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COMPARATIVE WEAR BEHAVIOUR OF AL6063 WITH SIC AND NANO SIC METAL MATRIX COMPOSITES

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ABSTRACT

The current paper investigates the wear behaviour of sic and nano sic reinforced with aluminium metal matrix composites were prepared by stir casting method. In this method five sets of both the Al mmc's were produced with incorporating 2,4,6,8 and 10 wt% of sic and nano sic particulate Aluminium composites, due to increase in weight percentage of sic and nano sic particulates reduces the fracture toughness, which results in higher wear rate. Plots depict that increase in % reinforcement of sic and nano sic reduces wear up to around 5 to 7% and beyond this the wear has a tendency to increase for Al composites. Pin on disc wear tests were conducted and the results were gives the effect of increasing sic with Aluminium increases wear rate.This work focuses on developing an Aluminium metal matrix composite (AMMC) material for turbocharger components made by wrought aluminium alloy with various weight fractions of aluminium silicon carbide and nano silicon carbide composites in order to make five different forms of metal matrix composites comparison on wear behaviour were discussed.

Keywords: aluminium, Nano SiC, metal matrix composite, stir casting, wear.

1. INTRODUCTION

In Recent times there are several researchers have been carried out to prepare al mmcs reinforcements of different materials because al mmc's are widely used in the emerging fields such as aerospace marine and automotive industries due to its light weight material alizadeheta l[1]investigated mechanical properties and wear behaviour of al-2% cu alloy composites reinforced by b4c particles ,the outcome of the experiment shows that the reinforcement of b4c reduces the wear rate and increased mechanical properties. Bharath*et al* [2] evaluated the mechanical and wear properties of 6063 Al-Al2o3 mmcs prepared by stir casting .the study shows the decreasing scenario of wear rate with increase in weight percentage of al2o3 upto 12% weight fractions. Balanarasimha*et al* [3] investigation focuses on preparing hybrid metal matrix composites alloy for wear and frictional properties of MMHC by varying 3% to 9% of graphite. The study indicates that on increase in %of reinforcement wear rate and co-efficient of friction decreases. Johnyjames*et al* [4] investigates the machining and mechanical properties of the hybrid aluminium metal matrix composites. This study shows the addition of reinforcement of sic and TIB2 the wear resistance behaviour was increased. Rajesh *et al* [5] investigates the dry sliding wear behaviour of graphite reinforced Aluminium MMC's. The results indicates the sliding distance for WVL, sliding distance and reinforcement of 5% of COF was found to be most effective factor among the control parameter on dry sliding wear. Alimazahery*et al* [6] studied the wear test under dry sliding conditions at different specific loads. It shows that the composite with the lowest matrix hardness displays the lowest wear rate.

The aim of current study is to compare the reinforcement of sic and nanosic in to Al 6063 on friction and wear behaviours for five different weight percentages.

Aluminium alloys are widely used in a large number of industrial applications due totheir excellent combination of properties, for example; good wear resistance, exceptional thermal conductivity, high strength to weight ratio, good tensile strength, and high ductility [7, 8]. Aluminium alloy are applicable for manufacturing automobile and aircraft components because of high strength to weight ratio in order to make the moving vehicle lighter, which results in saving in fuel consumption [9-12].

Hardness of the composites found increased with increased SiC content. And some authors; G.R.C. Pradeep, A. Ramesh, G.B. Veeresh Kumar studied that finer the grain size better is the hardness and strength of composites leading to lowering of wear rates [13] Most researchers agree that the wear rate of Al-Si alloys goes through a minimum at certain Si content. Silicon has received the most attention among all alloying elements studied. This is due to the fact that Al-Si alloys are corrosion resistant, strong, have low thermal expansion coefficients, and have superior tribological characteristics compared to the other aluminium alloys [14,15]. These alloys have been successfully used as substitutes for cast iron in applications such as pistons and cylinder linings for internal combustion engines [16], swash plates, connecting rods, and sockets in refrigerant compressors [17].The 6061aluminium alloy exhibited its potential to act effectively as a self lubricating material under dry sliding conditions recording a minimum wear rate and co efficient of friction at 5 Wt % and 15 Wt % graphite content respectively [18]. Earlier authors have reported that during dry sliding aluminium alloy graphite composite forms a layer of graphite with solid lubricant between the contacting surfaces [19]. This helps in reducing the friction and wear and post pones the onset of severe wear. The formation and retention of this lubricant layer, its thickness and hardness depends largely on the graphite

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content in the composite. Earlier works have also identified that with increasing graphite content richer graphite lubricating film formed on the lubricating surface lowers the wear rate [20].

In this paper, the material selection criteria involves the requirement of high strength and good corrosion resistance aluminium alloy for the matrix materials, and the inexpensive reinforcement particles which can result in increased ultimate tensile strength and hardness. The matrix materials used in the present work is Al 6063and the reinforcement materials are silicon carbide (SiCp) particulates of grain size 1000 mesh) 10% by wtand by virtue of which the tensile strength, hardness, and Al–SiC were evaluated. And effects of SiCp upper layer and lower layer of melted matrix in crucible were investigated in an attempt to understand the uniformity of SiC through-out the matrix.

2. EXPERIMENTAL DETAILS

The reinforced metal matrix composite material selected for present investigation was based on AL6063 matrix alloy source of materials in Table-1and its chemical composition is shown in Table-2. The matrix material used in the present investigation was pure aluminium .The different volume fraction of silicon carbide particulate aluminum alloy (6063) composite was used for this investigation. The equipment used includes a crucible furnace, stainless steel stirrer (powered by a motor), a thermocouple, and heat treatment furnace.

Table-1. Source of materials.

S. No.	Materials	Supplied by
1	Aluminum 6063	General Foundries Ltd. Bangalore.
2	Silicon carbide	Hindustan Traders .Chennai.
3	Nano Silicon carbide synthesis	High energy ball end mill equipment is utilized for synthesis of Silicon carbide at PSG Institute Of Technology, Coimbatore.

Table-2. Chemical composition of Al Alloy (6063).

Element	Composition	Element	Composition
Si	0.4430	Zn	0.0001
Fe	0.1638	Cr	0.0024
Cu	0.0041	Ti	0.0078
Mg	0.5382	Ca	0.0003
Mn	0.0132	Al	98.751

2.1 Synthesis of Silicon carbide

A High energy ball end milling is used as a type of grinder, it's a cylindrical device used in grinding materials likes ores, chemicals, ceramics raw materials and paints. Ball mills rotate around a horizontal axis, partially filled with the material to be ground plus the grinding medium. Different materials are used as media, including ceramic balls, flint pebbles and stainless steel balls. An internal cascading effect reduces the material to a fine powder.

2.2 Stir casting method

Stir casting was used to prepare the composites sic particles with the size of 500nm and with different weight fraction of 2,4,6,8 and 10 wt% were used as reinforcing materials for preparing A16063 mmcs First of all stirring system has been developed by coupling motor with gearbox and a mild steel stirrer as shown in Figure-1. All the melting was carried out in a graphite crucible in an oil-fired furnace. Scraps of aluminum were preheated at 450^{0}C for 3 to 4 hours before melting and mixing the SiC powdered particles were preheated at 1100^{0}C for 1 to 3 hours to make their surfaces oxidized. The furnace temperature was first raised above the liquids to melt the alloy scraps completely and was then cooled down just below the liquids to keep the slurry in a semi-solid state. At this stage the preheated SiC powdered particles were added and mixed manually. Manual mixing was used because it was very difficult to mix using automatic device when the alloy was in a semi-solid state. After sufficient manual mixing was done, the composite slurry was reheated to a fully liquid state

Figure-1. Stir casting furnace.

Figure-2. Stirrer used for reinforcement of AL6063+Nano SiC

2.3 SiC reinforced aluminium samples with different weight percentages

Figure-3. Different weight % of sic reinforced aluminium specimens.

Above figure shows the castsamples of Al-Sic matrix alloy and Al nanoSiCcomposites with different weight percentages.

Figure-4. Microstructure of Al6063+6%Sic.

Figure-4(a). Microstructureof Al6063+10% Sic.

From Figure-4 and Figure-4(a) it can be observed that, the distributions of reinforcements in respective matrix are fairly uniform. The ceramic phase is shown as dark phase, while the metal phase is white. Further these figures reveal the homogeneity of the cast composites. The microphotograph also clearly revels the increased filler contents in the aluminium metal matrix composites.

Reinforcement preheat temperature

Reinforcement was preheated at a specified 500 C temperature 30 min in order to remove moisture or any other gases present within reinforcement. The preheating of also promotes the wetability of reinforcement with matrix.

Addition of Mg

Addition of Magnesium enhances the wet ability. However increase the content above 1wt. % increases viscosity of slurry and hence uniform particle distribution will be difficult.

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Stirring time

Stirring promotes uniform distribution of the particles in the liquid and to create perfect interfacebond b/w reinforcement and matrix. The stirring time b/w matrix and reinforcement is considered as important factor in the processing of composite. For uniform distribution of reinforcement in matrix in metal flow pattern should from outward to inward.

Preheated temperature of mould

In casting porosity is the prime defect. In order to avoid these preheating the permanent mould is good solution. It will help in removing the entrapped gases from the slurry in mould It will also enhance the mechanical properties of the cast AMC. While pouring molten metal keep the pouring rate constant to avoid bubble formation.

Pin on disk apparatus for wear measurement

Figure-5. Pin on disk set up for wear measurement.

For the pin-on-disk wear test, two specimens are required. One, a pin with a radiused tip, is positioned perpendicular to the other, usually a flat circular disk. A ball, rigidly held, is often used as the pin specimen. The test machine causes either the disk specimen or the pin specimen to revolve about the disk centre. In either case, the sliding path is a circle on the disk surface. The plane of the disk may be oriented either horizontally or vertically. The pin specimen is pressed against the disk at a specified load usually by means of an arm or lever and attached weights. Other loading methods have been used, such as, hydraulic or pneumatic. Wear results are reported as volume loss in cubic millimetres for the pin and the disk separately. When two different materials are tested, it is recommended that each material be tested in both the pin and disk positions.

The amount of wear is determined by measuring appropriate linear dimensions of both specimens before and after the test, or by weighing both specimens before and after the test. If linear measures of wear are used, the length change or shape change of the pin, and the depth or shape change of the disk wear track (in millimetres) are determined by any suitable metrological technique, such as electronic distance gauging or stylus profiling. Linear measures of wear are converted to wear volume (in cubic millimetres) byusing appropriate geometric relations. Linear measures of wear are used frequently in practice since mass loss is often too small to measure precisely. If loss of mass is measured, the mass loss value is converted to volume loss (in cubic millimetres) using an appropriate value for the specimen density. Wear results are usually obtained by conducting a test for a selected sliding distance and for selected values of load and speed. One set of testconditions that were used in an inter laboratory measurement series. Other test conditions may be selected depending on the purpose of the test.

RESULTS AND DISCUSSIONS

Wear results may in some cases be reported as plots of wear volume versus sliding distance and time using different specimens for different distances. Such plots may display non-linear relationships between wear volume and distance over certain portions of the total sliding distance, and linear relationships over other portions. Causes for such differing relationships include initial "break-in" processes, transitions between regions of different dominant wear mechanisms, etc. The extent of such non-linear periods depends on the details of the test system, materials, and test conditions.

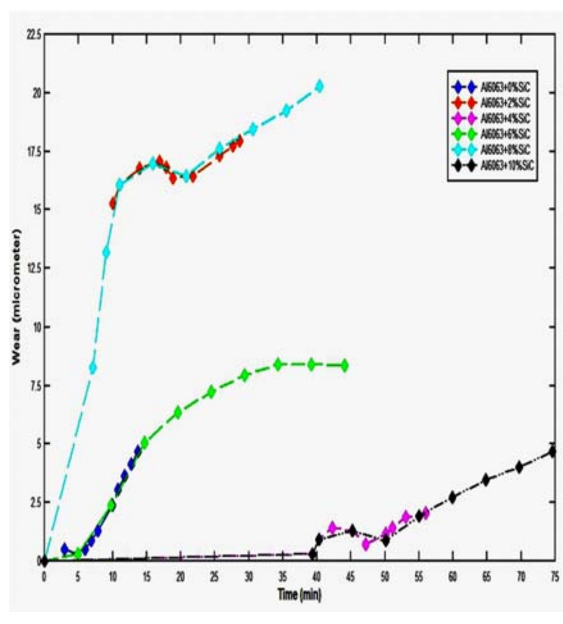

Figure-6. Comparative wear behaviour of Al6063 with different weight % of Sic.

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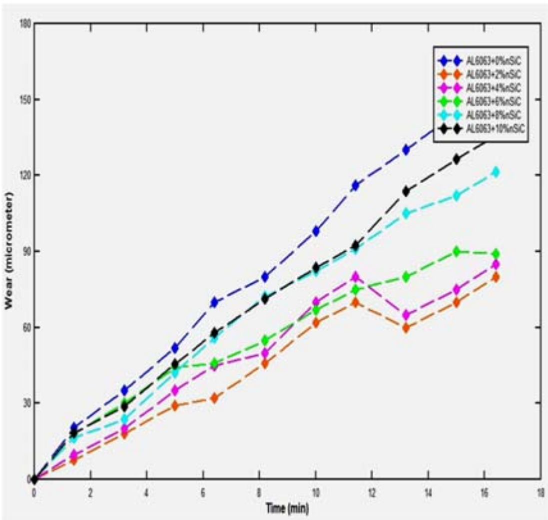

Figure-7. Comparative wear behaviour of Al6063 with different weight % of Nano Sic.

CONCLUSIONS

We evaluated standard uncertainty of the friction and the wear rate of thin films measured by pin-on-disc measurement. For this Aluminium (6063) is selected as matrix phase while SiC, Alumina and act as reinforcement. With the help of stir casting process we had successfully manufactured AMC at less cost. The main application of Al6063 is in the field where there is a greater chance of wear can takes place. So by replacing Al6063 alloy by this composite material we can reduce the wear to some extent and also we can increase life of the material. From the experimental the Al6063/SiC composite material has been successfully casted by using friction stir casting method. The wear resistance of the composite material increases with the addition of Nano silicon carbide content till 4% and then decreases.

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