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Effect of Stirrer Parameter of Stir casting on Mechanical Properties of Aluminium Silicon Carbide Composite

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ABSTRACT: -*Metal-matrix composites have been attracting growing interest in these days. MMC is engineered combination of matrix and reinforcement to get tailored properties. MMCs are routinely included as candidate materials for primary and secondary structural applications. One of the major challenges when processing MMCs is achieving a homogeneous distribution of reinforcement in the matrix as it has a strong impact on the properties of the material. In this paper the effect of stirrer parameter of stir casting is investigated. Also the significance of each stirrer blade is found by testing the specimen. The microstructure of the composite was examined by optical microscope. The ultimate tensile strength and elongation of the specimen is noted. The brinell hardness test was performed on different specimens and evaluation is done. The Stir casting method was chosen as the casting process due to its simplicity, flexibility and applicability. For this aluminium alloy (LM6) was selected while silicon carbide as reinforcement.*

KEYWORDS:-*Metal matrix composites, Stirrer blade, Microstructure, Tensile strength.*

I. INTRODUCTION

Metal matrix composites are metals reinforced with other metal, ceramic or organic compounds. They are made by dispersing the reinforcements in the metal matrix. Reinforcements are usually done to improve the properties of the base metal like strength, stiffness, conductivity, etc. Metal matrix composites materials have high specific strength and stiffness compare to common structural materials and are extensively used in several applications. Composite materials can be defined as combinations of two or more materials in which the combinations of different properties are differently constituted. Composite materials are achieving predominant acceptance due to their characteristics of behaviour. Nowadays with the modern development, an application for the composites goes on increasing for various engineering materials. To meet such demand MMC is one of dependable source. Aluminium is important not only because of its availability but also of its immense properties. The reinforcement used such as silicon carbide composites have become as a class of materials suitable for various applications. When embedded in metal matrix composites Silicon Carbide certainly improves the overall strength of the composite along with corrosion and wear resistance

Among the variety of manufacturing processes available for metal matrix composites, stir casting is generally chosen as a promising route. Its advantage lies in its simplicity, applicability to wide application for production.

The cost related to the casting method for preparation is carried to one-third to half of competitive methods, and for the production of large quantity, it is estimated to have a fall to one-tenth. A major task related to stir casting is settling of reinforcement particles during melting process. The method is acceptable for manufacturing composites to about 35% fraction of volume. Among all the uncompromising mmc's, stir casting is viable and a commercial.

Research has been conducted in recent years on production of MMCs by stir casting technique. But minimal research work has been done on Blade stirrer required for uniform distribution of particle in the matrix. S. BalasivanandhaPrabuet al. [3] attempted some research on influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite and found that from the hardness test, the speed and time influence the hardness of the composite. Greater speed in stirring the composite material and greater stirring time, gives good hardness composite of MMC and was obtained from 600 rpm and 10 min stirring time processing condition.

Naher et al. [5] studied the effect of stirring speed on uniform distribution of particle by simulation. They have conducted experiments on fluids with similar characteristics of liquid and semisolid aluminium. Sic reinforcement particulate similar to that used in aluminium MMCs was used in the simulation fluid mixtures.

G. G. Sozhamannan et al. [11] studied the effect of Processing Parameters on Metal Matrix Composites: Stir Casting Process and found that Aluminium mmc were fabricated by different processing temperatures with different holding time to understand the influence of process parameters on the distribution of particle in the matrix and the resultant mechanical properties Research has been conducted in an effort to optimize the mechanical properties of MMCs. But, in certain conditions the effect of the stirring action cannot be found as they take place in a non-transparent molten metal within a furnace.

One, four and five-bladed stirrers with blades normal to the axis of rotation as well as stirrer were used. Stirrer blades could be rotated about their longitudinal axis. A speed c dc motor enabled accurate control of the stirring speed. Most of the researchers have focused on effect of single parameter either stirring time or the percentage of the weight. From the previous work done by the different investigators it is quite promising to pursue research in the area of production of MMCs with stirrer blade. Substantial literature has been studied on metal matrix composite, silicon carbide, aluminium and stir casting methods. The objective of the present research is to find out optimum blades and effect and contribution of these parameter on the hardness and tensile strength.

II. PROBLEM IDENTIFICATION

The previous study showed the influence of several parameters on the tensile and hardness properties of a metal matrix composite. Stir casting of metal matrix composites suffer from limitations like uneven distribution, low wettability. The present study is aimed to optimize the number of blades on experimental testing with the help of stir casting furnace to analyses strengthening properties. The experimental observations were confirmed by the calculations and investigating the strength of Al Sic composites.

III. SYSTEM DESIGN

Hashim et al [12] studied one of the problems encountered in metal matrix composite processing is the settling of the reinforcement particles during melt holding or during casting. This arises as a result of density differences between the reinforcement particles and the matrix alloy melt. Research has been carried out in several years on production of MMCs by stir casting process. But very little research work has been done on Stirrer Blades.

Stirrer is used in stir casting machine to mix the aluminium and silicon carbide. However design of the stirrer blade is increased to find out the better particle distribution and strength of the composite. The design of mechanical stirrer is increased by 2 blade stirrer, 4 blade stirrer and 5 Blade stirrer. The geometry of the stirrer makes proper mixing in stir casting machine. . A dc motor helps to control the stirring speed. Height of the stirrer from the bottom of the beaker was adjustable.

The solid model of stirrer assembly with stirrer rod diameter 23 mm .The stirrer assembly rod height is 38 mm, width 20 mm, thickness 2 mm. Stainless steel material was used for making the blade as it has greater melting point. This stirrer assembly cover for the purpose of keeping the stirrer motor and stirrer rod. Various designs of the stirrer is shown in Fig. 1

Figure 1: Stirrer Blade preparation

IV. EXPERIMENTAL PROCEDURE

4.1 Raw materials

Aluminium LM6 alloy with 20 vol. % of Silicon carbide powder (20μm size) is used in this experiment

4.2 Experimental Methodology

Stir casting process is used to prepare aluminium matrix composites. First the blade stirrer which is made is welded into the rod. Then the scraps of aluminium have to be preheated for 3 to 4 hours at 450°C and silicon carbide also with 900°C. At first heater temperature is set to 500^{o}c and then it is gradually increased up to 900^{o}C. Required quantity of aluminium alloy is taken and cleaned to remove slag and kept in the crucible of stir casting machine. Then the heat treated Silicon Carbide particles is allowed to fall into the molten metal continuously through a funnel. Temperature of the heater is set to 620^{o}C which is below the melting temperature of the matrix. An electrical resistance furnace assembled with stainless steel impeller with 2 blade, 4 blade and 5 blade used as stirrer was used for stirring purpose. A uniform semisolid stage of the molten matrix was achieved by stirring it at 600 rpm. Pouring of preheated reinforcement at the semisolid stage of the matrix enhance the wettability of reinforcement, reduces the particle settling at the bottom of the crucible. After stirring for 10 minutes at semisolid stage slurry was reheated and hold at a temperature 900^{o}C to make slurry in liquid state. Stirrer rpm was then gradually lowered to the zero. The molten composite slurry is then poured in to the metallic mould which is preheated at temperature 500^{o}C this makes sure that the slurry is in molten condition throughout the pouring. While pouring the slurry in the mould, the flow of the slurry is kept uniform to avoid trapping of gas. Then it is quenched with the help of air to reduce the settling time of the particles in the matrix and to avoid oxidation. After the required casting pieces are made, it has to be shaped for testing purpose of microstructure analysis, tensile test and hardness test

3.3 Experimental testing

3.1.1 Micro Structure Analysis

The analysis for the purpose of reinforcing particles has a major influence in determining the densities and types in composite material. For this analysis, it is necessary to identify clearly the neighbours of each particle some researchers have attempted to do this by visual inspection. It can be seen that the composite materials made by the processing technique had a cast microstructure of the matrix accompanied with particles, distributed homogeneously throughout the casting relatively uniform distribution was observed in almost all the composites produced. The test specimens required for analysis were machined to cylindrical specimens and were then ground in successive steps using silicon carbide abrasive papers of various grit sizes.

The microstructures of the samples were observed to study the particle distribution. A section was cut from the castings for the purpose of microstructure analysis. The specimens were grinded thoroughly by using emery paper for certain time by using 300,600 and 900 grit papers and then polishing it with applying a paste. The samples are then mechanically polished and etched by Keller's reagent to obtain the accurate contrast structure. The casting procedure was examined under the light optical microscope was used having 100X resolution to determine the reinforcement pattern and cast structure.

3.1.2 Tensile Test

Many of the mechanical properties of a material can be well studied by performing a tensile test on a specimen of the material. Tensile strength is defined as a stress, which is measured as force per unit area. In the SI system, the unit is Newton's per square metre (N/m²). In tensile test, take a standard specimen and apply a tensile load on it in the universal testing machine. The tensile test was carried out for all specimens respectively. The samples were prepared according to ASTM E08.

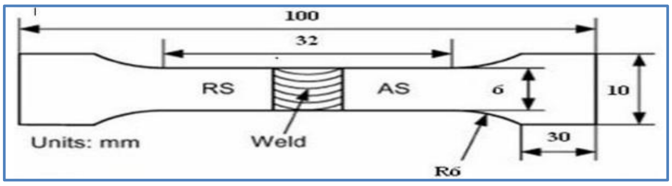


Figure 2: Standard Tensile Specimen

The tensile properties of the alloys were determined by performing the tension test on standard cylindrical tensile specimens

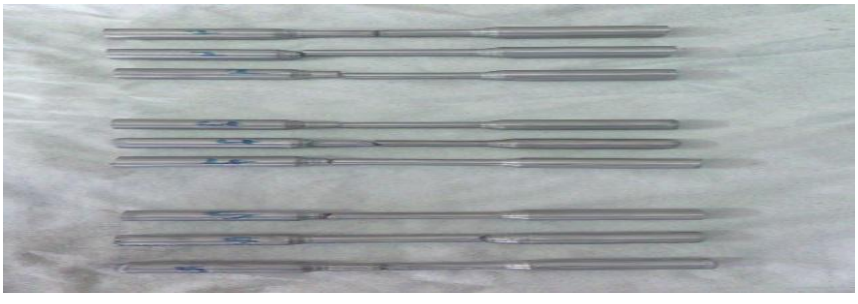


Figure 3: Tensile Test piece

3.1.3 Hardness Test

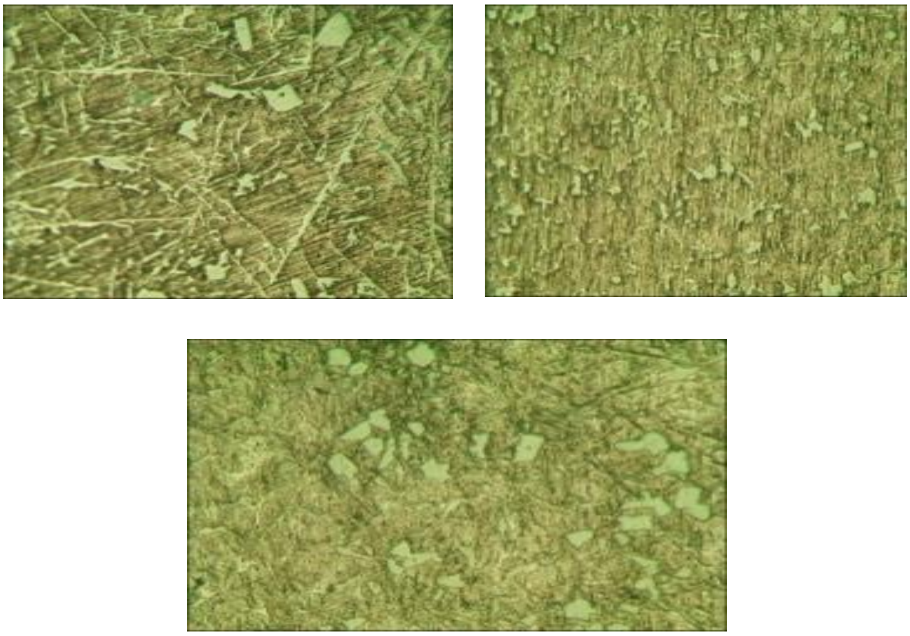
Hardness has been variously defined as resistance to local penetration, to scratching, to machining, to wear or abrasion, and to yielding .The hardness testing was carried out for all composite specimens. The hardness of the specimen determined by brinell hardness testing machine with 250 kg load and 5 mm diameter steel ball indenter. The brinell hardness number, or simply the brinellnumber is obtained by dividing the load used, in kilograms, by the actual surface area of the indentation, in square millimetres

IV. RESULTS AND DISCUSSION

4.1 Evaluation of microstructure

Homogeneous distribution of particles enhances the properties of the matrix alloy. It is observed from the figure that silicon carbide are dispersed uniformly in the AMC by using different blades. But the size of the silicon carbide present varies throughout the aluminium matrix in different structure. The Al- 20 wt. % Sic composite samples for microscopic study were prepared by grinding and fine polishing was done using diamond paste. After polishing the specimens were etched in Keller’s reagent at 70°C for 10 min followed by quenching in water. The microstructure of the polished and etched specimens were observed using optical microscopy

(a) (b)



(c)

Figure 4: Microstructure analysis of composite with (a) 2Blade, (b) 4 Blade, (c) 5 Blade Stirrer

In Fig. 4(a) it can be seen in figures that the presence of grooves of varying sizes was observed frequently on the surface. The debris particles are likely to act as third body abrasive particles. In Fig. 4(b) the hardness values of the composites increases to a large extent. Although there is an increase in the particle clustering with same temperature, it was observed that the tendency for formation of particle cluster was greater This is certainly due to the homogeneity in mixing SiC additions to the composite which acts as a reinforcement for the aluminium matrix. In Fig. 4(c) the presence of Sic of varying sizes was observed. It can be seen from the figures that there is an increase the particles cluster. Although there is an increase in the particle clustering with same temperature, it was observed that the tendency for formation of particle cluster was greater but not that much as 4 Blade

4.2 Evaluation of Tensile test

The tensile properties, such as, Tensile strength, Percentage elongation, were extracted from the stress - strain curves are represented in Table 1. It is clear from the tensile results that 4 Blade stirrer in has maximum ultimate tensile strength about 126.21 Mpa. The results of the tensile strength tests are given in Fig.5, which shows the variation of tensile strength with the changes in blade. The Ultimate strength of metal matrix composite with four blade has maximum strength with less elongation up to 4.92 %

Ultimate tensile stress = $\sigma = \frac{P}{A_o}$

Percentage of elongation = $\% \varepsilon = \frac{Lf - L_o}{L_o} \times 100$

Where,

σ is the engineering stress, ε is the engineering strain, *P* is the external axial tensile load, *Ao*is the original cross-sectional area of the specimen, *Lo* is the original length of the specimen, *Lf* is the final length of the specimen

Specimen	Load		Uts	Elongation
	Failure load	Mean load		
	kN	kN	Mpa	%
2 blade	2.8	2.77	97.92	6.6
	2.75			
	2.78			
4 blade	3.95	3.57	126.21	4.92
	3.98			
	2.8			
5 blade	3.75	3.33	117.72	5.04
	3.55			
	2.7			

Table 1: Results obtained from Tensile Test

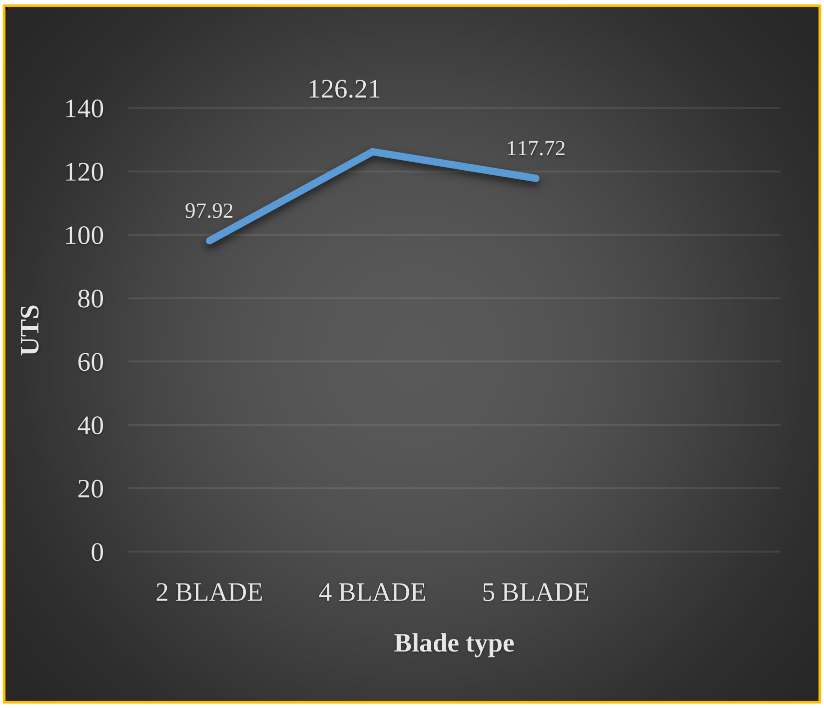


Figure 5: Graph of UTS vs BLADE TYPE

4.3 Evaluation of Hardness

Hardness tests were performed on a brinell hardness machine. The brinell hardness number was measured along length of the cast specimen and the results of the tests are shown in Fig.6. As shown, hardness shows greater value in mixing the composite with four blade stirrer has 90 BHN

Specimen	Load	Ball Diameter	Measured Diameter		Mean BHN
	Kgf	mm	Dia	Mean dia	
			mm	mm	
2 blade	250	5	2.3	2.28	58
			2.26		
			2.3		
4 blade	250	5	1.8	1.85	90
			1.9		
			1.85		
5 blade	250	5	1.96	1.98	77
			2		
			2		

Table 2: Results obtained from Hardness Test

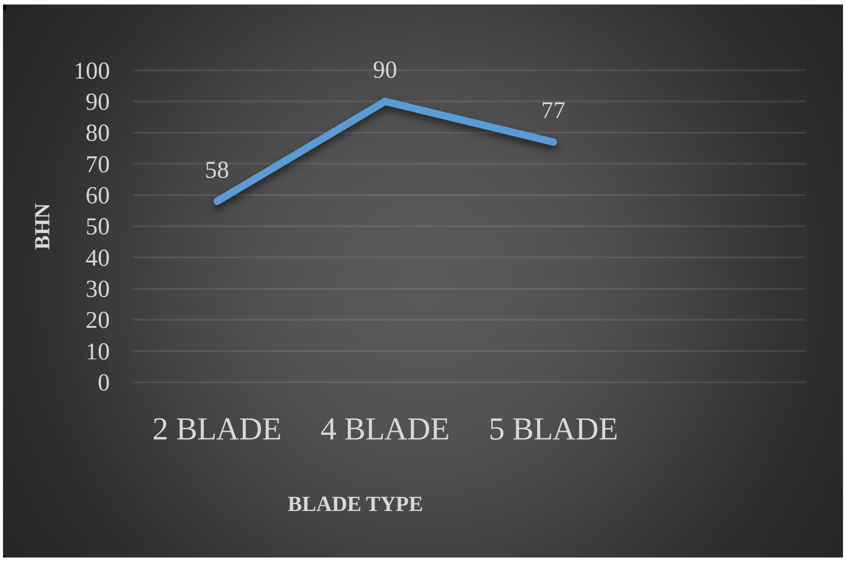


Figure 6: Graph of BHN vs BLADE TYPE

V. CONCLUSION

In the present study the objective is to find the effect of Stirrer parameter of stir casting on mechanical properties of aluminium silicon carbide. As there is various process parameters if they properly controlled can lead to the improved characteristic in composite material and to prepare aluminium matrix composite with help of stir casting process. Manufacturing of aluminium alloy based casting composite by stir casting is one of the most economical method of processing MMC on carbide composite. The leaf of the blade is increased to find out the optimum parameters. . The Al- 20 wt. % Sic composite samples for microscopic study were prepared by grinding and fine polishing was done using diamond paste. The microstructures of the polished and etched specimens were observed using optical microscopy. Although there is an increase in the particle clustering with same temperature, it was observed that the tendency for formation of particle cluster was greater in 4 Blade Stirrer. This is certainly due to the homogeneity in mixing Sic additions to the composite which acts as a reinforcement for the aluminium matrix. Test pieces were shaped for conducting tensile strength as per ASTM E08.Changes in Blade stirrer shows optimum in testing tensile strength and hardness. Reason of improved mechanical properties of the composites compare to matrix alloy may be the stir casting technique of production and reinforcement of Sic. The tensile strength increases but % of elongation decreases. It is clear from the tensile results that 4 Blade stirrer in has maximum ultimate tensile strength about 126.21 Mpa .The brinell hardness number has highest value at 4 blade stirrer which is apt for stir casting furnace for better results. By comparing the results we can confirm that mechanical properties tested shows greater strength and hardness for four blade stirrer than two blade and five blade.

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