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"EVALUATION OF PROPERTIES FOR ALUMINIUM ALLOY METAL MATRIX COMPOSITES REINFORCED WITH FLY-ASH"

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ABSTRACT

Materials are often selected for the structural applications due to the fact those mechanical characteristics combinations which are acceptable. Developing of hybrid Metal Matrix Composite has become an important area in material science. And hence it was aimed to evaluate physical properties of Aluminium, fly-ash and its combinations. This leads to the direction of developing a generation of new materials which are produced at low cost, lighter in weight and possess higher strength. The end results of research on this specialized subject led to the improvement of composites. Consequently, AL-MMC mixes the toughness of matrix and reinforcement strength to obtain a combination of desired properties, which are not found in the single conventional material. Al Based MMC is processed in Resistance-Furnace successfully at 1000º C reaction-temperature and 30 minutes' reaction-time. The Micro-Structural studies demonstrate formation of Al + 4.5%Cu+ Fly Ash phases exhibiting exothermal-reaction is complete. The Tensile-strength of 1-3 and 2-3 compositions were found to be greater than that of 1-1 and 2-1 compositions respectively. The Hardness values of 1-1 and 2-1 compositions were found to be greater than that of 1-3 and 2-3 composition respectively. The Tensile strength of MMC is increasing with the decrease in fly-ash.

Keywords: Aluminium-4.5% Copper, MMC, Resistance-Furnace, Micro Structural, Hardness, Tensile Strength

INTRODUCTION

Materials are often selected for the structural applications due to the fact that mechanical characteristics combination which are acceptable. Developing of hybrid Metal Matrix Composite (MMC) has become an important area in material science. And hence it was aimed to evaluate physical properties of Aluminium, fly-ash and its combinations. This leads to the direction of developing a generation of new materials which are produced at low cost, lighter in weight and possess higher strength. The end results of research on this specialized subject led to the improvement of composites. Consequently, AL-MMC mixes the toughness of matrix and reinforcement strength to obtain a combination of desired properties, which are not found in the single conventional material. [1] During 20th century the modern composites were found and consolidated from the origin and processing of new materials. With superior properties like thermal, mechanical and physical of the numerous synthetic resins, ceramic matrix and metallic alloys with very small diameter lesser than 10 mm fiber are developed from the materials. The huge amount of increase is found in properties like stiffness and strength. As fly ash has great mechanical properties, during the mid of 20th century it gained a momentum of use of it for reinforcement. Firstly, the fly ash was used as reinforced laminated plastic in aero-space instead of metallic parts. The composite designer caught the imagination of fly ash like carbon, boron, glass, plastic and Kevlar such as polyesters, phenolic and epoxies. The continuous study for new and better material was glass fly ash, which is commercially available from many years and are found to be very tough, long lasting, non-inflammable and not sensitive to weather. It was easy to mold there is in coated with glass fibers to any shape that can be complex curve.

LITERATURE SURVEY

The feature of a novel in-situ measure, which conventional in-got metallurgy in addition to quick cementing procedures were utilized to deliver Al+4.5 % Cu+ Fly Ash composites with micro-structures and improved scattering solidifying of fortifying stages.[2] The joining of carbides framed in-situ in a raised temperature compound composite, provides benefit such as expanding modulus quality of base combination far beyond that conceivable through customary strategies, while as yet keeping up a moderately low volume part to safeguard the break durability and extension, e.g, for example, the quickly hardened deliver Al+4.5% Cu+FlyAsh. To concentrates on the portrayal of the microstructure with changing Al:Cu proportions in the Al-Cu amalgams. The interfacial response between Al framework and support in Al composites is significant, in light of the fact that it can influence how the heap is moved and afterwards influence composites mechanical properties, also, the interfacial response changes piece of grid. Albeit restricted interface response and upgrade heap bearing abilities of composite, broad interfacial response will shape disservice of composites. Consequently, so as to get ideal mechanical properties, it’s essential to accomplish great holding between the Al frame-work and the fired fortifications through suitable interfacial response. On account of the Al+4.5% Cu+FlyAsh composites, in any case, the interfacial response between Al framework and Fly debris fortification isn't obviously settled, as referenced already. What's more, no information is accessible on the Al+4.5% Cu+FlyAshcomposite manufactured by a weight less penetration method under a nitrogen climate. Subsequently, in this examination, the Al+4.5% Cu+FlyAsh composite was created by the weight less penetration technique and the microstructures were researched.

MOTIVATION

Composite materials are deployed all around us. Wood, bones, tree, etc are naturally existing composites. But these are not sufficient, they get limited. But their characteristics like low weight and directional properties made their existence and need, but limitations made them to lead their search for material with better properties then that of the natural composite materials. The main aim is to get a composite material, with increased properties like strength and stiffness. These properties are achieved by reinforcement of fly-ash and get a metal matrix composite material with highest mechanical properties.

PROBLEM DEFINITION

Designs of Aluminium based MMC to enhance the mechanical properties with different compositions of reinforce metal Fly-ash. The MMC with different composition and diameters can increase the characteristics like strength and stiffness of the existing composites. The performance is measured in terms of tensile, wear, hardness etc.

OBJECTIVES

The objectives are

- To study composites and properties of Al and Fly Ash.[3]
- To develop the composite of Al-Fly Ash with different percentage composition of Aluminium with Fly Ash.
- To develop MMC of different diameter by reinforcing Fly Ash to the Aluminium and increase its application in different fields.
- To measure the Mechanical Properties (hardness, wear, tensile, etc) for enhancing the strength and stiffness of the MMC.
- To simulate results and demonstrate that the different compositions of MMC exceeds the best of all the other existing composites under various tests.
- To analyze the various mechanical properties like hardness test, wear test, tensile test, and do a micro structural studies to conclude that AL- Fly Ash MMC for the enhancement of stiffness and strength.

MATERIAL, EXPERIMENTAL PROCEDURES AND MICROGRAPHY

A pure commercial aluminium matrix was used along with Fly ash as reinforcement to prepare the different composites. The preparation and properties are clearly mentioned.

6.1 Composites Preparation

6.1.1 Furnace

To prepare particulate composite, the heated furnace being used is of capacity 12 KW with 4 phase resistance furnace. A heating coils of A1 grade with a Kanthal of 3 pairs of 14 gauges. A 1200˚c as temperature range with controlling ability of + 11˚c is associated with furnace.

Figure 6.1: shows the furnace.

The furnace is having 500̊C per hour of capacity. At center of the furnace an alumina crucible is fitted and it is tilted on horizontal axis with 90 degrees, this enables the melt to pour on the plate as shown in figure 6.1.

6.1.2 Standardization of Stirring Conditions

In casting MMC, care should be taken while adding particulate. To obtain the better properties, by some means it should be distributed evenly. The liquid melt need to be stirred in ordered to enhance properties, as grain-refinement is being occurred. In order to get a good quality of cast, different parameter like stirring depth, speed and etc, need to be optimized while stirring. The vortex being formed during stirring, may indulge bubbles of air and particulate distribution, which depends on stirring. The simulating condition of liquid melt is studied using water, so that stirring depth and speed is optimized. The working fluidity of water made it to be selected due to its transparency, good solvent, and abundant availability. The study of water is mainly done to simulate conditions of vortex along with melt in which all particles mix takes place homogenously. To prevent a cavity formed by air entrapping, this leads to defect in casting. The movement of particles is observed by adding a dye. As medium is transparent it can be clearly see the bubbles of air present. The stirring depth and speed of melt defines vortex formation. The mixing of water homogeneously with conditions optimized, results in a well-defined vortex. The liquid melt is applied with same results and placed in crucible having similar dimension like fluid-container.

6.1.3 Stirring depth and speed

A vortex is formed with certain stirring depth and speed, at which a uniform homogenous solution is produced in a breaker by mixing a water particles. Standardization technique (as shown in figure 4.2) is the process in which a well-defined vortex is formed by finding the depth and speed of stirring.

Figure 6.2: Shows the Standardization of depth and speed of stirring.

6.1.4 Standardization of Degassing of Melt Slurry

- **Stirrer-Blade:** The major role is played by blade in formation of vortex. Hence a thorough research is done with accessible reference and the shape of blade is chosen optimally.
- **Cover flux:** The flux in small quantity is sprinkled over the aluminium as it starts to melt (as shown in figure 4.3). The property of flux is to prevent oxidation of aluminium. If the oxygen enters aluminium melt, the shape of the cast may be ruined as bubbles are formed while pouring the melt in mold.
- **Degassing agent:** The degassing tablet is added when gas is turned off when temperature reaches 800˚C, where the aluminium is fully melted. In the form of gas, the impurities are removed. The tablets generate fumes, which is important to have good extraction system to remove it.

6.2 Micro-Structural Studies

A computer was interfaced to the optical microscope and microscopic study was carried out for the structural characteristics of a composite. From both technical and scientific point of view, metallurgist have microscope as most important tool. The mechanical properties of composite like shape and size of granule along with spread of various phases.

6.3 Tensile-Test

The various properties of tensile materials during cast conditions are great tensile-strength, ductility and young’s modulus are evaluated using servo-hydraulic with a capacity 40 ton. UTM Tensile tests consist of placing specimen which is prepared of specific shape and size to a gradually increasing uni-axial load (force) until failure occurs, while simultaneous observations are made of the elongation of the specimen. The operation is accomplished by holding opposite ends of piece under work and stretching it, which results in elongation of specimen in a direction parallel to load applied. The ductility of the specimens was evaluated in terms of percentage elongation. Yield-strength of composites is obtained in terms of MPa. Compression tests were conducted on a UTM at temperature of room. [4]

6.4 Hardness Test

The measure of resistance for deformation of material permanently called Hardness. To examine composite hardness, a ball-indentor is inserted in composite to carry out static indentation test. The hardness is measured in terms of area or depth of indentation with the relation to the total test force. The standard Brinell hardness testing machine was used to measure the hardness of composite. The 2.5 mm ball-indentor is used and 45 kg of applied load for 30 seconds of time period to the composite with dimensions like 40 mm of diameter and 6 mm of thickness. Many readings were recorded of each of the composite at different locations. By taking mean diameter of indentation, hardness of the composite is determined and similarly by dividing load applied to surface area results to the Brinell-hardness number (HB).

RESULTS AND DISCUSSION

At 30 minutes of reaction time and 1000˚C of reaction temperature the composites as shown in table 5.1 were prepared with different compositions in a furnace.

Table 7.1: The different composition of composites

SL.No	Composite diameter	Composite
1.	40 and 50 (mm)	Al + 4.5% Cu
2.		Al + 4.5% Cu+4% Fly-Ash
3.		Al + 4.5% Cu+8% Fly-Ash
4.		Al + 4.5% Cu +12% Fly-Ash

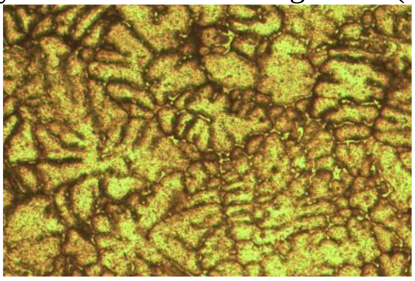
The test as given below is done over these different composites:

1. Micro-structural studies
2. Tensile-strength
3. Hardness-test
4. Wear-strength

7.1 Micro-Structural Studies

7.1.1 Micro Structural Studies for Al+ 4.5% Cu

The composite of Al+ 4.5% Cu micro-structure with diameter of 40 mm using an image analyzer are shown in figure. Microstructure includes aluminium solid solution of dendrites of inter dentritic regions with fine intermetallic particles. At 1000˚C reaction temperature and 30 minutes reaction-time is required preparation of composite. To finish exothermal reaction a 30 minutes reaction time and 1000˚C reaction temperature is required to obtain Al+ 4.5% Cu composite. In inter-dendritic region the presence of big Al-Cu particles along with Fly Ash is as shown in figure 7.1(a) and (b).



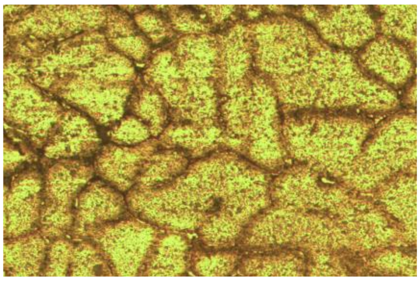
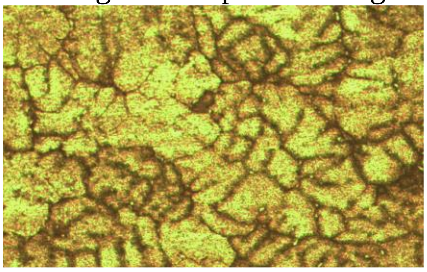


Figure 7.1(a) (b): Micro Photograph by Image Analyzer of composite Al+4.5% Cu with diameter 40mm.

7.1.2 Micro Structural Studies for Al+ 4.5% Cu+4%Fly Ash

Figure shows microstructure of as Al+4.5%Cu+4%Fly Ash (Dia 40mm) composite using Image Analyzer shown in figure. Microstructure consists of dendrites of aluminium solid solution with fine intermetallic particles at the inter-dendritic regions. The composites were prepared at a reaction temperature of 1000ºC and a reaction time of 30 minutes. Since the reactions involved clearly shows the formation of Al+4.5%Cu +4%Fly Ash composite, it is quite clearly established that the reaction temperature of 1000º C and a reaction time of 30 minutes is required for the exothermal reaction to be completed. The figure clearly shows the presence of large Al-Cu phases along with Fly Ash in the interdendritic region.



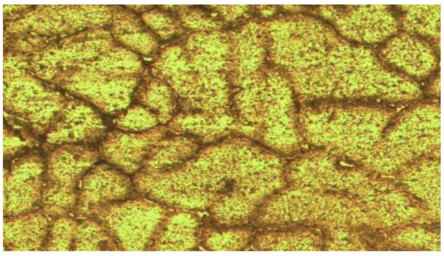
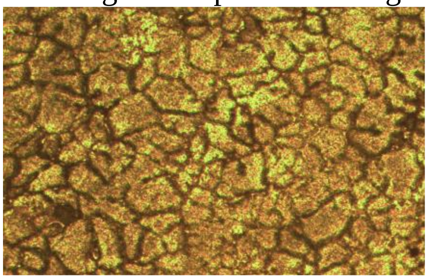


Figure 7.2(a)(b): Micro Photograph by Image Analyzer of composite Al + 4.5% Cu+4% Fly-Ash with diameter 40mm.

7.1.3 Micro Structural Studies for Al + 4.5% Cu+8% Fly-Ash

The composite of Al + 4.5% Cu+8% Fly-Ash micro-structure with diameter of 40 mm using an image analyzer are shown in figure. Microstructure includes aluminium solid solution of dendrites of inter dentritic regions with fine intermetallic particles. At 1000˚C reaction temperature and 30 minutes reaction-time is required preparation of composite. To finish exothermal reaction a 30 minutes reaction time and 1000˚C reaction temperature is required to obtain Al + 4.5% Cu+8% Fly-Ash composite. In inter-dendritic region, the presence of big Al-Cu particles along with Fly Ash is as shown in figure 7.3(a) and (b)



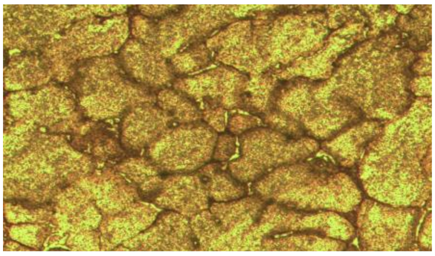


Figure 7.3(a)(b): Micro Photograph by Image Analyzer of composite Al + 4.5% Cu+8% Fly-Ash with diameter 40mm.

7.1.4 Micro Structural Studies for Al + 4.5% Cu+12% Fly-Ash

The composite of Al + 4.5% Cu+12% Fly-Ash micro-structure with diameter of 40 mm using an image analyzer are shown in figure. Microstructure includes aluminium solid solution of dendrites of inter dentritic regions with fine intermetallic particles. At 1000˚C reaction temperature and 30 minutes reaction-time is required preparation of composite. To finish exothermal reaction a 30 minutes reaction time and 1000˚C reaction temperature is required to obtain Al + 4.5% Cu+12% Fly-Ash composite. In inter-dendritic region, the presence of big Al-Cu particles along with Fly Ash is as shown in figure 7.4 (a)(b).

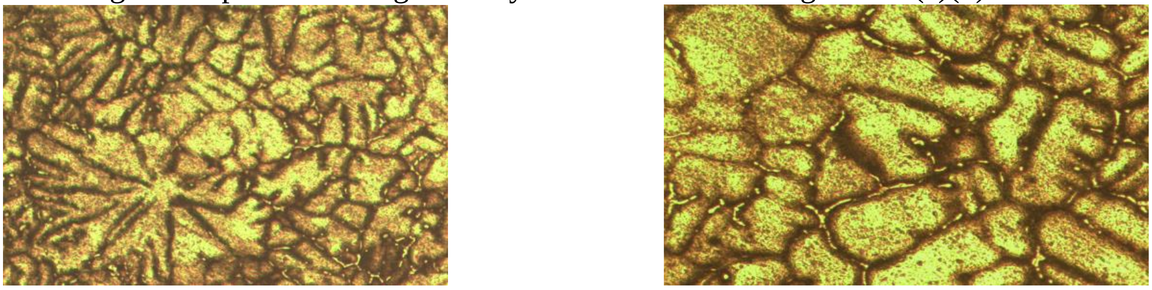


Figure7.4(a)(b): Micro Photograph by Image Analyzer of composite Al + 4.5% Cu+12% Fly-Ash with diameter 40mm.

7.1.5 Micro Structural StudiesAl+ 4.5% Cu

The composite of Al+ 4.5% Cu micro-structure with diameter of 50 mm using an image analyzer are shown in figure. Microstructure includes aluminium solid solution of dendrites of inter dentritic regions with fine intermetallic particles. At 1000˚C reaction temperature and 30 minutes reaction-time is required preparation of composite. To finish exothermal reaction a 30 minutes reaction time and 1000˚C reaction temperature is required to obtainAl+ 4.5% Cu composite. In inter-dendritic region, the presence of big Al-Cu particles along with Fly Ash is as shown in figure7.5 (a)(b).

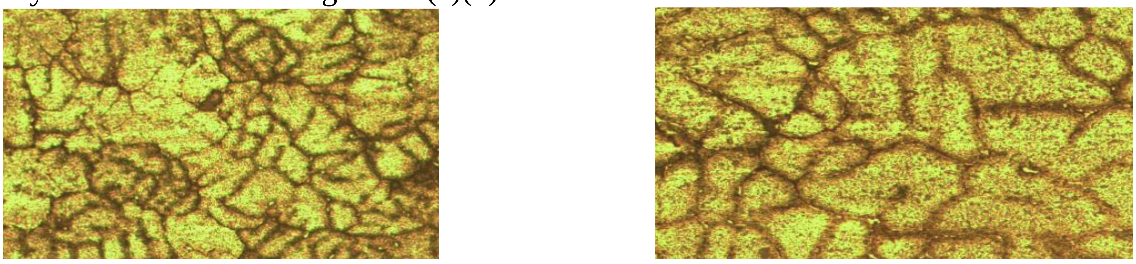


Figure 7.5(a)(b): Micro Photograph by Image Analyzer of composite Al+ 4.5% Cu with diameter 50mm.

7.1.6 Micro Structural Studies for Al + 4.5% Cu+4% Fly-Ash

The composite of Al + 4.5% Cu+4% Fly-Ash micro-structure with diameter of 50 mm using an image analyzer are shown in figure. Microstructure includes aluminium solid solution of dendrites of inter dentritic regions with fine intermetallic particles. At 1000˚C reaction temperature and 30 minutes reaction-time is required preparation of composite. To finish exothermal reaction a 30 minutes reaction time and 1000˚C reaction temperature is required to obtainAl + 4.5% Cu+4% Fly-Ash composite. In inter-dendritic region, the presence of big Al-Cu particles along with Fly Ash is as shown in figure 7.6 (a)(b).

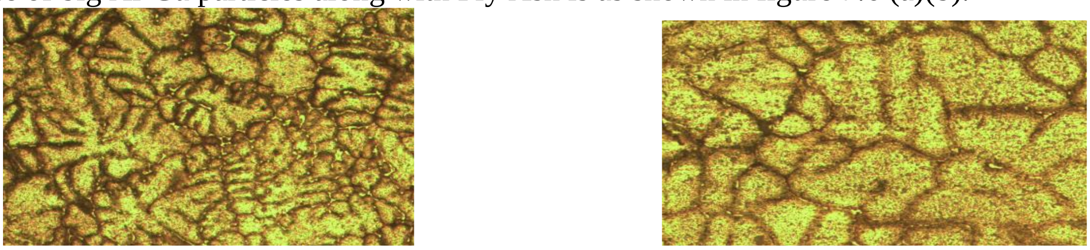
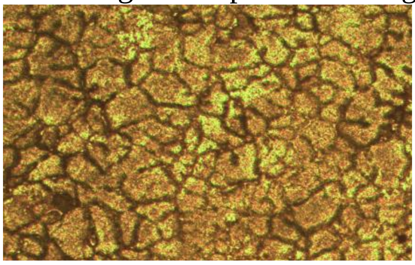


Figure 7.6(a)(b).: Micro Photograph by Image Analyzer o composite Al + 4.5% Cu+4% Fly-Ash with diameter 50mm.

7.1.7 Micro Structural Studies for Al + 4.5% Cu+8% Fly-Ash

The composite of Al + 4.5% Cu+8% Fly-Ash micro-structure with diameter of 50 mm using an image analyzer are shown in figure. Microstructure includes aluminium solid solution of dendrites of inter dentritic regions with fine intermetallic particles. At 1000˚C reaction temperature and 30 minutes reaction-time is required preparation of composite. To finish exothermal reaction a 30 minutes reaction time and 1000˚C reaction temperature is required to obtainAl + 4.5% Cu+8% Fly-Ash composite. In inter-dendritic region, the presence of big Al-Cu particles along with Fly Ash is as shown in figure 7.7 (a)(b).



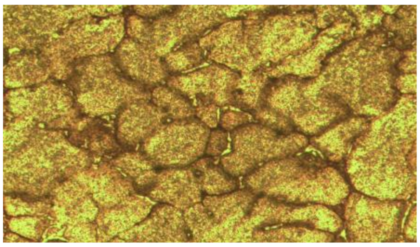
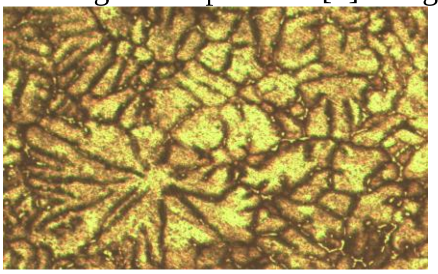


Figure 7.7(a)(b).: Micro Photograph by Image Analyzer of composite Al + 4.5% Cu+8% Fly-Ash with diameter 50mm.

7.1.8 Micro Structural Studies for Al + 4.5% Cu+12% Fly-Ash

The composite of Al + 4.5% Cu+12% Fly-Ash micro-structure with diameter of 50 mm using an image analyzer are shown in figure. Microstructure includes aluminium solid solution of dendrites of inter dentritic regions with fine intermetallic particles. At 1000˚C reaction temperature and 30 minutes reaction-time is required preparation of composite. To finish exothermal reaction a 30 minutes reaction time and 1000˚C reaction temperature is required to obtainAl + 4.5% Cu+12% Fly-Ash composite. In inter-dendritic region, the presence of big Al-Cu particles [5] along with Fly Ash is as shown in figure 7.8 (a)(b).



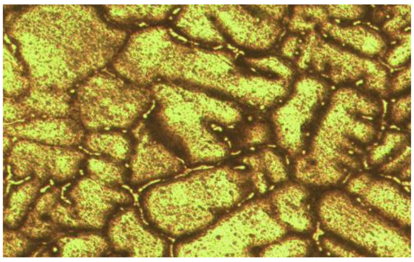


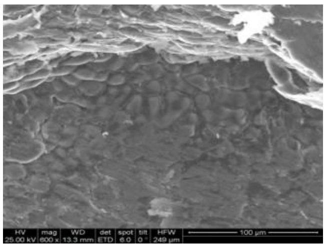
Figure 7.8(a)(b).:Micro Photograph by Image Analyzer of composite Al + 4.5% Cu+12% Fly-Ash with diameter 50mm.

7.2 Scanning Electro-Microscopy

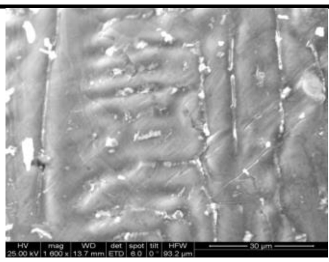
A micrograph of Aluminium 6061 and optical microstructure of the die-cast Al composite. The microstructure of the composite depicts that particles are irregular spheres of approximately 90-150µ m. The best bonding between matrix alloy and reinforcement can be obtained by the uniformly spreading of reinforce material is demonstrated. This dendrites growth on surface of particulate, a discontinuous thin composite layer is obtained by solidification process.

Figure 7.9: SEM equipment.

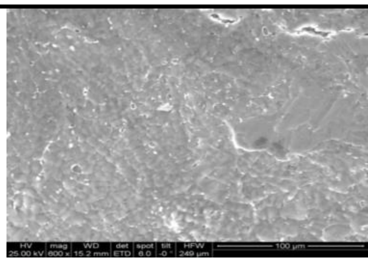
The SEM image is obtained by mean of atomic number of different phase. In SEM as shown in figure 7.8, the branch structure which represent dark in regions are aluminium rich and regions which are light represent other materials like Mg, Si, Fe, Cu, etc. The molecular structure of the composite as shown in figure 7.9 and 7.10 is given by Scanning Electron Microscopy (SEM).



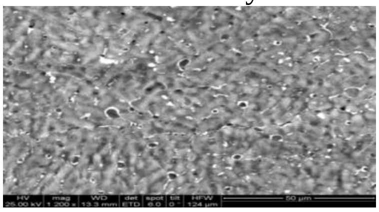
a. Al + 4.5% Cu



b. Al + 4.5% Cu+4% Fly-Ash

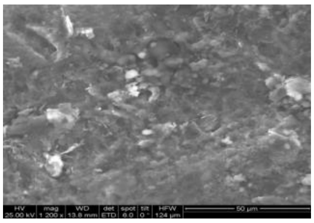


c. Al + 4.5% Cu+8% Fly-Ash

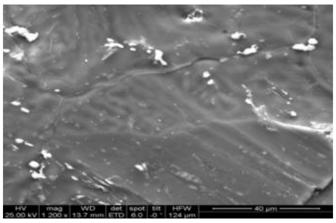


d. Al + 4.5% Cu+12% Fly-Ash

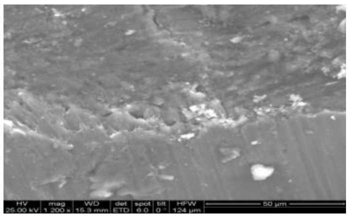
Figure 7.10: Shows the SEM of 40 mm specimen.



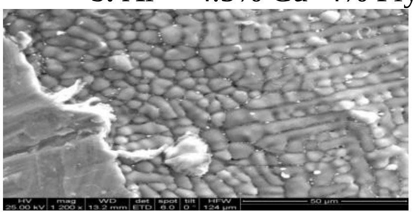
a. Al + 4.5% Cu



b**.** Al + 4.5% Cu+4% Fly-Ash



c**.** Al + 4.5% Cu+8% Fly-Ash



d**.** Al + 4.5% Cu+12% Fly-Ash

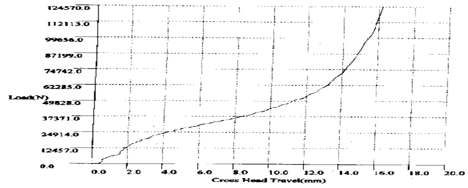
Figure 7.11: Shows the SEM of 50 mm specimen

7.3 Tensile Test (ASTM E8M-04)

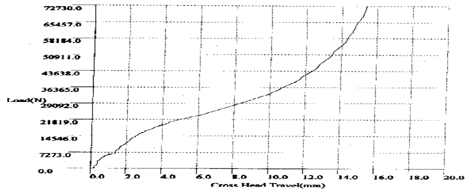
As the percentage of fly ash increases, there is decrease in tensile strength of Al-Cu composite is shown in table 7.1 and 7.2 and figure 7.11 and 7.12.

Table 7.1: Shows result of tensile test for 40mm dia.

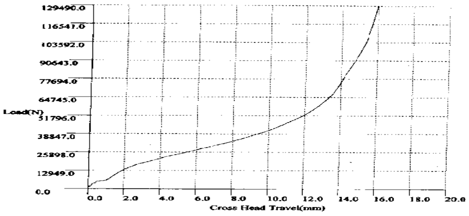
Sl.No	Specimen casted dia	Composite	Tensile strength,N/mm^2
1	40 (mm)	Al + 4.5% Cu	159.97
2		Al + 4.5% Cu+4% Fly-Ash	111.66
3		Al + 4.5% Cu+8% Fly-Ash	106.43
4		Al + 4.5% Cu+12% Fly-Ash	43.28



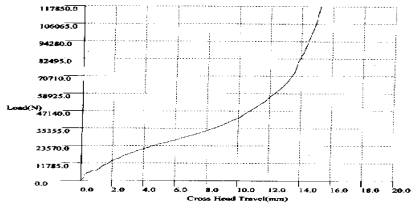
a. Al + 4.5% Cu



b. Al + 4.5% Cu+4% Fly-Ash



c. Al + 4.5% Cu+8% Fly-Ash

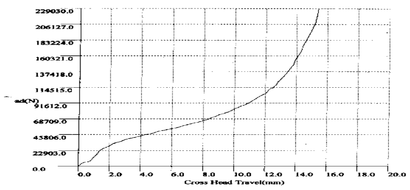


d. Al + 4.5% Cu+12% Fly-Ash

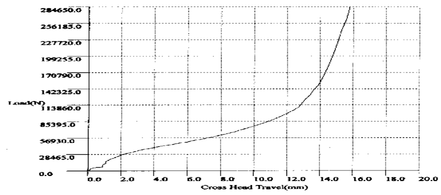
Figure 7.12**:** Tensile graph for 40mm diameter.

Table 7.2: Shows result of tensile test for 50mm dia.

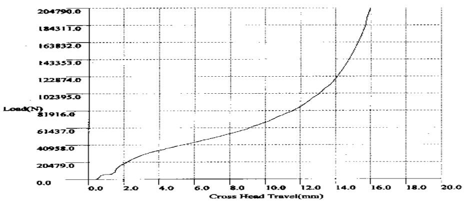
Sl.No	Specimen casted dia	Composite	Tensile strength,N/mm^2
1	50 (mm)	Al + 4.5% Cu	147.60
2		Al + 4.5% Cu+4% Fly-Ash	110.27
3		Al + 4.5% Cu+8% Fly-Ash	82.89
4		Al + 4.5% Cu+12% Fly-Ash	90.42



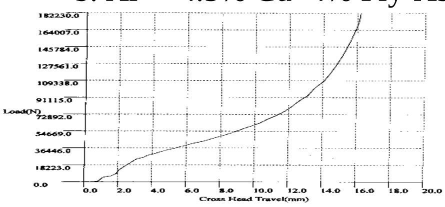
a. Al + 4.5% Cu



b. Al + 4.5% Cu+4% Fly-Ash



c. Al + 4.5% Cu+8% Fly-Ash



d. Al + 4.5% Cu+12% Fly-Ash

Figure 7.13**:** Tensile graph for 50mm diameter.

7.4 Hardness Test (Brinell Hardness)

With enhance in composition of Fly-Ash, the composite hardness is decreasing, as shown in table 7.3 and 7.4. The size of Aluminium – Fly ash reinforced composites play a main role in hardness of the specimen.

Table 7.3: Shows Results of hardness test for 40mm dia.

Sl.No	Specimen casted dia	Composite	Hardness
1	40 (mm)	Al + 4.5% Cu	53.8
2		Al + 4.5% Cu+4% Fly-Ash	51.0
3		Al + 4.5% Cu+8% Fly-Ash	49.6
4		Al + 4.5% Cu+12% Fly-Ash	44.0

Table 7.4: Shows hardness test results for 50mm diameter.

Sl.No	Specimen casted dia	Composite	Hardness
1	50 (mm)	Al + 4.5% Cu	51.9
2		Al + 4.5% Cu+4% Fly-Ash	47.5
3		Al + 4.5% Cu+8% Fly-Ash	47.5
4		Al + 4.5% Cu+12% Fly-Ash	43.7

7.5 Wear Test

The MMC with a pre-defined speed is made to rotate along the circumference in contact with surface of the disc. Then note initial and final weights, using this records the wear rate is tabulated for each of specimen. With increase in the fly-ash the wear rate of the specimen decreases as seen in table 7.5.

Table 7.5: Shows the test results for Wear Test.

Fly Ash Casted diameter (mm)	0%	4%	8%	12%
40	1072.63	949.398	1014.18	388.31
50	261.73	198	482.532	251.187

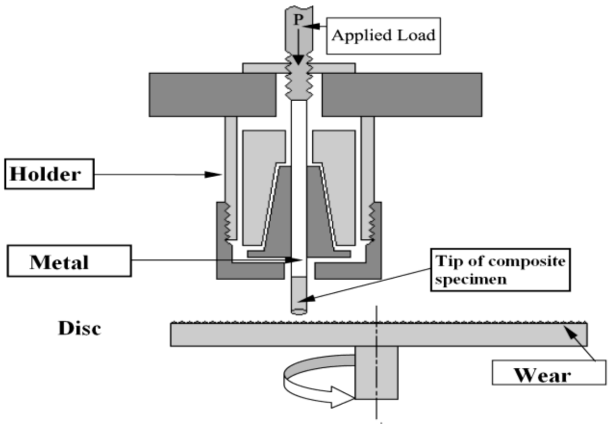


Figure 7.14: Wear testing machine.

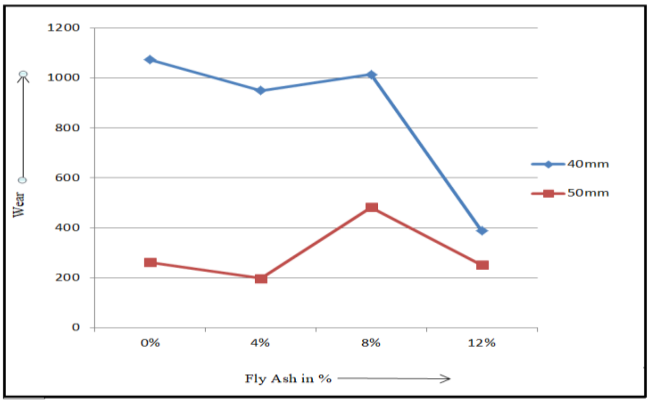


Figure 7.15: Result of Wear Test plotted in graph.

CONCLUSION

- Al Based MMC processed successfully in Resistance Furnace at 1000˚C of reaction temperature and 30 minutes of reaction time.
- In the present examination Aluminium + 4.5%Cu utilized as matrix and Fly Ash as reinforcement with varying in percentage.
- Aluminum-4.5% Copper alloy matrix composites reinforced with Fly Ash with different percentage like 4, 8 and 12 can be effectively characterized through stir casting technique.

- The formation of Al+5% Cu+FlyAsh in micro-structural studies clearly shows that exothermal reaction was complete.
- The Hardness values of composite are increasing with the decrease in the Fly Ash.
- The Tensile strength of composite is increasing with the decrease in the Fly Ash.

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NO CONFLICT OF INTEREST

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