Experimental Investigation of Mechanical Properties of Pure Al-Sic Metal Matrix Composite by Stir Casting Method

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Abstract - *Inexorably Metal matrix composites (MMCs) improved equities including high mechanical properties compared to unreinforced alloys. There has been an increasing interest in composites comprise low density and low cost reinforcements. Amid various incohesive dispersoids used. The unbiased of this experimental investigation is to produce pure aluminium, as a base material it is reinforced with the following additives each time (silicon carbide Sic,) with different volume fractions. Liquid state mixing proficiency was plugging away for the different integral. A thermocouple is used for checking temperature recurrently whilst unite. To diminish gas bubbles at the final cast degasser was combined to the content of the composite whilst unite. After liquefying and whilst, fluxes were poured in metallic mould then we got a cast from which specimens for numerous tests were prepared. In each case the mechanical properties were steadfast. The sic is accession with matrix alloy, it increases the ultimate tensile strength & the hardness, and decreased elongation of the composites in comparison with particular of the matrix. Waxing wt% of Sic, increased their strengthening effect but sic is the most effective strengthening particulates, for higher hardness, strength and grain size reduction. On the other hand, it decreases ductility and toughness. Further the Vickers hardness test, heat treatment process and microstructures were performed on specimen. The best result has been obtained at 20% weight fraction of sic with pure aluminium.*

Keywords: *Al-Sic, stir casting, Vickers hardness test, heat treatment, microstructure.*

I. INTRODUCTION:

It is very important to study the composite materials because it is the material for advanced technology, high temperature application where high strength / stiffness to-weight ratio is required. Composite Technology combines the most important properties of the components together in order to obtain a material with overall properties suitable for the design of the engineering part required. Generally the continuous phase is referred to as the matrix, while the scattered phase is called the reinforcement. A lot of work was done in this subject for the last decades since the production advances was highly touched by composites where you can tailor material properties as you need by mixing two peculiar materials without chemical reaction. Some of composites are of metallic matrices with ceramics additives to have what we call metal matrix composite (MMC), and some polymeric matrices (PMC) and excess are of ceramic matrices (CMC).

The melting point of aluminium is high ample to satisfy many application exaction, yet low ample to restore composite processing reasonably convenient. It can hold a diversity of reinforcing agents [1].

A number of more reinforcing materials such as illite clay, , Zirconium, graphite etc have been assimilated in Al using molten metal method. The key drawback of this method is the poor wet ability of ceramic particles with liquid Al alloys,[6-8]. Wet ability can be defined as the ability of a liquid to spread on a solid surface, and it represents the extent of confidential contact between a liquid and a solid [24], and this build up the drift of reinforcement cluster. This serve as a great challenge of producing cast metal matrix composites. This would normally result in poor distribution of the particles, high porosity content, and low mechanical properties. For that we need improve the wet ability of matrix with additives. For improving wet ability of Sic studies proved a high efficiency of wet ability improvement by accession of silicon or magnesium.

The confinement and trading of the particulates are very important in production of composites materials. Mg0 addition improves the retention and distribution of Al_2O_3within the matrix [8],[9].

Stirring was useful to obtain arrange of particulate percentages [10]. J. Has him et al.

The results was found that the Sic particles rounded in the matrix & the composites of the porosity content was mostly progressed by the milled composite powder injecting rather of the melt of untreated-Sic particles. Casting was done instead of fully liquid state from semisolid state had related effects. By injecting milled composite powders, the average size of Sic particles assimilated into the matrix was also significantly reduced from about 7 to 2 µm. The ultimate tensile strength, yield strength and elongation of Al/5 vol.%SiCp composite manufactured by compo casting of the (Al–Sic) injected melt were increased by 91%, 103% and 132%, respectively, manufactured by stir casting of the untreated-SiCp injected melt [25], compared to those of the composite. W. Zhou et al. studied a composites based on two aluminium alloys (A536 and 6061) reinforced with 10% or 20% volume of fraction Sic particles were produced by gravity casting and a unique two-step mixing method was applied strongly to improve the wet ability and distribution of the particles. The Sic particles were noticed to be located principally in the inter-dendrite regions, and a thermal lag model is proposed to explain the concentration of particles [21].

K. R. Suresh et al. studied wear and tensile properties of aluminium composites fabricated by squeeze casting method and correct rigid particulate distribution. The squeeze cast composites show peak strength of 216 MP a showing an increase of 11.6% in tensile strength. The matrix bond should strongly with the reinforcement but should not be chemically touched by adverse reactions. Proper matrix and reinforcement selection will promote part formability by various processes [13].

Reinforcement,as either continuous or discontinuous may constitute 10 to 60 vol % of the composite [14].The aim of this study was to probe the production of Al-MMC using a modified liquid state mixing called stir casting method. The technique was examined by employing the ceramic particulates of Sic to aluminium in the liquid state where casting temperature and heating temperature was serious after some trials to achieve two targets:

- ❖ High ample to add the additives and mix it properly and then cast before the aluminum starts to solidify.
- ❖ Not too high so that it may scorch the better of the additives before mixing them with the matrix and not to take a lot of time to solidify after casting so that the particulates may establish in the bottom of the mould due to gravity.

After that mixing properly and casting specimens, subjected to various micro-structural and mechanical tests consideration.

II. EXPERIMENTAL PROCEDURE:

For the preparation of the Aluminium silicon carbide alloy by using mass basis ratio of 100:0,100:5,100:7.5, 100:10, 100:15, and 100:20 are prepared. Figure illustrates the raw materials and samples of Aluminium Silicon Carbide material.

Stir- casting was used here in preparing composite samples. In this method the silicon carbide particles was homogenously in the aluminium microstructure by the established of eddy in molten metallic. Stir casting improved the mechanical and physical properties of the aluminium matrix in the process of silicon carbide particles pull through molten metallic & dispersed them homogenously. Matrix material cut into small pieces to attain the required weight according to reinforcement silicon carbide particles weight fraction (0, 5, 7.5,10,15, and 20 wt. %)[silicon carbide powder- (50- 100µm)- supplied from dhanlaksimi Chemicals Ltd (Vijayawada).

The samples of Pre-weighted were putted in alumina pots, and then the samples were inserted in Carbolite tube furnace setting at 500°C to ensure that melting the sample. These were provide the homogeneity of the silicon carbide particles added through molten aluminium, the electrical mixer was inserted in to the alumina pot which is kept in the Carbolite tube furnace at 500°C . So the Molten aluminium was stirred at (800 r.p.m.) to get suitable vortex. Later on the silicon carbide particles were added in to molten metal. This process was followed to the distribution through modify reinforcement particles of the molten aluminium.

The silicon carbide particles were pulled inward the molten metal and it was uniformly distributed due to the vortex effect. Molten aluminium was stirred for (0- 4 min.) until the aluminium of the molten becomes slurry. Than the slurry was poured into the suitable stainless steel mould box, which is preheated at 150°C to prevent sudden cooling effect for slurry. This process was repeated several times according to reinforcement particles ratio. It was noted obviously increasing the slurry viscosity especially at 9wt% of silicon carbide particles. This phenomenon requires long stirring time to overcome the difficulties in the casting process

Fig: 1.Composite (Al+Sic) without machining

Machining the components by using lathe machine up to required dimensions.

Fig: 2. Machined Composite Material.

Specimens for various tests were prepared from each melt. For tensile test samples was prepared according to ASTM-E8-95a and impact test samples were prepared according to the ASTM E23.

Composite	*Alloy*
1	100g(AL)+5g(SIC)
2	100g(AL)+7.5g(SIC)
3	100g(AL)+10g(SIC)
4	100g(AL)+15g(SIC)
5	100g(AL)+20g(SIC)

Table 1: Each Specimens total weight

The above table shows the different weightages of silicon carbide is mixed with aluminium. The each composition is made two components. The below figure is raw material of silicon carbide is divided in to required weightages.

III. WITHOUT HEAT TREATMENT PROPERTIES

S.No	Material	HARDNESS VALUES		
		Trail I	Trail II	Average
1	AI-10wt%Si,5.0wt%Sic	121	110	115.5
2	AI-10wt%Si,7.5wt%Sic	136	122	129
3	AI-10wt%Si,10wt%Sic	140	139	139.5
4	AI-10wt%Si,15wt%Sic	143	169	156
5	AI-10wt%Si,20wt%Sic	171	183	177

Table 2: Hardness Values

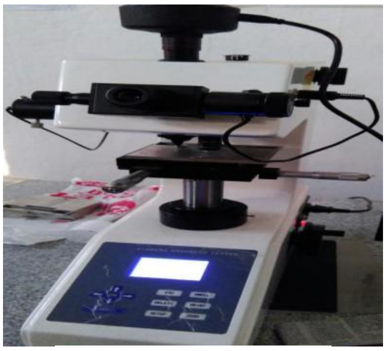

Fig: 3 Vickers testing machine

The machined components are polished by emery paper up to good surface finish.

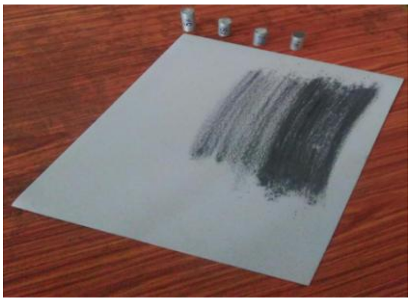

Fig: 4. Emery paper polishing

Fig: 5. Double disc polishing

After that by using double disc polishing machine to polish the component up to mirror finish.

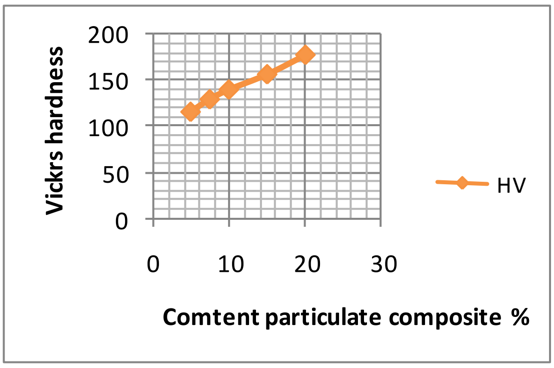

Fig: 6. Vickers hardness measurement graph.

The results of the Vickers hardness measurements are shown in graph. It increases with increasing wt% of the particulates used in this work.

1.3 MICROSTRUCTURES OF AL-SIC:

Fig 7: Metallurgical microscope

The following figures are different combination and magnification of Al-sic microstructures .we had chosen 500X and 200X magnification of lens(where 500X and 200X are size of lens that are used for magnification process)

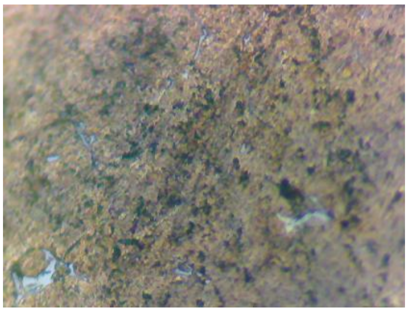

Fig 8: 100% AL of 5% SIC and Magnification: 100X

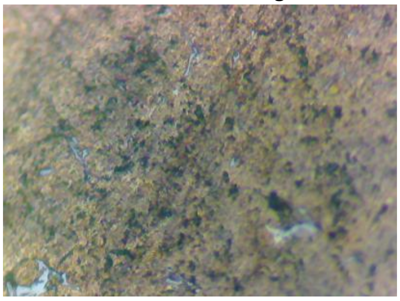

Fig 9: 100% AL of 5% SIC and Magnification: 200X

The microstructures have two main constituents. The darker gray particles are grains of silicon carbide (sic).they are dispersed through a matrix of aluminium.you can see the individual grains of the aluminum.

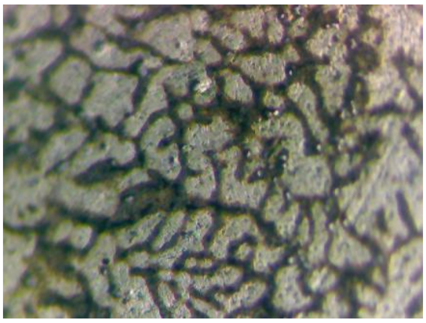

Fig 10: 100% AL of 7.5% SIC and Magnification: 100X

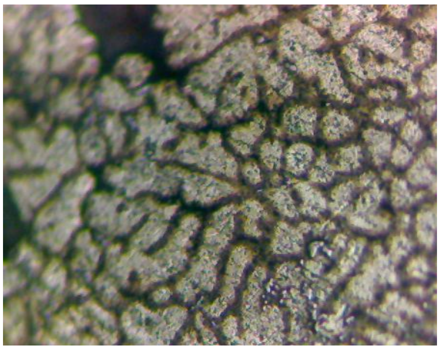

Fig11: 100% AL of 7.5% SIC and Magnification: 200X

The silicon carbide reduces the density of the aluminum and improves its stiffness and wear resistance. The toughness and ductility are reduced by the ceramics. These alloys have found applications in advanced bicycle frames, racing horse shoes and formula one racing car brakes.

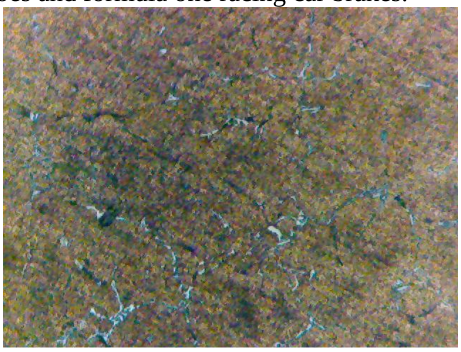

Fig 12: 100% AL of 10% SIC and Magnification: 100X

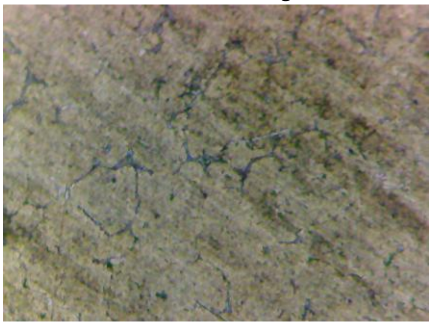

Fig13: 100% AL of 10% SIC and Magnification: 200X

You can see similar alloys and images of microstructures at other magnifications in the internal microscope.

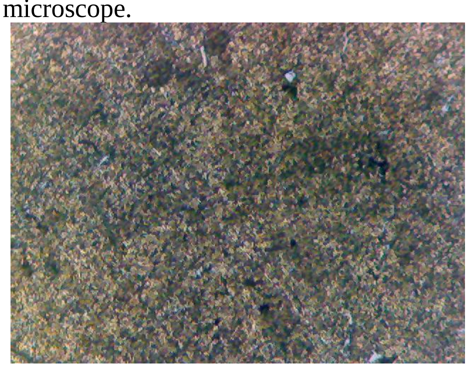

Fig14: 100% AL of 15% SIC and Magnification: 100X

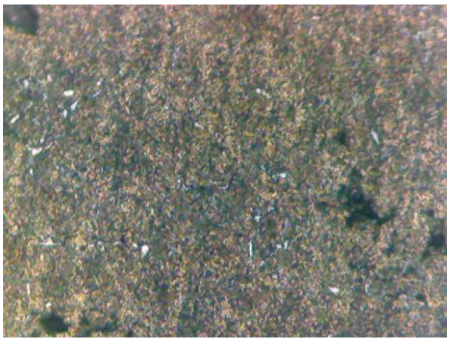

Fig15:100% AL of 15% SIC and Magnification: 200X

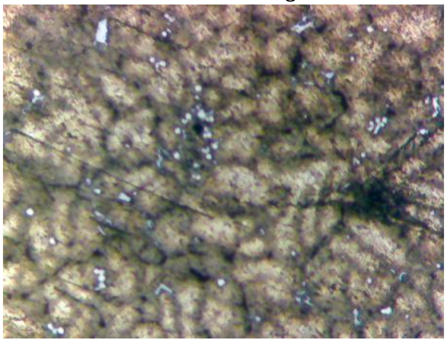

Fig16: 100% AL of 20% SIC and Magnification: 100X

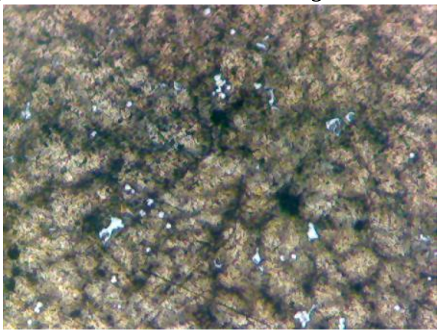

Fig17: 100% AL of 20% SIC and Magnification: 200X

IV. WITH HEAT TREATMENT PROPERTICES

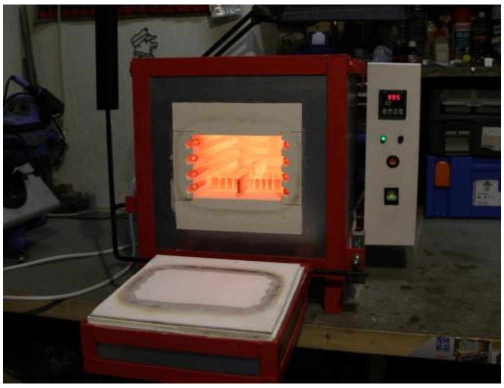

Fig18: furnaces

Go to the heat treatment process kept the components on the furnace at a temperature of 180^{0}c and cooling on room temperature. Once again conduct the hardness and microstructures of the specimens.

S.No	Material	HARDNESS VALUES		
		Trail I	Trail II	Average
1	AI-10wt%Si,5.0wt%Sic	95.68	90.97	93.325
2	AI-10wt%Si,7.5wt%Sic	93.06	98.33	95.695
3	AI-10wt%Si,10wt%Sic	98.25	98.92	98.585
4	AI-10wt%Si,15wt%Sic	103.3	101.2	102.25
5	AI-10wt%Si,20wt%Sic	137.5	133.2	135.35

Table3: Hardness Values

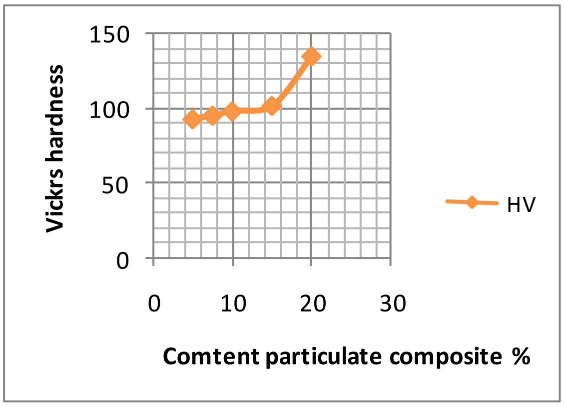

Fig19: Vickers's hardness measurement graph.

The results of the Vickers hardness measurements are shown in graph. It increases with increasing wt% of the particulates used in this work. These increases can be related -as mentioned before- to the interaction of the dislocations with the particulates and grain refinement with increasing wt% of the particulates.

V. MICROSTRUCTURES OF AL-SIC:

The following figures are different combination and magnification of Al-sic microstructures .we had chosen 500X and 200X magnification of lens(where 500X and 200X are size of lens that are used for magnification process)

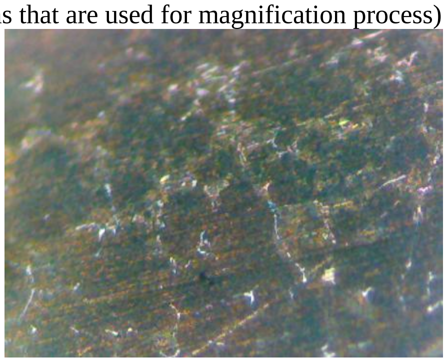

Fig20:100% AL of 5% SIC and Magnification: 100X

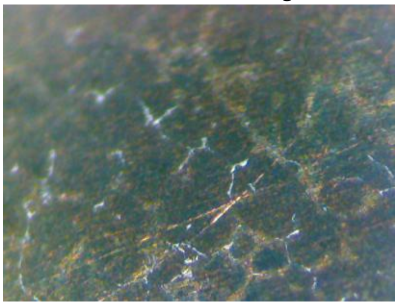

Fig21:100% AL of 5% SIC and Magnification: 200X

The microstructures have two main constituents. The darker gray particles are grains of silicon carbide (sic).they are dispersed through a matrix of aluminium.you can see the individual grains of the aluminum.

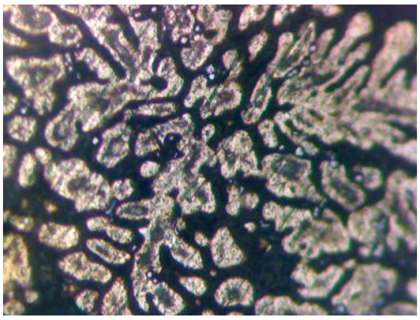

Fig22: 100% AL of 7.5% SIC and Magnification: 100X

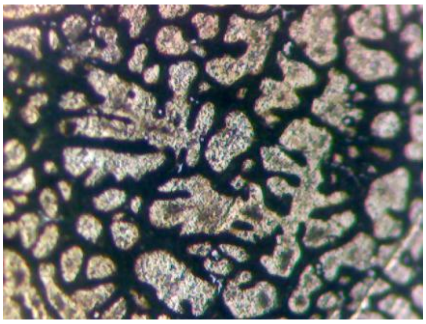

Fig23: 100% AL of 7.5% SIC and Magnification: 200X

The silicon carbide reduces the density of the aluminum and improves its stiffness and wear resistance. The toughness and ductility are reduced by the ceramics. These alloys have found applications in advanced bicycle frames, racing horse shoes and formula one racing car brakes.

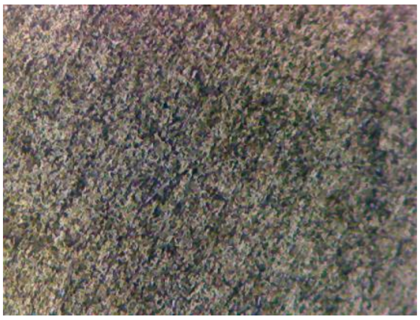

Fig24:100% AL of 10% SIC and Magnification: 100X

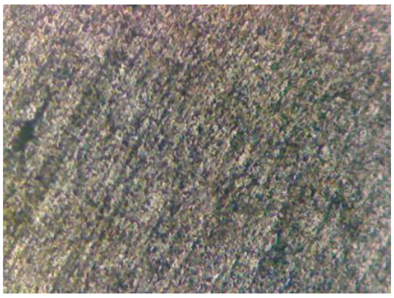

Fig25: 100% AL of 10% SIC and Magnification: 200X

You can see similar alloys and images of microstructures at other magnifications in the internal microscope.

Fig26:100% AL of 15% SIC and Magnification: 100X

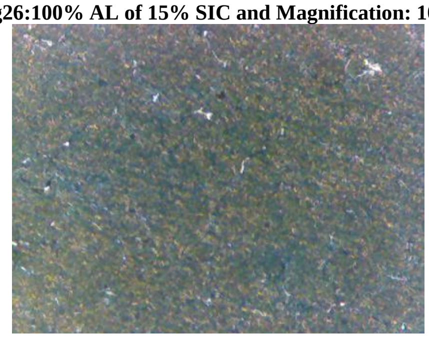

Fig27: 100% AL of 15% SIC and Magnification: 200X

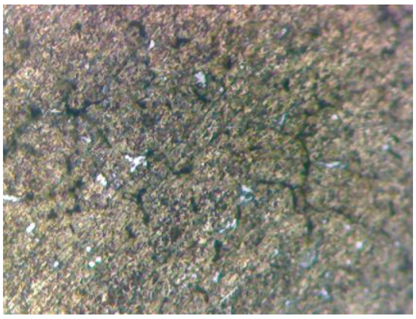

Fig28: 1.4.9 100% AL of 20% SIC and Magnification: 100X

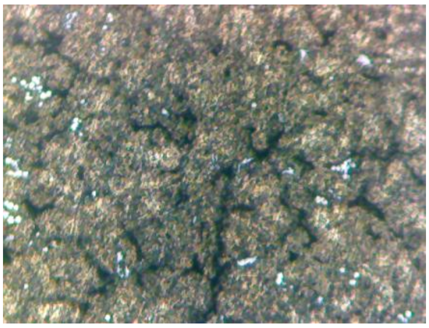

Fig29: 100% AL of 20% SIC and Magnification: 200X

After conducting the heat treatment process to seen the microstructures are of the specimens the grains size is increased, and the gap is also increased between the grains.

VI. ADVANTAGES:

- Al-Sic is one of the important applications for, MMC in internal combustion reinforced aluminum carry proved a good proxy for cast iron.
- After steel Aluminum is the most used metal.
- in the Earth's crust Aluminum is the most commonly occurring metal.
- Aluminum is 100% revocable without losing any of its natural characteristics.
- Al-SiC has the maximum strength-to-weight ratio of any metal.
- For applications where magnetism charges to be avoided, aluminum is an outstanding choice.

VII.CONCLUSIONS:

Accession of Sic severally at different percentages to aluminium matrix composite resulted in the following:

- Sic increases the strengthening effect in the process of increasing wt%, but in some times it is the most strengthening particulates for increasing hardness, grain size reduction and strength. While it decreases the toughness and ductility.
- The accession of Sic particulates into the matrix alloy consequently increases the yield strength, the hardness and decreases elongation of the composites in analogy with those of the matrix alloy.
- The grain size of the matrix was compared with the before particulate addition, it was High reduction in grain size of MMC's. It is affected by the presence of the particulates in the matrix alloy where they act as grain nucleation cites.

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