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Analysis of Mechanical and Metallurgical properties of Al-SiCp Composite by Squeeze-cum-Stir Casting

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ABSTRACT : Composites are one of the recent trends of interest in present material innovations. Mostly metal matrix composites (MMCs) have found its applications in aerospace and automobile industries. This is because of its highly attractive properties like low density, high strength, high temperature resistance, higher strength to weight ratio. Even though it has superior properties it faces several hurdles like high cost of production, poor dispersion of reinforcement material on the matrix. A study has been made to solve this problem by forming a metal matrix composite which has Aluminium (Al-97.47% C.P) has been the matrix material and Silicon Carbide (SiC- 31.5-32µm) been a reinforcement material. A new technique, Squeeze-Cum-Stir Casting, a method used to solve the problems faced in today‘s MMC production process. The experiments have been made by varying the volume fraction of SiC (5%, 15%, and 25%), while keeping all other parameters constant. Parameters like hardness, impact strength, and ultimate tensile strength were analyzed and observed and Scanning Electron Microscopy (SEM) analysis was performed.

Keywords – Composites, properties, Squeeze-Cum-Stir Casting, Scanning Electron Microscopy

I. INTRODUCTION

The composite materials play a vital role in the modern industrial sectors. Preparations of Metal matrix composites are also finding much useful in the field of applications such as aerospace, automobile, tool manufacturing due to its advantageous properties such as light weight, hardness, flexibility, etc [1]. Metal-matrix composites has great role in the modern engineering fields. These are used for the manufacturing the strong, hard and light-weighted engineering materials which sere used in latest machineries, parts of the speedy motors and vehicles. Silicon carbide is very important constituents of the metal-matrix composites because of its excellent homogeneous uniting properties. It also the back bone of every structure metal matrix composites. [2] The main focus of this paper is the preparation of AlSiC composites using Squeeze-Cum-stir casting method homogeneously. The raw materials like Al (98.41%) metal scraps homogeneously united with SiC (320 grit) usually by continuous stir-casting method. Stir-casting is the type of vortex heating with stirring method in which the raw materials gets homogeneously mixed with each other. The slurry was poured into the desired shaped moulds. By using stir casting technique many disadvantages such as complexity in production, chances of inclusion of foreign materials, not suitable for production in large quantities etc. In this paper we adopted a new casting technique Squeeze-Cum-Stir casting in order to overcome the problems faced in conventional stir casting method, for the production of the Metal matrix composite. The MMC were casted by using this Hybrid stir casting technique and prepared a total of three samples by varying percentile compositions of SiCp – 5%, 15%, 25% with Aluminium and these samples were tested for the improvement of properties such as harness, impact strength and tensile test.

II. COMPOSITE MATERIALS

A composite material is a combination of two or more materials in right proportions to get single entity and improved qualities from the single material. In terms of structure, materials can be divided into four basic categories: metals, polymers, ceramics, and composite materials. A composite a material composed of two or more phases combined in a macroscopic scale, whose properties are superior constituent materials, acting in an independent manner. In other words, a composite is a combination of at least two different materials both chemically and geometrically. Fibre reinforced composite materials are finding increased application in aircraft, spacecraft, automobile fields and electronic industry since, it has high strength to weight ratio and stiffness. Composites are made up of individual materials referred to as constituent materials. There are two main categories of constituent materials: matrix and reinforcement. At least one portion of each type 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 enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination. Engineered composite materials must be formed to shape. The matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mould cavity or onto the mould surface. The matrix material experiences a melding event, after which the part shape is essentially set. Depending upon the nature of the matrix material, this melding event can occur in various ways such as chemical polymerization or solidification from the melted state.

III METAL MATRIX COMPOSITES

Metal-matrix composite structure is generally designated purely by the term metal alloy of the matrix and the material in the form of the strengthening. The matrix is permeating soft part generally having excellent tensile strength, hardness, ductility and thermal conductivity which are set in the hard reinforcements having high tautness and low thermal expansion. For the development of metal-matrix, light metal composite materials mixed with light metal alloys are applied as matrix materials. During the metal-matrix production, the main contribution of special alloys is used in powder metallurgy which is used for the solidification.[2]

IV SQUEEZE-CUM –STIR CASTING EXPERIMENTATION

Squeeze-Cum-Stir Casting is a liquid state casting method of composite materials, in which dispersed phase is mixed with a molten metal-matrix by means of mechanical stirring. The term stir-casting is the process of stirring molten metal's are used for continuous stirring particles into metal alloy to melt and immediately pour into the sand mould then cooled and allow to solidify. The experimental arrangement has been assembled by the coupling motor and mild steel four blade stirrer. The melting of the aluminium (98.41%) scraps and silicon carbide powder (SiCp – 320 grit size) is carried out in the graphite crucible in to the coal-fired furnace. First the scraps of aluminium (98.41%) were preheated for 3 to 4 hours at 450°C and silicon carbide powder (SiCp – 320 grit size) also heated with 900°C and both the preheated mixtures is then mechanically mixed with each other below their melting points. This metal-matrix AlSiC is then poured into the graphite crucible and put in to the coal-fired furnace at 760°C temperature. After completing the stirring process the slurry has been taken into the sand mould with the help of a jet of compressed hot air which gives the squeezing effect to the slurry and it is allowed to solidify. The advantage of using this arrangement is that we create a closed compartment in which no temperature change is affected and the squeezing effect gives the proper flow of the molten metal or the slurry to the moulds without any wastage and reaches every part of the mould from which we get the advantage of a finished product with less or no defects i.e. blow holes etc. Finally we prepared a total of three samples by varying percentile compositions of SiCp – 5%, 15%, 25% with Aluminium as per specified by the objectives this paper.

V TESTING

The main objective of this paper is to develop a composite material which overcomes the drawbacks of conventional casting technique i.e. stir casting technique also the material samples are tested for the improvement of the properties which will find much applications in the field of the aerospace, automobile industry and other industries. After the casting the samples were taken for the following test.

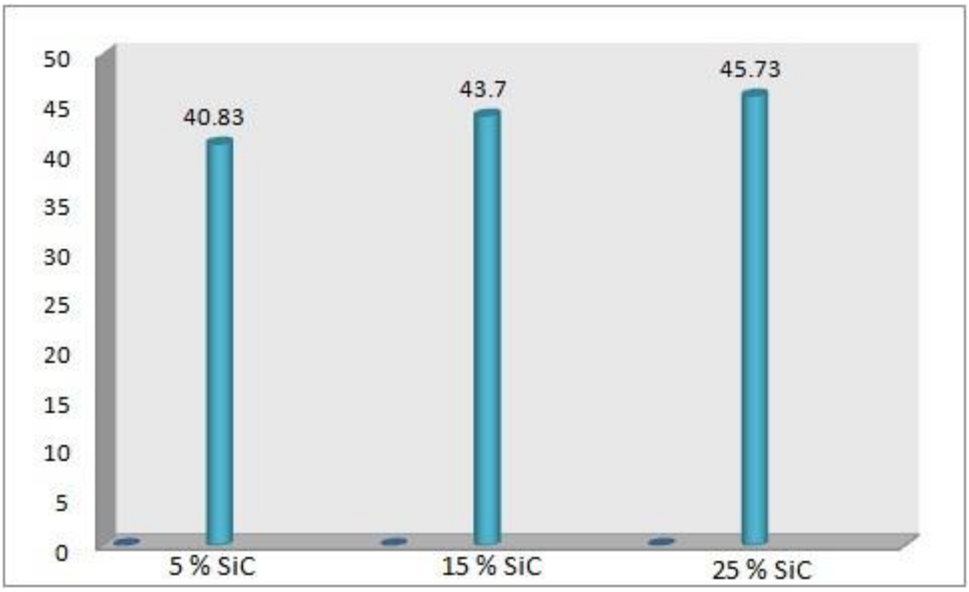
5.1 Hardness Test (Brinell hardness Test)

Hardness test has been conducted on each specimen using a load of 500 Kg and a steel ball of diameter 10 mm as indenter. Hardness tester is employed to evaluate the interfacial bonding between the particles and the matrix by indenting the hardness with the constant load and constant time of 15 seconds. The test load was calculated by the given formula $5D^2$ where D is the diameter of the indenter. The test results are shown in the Table.1

Sample No.	Sample Name	Hardness (Brinnel Hardness Test)			Mean Hardness
		Trial - 1	Trial - 2	Trial - 3	
1	5% SiC	40.77	40.93	40.77	40.83
2	15% SiC	43.70	43.70	43.70	43.70
3	25% SiC	46.0	45.6	45.6	45.73

Table.1: Hardness test of the samples

The graphical representations of the above results are given in Graph 1;



Graph.1: Graphical representation (Hardness Test)

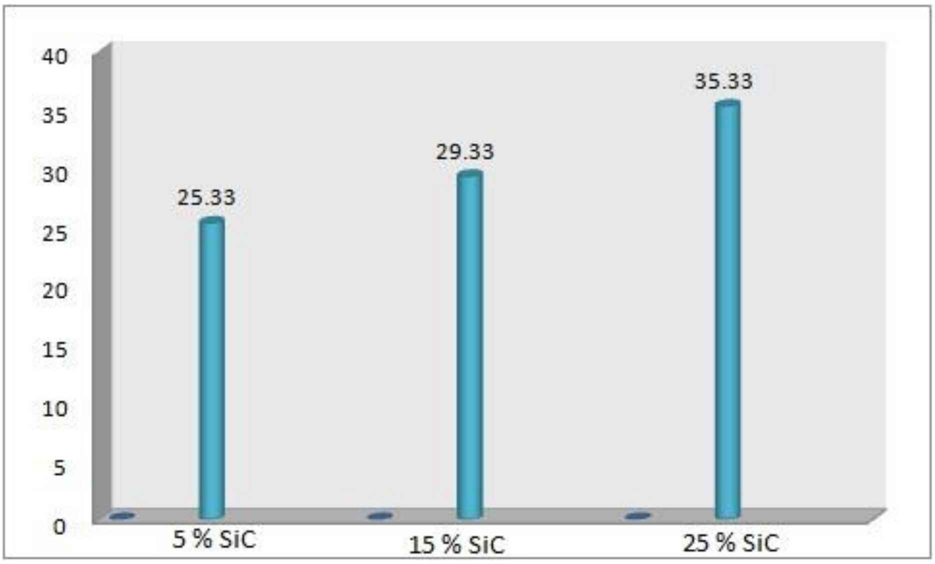
5.2 Impact Strength Test

Impact Strength test is done by Charpy V Notch pendulum impact testing machine. The square bar test specimens is applied on a simply supported beam. A Specimen is made according to the ASTM standards length with 45 degree v notch at center. Single blow of hammer is given at mid span of specimen. The blow should be sufficient to bend or break the specimen at center. The energy spent in bending or breaking the specimen is taken as Charpy impact value, the result of the specimens trials are shown in the Table.2 and its graphical representations are given in the Graph No.2;

Sample No.	Sample Name	Impact strength (Charpy V notch)			Mean in Joules
		Trial - 1	Trial - 2	Trial - 3	
1	5% SiC	24	26	26	25.33
2	15% SiC	28	30	30	29.33
3	25% SiC	36	34	36	35.33

Table.2: Impact Strength test of the samples

The graphical representations of the above results are given in Graph 1;



Graph.2: Graphical representation (Impact Strength Test)

5.3 Metallurgical Analysis

Metallographic samples were sectioned from the samples cast. A 0.5 % HF solution was used to etch the samples wherever required [3]. To see the difference in distribution of SiC particles in the aluminum matrix, microstructure of samples were developed on Inverted type Metallurgical Microscope. All samples were developed by using two the new hybrid stir casting method by taking varying weight fractions of SiC particles. The various weight fractions were 5%, 15%, and 25% of SiC particles.

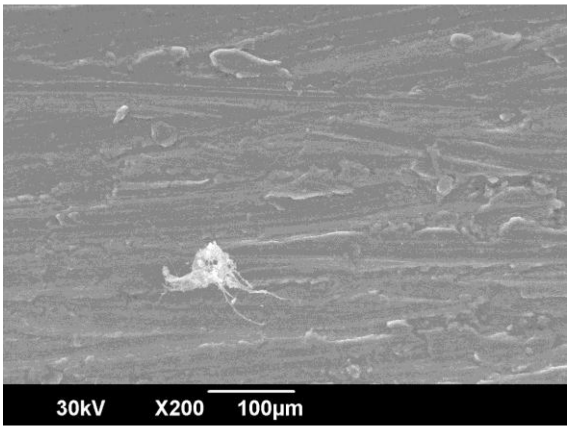


Fig. 1 Micrograph of sample containing 5% SiC by weight

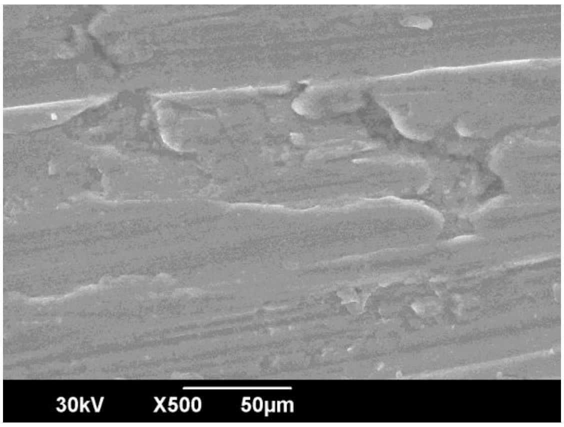


Fig. 2 Micrograph of sample containing 15% SiC by weight

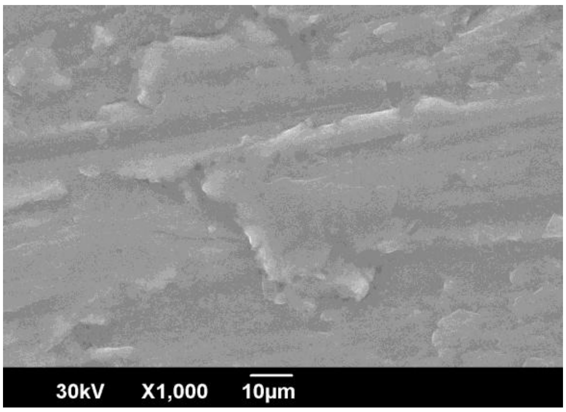


Fig. 2 Micrograph of sample containing 25% SiC by weight

As observed from figures 1,2 and 3 we can understand that the figure 2 i.e. sample containing 15 % of SiC shows the homogenous distribution of the material also it is been noted that the density of the particles decreases inspite of an increase in concentration.

VI CONCLUSION

After getting the result of the composition Al-SiC (5%, 15% and 25%) ready samples were tested and checked the hardness test, impact of strength test and metallurgical analysis, The experimental study reveals following conclusions:

1) The results of study suggest that with increase in composition of SiC with the weight of Aluminium, an increase in hardness and impact strengths have been observed.
2) The best results has been obtained at 25% weight fraction of 320 grit size SiC particles. Maximum Hardness = 45.73 BHN and Maximum Impact Strength = 35.33 J.
3) From the testing of the composite material it has been come into notice that by using the new method of casting i.e. squeeze-cum-stir casting an improvement in the properties of the composite has been observed than that we have seen while using the conventional casting method.
4) Also it is been noted that the density of the particles decreases inspite of an increase in concentration.

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