 1. the density and hardness values of the Mg and Mg-SiC alloy decrease with the sintering temperature, however the coefficient of friction is also decreasing with increasing sintering temperature. The wear test results illustrated a sig-

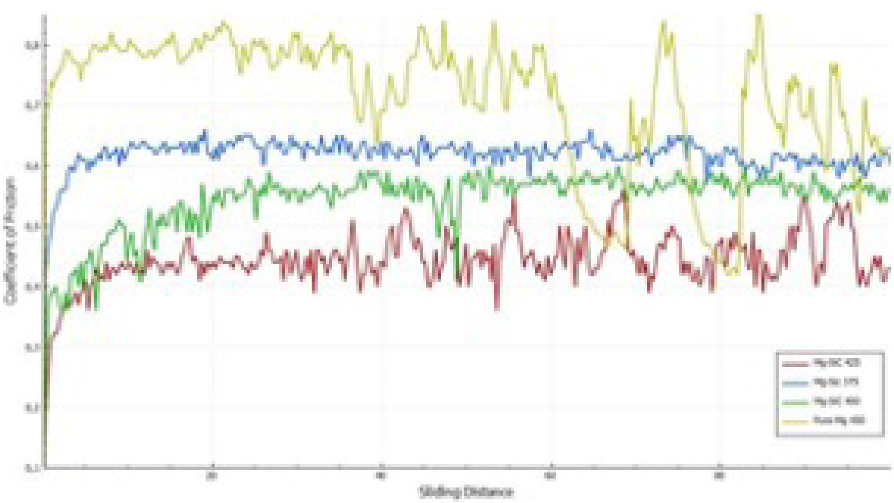

Figure 3. Coefficient of friction change with sliding distance.

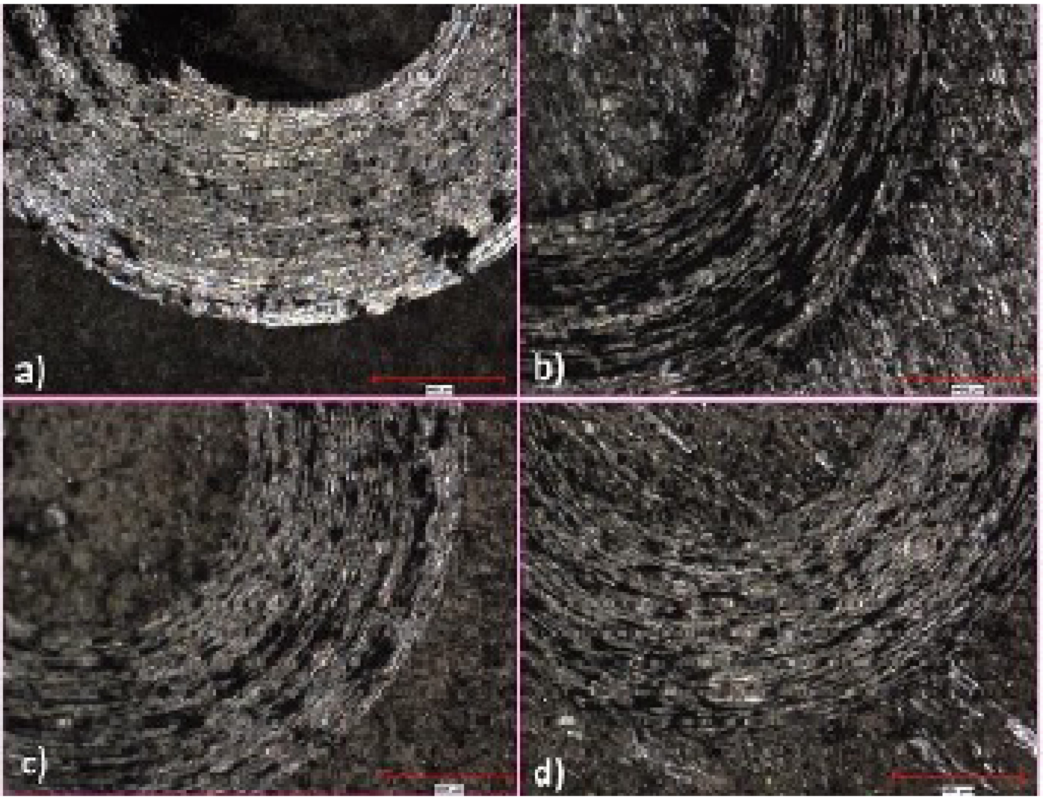

Figure 4. Worn surfaces of the samples a) Pure Mg. b) Mg-SiC 375°C. c) Mg-SiC 400°C. d)Mg-SiC 425°C.

nificant effect of the SiC on decrease of the coefficient of friction of the samples (specially for the 425°C Mg-SiC alloys). With SiC addition to the Mg matrix materials obtained with lower weight and better wear resistance. This effect will be further investigated with further research. . No significant and extra plastic deformation was observed except defined abrasive and adhesive wear tracks on the worn surface of the samples.

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