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Fabrication and Testing Mechanical Behaviour of Nanocomposite Bars

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Abstract:

The present work is aimed to process characterization of the mechanical properties and microstructure of Al-Sic nanocomposites with grapheme flakes. It is planned to use various combinations with weight percentage of grapheme and Sic and to produce the Aluminum matrix composites by Ball milling technique. The mixtures are to be mixed with Aluminum by weight percentages of adding Sic, Graphene particles followed by Friction stir processing to make a rigid form. Graphene has endowed with excellent physical and mechanical properties such as Tensile strength, elastic modulus and thermal conductivity and has got attention in the field of electronics, automobile industries, aerospace projects and other engineering applications. Lot of work has been carried on synthesis of Al–Sic-Graphene composites for various engineering applications. The prepared compacts must undergo microstructure evaluation by Metallurgical microscope and also find the mechanical properties.

Keywords: **Aluminium nano Powder, SiC Nano power, Graphene Nano Powder, Hardness test, Microstructure, Stir casting.**

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1: INTRODUCTION

[1] present work studied the metal matrix composite specimens were fabricated successfully by stir casting method by varying SiC from 3% to 18% in weight of aluminium. The mechanical properties such as tensile strength and hardness of various composition of reinforcement were found. All the specimens were tested in tensile testing machine and hardness testing machine. In this test result shows that as the percentage of weight in reinforcement increases the tensile strength and hardness also increases.

[2]. In this study, AA 6061-Graphene- SiC composites were processed by ultrasonic liquid processing of Al 6061 particles and Graphene followed by SiC (Varying the SiC concentrations) by ball milling successfully. The precursor are preheated and compacted in the liquid-solid semi state. Finally, the compacts are sintered in conventional and microwave sintering method successfully. XRD analysis has revealed the existence of all major alloying elements of Al 6061 including Graphene (peak at 26.50°) in the developed composite and no carbide formation at the surface. The micro hardness values are seen better yielded in microwave sintering method compared to conventional method.

[4] Present work studied 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.

1.2 What is Nanotechnology?

Nanotechnology is playing a very important role in the burgeoning day by day, making an impact in all spheres of human life. Nanotechnology briefly implies to the design, characterization, production, application of structures, devices and systems by controlled manipulation of size and shape at the Nanometer scale (atomic, molecular, and macromolecular scale) that produces structures, devices and systems with at least one superior characteristic or property. "Nano" means one billionth, one Nano meter is $10^{-9}$of a meter. Nano is the Greek word refers to a reduction of size. The frame work for Nano science and technology emerges from the revolutionary remark "There is the plenty of Room at the bottom". This word was delivered by 'Richard Feynman' at an American physical society meeting in 1959. He also suggested that scaling down to Nano level and starting from the bottom was the key to future technology and advancement. In1974, Norio Taniguchi coined the term 'NANOTECHNOLOGY' and this was popularized by K. Eric Drexler during 1980's by the concept of building machines on a molecular scale. Nanotechnology encompasses the production and application of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to submicron dimensions, as well as the integration of the resulting Nanostructure into large systems.

1.1 What are Nanomaterials?

Nanomaterials are usually considered to be materials with at least one external dimension that measures 100 nm or less or with internal structures measuring 100 nm or less. They may be in the form of particles, tubes, rods or fibers. Nanomaterials are cornerstones of nano science and nanotechnology. Now a day in research & development the major sectors are energy, environment, water technology, pharmaceuticals etc. The usage of nanomaterials is enormous as energy storage devices such as fuel cells, detection of threats in defense, navy, drug delivery and water purification. Industrial revolution has made life easy and pleasant. Today's high speed personal computers and mobile communications would not have certainly been possible without the use of Nano science and Nano technology.

Nano-technology is an advanced technology, which deals with the synthesis of Nano particles, processing of the Nano materials and their applications. Normally, if the particle sizes are in the 1-100 nm range, they are generally called Nano-particles or materials. To give an idea on this size range, let us look at some dimensions 1 nm= 10 A^0= 10^{-9}m and 1μm (*i.e.,* 1 micrometer) = 10^{-4} cm =1000 nm. For oxide materials, the diameter of one oxygen ion is about 1.4 A^0. Seven oxygen ions will make about 10 A^0 or 1 nm, *i.e.,* the 'lower' side of the Nano range. On the higher side, about 700 oxygen ions in a spatial dimension will make the so-called 'limit' of the Nano range of materials.

1.4 Types of Nanoparticles:

Nanoparticles are classified as 0-Dimensional (D), 1D, 2D, or 3D depending on their overall shape.

0-D Nanomaterials: In zero-dimensional (0D) nanomaterials all the dimensions are measured within the nanoscale (no dimensions are larger than 100 nm). Most commonly, 0D nanomaterials are Nanoparticles, Nanograins, Nano shells, Nano capsules, Nano ring's, Fullerenes, Colloidal particles, Nano porous silicon, Quasi crystals.

1-D Nanomaterials: 1-D nanomaterials have thin films or surface coatings. Two dimensions are at Nano scale and one dimension is macroscale. Ex: Nanorods, Nanofilaments, Nanotubes, Quantum wires, Nano wires.

2-D Nanomaterials: 2-D nanomaterials have fixed and long nanostructures with thick membranes. Two of the dimensions are not confined to the nano scale i.e. Two dimensions are at macro scale and one dimension is at Nano scale. Ex: Platelets, Ultrathin films, Super lattices, Quantum wells.

3-D Nanomaterials: 3-D nanomaterials are fixed and small nanostructures where thin films are deposited under conditions that generate atomic-scale porosity, colloids, and free nanoparticles with various morphologies.

2. PROPERTIES OF NANOMATERIALS:

i. Physical Property
ii. Chemical Property
iii. Mechanical Property

iv. Electronic Property
v. Electrical Property
vi. Magnetic Property
vii. Surface effects
viii. Optical Property
ix. Thermal Properties

3. SYNTHESIS TECHNIQUES

Synthesis means to combine several different pieces into a whole. Synthesis is about concisely summarizing and linking different sources to review the literature on a topic, make recommendations, and connect your practice to the research. Synthesis usually goes together with analysis because you break down a concept idea into its important parts/points (analysis), so you can draw useful conclusions or make decisions about the topic or problem (synthesis).

Different Synthesis Techniques: -

1. Ball Milling Method.
2. Herbal Method.
3. Solution Combustion Method.

3.1 Stir Casting Process

Stir casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies. In preparing metal matrix composites by stir casting method some of the factors that need considerable attention are as follows,

i. To achieve uniform distribution of the reinforcement material,

ii. To achieve wet ability between the two main substances,

ii. To minimize porosity in the cast metal matrix composite.

3.2 Process Parameters:

a). Stirrer Design: It is very important parameter in stir casting process which is required for vortex formation. The blade angle and number of blades decides the flow pattern of the liquid metal. The stirrer is immersed till two third depth of molten metal. All these are required for uniform distribution of reinforcement in liquid metal, perfect interface bonding and to avoid clustering.

b). Stirrer speed: Stirring speed is an important parameter to promote binding between matrix and reinforcement i.e. wet ability. Stirring speed decides formation of vortex which is responsible for dispersion of particulates in liquid metal. In our project stirring speed is 300 rpm.

c).Stirring temperature: Aluminium melts around 650°C, at this temperature semisolid stage of melt is present. Particle distribution depends on change in viscosity. The viscosity of matrix is mainly influenced by the processing temperature. The viscosity of liquid is decreased by increasing processing temperature with increasing holding time for stirring which also promote binding between matrix and reinforcement. Good wet ability is obtained by keeping temperature at 800°C.

d).Stirring time: As stirring promote uniform distribution of reinforcement partials and interface bond between matrix and reinforcement, stirring time plays a vital role in stir casting method. Less stirring leads to non-uniform distribution of particles and excess stirring forms clustering of particles at some places. Stirring time is 5 minutes in our case.

4. EXPERIMENTAL SETUP AND PROCEDURE:

The process of stir casting starts with placing empty crucible in the furnace. The heater temperature is then gradually increased up to 800°C. Aluminum alloy is cleaned to remove dust particles, weighed and charged in the crucible for melting. Required quantities of reinforcement powder and magnesium powder are weighed on the weighing machine. Reinforcements are heated for 45 minutes at a temperature of 500°C. When matrix was in the semisolid stage condition at 650°C, 1 % by weight of pure magnesium powder is used as wetting agent. After five minutes the scum powder is added which forms a scum layer of impurity on liquid surface which to be removed.

Heater temperature is then gradually increased to 800°C. At this heater temperature stirring is started and continued for five

minutes. Stirring rpm is gradually increased from 0 to 300 RPM with the help of speed controller. Preheated reinforcements are added during five minutes of stirring. Reinforcements are poured manually with the help of conical hopper. The flow rate of reinforcements measured is 0.5 gram per second. Stirrer rpm is then gradually lowered to the zero. Then molten composite slurry is poured in the metallic mold without giving time for reinforcement to settle down at crucible bottom. Mold is preheated at 500°C temperature for one hour before pouring the molten slurry in the mold. This is necessary to maintain slurry in molten condition throughout the pouring. While pouring the slurry in mould the flow of the slurry is kept uniform to avoid trapping of gas, also distance between crucible and mold plays a vital role in quality of casting.

Fig4.1: -AluminumNano powder

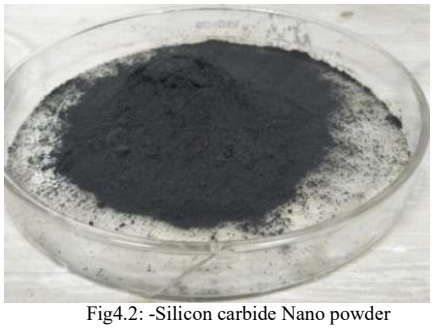

Fig4.2: -Silicon carbide Nano powder

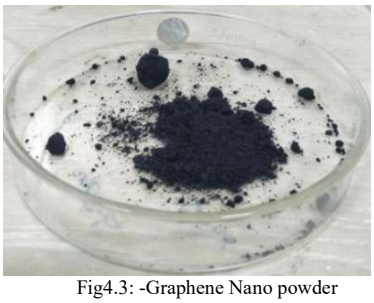

Fig4.3: -Graphene Nano powder

Fig 4.4 pouring of liquid into dies

Fig 4.5 work pieces after stir casting

Fig 4.6 work pieces after Finishing

Fig4.7: - Sample Test Piece for Rockwell Hardness Test

5. RESULTS & DISCUSSION:

(a) Observations during Rockwell Hardness Test

S. No	Composition (%)	Trail -1	Trail-2	Trail-3	Average
1	70-20-10	80	86	96	88
2	70-18-12	70	86	86	81
3	70-16-14	72	94	60	75
4	70-14-16	66	64	66	65

Table 5.1 Observations during Rockwell Hardness test

(b). Microstructure of Workpieces

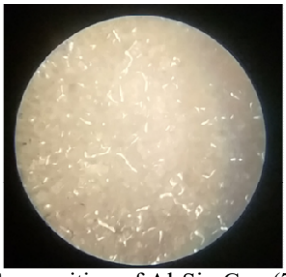

Fig:5.1. Composition of Al-Sic-Gnp (70-20-10)

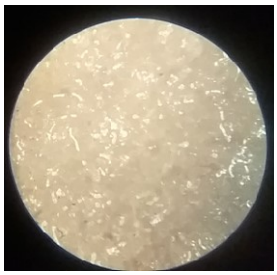

Fig:5.2. Composition of Al-Sic-Gnp (70-18-12)

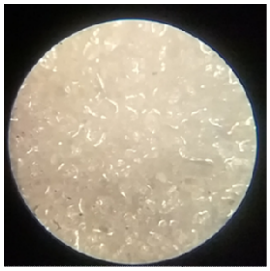

Fig:5.3. Composition of Al-Sic-Gnp (70-16-14)

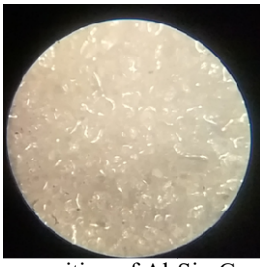

Fig:5.4. Composition of Al-Sic-Gnp (70-14-16)

6. CONCLUSION:

1. The Sic & Graphene are the most effective strengthening particulates, for higher strength, hardness & grain size reduction.
2. As it is also noted that Addition of these composites to the aluminium results in the increase of hardness number for a material which reduces the weight of the material and possess high thermal and electrical conductivity of the material.
3. So, the percentage of aluminum is kept constant as 70%, silicon is decreasingly added from 20% and the graphene is increased from 10%.
4. Finally, we conclude that a lot of work has been carried on synthesis of Al –Sic –graphene composites for various engineering applications.
5. Then the prepared compacts must undergo microstructure evolution by Metallurgical microscope and find the hardness by Rockwell Hardness Test Experiments.
6. By this project we conclude that the hardness number 88 is the highest value for the sample 1 having the composition of 70%-20%-10% (Al-Sic-Gnp).

REFERENCES

[1]. S.Vijayakumar, M.Soundarrajan, P.Palanisamy, K.Pasupathi "Studies on Mechanical Properties of Al-Sic Metal Matrix Composite" SSRG International Journal of Material Science and Engineering (SSRG-IJMSE) volume 2 Issue6 November to December 2016

[2] Siddhartha Jauhari, Prashantha Kumar H.G, Anthony Xavior .M "synthesis and characterization of AA 6061- Graphene – SiC hybrid nanocomposites processed through microwave sintering" IOP Conf. Series: Materials Science and Engineering 149 (2016) 012086 doi:10.1088/1757-899X/149/1/012086.

[3]. Srinivasulu. Dorasila, M.Venkata Sai, M.Hemanth Sai , Venkatesh, D.Moshea, V.Arun Kumar – " Fabrication And Testing Mechanical Behaviour Of Jute Fibre And Aluminium Composite Materials" International Research Journal of Engineering and Technology (IRJET)- e-ISSN: 2395-0056, p-ISSN: 2395-0072, Volume: 07, Issue: 05 | May 2020 , Pages 7086 - 7096.

[4]. Redankamma Yenumula, Srinivasulu Dorasila, SCV Ramana Murthy Naidy, Rambabu Kalpukuri – "Experimental Investigation of Mechanical Properties of pure Al-Sic Metal Matrix Composite by Stir Casting Method" *International Journal of Engineering Trends and Technology (IJETT)-ISSN:2231-5381 Volume 59, Issue 3 - May 2018. pg, 148-154.*

[5]. Srinivasulu Dorasila, Dr.Ch.Srinivas Rao and Dr.D.Lingaraju -"An Experimental Investigation On Design and Development of Rotational Arc welding Machine and parametric study on process variables" *International Journal of Science, Engineering and Technology Research(IJSETR)-April/2016.*

[6]. Al-Sayed,Al-Sherbini,MonaBakr,Iman, Ghoneim, Mohamed, Saad. Exfoliation of graphene sheets via high energy wet milling of graphite. Journal of Advanced Research Volume 8, Issue 3, May 2017, Pages209-215

[7]. Charles Chikwendu Okpala.Nanocomposites – An Overview Department of Industrial /Production Engineering, Nnamdi Azikiwe University, P.M.B. 5025 Awka, Anambra State,Nigeria.

[8]. Kamaal Haider, Md.Azad Alam, Amit Redhewal,Vishal Saxena. Investigation of Mechanical Properties of Aluminium Based Metal Matrix Composites Reinforced with Sic & Al2O3 et al. Int. Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 5, Issue 9, (Part - 2) September 2015,pp.63-69

[9]. Manjunath Naik H R, Manjunath L H, Puneeth N. Synthesizes and Characterization of Al 6061-Graphene-Silicon Carbide Hybrid Composites by Powder Metallurgy Route. International Journal of Advances in Scientific Research and Engineering (injure) E-ISSN: 2454-8006 Vol. 3. Special Issue 1,August-2017.

[10]. M. Ramezani, T. Neitzert. Mechanical milling of aluminum powder using planetary ball milling process. Mechanical milling of aluminum powder using planetary ball milling process, Journal of Achievements in Materials and Manufacturing Engineering 55/2 (2012)790-798.

[11]. R.S. Rana, Rajesh Purohit, V.K. Soni, S. Das. Characterization of Mechanical Properties and Microstructure of Aluminum Alloy-Sic Composites. Materials Today: Proceedings Volume 2, Issues4–5.

[12]. S.Vijayakumar, M. Soundarrajan, P. Palanisamy, K. Pasupathi. Studies on Mechanical Properties of Al-Sic Metal Matrix Composite. SSRG International Journal of Material Science and Engineering (SSRG-IJMSE) volume 2 Issue6 November to December 2016 ISSN:2394.

[13]. Ternopol, Z, Kyzas, G.Z, Bikiaris, D.N. Recent advances in nanocomposite materials of graphene derivatives with polysaccharides. Division of Chemical Technology, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, GR-541 24, Greece MaterialsVolume 8, Issue 2, 2015, Pages652-683.

[14]. Vijaylaxmee Mishra, Richa Sharma, Nakuleshawar Dut Jasuja, Deepak Kumar Gupta. A Review on Green Synthesis of Nanoparticles and Evaluation of Antimicrobial Activity. Department of Biotechnology and AlliedSciences.

[15]. Sable, A.D., Deshmukh, S.D., "Preparation of MMCs By Stir CastingMethod" IJMET, pp.3,(2012)

[16]. Aqida,S.N.,Ghazali,M.I.,Hashim.J.,"The Effects of Stirring Speed and Reinforcement Particles on Porosity Formation in Cast MMC"pp.

[17]. RajeshKumar,ParshuramM.,"Preparation of Aluminum Matrix Composite by Using Stir Casting Method" IJEAT, Vol-3,(2013)

[18]. J.Hashim,L.Looney, "Metal matrix composites: production by the stir casting method" IJEAT(1999)

[19]. Shubham Mathur, Alok Barnawal, " Effect of Process Parameter of Stir Castingon Metal Matrix Composites"IJSR.

[20]. ClyneTW, Withers PJ, "An introduction to metal matrix composites", 1st edition. Cambridge: Cambridge University Press.

