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Characterization of Aluminium Based Hybrid Metal Matrix Composites

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ABSTRACT

Aluminum-reinforced with SiC and Al_2O_3 composites have been fabricated by stir casting method. The scanning electron microscope image of composite specimen's show that the reinforcements are uniformly distributed in the matrix. Hardness of the specimens at the room temperature was also measured by Vickers hardness testing machine. The hardness of the composite test specimens increases with increasing in percentage of reinforcements. The tensile strength and yield strength value of reinforced composite shows that increase in reinforcement tends to increase in tensile and yield strength value respectively.

Keywords*:* Aluminum alloy, Stir casting, Scanning electron microscope, Vickers hardness.

1. INTRODUCTION

A heterogeneous mixture of two or more constituents is known as composite material. The constituents are combined at microscopic levels which are insoluble in each other. In general, a composite material is composed of a matrix- the main constituent (metals, polymers) and reinforcements (fibers, particulates and flakes). These reinforcements are embedded in the matrix. Being a multiphase element it shows attributes of both matrix as well as reinforcements [1, 2]. The most primitive man-made material are straw and mud combined together to form bricks for building construction. Aluminum alloys possess a number of mechanical and physical properties that make them attractive for automotive applications, but they exhibit extremely poor resistance to seizure and galling. Reinforcement of aluminum alloys with solid lubricants, hard ceramic particles, and short fibers and whiskers results in advanced metal–matrix composites (MMC) with precise balances of mechanical, physical and tribological characteristics[4,6]. Advanced manufacturing technologies such as squeeze infiltration of molten alloys into fiber performs can be employed to reduce near net-shape components. Brake rotors, pistons, connecting rods and integrally cast MMC engine blocks are some of the successful applications of Al MMCs in automotive industry. Material selection is one of the most important and critical steps in the structural or mechanical design process. If the material selection is not done properly, the design may show poor performance, may require frequent maintenance, repair, or replacement, and in the extreme, may fail, causing damage, injuries, or fatalities [8]. The material selection process requires the knowledge of the performance requirements of the structure or component under consideration. It also requires the knowledge of types of loading- axial, bending, torsion, Mode of loading- static, fatigue, impact, shock and Operating or service environment- temperature, humidity conditions, presence of chemicals.

2. STATEMENT OF THE PROBLEM

This experimental study is aimed to find out the answer for the following questions: 1. Is the newly developed Al-SiC, Al_2O_3 and hybrid MMC in this experimental study suitable to be an alternative material for clutch plate. 2. What is the influence of particle sizes of SiC and Al_2O_3 , its weight percentage, pouring temperature and stirring time to the wear, hardness, density and yield strength of the Al-SiC,

Al_2O_3 and hybrid MMCs.3.Which composite (Al+SiC or Al+ Al_2O_3 or hybrid) is best for the application.

3. MANUFACTURING METHODOLOGY

Metal matrix composites are generally produces either by liquid metallurgy route (LMR) or Powder metallurgy technique (PM). In the LMR particulate phases are mechanical dispersed in the liquid before solidification of melting. Here with stir casting technique is known as a very promising route for manufacturing near net shape hybrid metal matrix composite components at relatively cost. The implementation of stir casting technique yields relatively homogenous and fine microstructure and improve the addition between the molten metal and reinforcement. In addition the porosity level of composite should be minimized and the chemical reaction between reinforcement and matrix would be avoided. The proper selection of process parameter such as pouring temperature, stirring speed, pre-heat temperature of reinforcement can be able to produce good quality of composite. Schematic diagram of stir casting shown in fig.3.1. The stir casting furnace is mounted on the ground. Base metal is taken in a crucible and it is melted to a temperature of 700ºC in the furnace. The reinforcements are preheated to a temperature of 400ºC. The reinforcements of Particle Size: 10-15 µm are preheated to improve the wettability, remove moisture and also to reduce the temperature gradient between molten metal and reinforcements. Two thermocouple and one PID controller are used for this purpose.

Figure 3.1 Stir cast unit

Mild steel material is selected for the stirrer rod and impeller, because of it stability at high temperature. This stirrer was connected to 1HP DC Motor through flexible link. Stirrer is used to stirrer the molten metal in semi-solid state. The screw operator lifting is usedto bring the stirrer in contact

Figure 3.2 Fabricated material

in composite material. The melt is maintaining at a particular temperature, which is depends on matrix material for one hour. Vortex is creating using a mechanical stirrer. Preheated particle reinforcement will add to the melt during stirring. Stirring will be carried out for 5 min at 180 rpm for all samples.

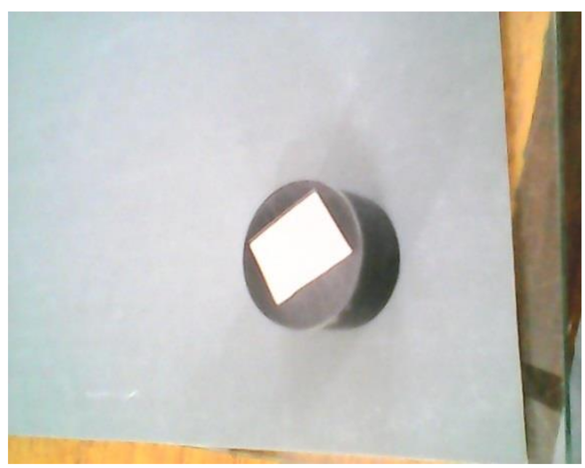

Figure 3.3 Polishing using emery

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Figure 3.4 Mounted specimen

Figure 3.5 Machine polishing

The material produced using stir casting is showed in fig 3.2 then it is machined for required dimension followed by mounting the specimen in mounting press machine. Polishing is done using emery sheet of various grid size and machine polishing is done for microscopic and SEM test.

4. SEM TEST AND MECHANICAL PROPERTIES

4.1 SEM test

The scanning electron microscopic images of Al_2O_3, SiC and hybrid composites of different weight percentages taken at 50X magnification were shown in the figures.

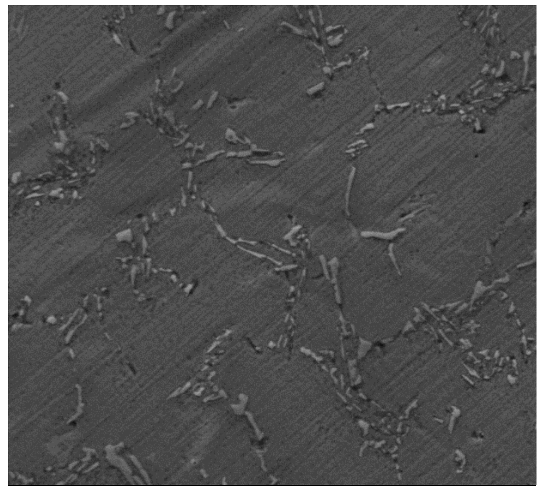

Figure 4.1.1: Al_2O_3 – 10%

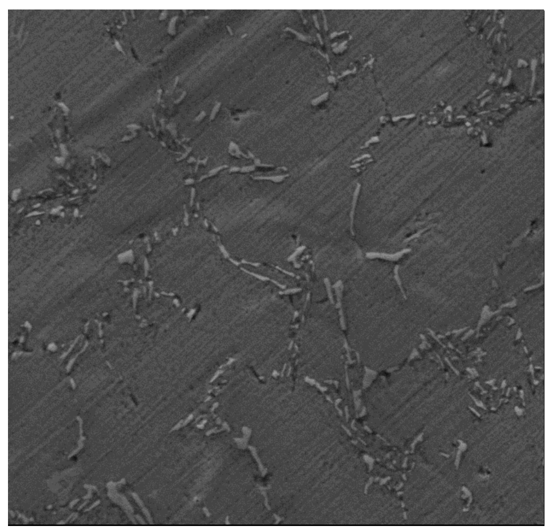

Figure 4.1.2: Al_2O_3 – 15%

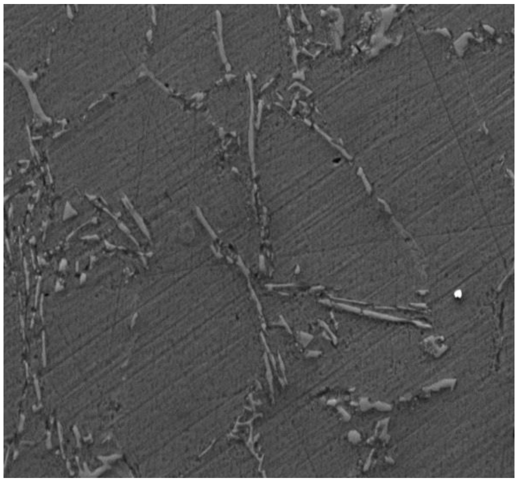

Figure 4.1.3: Al_2O_3 – 20%

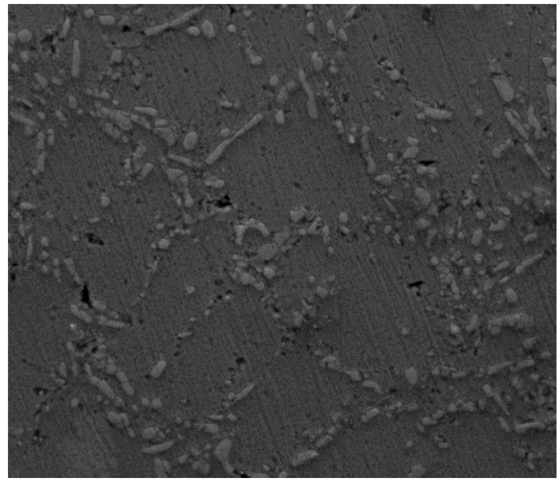

Figure 4.1.6: SiC-20%

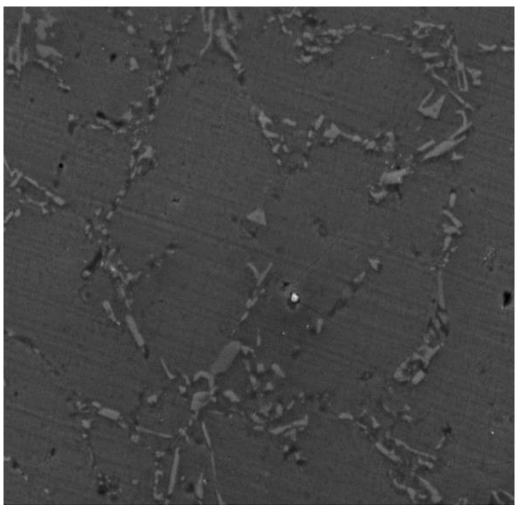

Figure 4.1.4: SiC-10%

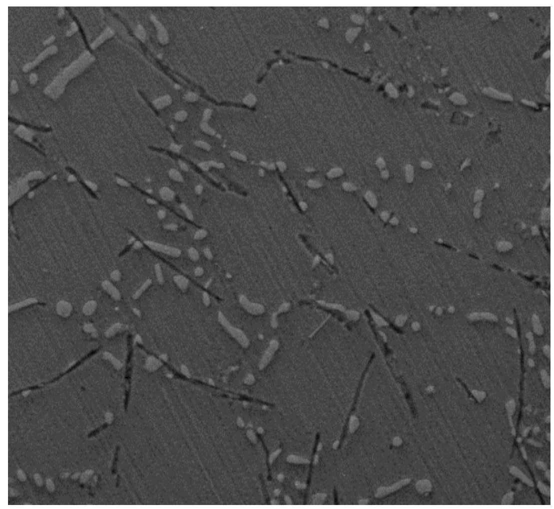

Figure 4.1.7: Hybrid – 10%

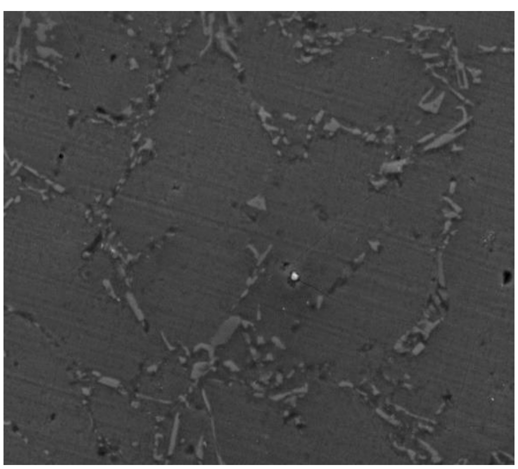

Figure 4.1.5: SiC-15%

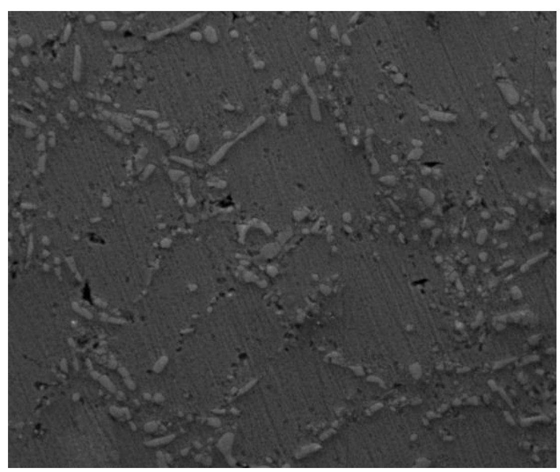

Figure 4.1.8:Hybrid – 15%

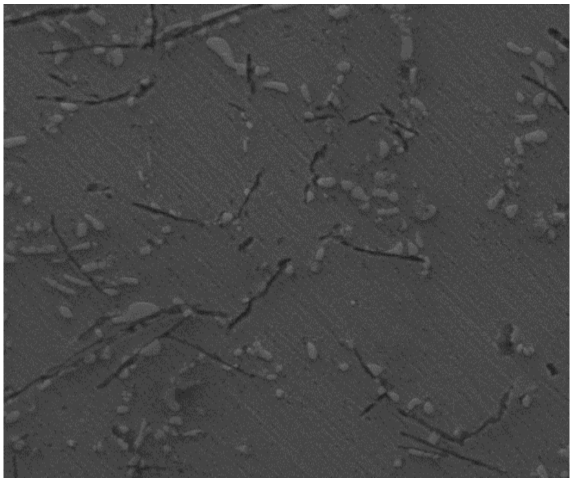

Figure 4.1.9: Hybrid – 20%

It is evident from the figure that reinforcements were evenly distributed among the base material which is necessary for the application.

4.2. Hardness

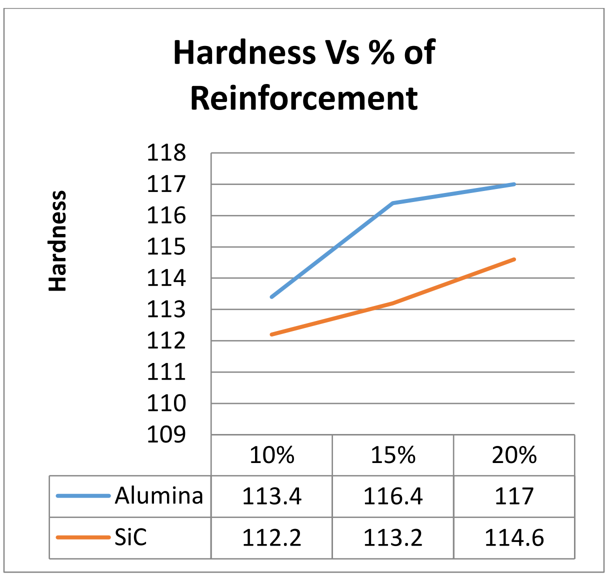

Figure 4.2.1 shows that increase in percentage of reinforcement tends to increase in hardness, here alumina reinforced composite processes higher hardness value compare to Silicon carbide reinforced composite which is suitable for the application.

4.3 Tensile strength

The table gives the tensile strength value of Al_2O_3 and SiC reinforced composite, it shows that increase in reinforcement tends to increase in tensile strength value. From the table it is evident that tensile strength value ranges from 220Mpa to 300Mpa which meets the demand of application.

Table 4.3.1: Tensile strength values

Composition	Tensile strength(Mpa)
AL+10%AL_2O_3	273.35
AL+15%AL_2O_3	244.13
AL+20%AL_2O_3	247.28
AL+ 10%SiC	245.45
AL+ 15%SiC	238.09
AL+ 20%SiC	260.63

4.4 Yield strength

Table 4.4.1: Yield strength values

Compositions	Yield strength (Mpa)
AL+10%AL_2O_3	228.45
AL+15%AL_2O_3	203.5
AL+20%AL_2O_3	216.5
AL+ 10%SiC	217.6
AL+ 15%SiC	200
AL+ 20%SiC	215.8

The table gives the yield strength value of Al_2O_3 and SiC reinforced composite, it shows that increase in reinforcement tends to decrease in yield strength value. From the table it is evident that yield strength

Value ranges from 190Mpa to 250Mpa which meets the demand of application.

4.5 Comparison Of Mechanical Properties Between Existing & Experimental Material

Table 4.5.1: Comparison chart

FACTOR	GREY CAST IRON	PROJECT MATERIAL
Tensile strength(Mpa)	230-280	220-300
Hardness(HV)	110-140	110-120
Yield strength(Mpa)	200-250	190-250

Table 4.5.1 shows that mechanical properties of the project material are more or less equal to the mechanical properties of the existing material (grey cast iron) used in automobile application.

5.CONCLUSION

- The heat loss can be controlled, the oxidation reaction can be avoided and time consumption can be reduced if the stir casting setup is carried in a closed atmosphere in presence of argon & krypton gas.
- The solidification becomes rapid at time of pouring in the die, in order to avoid that the die is to be preheated to more or less control the rapid solidification. Temperature maintenance, Solidification rate& proper distribution of reinforcement is hard even at 20% of reinforcement Because of hybrid composite
- The scanning electron microscope images of composites produced by stir casting method show that the distribution of reinforcement particulates in the metal matrix is uniform.
- The hardness and tensile strength of the composite specimens increases with the increasing percentage of the reinforcements

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