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Research paper

Studies on Wear Behaviour of Aluminium 6061Alloy Reinforced with B_4C & Mica Particulates Hybrid Metal Matrix Composite

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Abstract

Hybrid Metal matrix composites are commonly used in Aerospace, Automobile industries because of its light weight, High tensile strength, high resistance to wear and improved specific strength. This is mainly due to improved mechanical and tribological properties like strength, stiffness, abrasion, impact resistance and wears resistance. In the present scenario, a lot of research activities were on automobile. This paper direct the researchers and engineer towards suitable selection of materials by its properties in the relevant area and various techniques involved in fabrication of metal matrix composites, predominantly on the liquid state metal processing method. In this work Al6061, Boron carbide, mica and hybrid Aluminium metal matrix composites are fabricated using Stir casting Techniques with varying mass fraction of mica 3%, 4%, 5% incorporated into the alloy, Sustaining the mass fraction of boron carbide as 10% for all proportions. Mica and B_4C ceramic particles were incorporated into Al 6061 alloy by stir-casting method. In Stir casting method of composite materials synthesis, a dispersed phase (ceramic particles, short fibers) is mixed with a molten metal matrix by means of mechanical stirring. The samples were studied using scanning electron microscope (SEM) one of the most useful instrument for future research to know its microstructure. This study emphasize on the dry siding wear behaviour of aluminium reinforced with 3%,4%,5% mica and constant quantity of 10% boron carbide hybrid composite using a pin on disc. Wear performance of the hybrid composites were evaluated over a different load ranges and at different sliding velocities.

Keywords: Hybrid metal matrix, Al 6061, B4C, Mica, Stir casting, SEM, Pin on disc [Tribometer].

1. Introduction

Metal matrix composite emphases mainly on an improved wear resistance, light weight, high tensile strength, improved specific strength application. From the literature it is clear that metal matrix composites are considered as potential materials and it is mainly used to replace conventional materials in automotive and aerospace application. With the increasing demand of light-weight materials in the emerging industrial application. A review of the literature has paved the way for the researcher to investigate the Wear properties of ceramic- mica reinforced hybrid composites. As there was no clear and specific investigation, have not been carried out to find the Wear properties of hybrid Al/ B_4C- mica composites. In this present study, B_4C reinforcement is added to the Al6061/mica composites. The Wear property of Al-6061/B_4C-mica composites and the detailed metallurgical Examination and Energy dispersive analysis is to be carried out. The main aim involved in designing metal matrix composites is to join the attractive attributes of ceramics and metals. The addition of refractory particles having high strength, high modulus to a ductile metal matrix produces a material, whose mechanical properties are in between the alloy matrix and the ceramic reinforcement. Aluminum is the third most abundant element next to oxygen and silicon. It makes up in relation to 8% by mass of the Earth's solid surface. Due to easy availability, High strength to weight ratio, easy machinability, durable, ductile and malleability. Aluminum is the most extensively used non-ferrous metal in 2005.

A composite material is a material made from two or more constituent resources with significantly diverse physical or chemical properties, when combined, produce a material with characteristics different from the individual components. The components stay behind separate and distinctive within the finished structure. The new material might be chosen for many reasons: common examples include resources which are stronger, lighter, or less expensive, when compared to the traditional materials. Composites are made up of individual materials referred to as ingredient resources. There are two major categories of essential materials: matrix and reinforcement. At least one portion of each type is required. The matrix material environs and supports the reinforcement materials by maintaining their relative positions.

The ultimate compressive strength of the composite was increase in the weight percentage of the boron carbide in the composites.

2. Aluminum

Aluminium has a density around one third that of steel and is used advantageously in applications where high strength and low weight are required. This includes vehicles where low mass results in greater load capacity and reduced fuel consumption.When the surface of aluminium metal is exposed to air a protective oxide

coating forms almost instantaneously. This oxide layer is corrosion resistant and can be further enhanced with surface treatments such as anodizing.
Aluminium is an excellent conductor of both heat and electricity. The great advantage of aluminium is that by weight, the conductivity of aluminium is around twice that of copper. This means that aluminium is now the most commonly used material in large power transmission lines.
The best alternatives to copper are aluminium alloys in the 1000 or 6000 series. These can be used for all electrical conduction applications including domestic wiring
Aluminium is not only non-toxic but also not release any smells or ruin products with which it is in contact. Thus, aluminium suitable for use in packaging for sensitive materials such as food or pharmaceuticals where aluminium foil is used.

3. Selection of Aluminum Alloys [Al 6061]:

Aluminum alloys are those alloys in which aluminium (Al) is the prime metal. The typical adding elements are copper, magnesium, silicon, manganese and zinc. There are two main classifications, namely casting alloys and wrought alloys, both of which are further classified into the categories heat-treatable and non-heat-treatable. About 86%of aluminium is used for wrought products, for example rolled plate, foils and extrusion.
The families of aluminium alloys are represented by 1xxx up to 8xxx. The first digit provides basic information about the prime alloying elements as shown in table 2. The designation system also says something about the hardening of the alloys belonging to a family. Table 3 shows the nominal composition wt% of Al-6061 matrix material. The 1xxx, 3xxx, and 5xxx series are non heat treatable alloys; they gain their strength by alloying (increasing the content of Mg) and work hardening. The 1xxx series designation consists unalloyed aluminium materials, which are distinguished according to their degree of clarity. The 8xxx series designations are the miscellaneous alloys which cannot be grouped in other families. The 2xxx, 6xxx, and 7xxx series are the heat treatable alloys, which gain strength by alloying, but make use of precipitation hardening as the main mechanism among several series of aluminium alloys, heat treatable A16061 and A16707 are much explored. Among them A16061 alloy is highly corrosion resistance extricable in nature and exhibits moderate strength. It finds vast applications in the field of construction automotive aerospace marine and other allied fields they have been studied extensively because of their technological importance and their exceptional increase is obtained by precipitation hardening

Table 1: Chemical analysis of the Al 6061 alloy

Mg%	SI%	Ti%	Mn%	Zn%	Cu%	Fe%	Al%
0.8-1.2	0.4-0.8	Max 0.15	Max 0.15	Max 0.25	0.15-0.40	Max 0.7	Balance

Table 2: Mechanical properties of the Al 6061 alloy

Density ($g.cm^{-3}$)	Ultimate tensile strength(MPa)	Yield tensile strength(MPa)	Material elongation %	Young's modulus (MPa)
2.70	120	55	25-30	69

In Aluminium matrix composite (AMCs), the ceramic reinforcements are generally oxide or carbides or borides
such as Al_2O_3, TiB_2, TiO_2, SiC, TiC, B_4C.

4. Boron Carbide [B_4c]:

Typical Boron carbide particles are characterized by its extreme hardness, high wear resistance and low density. Boron carbide produced by reducing boron oxide with carbon at high temperatures in an electric furnace. After grinding, the black powder is solidified by pressing at temperatures exceeding 2,000°C.
It is one of the hardest known material behind Cubic boron nitride and Diamond. It has ability to absorb neutron so it act has shielding. Another name of boron carbide is Black Diamond. Crystal structure is Rhombohedral.
Good nuclear properties and Excellent resistance factor of flammability, organic solvents, cid and alkaline (strong and weak), ultraviolet rays and wear.

Table 3: Mechanical Properties of the Boron Carbide

Density ($g.cm^{-3}$)	Melting point (^0C)	Young's modulus (GPa)	Thermal Conductivity (at 25^0C-W/m-K)	Hardness (kg/mm^2)
2.52	2445	450-470	30-42	2900-3580

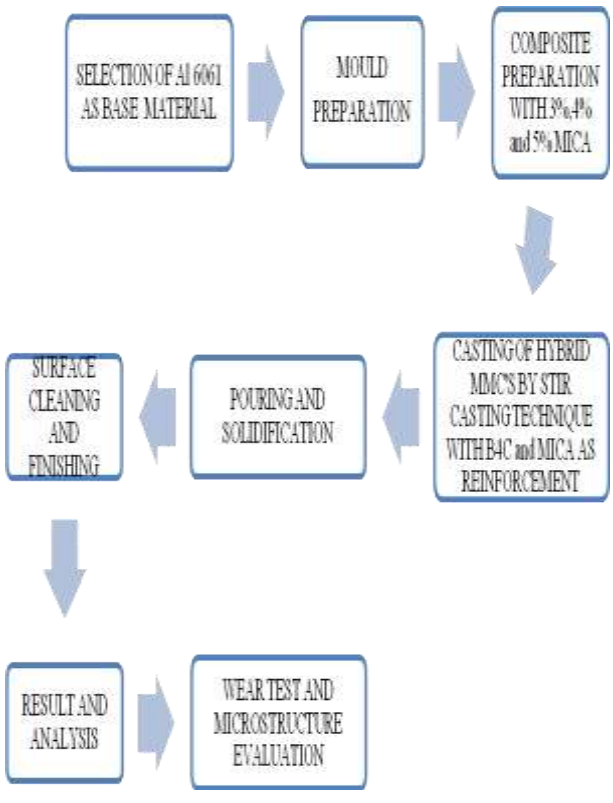
4.1. Mica:

Mica is a common term applied to a grouping of aluminosilicate minerals having a sheet like structure with different composition and physical properties. All mica forms flat six side nonclinical crystals with a significant cleavage in the direction of large surface, which allows them to easily divide into optically flat films. When split into thin films, they continue tough and elastic still at high temperature. Mica possesses the most outstanding collections of chemical physical, electrical, thermal and mechanical properties, which are not established in any other product. Mica powder in different forms is bought by grinding breaking mica scrap which is costly and complicated process, because of the morsel being tough and plate like structure. Scrupulous care and precaution has to be taken so that there is no corrosion of its natural brilliance, colour and properties.

Table 4: Chemical analysis of the Mica (mass fraction %)

SiO_2	Al_2O_3	K_2O	Fe_2O_3	Na_2O	TiO_2	CaO	MgO
45.57	33.10	9.87	2.48	0.62	Traces	0.21	0.38

5. Methodology:



5.1. Tir Casting:

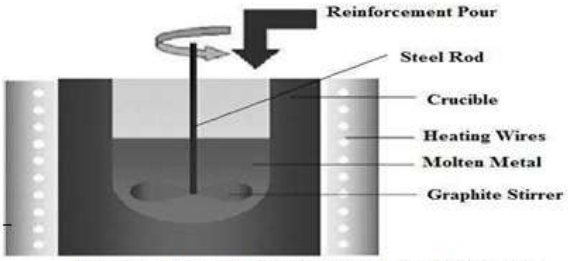


Figure 1: The graphical representation of stir casting

Stir casting route is used for manufacture the metal matrix composite. In Stir casting method of composite materials production, a dispersed phase (ceramic particles, short fibers) is combined with a molten metal matrix by means of mechanical stirring. The liquid composite material is then fabricates by conventional casting methods and may also be synthesized by conventional metal forming technologies. The stir casting methodology is relatively easy and low cost. This can usually be prepared by fairly conventional processing equipment and can be carried out on a continuous and semi continuous basis by the use of stirring mechanism

5.2. Wear Test:

The wear test is carried out on all specimens. The test is done by using Pin-on-Disc wear device (see Fig. 2). It consists of variable speed motor driving rotary horizontal steel disc. The test specimen is detained in the specimen holder that fixed firmly to the loading lever adjacent to the rough counter-face. Through two slim spring steel sheets, where strain gauges are used, friction coefficient can be calculated. The load is forced by dead weights (1600 gm) at 3.5 linear velocities with constant time. Before test, polish the contact surface of the test specimens by an emery paper. The opposite face is in the shape of an emery paper of 80 grad attach on a steel disc of 50 mm inner diameter.

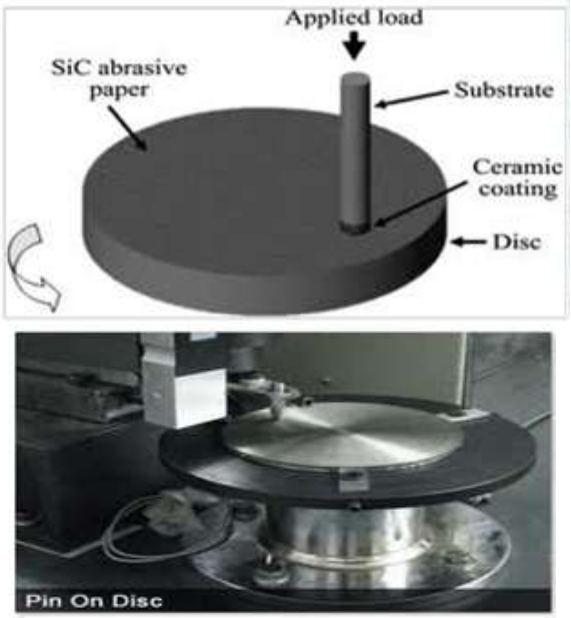


Figure 2: Pin on Disc (TRIBOMETER)

6. Scanning Electron Microscope:

SEM stands scanning electron microscope.SEM has allowed researchers to study a much larger specimens, the scanning electron microscope has several advantages than traditional microscopes. The SEM has a large power of field, which permits a specimen to focus at one time. The SEM has also higher resolution, so closely packed specimen can be extravagant at much higher levels. Because, SEM uses electromagnets rather than lenses, the researcher has more control in the grade of magnification advantages as well as strikingly clears images, make the scanning electron microscope one of the most constructive instruments in research today. Microstructure of the hybrid material matrix can be easily studied.

7. Discussion:

Hardness behavior of matrix metal and composites. Previously an attempt has been made for investigation on properties of B_4C reinforced Al6061 metal matrix composites. It can be experimental that hardness shows rising trend with increasing percentage of B_4C particulates

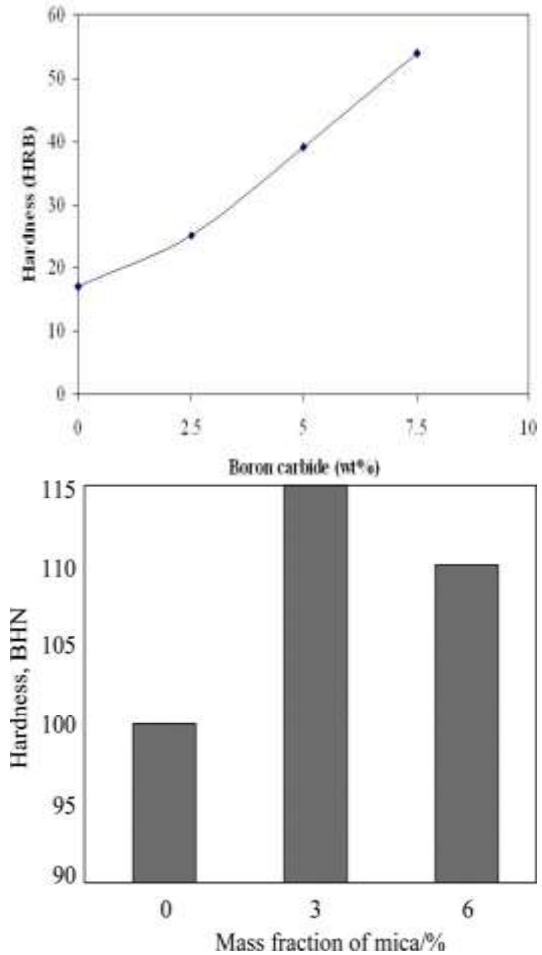


Figure 3: Graphical representation of hardness on B_4C and Mica

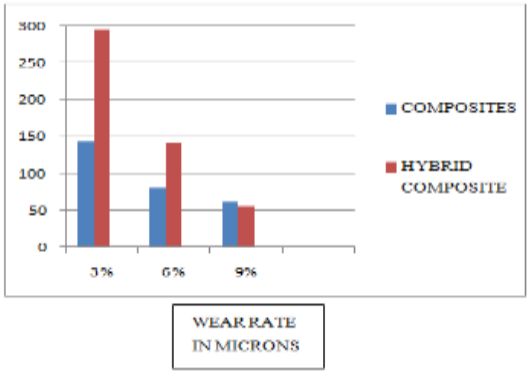


Figure 4: Wear rate of Composite and Hybrid composite

8. Conclusion:

The review literature reveals that extensive work has been placed, to enhance the properties of different aluminium based MMC by producing their composites being reinforced with different materials such as Al2O3, TiB2, TiO2, SiC, TiC and B4C etc., It has been observed that one of the least expensive methods to fabricate MMC is STIR CASTING. • It has been observed that the density of the composite increases with the addition of the hard ceramic reinforcement into the matrix material.Behaviour of hybrid composites under solid particle erosion is another open end for the meaningful research. • It has been observed that there is an increase of 30% in hardness and there is an increase in tensile strength that is almost twice the base aluminium alloy.

Process parameters plays a very important role on properties of Al based MMC. In case of Stir casting process, the parameters like stirring rate, pouring temperature, stirring temperature etc., are to be maintained for achieving better properties of MMC. For the manufacturing of composite material by stir casting method, knowledge of its operating parameters, different fabrication techniques such as solid state processes including powder metallurgy (PM Route), high energy ball milling, friction stir process, diffusion bonding and vapour deposition techniques are very essential. If the process parameters are properly controlled, it could lead to the improved properties in composite material.

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