Fabrication and Properties of Aluminium Matrix Hybrid Nanocomposites by Stir Casting Technique

Rakesh Kumar Yadav, Zahir Hasan, Akhtar Husain Ansari

Abstract*: Regular materials like steel, brass, aluminum and so on will fall flat with no sign. Breaks commencement, spread will happens with in a limited ability to focus. Presently multi day to beat this issue, regular materials are supplanted by Aluminum Composite materials. The best alternative for aluminum composite materials is its unique ability to design the materials to provide necessary features. In this paper, classical simple techniques for manufacturing AMMCs with achievable characteristics are explored by dispersing silicon carbide micro and nano particles in the matrix. The matrix and the reinforcement material were chosen for aluminium (A356) and silicon carbide (micro and nano particles). Experiments carried out were a SiCmicro weight fraction for 10%, and a SiCmicro weight fraction varying for 1%, 2%, 3% and 4%. The result showed that the stir casting method was very successful in achieving uniform strengthening dispersion in the matrix. This was obvious by the improvement of properties of composites over the base metal. The increase in hardness, marginals decrease in electrical conductivity and marginal changes in relative density were shown to be aluminum hybrid nanocomposites

***Keywords* : Aluminium Hybrid Composite, Related Density, Electrical Properties, SEM**

I. INTRODUCTION

Metal matrix (MMC) is a variety of high-quality materials that are metal and hard particle combinations, usually ceramic. A broad variety of apps is possible using this product. The MMC has better functions than the base metal. These include enhanced thermal conductivity, resistance to abrasion, tribology, resistance to creep, dimensional stability and extremely high rigidity. Aluminium matrix composites are, as all composites, not a single material but a family of materials that can be adjusted for their rigidity, strength, density and thermal and electrical properties [1].

Aluminum Metal Matrix Composites (AMCs) are regarded as one of the most promising lightweight products with improved mechanical characteristics used in multiple sectors for their lightweight, financially savvy and high rigidity [2]. It tends to be utilized as a substitute in automotive and aviation applications by fortifying with Al2O3 and SiC which will diminish the weight and subsequently increment the motor productivity, decreasing the fuel utilization [3]. Supplanting cast iron motor parts with lightweight aluminum combinations requires defeating of the poor bond and seizure obstruction of Al. This can be accomplished by scattering Al2O3, SiC or graphite particles in Al. Extensive decrease of wear and erosion attributes can be accomplished by the utilizing these particulates. Additionally, chamber weights can be expanded on the grounds that AMCs can withstand high warm and mechanical loads and lessen the loss of warmth by allowing nearer fit that can be accomplished as a result of the lower warm development coefficient of AMCs [4].

Metal Matrix Composites can be delivered by various strategies, for example, fluid penetration, blend throwing, shower statement and powder metallurgy system. Among these procedures, Stir Casting is the best strategy for assembling MMCs with high volume of fortification and uniform appropriation. MMC's which are prepared by some customary systems brings about certain deformities like non uniform dissemination of fortification, porosity, and sporadic grain shapes and so on. Additionally the time required for these procedures is extremely high [5].

The above techniques have its very own points of interest and burdens. Indeed, even through powder metallurgy is more confounded than casting procedures, it yields a superior interface between the fortification and grid combination and improves mechanical properties of the composite. Broad works have been completed to assess different ceramic particles as the support materials for AMMCs [6].

The composite's ductility is, however, deteriorated by aluminum re-enhanced by single ceramic parts because they have a tendency to crack when the matrix is high at loading conditions. Additionally, incorporating nanoparticles improve mechanical characteristics of composites by hindering the motion of dislocation and encouraging the structure of fine grain [7]. Thus, general improvement of composite efficiency can be accomplished by decreasing micro-particle concentrations and increasing the volume of nanoparticles to improve synergistically mechanical and tribological characteristics [8].

Directly, SiC, B4C, Al2O3 and TiC are broadly utilized as a support in aluminum network

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composite due to its upgraded mechanical and tribological properties. Among different accessible strengthening particles, SiC particles are favored on the grounds that its thickness is near aluminum grid.

[9] Furthermore, SiC have higher strength and inflexibility both at room and raised temperature alongside high hardness and expanded wear obstruction. The mechanical and wear conduct of aluminum grid strengthened with two fired (SiC+TiB2, SiC+Al2O3 and so forth.) particles were contemplated in writing [10]. The present study therefore aimed at producing a Stir casting technique for the dispersion of micro and nano-silicon carbide Enhanced aluminum hybrid nano composites. Sample mapping was carried out in SEM, and elemental, In order to investigate the Electrical Conductivity and Relative Density.

II. EXPERIMENTAL PROCEDURE

A. Material Preparation

Micro SiC powder, Nano SiC powder and aluminum powderwere bought from Otto chemie Pvt Ltd. Mumbai and Purshottam Brothers Kanpur bought A356 ingots.

Table- 1: Required Parameters for Preparation of Material

Process	Input Parameters			Reinforcement		Matrix	Specimen No.
Milling	Al fine powder and SiC_{nm}			$SiC_{\mu m}$ (wt%)	SiC_{nm} (wt%)		
	Mixing	Duration	Ten Hours	-	-	Aluminium Alloys (A356) Ingots	1
		Rotation	110 rpm	10	-		2
	Ball to powder ratio		10:1		1		3
Stir Casting	Stirring	Speed	400-500 rpm		2		4
		Time	15 minutes		3		5
	Pouring Temperature		700^0C		4		6

B. Preparation of Palettes for AMMC

Take equal mass of nano powder & fine aluminium powder (25µm particle size) mixed the two material regoursily So that they form homogeneous bonding. Aluminium is taken because of its ductility and SiC is brittle. Any other ductile material like copper could have been used, but in our case we have used aluminium alloy (A356) as the base materials.
For preparation of palette of 10 grams each use of 25 mm die is required. Mixed powder above is poured into the die cavity and a load of one tone is applied by the punch on the material. Palette preparation is necessary to prevent nano powder from flying away during direct mixing. Figure.1 shows palette and punch & die.

Fig. 1(a) Palette and systematic arrangement of making palette

C. Preparation of hybrid composites by stir casting

A356 ingots form is heated in electrical furnace to the temperature of 800^0C to 850^0C. This causes the metal to melt in molten metal the flux (coverol) weighing 20-25gram is added. This is done in order to reduce the impurities and also as a blanket in order to minimize the heat loss from the molten metal. Next in order to oxidation of aluminium and inert atmosphere of organ gas is maintain for 5 to 10 minutes. Thereafter slag is removed from the crucible and there why clean metal is obtained. After cleaning, to prevent oxidation of the aluminium metal matrix composites thus prepared the palettes are wrapped in alluminium file, held with tongs & inserted in direct molten metal thus creating the oxygen free surroundings. Now furnace temperature is reduced to around 725oC to 750oC. Stiring is done through the stirrer at speed of 400 to500 rpm, While stirring is done reinforcement of SiC microparticle is being added by means of spoon according the weight required. This process is continuing for 10 minutes approximately. Churning is continuously done so as to avoid lamp formation. Visible inspection is done through the glass magnifier to check the uniformity of the composite material. If it is not ok, Stirring process is repeated several time till the homogeneous mixture is maintain. Once the homogeneous mixture is made the stirrer is taken out & the liquid composite heated again for 15 minutes at temperature of 800^0C to 850^0C which served as suitable pouring temperature.

Side by side graphite coated mould is prepared for receiving the molten aluminium metal matrix composite. Mould is first preheated to temperature of 250^0C to 300^0C. Graphite coating is done for easy removal of solidify coating as well as does not react with mould.

This is essentially a gravity casting process where in gravitational force is used for mixing & pouring material solidifies in approximately 10-15 minutes. Now solidify casting is fit for use that is as primarily samples for test which becomes usable after machining. Figures 2(a) shows steps for preparation of hybrid composite and figures 2(b) shows final product of hybrid composite.

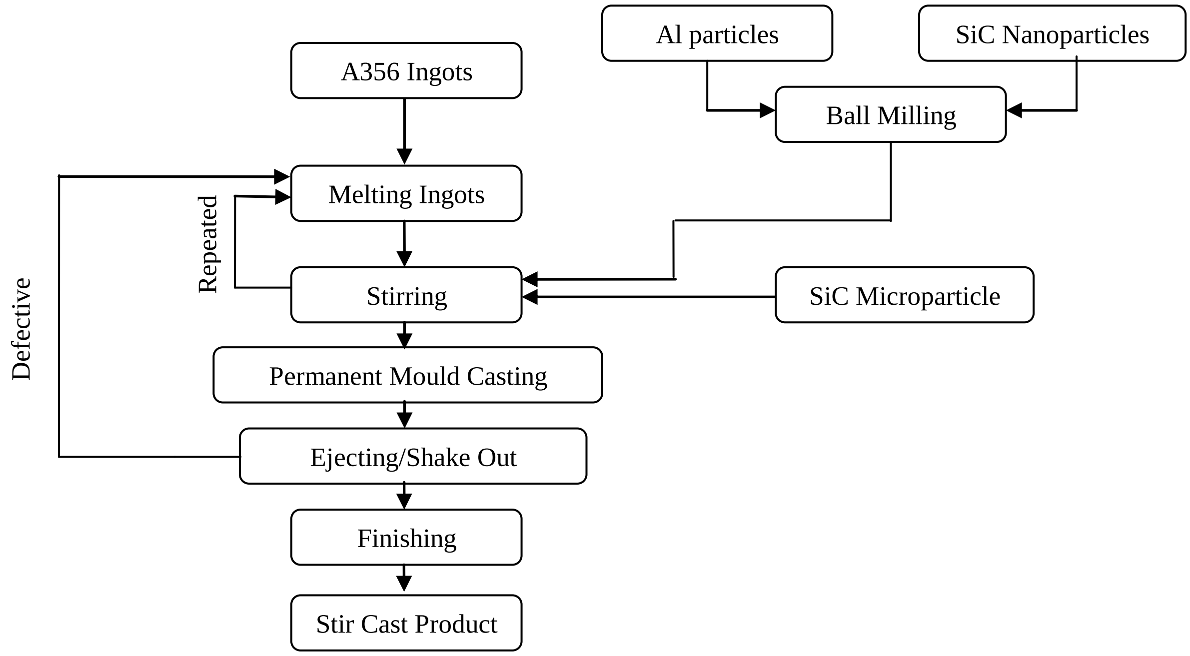


Fig. 2(a) Steps for preparation of hybrid composite

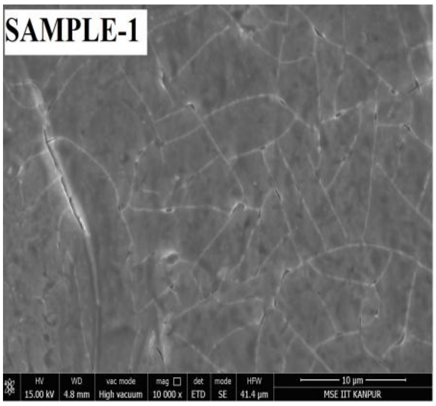

Fig. 2(b) Final product of hybrid composite after solidification

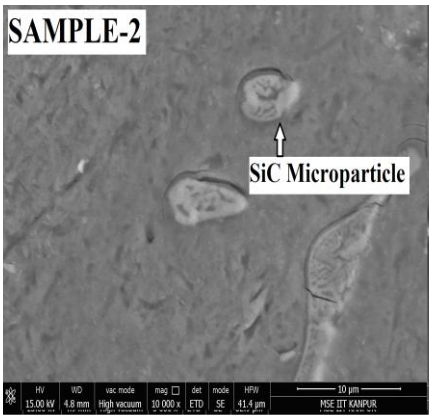
III. RESULTS AND DISCUSSION

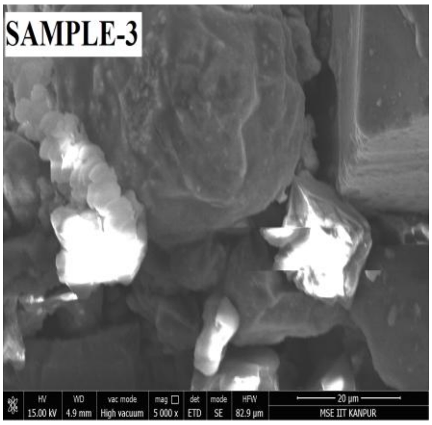
A. FE-SEM

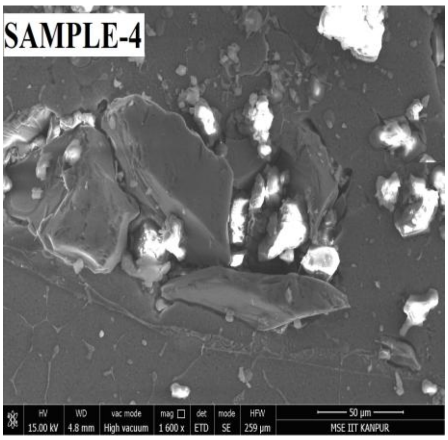
Stir Casting samples thus prepared were examined by FE-SEM under different magnification viz 350X to 10000X. Result was in case of sample 3 figure 3(a) lump formation was observed for nano & micro particles. But the size was not larger than hundred nanometer. This lump formation is evident in all nano composites when the stir casting method was used. It was also observed when the amount of Reinforcement SiC nano composite was increased from 1 to 4%. A good amount of distribution was seen. And lowest amount of SiC is observed in sample No. 1 and 2, not of pores (voids) were observed under FE-SEM images.

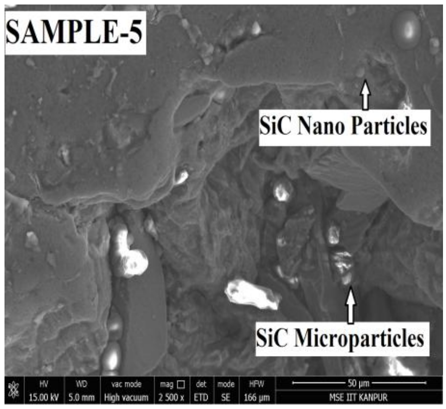
In FE-SEM images voids were observed in different sizes. Average microporosity size in nano composites prepared by stir casting method was smaller than the sample 1 & sample 2. The smallest voids were observed in sample 5 & 6











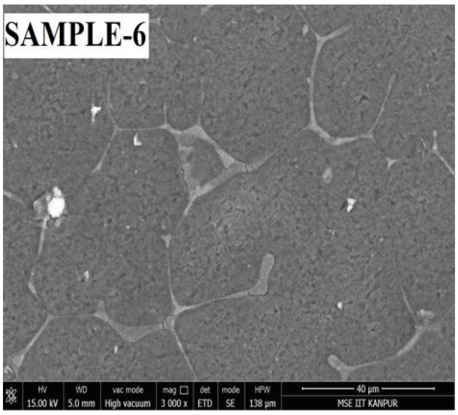


Fig. 3(a). Various samples of FE-SEM pictures

Related Density

The term related density may be used to indicate ratio of practical density (measured density) to theoretical density (Mathematically calculated density).

$$\text{Related Density} = \frac{\text{Experimental density}}{\text{Theoretical density}}$$

Practical density is obtained by displacing equal volume of water the method used by Archimedes. Mathematical density calculated by the weighted average method. Result of the graph indicates that as there is a inverse relation of silicon carbide percentage weight with respect to related density. As SiC percentage increases above 10% weight the related density is reduce. Main cause of this reduction is related density is that SiC particles are hard and do not undergo any deformation during application of pressure for making it dense. Therefore voids between the particles are not eliminated completely. From the figure it is observed that addition of 1% SiC nano particles is having more related density then Al-10%SiC. The possible reason for this is the nano particle of SiC occupy the micro SiC voids & hence become more dense. This trend is also observed the case of addition of 2%, 3% and 4% SiC nano particles. Figure 3 (b) shows the related density of various specimens.

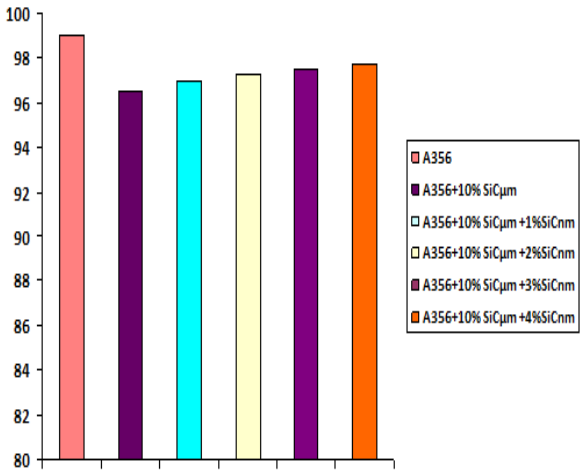


Fig. 3(b). Related Density of Different Samples

Electrical Conductivity

Sample from stir casting were prepared for testing of electrical conductivity. Dimension was prepared 12 mm diameter and length 30 mm long. The testing operates used were indirect method on working voltage of 20.0 mV. Measurements were taken for current, voltage, Resistivity & conductivity. It was observed that as percentage composition of SiC nano particle increase the electrical conductivity value declined. This fact is also reflected in the graph.

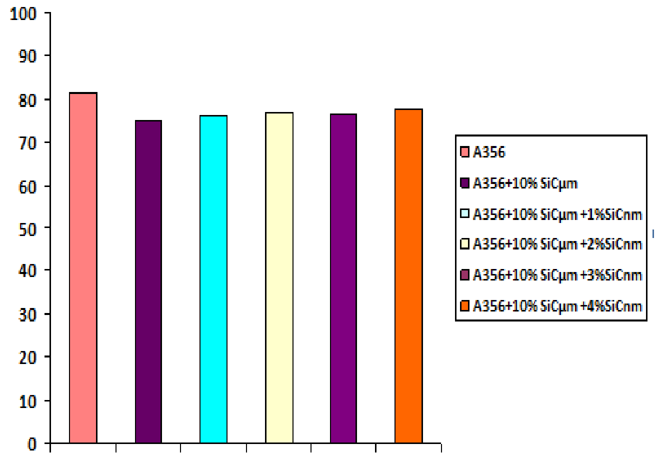


Fig. 3(c). Electrical Conductivity of various samples

IV. CONCLUSION

1. It is found that the process of stir casting is appropriate process of stir casting is appropriate process sample preparation. As it results in homogeneous & pure, unoxidize AMMC's using A356 ingot form 10 % weight SiC micro particle and various combination of SiC nano particle reinforcement.
2. FE-SEM images soured that SiC nano and micro particles were uniformly distributed. Nano composites is prepared by stir casting having less porosity as compared to pure & micro SiC particles.
3. It is observed that Related density of pure aluminium is highest but when be reinforcement of 10% SiC micro particles. There is drop in relative density, this relative density goes on increasing slightly as we add 1%, 2%, 3% and 4% SiC nano particle.
4. It has been observed that with the addition of microparticle, decreases in electrical conductivity are observed. And also addition of nano particle electrical conductivity slightly increases.

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Rakesh Kumar Yadav is currently a Ph.D scholar at Department of Mechanical Engineering, Dr. APJ Abdul Kalam Technical University (AKTU) Lucknow, (India). He has 10 technical research papers published in national and international journals and conferences. Currently, he is emphasizing on fabrication of aluminium-ceramics nanocomposites through Stir Casting process.

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