CHARACTERIZATION OF ALUMINIUM REINFORCED WITH SILICON CARBIDE AND GRAPHENE METAL MATRIX COMPOSITES

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Abstract : In this present work the aluminum metal matrix composite has been studied. Physical and mechanical properties of the aluminum metal matrix were tested. Aluminum powder (Al) was reinforced with Silicon Carbide (SiC) (5, 10, 15 wt.%) and Graphene (3, 4, 5 wt.%) through powder metallurgy process. The specimens are sintered by using furnace. The density, hardness and wear using pin-on-disk were tested on various specimen as per ASTM G99 standards. The specimen material properties were improved by adding Silicon Carbide and Graphene with various weight percentage.

Index Terms **– Aluminium, Silicon Carbide, Graphene, Powder Metallurgy**

I. INTRODUCTION

In this work the aluminum matrix composites are used because they are having good physical and mechanical properties. Metal matrix composites are metals reinforced with other metals, ceramic or organic compounds. They are made by dispersing the reinforcements in the metal matrix [1]. Increasing qualities of metal matrix composites (MMCs) are being to replace conventional composite materials in many applications, especially in the automobile and recreational industries, owing to increasing performance requirements. The most popular types of MMCs are aluminum alloys reinforced with ceramic particles. These low-cost composites provide higher strength, stiffness and fatigue resistance with a minimal increase in density over the base alloy. The superior mechanical properties achieved by the reinforcements in MMCs, on the other hand, significantly influence their machinability [2].

MMCs are widely used in aircraft, aerospace, auto-mobiles and various other fields. The reinforcements should be stable in the given temperature and non-reactive too. The most commonly used reinforcements are Silicon Carbide (SiC) and Aluminum Oxide (Al_2O_3) [3]. SiC reinforce increases the tensile strength, hardness, density and wear resistance of Al and its alloys. The experiment is carried out by powder metallurgy. Powder metallurgy is a term covering a wide range of ways in which materials or components are made from metal powders. PM processes can avoid, or greatly reduce. The investigation of addition of Al and SiC particulates into the Aluminium matrix showed increased yield strength, ultimate tensile strength & the hardness, & decreased elongation (ductility) of the composites in comparison with those of the matrix. Increasing wt% of Al and SiC increased their strengthening effect and SiC is the most effective strengthening particulate, for higher strength, hardness, & grain size reduction [4-5].

II. EXPERIMENTAL SETUP

Table 1 shows the composition percentage of Aluminium (Al) with reinforces Silicon Carbide (SiC) and Graphene weight percentage.

Table 1 Weight percentage of Matrix and reinforcement of MMC

Specimen	Aluminium	Silicon Carbide	Graphene
1	100	0	0
2	95	5	0
3	90	10	0
4	85	15	0
5	82	15	3
6	81	15	4
7	80	15	5

Fig. 1 Metal Matrix Composite Specimen

Figure 1 shows fine metal particles are placed into a flexible mould and then high pressure is applied to the mold, in contrast to the direct pressure applied by the die faces of a die pressing process. The resulting article is then sintered in a furnace which increases the strength of the part by bonding the metal particles. This manufacturing process produces very little scrap metal and can be used to make many different shapes. The tolerances that this process can achieve are very precise, this is the most efficient type of powder compacting.

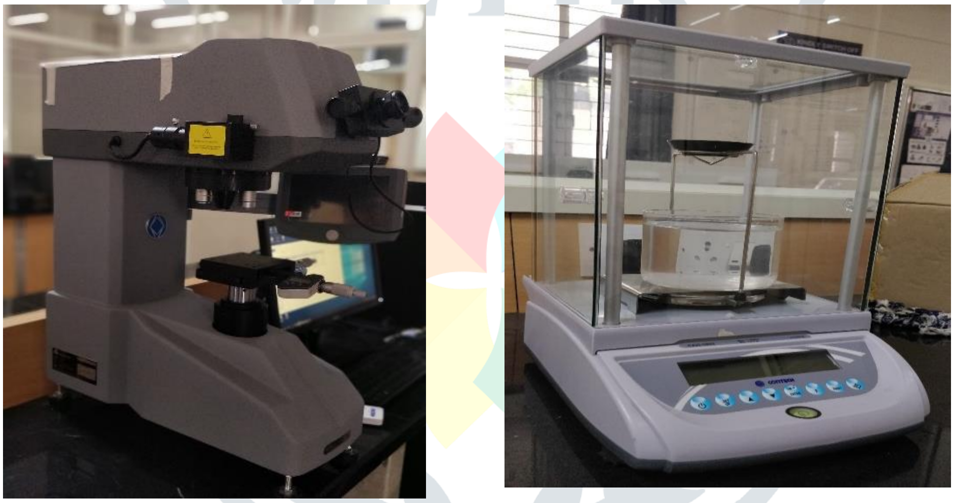

Fig. 2 (a) Micro Vikers Hardness Tester (b) Density Measuring Instrument

Figure 2a shows Micro Vikers Hardness Tester, Buehler make the following specification model: VH110, LOAD RANGE: 10GF – 1000GF, HARDNESS SCALE: VICKERS (HV)/KNOOP (HK) (OPTIONAL), test force accuracy conform to EN-ISO 6507/ ASTM E384).

Figure 2b shows the density of a material is defined as mass of the material per unit its volume.Density Determination kit is available in 2 types one to be mounted on the pan and the other type is with attachment for weight below the balance. Density determination kit consists of density weighing pan assembly, stainless steel base for beaker, glass beaker, optional sinker for testing materials having density less than water and software for density determination. The density of compacted powder increases with the amount of pressure applied.

Pin-on-disc manufactured by Contech Microsystems, the experiments were conducted as per ASTM G99-90 standard, using counter face of steel disk 316L/EN-32 hardened to 62-65 HRC. During wear test, the load was applied on the pin, normal to the sliding contact for different loads and the track radius was kept constant at 70 mm and the rotating speed of the disc was maintained at 200 rpm, which corresponds to a linear speed of 1.5 m/s at the track. In the present investigation, a brush of camel hairs was used to remove wear debris from the track during sliding. This was carried out with the aim to prevent the debris from getting easily trapped between the worn surface of the pin and the counter face. During pin-on-disc wear tests, the coefficient of friction was continuously monitored and the material removed was determined by thickness loss measured at specific intervals of time. Wear tests were carried out for a total sliding distance of about 8790 m for each specimen.

Fig. 3 Pin-on Disk Wear Testing Machine

Figure 3 shows the Friction and wear characterization of materials is typically performed using various types of tribometers, while pin on disk test being probably one of the most common. The popularity of the method is due to its relative simplicity and abundance of the tribological contacts that can be well described by a simple pin on disk motion: from dry contacts of bolt screws to rail wheels to rail contact and to lubricated contact of biological implants. The test typically allows to test several motion modes, such as unidirectional, fretting modes and recently any other complex motion patterns.

III. Result and Discussion

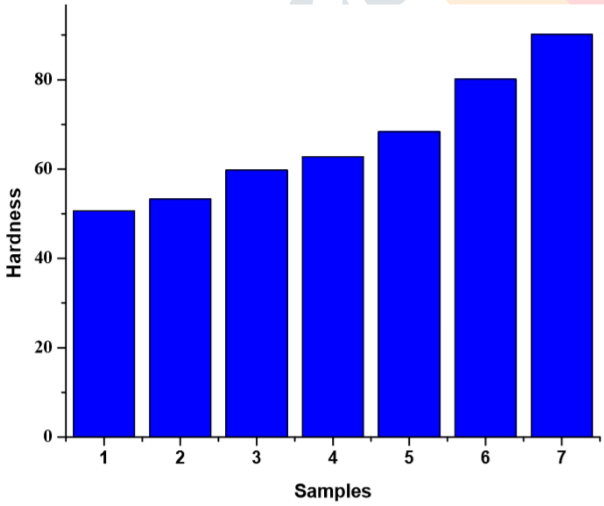

Fig.4 Bar Graph of Vickers Hardness

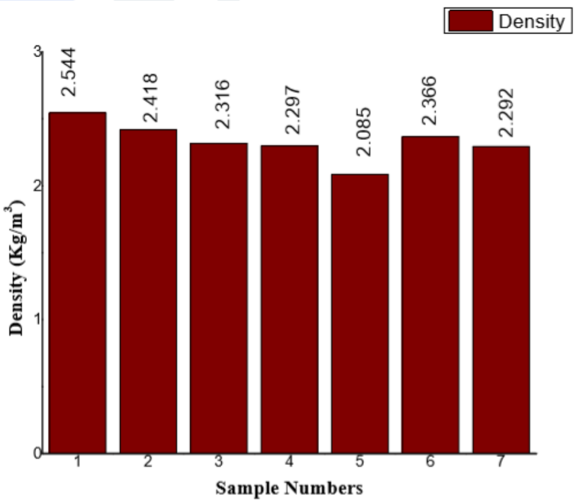

Fig.5 Bar Graph of Density

Figure 4 shows the bar graph the hardness increases of composite is greater than Aluminium mixed Silcon Carbide and pure aluminum. Pure Al > Al+SiC > Al+SiC+Graphene.

Figure 5 Shows the bar graph of density is higher value of pure aluminum compare to other composite materials.

Pure Al < Al+SiC < Al+SiC+Graphene.

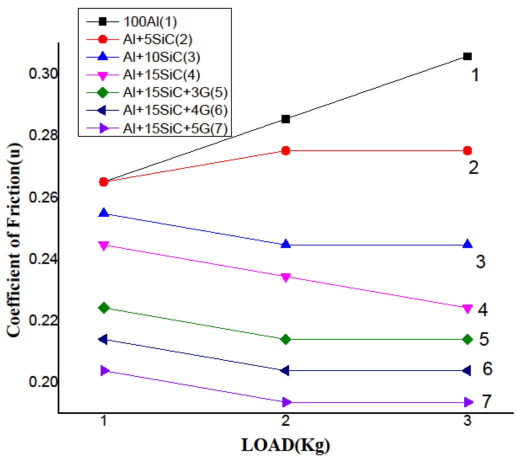

Fig.5 Load Vs Coefficient of Friction

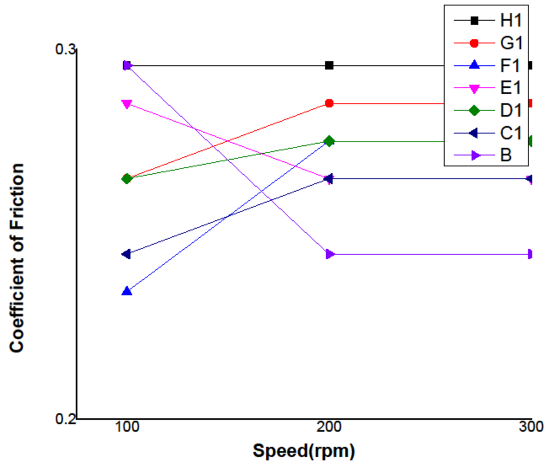

Fig.6 Speed Vs Coefficient of Friction

Figure 5 shows the coefficient of friction is decreased as the composition of SiC and Graphene reinforce to Al. The pure Al has been observed that the cof increase as the load increases. Where as the cof decreased by addition SiC also reduced the cof values in grapheme and SiC blended matrix of Al.

Figure 6 shows the coefficient of friction decreases the composite of Aluminium, Silicon carbide and Graphene compare to Aluminium, Silicon carbide and pure Aluminum as increase speed of 100, 200, 300rpm.

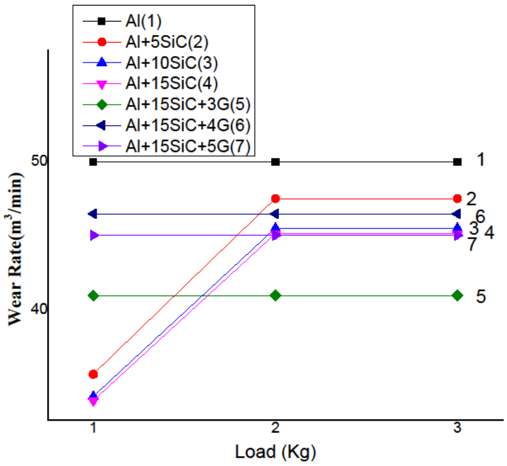

Fig. 7 Load Vs Wear Rate

Figure 7 shows the effect of SiC and Graphene particles on the wear rate of composite. It has been found that the wear resistance the Al matrix is higher than that of the composites of various percentage SiC and Graphene. This can be related to the fact that the hard ceramic material protect the surface several contact.

The heat treated alloys shows lower wear rate when compared to as pure Al. The heat treated alloy at 1kg load shows much lesser wear rate. This indicates that the heat treatment of the alloy resulted in a protective oxide films probably the SiC and Graphene due to their presence in an appreciable amount of self lubricating in the alloy.

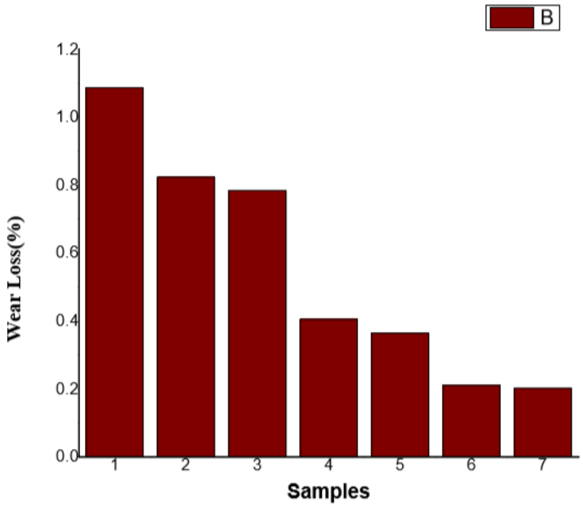

Fig.8 Bar Graph of Cumulative Wear Loss

Fig.8 Bar Graph of Cumulative Wear Loss is plotted against samples for a load of 1kg and 200 rpm speed under two body abrasive test. It is observed from plot that the wear rate of pure aluminium is higher than as aluminium mixed with Silicon carbide and aluminium, Silicon Carbide and Graphene. Further the wear rate observed in adhesion test with EN-32 plate is found to be very less in comparison to abrasive wear with SiC paper.

IV. CONCLUSION

In this experimental study, AMCs of varying SiC (5,10 & 15wt%) and Graphene (3,4 &5 wt %) were prepared using powder metallurgy technique. Hardness , density and wear characteristics of the prepared composites were studied. Based on experimental evaluation, following conclusion can be expressed

1. Addition of SiC and Graphene in Aluminum matrix is increased and conformed by Vickers hardness tester.
2. Wear resistance of SiC and Graphene reinforce AMCs showed increased with decrease of wear loss.
3. Decrease in the density values are the reinforced SiC with Aluminium and increasing the density in SiC and Graphene into Aluminium matrix.

From the results above, SiC and Graphene reinforced AMCs showed better hardness and wear resistance the unreinforced Al.

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