Study on Wear Characterisation of Aluminium/Basalt Fiber/TiC Reinforced Metal Matrix Composites

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ABSTRACT - Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. So in this project deals with the fabrication and investigation of aluminium based metal matrix composites using Al 6061 as the matrix material with reinforcement of 6% of Titanium carbide (TiC) and 4% of basalt fiber. The sample composites were fabricated by stir casting methodology and which is a liquid state material manufacture and economical method. Experiments were conducted based on the plan of experiments. Investigation to find the influence of sliding speed, applied load and sliding distance on wear rate, as well as the coefficient of friction during wearing process was carried out using regression equation for each response were developed for both 4% and 6% Basalt fiber and TiC reinforced Al-6061MMCs. Objective of the model was chosen as "smaller the better" characteristics to analyze the dry sliding wear resistance. Finally Scanning Electron Microscope(SEM) were done on wear surfaces.

1. INTRODUCTION

Many of our modern technologies require materials with unusual combinations of properties that cannot be met by the conventional metal alloys, ceramics, and polymeric materials. Aluminium alloys reinforced with metal particulates have significant potential for structural applications due to their high specific strength and stiffness as well as low density. These properties have made particle reinforced metal matrix composite (MMCs) an attractive candidate for the use in weight-sensitive and stiffness-critical components in aerospace, transportation and industrial sectors. Aluminium metal matrix composite, applications are growing in the field of automotive and aerospace because of their predominant physical, mechanical, and tribological properties. Particularly Aluminium metal matrix composite materials are finding expansive level applications in many industries because of their lower density, better wear, and corrosion resistance, high strength to weight ratio, great formability, high hardness, high thermal shock resistance, high modulus, high fatigue strength and so on. A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. The two constituents are a reinforcement and a matrix. Composites are classified according to the matrix material used and the reinforcement added. They are Metal matrix composite, Polymer matrix composite, Ceramic matrix composite. But we are using Metal matrix composite. Metal matrix composite are composed of a metallic matrix (aluminium, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase. Metal matrix composites constitute a new class of materials, now starting to make a major industrial impact in fields as diverse as aerospace, automotives and electronics. Some reference book gives a comprehensive, integrated coverage of these materials, including the background to analytical- ,experimental-, production and application-oriented aspects. These encompass mechanical, thermal, electrical, environmental and wear behavior. Manufacturing methods of particle reinforced MMCs can be classified into two types. They are liquid state fabrication and solid state fabrication. We are using liquid state fabrication. For producing cast particulate composites using liquid state fabrication method are, stir casting, squeeze casting, and spray deposition. Andalso we are investigating wear behavior with the help of stir casting method.

1.1. SUMMARY

Aluminium alloys finds application where efficient and high strength to weight ratio is essential. Dry sliding wear behavior of these alloys may be improved by reinforcing them with materials. The properties of composites depend upon the type of reinforcement, their amounts, orientation, and the geometry of the reinforcement. Then the stir casting set up is to be a successful and also cost-effective method for make the composites. The following chapter will present a detailed explanation of the work conceded in the dry sliding wear behavior of metal matrix composite material.

2. LITERATURE REVIEW

Sumathy muniamuthu(2016) investigated the mechanical properties of Al7075 reinforced with Alumina particulate(Al203). The composites are fabricated by using stir casting technique.

Velmurugan (2011) investigated the mechining properties of Al6061 Hybrid Metal Matrix composites prepared by the electrical discharge machining(EDM) process. The reinforced materials are silicon carbide(SiC) and graphite particles in the amount 10% SiC and 4% of graphite.

Francis Xavier (2015) investigated the dry sliding wear behavior of aluminium 6063 reinforced with wet grinder stone dust particle, aluminium oxide and waste tonner. Where Pin On Disk apparatus is used for calculate the wear behavior and the composites is formed using Discard process.

Tony Thomas (2014) investigated the aluminium by reinforcing copper and gun metal in various proportions. Stir casting method is used to prepared the composites and Pin On Disk apparatus as used to study the wear properties. By the results he concluded the strength of composites is increases based on increases in aluminium matrix and gun matel.

From the literature review, it is evident that a considerable quantity of work will be carried out in the field of PAMCs and its manufacturing techniques to attain different mechanical and tribological properties. However, Al6061 reinforced with basalt fiber and TiC has not been studied in details so far. Hence our project is planned to study the wear behavior of Al6061 reinforced with basalt fiber and TiC.

3. MATERIAL AND METHOD

In the investigation, Al6061 was chosen as the base matrix since its properties can be tailored through heat treatment process.The addition of reinforcements in metal matrix significantly improve the wear, thermal and various mechanical

properties. TiC and basalt fibre selected as reinforcement material. Titanium Carbide (TiC) is an extremely hard refractory ceramic material, similar to tungsten carbide. It has the appearance of block powder with the sodium chloride. Basalt fibre is a material made from extremely fine fibre of basalt, which is composed of the minerals plagioclase, pyroxene and olivine.

3.1. Composite preparation

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibres) is mixed with a molten matrix metal by means of mechanical stirring. Stir casting is the simplest and the most cost effective method of liquid state fabrication. In stir casting method before the casting, reinforcements preheated to 3500 C for 15 minutes to remove moisture and gasses from the surface. Now the required amount of Al6061 is weighed and placed in the graphite crucible and heated to 8500 C using resistance furnace. Then the matrix Al6061 is reinforced with TiC and Basalt fibre particulates with different weight percentages (6% and 4%). The micro particle of TiC and Basalt fibre was added at the temperature of 8500 C and a constant vigorous stirring was done cylinder formed. After complete solidification and then it is withdrawn from according to ASTM standards (10 mm diameter and 30 mm length).

3.2. Wear Test

The pin on disc test apparatus was used to determine the sliding wear characteristics of the composite. Specimens of size 10 mm diameter and 30 mm length wear cut from the cast samples, and then machined. The contact surface of the cast sample (pin) was made flat so that is should be in contact with the rotating disk. During the test, the pin was held pressed against a rotating EN31 steel disc (hardness of 64HRC) the applying load that acts as counterweight and balances the pin. The track diameter was 100 mm and the parameters such as the load, sliding velocity, sliding distance were varied in the range given in table 3.6. A LVDT (load cell) on the lever arm helps determine the wear at any point of time by monitoring the movement of the arm. Once the surface in contact wears out, the load pushes the arm to remain in contact with the disc. This movement of the arm generates a signal which is used to determine the maximum wear and the coefficient of friction is monitored continuously as wear occurs and graphs between coefficient of friction and time was monitored for both of the specimens

Table 3.2: Process and Parameter and Level

Level	Load (N)	Sliding Velocity (m/s)	Sliding Distance (M)
1	20	2.3	1500
2	20	2.3	1500
3	30	2.3	1500

4.RESULT AND DISCUSSION

In this chapter, the dry sliding wear behaviour of Al6061 reinforced with titanium carbide and basalt fiber

Wear rate =Volume loss/Sliding distance (or) Δw =m/($\rho * D$)

=Wear rate/Load (or) $k = \Delta w/W$ Co-efficient of friction =Frictional force/Applied load

4.1.DRY SLIDING WEAR BEHAVIOR OF MMC

In this current work, load, velocity, sliding distance during wear test of aluminium based MMC for same combination of different parameters.

Table.4.1a. Experimental runs and their results

Level	Mass before test (gms)	Mass after test (gms)	Wear rate (mm^3/m)	Frictional force (Nm)
1	7.12	7.118	0.00480	7.68
2	6.65	6.642	0.00193	4.30
3	6.652	6.648	0.00096	4.05

Table.4.1b. Calculations

Ex	Wearrate	Sp.wear	Cof
1	**0.00480**	**0.000024**	**2.6041**
2	**0.00193**	**0.000096**	**4.6511**
3	**0.00096**	**0.000048**	**4.9382**

Analysis of regression has functioned of known the factor behaviour on response i.e. wear rate, COF and specific wear rate.

4.2.MICROSTRUCTURE ANALYSIS

The Scanning Electron Microscope analysis for the pure AL6061 alloy and AL6061 reinforced with titanium carbide and basalt fiber(MMC) and also low wear rate composite specimens are done and their micrographs are obtained at different magnification factor and shown in figs.1 (a) (b) and 2 (a) (b) & 3 (a) (b). The figs.1 (a) (b) shows the microscopic image of pure AL6061 at 10 and 20 micro meters with corresponding magnification of 500X and 2000X.

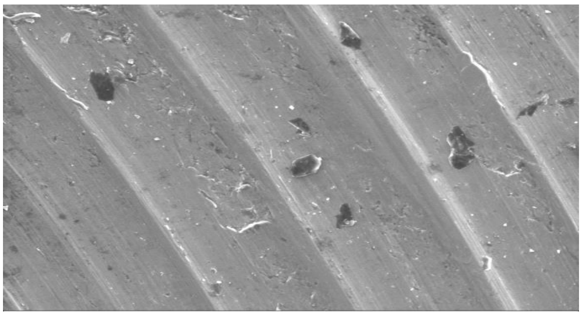

Fig.1(a) AL6061 at 500X magnification

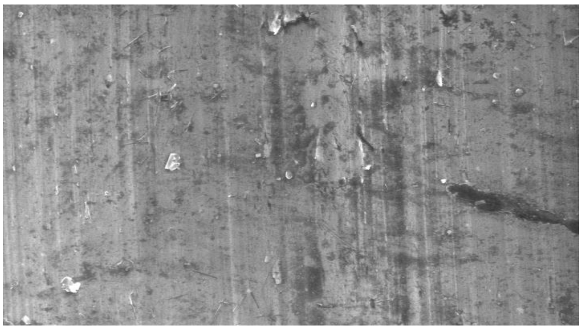

Fig.1(b) AL6061 at 2000x magnification

Fig.2 (a) & 2 (b) shows the micrograph image of aluminium based metal matrix (AL6061) reinforced with titanium carbide and basalt fiber at 500X and 2000x magnification.

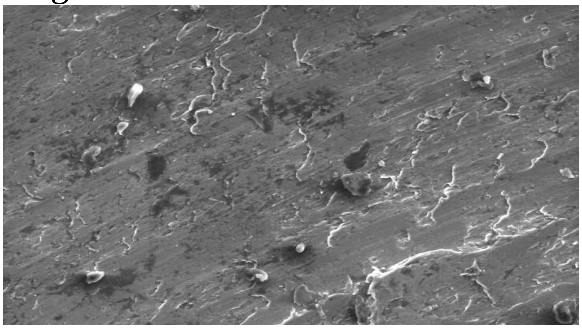

Fig.2(a) AL6061/TiC/BASALT at 500X magnification

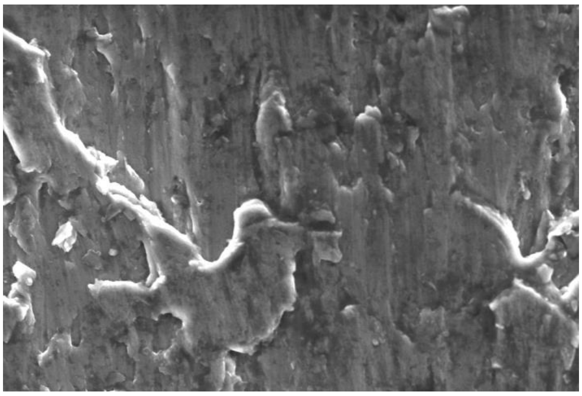

Fig.2(b) AL6061/TiC/BASALT at 2000X magnification

Fig.3(a) & 3(b) shows the micrograph image of low wear rate aluminium based metal matrix (AL6061) reinforced with titanium carbide and basalt fiber at 500X and 2000x magnification

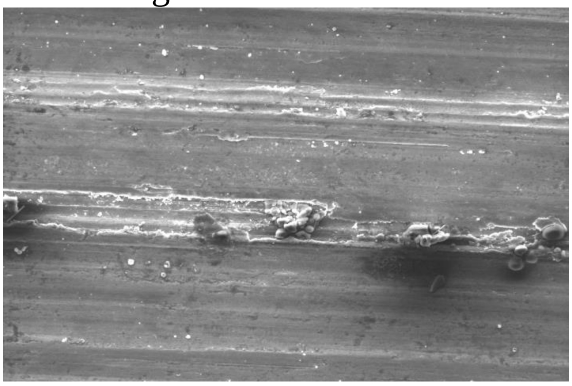

Fig.3(a) AL6061/TiC/BASALT at 500X magnification

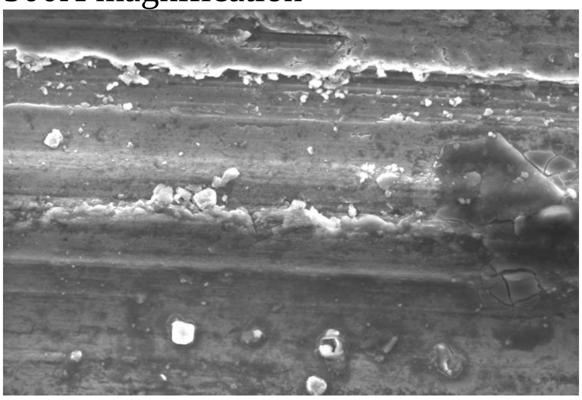

Fig.3(b) AL6061/TiC/BASALT at 2000X magnification

5.CONCLUSION

Among the different manufacture process, Stir casting method is an efficient casting method to develop the aluminium based metal matrix composite, to obtain the homogeneous mixing of the reinforcement casting. It is also commonly adequate method due to its low cost and easy method . Then the pin-on-disc apparatus was used for the wear testing process and SEM test were worn out.

From the results of our experiments it is concluded that,

- When compare the hardness of the prepared composite was better than that of base alloy. Al6061 reinforced with 6% titanium carbide and 4% basalt fiber have better wear resistance then the base Al6061.
- Load is the factor that has greater influence on wear rate followed by sliding distance and sliding velocity.

From the microstructure study of worn surface, it is observed that mostly abrasive wear mechanism has occurred on the wear tracks with some traces of adhesive wear mechanism.

6.REFERENCES

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