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

CCFA 4

December 16-17, 2014, Tehran, Iran

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

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

Mechanical Properties of Al-Gr Composite Produced by Two Ways: 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

CCFA-10-1224-2

Mechanical properties of Al-Gr composite produced by two ways: SPS and cold pressed and sintered in furnace

H. Pakdell Noghabi [1*], S. A. Sajjadi [2], A. Babakhani [3]
[1] Msc. Student, [2] Professor, [3] Associate 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. To investigate the mechanical properties of samples, compression, hardness and wear tests were performed. Finally, the microstructure was investigated by OM and SEM. Based on the results and observations it was cleared that distribution of graphite particles was much better than other methods. Thus threefold compression strength in comparison with other mixing methods and dramatically improved wear property were obtained as the addition of graphite reaches 3 percent by weight.

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

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

Mechanical properties of Al-Gr composite produced by two ways: SPS and cold pressed and sintered in furnace

[1*] Pakdell Noghabi, H., [2] Sajjadi, S.A. and [3] Babakhani, A.
[1] Msc. Student, Department of Materials Engineering,Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran
[2] Professor, Department of Materials Engineering,Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran
[3] Associate 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.To investigate the mechanical properties of samples,compression,hardness were performed. Finally, the microstructure was investigated by OM and SEM.Based on the results and observations it was cleared that distribution of graphite particles was much better than other methods. Thus threefold compression strength in comparison with other mixing methods and dramatically improved wear property were obtained as the addition of graphite reaches 3 percentby weight.**

Keywords - Al/Gr composite, liquid phase homogenization, SPS, Mechanical properties.

I. INTRODUCTION

Composites Al/Gr due to its lubricating properties and good abrasion properties of the lubricant film formation on the surface [1], light [2], better grindability than the background [3], low thermal expansion coefficient, attracting vibration [4,5], have potential for manufacturing cylinder liners, pistons, bearings and general engineering applications [6]. The presence of graphite in the aluminum, usually reduces the mechanical properties of the composites [7]. The investigation showed that, generally, by increasing the percentage of graphite, hardness and tensile properties and fracture toughness of composites Al / Gr is reduced [8,9]. The need for a composite to show its high efficiency, uniform distribution of the reinforcing phase. Reinforcing particle agglomeration, the reduction in mechanical properties [10,11]. 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 μmand 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/mm²current 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 prepared composites were observed by OM and SEM to recognize the distribution of graphite within aluminum.To investigate the mechanical properties of samples,compression, hardness tests were performed.

III. RESULTS AND DISCUSSION

According to observations by OM and SEM (Figure 1), 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. But yet again the uniformity and homogeneity in comparison with similar samples generated by other methods more. The optimal amount of graphite (graphite aluminum with three percent) are much more efficient than the same graphite composites produced by other methods (in other production methods, optimal value, 1%.).

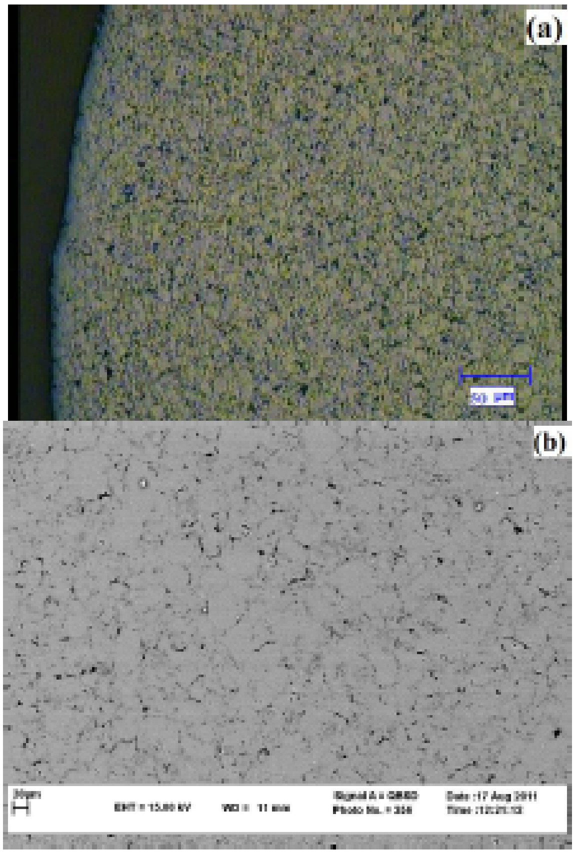

Fig. 1: (a) OM of sintered composites Al-1.5%Gr by SPS. (b) SEM of sintered composites Al-3%Gr by cold pressed-sintered in furnace.

The smaller, more uniform distribution of bulk graphite contributed to the improved mechanical properties.
Table 1, the compressive strength, hardness for specimens with different percentages of graphite shows. As observed, the value of all the parameters, with the addition of graphite to the amount of 1.5 percent, much higher than pure aluminum. And with the addition of graphite to 3%, the value rose. In other words, optimum and maximum values of these parameters in the Al-3% Gr composite. With the addition of graphite to the amount of more than 3 percent, the value of this parameter, compared to 1.5 percent lower. The value of the 3% most of the graphite, the value of this parameter decreases. Because it can be expressed as follows: uniform distribution of graphite, aluminum, and non-agglomeration and reduce porosity, to optimum percentage.

TABLE I: Compressive Stress and BRINELL HARDNESS DATA FOR THE VARIOUS MATERIALS AND CONDITIONS.

Material	Condition	Brinell hardness (HB)	Compressive Stress (MPa)
Al-0%Gr	SPS	20.7	149.77
	furnace	28.4	125.39
Al-1.5%Gr	SPS	29.9	263.53
	furnace	29.1	251.19
Al-3%Gr	SPS	35.1	357.83
	furnace	32.1	268.03
Al-4.5%Gr	SPS	22.7	123.59
	furnace	22.4	74.09

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 compressive strength, hardness is increased. For amounts greater than the optimal value, the reverse process occurs. Also, with the addition of graphite is greater than the optimal value, larger spherical masses of graphite was observed. As is the site of stress concentration. And a decrease in mechanical properties.

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] Lin, J. F., Shih, M. G. and Chen, Y. W.,Wear, PP. 58-70, 1996.
[2] Rohatgi, P. K., Liu, Y., Yin, M. and Barr, Ti., Mater. Sci. and Eng., PP. 213-218, 1990.
[3] Basavara Jappa, S., Chandramohan, G. and Paul Davim, J., Materials and Design, PP. 1393-1398, 2006.
[4] Das, S., Parasad, S. V. and Ramachandran, T. R., Mater. Sci. and Eng. A, PP. 123-132, 1991.
[5] Rohatgi, P. K., Liu, Y. and Barr, Ti. Metallurgical and Mater. Trans., PP. 1435-1441, 1991.
[6] Yang, J. B., Lin, C. B., Wang, T.C. and Chu, H. Y., Wear 257, PP. 941-952, 2004.
[7] Ibrahim, I., Mohamed, A. F. and Lavernia, A. E. J., J. of Mater. Sci., PP. 1137-1 156, 1991.
[8] Liu, H. and Rohatgi, P. K., Metallurgical Trans. A22, PP. 151-159, 1993.
[9] Pillai, U. T. S., Pal, B. C., Satyanarayana, K. G. and Damodaran, A. D., J. of mater. Sci., PP. 1455-1461, 1995.
[10] Parasad, K. and Das, S., Mater. Sci. Eng., PP. 229-235, 1991.
[11] Wei, J. N., Cheng, H. F., Zhang, Y. F., Han, F. S., Zhou, Z. C. and .Shui, J. P., Mater. Sci.and Eng., PP. 444-453, 2002.