

LIQUID STATE FABRICATION OF METAL MATRIX COMPOSITE USING STIR CASTING

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ABSTRACT

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. Metal matrix composites possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. The aim of present study is to find the suitable method for the fabrication of metal matrix composite. Casting route is preferred as it is less expensive and amenable to mass production. Among the entire liquid state production routes, stir casting is the simplest and cheapest one. 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.

Keywords: *Material, Metal matrix composite, reinforcement, stir casting, strength.*

I. INTRODUCTION

Metal Matrix Composites are composed of a metallic matrix (Al, Mg, Fe, Cu etc) and a dispersed ceramic (oxide, carbides) or metallic phase (Pb, Mo, W etc). Ceramic reinforcement may be silicon carbide, boron, alumina, silicon nitride, boron carbide, boron nitride etc. whereas Metallic Reinforcement may be tungsten, beryllium etc. MMCs are used for Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs and a variety of other applications. From a material point of view, when compared to polymer matrix composites, the advantages of MMCs lie in their retention of strength and stiffness at elevated temperature, good abrasion and creep resistance properties [1]. Most MMCs are still in the development stage or the early stages of production and are not so widely established as polymer matrix composites. From a material point of view, when compared to polymer matrix composites, the advantages of MMCs lie in their retention of strength and stiffness at elevated temperature, good abrasion and creep resistance properties. Most MMCs are still in the development stage or the early stages of production and are not so widely established as polymer matrix composites. The biggest disadvantages of MMCs are their high costs of fabrication, which has placed limitations on their actual applications. Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed as reinforced particles with a molten matrix

metal by means of mechanical stirring [2]. The liquid composite material is then cast by conventional casting method sand may also be processed by conventional Metal forming technologies.

II. SELECTION OF PROCESS FOR FABRICATION OF METAL MATRIX COMPOSITES

The methods of liquid state fabrication of metal matrix composites are:

- Stir casting
- Infiltration
- Gas Pressure Infiltration
- Squeeze Casting Infiltration
- Pressure Die Infiltration

2.1 Stir Casting Process

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 method sand may also be processed by conventional Metal forming technologies [3]. The Stir casting setup is shown in Fig.1



Fig.1 Stir casting

2.2 Infiltrations

Infiltration is a liquid state method of composite materials fabrication, in which a preformed dispersed phase e.g. ceramic particles, fibers, are soaked in a molten matrix metal, which fills the space between the dispersed phase inclusions. The motive force of an infiltration process may be either capillary force of the dispersed phase or an external pressure applied to the liquid matrix phase. Infiltration is one of the methods of preparation of tungsten-copper composites.

2.3 Gas Pressure Infiltration

Gas pressure infiltration is a forced infiltration method of liquid phase fabrication of metal matrix composites, using a pressurized gas for applying pressure on the molten metal and forcing it to penetrate into a preformed dispersed phase. In contrast to the methods using mechanical force, Gas Pressure Infiltration results in low damage of the fibers. The Figure 1.2 shows the Schematic view of Gas pressure infiltration.

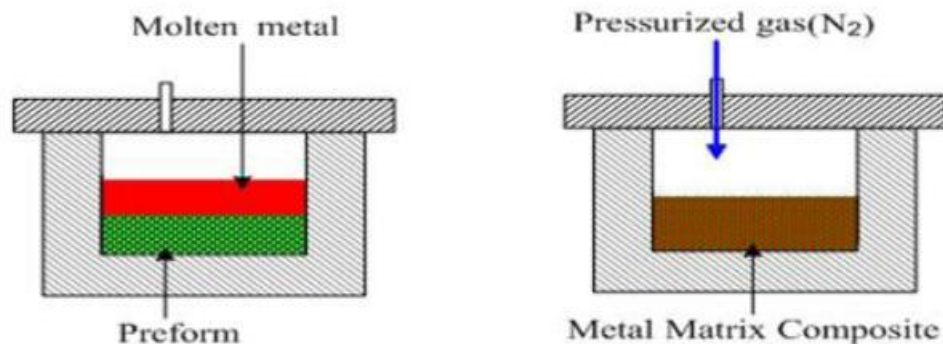


Fig.2 Gas Pressure Infiltrations

2.4 Squeeze Casting Infiltration

Squeeze casting infiltration is a forced infiltration method of liquid phase fabrication of metal matrix composites, using a ram for applying pressure on the molten metal and forcing it to penetrate into a dispersed phase, placed into the lower fixed mold part. Infiltration method is similar to the squeeze casting technique used for metal alloys casting. Figure 1.3 shows the Schematic view of squeeze casting Infiltration.

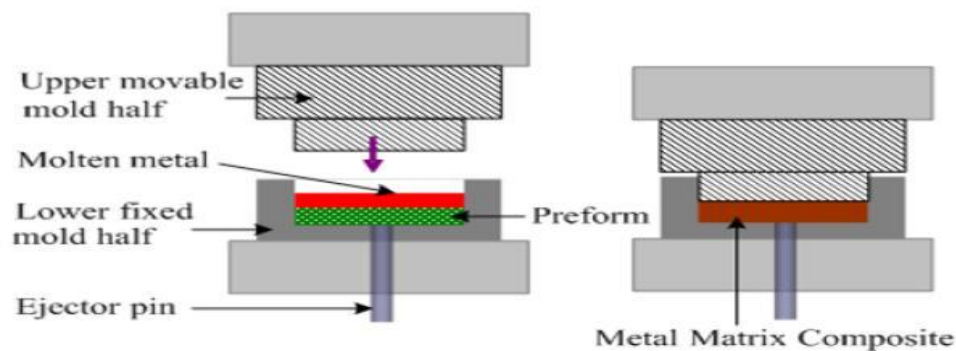


Fig. 3 Squeeze Casting Infiltrations

2.5 Pressure Die Infiltration

Pressure Die Infiltration is a forced infiltration method of liquid phase fabrication of Metal Matrix Composites, using a Die casting technology, when a preformed dispersed phase is placed into a die which is then filled with a molten metal entering the die through as pour and penetrating into the perform under the pressure of a movable piston[4].

By the analysis of various methods of liquid state fabrication of metal matrix composites and their advantages and disadvantages. The simplest and the most cost effective method of liquid state fabrication is Stir Casting.

III. METHODOLOGY FOR THE FABRICATION OF METAL MATRIX COMPOSITE BY USING STIR CASTING

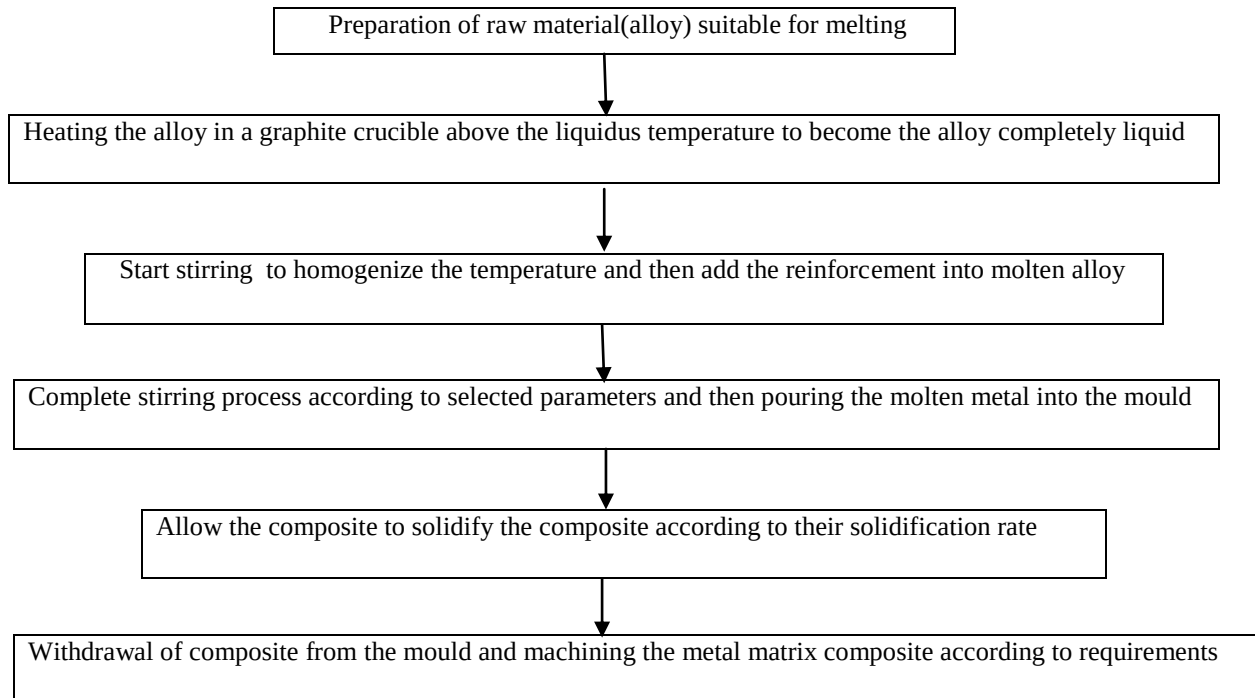


Fig. 4 Flow Chart shows various steps involved in Stir Casting

A stir casting setup as shown in Fig.5, including resistance Muffle Furnace and a stirrer assembly is used to synthesize the composite[3]. The stirrer assembly consisted of a graphite stirrer, which is connected to a variable speed vertical drilling machine with range of 80 to 290 rpm by using a shaft. The stirrer consisted of three blades at an angle of 120° apart. Graphite crucible placed inside the furnace. During melting operation, approximately 1Kg of alloy in solid form melted at its melting point in the resistance furnace and then preheating of reinforcement material is done for one hour to remove moisture and gases. The speed of the stirrer gradually rose to 290 rpm and the preheated reinforced particles added with a spoon at the rate of 10- 20g/min into the melt. The speed controller maintained a constant speed of the stirrer, as the stirrer speed slow down by 50-60 rpm due to the increase in viscosity of the melt when particulates added into the melt. After the addition of reinforcement, stirring continued for 8 to 10 minutes for proper mixing of prepared particles in the matrix. The melt kept in the crucible for approximate half minute in static condition and then it was poured into the mould and solidification of the metal matrix composite starts according to the solidification rate and solidification time of composite material. After solidification, metal matrix is removed from the mould and ready for use and testing after machining.

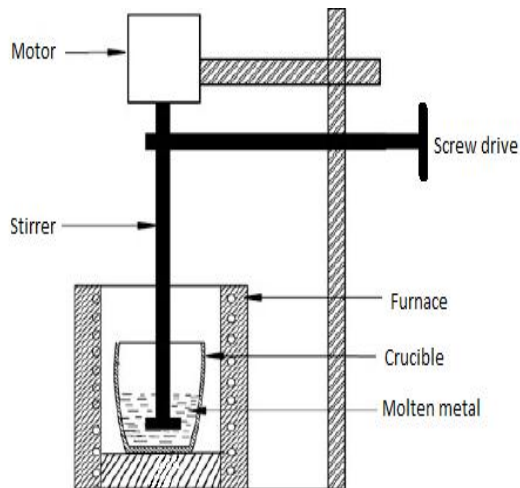


Fig. 5- Stir Casting setup



Fig. 6 Stirring of Molten Metal



Fig. 7 Pouring MMCs in mold



Fig. 8 Solid MMCs in mold



Fig. 9 Metal matrix composites prepared by Stir Casting

IV. CONCLUSION

Metal matrix composites have emerged as a class of materials capable of advanced structural, aerospace, automotive, electronic, thermal management and wear applications. These alternatives to conventional materials provide the specific mechanical properties necessary for elevated and ambient temperature applications. The

present study shows that there are a lot of the possibilities of obtaining the new composite materials with required structure joining positive properties composite material components. It's also observed that stir casting is also a most effective and economical method for the fabrication of metal matrix composite.

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