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Optimization of the wear resistance of AA2024 matrix composites fabricated with hot pressing

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ABSTRACT

Purpose: In the present study, the effects of B_4C reinforcement volume fraction (% 5-15-20) on the abrasive wear properties of AA2024 matrix composites produced with hot pressing methods were investigated.

Design/methodology/approach: As-received samples were also used for comparison. AA 2024 powder was mixed with B_4C-SiC-Al_2O_3 particles by a three dimensional mechanic mixer for 30 minutes. Mixed powder was pressed under 60 MPa at room temperature in the steel mold by unidirectional. Steel mold kept in the furnace at 550°C after the pre-pressing for 30 minutes. Samples were pressed in heated mold under 100 Pa. The wear tests were carried out using a pin-on-disk wear tester by sliding at sliding speeds of 1.2 m/s against silicon carbide paper. Normal loads of 10, 20 and 30 N at constant sliding speed at room temperature.

Findings: The experimental result showed that B_4C volume fraction significantly influence the wear behavior of AA2024 matrix composites produced with hot pressing methods.

Originality/value: It was also found that the wear resistance of AA2024 matrix composites produced with hot pressing methods increases with increasing B_4C volume fraction. The highest weight loss was obtained in the unreinforced matrix material.

Keywords: Metal Matrix Composite; AA2024; B_4C; Hot pressing

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PROPERTIES

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1. Introduction

Because of their high mechanical properties and low cost Aluminium Matrix Composites (AMCs) reinforced with ceramic particles have been extensively selected in automotive and aerospace industries [1-3].

The addition of an appropriate level Al_2O_3 SiC increased the wear performance of the AMCs [4-8]. Lee et. al investigated the effect of porosity, volume fraction and size of SiC particles on the abrasion resistance of powder metallurgy aluminium alloy matrix composites was investigated. The experimental result showed that wear resistance of the aluminium alloy decreased drastically with increasing porosity and wear resistance increased with increasing SiC rate [9].

B_4C is one new reinforcing materials used in AMC [10-14]. Tan et.al [4] studied to the effects of sliding speed and applied load on dry sliding friction and wear properties of that the AMC. Result showed that containing B_4C particulates exhibited improved wear properties. B_4C content is generally below 15 wt.% in the metal matrix composite [9-12].

Most of the studies focus on the mechanical properties of B_4C reinforced Al matrix composite [12-15]. A few research study the effects of reinforcement content on the wear resistance of B_4C reinforced Al matrix composite produced with hot pressing method [16].

In the present work, the effects of B4C content (5, 15 and 20 wt.%) on the abrasive wearing properties of AA2024 matrix composites produced with hot pressing methods were investigated.

2. Material and method

AA2024 was used for matrix material in the present study. The chemical composition of alloy is given in Table 1.

Table 1.
Chemical composition of Al6061 alloy

Element wt. %	Si	Mg	Cu	Cr	Fe
	0.5	1.2-18	3.8-4	0.10	0.5
	Ti	Zn	Mn	Al	
	0.15	0.25	0.3-09	Rest	

Schematic representation of AMC composite fabrication by hot pressing is shown Fig. 1 AA2024 alloy powders mixed with B_4C content 5, 10 and 15 wt.%. As-received samples were also used for comparison. AA 6061 powder was mixed with B_4C particles by a three dimensional mechanic mixer for 30 minute. Mixed powder was pressed under 100 MPa at room temperature in the steel mould by unidirectional. Steel mould kept in the furnace at 550°C after the pre-pressing for 30 minutes. Samples were pressed in heated mould under 100 MPa. The final billets were 30 mm in diameter T6 heat treatment was applied for all samples to increase strength.

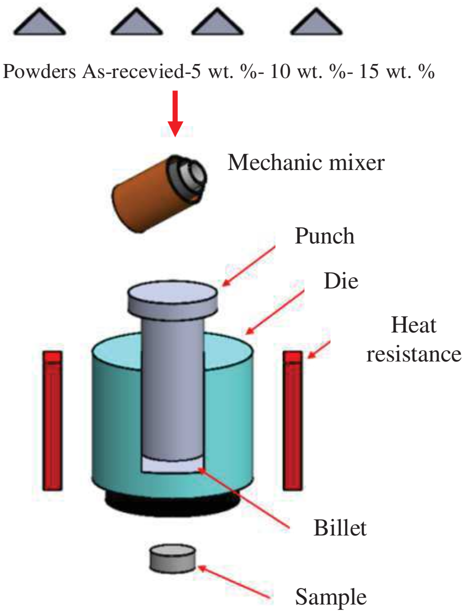

Fig. 1. Schematic representation of AMC composite fabrication by hot pressing

The wear tests were carried out by a pin-on-disk wear-testing device according to ASTM G132-96. Samples surfaces were grounded with 80 SiC paper for removing rough surface than the ACM test pin, with a diameter of 10 mm, was fixed and counterface abrasive disk (abrasive paper 150 grit) during the test. The wear test was performed in distance 100, 200 and 300 m, at speed of 1.2 m/s and with imposed load of 5, 10 and 15 N. Prior to measuring, samples were cleaned in acetone for cleaning of surface contaminants, dried and then weighed using an electronic balance having a resolution of 0.001 mg.

Surface roughness measurements were performed by using a “Mahr Perthemoter M1” with a cut-off length of 0.8 mm.

3. Results and discussion

3.1. Effect of the sliding distance and load on the weight loss of AMC

Variation in weight loss as a function of sliding distance, B_4C content and load are given in Figures 2-5. As-received samples showed the highest weight (Fig. 2). The result can be explained with lower hardness of sample. Similar phenomena have also been observed in the previous studies [6-9]. It can be clearly seen that the reinforcement content influence the wear performance of aluminium composite. The weight loss decreases with increasing B_4C content (5, 10 and 15 wt.%). The result clearly reveals that matrix and reinforcement have good wetting ability for all content. The 15 % B_4C sample have the highest hardness value. Therefore, the lower weight loss was obtained at 15 wt.% B_4C reinforced samples. The superior wear resistance can be explained by higher hardness. The sliding distance and load significantly influence the weight loss. The weight loss increases with increasing sliding distance and load.

Load and distance conditions define the wear mechanisms [12-14]. Contact time between the wear surfaces is increased with increasing sliding distance. Therefore, higher weight loss was obtained higher sliding distance.

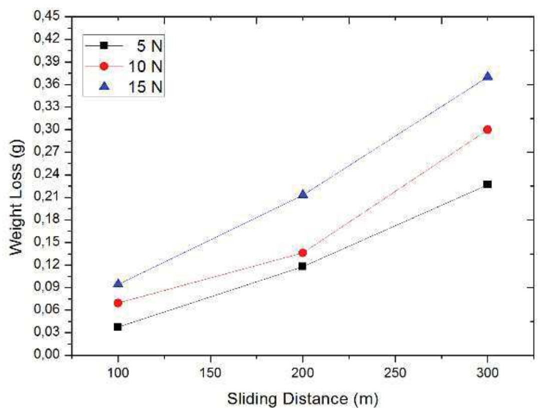

Fig. 2. Variation in weight loss as a function of sliding distance at as-received materials

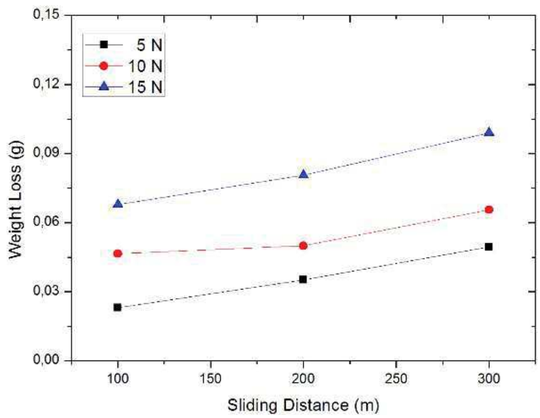

Fig. 3. Variation in weight loss as a function of sliding distance at 5 wt.% B_4C materials

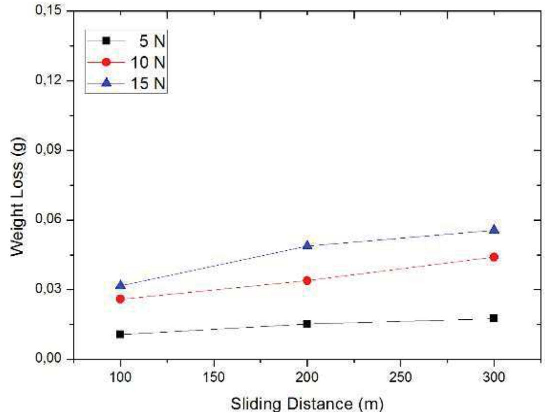

Fig. 4. Variation in weight loss as a function of sliding distance at 10 wt.% B_4C materials

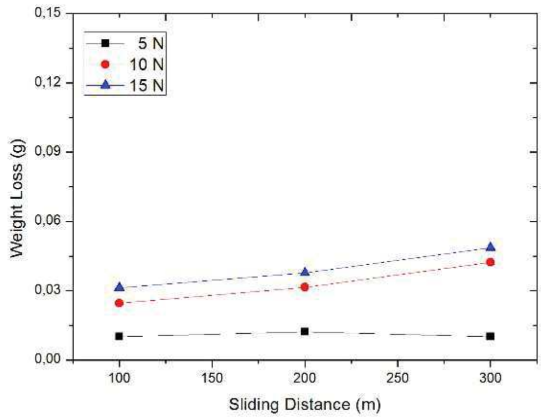

Fig. 5. Variation in weight loss as a function of sliding distance at 15 wt.% B_4C materials

3.2. Hardness and surface roughness

Hardness and surface roughness are the key parameters used for evaluation of wear behaviour. Surface roughness of worn surface were examined. Surface roughness's of worn surface are given in Figure 6. As-received sample showed the highest surface roughness. The result can be attributed to lower hardness [10-12]. The variation of hardness with respect to B_4C rate is given in Table 2. Hardness increase with increasing B_4C rate. The highest hardness was obtained at 15 wt.% sample. It can be seen that hardness, B_4C rate and surface have good correlation. Similar results have also been observed in the previous studies [11-12].

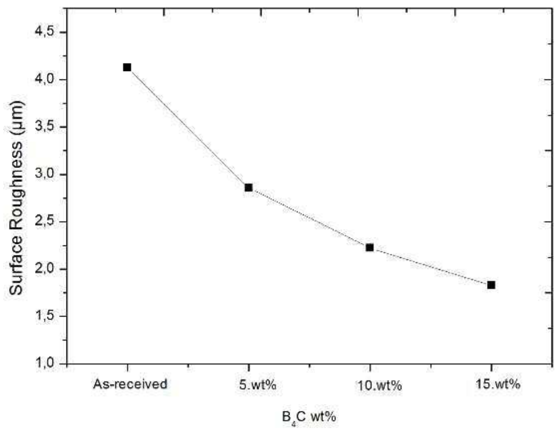

Fig. 6. Surface roughness of all experiment samples

Table 2.
Hardness values of all experiment samples.

Material	Al 2024	5 wt.%	10 wt.%	15 wt.%
Hardness (BHN)	85	108	123	135

4. Conclusions

The effects of B_4C content (5, 15 and 20 wt.%) on the abrasive wearing properties of AA2024 matrix composites produced with hot pressing methods were investigated in the present work, The highest wear resistance was obtained at 15 wt.% B_4C reinforced samples. The highest hardness was obtained at 15 wt.% sample. Hardness, B_4C rate and surface have good correlation. The highest surface roughness was obtained at as-received sample showed. The wear resistance of AA2024 matrix composites produced with hot pressing methods can be improved with controlling B_4C rate.

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