MECHANICAL CHARACTERIZATION OF nSiC AND MWCNT REINFORCED ALUMINIUM METAL MATRIX COMPOSITES

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Abstract: *In this research work an effort has been made to prepare hybrid Aluminium metal matrix composite to study its mechanical properties. Preparation of hybrid aluminium (Al 6061) metal matrix composite is made by reinforcing nano Silicon Carbide (SiC) and Multiwall carbon nano tubes (MWCNT) by Stir casting method. Mechanical test was carried out on the tensile sample prepared from the cast specimen of different composition. The hardness test shows addition of reinforced Silicon Carbide and multiwall carbon nano tubes increases the hardness value. The advantage of hardness materials are of having a high tensile strength and toughness combined with low density. The Aluminium (Al 6061) based metal matrix composite is used for structural, aerospace, marine and automobile applications for its light weight, high strength and low production cost. The result reveals that the addition of Silicon Carbide and Multiwall Carbon nano tube particles in Aluminium (Al 6061) metal matrix improves the mechanical properties.*

Keywords- **Aluminium (Al6061), nSilicon Carbide, MWCNT, Composite, Stir casting**

I.INTRODUCTION: A Composite material is a material composed of two or more distinct phase (matrix phase and reinforcing phase) and having bulk properties significantly different from those of constituents. When a composite material is combined they produce a material with characteristics different from the individual components. Generally, a composite material is composed of reinforcement (fibres, particles, flakes, fillers) embedded in a matrix (metals, polymers). Matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix.

When designed properly the new combined material exhibits better strength than each individual material. The most primitive manmade composite are straw and mud combined to for bricks for building construction. The role of reinforcement material in a composite material is to increase the mechanical properties of the system. All of the different particulates, fibres used in composites have different properties and so affect the properties of the composites in different ways.

Aluminium is the most abundant metal in the earth's crust, and the third most abundant element after oxygen and silicon. It makes about 8% by weight of the Earth's solid surface. The chief source of Aluminium is Bauxite ore. Aluminium is a soft, durable, lightweight, ductile and malleable metal with appearance ranging from silvery to dull grey, depending on the surface roughness, Aluminium is nonmagnetic and non-sparkling. Aluminium has one third the density and stiffness of steel. It is easily machined, cast, drawn and extrude.

Silicon Carbide (SiC), also known as carborundum is a compound of silicon and Carbon with chemical formula SiC. It is originally produced by a high temperature electro chemical reaction of sand and carbon. Silicon Carbide is an excellent abrasive and has been produced and made into grinding wheels. It is used in refractories, ceramics, and numerous high performance applications.

Carbon nanotubes (CNTs) are cylindrical molecules that consists of rolled up sheets of single layer carbon atoms. They can be single walled with a diameter less than 1 nanometer (nm) or multi walled. Carbon nanotubes are the strongest and stiffest materials in terms of tensile strength and elastic modulus. Their tensile strength can be 400 times of steel. They are very light in weight. CNTs are well suited for application requiring high strength, durability and light weight properties. They are commercially available as a powder

The advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirement of a particular application because of high stiffness, strength, low density, high temperature, stability, high electrical and thermal conductivity.

II.EXPERIMENTAL PROCEDURE: The metal matrix Al 6061 is obtained in the form of sheets. The sheets are heated in graphite crucible in induction furnace. Nano Silicon Carbide (nSiC) and Carbon nanotubes are used as reinforcement materials. The composition of Al 6061, nSic, Multiwall Carbon nanotubes are shown in the table 1. The Stir casting method is used to prepare composites. The Al 6061 sheets were heated to 1000^0C.The reinforcement particles nSiC and Multiwall Carbon nanotubes are preheated to 500^0C and then added with molten alloy. The heated slurry was stirred at 800rpm for 5-10 minutes using a high harden inconal impeller to ensure uniform incorporation of the nSiC and Multiwall Carbon nanotube particles into the Aluminium matrix. The impeller was placed just 15mm above the bottom of the crucible and the blade of the impeller covers a relatively large area of the crucible when it was rotated. This design prevents the nSiC from settling when the melted slurry was stirred for 5 minutes. Furthermore, stirring at an optimized speed of 800rpm created a vortex in the melt and this effectively enhanced the distribution of the particles. The stirring process was used to ensure the homogeneity of the melted slurry. The melt with nano Sic particles and Multiwall Carbon nanotubes fibre is poured into a mould of length 200mm and diameter 20mm as a rod. The castings that are taken out from the mould having a diameter of 20mm and length 200mm is machined in a conventional lathe machine. These specimens are made according to ASTM standard.

Table 1. Composition of matrix and reinforcement materials

Specimen	Al 6061	nSiC	MWCNT
1	98.5%	1%	0.5%
2	97.5%	2%	0.5%
3	96.5%	3%	0.5%

Fig II. a. Stir casting furnace and impeller

Fig II. b. Stirring of molten slurry

III.RESULTS AND DISCUSSION:

1. MICRO STRUCTURE:

Figure 1(a to d) shows the microstructure of the fabricated metal matrix composite specimens It shows even distribution of reinforcement particles in Aluminium(Al 6061) metal matrix. The metal matrix shows completely dissolved and reprecipitated as fine particles in Aluminium solid solutions.

Fig (1.c and 1.d) shows lean distribution of the composite particles and the metal matrix of aluminium alloy. Presence of some particles in intergranular space is observed and also it shows the cluster of composite particles in the metal matrix.

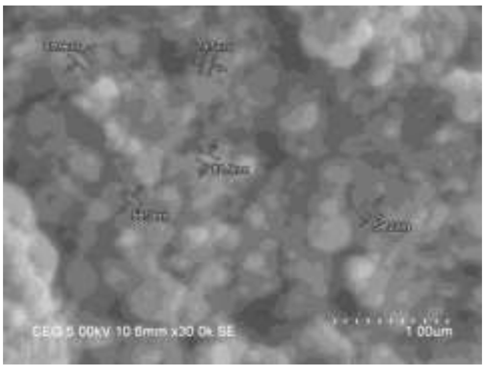

Fig.1.a

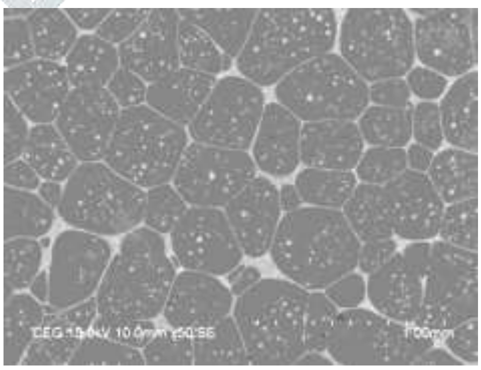

Fig.1.b

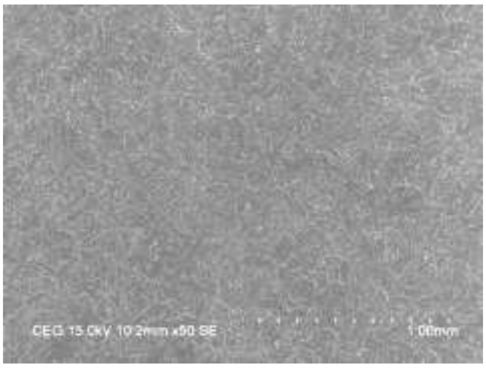

Fig.1.c

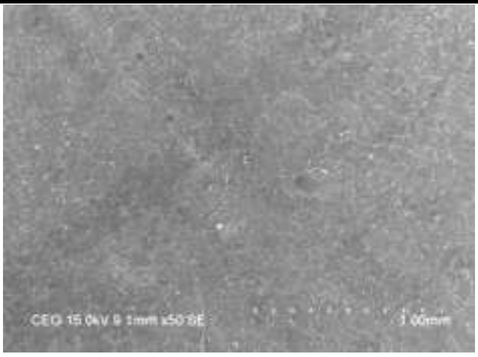

Fig.1.d

Fig.1 (a to d) Micro structure of the fabricated composite specimen

The above Fig.1 shows how the nSiC particles and Multiwall Carbon nanotubes are reinforced in the Aluminium metal matrix. It also shows that, in each stage the amount of reinforcement particulates are increased considerably.

2. HARDNESS TEST:

The Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a load of 1 to 100 kgf. The full load is normally applied for 10 to 15 seconds. The two diagonals of the indentation left in the surface of the material after removal of the load are measured using a microscope and their average calculated. The area of the sloping surface of the indentation is calculated. The Vickers hardness is the quotient obtained by dividing the kgf load by the square mm area of indentation.

When the mean diagonal of the indentation has been determined the Vickers hardness may be calculated from the formula, but is more convenient to use conversion tables. The Vickers hardness should be reported like 800 HV/10, which means a Vickers hardness of 800, was obtained using a 10 Kgf force. Several different loading settings give practically identical hardness numbers on uniform material, which is much better than the arbitrary changing of scale with the other hardness testing method.

The advantage of the Vickers hardness test are the extremely accurate readings can be taken, and just one type of indenter is used for all types of metals and surface treatments. The comparisons of mean hardness of the various percentage of Nano Silicon Carbide content with different samples are shown in in Fig.2.1 and 2.2.

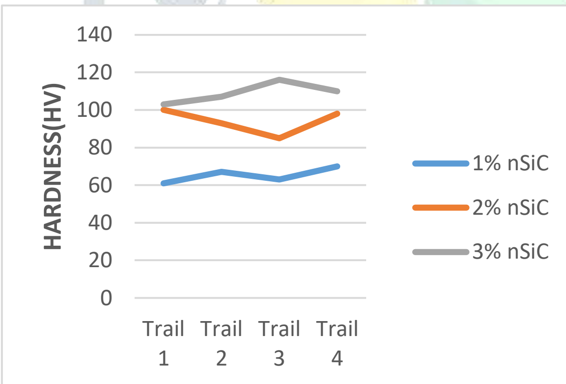

Fig 2.1 Hardness of the various weight percentage of nano Silicon Carbide

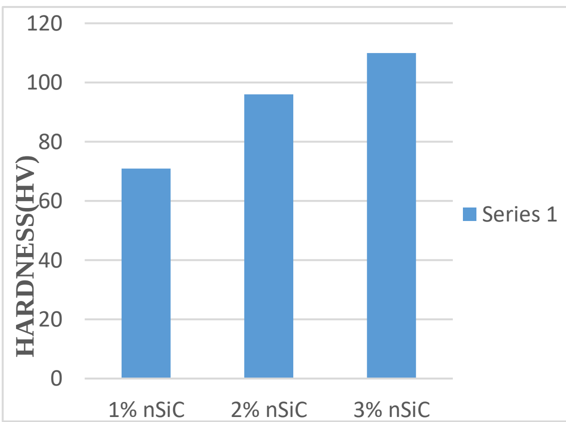

Fig 2.2 Mean Hardness of the various weight percentage of nano Silicon Carbide content

From the above graphs, we can conclude that the hardness increases with 3wt% of Nano Silicon Carbide compared to 1% Nano SiC and 2%Nano SiC.

3.COMPRESSION TEST:

Compression tests are used to determine a material's behaviour under applied crushing loads, and are typically conducted by applying compressive pressure to a test specimen (usually of either a cuboid or cylindrical geometry) using platens or specialized feature on UTM. During test various properties of the material are calculated and plotted as stress strain diagram which is used to determine qualities such as elastic limit, proportional limit, yield strength and for some materials, compressive strength. Compression test allows manufacturer to assess the integrity and safety of materials, components and products during several phases of the manufacturing process.

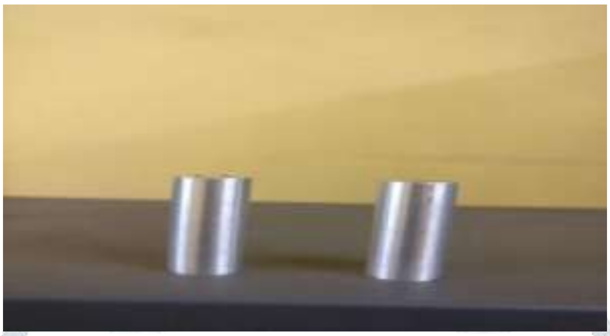

Fig.3.1 Compression Specimen Before Testing

A common method of conducting the test, as described in several published standard test methods, is to compress a box at a constant rate of ½ inch (12.5mm) per minute between two rigid platens. The platens can be fixed so that they remain parallel or one can be pivoted or "floating". The test can be conducted on empty or filled boxes, with or without a box closure, conditioning to standard temperature and humidity is important.

Fig.3.2 Compression Tested Specimen. (1) 1wt%NanoSiC (2) 2wt%NanoSiC (3) 3wt%NanoSiC

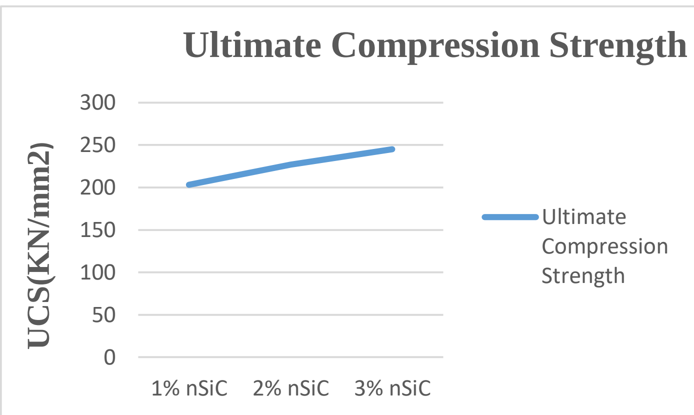

Fig 3.3 UCS of various weight percentage of nSiC

From the fig. 3.3, with increasing proportion of silicon carbide in the composite, the material improves its compressive strength. Maximum compressive strength was achieved with 3.0% of nano silicon carbide particles.

4.TENSILE TEST (ASTM A370 STANDARD):

A tensile test applies tensile (pulling) force to a material and measures the specimen's response to the stress. By doing this, tensile tests determine how strong a material is and how much it can elongate. By measuring the material while it is being pulled, we can obtain a complete profile of its tensile properties. When plotted on a graph, this data results in a stress-strain curve which shows how the material reacted to the forces being applied. One of the most important properties we can determine about a material is its Ultimate Tensile Strength (UTS). This is the maximum stress that a specimen sustains during the test. The UTS may or may not equate to the specimen's strength at break, depending on whether the material is brittle, ductile, or exhibits properties of both.

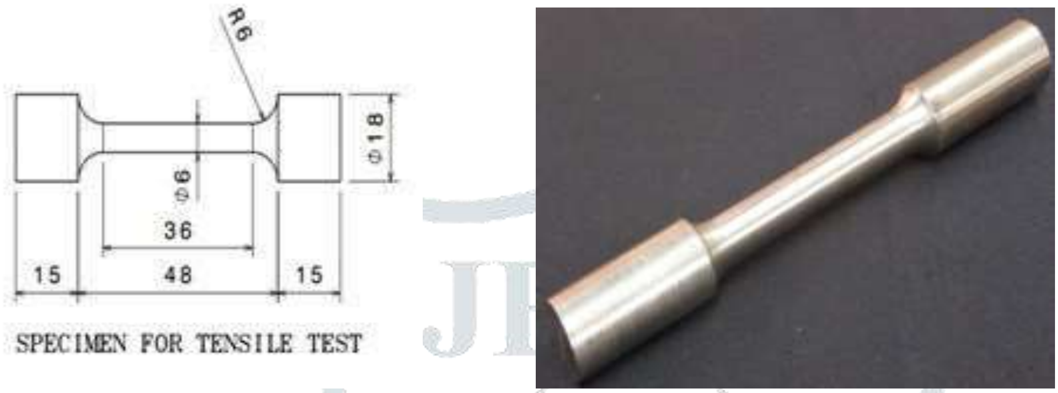

Fig.4.1 Tensile test specimen

- The specimens provided are made of aluminium-nano SiC.
- Marking the location of the gauge length along the parallel length of each specimen for subsequent observation of necking and strain measurement.
- Fit the specimen on to the Universal Testing Machine (UTM) and carry on testing. Record load and extension for the construction of stress-strain curve of each tested specimen.
- Calculate ultimate tensile strength of each specimen and record on the provided table.

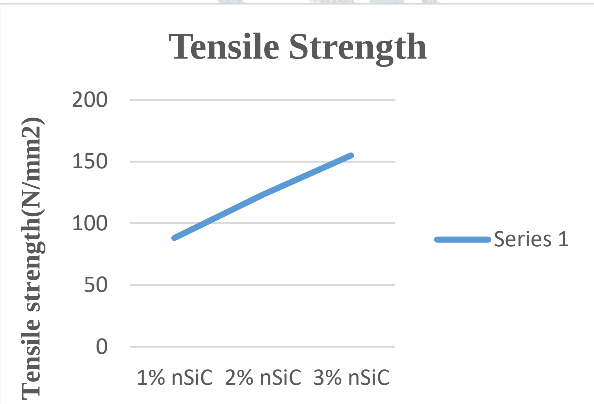

Fig.4.2 Tensile Strength of various weight percentage of nSiC

IV.CONCLUSION In this study Nano Silicon Carbide and Multiwall Carbon nanotube are selected as reinforcement material for making aluminium Metal Matrix Composites by considering good mechanical and physical properties. Composites Specimens were prepared for mechanical testing with various weight fractions of reinforcement particulates by stir casting method.

- Results show that Nano Silicon Carbide and Multiwall carbon nanotube particles are used as reinforcement material to improve the properties of the Al6061.
- Aluminium (Al 6061) reinforced with nSiC and MWCNT exhibits better Hardness and strength.
- Tensile testing result shows that the tensile strength of the specimen increases gradually up to 3wt%nSiC-Al metal matrix composite.

With increasing proportion of nano silicon carbide in the composite, the material improves its compressive strength. Maximum compressive strength was achieved with 3wt% of nano silicon carbide particles.

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