Applied Mechanics and Materials
ISSN: 1662-7482, Vols. 766-767, pp 320-323
doi:10.4028/www.scientific.net/AMM.766-767.320

Submitted: 2015-01-21
Revised: 2015-01-30
Accepted: 2015-02-05
Online: 2015-06-08

TRIBOLOGICAL PERFORMANCE AND MICROSTRUCTURAL ANALYSIS OF AN ALUMINIUM ALLOY BASED HYBRID COMPOSITE PRODUCED BY P/M

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Keywords: Aluminium alloys, MMC, Graphite, Wear, Hardness, SEM.

Abstract

In the field of material science and engineering, there is a great impact ever since the invention of composites materials. High strength to weight ratio provides the attractive combination that moves composite materials into new era. The conventional materials like cast iron, steel, and aluminium alloy are replaced by the composite materials due to its superficial properties and could be applied in aerospace and automotive applications. Powder metallurgy fabrication technique is one of the best and attractive methods for producing metal matrix composites because of its better distribution of particles and reliability and cost in manufacturing. In this paper, composites based on aluminium alloy (Al 2024) reinforced with 10% weight fraction of hard ceramics like Aluminium oxide (Al_2O_3) and 10% weight fraction of Aluminium oxide (Al_2O_3) with 5% graphite particles is produced by Powder metallurgy method. Hardness and wear test are conducted for the Al 2024, Al-10%Al_2O_3, and Al-10% Al_2O_3-5% Graphite. In addition the surfaces of the composite are analyzed by SEM to study the wear of the composites.

Introduction

Kok et al. (2005) said that there is an increasing tendency towards composite materials in order to achieve better performance in engineering materials. Thus, production and application of metal matrix composites (MMC) have greater than before in recent years. Sevik et al. (2006) discussed that MMC of Al–Al_2O_3 $_{has}$ showed better mechanical properties and best in wear resistance under versatile application. Dobrzanski, et.al (2006) and Torralba et.al (2003) showed that aluminium matrix composites have low density, high corrosion resistance and high toughness. It can be used in aerospace, automotive, military and electronic industry. Due to low wear resistance, pure aluminium could not be used in much application. Torres et.al (2002) and Sahin et.al (1996) suggested that aluminium matrixes can be mixed with ceramic particles to improve the hardness, strength corrosion and wear resistance. Dobrzanski, et.al (2006) showed that by varying the size, volume fraction, the particle reinforcement has better microstructure control and mechanical properties. The Al_20_3 ceramic particle reinforcement don't respond metal matrix at high temperature (Kok et al. (2005)). Min et al. (2005) investigated that powder metallurgy technique is used to manufacture net shape product at minimum cost. In this research, the composite samples were produced by uniaxial pressing. The effects of temperature, size of reinforcement particles on wear properties, microstructure, sintering time, hardness of samples and relative density were studied. The optimum processing parameters can be studies from this investigation In this paper, composites based on aluminium alloy (Al 2024) reinforced with 10% weight fraction of hard ceramics like Aluminium oxide (Al_2O_3) and 10% weight fraction of Aluminium oxide (Al_2O_3) with 5% graphite particles is produced by Powder metallurgy method. Hardness and wear test are conducted for the Al 2024, Al-10%Al_2O_3, and Al-10% Al_2O_3-5% Graphite. In addition the surfaces of the composite are analyzed by SEM to study the wear of the composites.

Experimental methods

Materials

Al 2024, Al-10%Al_2O_3, and Al-10% Al_2O_3-5% Graphite composites required for the investigation are fabricated by P/M. In order to process the specimens, powders of Aluminium, Al_2O_3 and Graphite have been weighed with the weight fractions.

Composite processing

The fabricated samples were uniaxially pressed at 440 MPa and glycerol's was applied for reducing friction and wear in the matrix material. Sintering of these raw samples was done in argon environment at different temperatures of 500^0C, 550^0C and 600^0C and different time periods of 30, 45, 60 and 90 min. The microstructure examination was done using Tescan VEGA-II XMU and Philips XL30 electron microscopes. Keller reagent was used as the etchant. ASTM B328 standard was followed to measure the densities (Metals handbook, 1993). Variations in the grain size were Investigated utilizing Clemex image analyzer. Brinnel Hardness test with an indenter of 2.5 mm diameter and a 30 kgf force was used to measure the hardness. Pin on disc test was conducted for 100, 200, 300 and 400 m distances. Wear test samples had a cylindrical shape with a diameter of 7 mm. The running in distance was set at 1500 m and the disc material was AISI4140 steel (Al-Qutub et.al (2006)). The applied load was 5 N which is equivalent to 0.129 MPa on the pin and a constant Sliding speed of 1 m/s was set. Alcohol was used to clean the specimens thoroughly and the specimens were dried prior to weighing. The wear behavior was based on three tests under identical conditions.

Results and discussion

Hardness

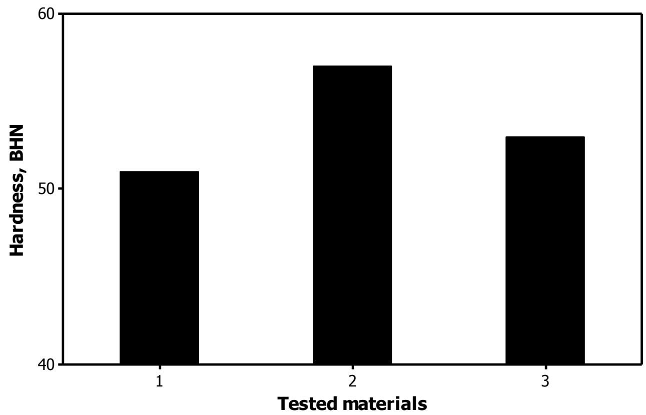


Fig. 1 Hardness vs. tested materials

The hardness comparison of the aluminium, aluminium with aluminium oxide, aluminium with aluminium oxide and graphite is shown in the figure 1. The hardness of Al-10%Al_2O_3-5%Gr is 5% higher than aluminium alloy and 3% lower than aluminium with 10% of aluminium oxide.

Wear loss

The wear test conducted for the various sizing distance at constant load for the three testing materials. Figure 2 shows that the wear loss of testing materials as a function of slicing distances. The Al-10%Al_2O_3-5%Gr composite wear loss reduces 3% to 12% compared with Al 204 and reduces 6%-7% compared with Al-10%Al_2O_3 at various slicing distance.

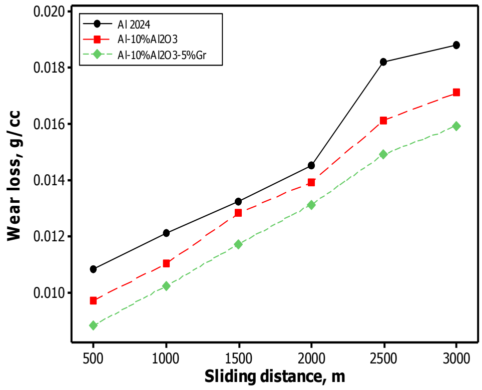


Fig. 2 Wear loss vs. tested materials

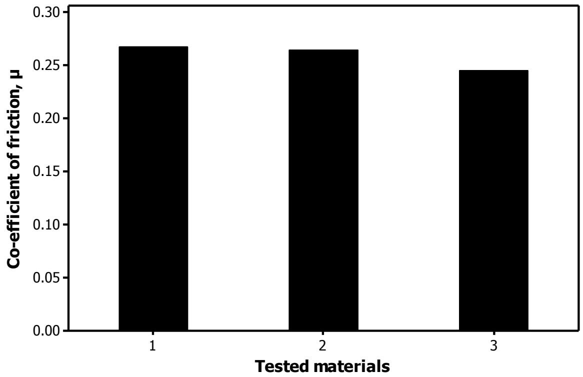


Fig. 3 Coefficient of friction vs. tested materials

Coefficient Of Friction

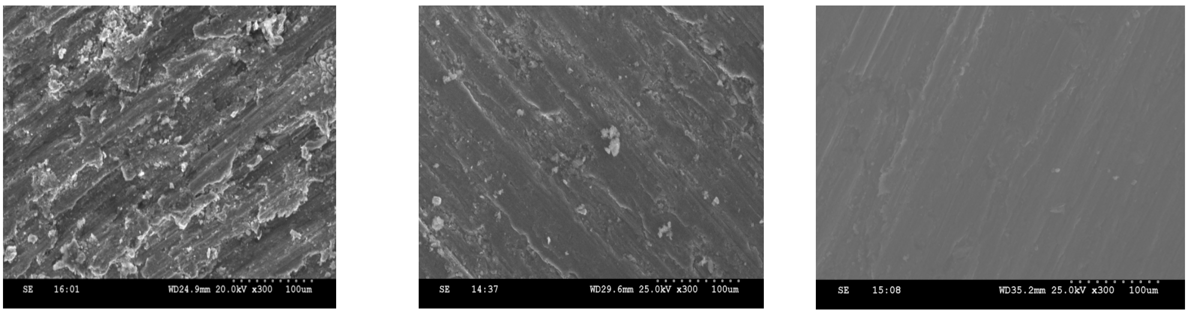
The coefficient of friction comparison of the aluminium, aluminium with aluminium oxide, aluminium with aluminium oxide and graphite is shown in the figure 3. The coefficient of friction of Al-10%Al_2O_3-5%Gr is 11 % lower than aluminium alloy and 8 % lower than aluminium with 10% of aluminium oxide.

Scanning electron microscopy (SEM)

The surface fracture morphology of composite samples was tested by the scanning electron microscope (SEM) JEOL JSM-6480LV.The samples are rinsed, cleaned thoroughly, air-dried and are coated with 100 Å thick platinum in JEOL sputter ion coater and observed SEM at 20 kV. The composite samples with silver paste are mounted on stubs. In order to improve the conductivity of the samples, a thin film of platinum is vacuum-evaporated onto samples before the photomicrographs are taken. The SEM result is used to identify the treated and untreated component and also used to study the morphological properties of the given composites.

SEM analysis

From the above figure 4, it is clearly observed that the Al2024 has poor wear resistance compared to Al-10%Al_2O_3 and Al-10%Al_2O_3-5%Gr. It is evident from the scratches found in the microstructure which are less in the remaining two samples. Al-10%Al_2O_3-5%Gr has shown better wear resistance compared with other two tested samples due to the presence of graphite. The void space in the Al-10%Al_2O_3-5%Gr is less compared to other two samples.



(a) Wear of Al (b) Wear of Al-10%Al_2O_3 (c) Wear of Al-10%Al_2O_3-5%Gr

Fig 4. SEM microstructure of tested samples

Conclusion

The effects of the amount of lubricant powder on tribological properties of sintered Al2024, Al_2O_3, gr hybrid composites were investigated. Based on the results the following conclusions were made:

- The hardness of Al-10%Al_2O_3-5%Gr is 5% higher than aluminium alloy and 3% lower than aluminium with 10% of aluminium oxide.
- The Al-10%Al_2O_3-5%Gr composite wear loss reduces 3% to 12% compared with Al 204 and reduces 6%-7% compared with Al-10%Al_2O_3 at various slicing distance.
- The co-efficient of friction is low for Al-10%Al_2O_3-5% Gr compared with Al2024 and Al-10%Al_2O_3
- The SEM microstructure images has shown that Al-10%Al_2O_3-5% Gr is having higher wear resistance and less void spaces compared with Al2024 and Al-10%Al_2O_3.

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