The 4th International Conference on Composites Characterization, Fabrication and Application

CCFA 4

Composites Characterization, Fabrication & Application

December 16-17, 2014, Tehran, Iran

Dear Pakdell Noghabi, H., Babakhani, A., Sajjadi, S.A.

We appreciate your active participation in the CCFA-4, also thank you for presenting your paper in this conference, entitled:

Wear Properties of the Al-Gr Composite Homogenized in the Liquid Produced by Two Methods: SPS and Cold Pressed and Sintered in Furnace

Sincerely yours,
Conference Chairs

M.M. Shokrieh, PhD
Professor,
School of Mechanical Engineering,
Iran University of science and Technology, Tehran, Iran

IUST

A. Varvani, PhD, PEng
Professor,
Department of Mechanical Engineering,
Ryerson University, Toronto, Canaca

RYERSON UNIVERSITY

A-10-1224-3

Wear properties of the Al-Gr composite homogenized in the liquid produced by two methods: SPS and cold pressed and sintered in furnace

H. Pakdell Noghabi [1*], A. Babakhani [2], S. A. Sajjadi [3]
[1] Msc. Student, [2]Associate Professor, [3] Professor

Dept. of Metallurgical and Materials Engineering,
Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran
*(Corresponding author: hpn1391@gmail.com)

Abstract

To produce aluminum matrix composite reinforced with graphite particles, mixing of pure aluminum and graphite powders by a new method called homogenization in liquid phase was performed. The graphite content was chosen from zero to 4.5 percent by weight of graphite in this study. Composite samples were produced using the dried powder by two ways: spark plasma sintering (SPS) and cold pressing and thereafter sintering in a vacuum furnace under different pressure, temperature and time. The microstructure was investigated by OM and SEM. Pin on disc rotating wear tests was conducted at room temperature and atmospheric environment. Finally, the wear mechanism were studied using OM and SEM. Experimental results showed that the optimum percentage of graphite was 3 wt.%, and with a uniform distribution of graphite particles in the matrix without agglomeration were observed. and the highest wear resistance were obtained. The presence of graphite as a reinforcing phase in the aluminum grains, increasing the wear resistance of the composite specimens compared to pure aluminum. Also, for the composites that fabricated using this mixing method, the wear resistance was much higher in comparison with other methods.

Keywords: Aluminum matrix composite, Graphite, liquid phase homogenization, SPS, wear.

IUST RYERSON UNIVERSITY ICI

The 4th International Conference on Composites: Characterization, Fabrication and Application (CCFA-4)
Dec. 16-17, 2014, Iran University of Science & Technology, Tehran, Iran

Wear properties of the Al-Gr composite homogenizedin the liquid produced by two methods: SPS and cold pressed and sintered in furnace

[1] *Pakdell Noghabi, H., [2]Babakhani, A. and [3] Sajjadi, S.A.
[1] Msc. Student, Department of Materials Engineering,Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran
[2] Associate Professor, Department of Materials Engineering,Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran
[3] Professor, Department of Materials Engineering,Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran

*(corresponding author: hpn1391@gmail.com)

***Abstract*- To produce aluminum matrix composite reinforced with graphite particles, mixing of pure aluminum and graphite powders by a new method called homogenization in liquid phase was performed. The graphite content was chosen from zero to 4.5 percent by weight of graphite in this study. Composite samples were produced using the dried powder by two ways: spark plasma sintering (SPS) and cold pressing and thereafter sintering in a vacuum furnace under different pressure, temperature and time. The microstructure was investigated by OM and SEM. Pin on disc rotating wear tests was conducted at room temperature and atmospheric environment. Finally, the wear mechanism were studied using OM and SEM. Experimental results showed that the optimum percentage of graphite was 3 wt.%, and with a uniform distribution of graphite particles in the matrix without agglomeration were observed. and the highest wear resistance were obtained. The presence of graphite as a reinforcing phase in the aluminum grains, increasing the wear resistance of the composite specimens compared to pure aluminum. Also, for the composites that fabricated using this mixing method, the wear resistance was much higher in comparison with other methods.**

Keywords – Al/Gr composite, liquid phase homogenization, SPS, wear.

I. INTRODUCTION

The most well known composite metal matrix composite, the matrix Al. However, its use is limited at high temperatures. Because of the decomposition matrix composite. Another limitation is the relatively low modulus of Al is. In fact, it is expected that at the aluminum composite, graphite wear and friction performance is developed [1]. The behavior of graphite is of great importance in industry. Since the graphite particles are lighter than the metal matrix, the aluminum-graphite composites are used to reduce the weight of the pieces [2]. Aluminum and graphite materials are acceptable for automotive components. Recent advances in vehicle engine technology, the need to develop new materials for performance, wear and traction in pieces like a piston and shaft transmission is triggered [3]. For example, for wear applications, aluminum-graphite composite materials to reduce weight and cost, and its advantage is lubricated. Graphite particles increases the strength of the aluminum composites are compared to pure aluminum [4,5]. Techniques of adding reinforcements and their distribution in the field, including methods for liquid and solid exist. In this case it will be non-uniformly distributed particles. In the SPS, the pressure and sintered powders are done simultaneously. Compared with other methods is done in a shorter period and lower temperatures and extremely high efficiency of this method. In the present study, for mixing powders Al / Gr, a new method was used. I called this method, the method of homogenization in the liquid. This is the first time I got in the Faculty of Engineering, Ferdowsi University of Mashhad. This method is a powder metallurgy method. The preparation and mixing of powders in liquids by ultrasonic devices were used. The composite strength by reinforcing particles is dependent on the following factors: type and particle size, morphology, volume fraction, distributed. Using homogenization method allows uniform distribution of particles in the liquid phase exists.

II. EXPERIMENTAL PROCEDURE

The as received Al powder with purity of 99.9% and average particle size of 45 µm and Graphite with an average particle size of 10µm that used in this study was.The concentration of graphite in the composites was 0, 1.5, 3 and 4.5% by weight.

First, the graphite was dispersed in acetone using ultrasonic with the frequency of 50 kHz for 1 h. Then, the Al powder was slowly added into the solution and sonicated for 4 h to obtain a homogenous mixture. The mixtures were filtered and dried at 90°C for 6 h to form the powder. The mixed powders filled in cylindrical graphite dies with 6 mm diameter and after placing the die inside the SPS apparatus, uniaxial pressure of 28 MPa was applied to the samples. The pressure was exerted to the samples during entire sintering time. Sintering was carried out by applying a pulsed DC current with 7 A/mm^{2}current density for 390 sec under high vacuum (10^{-2} Torr). The temperature variations of die during the process was measured by a placing the thermocouple inside the die and sintered at temperature of 590°C. After sintering, the DC current was turned off and samples cooled naturally. The sintered compact cylindrical sample had a diameter of 6mm and a length of 10 mm. Also, using other method, The mixed powders was pressed at 500 MPa for 5 min to make a cylindrical shape with the ratio of 1:1 between diameter and height. The pressed samples were sintered at 500°C for 6 h in the furnace. The microstructure was investigated by OM and SEM. Pin on disc rotating wear tests was conducted at room temperature and atmospheric environment. Finally, the wear mechanism were studied using OM and SEM.

III. RESULTS AND DISCUSSION

According to observations by OM and SEM, it can be concluded that: In this way, the addition of graphite to an optimal value, the aggregate does not occur. and distribution will be uniform. But with the addition of graphite over the optimum, uniform distribution declined.

In this study, the wear rate is defined as follows: the reduced weight (gr) the distance traveled (m). This parameter, for example with 5N load is shown in Table 1. It was observed that by increasing the amount of graphite to the optimal (3%), increased wear resistance occurs. The reason is that, with the addition of graphite to the optimal value, increases the amount of lubrication (lubrication) levels. Because it increases the amount of graphite with a uniform and homogeneous distribution. And also because of their high strength, wear rates are reduced. But with the increasing rate over the optimal value may cause agglomeration of the graphite. And given the softer the graphite, resulting in a softer composite and increase the wear rate. But composites produced by this method, much less wear compared to pure aluminum. Because it increases the lubrication properties of graphite, uniform and homogeneous distribution produced by this method, small lumps, and also due to the high strength of the composite.

TABLE I: Wear Rate DATA FOR THE VARIOUS MATERIALS AND CONDITIONS.

Material	Condition	Wear Rate (gr/m)
Al-0%Gr	SPS	0.00022
	furnace	0.00033
Al-1.5%Gr	SPS	0.00015
	furnace	0.00022
Al-3%Gr	SPS	0.00010
	furnace	0.00015
Al-4.5%Gr	SPS	0.00019
	furnace	0.00028

Figure 1, the OM and SEM images of the samples prepared from the pure and composite wear shows. As was observed in pure samples, severe wear was observed with much depth. Due to the soft nature of the wear of the samples. In contrast, the composites containing graphite from 1.5 to 3 percent more resistance to shear stress is applied, compared to pure aluminum. Although the frictional forces created here. But such a strong bond (between graphite and field), are not easily uprooted. Figure 1 show that, with the addition of graphite, the wear is reduced. Also, the deformation caused by the wear on the case, continued and intensified seen. And it has, instead of a vertical deflection and dive abrasive, most of the material flow around wear lines exist.

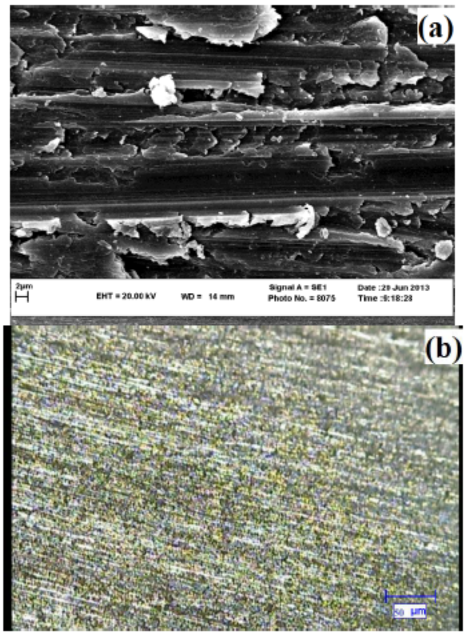

Fig. 1: (a) the SEM images of the sample prepared from the pure Al wear shows. (b) the OM images of the sample prepared from the composite wear shows.

IV. CONCLUSIONS

using graphite particles homogenization of liquid and powder metallurgy method can achieve uniform distribution of graphite, which improves the mechanical properties. Also, with the addition of graphite to the optimal value, the the resistance to wear is increased. For amounts greater than the optimal value, the reverse process occurs. Also, For sintering, SPS method is most efficient when compared to other methods is sintered powder metallurgy samples.

ACKNOWLEDGMENT

The authors wish to express their appreciation to father and mother's Pakdell Noghabi Hossein for their kind support and contribution to the paper.

REFERENCES

[1] Latief, F.H., and Sherif, M., Journal of Industrial and Engineering Chemistry, pp. 2129–2134, 2012 .
[2] Saravanan, M., Pillai, R.M., Ravi, K.R., Pai, B.C. and Brahmakumar, M., Composites Science and Technology, pp. 1275–1279, 2007.
[3] Pillai, U. and Pal, B. C., .J. of mater. Sci , pp. 1455-1461, 1995.
[4] Parasad, K. and Das, S. , Mater. Sci. Eng , pp.229-235, 1991.
[5] Liu H. and Rohatgi, P. K, Metallurgical Trans. A22,pp. 151-159, 1993.