American Journal of Materials Science 2015, 5(3C): 53-57
DOI: 10.5923/c.materials.201502.11

Effect of B_4C Particulates Addition on Wear Properties of Al7025 Alloy Composites

Sallahauddin Attar[1,*], Madeva Nagaral[2], H. N. Reddappa[1], V. Auradi[3]

[1]Department of Mechanical Engineering, Bangalore Institute of Technology, Bangalore, India
[2]Aircraft Research and Design Centre, HAL, Bangalore, India
[3]Department of Mechanical Engineering, Siddaganga Institute of Technology, Tumkur, India

Abstract In the present work, an attempt has been made to develop and study the wear properties of Al7025-B_4C reinforced aluminum metal matrix composites. The composites were prepared by using liquid metallurgy technique. Al7025 alloy was taken as the base matrix to which B_4C particulates were used as reinforcements. 3 and 6 wt. % of B_4C particulates were added to the base matrix. For each composite, reinforcement particles were pre-heated to a temperature of 500 degree Celsius to improve wettability and distribution. The microstructural study was done by using scanning electron microscope, which revealed the uniform distribution of particles in matrix alloy. A pin-on-disc wear testing machine was used to evaluate the wear rate, in which a hardened EN32 steel disc was used as the counter face. The results indicated that the wear rate of the composites was lesser than that of the Al7025 matrix. However, the material loss in terms of wear rate increased with the increase in load and sliding speed both in case of composites and the alloy. The worn surfaces were characterized by SEM microanalysis to know the different wear mechanisms.

Keywords Al7025 alloy, Wear, B4C, Stir casting, Composites

1. Introduction

In recent years there has been a considerable interest in metal matrix composites (MMCs). Metal-matrix composites (MMCS) have recently become candidates for critical structural applications because of their superior specific strength and stiffness [1-2]. The need for new wear-resistant materials for high performance tribological applications has been one of the major incentives for the technological development of ceramic particulate reinforced aluminium alloys during the last decade [3]. Continuous progress in science and technology creates an increasing demand for improved structural materials. Materials like cast iron with graphite or steel with high carbide content, as well as tungsten carbides, consisting of carbides and metallic binders, also belong to this group of composite materials. Metal matrix composites (MMCs) usually consist of a low-density metal, such as aluminium or magnesium, reinforced with particulate or fibers of a ceramic material, such as Boron carbide, silicon carbide or graphite [4-7]. Compared with unreinforced metals, MMCs offer higher specific strength and stiffness, higher operating temperature, and greater wear resistance, as well as the opportunity to tailor these properties for a particular application. Metal composite materials have found application in many areas of daily life for quite some time [8]. Substantial progress in the development of light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications such as in traffic engineering, especially in the automotive industry. However, despite the increased use of MMCs in recent years, the problems of poor fracture toughness and unsatisfactory fatigue properties have limited their application in certain fields [9-11]. With hard particles dispersed in a relatively ductile matrix, aluminium alloy matrix composites possess an ideal structure for wear-resistant materials. These Al alloy composites which are reinforced with ceramic particulates led to a new generation of tailorable engineering materials with improved specific properties. Most of the composites having actual or potential use as structural materials are manufactured by powder processing, casting or squeeze casting, or a method similar to one of these (such as rheocasting), although other methods are also used (e.g., spray deposition) [12-15].

* Corresponding author:
sallahauddin@gmail.com (Sallahauddin Attar)
Published online at http://journal.sapub.org/materials

2. Experimental Details

In the present work, an experiment was made to study the wear properties of as cast and Al7025-B_4C particulate composites. The composites containing 3 and 6 wt. % of B_4C particulates were prepared using liquid metallurgy route in particular stir casting technique. Table 1 represents the chemical composition of Al7025. Initially required amount of charge or matrix material was placed in a graphite or silicon carbide crucible, which will be placed in electric resistance furnace at a temperature of around 730°C. After complete melting of Al7025 matrix degassing was carried out by using Solid HexaChloro ethane, which helps to remove unwanted adsorbed gases from the melt [16-18]. Once degassing is over, the preheated ceramic reinforcement particles (B_4C) of size 80 microns were introduced into matrix in a novel way which involves two-stage additions of reinforcement during melt stirring. This novel two stage additions of reinforcement into matrix Al7025 will increases wettability of the matrix and ceramic reinforcement and there will be uniform distribution of the particles.

Table 1. Chemical Composition of Al7025

Element	Zn	Cu	Mn	Mg	Fe	Cr	Si	Ti	Al
Weight %	5	0.1	0.6	1.5	0.4	0.35	0.3	0.1	Bal

A continuous stirring process was carried out during addition of reinforcement into matrix. During composite preparation 300rpm stirring speed was maintained. After 10 minutes of continuous stirring, entire molten metal was poured into cast iron die. The prepared composites were machined and tested for micro structural studies. After revealing uniform distribution of particles in the matrix further process was continued.

For tribological study wear test was carried out using pin on disc equipment to know the wear behaviour on the prepared specimens. Wear test is conducted on base alloy, composites containing 3 and 6 wt. % of B_4C particulates. Cylindrical specimens (both alloy and composites) of 8mm diameter and 25mm height were used as test samples. The specimen end surfaces were polished metallographically. Wear studies were conducted under varying conditions of load and sliding velocities. Measurement of wear loss of the pin was used to evaluate the volumetric loss (VL) during the wear test. Load was varied from 2 to 4Kg while the disc speed varied from 200 to 4000rpm. A track radius of 60 mm and sliding distance of 2000mm had been used for all the experiments .All the tests were conducted in air at room temperature. The weight loss method was used to calculate the wear rates. The wear rates of all the specimens were obtained.

Volumetric wear loss is calculated by:

VL = (initial weight – final weight)/density of the material

Wear rate is obtained by:

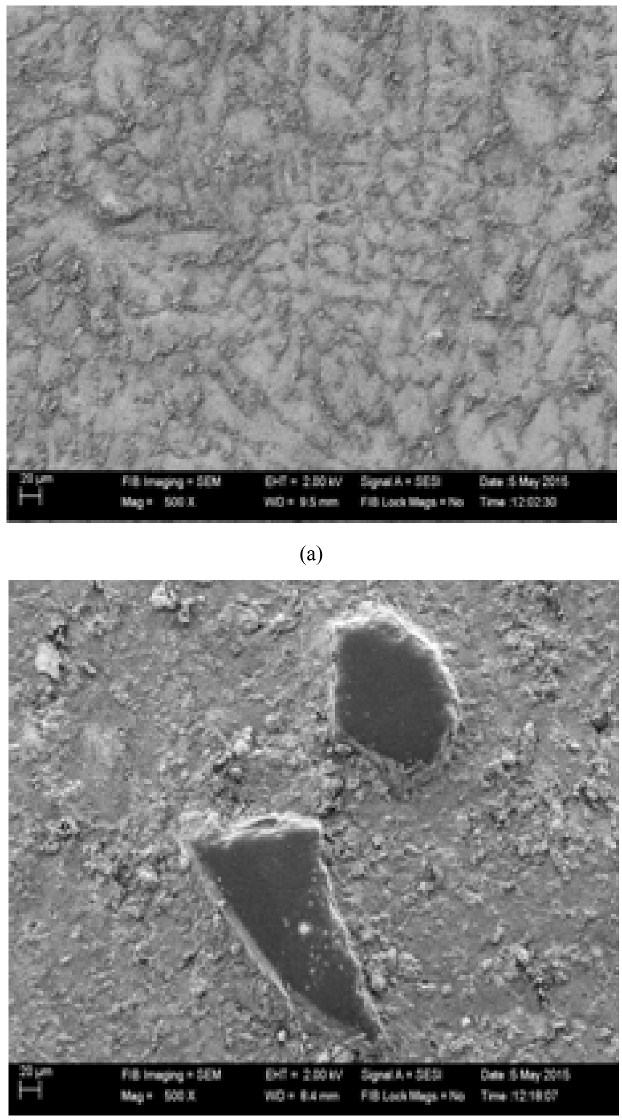
Wear rate = V/ (L*N)

Where V is the volumetric loss, L is sliding distance and N is normal load.

3. Results and Discussion

3.1. Microstructure

Microstructure for different samples was studied using scanning electron microscope. Figure 1 (a)-(b) shows microstructure of as cast Al7025 and Al7025 with 6wt% B_4C particulates where microstructure was viewed under scanning electron microscope. Figure 1(b) reveals the distribution of B_4C particulates in specimens and it can be observed that there is fairly uniform distribution of particles. Excellent bonding between the matrix and the reinforcement is observed.



(a)

(b)

Figure 1. Showing the SEM microphotographs of (a) as cast Al7025 alloy (b) Al7025-6% B_4C composite

3.2. Wear Properties

3.2.1. Effect of Load on Volumetric Wear Loss and Wear Rate

The load on wear test plays an important role in wear. Several experiments are carried out to observe the effect of normal load on wear rate of aluminium. To study the effect of load on wear, graphs were plotted for volumetric wear loss against varying loads of 2kg, 3kg and 4kg at a constant speed of 300 rpm. Similarly for wear rate the graphs were plotted. All the tests were carried out at room temperature. From Figures 2 & 3, it is observed that volumetric wear loss and wear rate increases with the increase in load. The hard B_4C particles increases the wear resistance of the composite materials, resists the cutting action of the pin surface, which results in low material removal from the pin surface. The wear rate increases with increasing applied load in all conditions. B_4C particles act as load bearing element.

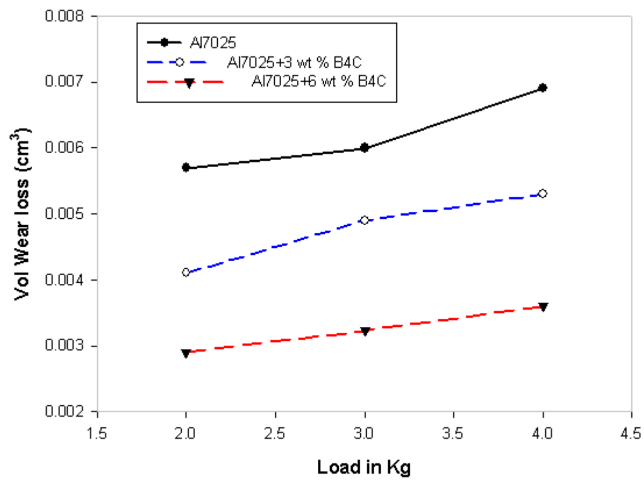


Figure 2. Volumetric wear loss Vs Load at 300 rpm

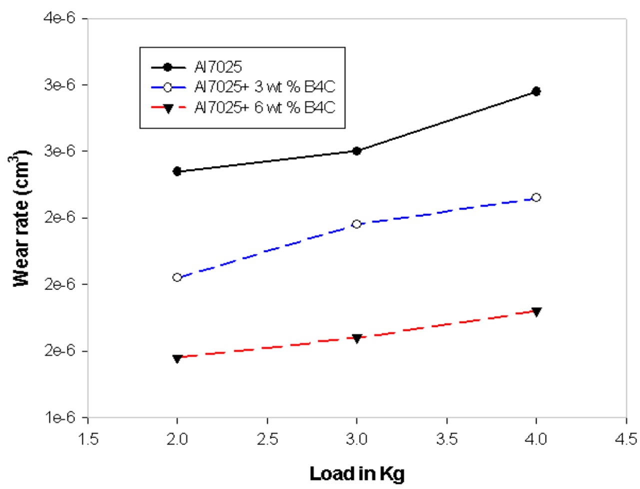


Figure 3. Wear rate Vs load at 300 rpm

3.2.2. Effect of Disc Speed on Volumetric Wear Loss and Wear Rate

Figures 4 & 5 shows the variation of volumetric wear loss and wear rate with the variation of speed. The test was conducted with varying disc speed of 200 rpm, 300 rpm and 400 rpm at a constant load of 3 kg. From this figure 5 it is observed that wear rate increases with the increase of sliding speed. For base alloy the effect is more compared to B_4C reinforced composite.

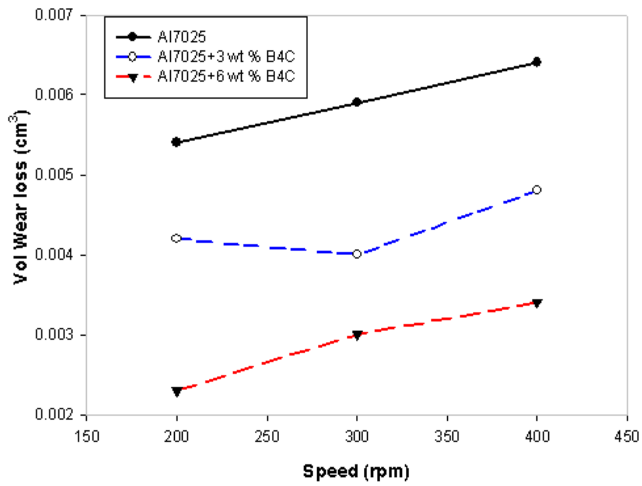


Figure 4. Volumetric wear loss Vs Speed at 3 kg load

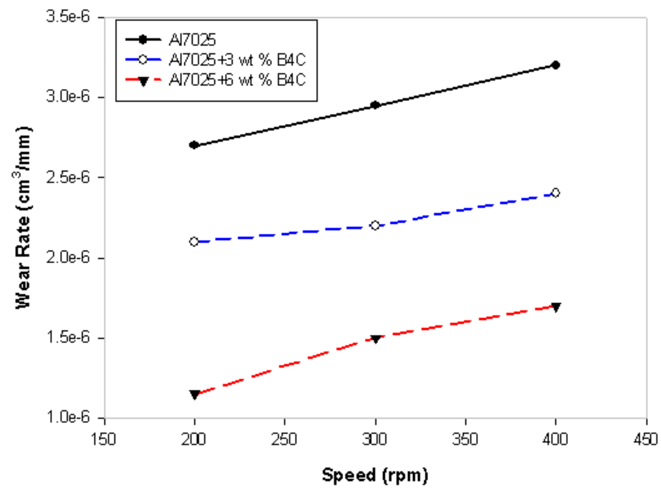
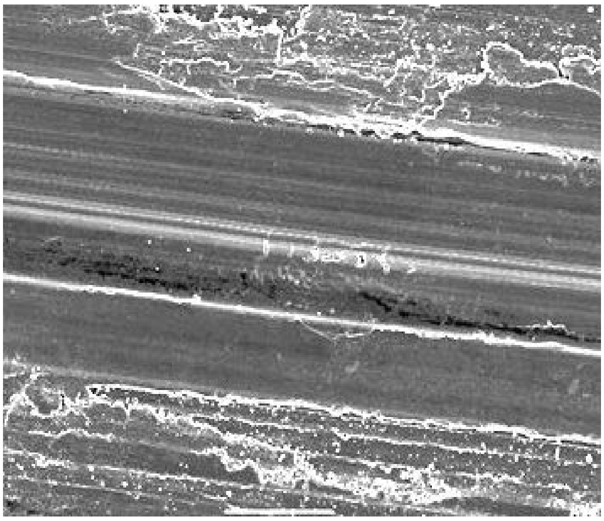


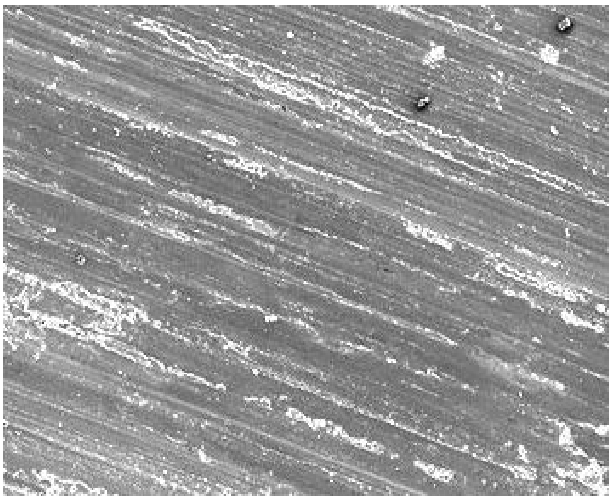
Figure 5. Wear rate Vs Speed at 3 kg load

3.3. Worn Surface Morphology

Scanning electron microscopy was done on base alloy Al7025 and Al7025+ 6 wt. % of B_4C composite samples. Figure 6 indicates the surface morphology after wear testing on base alloy Al7025 and 6 wt. % of B_4C composite specimen. The images support the argument that addition of hard B_4C particles improved the wear resistance of composites. It is clear from the Fig. 6 that the wear tracks and surface delamination are evident. Wear track is observed in case of Al7025, indicates the abrasive wear mechanism. Due to high temperate and friction, only oxide wear has taken place. The wear resistance is more in case of (Al7025+ B_4C) composites alloy. The results revealed that the composites with B_4C particulates have better wear resistance property compared to base alloy.



(a)



(b)

Figure 6. SEM microphotographs of worn suface of (a) as cast Al7025 alloy (b) Al7025-6% B_4C composite at 3 kg load and 300rpm

4. Conclusions

The present work on processing and evaluation of Al7025-B_4C metal matrix composite by melt stirring has led to following conclusions. Al7025 alloy based composites have been successfully fabricated by melt stirring method. The scanning electron microphotographs of composites revealed fairly uniform distribution of reinforcement particulates in the Al7025 alloy metal matrix. The addition of B_4C particles to Al7025 alloy matrix improves the wear resistance of the composite. The wear rate is dominated by load factor and sliding speed. The increase of loads and sliding speeds leads to a significant increase in the volumetric wear loss and wear rate. The Al7025-3 & 6 wt. % of B_4C composites have shown lower rate of wear as compared to that observed in as cast Al7025alloy matrix.

REFERENCES

[1] Sridhar Raja, K. S., V.K. Bupesh Raja, V. K., 2014, Effect of boron carbide particle in wear characteristic of cast aluminium A356 composite, IOSR Journal of Mechanical and Civil Engineering, 73-77.

[2] Rama Rao, S., Padmanabhan, G., 2012, Fabrication and mechanical properties of aluminium-boron carbide composites, International Journal of Materials and Biomaterials Applications, 2(3): 15-18.

[3] Cun-Zhu Nie, Jia-Jun Gu, Jun-Liang Liu, Di Zhang, 2007, Production of boron carbide reinforced 2024 aluminium matrix composites by mechanical alloying, Materials Transactions, Vol. 48, No. 5, 990-995.

[4] Saikeerthi, S. P., Vijayaramnath, B., Elanchezhian, C., 2014, Experimental evaluation of the mechanical properties of aluminium 6061- B_4C-SiC composite, International Journal of Engineering Research, 3, 70-73.

[5] Baradeswaran, A. Elaya Perumal 2013, Influence of B_4C on the tribological and mechanical properties of Al 7075–B_4C composites, Composites: Part B, 54, 146–152.

[6] Danny, C., Halverson Aleksander, J., Pyzikandllhan, A., Aksay William, Snowden, E., 1989, Processing of boron carbide-aluminium composites, J. Am. Cerum. SOC., 72 (5), 775-780.

[7] Yusof Abdullah, Mohd Reusmaazran Yusof, Azali Muhammad, Nadira Kamarudin, Wilfred Sylvester Paulus, Roslinda Shamsudin, Nasrat Hannah Shudin and Nurazila Mat Zali, 2012, Al/B_4C composites with 5 And 10 wt% reinforcement content prepared by powder metallurgy" Journal of Nuclear and Related Technologies, Vol. 9, No. 1.

[8] Vijaya Ramnath, C., Elanchezhian, M., Jaivignesh, S., Rajesh, C., Parswajinan, Siddique Ahmed Ghias, 2014, Evaluation of mechanical properties of aluminium alloy–alumina–boron carbide metal matrix composites, Materials and Design, 58, 332–338.

[9] Thirumalai, T., Subramanian, R, Kumaran, S., Dharmalingam, S., SRamakrishnan, S., 2014, Production and characterization of hybrid aluminium matrix composites reinforced with boron carbide (B4C) and graphite, Journal of Scientific & Industrial Research, 73, 667-670.

[10] Jiang, Q. C., Ma, B. X., Wang, H. Y., Wang, Y., Y.P. Dong , Y. P., 2006, Fabrication of steel matrix composites locally reinforced with in situ TiB_2–TiC particulates using self-propagating high-temperature synthesis reaction of Al–Ti–B4C system during casting, Composites: Part A, 37 133–138.

[11] Fevzi Bedir., 2007, Characteristic properties of Al–Cu–sicp and Al–Cu–B_4Cp composites produced by hot pressing method under nitrogen atmosphere, Materials and Design, 28 1238–1244.

[12] Ozkan Sarikaya, Selahaddin Anik, Salim Aslanlar, S., Cem Okumus, Erdal Celik, 2007, Al–Si/B_4C composite coatings on Al–Si substrate by plasma spray technique, Materials and Design, 28, 2443–2449.

[13] Fatih Toptan, Ayfer Kilicarslan, Ahmet Karaaslan, Mustafa Cigdem, Isil Kerti, 2010, Processing and microstructural

characterisation of AA 1070 and AA 6063 matrix B_4Cp reinforced composites, Materials and Design, 31, S87–S91.

[14] Ali Yazdani, E., Salahinejad, 2011, Evolution of reinforcement distribution in Al–B4C composites during accumulative roll bonding, Materials and Design, 32, 3137–3142.

[15] Auradi, V., Rajesh, G. L., Kori, S. A., 2014, Processing of B4C Particulate Reinforced 6061Aluminum Matrix Composites by melt stirring involving two-step addition, Procedia Materials Science, 6, 1068 – 1076.

[16] Rajesh, G. L., Auradi, V., Umashankar, Kori, S. A., 2014, Processing and evaluation of dry sliding wear behaviour of B_4Cp reinforced aluminium matrix composites, Procedia Materials Science, 5, 289 – 294.

[17] Vijaya Ramnath, C., Elanchezhian, M., Jaivignesh, S., Rajesh, C., Parswajinan, A., Siddique Ahmed Ghias, 2014, Evaluation of mechanical properties of aluminium alloy–alumina–boron carbide metal matrix composites, Materials and Design, 58, 332–338.

[18] Ruixiaozhenga, n, Jingchen, Vitanzhang, Keiameyama, Chaolimaa, 2014, Fabrication and characterization of hybrid structured al alloy matrix composites reinforced by high volume fraction of B_4C particles, Materials Science & Engineering A, 601, 20–28.

[19] Madeva Nagaral, Auradi, V., Kori, S. A., 2014, Dry sliding wear behavior of graphite reinforced Al6061 alloy composites, Applied Mechanics and Materials, 592-594, 170-174.