Preparation and processing of Al 336/ (0-10) wt. % SiC_p composites

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Abstract— **Aluminium alloy metal matrix reinforced with SiCp, composites have been increasingly used nowadays do to their high strength to weight ratio, good wear resistance, better temperature strength etc over unreinforced alloy. In the present study, Al 336 alloy, Al 336 -5 wt. % SiCp and Al 336- 10 wt. % SiCp composites were prepared. Preparation of Al 336 -5 wt. % SiCp and Al 336- 10 wt. % SiCp composites were done using Stir casting method. Micro structural analyses were performed on prepared Al 336/ (0-10) wt. % SiCp composites. The microstructure analysis of Al 336 alloy showed α- aluminium and eutectic silicon. But in the case of Al 336/ 5 wt. % SiCp and Al 336/ 10 wt. % SiCp composites, apart from α-aluminium and eutectic silicon, SiC particles were found to be uniformly distributed. Tests to determine the mechanical properties of Al 336/ (0-10) wt. % SiCp composites were performed before and after heat treatment operations. Mechanical properties like Ultimate tensile strength and hardness values of Al 336/ 10 wt. % SiCp composites were found to be highest compared to Al 336/ 5 wt. % SiCp and Al 336 alloy respectively.**

Keywords- Al 336 alloy, Al-SiCp composites, Stir casting method, Microstructure

I. INTRODUCTION

Metal matrix composites (MMC) in general consists of a metal matrix (generally an alloy) and a reinforcement. Particulate-reinforced metal-matrix composites have attracted considerable attention over other MMC due to the Successful development of manufacturing process to produce MMC with reproducible microstructures, availability of a spectrum of reinforcements at a competitive cost, excessive manufacturing cost associated with high cost of continuous fiber reinforcement material etc. Aluminium matrix composites (AMC’s) finds wide application in industrial, automobile, space related and military engineering fields [1].

Several metallic systems can be considered for use as a matrix material for metal matrix composites Such as Aluminum, Titanium, Magnesium, Copper, Bronze, Nickel, Lead, Silver etc. The most important have been the non-ferrous lightweight materials for structural use such as aluminum, titanium and magnesium because specific properties of these materials can be enhanced to replace heavier monolithic materials. Aluminum is the most attractive non-ferrous matrix material used particularly in the aerospace and transportation industries where weight of structural components is critical. Reinforcements used for the preperation of AMC’s are generally ceramics. Typically ceramics are oxides, carbides, and nitrides which are used because of their excellent combinations of specific strength and stiffness at both ambient temperature and at elevated temperatures. Silicon carbide, aluminium oxide and boron carbide are the key particulate reinforcements that are used nowadays for the preparation of AMC’s [2]. SiC reinforced aluminium alloy metal matrix composites have been increasingly used nowadays do to their high strength to weight ratio, good wear resistance, better temperature strength etc over unreinforced alloys.

Al 336 alloy is selected as the matrix material in this work. This is because, Al 336 alloy finds wide applications like automotive and diesel pistons, pulleys and other applications where high wear resistance, high-temperature strength, high thermal conductivity, low coefficient of thermal expansion etc are required. Here in this work SiC is selected as the reinforcement material and Al 336 alloy as the matrix material. Stir casting method was used for the preparation of Al 336/ SiCp composites. The main research challenge associated with Al-SiCp composite preparation was to get a uniform distribution of SiC in the aluminium matrix. Through various experimental findings, it was found that uniformity of SiC particles in the aluminium matrix were dependent on shear rate, shear period, cooling rate and volume fraction of the primary solid [3].

II. MATERIAL PREPARATION

'Oil fired tilting furnace' was used for the preparation of Al 336 alloy. Initially the Oil fired tilting furnace will be fired, and their after the vessel is allowed to be heated until it becomes ready for charging. Their after the charge components will be inserted onto the furnace in right proportions. Charge components that are used for the preparation of Al 336 alloy are Al 6063 wrought alloy, Al -50 wt. % Si, Al -50 wt. % Cu and Al -10 wt. % Ni master alloy. Chemical composition of Al 336 alloy (in wt. %) is given in table 1

TABLE 1 Chemical composition of Al 336 alloy

Al	Mg	Si	Fe	Mn	Cu	Ni	Zn
82.7	0.7	12	0.65	0.22	1.5	2	0.14

A. Al 336/ (0-10) Wt. % SiCp composite preparation

Stir casting method was used for the preparation of Al 336/ (0-10) wt. % SiCp composites [6]. Al 336/ (0-10) Wt. % SiCp composite preparation unit consist of a Stir casting furnace, Thyristor temperature controller, Heating furnace, Stirrer motor unit along with stirrer blade attached stirrer shaft, Stirrer speed regulator, Reinforcement addition unit (SiCp Injecting gun) and Permanent mould. Initially the temperature of stir casting furnace was set to a temperature above 890 ºC. The SiCp reinforcement was preheated to a temperature above 450 ºC for 4-5 hours using heating furnace.

When the stir casting furnace reaches the set value of temperature, Al 336 alloy that was selected as the matrix alloy was charged onto the furnace. After a required period of time the temperature of stir casting furnace was lowered to 725 ºC. When the molten Al 336 alloy reaches 725 ºC, lumps of magnesium (1 Wt %) wrapped in aluminium foil were plunged into the melt. Lumps of magnesium were added on to molten Al 336 alloy inordrer to improve the fluidity and Wettability between the matrix and SiC reinforcement. Their after the stirrer rod was inserted inside the graphite crucible containing molten Al 336 alloy which was driven by a speed variable motor and their by creating a vortex in the melt. After the formation of vortex in the melt region, preheated SiC particles were added on to the vortex, precisely at a uniform rate using injecting gun. The stirring of composite slurry was performed at 450 rpm and the mixture was stirred for 4-5 minutes. Upward and downward feed was given to stirrer rod for getting uniform mixing of SiC reinforcement in Al 336 alloy matrix. Molten Al 336/ SiCp composite mixture after thorough stirring in the crucible were taken out and poured onto a metallic mould. Thus by using this stir casting method Al 336/ 5 wt. % SiCp and Al 336/ 10 wt. % SiCp composites were prepared.

III. RESULTS

A. Microstructure

Microstructures of prepared Al 336 alloy, Al 336/ 5 wt. % SiC and Al 336/ 10 wt. % SiC composites were shown in Fig 1, Fig 2 and Fig 3. The microstructure analysis of Al 336 alloy showed α-aluminium, eutectic silicon and a few intermetallic compounds. But in the case of Al 336/ 5 wt. % SiCp and Al 336/ 10 wt. % SiCp composites, apart from α-aluminium and eutectic silicon, SiC particles were found to be distributed in a uniform manner.

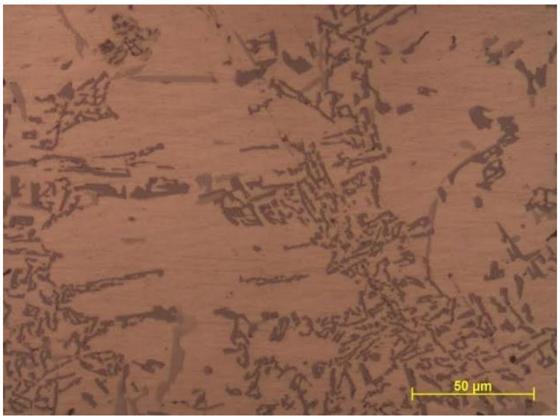

Fig. 1 Microstructure of Al 336 alloy at 500X Zoom

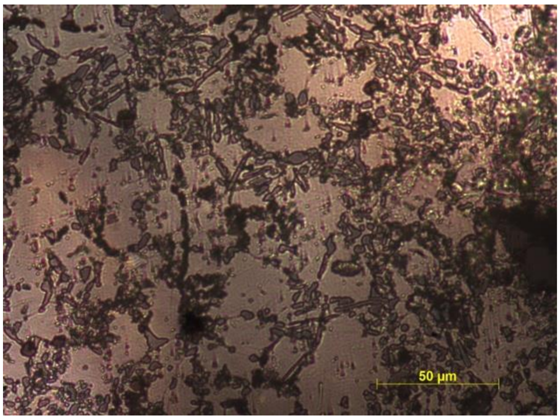

Fig 2. Microstructures of Al 336– 5 wt. % SiCp composite at 500X Zoom

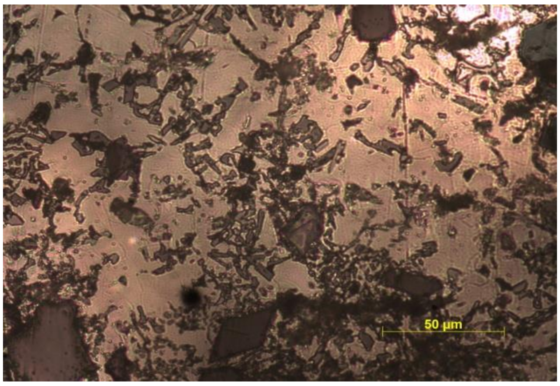

Fig 3. Microstructures of Al 336– 10 wt. % SiCp composite at 500X Zoom

B. Mechanical properties

Densities of prepared Al 336 alloy, Al 336 -5 wt %SiC and Al 336 -10 wt % SiC composites were 2.64 g/cc, 2.49 g/cc and 2.32g/cc respectively. Measurement of hardness of Al 336/ (0-10) wt. % SiC composites was done using Brinell hardness tester. Fig. 4 shows the variation in hardness value of Al 336/ (0-10) wt. % SiCp composite with respect to weight % SiCp before and after heat treatment. It is clear from fig.4 that hardness value increases with increase in weight % SiCp and after heat treatment conditions. Al 336 -10 wt. % SiCp composite processes the highest hardness and Al 336 alloy processes the lowest value of hardness. The Ultimate tensile strength of Al 336 -10 wt. % SiCp composites (241 MPa) was found to be the highest compared to Al 336 -5 wt. % SiCp (192 MPa) and Al 336 alloy (130 MPa) respectively.

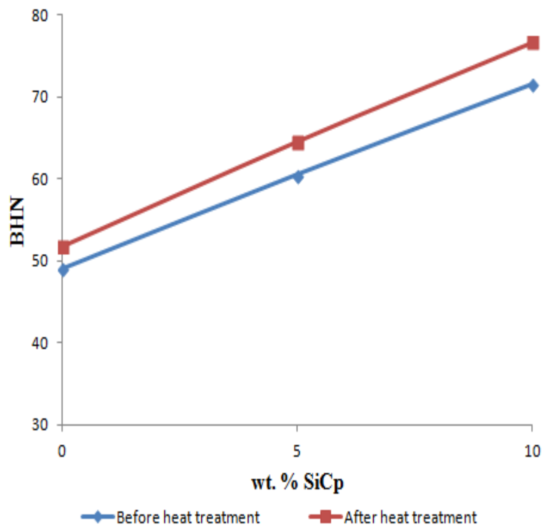

Fig. 4. Variation of BHN with wt. % SiCp

IV. CONCLUSION

- By using Stir casting method Al 336/ (0-10) wt. % SiCp composites were successfully prepared.
- Microstructure features of Al 336 alloy showed α-aluminium and eutectic silicon. Apart from α-aluminium and eutectic silicon, SiC particles were found to be uniformly distributed in Al 336 -5 wt. % SiCp and Al 336 -10 wt. % SiCp composites.
- Hardness values of Al 336 -10 wt. % SiCp composites was found to be the highest compared to Al 336 -5 wt. % SiCp composite and Al 336 alloy. Similorly Al 336 -5 wt. % SiCp composite have higher value of hardness than Al 336 alloy.
- Ultimate tensile strength of Al 336 -10 wt. % SiCp composites (241 MPa) was found to be the highest compared to Al 336 - 5 wt. % SiCp (192 MPa) and Al 336 alloy (130 MPa) respectively.
- Mechanical properties of Al 336/ (0-10) wt. % SiCp composites were found to be increased after heat treatment operations.

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