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Characterization of Al-SiO_2 Composite Material

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***Abstract:** The present investigation centers at assessing the mechanical properties of Aluminum within the sight of Silicon di-oxide, and their blends. The creations were signified the necessary level and mix throwing technique was utilized for the improvement of Aluminum Metal Matrix Composites. Basic portrayals were done on Metal Matrix Composites by X-beam diffraction techniques and Field Emission Scanning Electron Microscopy (FE-SEM) was utilized for the miniaturized scale basic examinations. The tests for mechanical properties of metal lattice composites like tensile quality and Hardness were done. Within the sight of Silicon di-oxide (0-10%) with Aluminum grid, it was clear that the densities of the composites were diminished and the hardness was expanded. Correspondingly, a decline in rigidity additionally had been seen with decline in support in the Metal Matrix. The SEM examination completed for contemplating the Material Morphology has likewise been emerged in this investigation.*

***Keywords:** Al-SiO2, Particle Size, Fracture Surface, Field Emission - Scanning Electron Microscopy Evaluation.*

I. INTRODUCTION

Aluminum 1100 is only one of a few regular aluminum compounds and is delicate, low quality and, at 99% min aluminum, is the industrially unadulterated aluminum. Copper, iron, magnesium, manganese, silicon, titanium, vanadium and zinc contain the rest of the components [1]. It can't be solidified by heat treatment and is entirely formable. Silicon dioxide, otherwise called silica (from the Latin silex), is a substance intensify that is an oxide of silicon with the concoction recipe SiO_2 [2]. It has been known since antiquated occasions. Silica is most regularly found in nature as quartz, just as in different living organisms. In numerous pieces of the world, silica is the significant constituent of sand. Silica is one of the most mind boggling and most copious groups of materials, existing both as a few minerals and being delivered artificially [3-5]. Striking models incorporate intertwined quartz, seethed silica, silica gel, and aerogels. With the contributions from experiencing writing relating to Metal Matrix Composites, this investigation is continued towards accomplishing a less thick material for the extent of car industry. Along these lines, a strengthening stage inside the metallic network by fortifying of Silicon di-oxide, and its extents with Aluminum in the metallic liquefy [6-8]. The composites were described with the assistance of Scanning Electron Microscope. Its malleable conduct and hardness in this manner assessed are exhibited in the points beneath.

II. EXPERIMENTAL PROCEDURE

Material quality can be found by testing the material in strain or pressure. Test examples are set up as indicated by ASTM E8 standard, every example having 30 mm width and 280 mm check length, as appeared in Figure. The example is stacked in PC controlled Universal Testing Machine (ASE – UTN 10) until the disappointment of the example happens. Tests are led on composites of various mixes of strengthening materials and extreme rigidity and pliability are estimated. Synchronous readings of burden and lengthening are taken at uniform interims of burden. Tractable test is done at room temperature. Uni-hub elastic test is directed on the manufactured example to get data with respect to the conduct of a given material under slowly expanding pressure strain conditions [9]. The 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, mixture particles.

ASTM STANDARD

Tensile specimen (ASTM E8 Standard [10])

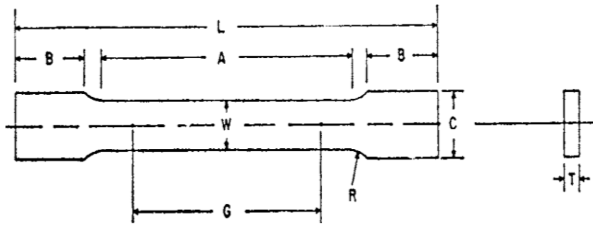

Fig 1: Tensile specimen

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Tensile Test

In this sample, the composition of SiO_2 in the Metal Matrix Composite is 5%. This has resulted in a slight increase in the Tensile behavior of the composite.
The Tensile test values are shown in graph below. It is inferred that the addition of SiO_2 increases the Hardness since the moving dislocation in the Aluminium which usually would favour it being ductile in its pure form has now been occupied by the fine Silicon di-Oxide. On the other hand, the yield point also lowers considerably. It can be observed that the graph after the yield point breaks abruptly at a point lower than it leading to failure if the material. Had it been in its pure form, the Aluminium would have shown higher yield point and be less brittle. Silicon di-Oxide has increased the hardness of the composite which favours its utilization in the heat affected zones of the automotive equipments.

Hardness Test

Mass hardness estimations were completed on the base metal and composite examples by utilizing standard Rockwell hardness test machine [11]. Tests utilized for the hardness tests are appeared in Fig 2.

Fig.2: Samples for Hardness tests

III. RESULTS AND DISCUSSION

The above graph shows the curve obtained from the Tensile test which the samples were subjected to. Similar graphs were obtained from the tensile tests of samples of 5% Al-SiO2 and 10% Al-SiO2. The averages of the samples of each composition were tabulated as shown in the Table 1 below.

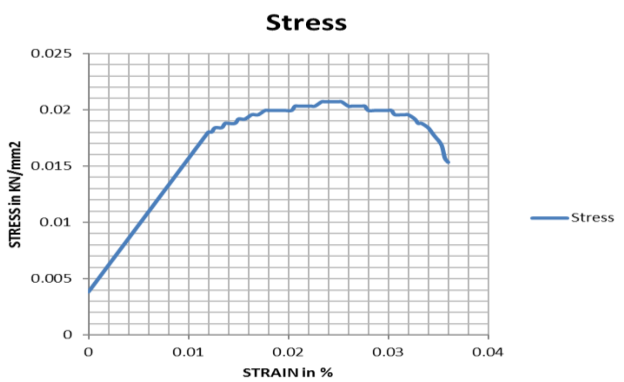

Fig.3 Stress Vs Strain

Table 1. Tensile tests results

Test Sample	Ultimate Breaking load (KN)	Ultimate stress (KN/mm²)	Elongation in %	Displacement mm
1	0.54	11.50	4	0.7
2	0.76	14.62	4	1.0

Validation of % Elongation value:
% ELONGATION = ORGINAL LENGTH -FINAL LENGTH/ORGINAL LENGTH
= 30-31.20/30*100
= 4 %

It is evident that the % Elongation in both the sample were 4% and the same has been validated from the calculation showed on theoretical basis.

Hardness test Results

Table 2. Hardness tests results

Indentation Locations	HV of Al- 5% SiO_2 at 0.3 kg	HV of Al- 10% SiO_2 at 0.3 kg
1	30.2	31.4
2	31.4	33.0
3	33.4	32.9
4	30.6	32.0
5	32.8	32.5

The above table 2 shows that the Hardness values increases with the increase in the composition of SiO2 as against 30.0 of Aluminium 10xx without reinforcement. The Al- 5% SiO2 shows an average value of 31.0 in the Hardness scale. Meanwhile, the Al-10 % SiO2 shows an average value of 32.0 in the Hardness scale. The samples tested under pin-on-disc tests indicated from the graphs that the Metal Matrix Composite has gradually increased wear rate with increase in time of contact with pin. This behaviour was exhibited upto certain extent and then after the Metal Matrix Composite showed negligible increase in wear rate thus maintaining a steady rate of wear. The friction factor on the other hand showed continuous and gradual increase with increase in time. Thus, this material has sustaninability under severe applications of high loading dynamic contact surfaces.

Fracture Surface SEM Images

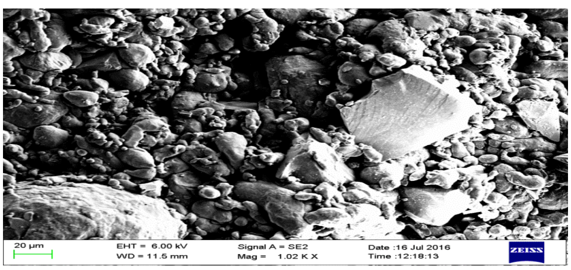

Fig. 4. Al- 5% SiO_2 Metal Matrix Composite

The ragged surface of the Al-SiO2 composite is appeared in Figure. It plainly shows the nearness of profound lasting scores and crack of the oxide layer, which may have caused the expansion of wear misfortune. Be that as it may, the well used surfaces of the two composites display better sections and slight plastic disfigurement at the edges of the depressions. The surface additionally gives off an impression of being smooth in light of the graphite fortification substance.

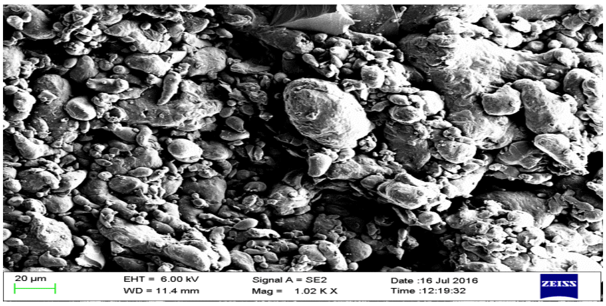

Fig.5 Al- 10% SiO2 Metal Matrix composite

The Fig.5 above shows the Scanned Electron Microscope image of Al- 10% SiO_2 Metal Matrix composite. Much of the blow-holes that showed up in the Al-SiO_2 structure has been avoided with the lobules being filled with excess SiO_2 added. But, there visualized some presence of cracks which could be a possibility of negligible dislocations that are needed to withstand elastic strain during loading.

Scope for Silicon di-Oxide as reinforcement

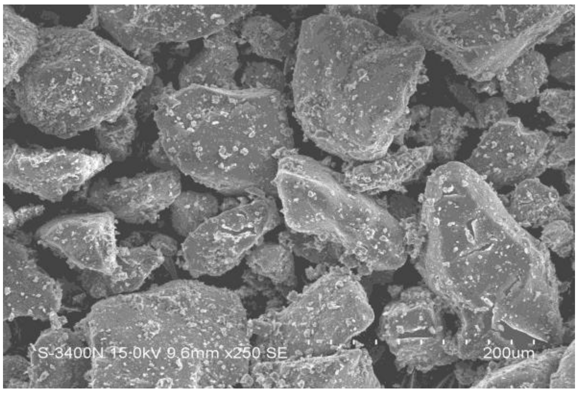

Fig. 6. SEM Micrograph Image of SiO2

In this research work, Silicon di-Oxide has been chosen as reinforcement. The so chosen Silicon di-Oxide is measured to be of 53µm in its average size. Whilst imaging under Scanning Electron Microscope, the Silicon di-Oxide exhibits from Cuboid to Sub-rounded in geometrical appearance. This geometry is very vital in occupying the lobules in-between the reinforcement material, here in this case Aluminium. The final structure after the Metal Matrix formed would give a viable material for applications which demands greater mechanical properties, Automotive parts for instance. The Fig.6 below shows the structure of SiO_2 particles captured under Scanning Electron Microscope, that being taken under a Magnification of 500x.

X- RAY Diffraction of White Silica Sand

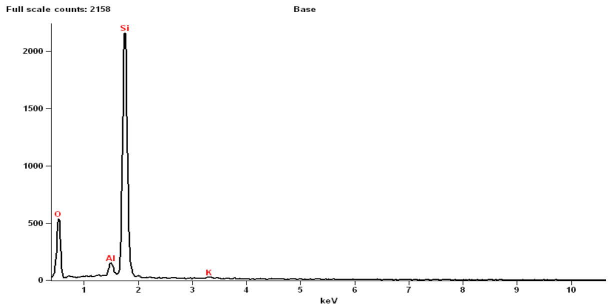

Fig.7. Semi-quantitative Analysis of SiO2

X-Ray diffraction quantifies the force of gem diffraction tops because of the individual concoction mixes in the example. The precious stone arrangement of silicon dioxide is Monoclinic. The X-beam diffraction example of SiO2 demonstrated the nearness of enormous measure of profoundly crystalline SiO2 Moganite. Notwithstanding, it is to be comprehended that the stature and sharpness of the XRD top is a measure of amount of mineral as well as its higher crystallinity. The semi quantitative investigation of synthetic mixes present in the white silica sand is appeared in Fig.7.

IV. CONCLUSION

- The images obtained from Scanning Electron microscope shows that increase in the composition of SiO2 in the Metal Matrix reduces dislocations in the base material but increases the chances of occurrence of crack formation. It is seen that addition of 10% SiO_2 may be considered maximum effective limit towards improving mechanical properties of Aluminium Metal Matrix Composites.
- The SEM images also validate the susceptibility of using SiO_2 as reinforcement with the uniform distribution into the base metal matrix.
- Tensile test result responds normally to the addition of the SiO_2 by reduction in the yield point and the failure point likely as in brittle materials.
- The Hardness values of the Al-SiO_2 metal matrix increases with the composition of SiO_2 which is an useful property enabling its utilization in Automotive components prone to exposure under severe thermal environments.
- The wear resistance has been evaluated to be high since the material removal rate has been observed to be low. This statement could be a probable cause of the high ductile nature exhibited by the matrix composite.
- Thus, Al-SiO_2 from this research performed to be an effective material under Metal Matrix Composites for effective utilization in light weight, high mechanical property desired applications.

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