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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF ALUMINIUM ALLOY REINFORCED WITH SILICON CARBIDE AND FLY ASH, HYBRID METAL MATRIX COMPOSITES

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ABSTRACT

Aluminium based metal matrix composites (MMCS) are advanced materials having the properties of high specific strength and modulus, greater resistance, high elevated temperature and low thermal expansion coefficient. These composites are widely used in industries like aerospace, defence, automobile, biomaterials as well as sports etc. The mechanical and metallurgical properties of aluminum alloy LM6 metal matrix composite are investigated. The composite are prepared using stir casting technique. The composite contains aluminum alloy LM6 reinforced with silicon carbide and fly ash respectively. Composites are fabricated through 'stir casting method'. Mechanical properties such as tensile, hardness, and compression test of the sample are measured. The results of the research work shows that the proposed hybrid composites are compared with Al-Si Alloy based metal matrix composites at corresponding values of test parameters.

Keywords: LM6, Sic, Fly Ash, Metal Matrix Composites: Stir Casting.

I. INTRODUCTION

Hybrid MMCs are made by dispersing two or more reinforcing materials into a metal matrix. They have received considerable research and trials by Toyota Motor Inc., in the early 1980s. Hybrid metal matrix composites are a relatively new class of materials characterized by lighter weight, greater strength, high wear resistance, good fatigue properties and dimensional stability at elevated temperatures than those of conventional composites. Automobile, Aeronautical industry or ship building industry are associated with continuous searching for material with low density, low specific gravity, high stiffness and specific strength, materials which preserve tensile and compression strength at high temperature. Among aluminium alloy LM6 is a popular choice for matrix material, it is primarily due to it has good mechanical properties, weld ability and fluidity characteristics .it contains silicon as its major alloying elements.

MMC can be fabricated in various method based on its end product use. Liquid –phase infiltration of MMCS is not straight forward, mainly because of difficulties with wetting the ceramic reinforcement by molten metal.

II. MATERIAL SELECTION

Pure form of aluminum is soft in nature. Therefore the tensile strength, hardness strength is usually low. In order to have a wide range of mechanical properties small amount of alloying element are added to the pure form of aluminium.

A. LM6 Alloy

Aluminium-silicon alloys, as a matrix material, are chosen for their good strength-to-weight ratio, ease of fabrication at reasonable cost, good thermal conductivity, high strength at elevated temperature, excellent corrosion resistance as well as good castability and wear resistance properties. Thus, these alloys are suitable for aerospace, automotive and military applications. Majority of eutectic or near eutectic Aluminum-silicon alloys are used to produce pistons and are, therefore, known as 'piston alloy', which provides the best overall balance of properties.

B, Silicon carbide

Silicon carbide has the density close to aluminium and is best for making composite having good strength and good heat conductivity. It occurs in nature as the extremely rare mineral moissionte.silicon carbide powder has been mass-produced since 1893 for use as an abrasive . Grains of silicon carbide can be bonded tighter by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plate in bulletproof vests.

C. Fly ash

Fly ash particles (usually of size0-100micron) which are extracted from residues generated in the combustion of coal can be used as reinforcement materials. As fly ash has low density, chances of having good weld ability between fly ash & matrix Al alloy. Particulate reinforced aluminium matrix composites are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing. The high electrical resistivity, low thermal conductivity and low density of fly ash may also helpful for making a light weight composites. Also production of Al may be significantly reduced by fly ash substitution.

II. FABRICATION OF MMC

The Al-Si alloy/Sic- FA metal matrix composite was manufactured by stir casting process. First, Al-Si alloy matrix material was melted in resistance heated furnace in a graphite crucible and liquid metal heated at 700^0C. Next Sic, fly ash are preheated to 400^0C were added into molten aluminium materials by means of argons gas flow with rate of 20g/min.

Fig. 2 Stir casting setup

Figure 1: stir casting setup

During the process, the molten matrix and Sic –Fly ash were stirred by a mixture with 450 rev/min. when the temperature of metal matrix materials decreased to near the melting point. Which makes the stirring process hard, the process was stopped, but the matrix material was heated again up to 700^{0}C to ensure the homogeneity of the mixture.

III. RESULTS AND DISCUSSIONS

The Al-Si alloy/Sic-FA metal matrix composite was manufactured by stir casting process and the following test conducted.

- Tensile test
- Hardness test
- Compression Test

1) Tensile test: Tensile tests were used to assess the mechanical behavior of the composites and matrix alloy. By following the ASTM standard tensile specimens with diameter of 6mm and gauge length of 30mm are prepared Ultimate tensile strength(UTS), often shortened to tensile strength (TS) ultimate strength, is the maximum stress that a material can withstand while being stretched or pulled before necking , which is when the specimens cross-section.

Table1: Results of tensile test

Materials	Aluminum LM6+Silicon carbide +Fly ash		
Specimen No	Fly ash Mixture (%)	Sic Mixture (%)	Tensile Strength(N/mm^2)
1	0	0	145 N/mm^2
2	5	0	167 N/mm^2
3	0	5	187 N/mm^2
4	2.5	2.5	190 N/mm^2

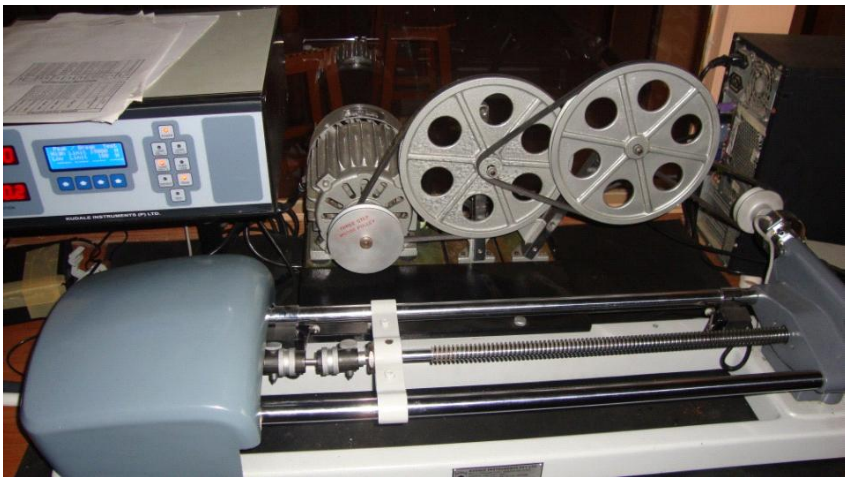

Figure 2: Tensile test equipment

Figure 3: Tensile sample before test **Figure 4: Tensile sample after test**

2) Hardness test:

Hardness tests are performed on as cast and composites to know the effect of fly ash particles in Al-Si alloy based MMC. Brinell hardness test is conducted on the specimen using a standard Brinell hardness tester (Model: RAB 1) as shown in Figure 5. A load of 500 kg is applied on the specimen for 30 seconds using a 10 mm ball indenter and the indentation diameter is measured using a microscope. The hardness is measured at three different locations of the specimen and the average value is calculated. The indentation is measured and hardness is calculated using Equation (1).

$$BHN = \frac{2P}{\pi D\left(D-\sqrt{\left(D^2-d^2\right)}\right)} \quad (1)$$

Where P = applied force (N),
D = diameter of indenter (mm) and
d = diameter of indentation (mm).

The Brinell hardness values of the specimens were measured on
Using diamond cone indenter with a load of 100gms and 15 seconds as a holding time.

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Table 2 Results of Hardness Tests

Materials	Aluminum LM6+Silicon carbide +Fly ash		
	Fly ash Mixture (%)	Sic Mixture (%)	Hardness (BHN)
1	0	0	57BHN
2	5	0	62BHN
3	0	5	75BHN
4	2.5	2.5	79BHN

Figure 5: Brinell hardness tester

Figure 6: Hardness Sample after test

3) Compression Test:

In this study, the compressive strength of the virgin alloy as well as the MMC specimens (L/D ratio: 1) are measured using universal testing machine (MECH.S/UTE20T) shown in Figure 3.18 and corresponding test specimens after testing are shown in Figure 3.19. The two end surfaces of the sample are polished using coarse SiC grinding papers before starting the compression test. The specimen is placed between two flat dies and the die surfaces are lubricated with a small quantity of zinc serrate powder to reduce the friction between the specimens and die surfaces during compression. Stress values are calculated for the three materials of similar geometry, after loading 50% of their heights. The compression test results are based on an average of three independent test values of each material

Table 3 Compression test for Composite

Materials	Aluminum LM6+Silicon carbide +Fly ash		
	Fly ash Mixture (%)	Sic Mixture (%)	Compression Strength (N/mm^{2})
1	0	0	462 N/mm^2
2	5	0	471 N/mm^2
3	0	5	479 N/mm^2
4	2.5	2.5	483 N/mm^2

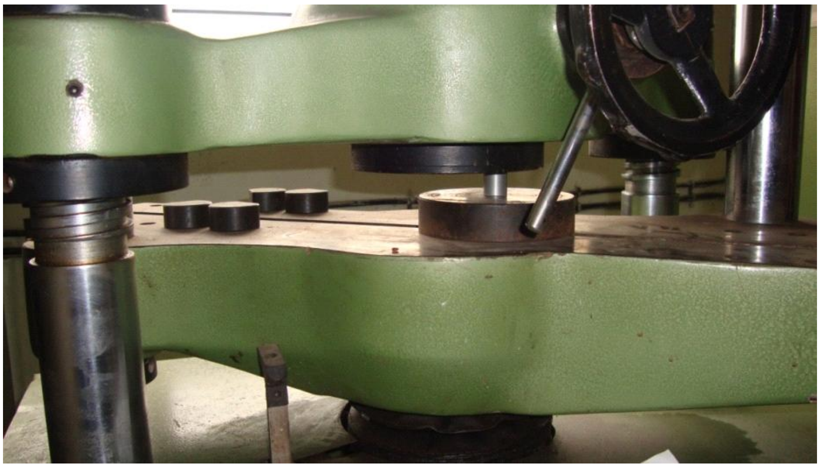

Figure 7: Compression testing machine (UTM)

Figure 8: Compression testing sample after test

IV. COCLUSION

The continuous stir casting method used to prepare the composites could produce uniform distribution of the reinforced fly ash and SiC particles. In the present investigation it is concluded that the hardness of the hybrid composites is higher than that of the unreinforced alloy as well other composite. Hardness value of the hybrid composite increased by 37 %, 27% and 6% in compare to Al-Si alloy, AlSi-FA composite and AlSI-SiC composite respectively. Similarly Tensile value of the hybrid composite increased by 31 %, 14% and 2% in compare to Al-Si alloy, AlSi-FA and AlSi-SiC composite respectively. Compression value of the hybrid composite increased by 5%, 3% and 1% in compare to Al-Si alloy, AlSi-FA composite and AlSI-SiC composite respectively. The experimental data reveals that selection of reinforcement is one of the important aspects in production of metal matrix composites especially when the enhanced mechanical properties are desired. Several iterations on volume fraction, types of reinforcement, characterization etc. are needed before manufacturing a suitable metal matrix composite.

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