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Analytical Study of Aluminum Matrix Composite using Experimental Determination

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Abstract: ***Study the properties of fly ash alumina reinforcement and prepared by using stir casting route method material. Constant weight of composite i.e. fly ash which is 3-100 µm in size and Al2O3 at 150 µm in size are used. Weight of reinforcement material is varying at %wt 5, 10 and 15% Al2O3. Tensile strength, ductility impact strength & hardness these are main mechanical properties which is studying in this paper. Tensile strength & hardness of the aluminium alloy composites increases with the increase in wt% of Al2O3 up to certain limit. More amount of reinforcement was added. due to poor wettability of the reinforced material tensile strength decreas. The Microstructure study of the samples indicated near uniform distribution of the fly ash and Al2O3 particles in the matrix. Aluminium alloy having better mechanical properties are required in castings of a shape. The alloy is used for resistance to corrosion.***

Keywords: Matrix, Reinforcement, Al2O3, Fly ash, Stair casting

1. Introduction

The composite materials that are needed for underwater, aerospace and transportation applications. Aluminum based matrix composites remain the most explored metal matrix material for the development of MMCs. As the addition of unequal amount of reinforcement (Silicon Carbide particles) increases in aluminum matrix materials, the ductility so that structural applications in many engineering situations are limited. Due to understanding strengthening mechanism it helps to improve the mechanical properties, such as the study of interfacial structure, precipitation during the aging process, dislocation generation. Due to the large difference between the coefficients of thermal expansion of the copper matrix and tungsten fibres, dislocation generation is produced. The enhanced strength could be accounted for by a high dislocation density. Composites (aluminium matrix composite) are one of the advanced production material which is used to developed weight critical applications in the aerospace, and more currently in the automotive industries. This material is used because of their correctly combination of high specific strength and better toughness.

2. Review

To enhance mechanical characteristics of the hybrid composite and to change in wear resistance of Composite material with respect to increasing percentage of reinforcement. Therefore this paper concentrates on the Aluminium alloy matrix composites reinforced with hybrid by the stir casting method can be successfully synthesized.

Sharanabasappa R Patil et.al. [1] have investigated the results of an experimental investigation of the mechanical properties of Alumina reinforced aluminum alloy (LM25) and fly ash composites samples, processed by stir casting route. Tensile strength, impact strength & hardness were studied. It was found that the tensile strength & hardness of the aluminum alloy (LM25) composites increases with the increase in %wt of Al2O3 upto certain limit. The charpy test shows that as decrease in impact load absorption with increase in %weight reinforcement. The main objective of study is to fabricate the hybrid metal matrix composite successfully by using flyash and alumina as particulate. Results of hybrid composite are also compared with simple composite and with parent metal

Sandeep Kumar Ravesh et.al. [2] fabricated hybrid MMCs containing Aluminium 6061,SiC and fly ash .Composites were fabricated by varying wt %fraction of SiC(2.5%,5%,7.5% and 10%) from results ,may found that tensile strength ,hardness & toughness increases with increases with increasing wt percentage of SiC.

Mahendra Boopathi et.al. [3] evaluated physical properties of Al2024 reinforced with SiC and fly ash SiC (5%) + fly ash (10%) and fly ash (10%) + SiC (10%)] . It was observed that tensile strength and hardness were increased as compared to Al-SiC and Al-fly ash composites.

K.K.Alaneme et.al.[4] studied microstructure mechanical properties and corrosion behavior of Al-Mg-Si matrix composites containing 0:10 , 2:8, 3:7,and 4:6 wt percentage bamboo leaf ash and SiC as reinforcement.From the experimental results it was found that hardness ,UTS and percentage elongation decreases the BLA contains increases. Fracture toughness of hybrid composites was higher as compared to single reinforced Al - 10 wt% SiC composite.

M.Sreenivasa Reddy et.al .[6] fabricated Hybrid Metal Matrix Composites (MMCs) constitute an important the different compositions of E-glass and fly ash particulates with Aluminium alloy (7075) by stir casting method .Tensile testing of the specimen were carried out and it was observed that was tensile strength of the hybrid MMC is better than Al7075.

Ashok Kr. Mishra et.al [13] studied the wear and frictional properties of the metal matrix composites by Al6061 reinforced with SiC particles (10% and 15%) using dry sliding wear test using a pin-on-disc wear tester. Experiments were carried out based on the plan of experiments generated through Taguchi's technique. A L9 orthogonal array was selected for analysis of the data. Effect of applied load, sliding speed and sliding distance on wear were studied and coefficient of friction.

N. Radhika et.al [15] studied wear behaviour aluminium alloy (Al-Si10Mg) reinforced with graphite (3%) and alumina (9%) fabricated by stir casting process. The frictional and wear properties of the hybrid metal matrix composites was examined by dry sliding wear test using a pin-on-disc wear tester. Experiments were carried out based on the plan of experiments produced through Taguchi's technique. A L27 Orthogonal array was chosen for analysis of the data. Investigation to find the influence of sliding speed, sliding distance and applied load on wear rate, as well as the coefficient of friction during wearing process was determined using ANOVA and regression equations for each response were developed.

From the literature review it is observed that, many researchers have done research on hybrid composite and they have successfully casted material at different % of reinforcement material. They have experimentally investigated and characterized the different test. They found that different mechanical and wear properties of hybrid composites are enhancing with increasing % of reinforcement.

3. Materials and Methods

a) Metal matrix composites

Metal-matrix composites are combination of two or more materials i.e. one of which is a metal. At production of MMCs having continuous or discontinuous whiskers, Fibers or number of metal particles. To achieve combinations of very high specific strength and specific modulus. The modern composites differ in the sense that any selected volume, shape and size of composites like high elevated temperature of reinforcement can be artificially defines in the matrix. The modern composites are non-equilibrium combinations of metals and ceramics, where are less thermodynamic obstacle on the relative volume percentages and shapes and size of ceramic phases. Composite materials have the possibility of attaining property combinations hence these could include many characteristics i.e. improved strength, reduced weight, more temperature, increased wear resistance, more elastic modulus, controlled coefficients of thermal expansion and increase fatigue characteristics.

b) Fly Ash

Fly ash is a material which is created by using combustion of coal. Fly ash is an industrial product produced from the flue gas of coal burning electric power plants. The components of the fly ash produced at same amount and continuously but all fly ash includes medium amounts of silica and lime. In general, fly ash consists of SiO2, Al2O3, and Fe2O3 as maximum compounds and oxides of Mg, Ca, Na, K etc. as minimum compounds. Fly ash particles having specific surface area between 250 and 600m2/kg, spherical in shape and size is less than 1 µm to 100 µm as well as specific gravity of fly ash change in the range of 0.6-2.8 gm/cc. Application of the Coal fly ash is a cement additive, in parts of building blocks, as a concrete admixture, as a material in less weight alloys, in roadway construction, in structural fill materials, as roofing granules, and in walls of kitchens. The major application of fly ash is in the cement and concrete industry also use in the fabrication of MMCs.

c) Alumina as Reinforcement

Figure 1: Fly ash

Aluminium oxide having strong ionic inter atomic bonding gives increase in its desirable material properties. It can exist in many crystalline states which all revert to the more stable hexagonal alpha state at elevated temperatures. Alpha phase alumina has strong and stiff of the oxide ceramics. Because of high hardness, good dielectric properties, refractoriness and good thermal characteristics make it the material of select for wide range applications. It resists attack by all gases except wet fluorine and is resistant to all general reagents expect phosphoric acid and hydrofluoric acid. The composition of ceramic body can be changed to change in size of particular desirable material characteristics. Other addition can be made to improve the ease and consistency of metals films fired to the ceramics for subsequent brazed and soldered assembly. Alumina particles are shown in fig.

Table 1: Properties of Alumina

99.5% Aluminium oxide		
Mechanical	Unit of Measure	S.I Unit
Mechanical	Unit of Measure	S.I unit
Density	Gm/cc	3.89
Porosity	%	0
Elastic	Gpa	375
Shear	Gpa	152
Bulk	Gpa	228

Poissons - .22
Fracture Mpa*m$^{1/2}$ 4
Hardness Kg/mm^2 1440
Compressive Mpa 2600

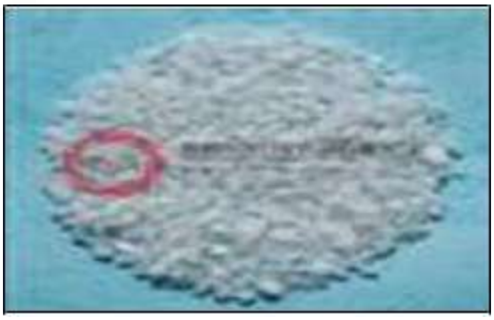

Figure 2: Alumina as reinforcement

4. Stir Casting

The composite will be manufactured by stir casting route. For removing the moisture reinforcement particle will be preheated to 3000C for three hour. At that time aluminium alloy will be melted in a resistance furnace. The temperature of the melt will be raised up to 7200C and by using purging hexa chloromethane tablets it will be degassed. Then the molten melt will be stirred with the help of a steel turbine stirrer and it will be maintained between 5 to 7 min at an impeller speed of specified rpm. At addition of reinforcement particles the melt temperature will be maintained 7000C. Then the solution will poured into the preheated metallic mould. The pouring temperature will be maintained at 6800C. The melt will be then allow to solidify the moulds. Silicon and magnesium were added to increase the wet ability of fly ash particles.

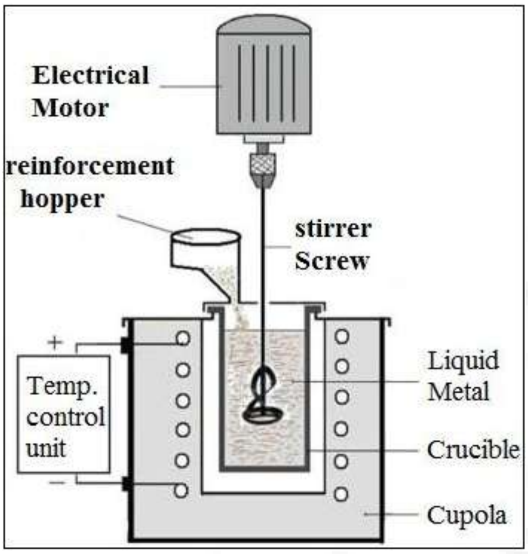

Figure 3: Stir Casting set up

A. Hardness

For measurement of hardness of composite material Brinell hardness test is used. Brinell hardness measurements were carried out in order to investigate the influence of particulate weight fraction on the matrix hardness. In this test load will be applied up to 62.5 kgs and indenter will a steel ball which is 2.5 mm diameter. All this test specimens are prepared by reference standardEN1706:1998/BS1490:1988.

B. Impact test

For the impact test size of the specimen takes 10 x 10 x 55 mm with a V notch size of 2 mm. Types of impact test is charpy and Izod test. For this composite material we take charpy test for measuring toughness. The impact tests are to be used as a quality control method to notch sensitivity. Also this test is used for comparing the relative toughness of engineering materials. During this test the slotted material is broken due to the impact of the pendulum. A stop pointer is used to record how far the pendulum moves to back after impacting the specimen. It is obtained by taking the height at which the pendulum is released and the height to which the pendulum moves after it has impact the specimen. Toughness is varies with temperature, this test is repeated various times with each specimen tested at a different temperature. The material is more ductile and impact toughness is higher at high temperatures. All this test specimens are prepared by reference standard EN1706:1998/BS 1490:1988.

C. Tensile Test

The tensile testing of the hybrid composite was carried out, on Universal testing machine. Standard specimens with 62.5 mm gauge length were used to evaluate ultimate tensile strength, yield strength, % elongation. The comparison of the properties of the composite material was made with the commercially pure Al356.

Tensile strength dictates how the material will react to forces being applied in tension. Tensile test is fundamental test of mechanical where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of specimen over some distance. All this test specimens are prepared by reference standard EN1706:1998/BS 1490:1988.

D. Compression Test

The tensile test also compression test is performed on UTM i.e. Universal Testing Machine. For compression test size of specimen is 10 mm Diameter and length 20 mm. A compression test is a method for determining the behaviour of materials under a compressive load. Compression tests are conducted by loading the test specimen between two plates and then applying a force to the specimen by moving the crossheads together. This test determines elastic limit, proportionality limit, yield strength and compressive strength, yield point. It is the maximum compressive stress that a material is capable of withstanding without fracture. All this test specimens are prepared by referencestandardEN1706:1998/BS1490:1988.

5. Results

[1] Hardness

Table 2: Hardness of Hybrid Composite material % wise reinforcement

No.	Samples Designation	Hardness (BHN)
1	Pure Al356	90
2	Al356+2%Fly Ash+2%Al2O3	84
3	Al356+4%Fly Ash+4%Al2O3	75
4	Al356+6%Fly Ash+6%Al2O3	77.5
5	Al356+8%Fly Ash+8%Al2O3	73.5
6	Al356+10%Fly Ash+10%Al2O3	72

[2] Impact test

Table 3: %wise increase in reinforcement vs. energy absorbed

No.	Samples Designation	Average (J)
1	Pure Al356	2J
2	Al356+2%Fly Ash+2%Al2O3	2J
3	Al356+4%Fly Ash+4%Al2O3	2J
4	Al356+6%Fly Ash+6%Al2O3	2J
5	Al356+8%Fly Ash+8%Al2O3	2J
6	Al356+10%Fly Ash+10%Al2O3	2J

The impact toughness of a metal is determined by measuring the energy absorbed in the fracture of the specimen is 2J Al356+4%Fly Ash+4%Al2O3 composite material is more so it is effecting on Hardness and Ultimate tensile strength of Material.

[3]Tensile Test

Table 4: Tensile properties composites

No.	Samples Designation	Hardness (BHN)	U.T.S (Mpa)	% Elongation
1	Pure Al356	90	151.27	2.2
2	Al356+2%Fly Ash+2%Al2O3	84	172.71	1.547
3	Al356+4%Fly Ash+4%Al2O3	75	164.244	2.717
4	Al356+6%Fly Ash+6%Al2O3	77.5	192.74	1.366
5	Al356+8%Fly Ash+8%Al2O3	73.5	119.95	0.74
6	Al356+10%Fly Ash+10%Al2O3	72	73.94	0.03

[4] Compression Test

Table 5: Compression Strength of Hybrid Composite material

Sr. No	Designation of Specimen	Compressive load at failure (KN)	Compressive Strength (MPa)
1	Pure Al356	53.4	679.91
2	Al356+2%Fly Ash+2%Al2O3	50	636.62
3	Al356+4%Fly Ash+4%Al2O3	57.95	737.84
4	Al356+6%Fly Ash+6%Al2O3	59.6	758.85
5	Al356+8%Fly Ash+8%Al2O3	60.23	766.56
6	Al356+10%Fly Ash+10%Al2O3	62.56	761.98

6. Conclusion

From Present Work it is concluded that the aluminum composite materials can be easily manufactured by stir casting method. The extensive work of above paper has been reported to improve mechanical properties of Aluminium Metal Matrix like hardness increases with increase in Weight percentage addition of Al2O3. While at the other end impact strength will gets reduced. A further study in this respect is needed particularly to find and compare the properties of aluminium alloy. Present research work includes, behavior of SiC particles in Metal Matrix Composites during hardness and impact test and improve the mechanical and physical properties after hardening test and impact test.

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