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Development and Property Evaluation of Aluminium Alloy Reinforced with Fly-Ash

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ABSTRACT

Metal matrix composites (MMCs) constitute an important class of design and weight-efficient structural materials that are encouraging every sphere of engineering applications. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuously dispersed solids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications. To produce Al matrix cast particle composites, wettability of the ceramic particles by liquid Al is essential. To improve wettabilty, elements such as Mg and Zn are added into Al melt to incorporate the ceramic particles. Wide size range (0.1-100µm) fly ash particles were used. Some reinforcements provide the mechanical strength whereas some improves the wear resistance of composites. There are various techniques available for producing metal matrix composites, but stir casting is one of the oldest and most economical methods for producing particulate metal matrix composites of low melting point metals such as aluminum, magnesium, zinc etc. In present work Al-6061 alloy is reinforced with Fly ash. Stir casting is used for melting and dispersion of reinforcement particles using mechanical stirrer. The developed composites were characterized by using relevant techniques of simple microscope, Brinell hardness, tensile strength and compression test. Results revealed that the presence of reinforcements improves the micro hardness significantly and hybrid composite containing 5% Fly ash produced highest micro hardness due to uniform dispersion of particles. Further, higher reinforcements led to agglomeration in matrix and cause anisotropy in composites, which lower the mechanical properties of material. Analysis of tensile tests revealed that with increase in reinforcement percentage, the strength linearly decreases and above 15% reinforcement levels, strength starts increasing.

Keywords: Metal matrix composites (MMCs). Fly ash, Brinell hardness, Tensile test, Compressive test.

1. INTRODUCTION

Metal matrix composite (MMC) is built combination of metal and laborious particle/ceramic to induce tailored properties. MMCs are either in use or prototyping for the ballistic capsule, electronic substrates, bicycle, cars, golf clubs and a spread of different application. Like all composites are not one material however a family of materials whose stiffness, strength, density, thermal and electrical properties may be tailored. The matrix alloy, reinforcement material, volume and form of reinforcement, location of the reinforcement and fabrication methodology will all be varied to realize needed properties. The aim concerned in planning metal matrix composite material is to mix the fascinating attribute of a metal and ceramics. The addition of high strength, high modulus refractory particles to a ductile metal matrix produces a fabric whose mechanical properties are unit intermediate between the matrix alloy and the ceramic reinforcement. Metals have a helpful combination of properties like high strength, malleability and extreme temperature resistance, however typically have low stiffness, whereas ceramic area unit stiff and robust though brittle. Among discontinuous metal matrix composites, stir casting is generally accepted as a particularly promising route, currently practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production [1].

The interfacial reaction between the materials is also important because if the load carrying transferred to the interface, it will affect the mechanical properties of the composite material. So, the properties of the material also depend on the other characteristics like micro structure, shape, processing time of technique and the way of

reinforcement etc. The way of reinforcement also changes the physical properties like wear resistance, hardness, thermal conductivity. The reinforcement can be either continuous or discontinuous. The MMC's prepared by discontinuous process are isotropic and by continuous process are anisotropic structure. The anisotropic structure occurs because the fibers such as carbon fibers and monofilament wires embedded in to the matrix in particular direction [2].

Particle-reinforced aluminum metal matrix composites (MMCs) containing SiC and Al2O3 have received great attention in the past few decades because of their improved wear resistance, reduced coefficient of thermal expansion (CTE), high elastic modulus, and improved strength compared to unreinforced aluminum alloys. Although they have found potential applications in weight-critical components in automobile, aerospace and defence systems, the application base of these particulate MMCs is limited by their high production cost. Aluminum- fly ash composite is metal matrix dispersion strengthened composite in which soft and ductile aluminum matrix is strengthened by hard and brittle fly ash particles. Discontinuously reinforced aluminum based metal matrix composites are of increasing interest because of their high specific stiffness and strength, high isotropic and excellent wear resistance as well as cost effective manufacturing. DRA composites have been developed in the past two decades for various automobile, aerospace, electronic packaging and other structural applications. The overall approach of the present study is to develop and fabricate something unique from the traditional metal or similar types of aluminum alloy. After completing the experimental work, the resulting composites we found were not only unique composites but they were also enhanced in physical properties. These composites can be used for vast and advanced applications with low production cost. Besides, this type of composites are much more sustainable and environment friendly than normal aluminum alloy.[3]Composite material are the material of recent generation which are developed to fulfil the demand of industries and new technologies [4].

2. RELATED WORK

Aluminum 6061 is used as a raw material with the inclusion of fly ash, magnesium and zinc. The fly ash is obtain from Bharat institute of technology workshop Meerut, India. The particle size of the fly as received condition lies in the range from (0.1-100 μm).

Stir casting is use to produce aluminum metal matrix composite with fly ash. 300gm Al 6061 and 5% fly ash is taken in a pan and fly ash is preheated for 3 hours to 3000C. Al 6061 is melted in furnace raised temperature 7200C and fly ash is added at this temperature. The stirring was maintained to melt and mixing homogeneously with the help of stirring rod and stirring was maintained for about 2 to 3 min. Sand mould is prepared by adding additives and preheated to remove moisture after that the melt is poured into the sand mould. The composite were made with a 5% amount of fly ash, magnesium added to increase the wet ability of fly ash particle and zinc prevent cracks [5].

2.1 FLY ASH: It is residue produced with the coal combustion, it has low cost and low density produced at the time of combustion of coal in power plant as a by-product.119 million ton of coal is generated in US from the power plant. Instead of waste it can be use in research and it is economical to work on fly ash also. For the production of cement in the cement industry [6].

2.2 HARDNESS TEST: Hardness is the ability of a material to resist penetration, scratches, wear and cuts. Hardness test were carried out on the specimen prepared from casting to investigate the inclusion of particle on the casting of Al 6061 metal matrix. Load applied was 750Kg and indenter was a steel ball of 5 mm diameter [7].

Fig (1)
Melting of metal in Open furnace

Fig (2)
Measurement of dia. by microscope for hardness test

i) Before Testing

ii) After testing

Fig (3) Specimen for Hardness test

2.3 TENSILE TEST: On Universal testing machine tensile testing incorporates. It is the resistant of material under tensile force. Standard specimens with 65mm gauge length were used to evaluate ultimate tensile strength. The comparison of the properties of the composite material was made with the commercially pure Al and Al, Mg, Zn different combination on the basis of wt. percentage [8].

Specimen Specification

Gauge length=65cm

Specimen diameter=12mm

Area of specimen=113.097mm*mm

(i) Al+4%Mg+2%Zn **(ii)** Al+4%Mg+4%Zn **(iii)** Al+2%Mg+2%Zn **(iv)** Al+6%Mg+6%Zn

Fig (4) Tensile test specimen before testing

Al+5% Fly ash specimen

Al+2%Mg+4%Zn+5% Fly ash specimen

Fig (5) Tensile test specimen After testing

2.4 COMPRESSION TEST: On Universal testing machine, compression test is carried out to evaluate the compressive strength. It is the resistant of a material under compressive load. Standard specimens with 35mm gauge length were used to evaluate ultimate tensile strength. The comparison of the properties of the composite

material was made with the commercially pure Al and Al+ Mg+ Zn and fly ash different combination on the basis of wt. percentage [9].

Specimen Specification

Gauge length=35cm

Specimen diameter=23mm

Area of specimen=415.47mm*mm

i) Al+4%Mg+2%Zn **ii)** Al+4%Mg+4%Zn Al+5%Fly ash and Al+2%Mg+4%Zn+5%Flyash

iii) Al+2%Mg+2%Zn **iv)** Al+6%Mg+6%Zn

Fig (6) Compression test specimen Before testing

i) Al+4%Mg+2%Zn **ii)** Al+4%Mg+4%Zn Al+5%Fly ash and Al+2%Mg+4%Zn+5%Flyash

iii) Al+2%Mg+2%Zn **iv)** Al+6%Mg+6%Zn

Fig (7) Compression test specimen After testing

3. EXPERIMENTAL RESULTS

The table shows that addition of ash particle in Al matrix causes affordable increase in hardness. The best result for hardness of aluminum alloy composite is obtain for Al+2%Mg+4%Zn so after adding 5% fly ash ,it is clearly show from graph enhanced increment in the hardness of Al composite of 2270.96 BHN.

Table 1 Hardness properties of composites

S.No.	SPECIMEN	HARDNESS NO.(BHN)
1	Al	100
2	Al+2%Mg+2%Zn	114.81
3	Al+4%Mg+4%Zn	165.39
4	Al+6%Mg+6%Zn	153
5	Al+2%Mg+4%Zn	231
6	Al+5% Fly ash	867.4
7	Al+2%Mg+4%Zn+5% Fly ash	2270.96

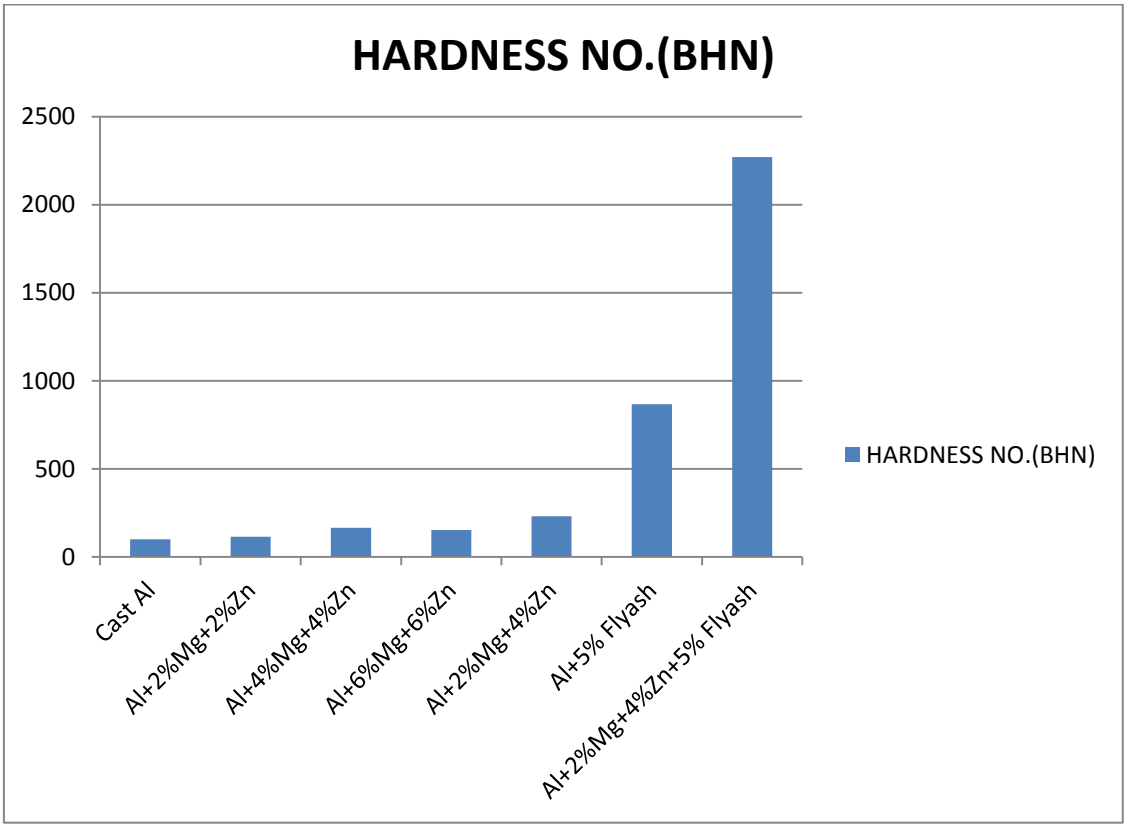

Fig.(8) Graph showing variation in hardness with composition of MMCs

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Table 2. Tensile properties of composites

S.No.	SPECIMEN	Tensile Strength(MPa)
1	Cast Al	78
2	Al+ 2%Mg+2%Zn	83.27
3	Al+4% Mg+4%Zn	173.479
4	Al+6%Mg+6%Zn	76.33
5	Al+2%Mg+4%Zn	235.93
6	Al+5% Fly ash	48.574
7	Al+2%Mg+4%Zn+5% Fly ash	124.9

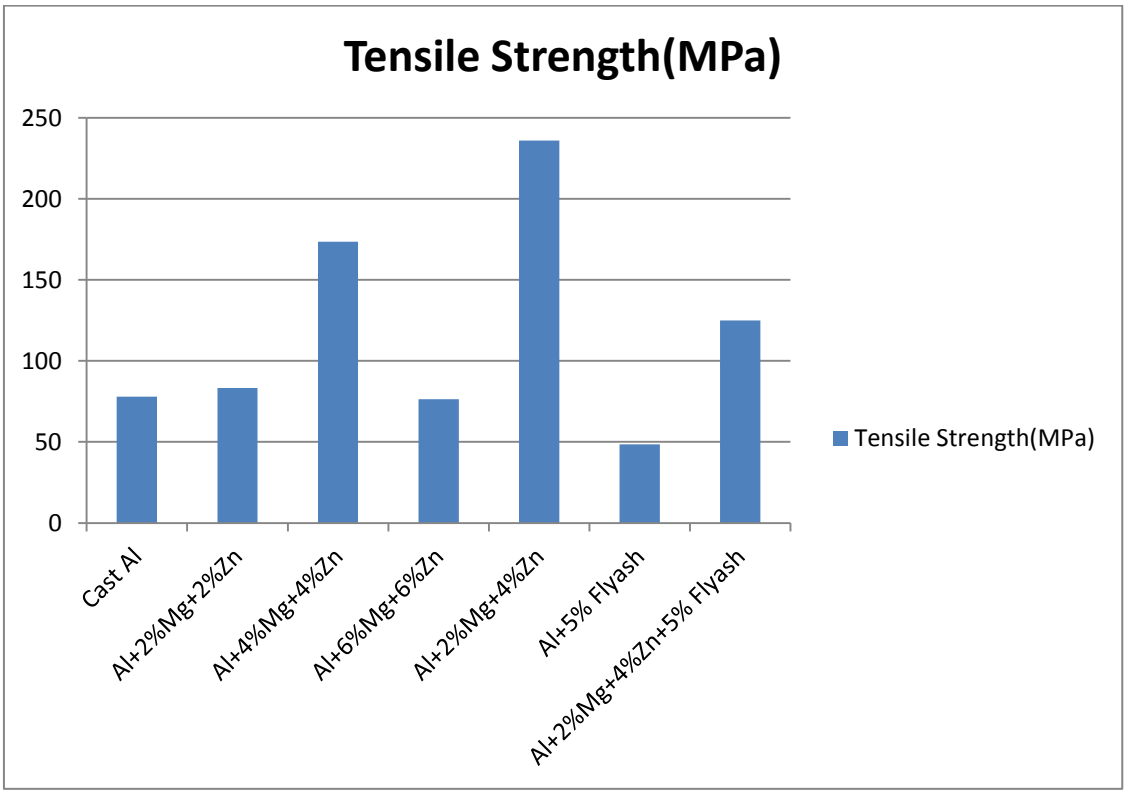

Fig.(9)- Graph shows variation in tensile strength with composition of MMC

Table 3. Compressive properties composites

S.No.	SPECIMEN	Compressive Strength(MPa)
1	Cast Al	450
2	Al+2%Mg+2%Zn	472.23
3	Al+4%Mg+4%Zn	637.51

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4	Al+6%Mg+6%Zn	443.9
5	Al+2%Mg+4%Zn	703.63
6	Al+5% Fly ash	377.78
7	Al+2%Mg+4%Zn+5% Fly ash	472.23

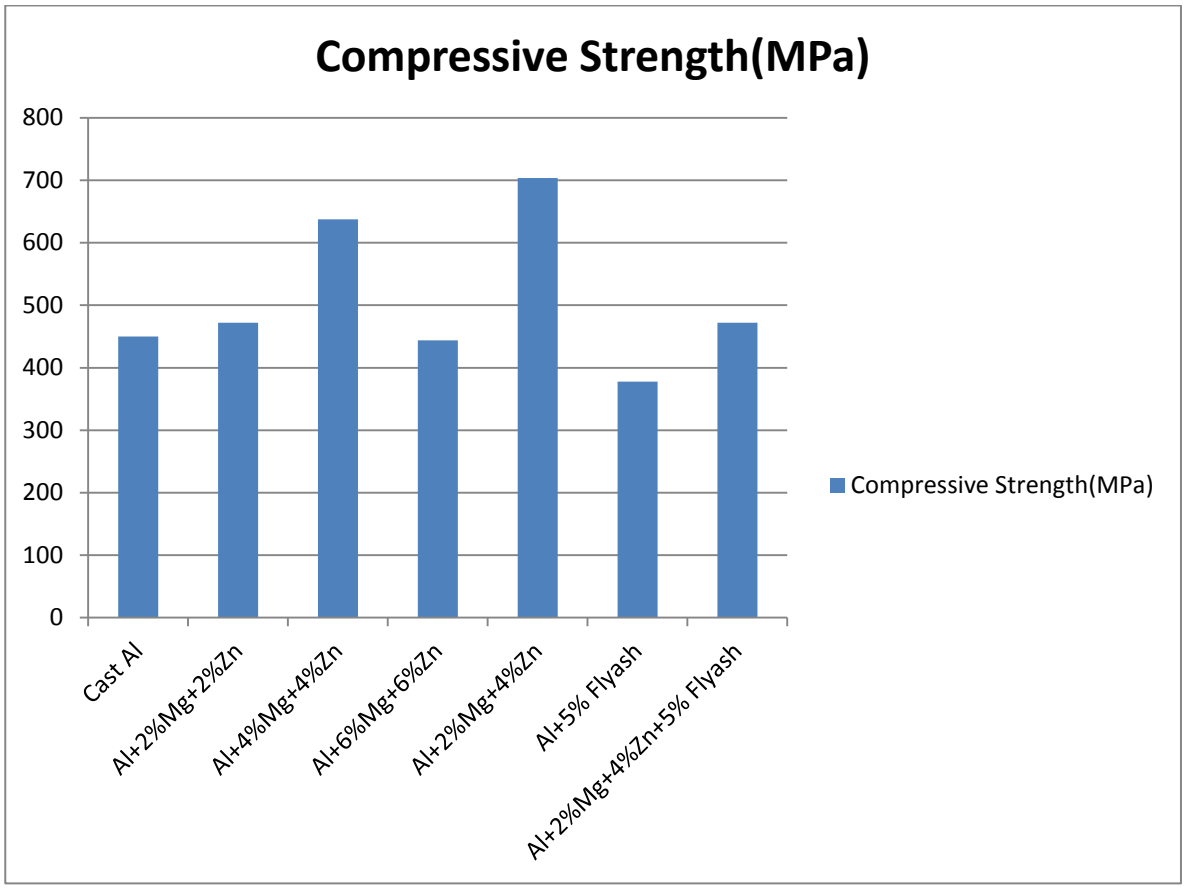

Fig.(10)- Graph showing variation in compressive strength with composition of MMC

4. CONCLUSION

The flowing conclusion may be drawn from the present work:

I. It is noted from the experimental work that fly ash use for the production of composites which increases the industrial wealth by using industrial waste.

II. Fly ash up-to 5% by weight added into Al 6061 successfully for the production of metal matrix composites.

III. By stir method Al-Fly ash composites produced which is homogeneous particle distribution.

IV. The magnesium increases the wet ability so the mechanical properties such as hardness , wear resistant increases.

V. Hardness of metal matrix composite is increases from 100BHN to 2270.96 BHN with the inclusion of fly ash and magnesium.

VI. The ultimate tensile strength has not improved so much with increase in fly ash content. while ductility has decreased with increase in fly ash content.

VII. Ultimate compressive strength has not improved so much by adding fly ash content .

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