STUDY ON MECHANICAL PROPERTIES OF ALUMINIUM BASED FLY ASH AND GRAPHITE REINFORCED HYBRID METAL MATRIX COMPOSITE

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Abstract—*This project deals with the study on mechanical properties of aluminium based fly ash and graphite reinforced hybrid metal matrix composites. The reinforcing particulate of MMC's varies as 3%, 6% and 9% Fly ash with 3% Graphite (constant) each by weight and the magnesium was added 2% by weight for increasing wettability of pure Aluminium. The Stir casting method is employed to fabricate the composite, in which the reinforced particulates are poured in the molten aluminium (LM25) and stirred by motor for uniform mixing before poured into moulds. The produced composite are subjected to hardness test, tensile test are compared with pure Aluminium (LM25). It was found that hardness increase with the addition of fly ash content. The tensile strength goes to decreases with a content of fly ash.*

Keywords— Aluminum LM25, Fly ash, Graphite, Hardness, Stir casting ,Tensile strength

1. INTRODUCTION

Metal Matrix Composites are composed of a metallic matrix (Al,Mg,Fe,Cu etc.) and a dispersed ceramic (oxide, carbides) or metallic phase (Pb,Mo,W etc.). Ceramic reinforcement may be silicon carbide, boron, alumina, silicon nitride, boron carbide, boron nitride etc. whereas metallic reinforcement may be titanium, tungsten, beryllium etc. MMCs are used for Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs and a variety of other applications. From a material point of view, when compared to polymer matrix composites, the advantages of MMCs lie in their retention of strength and stiffness at elevated temperature, good abrasion and creep resistance properties. A literature survey on aluminum based matrix composite has been done and related brief data is given.

2. LITERATURE REVIEW

Mr.Sharanabasappa, R.Patil, Prof B.S Motgi (2013) [1] were investigate the mechanical properties of fly ash and Alumina reinforced aluminium alloy (LM25) composites samples, processed by stir casting route are reported in this paper. Three sets of composites with constant weight fraction of fly ash (particle size of 3-100 μm) and Alumina (particle size of 150 μm) with different wt% were used. Composite samples have the reinforcement weight fractions of constant 3% fly Ash and varying %wt of 5, 10 and 15% Alumina. The main mechanical properties studied were the tensile strength,ductility, impact strength & hardness. Unreinforced LM25 samples were also tested for the same properties. It was found that the tensile strength & hardness of the aluminium alloy (Lm25) composites increases with the increase in %wt of Alumina up to certain limit. In addition of more amount of reinforcement the Tensile strength decrease due to poor wettability of the reinforced material with metal aluminium matrix.

H.C.Anilkumar, H.S.Hebbar&K.S.Ravishankar (2011) [2] were investigate the mechanical properties of fly ash reinforced aluminium alloy (Al 6061) composites samples, processed by stir casting route are reported in this paper. Three sets of composites with fly ash particle sizes of 4-25, 45-50 and 75-100 μm were used. The particle size ranges chosen as the said particle sizes were available more by weight fraction when sieve analysis was conducted on the sample collected for experiments and also the ones for which results are not reported. Each set had three types of composite samples with the reinforcement weight fractions of 10, 15 and 20%. The mechanical properties studied were the tensile strength, compressive strength, ductility and hardness. Unreinforced Al6061 samples were also tested for the same properties. It was found that the tensile strength, Increase in the weight fractions of the fly ash particles increases the ultimate tensile strength, compressive strength, hardness and decreases the ductility of the composite.

AnandhaMoorthy,Dr.N.Natarajan,R.Sivakumar, M.SureshM.Manojkumar, (2012) [3] were conduct the experimental investigation of hybrid metal matrix composites with fly ash and graphite reinforced aluminium alloy (Al 6061) composites samples, processed by stir casting route are reported. The aluminium alloy was reinforced with 3 wt.%, 6 wt.%, 9 wt.% fly ash and fixed 3 wt.% of graphite to mixture the hybrid composite. Hardness of the hybrid composite were tested it was found that when the hardness of the hybrid composites can be increased when compared to (Al 6061).

Viney Kumar, Rahul Dev Gupta, N K Batra(2014) [4] were done a comparison of mechanical properties of two metal matrix composites have been investigated. In first case AL6061, 4%MG chosen as a base metal and varying

composition of Fly ash i.e. 10%, 15% and 20% was taken as reinforcement in second case AL6061, 4%MG, 4%Graphite was taken as base material and varying composition of Fly ash i.e. 10%, 15%and 20% as reinforcement. It was found that tensile strength increase with addition of fly ash. Similarly when graphite was added then a decrease in tensile and hardness was observed. The composite with 4%Mg, 15%Fly ash found to be maximum tensile whereas composite of 4%Mg, 20%Fly ash was found to be of maximum hardness. Specific wear rate decreases with addition of fly ash up to a certain volume whereas with graphite addition it also decreases.

Dhanasekaran, SaiKrishna, Santosh, Pallavi, SreenathaReddy (2017) [5] The current research includes the study of metal matrix composite of aluminium alloy (A356) reinforced with alumina, graphite and silicon carbide for the application of water cooled cylinder block, which requires good tensile strength, hardness, wear resistance and low coefficient of friction. In the present investigation, 6 primary samples are fabricated with A356 as base metal, where three samples contains the composition of Sic (10%, 15% and 20%), 3%Gr, 10% alumina and other three samples containing Sic (10%, 15% and 20%), and 10% alumina. This study is mainly focused to improve the characteristics like hardness.

Bharat Admile, S.G.Kulkarni, S.A.Sonawane (2014) [6]. Metal matrix composites(MMC) reinforced with fly ash particulates have attracted considerable interest due to their inherent good mechanical properties such as tensile strength, compression strength ,hardness, wear resistance etc. Further, incorporation of fly ash provides overall weight reduction & filler material, thereby substitution of Al alloys Up to 20% wt., fly ash can be added in Al matrix. It can be concluded that almost all properties like tensile, compression, hardness, wear etc improved and hence fly ash should be implemented extensively in the commercial production of composites in industries as its use for the production of composites can turn industrial waste into industrial wealth. This also solves the problem of storage of fly ash as well as brings down the production cost giving an economical and eco friendly solution.

T.P.D.Rajan, R.M.Pillai, B.C.Pai, K.G.Satyanarayana, P.K.Rohatgi (2007) [7] In the investigation, the effect of three different stir casting routes on the structure and properties of fine fly ash particles (13 lm average particle size) reinforced Al–7Si–0.35Mg alloy composite is evaluated. Among liquid metal stir casting, compocasting (semi solid processing), modified compocasting and modified compocasting followed by squeeze casting routes evaluated, the latter has resulted in a well-dispersed and relatively agglomerate and porosity free fly ash particle dispersed composites. Interfacial reactions between the fly ash particle and the matrix leading to the formation of MgAl2O4 spinel and iron intermetallics are more in liquid metal stir cast composites than in compocastcomposites.The compression strength of Al–fly ash composite processed by modified compocasting cum squeeze casting is enhanced compared to the matrix alloy. However, the tensile strength has been reduced due to particle fracture and particle-matrix debonding.

3. RAW MATERIALS

A. Matrix or base material

In this paper a base material selected has aluminum LM 25 because it having a good thermal properties, good corrosion resistance and high strength to weight ratio. The table 1 shows that the mechanical properties of LM 25 and the figure 1 shows the aluminum LM 25 ingot block.

Table 1. Mechanical properties of Aluminium LM25

Mechanical Properties	LM25
Tensile Strength (N/mm^2)	130-150
Elongation (%)	3
Brinell Hardness	55-65
Modulus of Elasticity ($x10^3$ N/mm^2)	69

Figure 1 Aluminium lm25 ingot

B. Reinforced materials

2.1 Fly ash

There are two grades of fly ash available named class F and class C fly ash. In this project class F (100µm) grade was used because it having higher strength than class c. table 2 shows that the composition of fly ash and figure 2 shows the fly ash.

Figure 2 Fly Ash

Table 2. Chemical **composition** of Fly ash

Element	Fly Ash in Weight %	Element	Fly Ash in Weight %
SiO_2	(38-63) %	MgO	01-0.5) %
$Al2\ O_3$	(27-44)%	CaO	2-8)%
TiO_2	(0.4-1.8)%	$K_2\ O$	04-0.9) %
$Fe2\ O_3$	(3.3-6.4)%	$Na_2\ O$	0.07-0.43) %
MnO	(0.1-0.5)%	LOI	2-5.0)%

2.2 Graphite

The graphite powder was used in 50 t0 100µm particles size. It was having a high thermal stability and self lubricating properties. The figure 3 shows the graphite powder.

Figure 3 Graphite

4. FABRICATION PROCESS

There are four samples are prepared by using stir casting process. The table 3 shows that composition of different raw materials which were added in base alloy LM25.

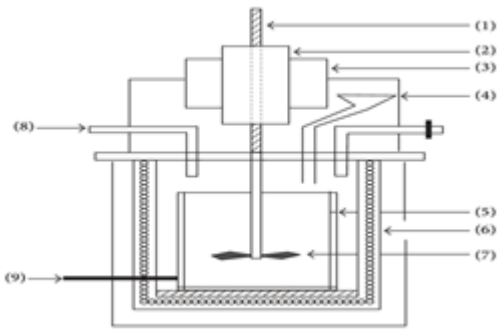
Table 3 Material weight composition of test specimens

Sample No.	Aluminium LM25 (%)	Fly ash (%)	Graphite (%)
	100	0	0
2	94	3	3
3	91	6	3
4	88	9	3

4.1 Stir casting procedure

In generally the stir casting process is the one of the liquid metallurgy manufacturing process and also it's the best suitable process for the aluminuium based composites because in this method the proper dispersion of reinforced materials occurred compare than other methods. The figure 4 and 5 shows that the stir casting equipment with their parts name and stir casting machine used in this project respectively.

Initially the aluminum LM25 was kept in a graphite crucible furnace and its heated up to 650 °C then the die also heated to 720°C in a preheater .when the base metal melted is it poured into the round shaped die having dimensions of 30mm diameter and 300mm length.



(1) Stirrer spindle, (2) sliding mechanism with impeller position control unit, (3) electric motor, (4) sprue, (5) crucible, (6) electric furnace, (7) impeller, (8) argon gas inlet, and (9) Thermocouple.

Figure 4 Schematic of modified two-stage stir casting setup

Figure 5 Conventional Stir casting machine with preheater.

Then to getting the composite material the mixture of 3% weight of fly ash and 3% weight of graphite is preheated in 400°C at 20 minutes. When the metal is melted at 700°C it was stirred by using the electrical motor arrangement and the magnesium is added to the molten metal for increases the wettability of the aluminum then the mixture of reinforced materials is feeded into the molten metal as range of feed is 1.5 to 2 g/s. the molten metal was poured into the die. Similarly the procedure is followed on 6% weight of fly ash and 9% weight of fly ash. Finally we are getting the four different composition samples. The figure 6 shows that the casting samples.

Figure 6 Casting samples

5. TESTS AND RESULTS

5.1 Tensile Test

The tensile test was done by the ASTM E8/E8M.The figure 7 shows that the tensile test specimens after the test.

Figure 7 Tensile test specimens

Table 4 Tensile test results

Specimen No.	Composition (%)	Elongation (%)	Yield stress (Mpa)	Tensile strength (Mpa)
1	(Al)	1.96	95	123.9
2	(Al/3FA/3Gr)	1.68	94	122.34
3	(Al/6FA/3Gr)	1.70	99	123.61
4	(Al/9FA/3Gr)	2.80	32	40.58

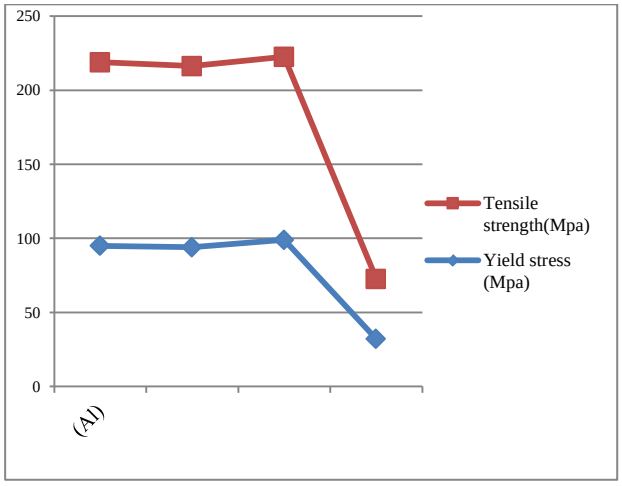


Figure 8 tensile test results

The table 4 show that the tensile strength, yield strength and elongation of four test specimens.

5.1 Hardness test

The Brinell hardness test was done by the ASTM E10. The figure 8 shows that the hardness test specimens and the table 5 and figure 10 show that the reading of hardness test. Readings on 3 locations was taken and average reading of each sample was considered as Brinell hardness number.

Figure 9 Hardness test specimens

Table 5 Hardness test results

Specimen No	Composition (%)	Brinell hardness number (HBW)			
		Reading 1	Reading 2	Reading 3	Avg. HBW
1	Al	67	67	67	67
2	Al/3FA/3Gr	62	67	67	65
3	Al/6FA/3Gr	72	67	72	70
4	Al/9FA/3Gr	72	77	77	75

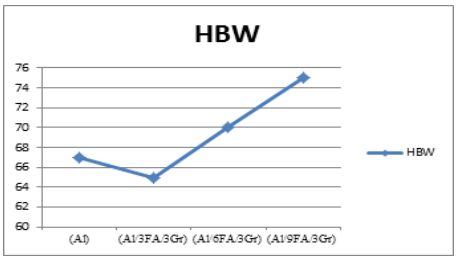


Figure 10 Comparison of hardness results

6. CONCLUSION

- Addition of the fly ash to pure aluminum lm 25 causes increases in hardness. The Al/9Fa/3Gr composite have a high hardness because of fly ash contents.
- However the addition of graphite causes decreases in hardness which resulting Al/3Fa/3Gr have less harness compare than the other ratios and pure metal
- Addition of the fly ash content cause slightly decreasing the tensile strength the ductility gets reduced.

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