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TRIBOLOGICAL BEHAVIOUR OF ALUMINIUM COMPOSITES

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ABSTRACT

In this study tribological behavior of Aluminum metal powder composite reinforced with SiC particles has been evaluated experimentally prepared by Powder Metallurgy route. Four number Cylindrical preforms (SiC-0 wt. %, 5wt. %, 8 wt. %) at a compaction pressure of 120 KN were prepared using a die and punch assembly on a Universal Testing Machine. The sliding wear behavior of cylindrical sample diameter 12mm was performed on a pin-on-disc wear tester against an EN- 32 steel disc (10 KN applied the load, distance 2300 M at 300 rpm) under dry ambient conditions. Hardness is measured using Rockwell's Hardness machine at 100 kg load applied at ball point. The microstructural characterization done by Scanning Electron Microscopy (SEM) to investigate the grain structure. Densification and hardness of specimen are increased with the increase of SiC percentage and sintering temperature. Wear decreases with the increase of SiC contents and sintering temperature when experimented. SEM test confirm uniformly distribution of SiC particles in Al matrix.

KEYWORDS: Aluminum (Al); Silicon Carbide (SiC); wear properties; sintering temperature; hardness, density, porosity, SEM analysis

1. INTRODUCTION

Composites are the materials having superior mechanical properties and light in weight. Epoxies and polyester commonly serves as a matrix material. The reinforcing fibers are usually graphite, glass, boron, etc. New developments concerns are in metal matrix and ceramic composite materials. Ceramics-matrix cutting tools are being developed, made of silicon carbide reinforced alumina, with greatly improved tool life. A composite material contains more than one component. The compound materials are amalgamated into the composites so as to take the advantage of their attributes, thus providing an improved version of the material. Cohesive structures form by physically combining the two or more than two compatible materials. Reinforced fibre composites are materials prepared heterogeneously by associating and bonding the material in a single structure possessing different properties. Due to the complementary properties generated by the forming of two or more materials develops additional and superior properties in it.

Sintering: It's a process by which we provide the strength and decrease the porosity of the green material by giving the heat treatment without achieving its point of liquefaction in a controlled atmosphere of Hydrogen or vacuum; sometimes when there's a non-availability of Hydrogen or vacuum, air can also acts as a working medium because air contains 78.09 % Nitrogen which almost behave as an inert but it's not an inert gas. Normally sintering temperature can be taken as 0.6 to 0.75 of the melting point of the sintering material. Different sintering processes are available, each processes have their own characteristics and mode of their application.

Wear: Wear is progressive slow removal of material while the mating surfaces are in relative motion. Wear phenomena is closely related to friction; in friction forces are generated because of two main physical processes i.e. Shearing and Ploughing. If solid surfaces meet each other without any aid of medium i.e. lubricant, wear happen. Where there lubricants came in scenario, it became a part of tribology. But here we are dealing with wear generated by solid to solid dry contact of the surfaces.

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2. LITERATURE REVIEW

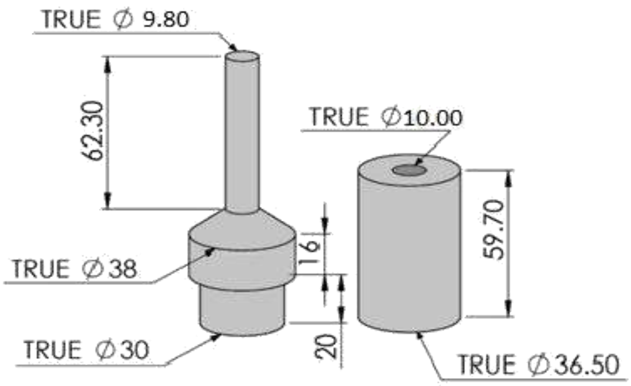
M. A. Salem et al. (2017) analyzed the impact of the Al lattice, SiC sizes and the SiC volume part on the microstructure development, mechanical properties of the composites. They worked on Al-SiC MMCs by taking different sizes, and volume parts were manufactured using ball milling machine and powder metallurgy. Al and Al-SiC composites of various volume fractions were processed for 120 hours and then, the Al and Al-SiC composites were compact under 125 MPa and then sintered at 450 °C. Then he measured the thermal conductivity, electrical resistivity and micro hardness analysis of the prepared composite samples. He conclude as we decrease the size of Al-SiC particle and increases the volume of Al-SiC will decrease the properties of the MMC's. On the other side micro hardness was increased when we took the small particle size of Al-SiC and increases their volume fraction.

Ashok Kumar Mishra and Rajesh Kumar Srivastava (2016) he studied the wear resistance and coefficient of friction on Aluminum Al-6061 reinforced with SiC particles of 150 and 600 mesh size and taking the weight fraction varying from 5%,10%, 15%, 20%, 25%, 30%, 35%, 40%. The tested the dry sliding wear properties using pin on disk wear tester using velocity at 2m/s and sliding distance of 2000m with applied load of 10, 20 and 30KN. He commented that wear increases with increase in load and sliding distance and coefficient of friction decreases with increases in weight percentage of reinforcement. He also said that wear will reduce till 35% weight fraction only. He analyzed the wear surfaces by optimal microscopy. And he obtained the best result with 35% SiC having 600 mesh size.

E. Gewfiel et al. (2012), analyzed the effects of Graphite and SiC formation on mechanical and wear properties of Aluminum-Graphite composite. Gewfiel took pure Aluminum and Silicon carbide with five weight percentages (1, 2, 3, 4, 5 wt %) of natural graphite flakes treated it with multiple process until they show uniform distribution with no acidity. For comparison he also prepared pure aluminum samples with the same process, and then he analyzed thermal properties, phase transformation, crystalline size, microstructure, composition, hardness and wear of the composite samples. And he confirmed that increasing the graphite concentrations reduces the wear rate to a good extent.

3. EXPERIMENTAL SETUP

For preparing the samples of the composite material, first the well-defined combination of powder performs a die and punch has been manufactured by turning the die steel on lathe then tempered the punch for withstanding the high load applications. The pin on disc machine has a pin holder of capacity varying from 6 mm to 12 mm. As the powder preforms should have sufficient contact area with the disc the pin diameter was decided as 10 mm. The figure below shows the photograph of the die and punch.



All dimension are in mm

Fig. 1. Die and Punch Setup

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Design of Experiments

Selection of sintering temperature: These three sintering temperature were used for the experimental work. Because the melting point of the Aluminum metal is around 660.32°C. So we work just below the recrystallization temperature. So as our powder don't get melt away and also do not recrystallize its structure.

T1= 480°C
T2= 500°C
T3= 520°C

Selection of Silicon Carbide content (weight percentage)

(SiC) 1 = 0%
(SiC) 2 = 5%
(SiC) 3 = 8%

Fig. 2. Sample and Optical Microscope

4. RESULTS & DISCUSSION

Wear and Friction Test

The samples are then tried to dissect the wear and Friction conduct on the Aluminum Metal Matrix Composite material additive with Silicon Carbide preforms in dry sliding condition. This experimentation is being completed on a Pin-On-Disk Wear testing machine.

The Pin on Disc Machine

This test strategy depicts a research center technique for deciding the wear of materials amid sliding utilizing a Pin-on-Disc device. Materials are tried in sets under ostensibly non-rough conditions. The key territories of trial consideration in utilizing this kind of device to measure wear are portrayed. The coefficient of Friction may find additionally. For the stick on-circle wear test, samples are required. One, a stick with a radius tip, is situated opposite to the next, as a rule a level roundabout circle. A ball, unbendingly held, is frequently utilized as the stick sample. The test machine causes either the plate sample or the stick sample to rotate about the disk center. In either case, the sliding way is a circle on the disk surface. The plane of the circle might be situated either on a level plane or vertically.

Hardness comparison at different SiC %'s

For T1 temperature (Where T1 = 480°C)

The hardness of 5%, 8% and 11% SiC as compared to that of Pure Aluminum (or 0% SiC) is 7%, 18%, 21% higher respectively.

For T2 temperature (Where T2 = 500°C)

The hardness of 5%, 8% and 11% SiC as compared to that of Pure Aluminum (or 0% SiC) is 6%, 13%, 19% higher respectively.

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For T3 temperature (Where T3 = 520°C)

The hardness of 5%, 8% and 11% SiC as compared to that of Pure Aluminum (or 0% SiC) is 3%, 6%, 11% higher respectively.

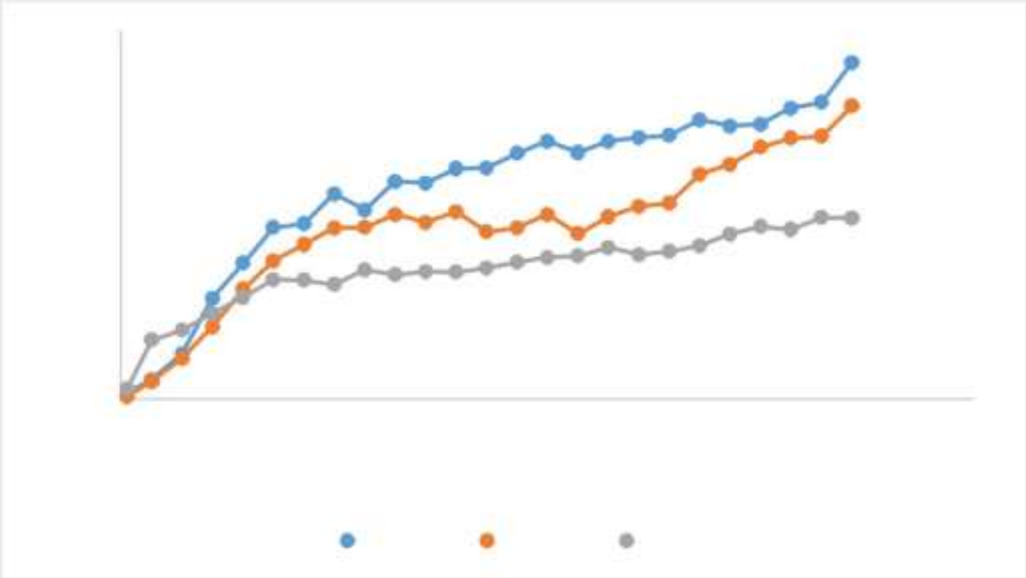

Fig. 3. Wear rate for 5% SiC at different temperature

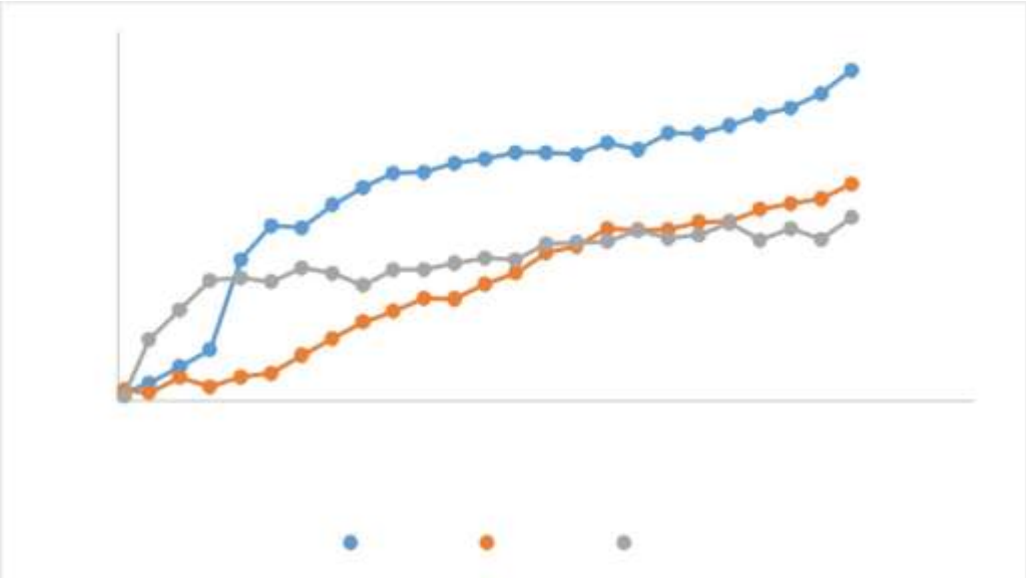

Fig. 4. Wear rate for 8% SiC at different temperature

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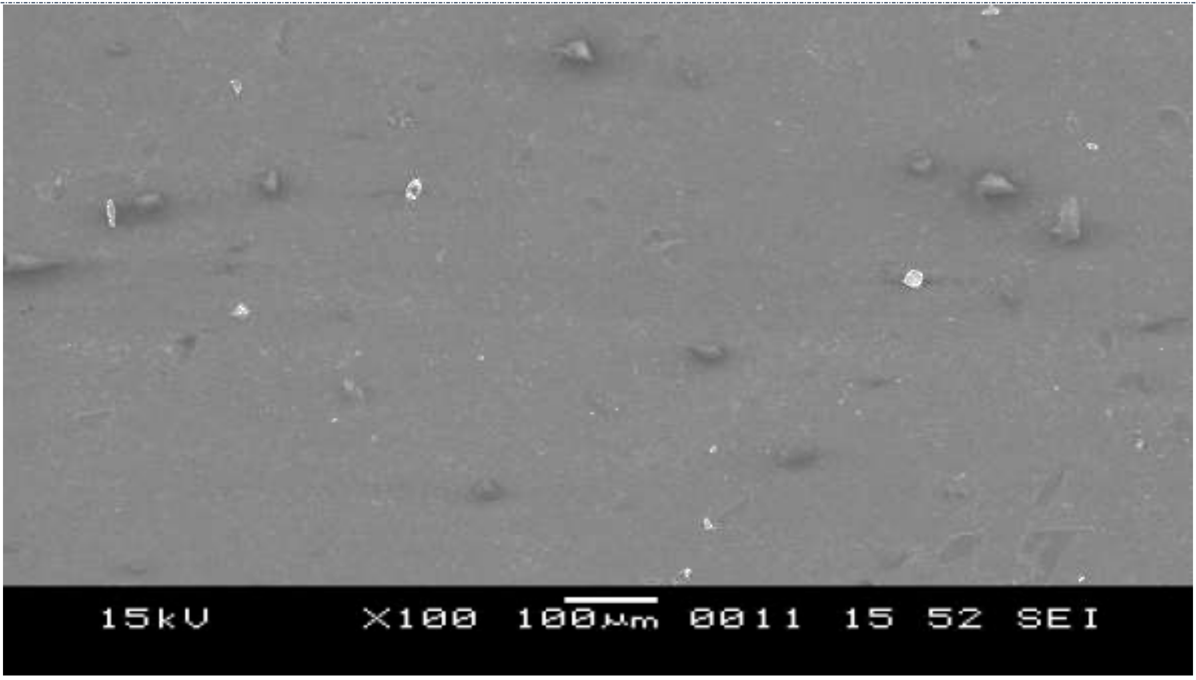

Fig. 5. SEM image for 5% SiC

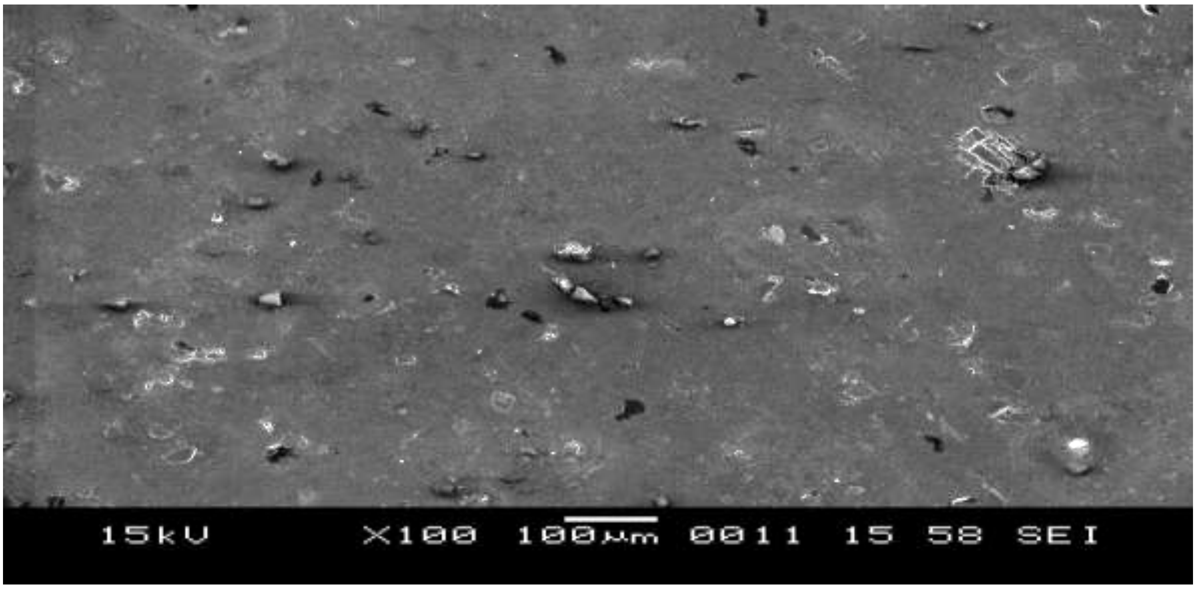

Fig. 6. SEM image for 8% SiC

In this work, wear, porosity, density and microstructure of Al-SiC composite were investigated. Result shows that wear is strongly depends on SiC contents and sintering temperature was found that:

- Specimen at 520°C confirms minimum wear and minimum COF as compared to 500°C and 480°C.
- Specimen at 8% SiC confirms minimum wear as compared to 0 % and 5%.
- Specimen at 8% SiC confirms minimum COF due to less wear as compared to 5 %.
- Hardness and density increases with increasing with SiC and sintering temperature.
- At 8% SiC content confirms dense structures compared to 0 % and 5%. Density increases from 480°C to 520°C.

In Micro cracks and porous microstructure was seen in Al-5% Silicon Carbide composite, but porous structure and micro cracks reduces in Al-8% Silicon Carbide. Black region represent Al matrix and white color represent Dispersion of Silicon Carbide particle. Silicon Carbide particle are dispersed uniformly. In Al-5% Silicon Carbide and Al-8 % Silicon Carbide matrix.

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