Analysis of metallurgical properties of al-sio2 composite material

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Abstract

The present study focus at evaluating the mechanical properties of Aluminium 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 aluminium 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 aluminium 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 aluminium-SiO_2-fly ash hybrid metal matrix composites extremely differed in all of the properties measured. The SEm analysis also carried out of the Material Morphology

Keywords: Aluminium, Fly Ash, Silicon di-oxide, .Material testing, Metallurgical Testing

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 constituentis 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 aluminium 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

Aluminium 1001 Properties

The Aluminum 1001 was selected because it have high compressive strength and high hardness. It as application of Maching work and automobile application. The silicon di-oxide is used for high compressive strength and high thermal properties. Hence we have selected for aluminium-sio$_2$ composites

Alumium properties of 1001 Temper H12

Tensile strength	:	16
Yield strength	:	15
Elongation (%) for the following gauge range	:	4to12
Ultimate strength	:	103.4

Table 1. Sio2 Properties

Property	Minimum Value (S.I.)	Maximum Value (S.I.)	Units (S.I.)
Density	2.17	2.65	Mg/m^3
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

Property	Minimum Value (S.I.)	Maximum Value (S.I.)	Units (S.I.)
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

2.2 Aluminim SEM Analysis

Pure aluminium was taken as matrix in this research work. Silicon dioxide particles 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 SiO2 particles and the SEM instrument are shown in Fig.1 and 2.

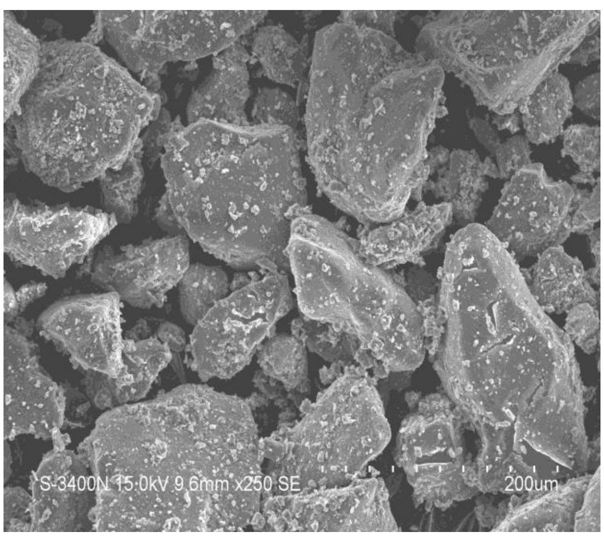


Fig. 1. SEM Micrographs Images of SiO_2

Fig. 2. Scanning Electron Microscope

2.3 X- RAY Diffraction of White Silica 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 SiO_2 showed the presence of large amount of highly crystalline SiO_2Moganite. 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 crystallinity. The semi quantitative analysis of chemical compounds present in the white silica sand is shown in Fig.3.

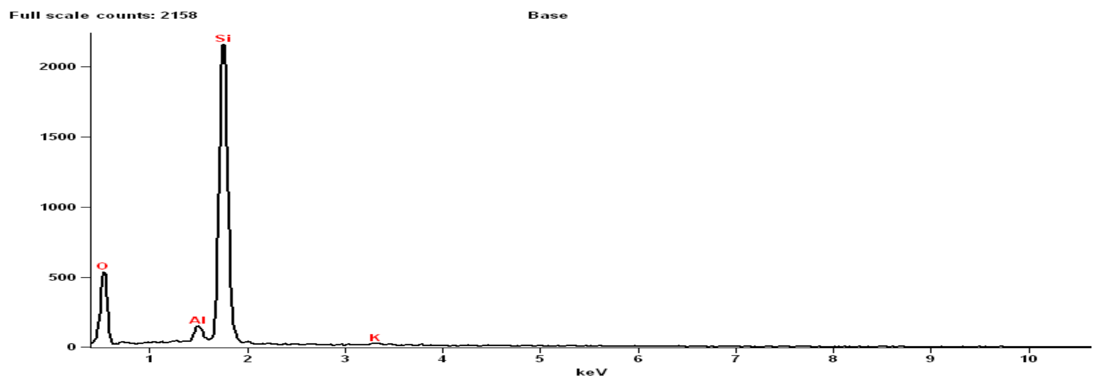


Fig. 3. Semi-quantitative Analysis of SiO_2

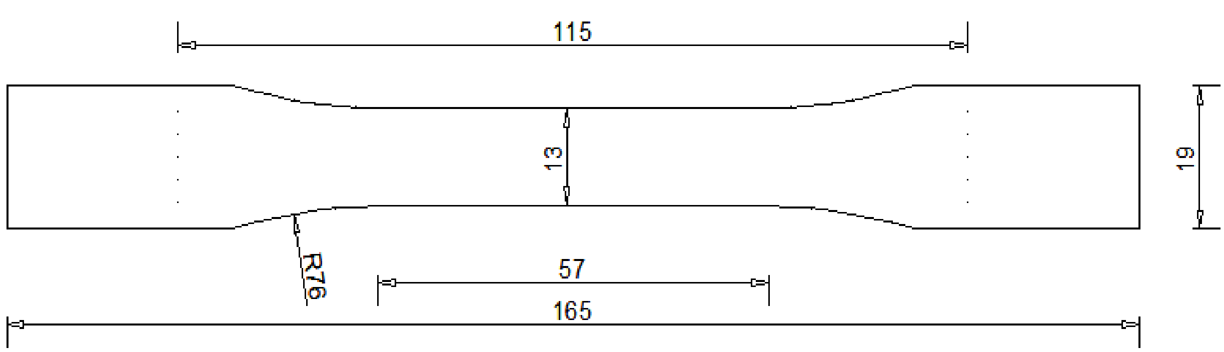
2.4. Experimental Work

The 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 aluminium-SiO_2, aluminum- fly ash, aluminium-SiO_2-fly ash and aluminium-fly ash-SiO_2 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 SiO_2, fly ash, SiO_2-fly ash mixtures in powder form. The fly ash and SiO_2 and their mixture were preheated to 300°C for three hours to remove moisture. Pure aluminium 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 wettability, 1of pure Al was added with all composites. The melt temperature was maintained 700°C during addition of Al, SiO_2, fly ash, SiO_2-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.

2.5. ASTM STANDARD

Tensile specimen (ASTM D638-03):



ALL DIMENSIONS ARE IN MM

Fig. 4. Tensile Specimen

3. Mechanical Properties Observation

3.1 SEM Image

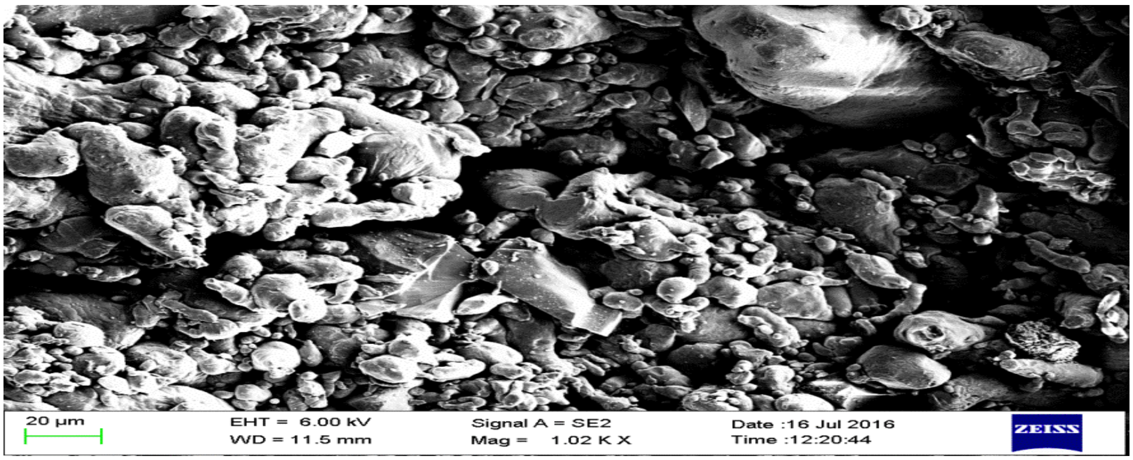


Fig. 5. SEM Image A

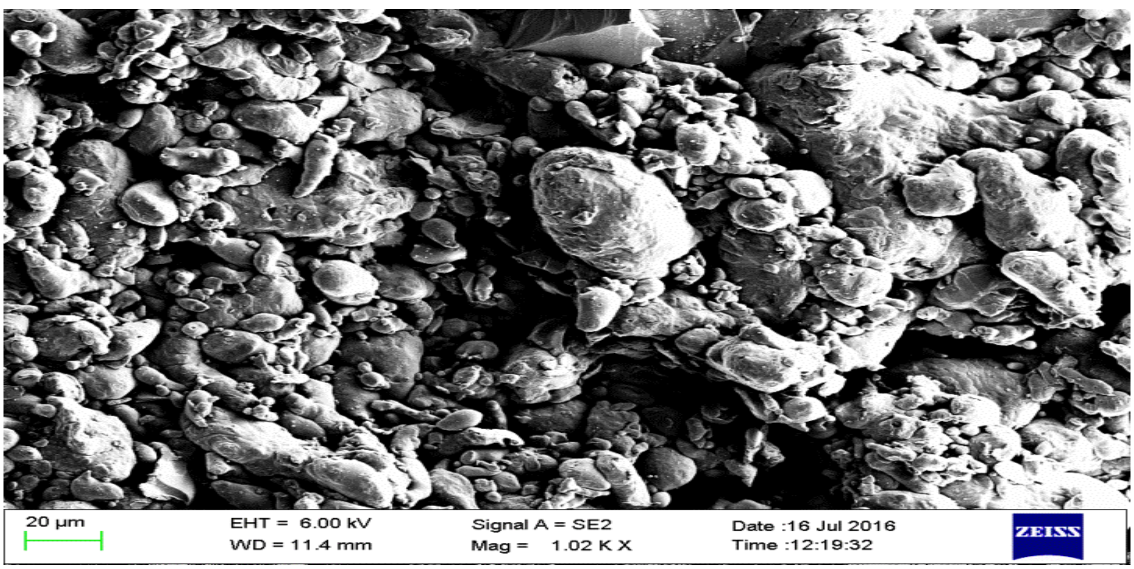


Fig. 6. SEM Image B

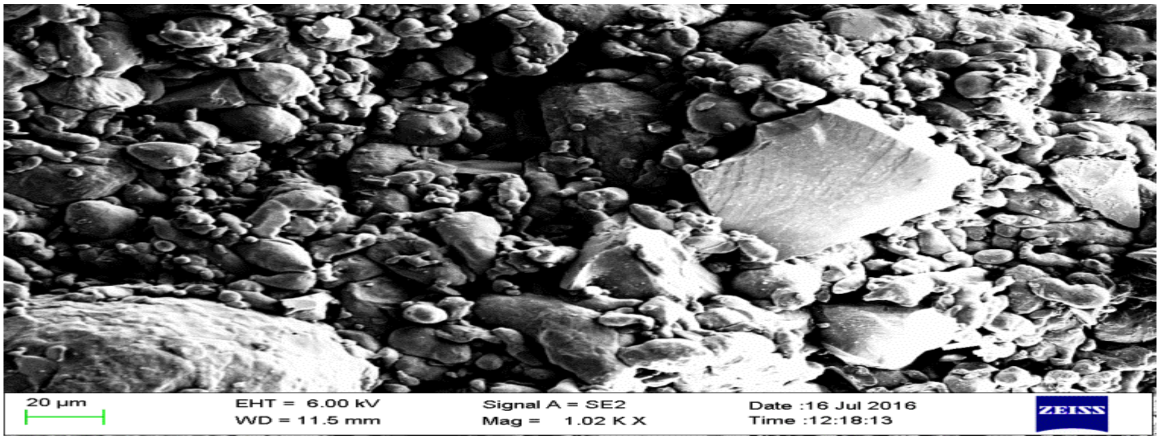


Fig. 7. SEM Image C

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 particullate orientation is clearly shown in the image A

In 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

4. Conclusion

Al-SiO_2, Al-fly ash, Al-SiO_2-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-SiO_2 and Al-fly ash composites, Al-SiO_2-fly ash composites show better performance. So these composites can be used in applications where to a great extent weight reductions are desirable
- Increase in area fraction of reinforcement in matrix results in enhanced tensile strength, yield strength and hardness.
- With the addition of SiO_2 and fly ash with higher percentage the rate of elongation of the hybrid MMCs is decreased drastically.
- Optical micrographs discovered that both the SiO_2 and fly ash particles are well distributed in aluminum matrix
- At last we can conclude that instead of Al-SiO_2 or Al-fly ash composites, the Al-SiO_2-fly ash composites could be considered as an incomparable material in sectors where lightweight and enhanced mechanical properties are essential.

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