

Conception and Construction of a Bottom Pouring Stir Casting Furnace Using Carrier Gas

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Abstract

Stir casting is an appealing processing method for manufacturing MMCs among the various composite materials processing methods. It is reasonably priced and provides a diverse range of materials and processing options. The stir casting method includes introducing pre-treated or warmed ceramic particles into the spinning impeller's molten alloy vortex. In this technique, the distribution of the reinforcement material in the matrix should be homogeneous, and the wet ability between the molten matrix and reinforcement particles should be adjusted in order to produce the best characteristics of the metal matrix composite. This technique may achieve appropriate integration by carefully selecting process parameters such as pouring temperature, stirring speed, reinforcement preheating temperature, carrier gas usage, and so on. Controlling usually undesired characteristics such as porosity caused by gas entrapment during mixing and oxide inclusions is critical to the effectiveness of stir casting. The current research focuses on the design of various forms of mechanical stirrers and their effects on vortex generation and dispersion, as well as the usage of a carrier gas such as Argon.

Keywords: Stir Casting, Reinforcement Preheating Temperature, Mechanical Stirrers, Spinning Impeller

INTRODUCTION

Stir casting is a basic production method in which a mechanical stirrer is inserted into the melt to create a vortex that mixes reinforcement into the matrix material. Because of its simplicity and ease of control of the composite structure, it is a good method for mass manufacturing of metal matrix composites. After melting the matrix material to a certain temperature, mechanical stirring is started by immersing the stirrer in the graphite crucible to form a vortex for a certain amount of time, then reinforcements particles are poured at a constant feed rate at the centre of the vortex using the feeder provided in the setup, and the stirring process is continued for a certain amount of time after the reinforcements have been completely fed. The molten liquid is then placed into a prepared mould and let to cool and solidify naturally. The following are important elements of primary processing:

- The reinforcing materials are distributed evenly.
- Achieving wet ability between the two primary materials.
- Keeping the porosity of the cast metal matrix composite to a minimum.

Carrier Gas

The carrier gas is an inert gas that does not react with the molten metal; nevertheless,

only the ceramic powder that is present in the carrier gas will combine with the molten metal, resulting in grain refinement.

LITERATURE REVIEW

Blade Design

Blade design has the greatest impact on the quality of a cast component. Blades aid in:

1. Particles are transferred into the liquid metal.
2. Keeping the particles in a suspended condition.
3. Increasing the solid's surface energies.
4. The liquid matrix alloy's surface tension is reduced.
5. At the particles-matrix interface, lowering the solid-liquid interfacial energy.

Figure 1 depicts the various blade designs that may be used to introduce reinforcement particles into the mould. Coating the reinforcement particles, adding alloying materials to the molten matrix alloy, treating the particles, and ultrasonic irradiating the melt and using carrier gas have all been used to enhance the wetting of the reinforcement particles with a molten matrix alloy. Mg has also been extensively utilised as an addition agent to enhance the wetting of various ceramic particles, such as silicon carbide & mica, by adding it to molten aluminium.

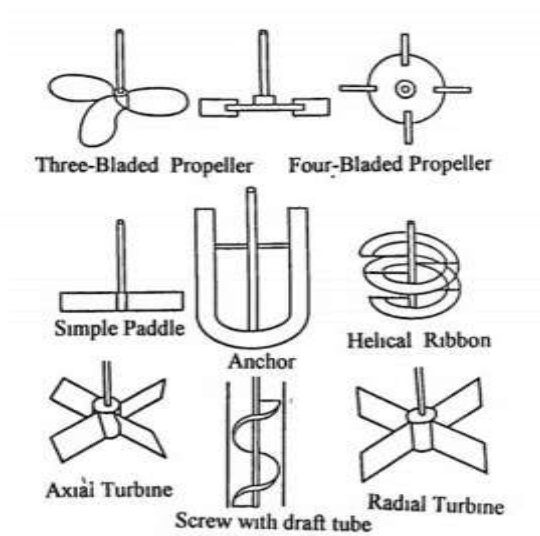


Figure 1: Different types of stirrer used in stir casting.

Porosity in Cast Metal Matrix composites

In a cast metal matrix composite, the volume fraction of porosity, as well as its size and distribution, play a significant role in regulating the material's mechanical characteristics. The corrosion resistance of the casting may also be harmed by this kind of composite flaw. As a result, porosity levels must be maintained to a minimum. While porosity cannot be completely prevented throughout the casting process, it may be managed. Porosity is caused by three factors in general:

- Gas entrapment during mixing,
- Hydrogen evolution
- Shrinkage during solidification

The process parameters of holding periods, stirring speed, and the size and location of the impeller, according to Zhou et al. will affect the development of porosity. The amount of gas porosity in casting is shown to be more dependent on the volume fraction of inclusions than the quantity of dissolved hydrogen.

LITERATURE GAP

Drawbacks

The stir casting method has been used to manufacture composite materials; however the cast composite materials include flaws such as porosity, blowholes, and uneven reinforcing particle distribution.

Overcomes

The employment of a stirrer and a carrier gas eliminates these flaws. Stirring aids in

the uniform distribution of reinforcement particles in the matrix material, while the carrier gas aids in the incorporation of reinforcement particles into the matrix material.

METHODOLOGY

The following are the study's goals, which were derived after a thorough literature review, and the technique used to achieve them is described in the next section.

- The initial goal is to create a CAD model for the suggested stir casting setup using several blade designs.
- The furnace body is constructed in conjunction with the furnace frame. The furnace structure is constructed of mild steel bar that has been welded and connected to create the body, which is made of mild steel sheet.
- After constructing the frame, the inside surfaces of the frame plates are covered with insulating paint to decrease the furnace's heat conductivity. Insulating bricks constructed of refractory materials cover the inner walls of the frame, acting as insulators and trapping heat. Inside is a graphite crucible with the appropriate heating setup.
- The mechanical stirrer is the next step in the stir casting process. The mechanical stirrer is connected with a variable speed motor in the stir casting process to regulate the stirrer speed, which is 500 to 600 rpm. Impeller stirrers come in a variety of stages, including single stage, double stage, and multistage impellers. Single stage impeller stirrers are commonly used in the fabrication of composites due to their flexibility and ability to avoid excessive vortex flow.
- Double stage and multi stage stirrers are primarily used in the chemical industry, whereas single stage impeller stirrers are commonly used in the fabrication of composites due to their flexibility and ability to avoid excessive vortex flow. The flow of liquid metal is determined by the blade angle and number of blades. The stirrer is submerged in the molten metal up to two-thirds depth
- Attachment for Inert Gas: A gas that does not conduct chemical reactions under certain circumstances is known as an inert gas. Argon gas is utilised as an inert gas, and the supply connection must be established at the same time as the furnace.

It is intended to construct a stir casting setup with different stirrer and carrier gas designs in accordance with the stated goals. The schematic design of a stir casting furnace with a carrier gas connection is shown in Fig. 2. Figure 3 depicts a computer-aided design (CAD) model of

stirrers with various blade shapes, blade numbers, and blade profiles. The experimental work will be done to assess the furnace's operation, and the primary goal of this study is to create a stir casting furnace that can manufacture composite materials with few flaws.

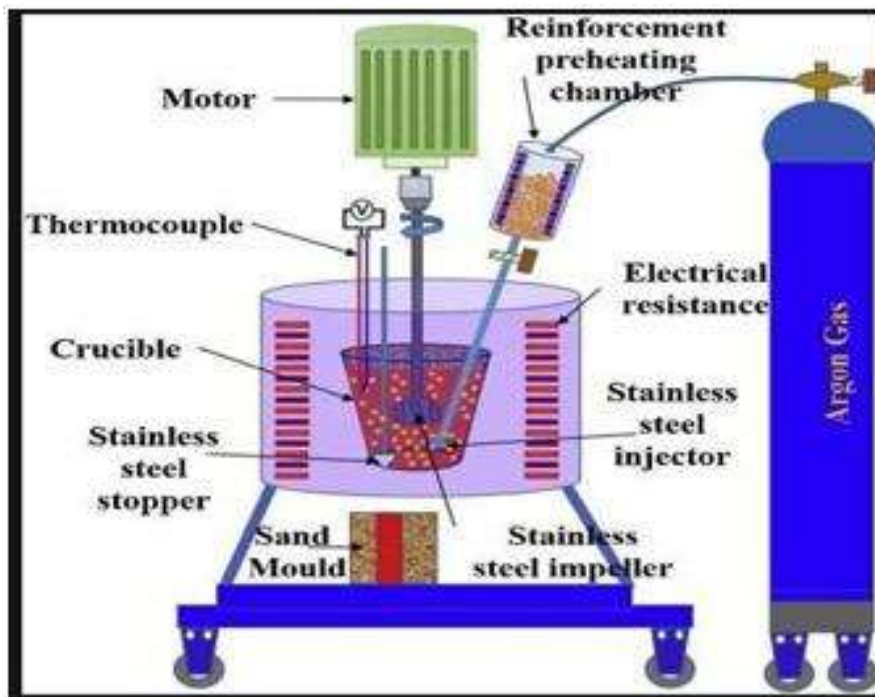


Figure 2: Schematic diagram of stir casting furnace



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Figure 3: CAD model of stirrer designed.

CONCLUSION

The following is a summary of the current project:

- Stir casting has been discovered to be the most cost-effective method of producing MMCs.
- The matrix material, reinforcement material, weight % of reinforcement, shape of the reinforcement particle, size of reinforcement particle, and processing temperature all influence the properties of composite materials.
- Preheating the reinforcement particles improves the interface response between the matrix and the reinforcement materials, resulting in better characteristics.
- Up to 30% by weight of reinforcement may be effectively incorporated into the matrix material, but any higher proportion results in the development of agglomerates.
- Adding magnesium to the molten metal will improve the reinforcing materials wet ability with the matrix material.
- Using a stirrer to mix reinforcement particles allows for improved particle dispersion in the matrix material and the breaking up of agglomerates, increasing the composites' strength.
- Use of two-step reinforcement particle mixing, i.e., integration of reinforcement particles in the matrix in two stages, with partial reinforcement added first, followed by stirring, and the remaining reinforcement material added last, followed by stirring.
- The use of strong ceramic reinforcing materials improves the materials' mechanical and wear resistance characteristics.
- Secondary processing methods are used to reduce flaws in original processed or cast materials.
- Secondary processing aids in the breaking up of agglomerates, followed by consistent reinforcing material distribution.
- Secondary-processed materials are stronger than cast-in-place materials.

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