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A Study on Carbon Nanoparticle Reinforced Aluminium Nanocomposite

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Abstract : *A nanocomposite is the one which consists of two or more nanosized materials which are dispersed in a matrix in order to perk up the properties of the primary material. Metal reinforced composites and hybrid composites are appropriate for several Engineering applications like automobile, aerospace, marine etc. as a result of glorious properties like the low constant of thermal growth, stiffness and lightweight. In this article different percentage of carbon, Nanoparticles were synthesised with aluminium metal by stir casting method. The mechanical properties such as hardness, the tensile strength of the composites and base alloy were investigated. Microscopic characteristics are characterised using SEM images. Chemical test for carbon Nanoparticle reinforced composite is studied.*

Keywords: Carbon Nanoparticle. Aluminium Nanocomposite, material properties, SEM images.

1. Introduction:

Aluminium and its alloys are most generally utilised in several industries like aerospace, transportation and a number of other structural applications due to their high specific strength, good formability and good corrosion resistance (G. Mathers et al., 2002)(N.R. Mandal et al.,2002). The material is developed to satisfy proper mechanical properties which might not be derived from standard materials. And also composites meet the requirements of specific design and performance, along with the required properties (Sijo, M. T et al., 2016). Nano particle Metal matrix composites (NMMCs) frame a gathering of designed materials have significant research. The most well-known fortifications are silicon carbide, alumina and graphite. Aluminium, titanium and magnesium amalgams are regularly utilised as the network stage. There are numerous authors studied about NMMCs by concentrating over the solid materials and includes high quality and high warm conductivity than the earthen materials, quality, higher warm conductivity than earthenware materials, great wear resistance, bring down coefficient of warm development (Hassan et al., 2009; Hassan et al., 2002). Nanoparticle Metal Matrix Composite can be strengthened by solid second periods of three-dimensional shapes (particulate), two-dimensional shapes (laminar), or one-dimensional shapes (stringy). All these three sorts may vary in both the mechanical properties and in the manufacture procedures. Aluminium metal matrix composites (NMMCs) are the fastest developing materials for structural applications because of their high specific weight, modulus, resistance to corrosion and wear, and high-temperature strength (Gangil et al., (2017). Aluminium was the most mainstream grid for the NMMC and hence aluminium and its combinations are a standout amongst the most broadly utilised materials as a part of NMMC as a model both for research and modern view focuses. Aluminium metal and its combinations are very alluring because of their low thickness, high warm and electrical conductivity. It offers an expansive assortment of mechanical properties relying upon the synthetic piece of the aluminium grid (Rahimian et al. (2010)). Aluminum Matrix Composites (AMCs) are normally fortified with earthenware production like Al_2O_3, C, SiC, SiO_2 and so forth. As examined a great deal of research has been accounted for utilising diverse fortifications, However, no deliberate endeavour has been made by utilising graphene as the support a part of aluminium lattice composites.

2. Specimen Preparation:

The composite preparation was done for three combinations mixture fixing aluminium alloy (A16061) as a base metal. Composites are prepared using graphite powder. Materials are prepared in various proportions forming metal matrix composite using a stir casting method which was liquid metal matrix composite preparation methodology has been adopted.

Table 2.1: Specifications of Carbon Black Nano Powder

Carbon Black Nano powder
Specifications
>99% C nanopowder
MW 12.1
SSA ca. 550 m^2/g
Ash content < 0.02%
Cat. Nr. PL-CB13-5g

The material chosen for the study was Aluminium alloy (Al6061), reinforced with 2%, 3%,5% of graphite Nano powder prepared by Stir casting method. In the stir casting method, discontinued reinforcing particles are blended to preheated molten aluminium to form a metal matrix composite. The Furnace crucible and mixed uniformly using a ceramic stirrer with the help of a motor. The temperature was raised above the liquidus temperature of the aluminium alloy above 880 °C. At this stage, continuous stirring was

carried out for about 30minutes at an average stirring speed rate of 650 RPM. The molten slurry was poured into a preheated Cylindrical Mould and allowed into a solid. The solidified casting was machined to our required size of 100 mm length and 10 mm diameter.

3. Methodology:

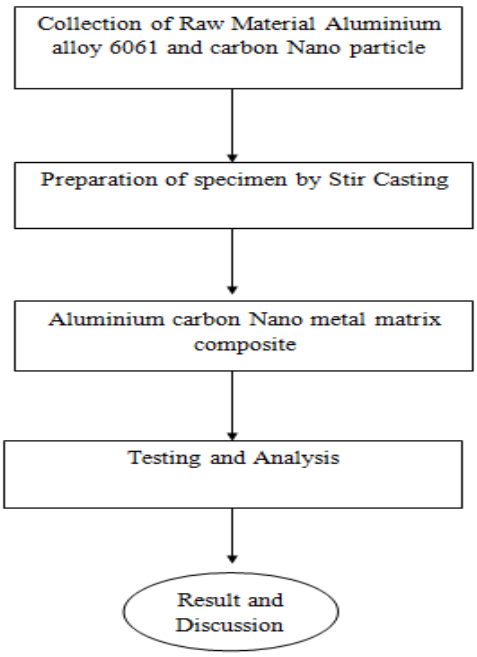

Figure 3.1: Process Flow chart

3.1 Mechanical Analysis:

3.1.1 Tensile Strength

Specimen Test piece was prepared for Tensile strength testing with an overall dimension of length 100mm and 10mm diameter where the area of interest has a dimension of 50mm length and 8mm diameter. The test was carried out in the universal testing machine of 40 Tonne capacity.

3.2 Microstructure Analysis:

For the microstructural study, specimens were cut from the cast. The Microstructure was imaged with a Dewinter optical microscope instrument. The microstructure was used to characterise the distributions of the material [8]. The microstructure was taken at a magnification of 150x and the agent used was Kellar ReagentHydro glorious solution. Images Show the polished matrix of metal matrix composite surface at 100X magnifications. The matrix shows the particles of composite Carbon Nano Particle was uniformly distributed.

3.2.1 SEM Analysis

For the micro structural studies, specimens were cut from the cast and then mechanically polished to a good finish. Reinforcement morphology and its distribution in the metal matrix along with other intrinsic microstructural features were identified by examining the samples in an EVO HD 15 ZEISS Germany makes Scanning Electron Microscope (SEM).

3.3 Chemical Analysis

The composition of Aluminium alloy 6061 was tested using stoichiometric Analysis were compounds present in Aluminium alloy are determined using this test. The presence of various compounds in Aluminium alloy is investigated.

4. Result and Discussion:

4.1Mechanical Analysis:

Composite mix of Al+ Carbon 2%

Table 4.1 *Composite mix of Al+ Carbon 2%*

Tensile Strength	280.59 MPa
Elongation	12.00%
Hardness	63 HRB

Mechanical Properties observed from a composite mix of aluminium and carbon nanomaterial of 2%. Where tensile strength value of 71.59 MPa, Elongation of 6% and Hardness of 46 HRB which were carried out in setting Aluminium Metal testing parameter of 100 Kg.

Composite mix of Al+ Carbon 3%

Table 4.2 *Composite mix of Al+ Carbon 3%*

Tensile Strength	284.62 MPa
Elongation	11.00%
Hardness	66 HRB

Mechanical Properties observed from a composite mix of aluminium and carbon nanomaterial of 3%. Where tensile strength value of 73.62 MPa, Elongation of 6% and Hardness of 48 HRB which were carried out in setting Aluminium Metal testing parameter of 100 Kg.

Composite mix of Al+ Carbon 5%

Table 4.3 *Composite mix of Al+ Carbon 5%*

Tensile Strength	289.87 MPa
Elongation	10.00%
Hardness	69 HRB

Mechanical Properties observed from a composite mix of aluminium and carbon nanomaterial of 5%. Where tensile strength value of 76.87 MPa, Elongation of 5% and Hardness of 51 HRB which were carried out in setting Aluminium Metal testing parameter of 100 Kg.

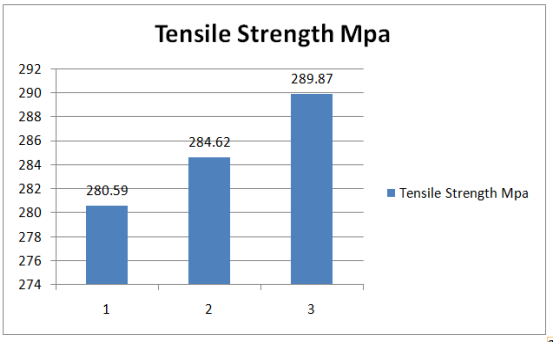

Figure 4.1 Tensile Strength

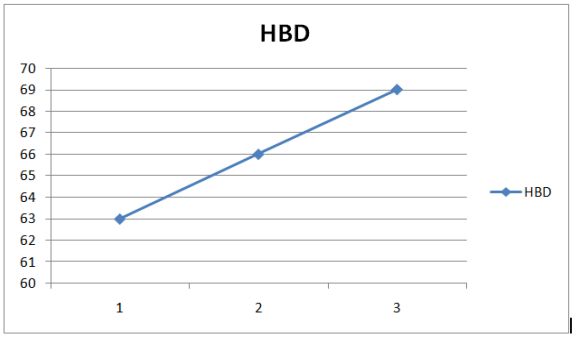

Figure 4.2 Hardness

3.1 Chemical Analysis:

Stoichiometric results investigating Aluminium alloy of 6061 which shows various Elements present in Aluminium Metal Matrix composite.

Table 4.4 Chemical Analysis of NMMC of Al 6061

Elements	Units	Findings
Silicon	%	0.360
Iron	%	0.356
Copper	%	0.058
Manganese	%	0.376
Magnesium	%	0.717
Nickel	%	0.000
Zinc	%	0.000
Lead	%	0.000
Tin	%	0.000
Titanium	%	0.057
Aluminium	%	Rem

4.3 Microstructure Analysis:

4.3.1 Composite mix of Al+ Carbon 2%

Figure 4.3 matrix of metal matrix composite surface

Figure 4.3 Shows the polished matrix of metal matrix composite surface. The matrix shows the particles of composite Carbon Nano Material is uniformly distributed. While the particles of Carbon present are finer the Si particles are larger and present as a lump in a metal matrix. The Carbon Nanoparticle occupied the grain boundary which is seen as thin grain boundaries as the matrix is not etched.

4.3.2 Composite mix of Al+ Carbon 3%

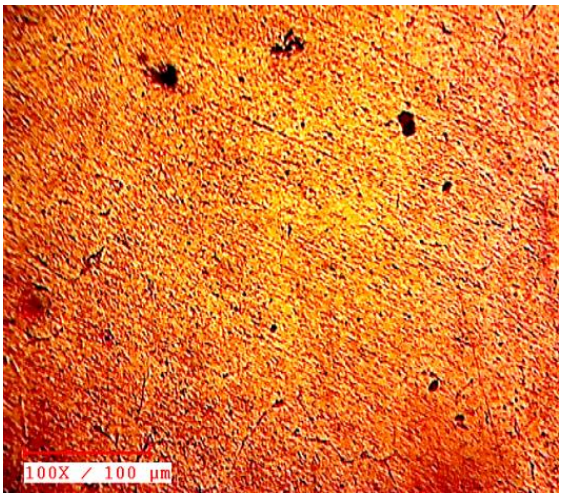

Figure 4.4 Distribution of Carbon in Aluminium matrix

Figure 4.4 Shows image shows the distribution of graphite in Aluminium matrix. The particles of Carbon Nanoparticle are finer and present inside the grain boundaries in size.

4.3.3 Composite mix of Al+ Carbon 5%

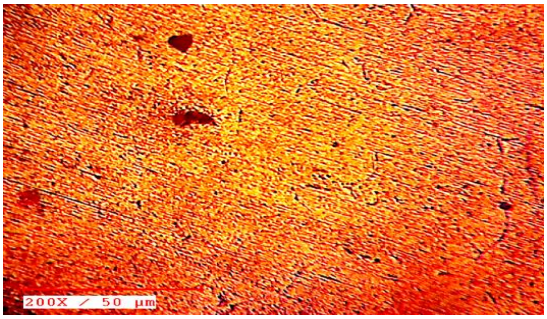

Figure 4.5 Graphite particles are more in the metal matrix.

Figure 4.5 Shows the Graphite particles are more present in the metal matrix.

4.3.4 Composite Mix Al+ Carbon 2 % as Etched

Here polished surface has been etched using Etchant: H.F Soln.

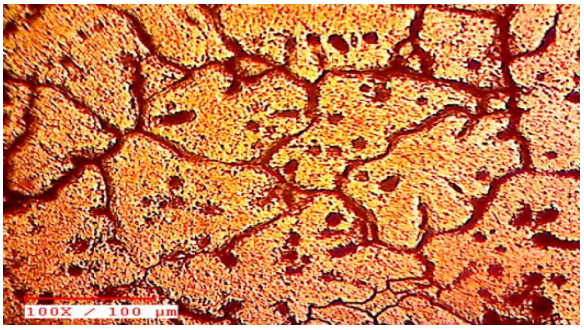

Figure 4.6 Boundaries after etching with Keller's reagent

Figure 4.6 Shows the clear thick grain boundaries after etching with Keller's reagent soln. the grain boundaries showed the occupied Carbon nano particles in it. Some particles also distributed in the matrix. The black round particles are Mg2Si eutectic particles precipitated in primary Alpha Aluminium solid solution.

4.3.5 Composite Mix Al+ Carbon 3 % as Etched

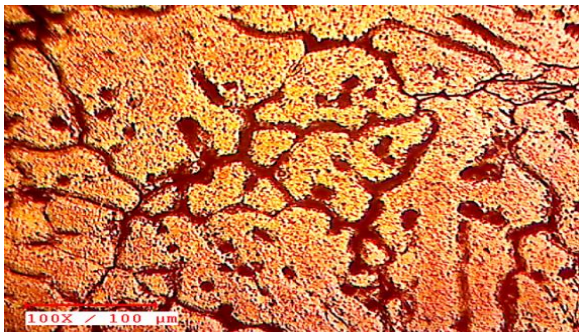

Figure 4.7 Higher distribution of Carbon

Figure 6.17 Shows Similar to figure 4.7 but with a higher distribution of Carbon Nano particle in grain boundaries.

4.3.6 Composite Mix Al+ Carbon 5% as Etched

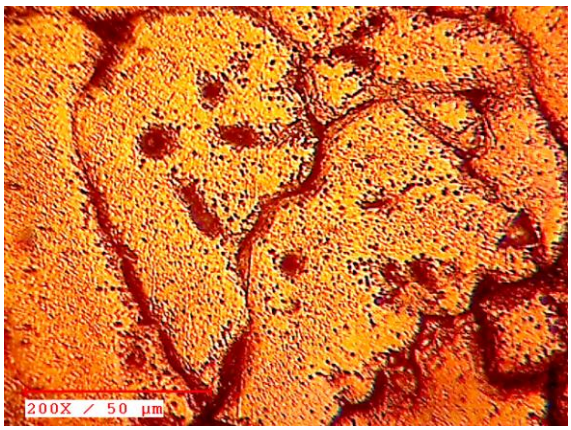

Figure 4.8 Microstructure at 200X

Figure 4.8 Shows the microstructure at 200X which resolved the grain boundaries of the primary Aluminium matrix. Carbon Nano particle has occupied the grain boundary voids. The black round particles are eutectic Mg2Si.

4.3.7 SEM Analysis For Composite Mix Al+Carbon 5%

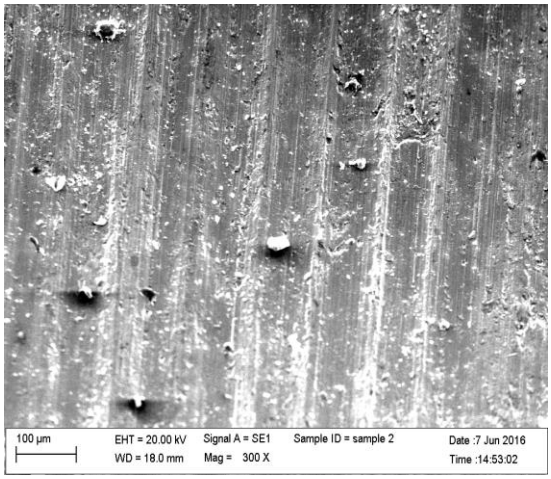

Figure 4.9 SEM Image of Aluminium Metal Matrix composite

Figure 4.9 Shows the track of metal matrix drilled with a step drill. The bore surface shows the Carbon Nano particles in the metal matrix present and which have surfaced. The debris of the particles of base metal aluminium alloy spread at the surface of the track. The SiC particle in alloy size is 30 to 40 microns and the track width is 110 microns.

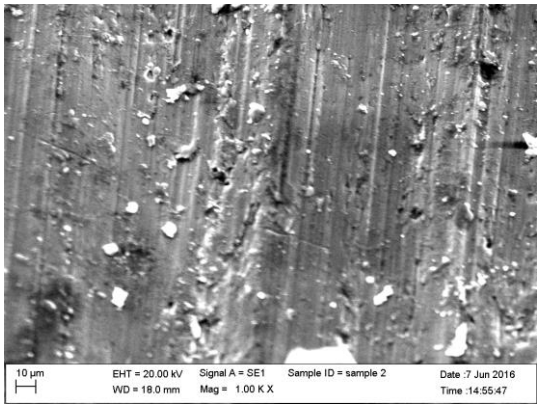

Figure 4.10 Magnified at 1000X

Figure 4.10 shows the same field shown in figure 6.7 magnified at 1000X which has resolved the metal matrix Composite.

4. Conclusion:

There was a strong demand in automobile and air vehicles structures for reduction of weight and they are constantly looking for new materials for replacing conventional materials. In this regards Nanoparticle reinforced metal matrix composites (NMMCs) have taken big initiatives towards replacing conventional material. Especially, Al based NMMCs are taken a big role in both automotive and air vehicles. In this regards, the present research work has taken initiative towards the development of lightweight and strong materials. Hence this research work has conducted the physical properties such as electrical resistance and CTE, mechanical such as, tensile, compression, etc. tribological properties such as, wear and corrosive-erosive wear along with microstructural and fracture surface studies. On the basis of results, the following conclusion is drawn.
In this experimental study, Composite preparation was done for three combinations mixture fixing Aluminium alloy (A6061) as a base metal. Composites are prepared using Carbon Nanoparticle. Altering Percentage of Nanomaterial in various proportions forming metal matrix composite using a stir casting method which was liquid metal matrix composite preparation methodology has been adopted.

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