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Stir Casting: A Versatile Method for Producing High-Quality Metal Matrix Composities.

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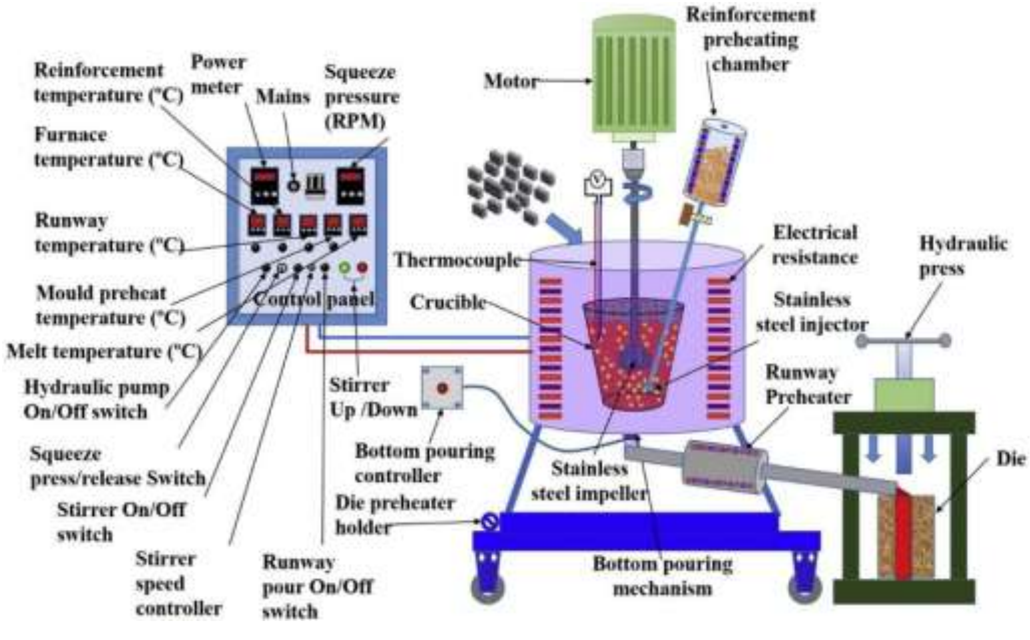
ABSTRACT:

Due to its simplicity, adaptability, and affordability, stir casting is evaluated in this review paper as a viable technique for creating Metal Matrix Composites (MMCs). The study examines several aspects of the stir casting process, such as the design of the furnace, the characteristics of the composites, manufacturing difficulties, and prospective research directions. Recommendations are also made for the design of the furnace, the choice of the matrix and reinforcement materials, the process variables, and additives in the review. The research presents simulation studies that were carried out to optimize particle distribution while highlighting the crucial issue of achieving a homogeneous dispersion of reinforcement particles in the matrix. The research offers simulation studies that enhance parameters for uniform particle dispersion in batch compo casting to overcome this problem. Overall, this review is pertinent to researchers and industry professionals who are interested in the manufacturing of MMCs utilizing stir casting and offers insightful information.

INTRODUCTION:

By integrating ceramic or metallic particles into a metallic matrix, stir casting is a popular casting technique for creating metal matrix composites (MMCs). In stir processing or liquid-state processing are two terms used to describe this procedure. To obtain a uniform dispersion of the particles in the matrix, the particles are added to the molten metal and stirred afterward in stir casting**.** A stirring mechanism is used in the procedure to induce a vortex in the liquid metal. A uniform distribution results from the particles' easier integration few different types of stirring devices that can be used. The characteristics of the metal and the particles, their size, and the level of mixing required all play a role in the choice of stirring mechanism. Due to its ease of use, low cost, and capacity for large manufacturing, stir casting has grown in favour. Because it enables the integration of different types and sizes of particles into the matrix, improving mechanical and physical properties of the final composite, it is especially well suited for creating MMCs. The size, shape, matrix material, kind, and quantity of the particles, as well as the processing circumstances, are some of the variables that affect how the composite behaves.



Schematic diagram of stir casting furnace. [9]

SETUP: The stir casting system looks like this. For the manufacturing of AMCs, a conical-shaped graphite crucible is employed since it can resist temperatures substantially higher than the requisite 680°C. In addition, at these temperatures, graphite won't react with metal. A high ceramic alumina muffle, in which this crucible is housed, is used. Which heating element is coiled around. The heating element is a coil called Kanthol-A1. Resistance heating furnaces are this type of furnace. Within 45 minutes, it can reach 900°C. Aluminium is highly reactive with air oxygen when it is liquid. When it comes into touch with fresh air, oxide production happens. As a result, the entire stirring procedure is carried out in a sealed chamber with nitrogen gas acting as an inert gas to prevent oxidation. With the aid of steel sheet, a closed chamber is produced. Comparing this to an open chamber minimizes heat loss and gas transfer. The liquid's current temperature is recorded using a K type temperature thermo-couple with a working range of -200°C to 1250°C. The material chosen for the stirrer shaft is EN 24 due to its resistance to atmospheric corrosion. A flange coupling connects the shaft's one end to a 0.5 hp PMDC motor. Blades are welded at the opposite end, meanwhile. A 45°C weld is used to attach 4 blades to the shaft. To prevent the particles from coagulating and segregating, reinforcement particles must be fed at a steady rate. Using a hopper can help with this. By heating aluminium alloy ingots in a furnace, an aluminium alloy matrix is created in the crucible. Initially moving at a sluggish 30 rpm, the stirring action picks in speed as it goes. utilising a speed controller, slowly rotating between 300 and 600 rpm. Al2O3, SiC, and graphite are a combination of reinforcements that must be integrated into the metal matrix at a semisolid level about 640 °C. It is recommended that you use a 5-minute dispersion time. Then, in order to ensure that the slurry is totally liquid, it is heated to a temperature above melting point.

PROCESS: Place the empty crucible in the muffle to begin the stir casting operation. The heater's temperature is initially set to 500°C and then gradually increased to 900°C. The muffle's high temperature promotes rapid melting of the aluminium alloy, lowers the level of oxidation, and improves the wettability of the reinforcing particles in the matrix metal. the aluminium alloy Al6061utilised as a Matrix resource. From the raw material, which is a round bar, the necessary amount of aluminium alloy is cut. The aluminium alloy is weighted after being cleaned to remove any dust particles, and it is then placed into the crucible to melt. To establish an inert atmosphere around the molten matrix, nitrogen gas is employed as an inert gas during melting.

As reinforcement, graphite, silicon carbide, and alumina powder are all employed. Pure magnesium powder is used as a wetting agent in an amount of 1% by weight. In the crucible, 700 grams of molten composite were treated at once. Magnesium powder and reinforcement powder in the necessary amounts are weighed on the weighing machine. Finally, using a blending machine, it is thoroughly combined with each other. The measured flow rate for reinforcements was 0.5 grams per second. Dispersion was measured in time. Counted as 5 minutes. To ensure that the slurry was totally liquid, it was heated and held at a temperature of 900°C after stirring for 5 minutes at the semisolid stage. Next the stirrer's RPM was steadily decreased till it reached zero. The stir casting device is manually positioned to the side, and then molten composite slurry is poured into the metal mould. Before putting the molten slurry into the mould, it is warmed to a temperature of 500°C mould. By doing this, the slurry is kept molten throughout the pouring process. To prevent gas from getting trapped, the slurry flow must be uniform while being poured into the mould. In order to shorten the period that the particles must settle in the matrix, it is then quickly quenched with the aid of air.

PARAMETERS:

Blade Angle: -The blade angle and number are important variables that affect how the liquid metal flows while being stirred. The blade with 45° and 60° angles will produce a uniform distribution. The recommended number of blades is 4. Blade position should be 20 mm above crucible's bottom. The flow pattern is greatly influenced by the blade pattern.

Stirring time: Stirring helps to generate a precise interface binding between the matrix and reinforcement as well as encourages uniform particle distribution throughout the liquid. The b/w matrix stirring time in the processing of composites, reinforcing is regarded as a key element. The flow pattern in metal should be from outward to inward to provide homogeneous distribution of reinforcement in the matrix.

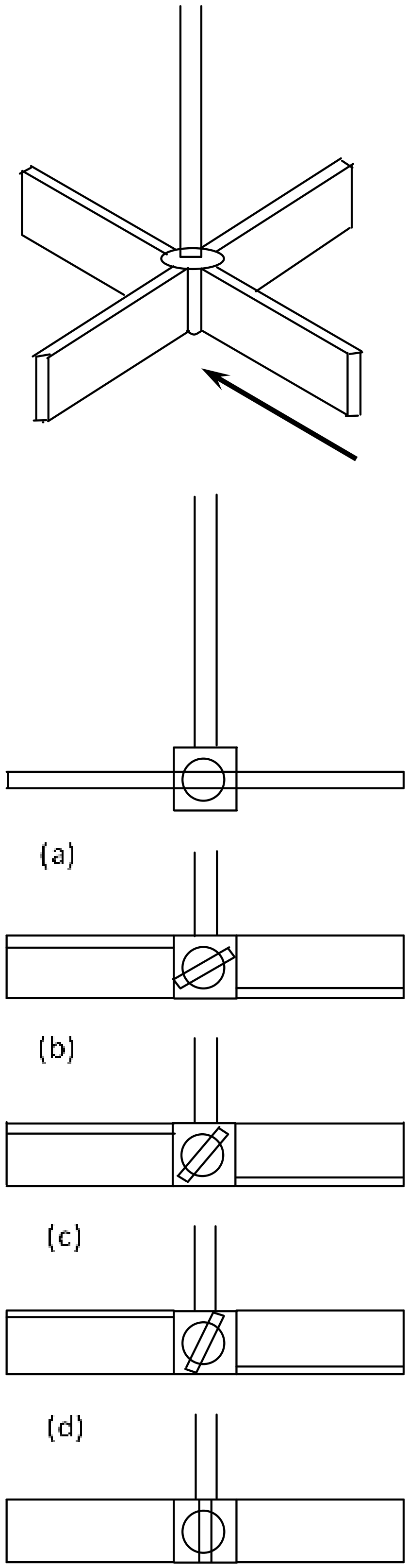
Inert Gas: -An oxide layer will be produced at the top when the aluminium melts and begins to react with the oxygen in the surroundings. Yet, because it will be tough to break, this oxide layer will prevent further oxidation. Hence, mixing metal reinforcement with such a layer will be quite challenging. Thus, inert gases like nitrogen were utilized to prevent this.

Preheated Temperature of Mould: The main flaw in casting is porosity. The use of permanent mould can help prevent this preheating. It will assist in releasing trapped gases from the slurry in the mould. Moreover, it will improve the cast AMC's mechanical qualities. To prevent bubble formation while pouring molten metal, keep the pouring rate consistent.

Stirring speed: Speed of stirring is a crucial process parameter because wettability, or the bonding of the matrix and reinforcement, is promoted by stirring. The rate of stirring will directly affect how the molten metal flows. Poor reinforcement and matrix mixing will not be encouraged by parallel flow. As a result, the flow pattern should have regulated turbulence. The greatest flow pattern is one that moves from within to outside. In our project, we maintained a speed between 300 and 600 rpm. The proportion of wettability will rise as the pace of solidification accelerates.

Stirring temperature: It is a crucial process variable. It has to do with the temperature of the aluminium-containing matrix. Around 650°C, aluminium typically melts. The viscosity of the Al matrix is mostly influenced by the processing temperature. The particle distribution in the matrix is impacted by the change in viscosity. As processing temperature was raised while stirring for longer periods of time, the viscosity of the liquid decreased. Moreover, it quickens the chemical reaction between the reinforcement and matrix. Our project's working temperature was kept at 630°C to maintain Al (6061)'s semisolid condition and to enhance good wettability.

Stirrer blade design: To prevent the interaction between stainless steel and Al alloys at higher temperatures, stirrer blades made of stainless steel are frequently employed and covered in zirconia. For the vortex to form and to ensure adequate melting of the melt, the impeller/blade design is crucial.



Four blades stirrer, showing different blade configurations (a) 0□ (b) 30□ (c) 45□ (d) 60□ and (e) 90□. [7]

Reinforcement size: The strength of the material in the stir casting process is influenced by particle size. The mechanical qualities improve with decreasing size.

DEFECTS AND REMEDIES:

Gas porosity: - It is the development of air pockets inside the projecting after it has cooled. This happens on the grounds that most fluid materials can hold a lot of broken up gas, yet the strong type of a similar material cannot, so the gas structures rise inside the material as it cools. Shiv Appa anticipated that gas porosity might introduce itself on the outer layer of the giving a role as porosity or the pore might be caught inside the metal which diminishes strength in that area. Nitrogen, oxygen, and hydrogen are the most experienced gases on account of gas porosity. In aluminium castings, hydrogen is the main gas that breaks down in huge amount, which can bring about hydrogen gas porosity. show the gas porosity imperfection present in the composites. In this investigation of aluminium castings, it is portrayed that the gas porosity is because of the metal pouring temperature too low, lacking metal ease, pouring excessively sluggish, slag on the metal surface and deficiently pre-warmed metallic moulds.

Composite Samples with different defects produced by inclined at 45o pouring of die. [10]

REMEDI: The material can be melted under a flux that prevents contact with the air, in a vacuum, or in a setting with low solubility gases like argon or carbon dioxide to prevent gas porosity. According to Brown and John's research, low super heat temperatures can reduce gas solubility. Turbulence from pouring liquid metal into the mould can also introduce gases; hence moulds are frequently designed to reduce this turbulence. Additional techniques include gas flushing, precipitation, and vacuum degassing. These issues are resolved in the current study by following proper foundry procedures, such as melt preparation and mould design, raising the temperature at which metal is poured, altering the composition of the metal to increase fluidity, pouring metal as quickly and uninterruptedly as possible, removing slag from the metal surface, and providing adequate venting for the mould and preheating the metal moulds. how few faults in composite materials remain after being machined away.

Metallurgical defects: This group of defects includes hot tears and hot patches. Once the casting cools, hot tears are a failure that happen. The American Foundry men Association demonstrated that this occurs because metal is brittle at high temperatures, and the residual stresses in the material can lead to casting failure as the material cools. As a result of cooling more quickly than the surrounding material, hot spots form on the surface of castings and become extremely hard. Because they are so little in this work, metallurgical flaws can be disregarded.

Remedies: This kind of flaw is prevented by proper mould design. Correct cooling procedures or altering the chemical makeup of the metal can prevent these flaws.

Process specific defects: It is sometimes referred to as metal pouring flaws. Misruns, cold shuts, and inclusions are all included. According to Avedisian, flow marks are scuffs left on the casting's surface from improper gating, sharp corners, or too much lubrication. According to this study, cold shuts happen when two fronts of liquid metal fail to fuse properly in the mould cavity, leaving a weak spot, and misrun happens when the liquid metal does not completely fill the mould cavity, leaving an empty portion. Back pressure from improperly vented mould cavities is another cause of cold shuts. A metal inclusion is a contaminant made up of dross or slag, depending on whether it is solid or liquid. These are contaminants from the mould or impurities in the metal that is being poured, most commonly oxides, nitrides, carbides, or sulphide. It is also noted in this study that these flaws can be brought on by cold dies, low metal temperature, filthy metal, or excessive lubricant. Other potential causes, such as a lack of fluidity in molten metal, poor pouring technique, inappropriate gating, or low metal or mould temperature, are also noted.

Remedies: There are numerous techniques to lower the concentration of inclusions. Before the metal is poured into the mould, other materials can be added to the mixture to make the dross float to the top where it can be skimmed off. Another approach is to add ceramic filters to the gating system. Alternately, swirl gates can be created, which swirl the liquid metal as it is put in, driving the lighter inclusions to the centre, and keeping them out of the casting. The metal was melted with flux in an inert atmosphere to prevent oxide formation. The optimum pouring temperature was adjusted. The gating system was modified. Head pressure was increased.

CONCLUSION:

The goal of the current study is to investigate the various stirring casting process operating parameters. AMC will also be prepared with the aid of the stir casting procedure. For this reason, Sic, Alumina, and Graphite serve as reinforcement materials along with Aluminium. We successfully produced AMC at a lower cost with the aid of the stir casting method. We discover that process parameters play a significant role in ensuring uniform reinforcement distribution when making AMC.

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