PREPARATION OF METAL-MATRIX COMPOSITES BY STIR-CASTING METHOD

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ABSTRACT

Composite materials play a vital role at the present modern industrial sectors. Preparations of metal-matrix composites are light weighted, high strength, extremely hard materials which were useful for every industrious area like aerospace, motor vehicle industries, mechanical tools manufacturing industries due to its advantageous properties like light in weight, flexibility, hardness, simplicity and easily applicable and so on. At the centre of research and growth of these sectors this paper emphasize the production of metal-matrix AlSiC composites using the duplex stir-casting method and prepared total six samples of varying percentile compositions of SiCₚ – 5%, 10%, 15%, 20%, 25% and 30% with aluminium. Presently these samples were tested under the hardness test, impact strength test, design of experiment and micrograph examinations were conducted.

Keywords: Composite Materials, Metal-Matrix Composite, AlSiC Stir-Casting

I. INTRODUCTION

As we know that the metal-matrix composites having extremely hard, abrasion resistance and mostly light weighted which are useful for the preparation of the high temperature and speed
parts like pistons, axles, high speed wheels and so on. The main focus of this paper is the preparation of AlSiC composites using stir-casting method homogeneously. We prepared metal-matrix of AlSiC composites using Al (98.41% C) and SiC (320 grit size) by duplex stir-casting method with high temperature into the graphite crucible with coal-fired furnace. The prepared homogeneous molten mixture should be poured into the sand moulds and kept it for solidification. We were prepared six rounded bars and six square shaped bar samples of varying the composition. These samples are to be checked further the test of hardness, impact strength, DOE and micrograph examination which will discussed in the next paper.

II. THE MAIN OBJECTIVES OF THE PAPER

2.1 Objectives

The main purpose this paper is to develop the strong light weighted metal-matrix AlSiC composite material which is useful in the industrial sectors as well as advanced machineries. The most important part of this paper is to fabricate AlSiC metal-matrix of by homogeneous stir-casting to produce High Strength Low Cost Material (HSLCM). We adopt the stir-casting method with high temperature in this project. This types of metal-matrix composite have very high specific strength, temperature resistance, fatigue resistance, abrasion resistance, corrosion resistance and stiffness properties that they are used in automotive and heavy goods vehicle, Braking systems, piston rods, frames, piston pins, valve spring cap, brake discs, axle tubes, reinforcement blade, gear box casing, turbine blades, racing car wheels and so on.

2.2 Composite Materials

Composites are considered to be mixture of materials different composition. The materials retain their identities in the composite; that is, they do not dissolve or unite completely into each other even though they perform. Normally, these materials can be physically identified and reveal an interface between one another. There were various types of composite materials; on the basis of matrix constituents these are Metal Matrix Composites (MMCs) Polymer Matrix Composites (PMCs) and Ceramic Matrix Composites (CMCs) and the other on the basis of fiber reinforced composites like particulate composites are by dispersing the particles of different shapes and sizes, layered composites prepared by parallel layers with two alternate different phases and fiber-reinforced plastics prepared by reinforcing plastic matrix with high strength fiber materials and infiltration composites. But nowadays the use of metal-matrix, ceramic-matrix and honey-comb structure plays a significant job which is useful for the new development. Nowadays fabrication of Silicon-Carbide (SiC) improves the
life of modern tools. Silicon carbide or carborundum used as an excellent materials which is made by 60% sand and 40% coke with addition of saw dust in an electric furnace at very high temperature about 1500°C with traces amount of salts. The SiC particles are mixed with a temporary binding agent like glue resins and then compressed and dried at the temperature 2000°C that gives homogeneous interlocked SiC crystals. Duplex-composite materials like Silicon carbide particles reinforced with aluminium (AlSiC) gives the great strength and also significantly prevent the severe wear-tear and high stress working.

2.3 Metals-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 toughness 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.

2.4 Stir Casting

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. In stir-casting, the particles are often tends to form agglomerates, which can be only dissolved by vigorous stirring with high temperature.

III. METHOD OF PREPARATION OF AlSiC METAL-MATRIX COMPOSITE

There are various types of metal-matrix composite materials fabrication techniques in engineering field like, Metallurgical melting method, Gas or Pressure infiltration method, Finishing by machining method, Pressing and sintering method, Forging and extrusion method, Squeeze or pressure casting method, Compo-casting method, vortex and Stir-casting method.
3.1 Stir-Casting Fabrication

Here we have been adopting the stir-casting method for the preparation of metal-matrix AlSiC composites. This whirlpool technique provides the high strength homogeneous set of aluminium composite materials. The necessary apparatus are required to fabricate the material with stepwise procedure are discussed below;

3.1.1 Frame of stirring system: Frame of the stir-casting system is prepared by 1” x 1” MS square iron pipes. The height of the frame is 70 cm from the ground and its length and width is 70 cm each side. The two square pipes are joined in the middle side at a distance 27cm from both sides which is used for the fitting of motor cum stirrer.

3.1.2 Stirrer Fabrication: Stirrer is made up of mild carbon steel. The length of stirrer is 95 cm and exactly plus sign blade having zigzag angle 90° of each side. The length of every side of stirrer blade is 9 cm each.

3.1.3 Graphite Crucible: Graphite crucible is used for heating the matrix material. The height of the crucible is 12 inch and upper side diameter is 8 inch and the bottom side diameter of the crucible is 6 inch.
3.1.4 **Motor-Dimmer:** The motor is fitted on the centre of the frame having 220 to 1400 rpm for stirring process and the rate of speed is adjusted by dimmer (0 to 260 volts).

3.1.5 **Furnace Specification:** Underground coal-fired furnace is used for the preparation of the homogenous metal matrix. The furnace opening dimensions 15” x 15” and the depth is 30”. Coal is used as fuel in for the preparation.

3.1.6 **Raw Material Selection:** For the preparation of metal-matrix composite silicon carbide and aluminium scraps are used as a raw material. Silicon carbide 320 grit size and 98.41% aluminium scraps required for the preparation.

3.2 **Methodology**

In the preparation process of this method, stirring has been carried out in graphite crucible in coal-fired furnace with continuous stirring of the molten metal-matrix gives homogeneous mixture of composites and instantaneously poured in to the sand mould to get solidify. Coal is used as a fuel for preparation. The working diagram of the coal-fired furnace is given in the experimental figure 2;

**Experimentation**

The experimental arrangement has been assembled by the coupling gear-box motor and mild steel four blade stirrer used. The melting of the aluminium (98.41%) scraps and silicon carbide powder (SiCₚ – 320 grit size) is carried out in the graphite crucible into the coal-fired furnace. First the scraps of aluminium were preheated for 3 to 4 hours at 450°C and SiC powder 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.
The furnace temperature was first increased above the composites completely melt the scraps of aluminium and then cooled down just below the components temperature and keep it in a semi-solid state. At this stage the preheated SiC\textsubscript{p} were added with manually mixed with each other. It is very difficult to mix by machine or stirrer when metal-matrix composites are in semi molten state with manual mixing taking place. When the manual mixing is complete then automatic stirring will carried out for ten minutes with normal 400 rpm of stirring rate. The temperature rate of the coal-fired furnace should be controlled at 760 ± 10°C in final mixing process. After complete the process the slurry has been taken into the sand mould within thirty seconds allow it to solidify. Tests should be taken of solidified samples like hardness and impact tests. This experiment should repeatedly conducted by varying the compositions of the composite powder of SiC (5%, 10%, 15%, 20%, 25% and 30%), weight of aluminium scraps in grams plus weight in grams of SiC powder as shown in the following chart 1. For each composition variation a total 2 kg (2000 gms) material mix is used for casting the test samples.

<table>
<thead>
<tr>
<th>Percentage</th>
<th>AlCp - 98.41%</th>
<th>SiC - 320 grit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>1900 gm</td>
<td>100 gm</td>
</tr>
<tr>
<td>10%</td>
<td>1800 gm</td>
<td>200 gm</td>
</tr>
<tr>
<td>15%</td>
<td>1700 gm</td>
<td>300 gm</td>
</tr>
<tr>
<td>20%</td>
<td>1600 gm</td>
<td>400 gm</td>
</tr>
<tr>
<td>25%</td>
<td>1500 gm</td>
<td>500 gm</td>
</tr>
<tr>
<td>30%</td>
<td>1400 gm</td>
<td>600 gm</td>
</tr>
</tbody>
</table>
Finally we prepared the six types varying samples including rounded bars and square bars as shown in the given fig. 3.

These final samples are now ready for further testing processes of hardness test, impact strength test and microstructure examination.

IV. RESULT AND DISCUSSION

The major aim and objectives of this paper is to prepare aluminum based silicon carbide particulate MMCs with an objective to develop a conventional low cost method of producing MMCs and to obtain homogenous dispersion of ceramic material. To achieve these objectives stir casting technique has been adopted. Pure Aluminum and SiC has been chosen as matrix and reinforcement material respectively. These metal-matrixes are very popular, cheap and beneficial for the modern engineering fields. After getting the varying the composition AlSiC (5%, 10%, 15%, 20%, 25% and 30%) samples are ready for the testing. Further we will check the hardness test, impact strength test and uniform distribution study of reinforcement in metal-matrix with micro-spectrograph analysis. And also DOE (design of experiment) is employed to evaluate the parameters for optimization. A full factorial design for several readings for a given matrix of data would be treated using ANOVA (Analysis of Variance) based on the percentage of SiC around the prospective sample Our main target is to prepare a very hard metal-matrix sample which becomes very popular, cheap and beneficial for the modern engineering era.

V. REFERENCES


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