MANUFACTURING OF ALUMINIUM MATRIX COMPOSITE USING STIR CASTING METHOD

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ABSTRACT

Aluminium Matrix Composites (AMC's) are widely used in aerospace, automotive, structural and marine applications due to their high strength to weight ratio, corrosion resistance. In AMC one of constituent is aluminium or its alloy which forms a network called as matrix phase and other constituent is embedded in matrix made of harder material generally ceramic or non metallic material called as reinforcement. Various processing techniques are available for manufacturing of AMC's. Stir casting is one of the economical and extensively used methods to enhance attractive properties of AMC's. This paper presents an overview of stir casing process, process parameter and preparation of AMC using aluminium alloy as matrix phase and alumina (Al_2O_3) as reinforcement by varying their proportion.

KEYWORDS: Aluminium Matrix Composite, reinforcement, stir casting.

INTRODUCTION

Industrial technology is growing at very rapid rate and there is increasing need of materials. Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the always increasing demand of modern day technology, composites are most promising materials. Composite materials are those formed by combining two or more materials on a macroscopic scale to form useful third material [6]. Metal matrix composites (MMCs) possess attractive properties like high specific strength, specific modulus, damping capacity and good wear resistance compared to unreinforced alloys.
Aluminium and its alloys have attracted the most attention as matrix material in metal matrix composites. AMC's offer greater strength, improved stiffness, reduced density,

improved high temperature properties. These advantages can be used to achieve excellent properties. For example, elastic modulus of pure aluminium can be enhanced from 70GPa to 240GPa by reinforcing with 60 vol. % continuous aluminum fiber. On the other hand incorporation of 60 vol% alumina fiber in pure aluminium leads to decrease in the coefficient of expansion from 24 ppm/°C to 7 ppm/°C. Similarly it is possible to process Al-9% Si-20 vol% SiCp composites having wear resistance equivalent or better than that of grey cast iron [3]. In AMC one of the constituent is aluminum, which forms percolating network and is termed as matrix phase. The other constituent is embedded in this aluminum and serves as reinforcement, which is usually non-metallic and commonly ceramic such as SiC, Al_2O_3, SiO_2 etc. In present study stir casting method is used for manufacturing of AMC's having aluminium 356 alloy as a matrix and alumina as reinforcement.

PROCESSING OF AMC'S:

Primary process for manufacturing of AMC's at industrial scale can be classified into two main groups [3].

1) Liquid state processes:
a) Stir casting b) Infiltration process c) Reactive processing d) Spray deposition
2) Solid state processes:
a) PM processing b) Diffusion bonding c) Physical vapour deposition.

STIR CASTING:

Stir casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies [8]. In preparing metal matrix composites by stir casting method some of the factors that need considerable attention are as follows [7],

- To achieve uniform distribution of the reinforcement material
- To achieve wettability between the two main substances
- To minimize porosity in the cast metal matrix composite

PROCESS PARAMETERS:

a) Stirrer Design:

It is very important parameter in stir casting process which is required for vortex formation. The blade angle and number of blades decides the flow pattern of the liquid metal. The stirrer is immersed till two third depth of molten metal. All these are required for uniform distribution of reinforcement in liquid metal, perfect interface bonding and to avoid clustering.

b) Stirrer Speed:

Stirring speed is an important parameter to promote binding between matrix and reinforcement i.e. wettability. Stirring speed decides formation of vortex which is responsible for dispersion of particulates in liquid metal. In our project stirring speed is 300 rpm.

c) Stirring temperature:

Aluminium melts around 650°C, at this temperature semisolid stage of melt is present. Particle distribution depends on change in viscosity. The viscosity of matrix is mainly influenced by the processing temperature. The viscosity of liquid is decreased by increasing processing temperature with increasing holding time for stirring which also promote binding between matrix and reinforcement. Good wettability is obtained by keeping temperature at 800°C.

d) Stirring Time:

As stirring promote uniform distribution of reinforcement partials and interface bond between matrix and reinforcement, stirring time plays a vital role in stir casting method. Less stirring leads to non-uniform distribution of particles and excess stirring forms clustering of particles at some places. Stirring time is 5 minutes in our case.

e) Preheat temperature of reinforcement:

Casting process of AMC's is difficult due to very low wettability of alumina particles and agglomeration phenomenon which results in non-uniform distribution and poor mechanical properties [1]. Reinforcement is heated to 500°C for 40 minutes. It removes moisture as well as gases present in reinforcement.

d) Preheat temperature of mould:

Porosity is the major problem in casting. In order to avoid porosity preheating of mould is good solution. It helps in removing the entrapped gases from the slurry to go into the mould. It also enhances the mechanical properties of the cast AMC. Mold is heated to 500°C for one hour.

e) Addition of Magnesium:

Addition of Magnesium enhances the wettability [7]. However increase the content above 1wt.% increases viscosity of slurry and hence uniform particle distribution becomes difficult.

f) Reinforcement feed rate:

Non-uniform feed rate promotes clustering of particles at some places which causes the porosity defect and inclusion defect, so to have a good quality of casting the feed rate of powder particles must be uniform. The flow rate of reinforcements measured is 0.5 gram per second [5].

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g) Pouring of melt:

Pouring rate and pouring temperature plays significant role in quality of casting. Pouring rate of slurry must be uniform to avoid entrapping of gases. At this stage the temperature of melt is 800°C. The distance between mould and crucible also plays vital role in quality of casting.

Apart from these size of reinforcement plays significant role in quality of casting.

EXPERIMENTAL SETUP AND PROCEDURE:

The process of stir casting starts with placing empty crucible in the furnace. The heater temperature is then gradually increased up to 800°C. Aluminium alloy is cleaned to remove dust particles, weighed and charged in the crucible for melting. Required quantities of reinforcement powder and magnesium powder are weighed on the weighing machine. Reinforcements are heated for 45 minutes at a temperature of 500°C. When matrix was in the semisolid stage condition at 650°C, 1 % by weight of pure magnesium powder is used as wetting agent. After five minutes the scum powder is added which forms a scum layer of impurity on liquid surface which to be removed. Heater temperature is then gradually increased to 800°C. At this heater temperature stirring is started and continued for five minutes. Stirring rpm is gradually increased from 0 to 300 RPM with the help of speed controller. Preheated reinforcements are added during five minutes of stirring. Reinforcements are poured manually with the help of conical hopper. The flow rate of reinforcements measured is 0.5 gram per second. Stirrer rpm is then gradually lowered to the zero. Then molten composite slurry is poured in the metallic mould without giving time for reinforcement to settle down at crucible bottom. Mould is preheated at 500°C temperature for one hour before pouring the molten slurry in the mould. This is necessary to maintain slurry in molten condition throughout the pouring. While pouring the slurry in mould the flow of the slurry is kept uniform to avoid trapping of gas, also distance between crucible and mould plays a vital role in quality of casting.

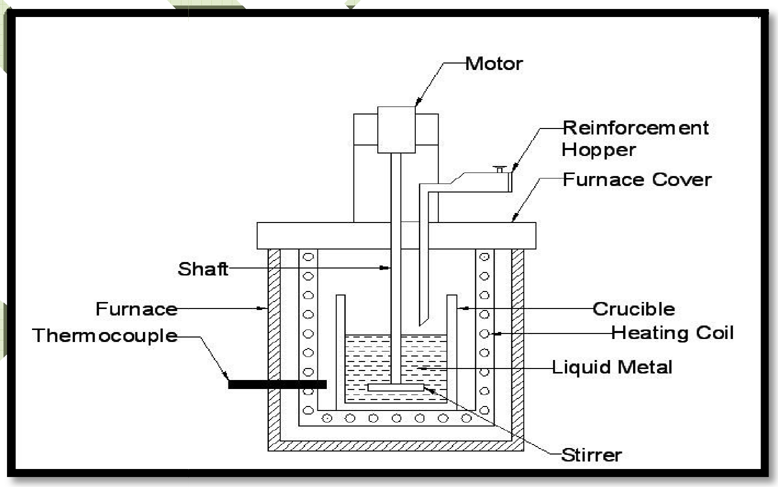

Fig 1 Schematic view of stir casting setup

CONCLUSIONS

Following conclusions are given from present work,

1) Stir casing process can successfully be used for manufacturing of AMC's having low density and enhanced mechanical properties.

2) Stir casting process is cost effective and conventional route for manufacturing of composite material.

3) Material having isotropic nature can be manufactured successfully.

4) Preheating of mould reduces porosity and enhances mechanical properties.

5) Addition of Magnesium is important to increase wettability.

6) Design of stirrer decides the flow pattern of melt.

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