MICRO STRUCTURE AND MECHANICAL PROPERTIES INVESTIGATION OF A356 MATRIX COMPOSITES REINFORCED WITH AL2O3 TIB2 AND FLY ASH USING STIR CASTING

Praveen Bhai Patel[1], Ramendra Singh Niranjan[2], Abhishek Kumar Chandra[3] and Gaurav Verma[4]
1,3-Chemical Engineering Deptt, UIET, CSJM University, Kanpur
2-Mechanical Engineering Deptt, UIET, CSJM University Kanpur
4- Academy of Scientific and Innovative Research Ghaziabad
*-pbpatel@csjmu.ac.in

ABSTRACT

Aluminum Matrix Composites (AMCs), which are lightweight and robust, are used in many industries. Aeronautical, automotive, and other industries are included. Nanoparticles can reinforce and stiffen a wide range of advanced composites (AMCs). "This research project focuses on the fabrication of aluminium matrix composites reinforced with varying weight percentages of SiC particles and fly-ash using a modified electromagnetic stir casting technique . Electromagnetic stir casting created these composites. The material's ultimate tensile strength, hardness, and density were studied. Investigating the material's characteristics was the goal. Electromagnetic stir casting is the easiest and most effective way to make flaw-free aluminum matrix composites. This research study uses modified electromagnetic stir casting to make aluminum matrix composites enhanced with SiC particles and fly-ash. Electromagnetic stir casting created these composites. The melt received argon gas from the outside during electromagnetic stirring. This improved matrix SiC and fly ash dispersion. Fly ash improved mechanical characteristics and tensile and yield strengths. Aluminum composites also react differently to different reinforcing materials. A356/Al2O3 Nano composites with MoS2 have lower hardness and UTS than those without. MoS2, which is softer than A356/Al2O3, causes nanoparticles to agglomerate. This study examines how reinforced particles and process factors affect an aluminum-based metal matrix composite manufactured by stir casting.

Keywords- Fly-ash Electromagnetic stir casting Microstructure, Aluminium.

INTRODUCTION

AMCs that have had their mechanical and physical properties improved by the addition of alumina particles exhibit exceptional qualities in both of these areas. Their use has been more important over the course of the last several decades in a variety of high-demand industries, such as the military, the car industry, the electrical field, airplanes, the area of biomedicine, and sports. The production of AMCs may be accomplished by a variety of manufacturing procedures, including stir casting, compo-casting, ultrasonic aided casting, powder metallurgy, and liquid infiltration, to name a few. Powder metallurgy, powder casting, and liquid infiltration are some more approaches that can be considered. Stir casting is by far the most common method, and it also happens to be the technique that requires the fewest resources to produce something with it. These composites offer improved mechanical and physical properties, such as a lower density, a bigger tensile strength, strong resistance to tear and corrosion, high hardness, and high stiffness . Additionally, these composites have a reduced volumetric weight. In addition to this, the old materials that are replaced by these composites have a smaller carbon impact. During the manufacturing process, lubricating particles were employed in order to boost the tribological qualities of composites and to generate an appropriate lubricating layer. This was done in order to make the production process run more smoothly. Graphite and MoS2 were two of the lubricating particles that were present among these others. The never-ending search for a material that is not only lighter but also manages to keep or even improve its strength and stiffness has brought a lot of attention to advanced materials and composites (AMCs), which is an abbreviation that stands for advanced materials and composites. The purpose of this work was to make Nano composites of A356 with 0.5 percent Al2O3, A356 with 1 percent Al2O3, and A356 with 1.5 percent Al2O3 correspondingly using a stir-casting process. The mechanical properties of these Nano composites, as well as their microstructures, were subjected to a number of different types of analysis. In the succeeding phase, 0.5 percent nano MoS2 was added to the three different combinations that were mentioned previously, and the changes in mechanical properties that were caused by the addition of MoS2 were evaluated. This step was followed by an analysis of the alterations. These distinctions can be attributed to the incorporation of MoS2, which was discussed earlier on in this paragraph.

A metal matrix composite is a type of composite material that consists of a metal or alloy serving as the matrix, together with a metal or non-metallic reinforcement. This type of composite material goes by the name "metal matrix composite." For the purpose of this form of reinforcement, either metal or a material that is not metal might be utilized. A metal matrix nano composite is a material that is generated when nanoparticles are added to a metal matrix composite in order to make it stronger. This process produces a material that is significantly more durable than the original metal matrix composite. When it comes to creating nanocomposites, there are a wide variety of different kinds of reinforced materials that may be used. Alumina, illmenite, and sic are a few examples of the materials that fall under this category. Because of its high strength-to-weight ratio, outstanding wear resistance, and corrosion resistance, aluminum is a material that is frequently used for matrix applications. This is due to the fact that aluminum is a very versatile material. The parameters of the resulting composite are not entirely dissimilar to those of either the matrix or the reinforcement; nonetheless, they are not exactly the same. This takes place when a refractory particle with both a high modulus and a high strength is combined with a matrix that has a low ductility. Adjustments to the processing conditions, the distribution of the reinforcement, and the relative quantity of the reinforcement are all things that may be done to help improve these attributes. When they are generated in the manufacturing process, metal matrix composites that are made up of aluminum can, in a broad sense, be separated into two main types. The term "liquid state process" refers to a range of industrial methods that includes "stir casting," "compo casting," "ultrasonic aided casting," and "squeeze casting." This kind of operation is the initial type of casting process that may be done. The second category is known as the solid state process, and it is comprised of the methods of powder blending followed by consolidation (also known as PM processing), the vapour deposition technique, the friction stir process, and the diffusion bonding method.

Stir casting

Stir casting mechanically disperses particle reinforcement in molten aluminum. S. Ray initially integrated alumina particles into molten aluminum in 1968. He mixed ceramic particles with molten aluminum alloys. Dehong Lu (2007). [1] Important machinery starts. This process yields acceptable composites with volume fractions up to 30%. Sudarshan Surappa et al.(2008);[2]. Particle settling upon solidification in stir casting can separate reinforcing particles. Particle dispersion in the final solid depends on mixing intensity, melt density, particle wetting, and melt solidification rate. The mechanical stirrer's form, location, melt temperature, and particle properties determine particle dispersion in the molten matrix.

Modern stir casting uses the two-step mixing method, or double stir casting. First, the matrix material is heated above liquid. After cooling, the molten substance becomes a solid-liquid mixture. Hot reinforcing particles combine with the slurry. This makes the slurry liquid again and mixed. Double stirring, a casting method, creates a more homogeneous microstructure than standard stirring. This two-step mixing method works by breaking the gas barrier surrounding the particle surface. This gas barrier keeps particles from moistening molten metal. Mixing particles when semi-solid helps break the gas layer because the high melt viscosity abrasively fractures it. It's semi-solid particles. Molten-state viscosity causes this. Selvam J (2013) [3] devised a three-stage stir casting process for nanoparticle reinforced composites. Before mixing, ball mills shatter reinforcement and Al particles to break nano particle clumping. Distributes nanoparticles. Mechanically swirl the composite powder into the molten material. Mix all powder. Ultrasonic probes or transducers sonicate the composite slurry to equally distribute reinforced particles after mixing. K. Kalaiselvan, et al. (2011) electromagnetically stirred molten aluminum.[4] This increased particle matrix interface bonding and created a fine grain structure.

Implications of reinforced particles on aluminium metal matrix

The physicochemical and mechanical properties of aluminum matrix composites (AMCs) that are strengthened by micron-to-nanometer-sized particles of aluminum oxide The researchers investigated the ways in which different processing parameters affected the microstructure and mechanical characteristics of AMC. These processing factors comprised particle heat treatment, the speed at which the mixture was stirred, the size of the reinforcement particles, and the percentage of the weight of the reinforcement particles. We came to the conclusion that the ideal Al2O3 reinforcement particle sizes were 20 microns and 50 nanometers. The Al2O3 particles are heated for twenty minutes at a temperature of 11000 degrees Celsius in an atmosphere devoid of oxygen. During this stage of the process, inert argon gas is introduced, and molten aluminum is spun at speeds of 200, 300, and 450 revolutions per minute (RPM). In the composite samples, an increase in the Al2O3 particle weight led to an increase in both hardness and porosity. Additionally, Al2O3 was able to reduce particle size while simultaneously increasing compressive strength. When it comes to compressive strength, nano composites perform far better than micro composites.

A356 was utilized in the production of nanometric alumina particle composites. At a ball-to-powder ratio of 21:1, the nano alumina particles were individually subjected to planetary ball milling for a full twenty-four hours.[5,6] After being ground, the particles were individually wrapped in aluminum foil before being added to the molten metal. After that, the liquid was stirred at a temperature of 8500 degrees Celsius for 4, 8, 12, and 16 minutes at 450 rotations per minute. A slurry of composite material was poured into a mold made of cast iron. The following procedures were used for the heat treatment of the cast specimens: After 8 hours at 4950 degrees Celsius, 2 hours at 5200 degrees Celsius, water quenching at 400 degrees Celsius, and 8 hours of artificial aging at 1800 degrees Celsius, the product was prepared for human consumption after those respective times. The addition of nano-alumina particles resulted in an improvement in tensile strength as well as hardness. The optimal density was achieved after agitation for a period of four minutes. The tensile performance of the composite material suffers as the stirring duration is increased.

OBJECTIVES

1. A Study on the Microscopic Structure and the Investigation of the Mechanical Properties of A356 Matrix Composites with Reinforced.
2. An investigation into the effects that reinforced particles have on the aluminium metal matrix.

RESEARCH METHODOLOGY

Matrix alloy

Because of its remarkable mechanical strength, ductility, hardness, fatigue strength, pressure tightness, fluidity, and machinability the A356 alloy was chosen to serve as the matrix alloy in this investigation. This decision was made in light of the aforementioned characteristics. In addition to that, it was decided that it would serve as the focus of this inquiry. The make-up of A356 in terms of the compounds it consists of and the properties it possesses as a whole.

Fly-ash

Fly-ash is a byproduct of combustion. "Fly" refers to flue gases' small particles and their composition. "Bottom ash" is ash that doesn't climb to the top. The term "fly-ash" is most often used in manufacturing to refer to coal ash. Table 1 lists fly ash compounds.[7]

This paper investigates the microstructure and mechanical characteristics of a hybrid composite material comprised of A356/(SiC and Fly-ash) that failed to be fabricated. The electromagnetic stir casting technique, SiC particle may be attacked by liquid A356 alloy, which results in SiC deterioration while making this hybrid composite. The reaction that follows will explain this decline.

$$3SiC + 4Al = Al_4C_3 + 3Si \quad (1)$$

Table1 Constituent of Fly-ash[8]

Component (%)	Bituminous	Sub-bituminous	Lignite
SiO_2	20–60	40–60	15–45
Al_2O_3	5–35	20–30	20–25
Fe_2O_3	10–40	4–10	4–15
CaO	1–12	5–30	15–40
LOI	0–15	0–30	0–5

Table 2 Composition of hybrid metal matrix composites[9,10]

S. no	Sample nos.	Composition of reinforcements	Silicon carbide (SiC) % wt	Fly-ash (% wt)
1	Sample 1	A356?20 % SiC?0 % Fly-ash	20	0
2	Sample 2	A356?15 % SiC?5 % Fly-ash	15	5
3	Sample 3	A356?10 % SiC?10 % Fly-ash	10	10
4	Sample 4	A356?5 % SiC?15 % Fly-ash	5	15
5	Sample 5	A356?0 % SiC?20 % Fly-ash	0	20

Two of the most recent methods that have been developed to guard against the assault of SiC are the intentional oxidation of SiC particles and the inclusion of SiO2 particles into SiCp per-forms. Both of these methods are described in more detail below. There is data from real-world applications that demonstrates both of these strategies are beneficial to utilize. According to the findings of a number of studies, the addition of a particular quantity of silicon into an aluminum matrix limits the dissolution of SiC, which in turn prevents the development of the unwanted aluminum carbide. This was shown to be the case when the amount of silicon added was specified. This is due to the fact that silicon hinders the dissolution of silicon carbide (SiC), which in turn prevents the creation of aluminum carbide (Al4C3). It is important to keep in mind that the primary component of fly ash is silica dioxide, also known as SiO2, and that both of these compounds have the potential to serve as sources of silicon.[11] However, this will depend on the quantity of magnesium that is present in the aluminum alloy as well as the temperature at which the composites are treated. It is probable that processes in the composites that lead to the creation of MgO or MgAl2O4 will be preferred.

$$2Al + 2SiO_2 + Mg = MgAl_2O_4 + 2Si \qquad (2)$$

Composition selection

Based on pilot studies and literature reviews, SiC and Fly-ash reinforcements were selected. Table 5 lists these mixtures, while Table 4 lists pilot study findings. The two reinforcements can make up 0–20% of the matrix they are implanted in by weight. If a hybrid metal matrix composite's reinforcing weight percent exceeds 20%, its physical and chemical properties no longer change.

Fabrication of hybrid metal matrix composite

Figure 1 presents a schematic depiction of the EMS setup that was designed for the processing of hybrid metal matrix composites (A356/SiC/ Fly-ash) . This arrangement was built in order to facilitate the production of hybrid metal matrix composites. After being cleaned and placed within the graphite crucible, the A356 alloy was then heated in the muffle furnace to a temperature that was greater than the temperature at which it reached its liquidus point. For the purpose of obtaining the temperature reading, a chromel–alumel thermocouple was utilised, and the resultant reading was 700 degrees Celsius. The temperature was able to be precisely controlled thanks to the connection that was made between the relay that was coming "from the muffle furnace and the thermocouple. Second, the liquid aluminium alloy A356" was placed in a graphite crucible and the temperature was kept at a particular level while this process was carried out. With the help of glass wool, an exceedingly thorough packing job was performed on the crucible (between crucible and winding). An aluminum-based metal matrix is coupled with a variety of various combinations of reinforcement, some of which include silicon carbide and fly ash.

The density of the metal matrix is 2.486 grammes per cubic centimetre, and it is reinforced with silica carbide polymer and fly ash. The fly-ash has an average particle size of -25 lm and comprises both solid and hollow spheres. It is a byproduct of the combustion of fossil fuels. A preheating operation lasting one hour and taking place at 440 degrees Celsius is performed on the particles of silicon carbide and fly ash before they are combined with the melt (A356 alloy). Within each matrix, the percentage of silicon carbide and fly ash that makes up each matrix spans anywhere from 0 to 20 percent by weight. As a consequence of this, we were able to produce five different composites, which are detailed in Table 5. During the process in which the hybrid metal matrix composite (A356/SiC/Fly-ash) was being stirred, a thermocouple was positioned within the graphite crucible so that it could provide feedback on the temperature of the composite. Argon gas was used at various points throughout the process of incorporating SiC and Fly-ash into the molten state of A356. As can be seen in Figure 1, coolant was utilised in order to provide the windings of the motor with the appropriate level of cooling. In addition, a "vacuum pump was used to create a vacuum within the box in order to minimise casting problems such as porosity and blow holes. This was done in order to prevent the flaws from occurring".

A number of tests were carried out in order to ascertain the best possible settings for the various "input process parameters (stirring speed, stirring duration, stirring temperature, current, and voltage). In the course of the pilot run, a stirring speed of 180 revolutions per minute (rpm) was arbitrarily selected for the production of A356/SiC/Fly-ash, while the other parameters were left at the values they had been initially set at. It was determined that the distribution of the silicon carbide was not uniform, and the bulk of the silicon carbide particles were located near the bottom of the A356/SiC/Fly-ash hybrid metal matrix composite.[12,13] Even when the speed of the stirring was increased to 215 revolutions per minute, it was seen that the silicon carbide particles did not settle down, and the distribution was uniform throughout. When the speed of the stirrer was brought all the way up to 220 revolutions per minute, it was seen that the molten A356 alloy was going dangerously near to escaping the crucible". The findings of the investigation led to the determination that 215 revolutions per minute would be the optimal speed for stirring. When determining the values for the many other process parameters, the same same methodology was utilised throughout the process. The findings that were obtained from the preliminary testing that was done are presented in Table 3 .

Figure 2 shows the best-performing method samples. After solidification, the top and bottom portions of each sample were sliced off. The centre sections of composites were dissected and analyzed to choose all essential samples for further investigation.

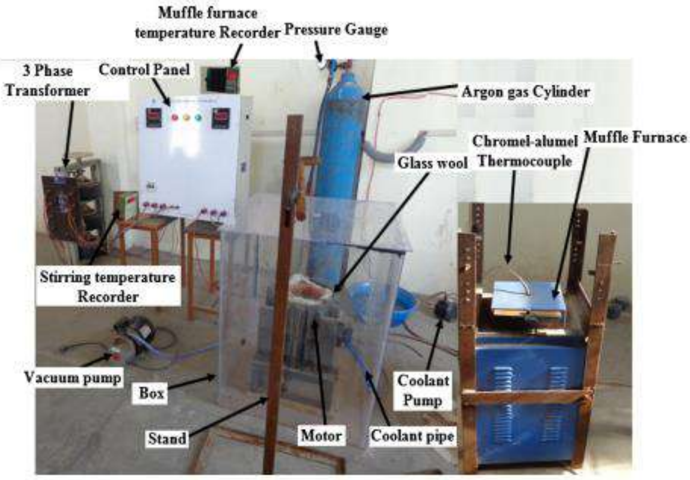

Fig. 1 The experimental setup for the electromagnetic stir casting method is shown in Figure 1.[14]

Table 3 Electromagnetic stir casting process parameters

S. no.	Parameters	Values set as
1	Voltage supply	180 V
2	Current	18 A
3	Stirring speed	215 rpm
4	Stirring time	3 min
5	Stirring temperature	700 °C
6	Percentage of SiC	0–20
7	Percentage of Fly-ash	0–20

Porosity and specific strength

Fly-ash cenospheres typically have a density that is lower than one gramme per cubic centimetre; however, this number can range anywhere from around 0.4 to 1.0 g/cm3 depending on the diameter and wall thickness of the cenosphere". The principal components of fly-ash are typically SiO2 (with a density equal to 2.18 g/cm3), Al2O3 (with a density equal to 3.96 g/cm3), and Fe2O3 (with a density equal to 4.88 g/cm3). A density of one gramme per cubic centimetre is attributed to fly ash as a standard measure of density. In order to arrive at the experimental densities of the hybrid composites, the Archimedes principle was utilised. In order to arrive at an approximation of the "theoretical densities of hybrid composites, a rule of mixing was utilized . This rule is as follows:

$$\rho_{A356/SiC/Fly-ash} = Vol._{A356} \times \rho_{A356} + Vol._{SiC} \times \rho_{SiC} + Vol._{Fly-ash} \times \rho_{Fly-ash}. \quad (3)$$

When examining the porosity of various materials, it is feasible to calculate the density of such materials. The degree of porosity in a material, in addition to the features of the pores themselves, such as their size, connectivity, and distribution, amongst other variables, has a significant impact on the quality of the material. Additionally, the degree of porosity in a material is directly proportional to the amount of air that can pass through it. If a material has a low porosity, the quantity of voids that may be discovered in composite material will be reduced to a minimum. Even if the substance in question has the same chemical composition as the one in issue, this will still be the case. In consequence of this, the thermal conductivity will increase despite the fact that the strength will increase, the water absorption will decrease, the permeability will increase, and the frost resistance will increase. Moreover, the thermal conductivity will increase.[15,16 The ratio of the total volume of a material to the volume of its pores, stated as a percentage of the total volume of the material, is referred to as the porosity of the material, and it is denoted by the letter P. The higher the porosity, the more open and airy the material is. The following is what makes it into what it is:

$$P = \left(1 - \frac{\rho_{\text{Experimental}}}{\rho_{\text{Theoratical}}}\right) \times 100\,\%. \qquad (4)$$

RESULTS AND DISCUSSION

Tensile strength

Ten samples of the A356/SiC/Fly-ash hybrid metal matrix composites material were prepared in accordance with the specification that is depicted in Figures 2 and 3, so that tensile testing could be performed on the material. These samples were divided into two groups: the first group had their casts preserved, while the second group underwent heat treatment. For the purpose of the test, the samples were allowed to remain at room temperature while the tensile strength of the samples was measured.[17] The length of the gauge is 36 millimeters, and the diameters of the produced sample measure 6 millimeters each. Table 4, which can be seen at this location, provides an overview of all of the movable and adjusting options that are offered by the computerized universal testing equipment for your perusal and consideration.

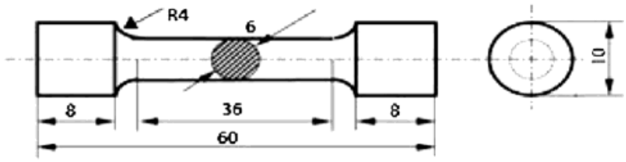

Fig. 2 The dimensions of the specimen for the tensile test

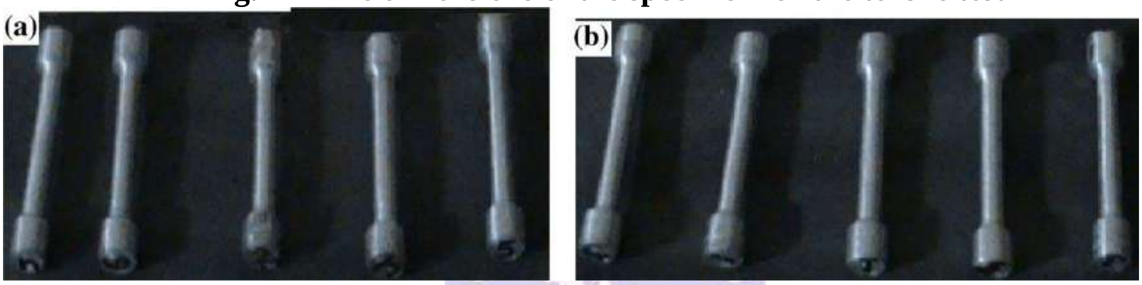

Fig. 3 Test specimens for tensile strength, shown an as cast and b as heat treated[18]

Table 4 Parameters of computerized universal testing machine

S. no.	Parameters	Values set as
1	Gauge length	25–50 mm
2	Maximum extension	5 mm
3	Maximum load	10 T
4	Specimen diameter	0.5–30 mm
5	Strain rate	10^{-4}–10^{-1}/s

In this experiment, the tensile strength of heat-treated samples is shown to be highest (364.55 MPa) when fly-ash particles are introduced to A356/15 percent SiC composites up to a volume fraction of 5 percent. This results in the highest possible shear modulus. In addition, the tensile strength of SiC continues to drop when the volume percentage of fly ash in the material is raised, with the value reaching a minimum when the volume fraction is twenty percent. In addition to that, the heat treatment method was carried out so that the thermal effects that it had on the specimen could be studied.[19] Figure 4 depicts the variation in tensile strength of "samples of hybrid composites (A356/SiC/ Fly-ash") taken from all over the world and then heat-treated. These swatches came from a variety of locations throughout the globe.

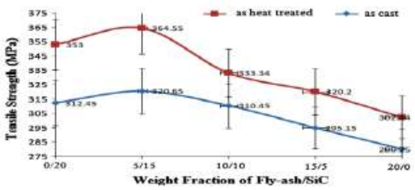

Fig. 4 Strength in tensile direction varies according on the weight percent of reinforcements

During tensile testing for as-cast and as heat-treated globally composites, the addition of reinforcements (SiC/Fly-ash) gives a significant boost in the work hardening of the material . This is the case regardless of whether or not the material has been heat treated. This holds true for both kinds of globally composite materials. There is a bigger increase in the amount of work hardening that takes place if there is a larger volume percentage of SiC present. On the other hand, it is reduced when there is a greater volume percentage of "fly ash present (more than 5 percent in A356/SiC). There is a suggestion that this is due to the clustering of fly-ash particles, which causes composites to become brittle". This phenomenon is known as the "fly-ash effect." The tensile test for the composite A356 with 15% SiC and 5% fly ash indicates improved results for both the as-cast and heated-treated versions of the composite. The improvement may be attributed to the increased strength of the composite. The data presented in Table 5 indicates that the tensile strength of a heat-treated A356/15 percent SiC/5 percent Fly-ash hybrid metal matrix composite is 12.04 percent higher than the tensile strength of an as-cast hybrid composite .[20]

Table 5 Tensile strength of different compositions

Composition of reinforcement	Tensile strength, as cast (MPa)	Tensile strength, as heat treated (MPa)	Improved tensile strength (%)
Sample 1	312.45	353	11.48
Sample 2	320.65	364.55	12.04
Sample 3	310.45	333.34	6.86
Sample 4	295.15	320.20	7.82
Sample 5	280.25	302.44	7.33

Charpy-V impact strength

In the Charpy-V impact test, the specimens were created with dimensions of 10 millimeters by 10 millimeters by 55 millimeters, as can be seen in Figure 8. This was done so that we would be better prepared for the test. These are the numbers that were determined to be the Charpy-V impact strengths of a variety of hybrid composite compositions through the use of measurement instruments. According to the findings, the "Charpy-V impact strength of hybrid composites (A356/SiC/Fly-ash) decreases when the concentration of Fly-ash is increased to more than 5 percent and when the percentage of SiC" is dropped. This was shown to be the case when the concentration of Fly-ash was increased to more than 5 percent. This is the situation regardless of whether the concentration of fly ash is raised or lowered. This holds true not just for heat-treated global composites but also for those that have been as-cast globally composites. More proof that voids are present is provided by the incorporation of fly ash; additional examination into these voids indicates that the rate of stress propagation is greater with fly ash than it is with SiC. The Charpy-V impact strength of hybrid metal matrix composites (A356/SiC/Fly-ash) first rises up to 5 percent by weight of Fly-ash in A356/SiC, but it continues to fall when the concentration of Fly-ash is increased even higher than that first increase in the concentration of Fly-ash. The fact that the Charpy-V impact strength has reduced indicates that fly-ash particles have agglomerated, which has led to an increase in void. This is evidenced by the fact that the void content has increased. The progression of stress may be traced back to an increase in the amount of emptiness that exists. The behavior f as-cast and as heat-treated worldwide hybrid metal matrix composites in relation to Charpy-V impact strength is seen in Figure 5. Figure 5 was constructed with the use of globally hybrid metal matrix composites. As a result of being heated, the Charpy-V impact strength of the A356/15 percent SiC/5 percent Fly-ash sample increased by 16.81 percent when compared to its initial condition as cast. This was determined by comparing the sample to its initial state .

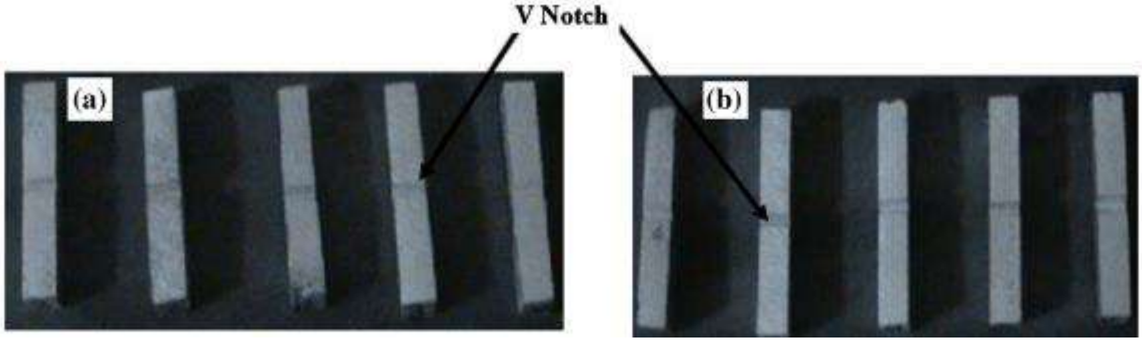

Fig. 5 Charpy-V impact test specimens a as cast, b as heat treated

Specific strength and porosity analysis

Table 14 presents the results of an experiment that determined the density of a mixture consisting of 15 percent by weight SiC and 5 percent by weight fly ash in an A356 matrix to be 2.65 grammes per cubic centimetre. This composition has a density that is comparable to that of matrix alloy A356, which is 2.685 grammes per cubic centimetre. According to what was said before, the composition A356/15% SiC/5% Fly-ash possesses outstanding mechanical characteristics.[21] The percentage of porosity for each of the different compositions is shown in both Table 6 and Figure 12, respectively. It is conceivable, based on the porosity measurement, to get to the conclusion that the porosity content will increase linearly when there is more than 5 percent weight of fly-ash. This is a valid conclusion to reach. The collapse of the specimen was eventually caused by a larger percentage of porosity, which led to the creation of an inhomogeneous cast MMC that was made of particle clusters. This contributed to the failure of the specimen. As shown in Table 6, it is also feasible to compute the specific strength of different compositions by dividing the ultimate tensile strength by the experimental density of the composite. This may be done in order to determine the composition's specific strength.

Table 6 The ultimate tensile strength by the experimental density of composite

Hybrid metal matrix composite	Theoretical density (g/cm3)	Experimental density (g/cm3)	Porosity (%)	Specific strength (tensile strength as cast/ experimental density) (kN-m/kg)
Sample 1	2.788	2.70	3.15	115.72
Sample 2	2.678	2.65	1.04	121
Sample 3	2.568	2.48	3.42	125.18
Sample 4	2.458	2.35	4.39	125.59
Sample 5	2.348	2.21	5.87	126.80

"Thermal expansion of the composites"

Thermal expansion occurs when a substance's volume changes with a change in temperature. After heating, particles travel more and retain a bigger average distance. Only a limited temperature range has this effect. Only in that temperature range do substances shrink when the temperature rises. The composite was heated in a 450°C electric furnace to measure thermal expansion. Table 7 lists thermal expansion values for each sample. Table 7 quantifies the dimension change caused by different compositions.[22,23] A356/0% SiC/20% Fly-ash had the least dimension change of any composition. The automobile and aerospace sectors cannot use the material due to its weak mechanical qualities. A356 with 15% SiC and 5% fly ash hybrid metal matrix composite has superior mechanical properties. Sample A356 hybrid metal matrix composite, made of 15% SiC and 5% fly ash, has a small size shift compared to samples 1, 3, and 4. Hence A356 with 15% SiC and 5% fly ash makes a versatile hybrid metal matrix composite .

Table 7 "Change in dimensions of samples due to heating up to450 °C"

Hybrid metal matrix complex	Before thermal expansion		After thermal expansion	
	Length(mm)	Width(mm)	Length (mm)	Width(mm)
Sample 1	30	25	27	26
Sample 2	30	25	29	24.5
Sample 3	30	25	29.5	26
Sample 4	30	25	29.6	26.3
Sample 5	30	25	29.7	25.8

CONCLUSIONS

According to the findings of this research, nanocomposite materials made up of aluminium 356, reinforced with nano alumina and hybrid The time-honored stir casting process was effectively utilised in the manufacturing of nanocomposites constituted of aluminium 356, which were reinforced with nanoscale MoS2 and nanoscale alumina particles. These nanocomposites were then successfully utilised in the production of nanocomposites. Nanocomposites viz., A356 + 0.5 percent alumina, A356 + 1 percent alumina and A356 + 1.5 percent alumina and hybrid Nano composites viz., A356 + 0.5 percent MoS2+ 0.5 percent alumina, A356 + 0.5 percent MoS2+ 1 percent alumina and A356 + 0.5 percent MoS2+ 1.5 percent alumina were created. The mechanical and physical features of hybrid nanocomposite materials are investigated and analysed, and they are compared to those of single reinforced composites.

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