Experimental Investigation on the Effect of Nano Sic and Graphite Particles and the Characterization of Aluminium Matrix Triple Nano Composites

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Abstract - *The growing calls for and numerous layout necessities with vast weight financial savings moreover as excessive strength-to-weight ratio in comparison to conventional substances have all raised a developing hobby in the direction of the sector of composites. Ceramic carbide has acquired huge interest because of its notable oxidation resistance, corrosion resistance and denseness or even at excessive temperatures. In latest years, aluminum matrix composites are hired within side the automobile enterprise due to their light-weight property. Alumina LM25 compromise a completely excessive unique strength, brilliant castability, accurate damping potential and extra machinability. Nanoparticle reinforcements can substantially enhance the mechanical homes of the matrix with the aid of using greater efficiently stimulating the particle hardening mechanisms than micron-sized debris. This undertaking paintings offers with the fabrication and characterization of aluminum matrix bolstered with specific wt % (0.5,1 and 1.5) of nano SiC & (1 wt%) of Graphite debris organized with the aid of using stir casting process. Mechanical homes including micro hardness and tensile take a look at and microstructure of the composites have been observed. Microstructure of nano SiC composites have been investigated with the aid of using inverted microscope.*

***Key Words*: Alumina LM25, Stir Casting Process, Inverted Microscope.**

1. INTRODUCTION

Composites are created from individual materials named as constituent materials with considerably completely different physical or chemical properties, that once combined, manufacture a fabric with characteristics different from the individual parts. The individual components stay separate and distinct among the finished structure. There are two main classes of constituent materials: matrix and reinforcement. a minimum of one portion of every kind is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to reinforce the matrix properties. A synergism produces material properties unobtainable from the individual constituent materials, whereas the large choice of matrix and strengthening materials permits the designer of the merchandise or structure to decide on an optimum combination. Built composite materials should be shaped to shape. The matrix material will be introduced to the reinforcement before or when the reinforcement material is placed into the mold cavity or onto the mold surface. Over the last thirty years composite materials, plastics and ceramics are the dominant rising materials. The volume and vary of applications of composite materials have adult steadily, penetrating and conquering new markets relentlessly. Trendy composite materials represent a significant proportion of the designed materials market ranging from everyday products to trendy applications. Whereas composites have already proven their value as weight-saving materials, this challenge is to form them cost effective. The efforts to produce economically engaging composite components have resulted in several innovative manufacturing techniques currently obtaining used inside the composites industry. It is obvious, in particular for composites, that the development in production era by myself isn't sufficient to conquer the price hurdle. It is important that there be an included attempt in design, material, process, tooling, great assurance, production, or even application control for composites to turn out to be aggressive with metals. Composites include one or greater discontinuous stages embedded in a non-stop section. The discontinuous section is generally tougher and more potent than the non-stop section and is referred to as the reinforcement or reinforcing material, while the non-stop section is called because the Properties of composites are strongly depending on the residences in their constituent materials, their distribution and the interplay amongst them. The composite residences can be the quantity fraction sum of the residences of the Constituents or the elements may also engage in a synergistic manner ensuing in advanced or higher residences.

1.1 Specification of Stir Casting

- Maximum temperature of pathway furnace: 1500 °C
- Maximum temperature of preheat chamber: 500 °C
- Stirring speed: Up to 1500 rpm
- Variable stirring time
- Die/Mould: Split type to obtain a cast of 50 mm OD x 250 mm Long (Standard)

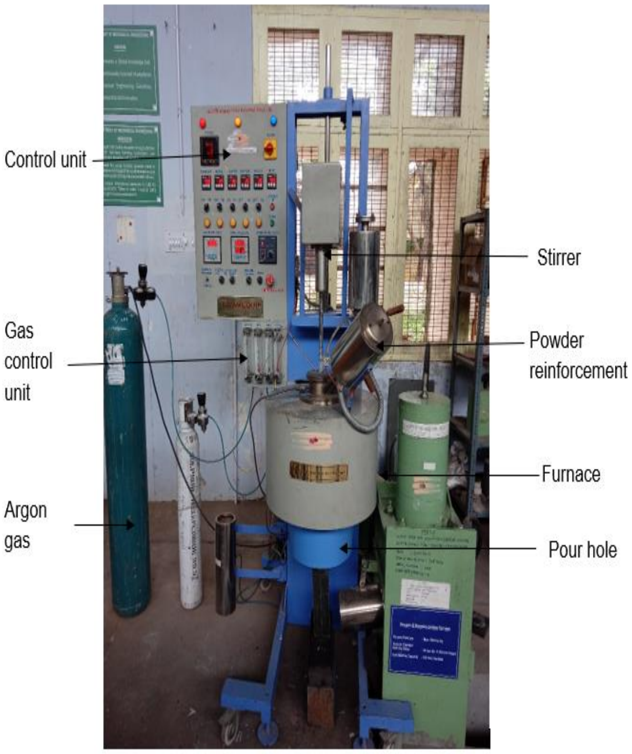


Fig -1: Stir Casting machine

2. MATERIALS AND METHOD

The materials used for this work are Aluminium alloy LM 25 used as matrix material and Aluminium Oxide and Silicon Carbide and Graphite used as reinforcement material

2.1 Aluminium Alloy LM25

Aluminium is chosen because the metallic matrix for the composite because of its abundance, low value and already confirmed tune file for the same purpose. It is extraordinarily soft, durable, mild weight, ductile, malleable metallic and has excessive corrosion resistance, exquisite warmness conductivity. The decided on aluminium alloy LM 25 bears exquisite traits for marine applications. The composition is proven within side the table 1. It has foremost alloying factors Silicon, Copper which contributes for higher strength, machinability and castability.

Table -1: Properties of aluminium alloy LM25

ALLOYING ELEMENT	% COMPOSITION
Copper	0.2 max
Magnesium	0.20-0.60
Silicon	6.5-7.5
Iron	0.5 max
Manganese	0.3 max
Nickel	0.1 max
Zinc	0.1 max
Lead	0.1 max
Tin	0.05 max
Titanium	0.2 max
Aluminium	Balance

2.2 Aluminium Oxide (Al_2O_3)

Aluminium oxide (Al_2O_3) it has good wettability with Al, high hardness, and high temperature stability. Aluminium oxide Al_2O_3 in its various levels of purity is used more often than any other ceramic material. The properties of Aluminium oxide are listed in Table 2.

Table -2: Properties of Aluminium Oxide (Al_2O_3)

Density	3.75 to 3.95 g/cm^3
Melting point	3160 °C
Mechanical strength	300 - 630 MPa
Thermal conductivity	20 to 30 W/mK

2.3 Silicon Carbide (SiC)

Silicon Carbide (SiC) is taken as the reinforcement phase due to the fact that are highly wear resistant with good mechanical properties, including high temperature strength and thermal shock resistance. Silicon Carbide (SiC) in its various levels of purity is used more often than any other ceramic material. The properties of Silicon Carbide (SiC) are listed in Table 3.

Table -3: Properties of Silicon Carbide (SiC)

Density	3.2 g/cm^3
Melting point	2200 °C
Mechanical strength	240 MPa
Thermal conductivity	110 W/mK

2.4 Graphite

Graphite is nicely referred to as a stable lubricant and its presence in aluminium alloy matrices makes the alloy, self-lubricating. Graphite being a stable lubricant can enhance the machinability of the composites. Furthermore, graphite possesses extremely good thermal and electric conductivity thereby, can enhance the undertaking functionality of aluminium composites. The properties of graphite are listed in table 4.

Table -4: Graphite

Density	2.266 g/cm^3
Modulus of Elasticity	8-15 GPa
Thermal conductivity	25-470 W/Mk
Melting point	4300 K
Crystal structure	Hexagonal

3. EXPERIMENTATION

The experimental setup of stir casting basically includes an electric powered furnace and a mechanical stirrer. The electric powered furnace consists of a crucible of capability 2kg. The most working temperature of the furnace is 1000°C. The modern score of furnace is unmarried section 230V AC, 50Hz. The matrix fabric is aluminium alloy LM 25. Samples are to be organized the use of LM 25 strengthened with Silicon Carbide Sic (0.5%, 1%, 1.5%), Aluminium oxide Al2O3 (1%) and Graphite (1%) with the aid of using extent at diverse melting temperatures of 700°C, 750°C and reinforcement pre-warmness temperatures as 250°C and 300°C.

The aluminium alloy LM 25 ingots have been reduce in energy hacksaw gadget to the small rods of 50 mm thickness and 25 mm diameter to feed the substances in to the crucible. The required proportion of the rods as in step with experimental plan is fed in to crucible and melted with the aid of using heating within side the induction furnace on the temperature of 700 - 750 °C for 1 to two hours and soften the rod above its liquids temperature to make it within side the shape of semi liquid state (around 600°C). The Al2O3 and graphite debris within side the proper percentage as in line with the experimental plan are preheated to a temperature of 250 - 300°C to make their floor oxidized. Preheated die is heated to a temperature of 200°C for correct solidification. During the reheating system of aluminium alloy at 750°C stirring is finished by a mechanical stirrer which rotates at a velocity of 600 rpm. Then the reinforcement powders are delivered to semi liquid aluminium alloy within side the furnace. Argon gas is exceeded in to the molten steel to take away the soluble gases gift within side the liquid nation steel. Stirring of molten steel is carried for 3 mins duration.

The aluminium composite material reaches absolutely liquid state on the temperature of approximately 750°C and the absolutely melted aluminium hybrid composite is poured in to the everlasting steel die and subjected to solidification to supply the specified specimen. Figure 2 Reinforcement preheater. The samples casted are shown in figure 3. Thus, all samples have been casted as per experimental plan.

Fig -2: Pre-heater

Fig -3: Casted Samples

3.1 Specimen Preparation for Microstructural analysis

Proper sample preparation is essential for the investigation of the microstructures of metal alloys. The sample is first synthesized with the desired method, most commonly casting or additive manufacturing. Mounting in resin is often the next step to facilitate the easy handling of the sample.

To eliminate major surface imperfections, the sample is then roughly ground by hand or by machine using grinding papers. The final step in preparation is automated polishing, where the surface is given a mirror-like finish and micron scale scratches are removed.

The dispersion of reinforcement particles in the matrix alloy is analyzed by means of inverted microscope. An inverted microscope is a kind of microscope with its light source and condenser on the top, above the stage pointing down, while the objectives and turret are below the stage pointing up. The stage of an inverted microscope is usually fixed, and focus is adjusted by moving the objective lens along a vertical axis to bring it closer to or further from the specimen.

Samples were prepared creating flat surfaces by facing, well-polished with the help of fine grade emery paper and then etched with etching solution Kellogg reagent for 30 seconds and tested as per test reference.

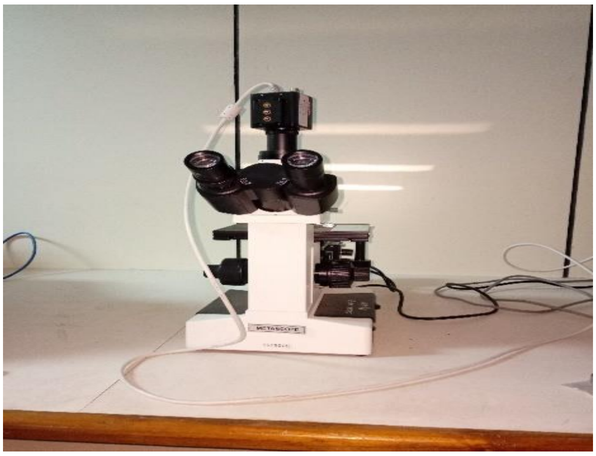


Fig -4: Casted Samples

3.2 Specimen preparation for Rockwell Hardness Test

A standard load (Based on variety of material) is applied through a regular indenter (cone or ball indenter) for a standard duration of time. Rockwell hardness testing could be a general technique for measurement the majority hardness of bimetal and compound materials. Though hardness testing doesn't provides a direct measurement of any performance properties, hardness of a fabric correlates directly with its strength, wear resistance.

Alternative Hardness testing is wide used for material analysis as a result of its simplicity and low value relative to direct measurement of the many properties. Specifically, conversion charts from Rockwell hardness to durability are offered for a few structural alloys, as well as steel and aluminium.

The indenter is either a conical diamond or a tough steel ball. Completely different indenter ball diameters from 1/16 to 1/2 in. are used counting on the test scale. Figure 5 shows the samples ready for hardness test.

3.3 Specimen preparation for Tensile Test

Tensile testing, also called tension testing may be a elementary soft materials science test within which a sample is subjected to a tension till failure.

The results from the test are unremarkably wont to choose a material for an application, for quality control, and to expect however a cloth can react beneathneath traditional forces. Properties which might be directly measured through a tensile take a glance at are final tensile strength, most elongation and discount in area.

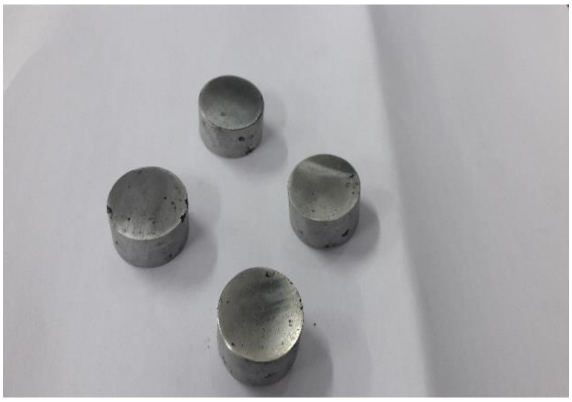


Fig -5: Hardness Test Samples

The nomenclature of the tensile specimen as Shown in figure 6, this specimen is a standardized sample cross-section. The two-shoulder sand gage (section) in between.

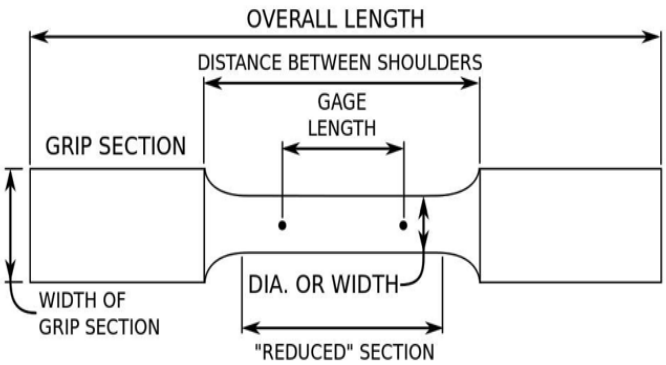


Fig -6: Test Specimen Nomenclature

The required dimensions to prepare tensile specimen as shown in figure7, this specimen is machined according to the ASTM - E8 standard. The shoulders are large so they can bereadily gripped, whereas the gauge section has a smaller cross-sections that the deformation and failure can occur in this are

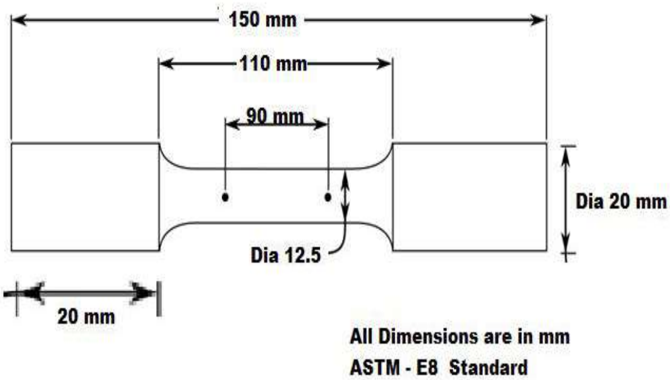


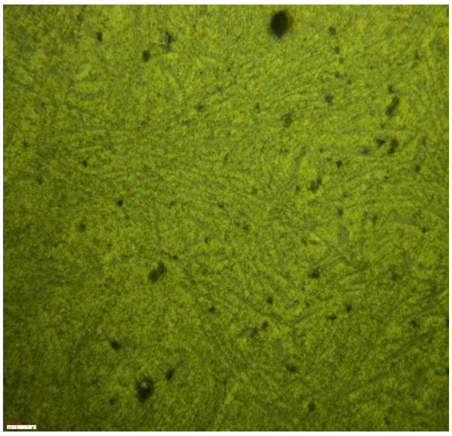
Fig -7: Dimensions of Test Specimen

Fig -8: Machining of Specimens as per ASTM Standard

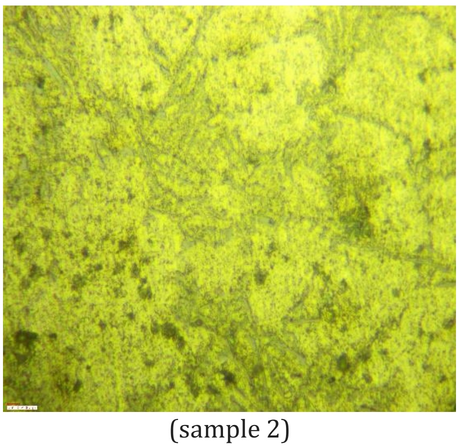
4. RESULTS AND DISCUSSION

4.1 Microstructure

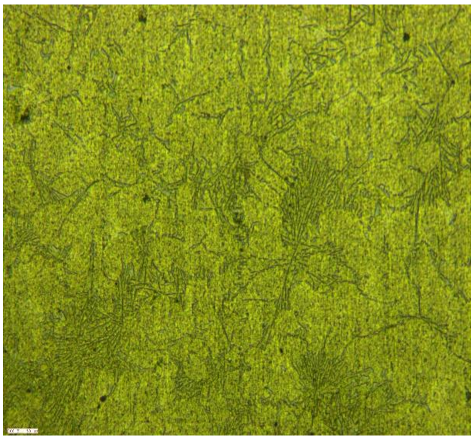
Figure 9 shows the micrograph of the samples. The micrograph clearly reveals the absence of dendrite morphology in all the composites under investigation.



(sample 1)



(sample 2)



(sample 3)

Fig -9: Microstructure of Test Specimens

The dendritic shape may be changed in the course of casting that's encouraged with the aid of using many elements which include dendritic fragmentation, restrict of dendritic growth with the aid of using the debris, and thermal conductivity mismatch among the debris and melt.

Dendritic fragmentation may be attributed to the shearing of preliminary dendritic fingers with the aid of using the stirring action. It became additionally determined that the perturbation within side the solute subject because of the presence of debris can extrade the dendrite tip radius and the dendrite tip temperature. These outcomes deliver upward thrust to a dendrite to molecular transition because the density of particle is increased. Also, the period of the dendrite is decreased within side the presence of the debris.

Ceramic debris additionally act as a barrier for dendritic boom and this phenomenon is greater suggested if the cooling charge is high. In these images suggested that the particle may be assumed to behave as a barrier to the dendritic boom.

Overall evaluation of shape suggests that the strengthened debris are uniformly allotted within side the alloy matrix. The proper bonding among debris and alloy matrix is likewise discovered within side the micro structural evaluation.

Moreover, porosity is at minimal stage and now no longer located within side the optical examination, although clustering is visible at a few locations within side the composite. The maximum outstanding characteristic located in all composite within side the absence of dendritic growth that's accounted for higher stir casting processing of composites.

4.2 Rockwell Hardness Test

Micro hardness check at diverse places changed into accomplished to understand the impact of reinforced particulates at the alloy matrix as given in Table 5. Rockwell hardness dimension has been accomplished at the embedded reinforcement debris in addition to within side the locality of debris and matrix.

Table -5: Rockwell Hardness Values

Sample No.	Trial 1	Trial 2	Trial 3	Average
1	59	59	59	59
2	66.5	66.5	65	66
3	60.5	55	60	58.5

Hardness test results indicate that the variation of hardness in the locations due to the uncertainty of reinforcement particles presence at the indentation location. The sample 2 with combination of 1% Silicon Carbide, 1% Aluminium oxide and 1% graphite with remaining Alumina LM 25 is having higher hardness.

4.3 Tensile Test

The Tensile test is carried out on the casting samples, the samples is loaded in the machine and tensile load is given to test the specimen's tensile strength. The unit of load measured is in N/mm2. Figure 10 shows the specimen is after breaking by applied the tensile load on the specimen, the tensile load of specimen breaking is noted in the table 6

Fig -10: Test Specimens after Tensile Test

Table -6: Tensile Test Results

SAMPLE NO	YIELD STRENGTH (N/mm^2)	ULTIMATE TESILE STRENGTH (N/mm^2)	% OF ELONGATION
1	45.77	56.92	1.24
2	156.35	156.35	2.72
3	121.53	121.53	2.80

Through the tensile test maximum tensile strength of sample2 has obtained highest tensile strength of 156.35N/mm^2, compared to other samples. Test result shows that by increasing the nano SiC then the tensile strength also gradually increased.

5. CONCLUSION

The hybrid composite samples of LM 25S as matrix, Al_2O_3, SiC and Graphite particulates as reinforcements were fabricated using stir casting process. The microstructure analysis shows fairly even distribution of particles and some agglomerations of Al_2O_3 and Graphite. Composite having 1% Al_2O_3 and 1% SiC and 1% Gr and 95% LM25 combination fabricated at melting temperature 750°C and reinforcement pre-heat temperature 300°C has higher hardness (66 HV) and tensile strength is high (156.35 N/mm^2) compared to other combinations. This hybrid composite can be explored for use in applications where higher hardness and tensile strength is required.

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