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Synthesis and Analysis of Aluminium 6063, Graphite and CNT (Hybrid) Nano Composites by using Powder Metallurgy

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Abstract: The aluminum-graphite and carbon nano tubes hybrid composites have been successfully fabricated by powder metallurgy and hot extrusion techniques. The hybrid nano Composite displayed uniform dispersion of gr-cnt and an excellent interfacial bonding with the aluminum matrix micro structural characterization revealed that composite displayed uniform dispersion of gr-cnt and excellent interfacial bonging with aluminum bonding. Hardness testing showed that there occurs a significant increment in hardness value of fabricated composites. The strengthening of aluminum matrix by gr-cnt is mainly due to grain refinement and effective load transfer. Our results indicate that gr-cnt increases the tensile strength ofthe aluminum by up to12%. High resolution SEM microscopy revealed that the defective nature of gr-cnt produced by thermal exfoliation/reduction of graphite oxide is likely responsible for promoting aluminum carbide formation. Despite of the presence of defects in gr-cnt particles. The hardness testing showed that enhanced interfacial binding and load transfer of aluminum matrix composites are superior compared to that of polymer matrix composite.

Keywords: Hybrid composite, aluminum 6063,graphite(gr),carbon nano tubes(cnt),powder metallurgy

I. INTRODUCTION

Nanocomposites Metal network can likewise be characterized as fortified metal framework composites. This kind of composites is named constant and non-ceaseless strengthened materials. A standout amongst the most imperative nanocomposites is Carbon nanotube metal framework composites, which is a rising new material that is being created to exploit the high elasticity and electrical conductivity of carbon nanotube materials. Basic to the acknowledgment of CNT-MMC having ideal properties in these zones are the advancement of manufactured methods that are (a) financially producible, (b) accommodate a homogeneous scattering of nanotubes in the metallic lattice, and (c) prompt solid interfacial grip between the metallic framework and the carbon nanotubes. This material might be utilized for different reasons like lighter weight, more grounded than the already acquired material, more affordable contrast with customary material.

II. LITERATURE SURVEY

Most of the literature survey carried has been primarily focused on fabrication and synthesis of nanocomposites. In this study, effect of sintering temperature on mechanical and structural properties of gr-cnt reinforced aluminum matrix composites has been investigated. Initially, gr-cnt reinforcement was prepared by oxidizing graphite powder to graphite oxide (GO) using Hummer's method followed by chemical reduction of graphite oxide using benzyl alcohol (BnOH). Gr-cnt reinforced aluminum matrix composites have been prepared by powder metallurgy process. X-ray diffraction pattern, microstructure, density, hardness and compressive strength of prepared samples has been investigated. XRD studies showed the presence of pure aluminum and gr-cnt phase only. And SEM study shows the formation of dendrite microstructure which indicates the formation of Al_4C_3 phase due to reaction between aluminum and grapheme particles. Thickness and hardness of the examples rely upon the sintering temperature. In reinforcement of aluminum matrix addition of graphene increases the strength of aluminum. As the percentage of graphene increases it improves the strength of the composite[1].mechanical properties and Microstructure of aluminum alloy 6063 (Al6063)/few-layer gr-cnt composites can be produced by ball milling and hot rolling has been investigated. The presence of dispersed FLGs with high surface area increases the strength of the composites. The composite having 0.7 vol.% FLGs exhibits tensile strength of 700 MPa, twice than that of monolithic Al6063, and around 4% elongation to failure. Amid plastic miss hapening, confined disengagement exercises and the gathered separation at between FLGs can be utilized for reinforcing of Al6063 composites[2].Composites of gr-Cnt and powdered aluminum were made using ball milling, hot isostatic pressing and extrusion. The mechanical properties and microstructure has been studied using hardness and tensile tests, as well as electron microscopy, differential scanning calorimetry and X-ray diffraction. Compared to the pure aluminum and multi-walled carbon nanotube composites, the graphite–aluminum composite showed decreased strength and hardness[3].Graphite oxide (GO) powder and carbon nanotubes was dispersed in an AlMg5 matrix with the help high energy ball milling. The blend obtained was then hot pressed. No further hardening processes were performed. Only 1vol % of GO-CNT in the Aluminum alloy matrix leads to a improvement of the mechanical resistance. The ultimate tensile strength (540 MPa) and the macro hardness (166 HV) are increased by a factor of 2 compared to the same AlMg5 alloy without nano particulates material and compacted under the same conditions. Even the bending strength was increased by a factor of 4 reaching a value over 800MPa. The Graphene oxide powder can be used as a mechanical reinforcement to other material such as polymer and ceramic systems[4].

The present work focuses on the development of multilayer gr-cnt reinforced aluminum metal matrix composites by powder metallurgy followed by hot extrusion. Microstructure, grain size analysis and mechanical properties of hot extruded unreinforced aluminum and gr-cnt reinforced aluminum composites are presented here. Microstructure shows uniform distribution of grapheme throughout the matrix. Experimental study results significant increase in hardness as well as tensile strength of composite as compared to unreinforced aluminum. The improvements in properties are obtained uniformly dispersed graphene sheets, an excellent interfacial bonding between graphene and aluminum matrix and grain refinement caused by the addition of graphene. Further, the strengthening involved in the aluminum-graphene composite have been discussed[5].

III. MATERIAL SELECTION

A. Aluminium 6063

Aluminum is the a standout amongst the most to a great extent accessible component in earth. AA 6063 is an aluminum composite, with magnesium and silicon is taken as alloying components. The standard controlling its piece is kept up by The Aluminum Affiliation. It has for the most part great mechanical properties and is warm treatable and weld able. It is like the English aluminum composite HE9. 6063 is the most widely recognized amalgam utilized for aluminum expulsion. It enables complex shapes to be framed with extremely smooth surfaces fit for anodizing as is prevalent for noticeable building applications, for example, such as window frames, door , roofs, door frames and sign frames. Applications requiring higher strength typically use 6061 or 6082 instead.

Figure.1: Aluminum 6063

Indeed, even in contender air ship, which as of now has composite material rates in the scope of 40– 50 %, aluminum still assumes a critical part. The engaging quality of aluminum is that it is a moderately minimal effort, lightweight metal that can be warm treated to genuinely high-quality levels, and it is a standout amongst the most effortlessly created superior materials higher metal evacuation rates are a prompt advantage of fast machining, an extra cost sparing is the capacity to machine to a great degree thin dividers and networks.

Constituents	percentage
Silicon	0.2-0.6
Iron	0.35
Copper	0.10
Manganese	0.10
Magnesium	0.45-0.9
Zinc	0.10
Chromium	0.10

Table 1: Chemical Composition of Al-6063

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B. Graphite

Graphite is an allotrope of carbon as a two-dimensional, nuclear scale, hexagonal cross section in which one particle shapes every vertex. It is the essential auxiliary component of different allotropes, including, charcoal, carbon nanotubes and fullerenes. It can be considered as an inconclusively vast fragrant atom, a definitive instance of the group of level polycyclic sweet-smelling hydrocarbons.

Graphite has numerous unordinary properties. It is around 200 times more grounded than the most grounded steel. It proficiently directs warmth and power and is almost straightforward.

Graphite has a hypothetical particular surface region (SSA) of 2630 m2/g. This is significantly bigger than that answered to date for carbon dark (regularly littler than 900 m2/g) or for carbon nanotubes (CNTs), from ≈100 to 1000 m2/g and is like enacted carbon.

Figure.2: Graphite

C. Carbon nano tubes

A carbon nanotube is a tube-shaped material, made of carbon, having a diameter measuring on the nanometer scale. A nanometer is one-billionth of a meter, about 10,000 times smaller than a human hair. CNT is unique because of the bonding between the atoms is very strong and the tubes can have extreme aspect ratios. Nanotubes are members of the fullerene structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene.

Carbon nanotubes are the strongest and stiffest materials yet discovered in terms of tensile strength and elastic modulus respectively. This strength results from the covalent sp2 bonds formed between the individual carbon atoms.

Although the strength of individual CNT shells is extremely high, weak shear interactions between adjacent shells and tubes lead to significant reduction in the effective strength of multi-walled carbon nanotubes and carbon nanotube bundles down to only a few GPa.

IV. METHODOLOGY

A. Powder Metallurgy

Powder metallurgy (PM) is a term covering a wide range of ways in which materials or components are made from metal powders. PM processes can avoid, or greatly reduce, the need to use metal removal processes, thereby drastically reducing yield losses in manufacture and often resulting in lower costs.

A very important product of this type is tungsten carbide (WC). it is used to cut and form other metals and is made from WC particles bonded with cobalt. It is very widely used in industry for tools of many types and globally ~50,000t/yr. is made by PM. Other products include sintered filters, porous oil-impregnated bearings, diamond tools and electrical contacts.

Powders of the elements niobium, tantalum, calcium, titanium, vanadium, thorium, and uranium have been produced by high-temperature reduction of the corresponding nitrides and carbides. Iron, uranium, nickel, and beryllium sub-micrometer powders are obtained by reducing metallic oxalates and formats. Exceedingly fine particles also have been prepared by directing a stream of molten metal through a high-temperature plasma jet or flame, atomizing the material. Various chemical and flame associated powdering processes are adopted in part to prevent serious degradation of particle surfaces by atmospheric oxygen.

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Figure.3: Powder Metallurgy Process

B. Planetary Ball Mill

Figure.4. Planetary Ball Mill Equipment

A ball mill is a type of grinder used to grind and blend materials for use in mineral dressing processes, ceramics, paints, pyrotechnics, and selective laser sintering. It works on the principle of impact and attrition were size reduction is done by impact as the balls drop from near the top of the shell.

A ball mill consists of a hollow cylindrical shell rotating about its axis. The axis of the shell may be a small angle to the horizontal. It is partially filled with balls. The grinding media is the balls, which may be made of steel (chrome steel), ceramic, stainless steel, or rubber. The inner surface of the cylindrical shell is usually lined with an abrasion-resistant material such as manganese steel or rubber. Less wear takes place in rubber lined mills. The length of the mill is approximately equal to its diameter.

In case of continuously operated ball mill, the material to be ground is fed from the right product is discharged through a 30° cone and left through a 60° cone. As the shell rotates, the balls are lifted up on the rising side of the shell and then they cascade down from near the top of the shell. In doing so, the solid particles in between the balls and ground are reduced in size by impact.

A ball mill is a cylindrical device used in grinding (or mixing) materials like ores, chemicals, ceramic raw materials and paints. Ball mills rotate around a horizontal axis, partially filled with the material to be ground plus the grinding medium. An internal cascading effect reduces the material to a fine powder

V. BLENDING OF SAMPLES (AL- GRAPHITE COMPOSITES)

The fluctuating part of aluminum 6063 and were added to graphite powder in each trail. A natural dissolvable, ethanol liquor was utilized while processing the powder to stay away from oxidation of the powder. Ethanol liquor was utilized for each operation of graphite powder

The ball processing for 1wt% ,2wt% ,3wt% of graphene is included aluminium6063 powder and same weight % were ball processed for 3hour at 160rpm. the presence of powder after ball processing SEM picture has been appeared. it can be noticed the complexity of the powder have changed

A. SEM pictures before compaction

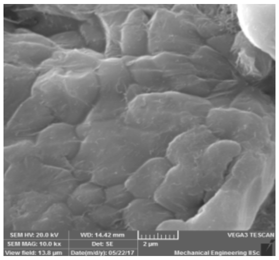
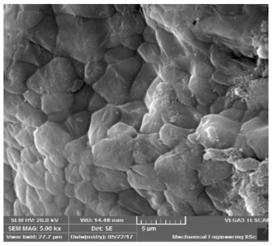


Figure.4: SEM Image of Al-6063 -1%Gr



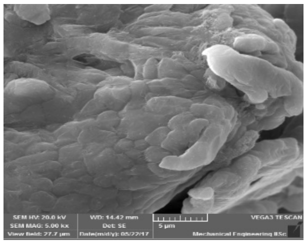


Figure.6: SEM Image Figure.7: SEM of Al-6063-2%GrImage of Al-6063 3%Gr

VI. SONICATOR

Sonication is the represent applying sound vitality to shake particles in an example, for different purposes. Ultrasonic frequencies (>20 kHz) are typically utilized, prompting the procedure likewise being known as ultra sonication or ultra-sonication.

In the lab, it is normally connected utilizing a ultrasonic shower or a ultrasonic test, conversationally known as a Sonicator. In a paper machine, a ultrasonic thwart can convey cellulose strands all the more consistently and reinforce the paper. Sonication can be utilized for the generation of nanoparticles, for example, nanocrystals, liposomes, nanoemulsions, and wax emulsions, and additionally for wastewater filtration, degassing, extraction of plant oil, creation of biofuels, raw petroleum desulphurization, extraction of anthocyanin's and cancer prevention agents, polymer and epoxy handling, cement diminishing, and numerous different procedures.

Figure.8: Sonicator

VII. HYDRAULIC PRESS

A pressure driven press is a gadget utilizing a water driven chamber to produce a compressive power. In the water driven press the weight all through a shut framework is steady. One a player in the framework is a cylinder going about as a pump, with an unassuming mechanical power following up on a little cross-sectional region; the other part is a cylinder with a bigger region which creates a correspondingly extensive mechanical power. Just little distance across tubing (which all the more effortlessly opposes weight) is required if the pump is isolated from the press barrel.

Figure.9 : Hydraulic Press Equipment

A liquid, for example, oil, is uprooted when either cylinder is pushed internal. Since the liquid is incompressible, the volume that the little cylinder dislodges is equivalent to the volume uprooted by the vast cylinder. This causes a distinction in the length of uprooting, which is relative to the proportion of zones of the leaders of the cylinders, given that volume = territory × length. In this way, the little cylinder must be moved an expansive separation to get the vast cylinder to move altogether. The separation the substantial cylinder will move is the separation that the little cylinder is moved isolated by the proportion of the zones of the leaders of the cylinders. This is the means by which vitality, as work for this situation, is preserved and the law of preservation of vitality is fulfilled. Work is compel connected over a separation, and since the power is expanded on the bigger cylinder, the separation the power is connected over must be diminished.

A. Compaction of Mixed Examples

Compaction is the way toward compacting metal powder in a kick the bucket through the utilization of high weight. ordinarily, the instrument is held in the vertical introduction with the punch apparatus shaping the base of the depression. powder is then compacted into a shape and after that catapulted from pass on pit. In some of these application the parts may require next to no extra work for their proposed utilize making exceptionally cost proficient assembling normal weight territory from 70mpa to1Gpa, weight from 1000psi to 1000000psihave been acquired to accomplish a similar pressure proportion over a segment with more than one level or tallness it is important to work with different lower punch. a round and hollow work piece is made by single level tooling. a more mind boggling shape can be made by the basic numerous level tooling. creation rates of 15to 30parts every moment are normal tooling must be outlined so it will withstand and extraordinary weight without misshaping or twisting. apparatus must be produced using material that are cleaned and wear A kick the bucket was produced using HDS (hot bite the dust steel) material. the powder was filled into the bite the dust and was shut with plunger and squeezed. the mixed powder was warmed at 150 c to evacuate all the dampness content. the powder was filled into the kick the bucket and the pass on was produced using HSD material. graphite thwart was utilized got launch of the conservative. subsequent to filling the powder, the plunger was stacked and weight was connected for length of five moment. the conservative was launched out and subjected to sintering. the measurement of minimal were15 mm width and 10-15 mm long. the minimal had great quality and had enough

Figure 10 compacted sample of Al-6063

VIII. SINTERING

Sintering is the process of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquefaction is known as sintering.

Sintering happens naturally in mineral deposits or as a manufacturing process used with metals, plastics, ceramics, and other materials. The atoms in the materials diffuse across the boundaries of the particles, fusing the particles together and creating one solid piece. Because the sintering temperature does not have to reach the melting point of the material, sintering is often chosen as the shaping process for the materials with extremely high melting points such as tungsten and molybdenum. The study of sintering in metallurgy powder-related processes is known as powder metallurgy. Examples of pressure-driven sintering are the compacting of snowfall to a glacier

Figure.11: Sintering Furnace

IX. CHEMICAL TEST

A. Chemical Analysis Of Metals

Chemical analysis of metallic materials is important to ensure that you and your clients are getting the material that is appropriate for the intended end use. ICP analysis, OES analysis, SEM-EDS analysis and XRF analysis are a few common ways of determining material composition of metals.

X. ANALYSIS METHODS

A. Icp-Ms Analysis

ICP-MS (Inductively Couple Plasma - Mass Spectrometry) provides analysis of metals down to the parts per billion level for solutions and the parts per million level on solid samples. Our standard turnaround is 3-5 days depending on the sample and analysis needed.

B. Icp-Aes Analysis

ICP-AES analysis (Inductively Coupled Plasma - Atomic Emission Spectroscopy) provides analysis of metals down to trace levels. We can provide trace element analysis results as low as 50 ppm depending on your material, sample size and components asked. ICP analysis can work with littler examples because of the reality corrosive assimilation is required. Our standard turnaround is 3-5 days relying upon the multifaceted nature of the processing expected to put the example into arrangement. 5.2.4SEM-EDS OR SEM-EDX

C .Sem-eds or sem-edx

SEM-EDS Analysis (Scanning Electron Microscopy - Energy Dispersive Spectroscopy) is especially valuable with a little example, for example, in a disappointment investigation where you may just have garbage or shavings. While some light components can't be distinguished, our group can regularly give you an announcement that the example isn't reliable for the components checked with a coveted detail.

D. Xrf analysis

Wavelength-Dispersive X-Ray Fluorescence Spectroscopy (WD-XRF) offers compositional examination of different metals. The technique requires a strong example ready to cover a 29mm distance across opening; be that as it may, littler examples can be obliged. Note that some light components, (for example, boron, beryllium, and so on.) can't be distinguished by means of this technique.

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E. Scanning electron microscope

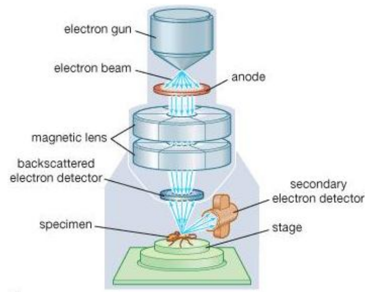

Figure.12: scanning Electron Microscopy Setup

A scanning electron magnifying lens (SEM) is a sort of electron magnifying lens that produces pictures of an example by examining the surface with an engaged light emission. The electrons communicate with particles in the example, delivering different signs that contain data about the example's surface geography and creation. The electron bar is filtered in a raster check design, and the bar's position is joined with the distinguished flag to create a picture. SEM can accomplish determination superior to 1 nanometer. Examples can be seen in low vacuum or wet conditions in factor weight and high vacuum in regular SEM and at an extensive variety of cryogenic or raised temperatures with particular instruments. The most normal SEM mode is location of auxiliary electrons produced by particles energized by the electron shaft. The quantity of auxiliary electrons that can be distinguished depends, in addition to other things, on example geography. By filtering the example and gathering the auxiliary electrons that are transmitted utilizing an extraordinary finder, a picture showing the geology of the surface is made.

XI. HARDNESS TEST

Hardness is a measure of how safe strong issue is to different sorts of lasting shape change when a compressive power is connected. A few materials (e.g. metals) are harder than others (e.g. plastics). Plainly visible hardness is by and large described by solid intermolecular bonds, however the conduct of strong materials under power is mind boggling; in this manner, there are diverse estimations of hardness: scratch hardness, space hardness, and bounce back hardness. Hardness is reliant on, versatile firmness, quality, sturdiness, pliancy, strain, flexibility viscoelasticity, and thickness. There are three fundamental sorts of hardness estimations: scratch, space, and bounce back. Inside each of these classes of estimation there are singular estimation scales. For pragmatic reasons change tables are utilized to change over between one scale and another.

A. Scratch Hardness

Scratch hardness is the measure of how safe an example is to crack or lasting plastic twisting because of erosion from a sharp question. The standard of that a protest made of a harder material will scratch a question made of a gentler material. When testing coatings, scratch hardness alludes to the power important to slice through the film to the substrate. The most widely recognized test is Mohs scale, which is utilized as a part of mineralogy. One instrument that make this estimation is the sclerometer. Another device used to make these tests is the pocket hardness analyzer. This instrument comprises of a scale arm with graduated markings connected to a four-wheeled carriage. A scratch device with a sharp edge is mounted at the foreordained point to the testing surface. So as to utilize it a weight of known mass is added to the scale arm at one of the graduated markings, the apparatus is then drawn over the test surface. Indentation hardness measures the protection of an example to material distortion because of a steady pressure stack from a sharp question; they are essentially utilized as a part of designing and metallurgy fields. The tests chip away at the fundamental preface of estimating the basic measurements of a space left by a particularly dimensioned and stacked indenter. Common space hardness scales are Rockwell, Shore, and Brinell, Vickers. Two scales that measures bounce back hardness are the Bennett hardness scale and Leeb bounce back hardness test.

B. Vickers Hardness Test

For our example Vickers hardness test was directed to discover the hardness of Nanocomposites tests. The Vickers hardness test was estimated on all example which were compacted and sintered to be specific 1%,2%,3%, Al6063. The example were made prepared by cleaning the surfaces utilizing coarseness paper were subjected to a Vickers hardness analyzer.

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Figure.13: Vickers Hardness Test

The Vickers test is regularly less demanding to use than different hardness tests since the required computations are autonomous of the span of the indenter, and the indenter can be utilized for all materials independent of hardness. The essential guideline, as with every single regular measure of hardness, is to get the scrutinized material's capacity to oppose plastic twisting from a standard source. The Vickers test can be utilized for all metals and has one of the most extensive scales among hardness tests. The unit of hardness given by the test is known as the Jewel Pyramid Hardness (DPH) or Vickers Pyramid Number (HV). The hardness number can be changed over into units of Pascal's, yet ought not be mistaken for weight, which likewise has units of Pascal's. The hardness number is dictated by the heap over the surface zone of the space and not the zone ordinary to the power, and is along these lines not weight. It was chosen that the indenter shape ought to be fit for creating geometrically comparative impressions, independent of size; the impression ought to have very much characterized purposes of estimation; and the indenter ought to have high protection from self-disfigurement.

XII. RESULTS AND DISCUSSION

A. *Chemical Test Report*

The chemical test was carried in raghavendra spectro metallurgy labroratory, using ICP-OES in bangalore

Equipment used: ICP-OES, PerkinElmer

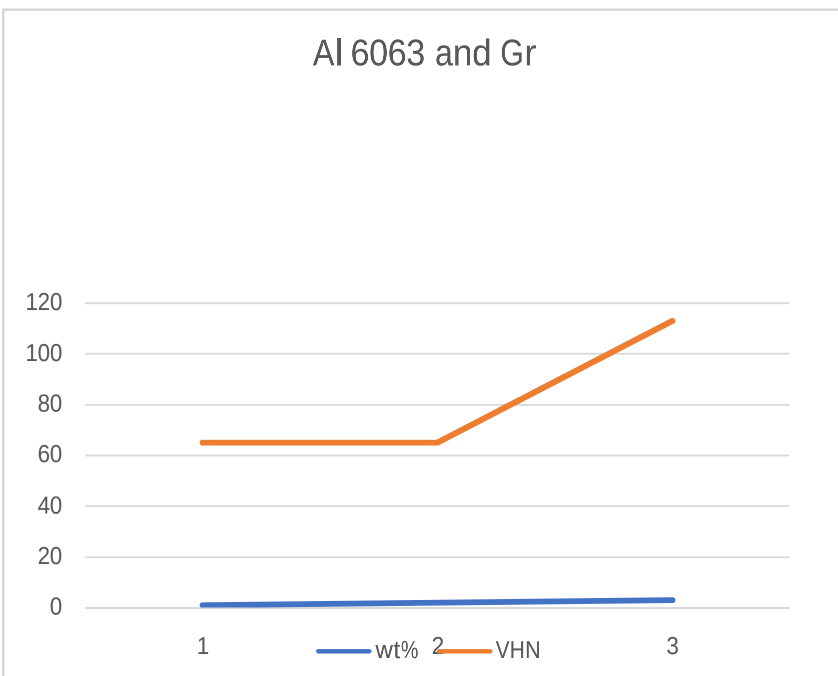
Sl.No	Parameter	Symbol	Unit	Result
1	Iron	Fe	%	0.080
2	Silicon	Si	%	0.49
3	Manganese	Mn	%	0.005
4	Magnesium	Mg	%	0.85
5	Zinc	Zn	%	0.049
6	Copper	Cu	%	0.80
7	Lead	Pb	%	0.016
8	Tin	Sn	%	0.010
9	Zirconium	Zr	%	< 0.001
10	Chromium	Cr	%	0.036
11	Titanium	Ti	%	0.003
12	Aluminium	Al	%	Remainder

Table 6.1 chemical analysis of Al 6063

B. Vickers hardness Test

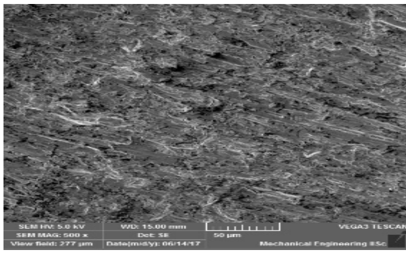
Ball milling Time at 160rpm	composition	VHN after sintered 560° C
3hour	Al 6063	83
3hour	1 wt % Al 6063&graphene	97
3hour	2 wt % Al 6063&graphene	96
3hour	3 wt % Al 6063&graphene	104

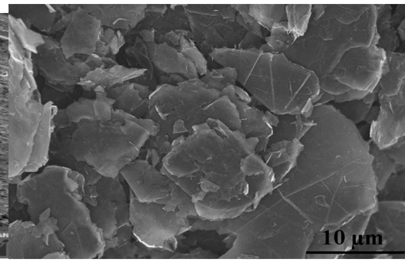
The vicker hardness of nano composites indicated that 3% Al/gr had the highest when compared to the other nanocomposites .



Graph AL-6063 v/s Gr

C. SEM images of Al6063/gr after compaction





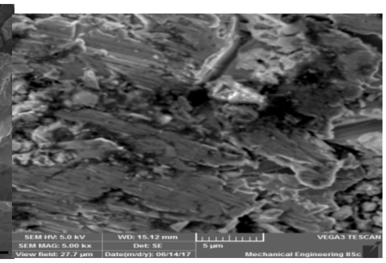


Figure 14 Sem image 1wt% Figure 15Sem image 2wt% Figure 16 Sem image 3wt

XIII. CONCLUSION

The following conclusions are drawn from the present study:

The aluminum-graphite composites have been successfully fabricated by the combination of powder metallurgy and hot extrusion techniques.

Microstructural characterization revealed that composite displayed uniform dispersion of graphite and an excellent interfacial bonding with the aluminium matrix.

Hardness testing showed that there occurs significant increment in hardness values of the fabricated composites. Hardness increases with increasing volume fraction of the graphite reinforcement. This indicate that the graphite can be used an effective reinforcement for aluminium matrix. Grain size refinement and load transfer strengthening are believed to be the major strengthening mechanisms of the fabricated aluminum matrix composites.

prone to agglomerate by forming clusters of particles within the matrix of aluminum alloy during processing. This tends to reduce the hardness and tensile strength of aluminum.

High resolution SEM micrographs revealed that defective nature of graphite produced by thermal exfoliation/ reduction of graphite oxide is likely responsible for promoting aluminum carbide formation. Despite the presence of defects in graphite particles, hardness testing showed that enhanced interfacial binding and load transfer of aluminum matrix composites are superior compared to that of with polymer matrix composites.

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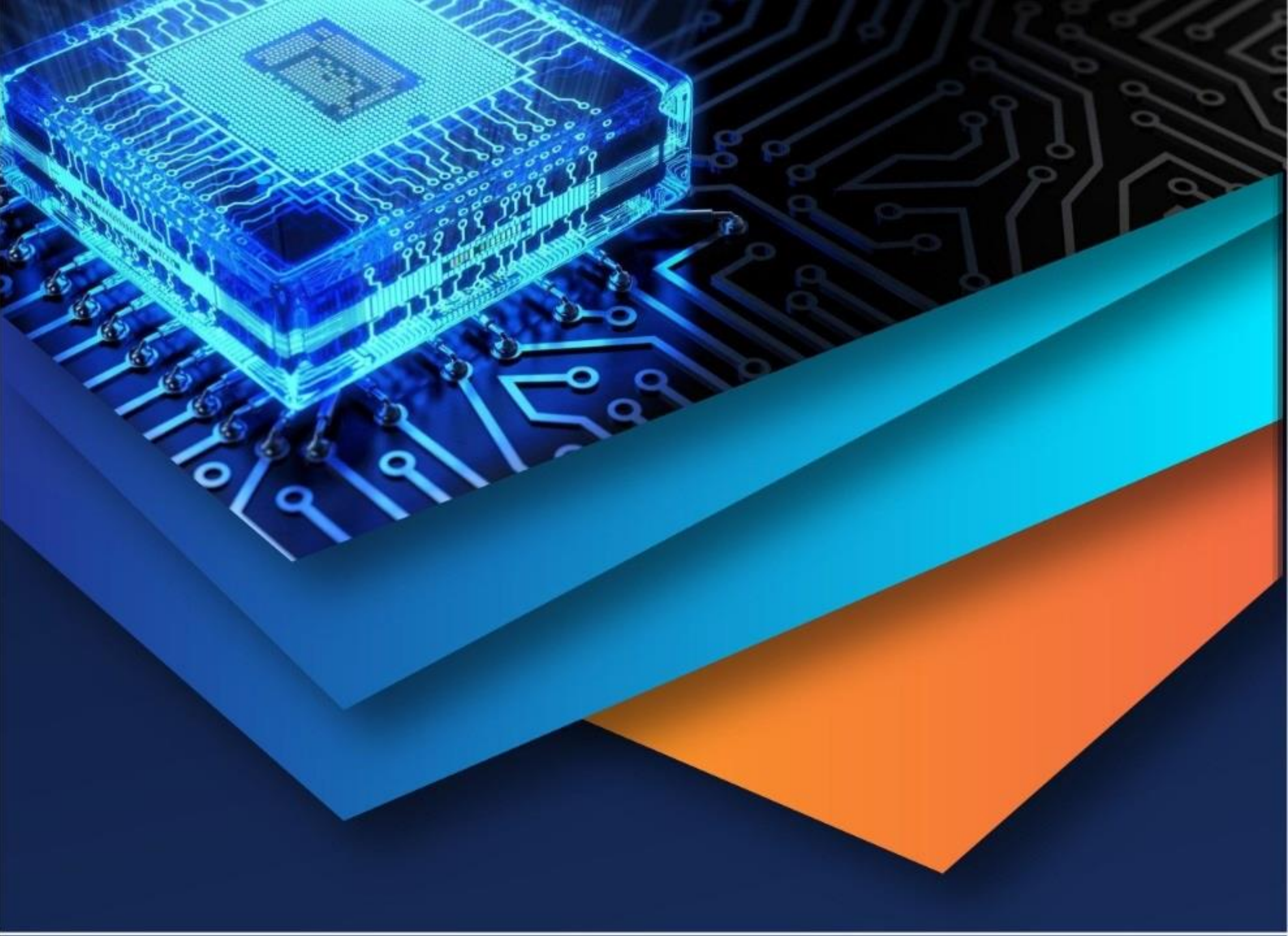

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