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Study on Behavior of Ilmenite as Reinforcing Element on Properties of Al2014 Based MMC by Stir Casting Method

Jagannath Pattar[1], Vundi Saichandra[2]
[1,2]*Asst. Professor, Dept. of ME, Global Institute of Engineering and Technology*
Email: jagannathpattar12@gmail.com[1], saichandra119@gmail.com

Abstract: The demand for aluminum hybrid metal matrix composites has increased in recent times due to their enhanced mechanical properties for satisfying the requirements of advanced engineering applications. The performance of these materials is greatly influenced by the selection of an appropriate combination of reinforcement materials. Manufacturing of aluminium alloy based casting composite materials via stir casting is one of the prominent and economical route for development and processing of metal matrix composites materials. Properties of these materials depend upon many processing parameters and selection of matrix and reinforcements. In this paper, an attempt has been made to prepare an Al2014 metal matrix composite reinforced with particulates with different weight fractions of ilmenite as reinforcing element by a stir-casting process. The experimental study has been carried out on the prepared composite to investigate the mechanical properties due to the addition of multiple reinforcement materials. The density and mechanical properties, such as ultimate tensile strength, yield strength, impact strength, and the hardness and wear characteristics of the proposed composite, are compared with those of unreinforced Al2014. The experimental investigation is also aimed at observing the variation of properties with a varying weight percentage of the reinforcement materials. AL2014 compositions namely pure 5%, 10%, 15%, by weight were tested which is reinforced with Ilmenite (FeTiO3). The outcome of the experimental investigation revealed that the proposed hybrid composite with 5%, 10% & 15% of total reinforcement material exhibits high hardness, high yield strength, and low wear rate but no considerable improvement in impact strength.

Index Terms— Stir casting process, Aluminium Matrix composite, Reinforcement, Mixing and Agitation.

1. INTRODUCTION

1.1. Stir Casting Process

Metal matrix composites (MMC) are a range of advanced materials providing properties have not achieved by conventional materials. This stir casting material properties increased strength, high elastic models, higher service temperature, improve wear resistance, decreased part weight, low thermal shocks, high electrical and thermal conductivity, and low coefficient of thermal expansion compound compared to conventional metal and alloys, the excellent mechanical properties of these materials and the relatively low producing cost make them very attractive for a variety of application in automotive and aerospace industries.

Fig 1.1 STIR CASTING MACHINE

1.2 Stir Casting Process

In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring. Stir casting of metal matrix composites was initiated in 1968, when S. Ray introduced alumina particles into an aluminium melt by stirring molten aluminum alloys containing the ceramic powders. Mechanical stirring in the furnace is a key element of this process. The resultant molten alloy, with ceramic particles, can then be used for die casting, permanent mold casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement.

The cast composites are sometimes further extruded to reduce porosity, refine the microstructure, and homogenize the distribution of the reinforcement. A major concern associated with the stir casting process is the segregation of reinforcing particles which is caused by the surfacing or settling of the reinforcement particles during the melting and casting processes. The final distribution of the particles in the solid depends on material properties and process parameters such as the wetting condition of the particles with the melt, strength of mixing, relative density, and rate of solidification. The distribution of the particles in the molten matrix depends on the geometry of the mechanical stirrer, stirring parameters, placement of the mechanical stirrer in the melt, melting temperature, and the characteristics of the particles added.

An interesting recent development in stir casting is a two-step mixing process. In this process, the matrix material is heated to above its liquids temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state. At this stage, the preheated particles are added and mixed. The slurry is again heated to a fully liquid state and mixed thoroughly. This two-step mixing process has been used in the fabrication of aluminum. Among all the well-established metal matrix composite fabrication methods, stir casting is the most economical. For that reason, stir casting is currently the most popular commercial method of producing aluminum based composites.

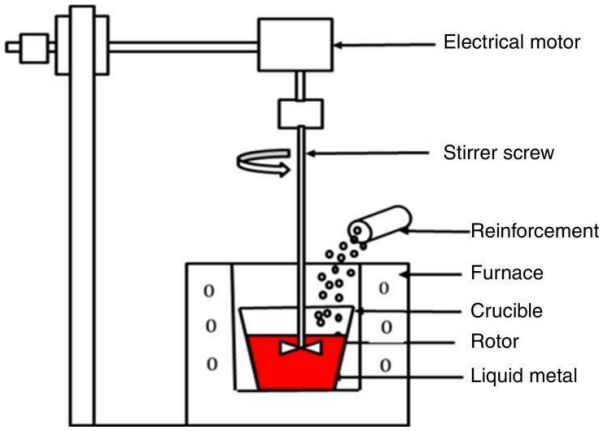

Fig 1.2 Stir Casting Process

1.3 Process Performed

1.3(a) For Base Metal

At first, we have to weigh 600g of Aluminium 2014. Now we have to set Stir casting machine at a temperature of about 900°c, which has a capacity of 1050°c. Now the weighed Al2014 is placed in a crucible and is placed in the Stir casting machine to be melted**.** The die we are using must also be preheated upto a certain temperature so that the melted form and the die can be resistable. The melted Al2014 is poured into the preheated die, which gives us four samples.

1.3(b) For 5% Ilmenite

At first we have to weigh 570g of Aluminium 2014 and 30g of Ilmenite powder. That means we are adding 5% Ilmenite to Al2014. Now we have to set Stir casting machine at a temperature of about 900°c, which has a capacity of 1050°c. Now the weighed Al2014 is placed in a crucible and is placed in the Stir casting machine to be melted. Mean while we have to preheat the reinforcement we are using Ilmenite powder in the Muffle furnace which is set upto a temperature of 600°c, for about half an hour. The die we are using must also be preheated upto a certain temperature so that the melted form and the die can be resistable. Once the Al2014 is melted it must stirred. The preheated Ilmenite powder must be taken into aluminium coil and must be wrapped. In the melted liquid metal the rotor of the machine must be placed, so that it gets stirred. At below of the machine the speed control of the stirrer is placed, using that we have to adjust the speed. The stirring speed is upto 1200rpm. We must pour the reinforcement that is Ilmenite powder wrapped in the aluminium coil. Here we also adding Magnesium which is also wrapped in the aluminium coil. While stirring both of them are added and must be stirred upto it mixes well. It takes about seven minutes to mix well. Now the mixture is poured into the preheated die having four holes, so that we obtain totally four samples.

1.3(c) For 10% Ilmenite

At first we have to weigh 540g of Aluminium 2014 and 60g of Ilmenite powder. That means we are adding 10% Ilmenite to Al2014. Now we have to set Stir casting machine at a temperature of about 900°c, which has a capacity of 1050°c. Now the weighed Al2014 is placed in a

crucible and is placed in the Stir casting machine to be melted. Mean while we have to preheat the reinforcement we are using Ilmenite powder in the Muffle furnace which is set upto a temperature of 600°c, for about half an hour. The die we are using must also be preheated upto a certain temperature so that the melted form and the die can be resistable. Once the Al2014 is melted it must stirred. The preheated Ilmenite powder must be taken into aluminium coil and must be wrapped. In the melted liquid metal the rotor of the machine must be placed, so that it gets stirred. At below of the machine the speed control of the stirrer is placed, using that we have to adjust the speed. The stirring speed is upto 1200rpm. We must pour the reinforcement that is Ilmenite powder wrapped in the aluminium coil. Here we also adding Magnesium which is also wrapped in the aluminium coil. While stirring both of them are added and must be stirred upto it mixes well. It takes about fifteen minutes to mix well. Now the mixture is poured into the preheated die having four holes, so that we obtain totally four samples

1.3(d) For 15% Ilmenite

At first we have to weigh 510g of Aluminium 2014 and 90g of Ilmenite powder. That means we are adding 15% Ilmenite to Al2014. Now we have to set Stir casting machine at a temperature of about 900°c, which has a capacity of 1050°c. Now the weighed Al2014 is placed in a crucible and is placed in the Stir casting machine to be melted. Mean while we have to preheat the reinforcement we are using Ilmenite powder in the Muffle furnace which is set up to a temperature of 600°c, for about half an hour. The die we are using must also be preheated up to a certain temperature so that the melted form and the die can be resistible. Once the Al2014 is melted it must stirred. The preheated Ilmenite powder must be taken into aluminium coil and must be wrapped. In the melted liquid metal the rotor of the machine must be placed, so that it gets stirred. At below of the machine the speed control of the stirrer is placed, using that we have to adjust the speed. The stirring speed is upto 1200rpm. We must pour the reinforcement that is Ilmenite powder wrapped in the aluminium coil. Here we also adding Magnesium which is also wrapped in the aluminium coil. While stirring both of them are added and must be stirred upto it mixes well. It takes about twenty minutes to mix well. Now the mixture is poured into the preheated die having four holes, so that we obtain totally four samples.

1.3(e) Equipment Used while Casting

Fig 1.3 Weighing machine

Fig 1.4 Heating foil

Fig 1.5 Muffle Furnace

Fig 1.6 Magnesium in chips form

Weighing machine is used for weighing magnesium, aluminium, ilmenite powder. Heating oil is used for preheating of the coil. Muffle furnace is used for preheating of ilmenite powder. Fig 1.6 clearly shows the chips form of magnesium.

1.3(f) Specimen obtained after Casting

Fig 1.7 Specimens shape

Fig 1.8 Specimen after Turning

After casting process had completed we obtain four samples for each cast which are shown in above Fig 1.7. Those were the samples which is taken to next step that is for turning operation so that they can be shaped to certain dimensions that are used for future experiments like tensile test etc,. The turning operation gives us the sample shape as shown in above Figure 1.8

2. CONCLUSION

In present study the aim is study the various operating parameter of stir casting process. And to prepare AMC with help of stir casting process. For this Aluminium (2014) is selected as matrix phase while ilmenite (FeTiO3). act as reinforcement. With the help of stir casting process we had successfully manufactured AMC at less cost. Stir casting can be a promising and economically viable route for the production of particle reinforced MMCs. Stress at elastic limit is significantly affected by the stirring time and stirring speed. The ultimate stress is significantly affected by time than the speed. As time increases ultimate strength also decreases. During solidification settling time must be minimized. Process parameters plays a vital role on properties of Al based MMC. In case of Stir casting, process parameters like stirring rate, stirring temperature, pouring temperature etc., are to be maintained for achieving improved behavior and performance in the MMCs. While manufacturing AMC we come to know that process parameter are play a major role for uniform distribution of reinforcement.

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