Analysis of Mechanical and Metallurgical Properties of Al- Fly Ash Composite Material

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Abstract - *The present study focus at evaluating the mechanical properties of Aluminum in the presence of silicon dioxide, and its combinations. The compositions were added up to the required level and stir casting method was used for the development of aluminum metal matrix composites. Structural characterizations were carried out on metal matrix composites by x-ray diffraction methods and optical microscopy was used for the micro structural studies. The mechanical properties of metal matrix composites like tensile strength and hardness tests were carried out. Wear test was also performed using pin on disc. In the presence of silicon dioxide and fly ash (0-10%) with aluminum matrix, it was fairly observed that the densities of the composites were decreased and the hardness was increased. Correspondingly, the decrease in tensile strength was observed with decrease in addition of reinforcement. The aluminum-Fly ash-fly ash hybrid metal matrix composites extremely differed in all of the properties measured. The SEM analysis also carried out of the Material Morphology.*

***Key Words*: Aluminum1, Fly Ash2, Silicon di-oxide3, Material testing 4, Metallurgical Testing 5**

1. INTRODUCTION

The composites industry has started to recognize the commercial operations of composites promise to offer much better business opportunity than the aerospace sector due to the absolute size of transportation industry. Thus the shift of aggregated applications from aircraft to alternate commercial uses has become prominent in recent years [1]. For certain applications, the use of composites considerably than metals has in fact resulted in savings of both cost and weight. Some examples are descend for engines, curved fairing and fillets, replacements for welded metallic parts, cylinders, tubes, ducts, blade containment bands [2]. Further, the need of composite for lighter construction materials and more seismic resistant structures have placed high emphasis on the use of new and advanced materials that not only decreases dead weight but also absorbs shock and vibration through tailored microstructures. Composites are now extensively being used for rehabilitation of pre-existing structures have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity [3-6]. Hybrid materials are composites consisting of two constituents at the nanometer or molecular level [7]. Commonly one of these compounds is inorganic and the other one organic in nature. They differ from traditional composites where the constituents at the macroscopic (micrometer to millimeter) level [8-11]. The increased volume has resulted in an expected reduction in costs [12] .The objective of the present study is to form the reinforcing phase within the metallic matrix by reinforcing of silicon dioxide, fly ash and its proportions with aluminum in the metallic melt. The composites were characterized with the help of x-ray diffraction methods and optical microscopy. Its tensile behavior, hardness and wear behavior were also evaluated.

2. MATERIALS AND METHODS

2.1 Materials

Aluminum 1xxx Properties

The Aluminum 1001 was selected because it have high compressive strength and high hardness. It as application of machining work and automobile application. The silicon di-oxide is used for high compressive strength and high thermal properties. Hence we have selected for aluminum-fly ash composites.

Aluminum properties of 1xxx Temper H12
Tensile strength :16
Yield strength : 15
Elongation (%) for the following gauge range : 4to12
Ultimate strength
: 103.4

2.2 Aluminum SEM Analysis

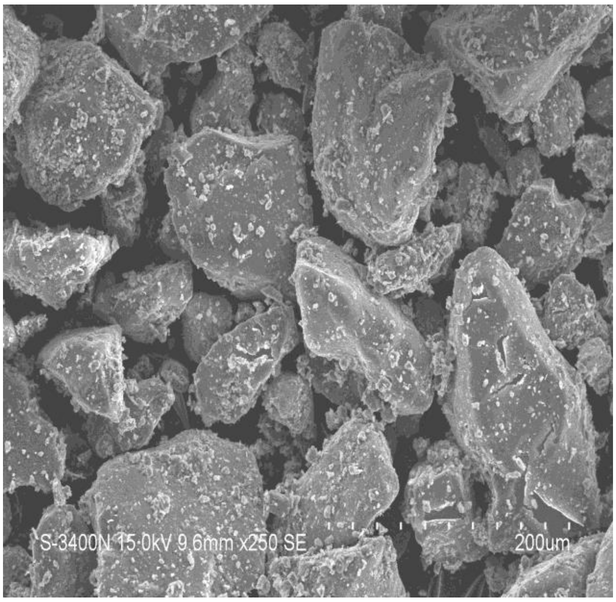


Fig. 1. SEM Micrographs Images of Fly ash

Fig. 2. Scanning Electron Microscope

Pure aluminum was taken as matrix in this research work. A silicon dioxide particle of average size 53µm was taken as reinforcement and it was observed using scanning electron microscope (SEM) for morphological studies. The essential feature of SEM used has magnification of 5x to 300,000x and resolution of 3nm @30kV HV mode, 10nm @ 3kV HV mode. SEM studies reveal that the White silica sand is angular to sub rounded in shape. The SEM micrograph of Fly ash particles and the SEM instrument are shown in Fig.1 and 2.

Table -1: Properties SEM micrograph of Fly ash particles and the Units.

Property	Minimum Value (S.I.)	Maximum Value (S.I.)	Units (S.I.)
Density	2.17	2.65	Mg/m3
Bulk Modulus	33.5	36.8	GPa
Compressive Strength	1100	1600	MPa
Elastic Limit	45	155	MPa
Endurance Limit	43	143	MPa
Fracture Toughness	0.62	0.67	MPa.m 1/2
Hardness	4500	9500	MPa
Poisson's Ratio	0.15	0.19	
Shear Modulus	27.9	32.3	GPa
Tensile Strength	45	155	MPa
Young's Modulus	66.3	74.8	GPa

2.3 X- RAY Diffraction of White Fly ash Sand

X-Ray diffraction measures the intensity of crystal diffraction peaks due to the individual chemical compounds in the sample. The crystal system of silicon dioxide is Monoclinic. The X-ray diffraction pattern of Fly ash showed the presence of large amount of highly crystalline Fly ashMoganite. However, it is to be understood that the height and sharpness of the XRD peak is a measure not only of quantity of mineral but also its higher crystalline. The semi quantitative analysis of chemical compounds present in the white silica sand is shown in

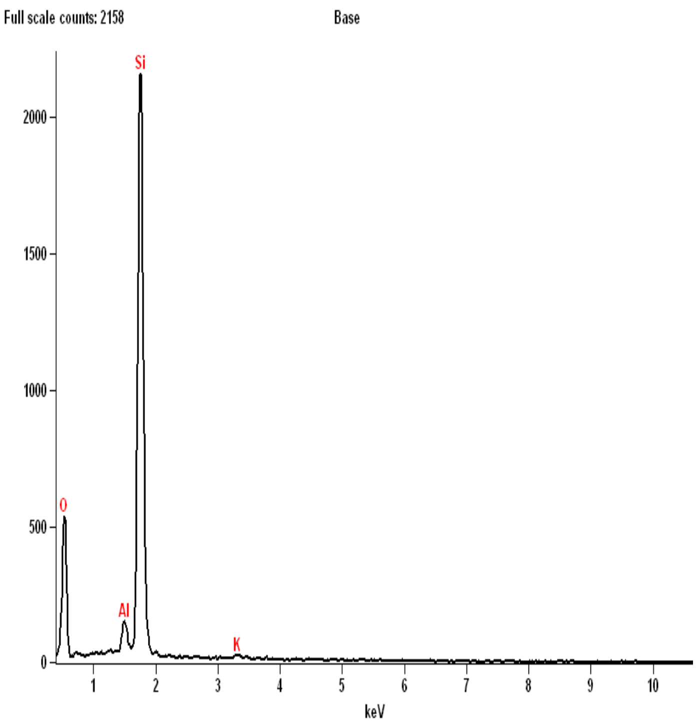


Fig.3:Semi-quantitative Analysis of Fly ash

2.4. Experimental Work

Stir casting method or liquid state method is used for the hybrid composite materials fabrication, in which a dispersed phase is mixed with a molten matrix metal by mechanical stirring. The liquid composite material is then cast by conventional casting method and also be processed by conventional metal forming technologies.In this study, the aluminum-Fly ash, aluminum- fly ash, aluminum-Fly ash-fly ash and aluminum-fly ash-Fly ash metal matrix hybrid composites were prepared by stir casting route .For this study we have chosen 100gm of commercially pure aluminum and desired amount of Fly ash, fly ash, Fly ash-fly ash mixtures in powder form. The fly ash and Fly ash and their mixture were preheated to 300°C for three hours to remove moisture. Pure aluminum was melted in a resistance furnace. The melt temperature was raised to 720°C and then the melt was stirred with the mild steel turbine stirrer. The stirring was maintained from 5 to 7 min at an impeller speed of 200 rpm. To increase wet ability, 1of pure Al was added with all composites. The melt temperature was maintained 700°C during addition of Al, Fly ash, fly ash, Fly ash-fly ash mixture particles. The dispersion of fly ash and other particles were achieved by the vortex method. The melt with reinforced particulates

were poured into the preheated permanent metallic mold. The pouring temperature was maintained at 680ºC. The melt was then allowed to solidify in the mould.

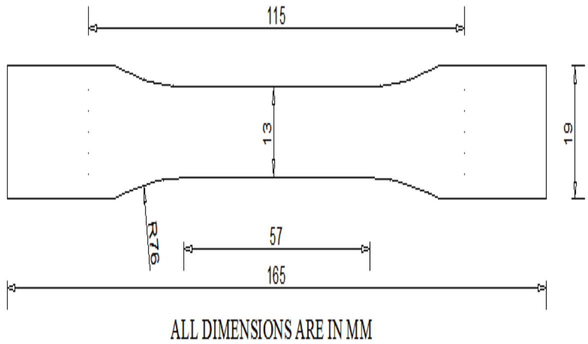


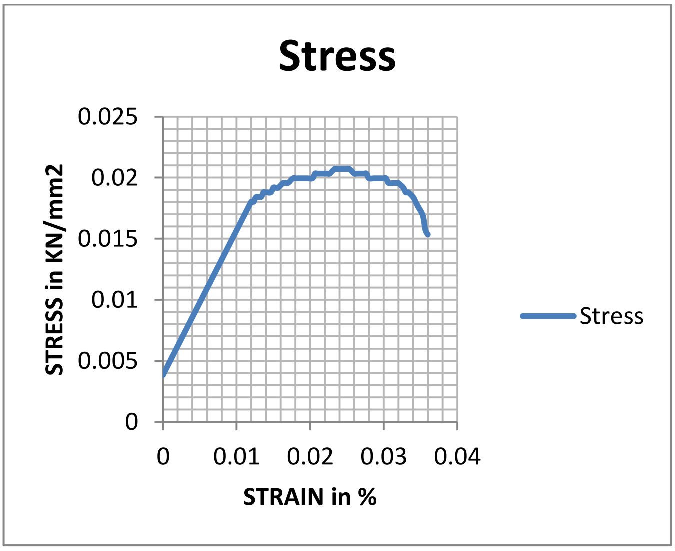
Fig. 4 Tensile specimen (ASTM D638-03)

3. Mechanical Properties Observation

3.1. Tensile Test

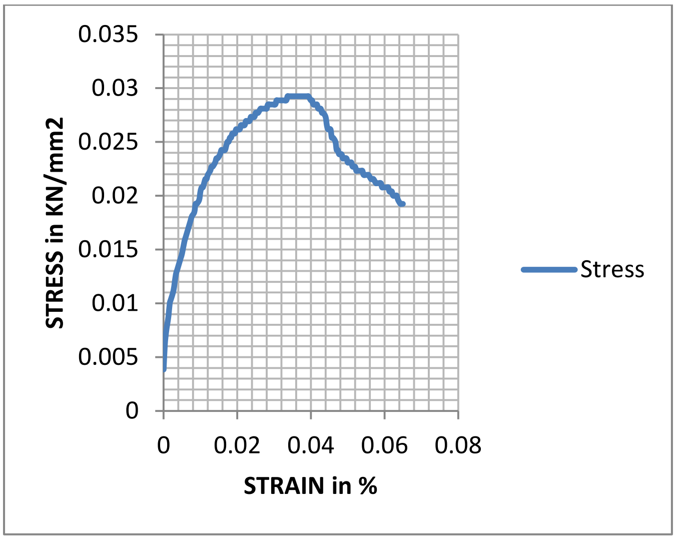
Material strength can be found by testing the material in tension or compression. Test specimens are prepared according to ASTM D638 standard, each specimen having 30 mm width and 280 mm gauge length, as shown in Figure. The specimen is loaded in computer controlled Universal Testing Machine (ASE – UTN 10) until the failure of the specimen occurs. Tests are conducted on composites of different combinations of reinforcing materials and ultimate tensile strength and ductility are measured. Simultaneous readings of load and elongation are taken at uniform intervals of load. Tensile test is carried out at room temperature. Uni-axial tensile test is conducted on the fabricated specimen to obtain information regarding the behavior of a given material under gradually increasing stress strain conditions.

AL-95+fly ash5%:



Stress Strain Curve

AL-90+fly ash10%:



Stress Strain Curve

3.2. Hardness

Bulk hardness measurements were carried out on the base metal and composite samples by using standard Rockwell hardness test machine. Rockwell hardness measurements were carried out in order to investigate the influence of particulate weight fraction on the matrix hardness. Load applied was 3 kg and indenter was ¾ balls. Samples used for the hardness tests are shown in Fig

Fig .5: Samples for Hardness tests

Table -2: Comparison of Hardness Measurement

LOCATION	AL-95+Fly ash 5%	AL-90+flyash10%
1	35	30
2	34	28
3	36	32
4	37	30
5	36	35

3.3 Sem Image

The SEM image shown in above diagram is taken from ZEISS testing machine having 100X resolution and 0.6.In the SEM image, the fiber direction is uniformly distributed. The void of the image is under control limit. The morphology of the image is clearly distributed. The particulate orientation is clearly shown in the image AIn the SEM image B , the particle in some places are Crack due to loading pressure and the properties of mixture is evenly distributed and in the SEM image C also the particle are crack in some places due to loading pressure and the properties of mixture is evenly distributed.

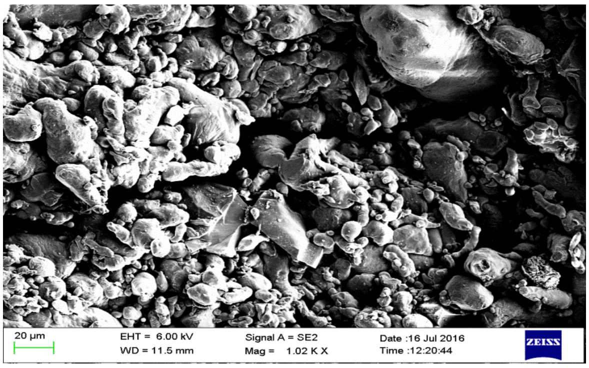


Fig.6: Sem Image A

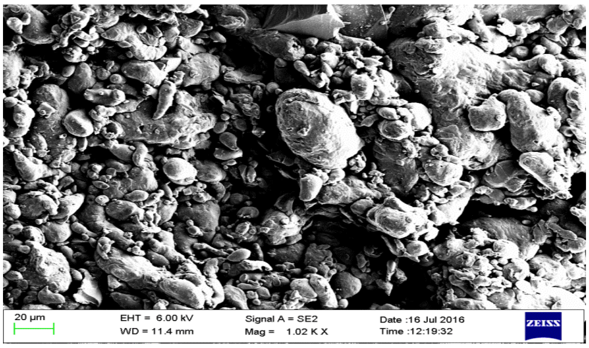


Fig.7: Sem Image B

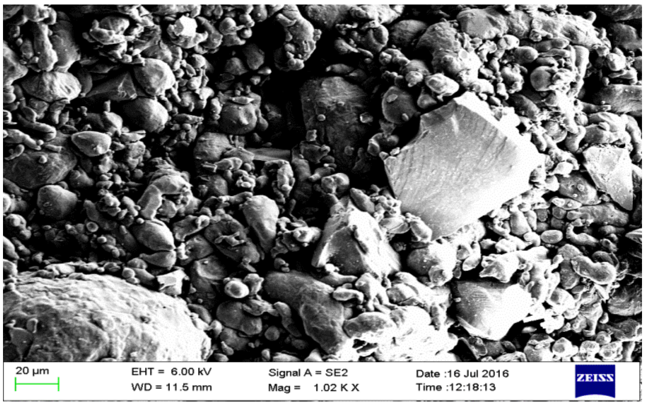


fig.8: Sem Image C

4. CONCLUSIONS

Al-Fly ash, Al-fly ash, Al-Fly ash-fly ash (various concentrations) composites were successfully fabricated by two-step stir casting process. Based on the experimental observations the following conclusions have been drawn. Density of the composites decreased by increasing the content of the reinforcement. Hence, it was found that, instead of Al-Fly ash and Al-fly ash composites, Al-Fly ash-fly ash composites show better performance. So these composites can be used in applications where to a great extent weight reductions are desirableIncrease in area fraction of reinforcement in matrix results in enhanced tensile strength, yield strength and hardness. With the addition of Fly ash and fly ash with higher percentage the rate of elongation of the hybrid MMCs is decreased drastically. Optical micrographs discovered that both the Fly ash and fly ash particles are well distributed in aluminum matrix.At last we can conclude that instead of Al-Fly ash or Al-fly ash composites, the Al-Fly ash-fly ash composites could be considered as an incomparable material in sectors where lightweight and enhanced mechanical properties are essential

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