MECHANICAL BEHAVIOUR OF Al-6061 WITH REINFORCEMENT OF E-GLASS FIBER, SiC AND FLY ASH BY USING STIR CASTING EQUIPMENT

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Abstract : This paper scrutinize the Mechanical behavior of Hybrid Metal Matrix Composites prepared by using Al-6061 alloy as a Matrix, E-Glass Fiber, SiC and Fly ash as reinforcement particles. Here SiC and Fly ash are assorted with respect to the weight percentage while E-Glass Fiber is kept constant with some weight percentage. After that samples were composed by using stir casting method. Four different samples were taken as (0%, 1%, 2%, and 3%). This work divulges that addition of reinforcement increases the ultimate tensile strength, Hardness and density of the composite material.

IndexTerms **- Hybrid Metal Matrix, E-Glass Fiber, SiC, Fly ash, Stir casting, Hardness, Density, Tensile Strength**

I. INTRODUCTION

Metal Matrix Composites (MMCs) have increased applications in the fields of automobile, aerospace, defence, marine and industries due to their improved properties such as high specific modulus, specific strength, good wear resistance and a ceramic phase or metal phase. Ceramic reinforcement is in the form of silicon carbide, silicon nitride, alumina, boron carbide, boron nitride etc. and metallic reinforcement in the form of tungsten, molybdenum, beryllium etc. Among these materials Aluminium Metal Matrix composites (AMCs) with ceramic reinforcement are widely used for the design of components for most of the advanced applications. It has been reported that the use of AMCs in automobiles and aircrafts engine applications can reduce the total weight and fuel consumption. AMCs reinforced with either silicon carbide (3.21 g/cm3) or fly ash(1.5 g/cm3) particles are attractive materials for such applications. The density of these ceramic reinforcements is greater than aluminum alloys (2.7 g/cm3) and due to that weight of these composites increases based on the reinforcement content. Apart from other reinforcements, ceramic reinforcement materials are having admirable strength and it is used as primary reinforcement for the development of hybrid composites. But the cost of the ceramic reinforcement material is high. However, the cost of the secondary reinforcement is low as they were readily available in the market and the density is very low when compared to the other reinforcement materials. When primary and secondary reinforcements are combined, they can procure good mechanical properties. Using industrial wastes are less cost and they posses lower densities when compared to the ceramic reinforcements. Among the industrial wastage, Fly ash is considered as one of the reinforcement as it is available from thermal power plants. In aluminium matrix, when Fly ash is used as reinforcement results increase in Hardness, compressive strength and decrease in density. The results of experimental investigation of SiC and Fly ash reinforced aluminium alloy hybrid composites shows that, mechanical properties such as hardness, ultimate tensile strength and compressive strength increases with weight fraction of reinforcement increases. E-glass fiber having low density improves hardness and ductility of the material. In this work an attempt is made to develop 6061 aluminium hybrid metal matrix composites reinforced with different weight fractions of SiC and Fly Ash at different proportions keeping the weight percentage of the glass fiber as constant. The ultimate tensile strength, density and hardness properties of these hybrid composites are studied.

2. LITERATURE REVIEW:

Sidharth patel et.al.[1] described that Heat sinks made up of aluminium alloy when reinforced with E-glass Fiber and Fly ash in different weight percentage(0%,3%,6%,9%) by using stir casting method found that Tensile, compressive and yield strength increases with increase in addition of fly ash.

Pujan sarkar et.al.[2] found that, Glass Fiber when it is reinforced with epoxy composites by taking aluminium powder as base metal by conventional hand layup technique. Results described that friction and wear rate increases with addition of aluminium powder.

A.Benham et.al.[3] studied on different ratios of glass fiber (0%,5%,10%) and silicon carbide particles in different proportions. Tensile, flexural and impact strength has been increased by the addition of SiC to fiber epoxy composites.

V.R.Arun prakash et.al[4]noticed in their research that E-glass fiber when treated Aluminium 6061 and SS-304 wire mesh lowers Tensile strength/ flexural strength, Izod impact strength due to poor adhesion of metal surfaces.

Rajesh Purohith et.al.[5] made an analysis on the mechanical properties of Fiber glass, epoxy resins and fly ash by using hand lay up method. The fabricated polymer matrix composites were subjected to micro-structural study, Impact strength test and tensile strength test. Tensile strength decreases with the addition of fly ash and flexural strength increases with the addition of fly ash.

H.T.Gao et.al.[6]described in their article that Blast furnace slag was chosen as the main material with glass fiber and alumimium

powder as reinforcement. Results suggested that glass fiber has a better reinforcement effect of aluminium powder as it exhibits high mechanical strength.
Gajendra Dixit et.al.[7] in his work described that Hardness have been improved by the reinforcement of SiC and Fly ash to Al6061 and resulted that Hardness is improved while the tensile strength is reduced but it exhibits better wear resistance.

3. EXPERIMENTAL WORK:

3.1. Materials:

In this study, Al 6061 with density 2.71 g/cm^3 is used as Matrix material. It is one of the most popular in its series. Chemical composition of Aluminium alloy is given in the below tabular form.

Material	Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
% of constituents	6061	0.65	0.70	0.25	0.15	0.9	0.07	0.25	0.15	Remainder

Fig 1. Aluminium alloy

3.2. Reinforcement Material:

3.2.1. E-Glass Fiber:

E-Glass or electrical grade glass are used as insulators for electrical wiring. Later found that the e-glass is having excellent fiber forming capabilities and is now used almost solely as the reinforcing phase in the material commonly known as e-glass fiber. E-Glass fibers have a nominal composition of SiO_2, Al_2O_3, CaO, MgO, B_2O_3, Na_2 and K_2O.

fig2. E-glass fiber

Fiber reinforced composite materials consist of fibers embedded and bonded to a matrix material. In this form, both fibers and matrix retain their physical and chemical properties individually. Optimal strength and desirable properties are gain when the fibers are continuously aligned straight and parallel in a single direction. To support strength in other directions, construction of laminate structure can be done, with continuous fibers aligned in other directions. E-glass fiber, is low cost, high strength, good reinforcement and easily available in the market.

3.2.2. Fly ash:

Fly ash is a ravage product produced from the combustion of pulverized coal in electricity power plants, and contains fine particles that rise with the flue gases. Ash which collects at the bottom of the burning chamber is termed as bottom ash. Ash produced during the combustion of coal is generally referred as Fly ash. It can be generally collected by electrostatic precipitators or other particle filtration equipment. Flue gases reach the chimneys of coal fired power plants the ash is collected by electrostatic precipitators and other particle filtration equipment. Fly ash is classified into two types that is Class F fly ash and Class C fly ash. Class F fly ash contains calcium oxide more than 20% whereas Class C class Fly ash contains less than 20% of CaO. 75 micron grain size was used for the preparation of composite.

fig3. fly ash

3.2.3. Silicon carbide (SiC):

Silicon carbide is also known as carbondium which contains silicon and carbon. Grains of the silicon carbide can be bonded together by sintering to form very hard ceramics which are used in wide applications requiring high endurance, such as car brakes, car clutches and ceramic plates.

fig4.Silicon carbide(SiC)

3.3. Preparation of samples of Hybrid Composites:

Firstly, Fly ash, an Industrial wastage was collected near Thermal power plant and was sieved to attain a grain size of 75 microns. They are pre heated upto 200^0c in Muffle furnace in order to remove moisture content, absorbed gases and agglomeration present in the powder. Also, silicon carbide on an average of 30 microns is preheated upto a temperature of 200^0c. E-glass fiber is chopped into pieces.Stir casting is a liquid metallurgical method of composite material fabrication, in which a dispersed phase like ceramic particles, short fibers etc. is mixed with molten metal by means of a stirrer attached to it.

Fig.5. Bottom type Stir casting equipment

The material Al 6061 is dropped into chamber of the stir casting and then furnace is made to heat upto 750^0c. Aluminium starts melting to a temperature of 650^0c and then it enters into Liquified state. SiC and Fly ash is mixed with different proportions keeping the weight percentage of the E-glass Fiber as constant. All the three reinforcements is mixed and stirred well at 600 rpm. Molten metal is poured into dye to obtain a required shape. After removing the material from the dye, it is made to cool in air for about half an hour. For obtaining a proper finish, it was machined on Lathe. The composition of the material is mentioned below.

Casting	Al6061	E-glass fiber	Silicon Carbide	Fly ash
0	100%	-	-	-
1	99%	0.5%	0.25%	0.25%
2	98%	0.5%	0.75%	0.75%
3	97%	0.5%	1.25%	1.25%

Table 2.Composition of Reinforcement

4. Results and discussion:

4.1. Hardness strength:

The hardness strength is an ability of the materials to withstand the resistance against the indentation or abrasion. It is tested by hardness testing machine, Hardness can be tested by the three types of hardness tester Brinell's, Rockwell's, and Vickers hardness testing machine. In this research the DIGITAL MICRO VICKER HARDNESS TESTER is used to analyze the hardness strength of the sample. The diamond type indenter tool is used. The hardness strength of composite materials result is shown in figure.

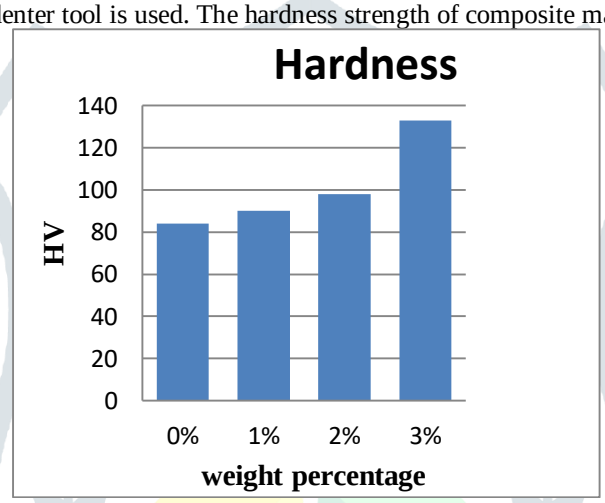

fig6.Hardness test graph

From the above graph it was concluded that the hardness value increases with increase in weight percentage of SiC and Fly ash with constant weight percentage of fiber glass.

4.2. Ultimate Tensile strength:

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure or breaking. It is tested by Universal Testing Machine. The tensile strength of the composite materials samples results is shown in the figure.

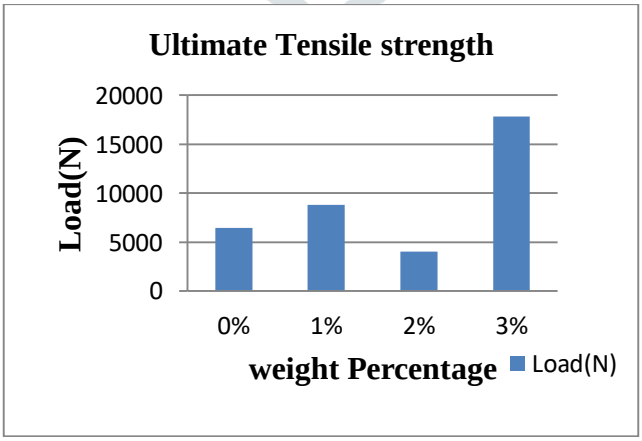

Fig7.Tensile test graph

From the above graph it has been concluded that second sample tensile strength has been increased by 26% compared to first sample while third sample tensile strength has been reduced to 54% when compared to second sample and fourth sample tensile strength is increased by 77% compared to third sample.

4.3.Density:

Measured density values of the AA 6061 alloy and its respective composites were given in a graph. It was observed that the addition of E-glass fiber, SiC, Fly ash into the AA 6061 alloy matrix significantly increased the density of the resultant composites when compared to the base alloy.

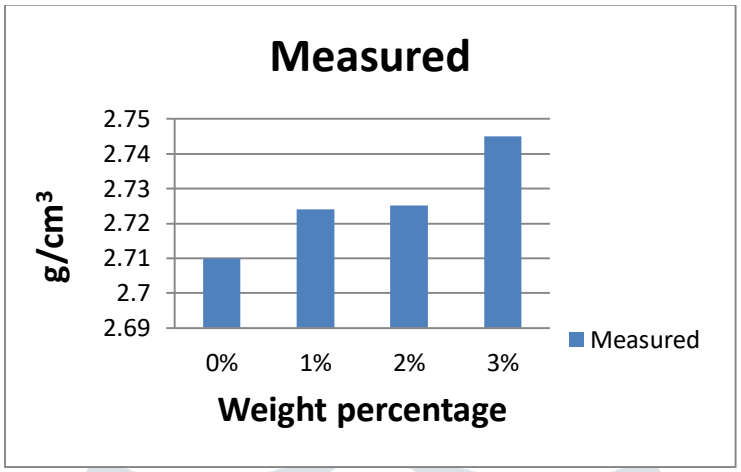

Fig.8 Density test graph

5. CONCLUSION:

Ceramic particles and short fibers reinforced Metal matrix have been successfully fabricated.

- Hardness increases with increase in the percentage of reinforcement.
- Tensile strength decreases at 2% of reinforcement and gradually increases at 3%.
- Density of the composite material increases with increase in the proportion of reinforcement compared to the density of the material.

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