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# Investigation of optimum process parameter of lost foam casting of A356/SiC metal matrix composite

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## Abstract

Metal Matrix Composites (MMCs) are unceasingly substituting engineering materials because of its high stiffness and strength over homogeneous materials formulation. It has been utilized in engineering structural applications like aerospace, automotive and defense. In industries MMCs are mostly fabricated by squeeze casting, stir casting, infiltration technique, and spray deposition technique. In these processes, there are some limitations like difficulties in producing intricate shapes, homogeneous distribution of ceramic particles and poor wetting property between reinforcement and matrix alloy etc. To overcome these limitations, Lost Foam Casting (LFC) is used to fabricate MMCs. In this investigation an attempt has been made to produce intricate castings of (A356 Al alloy-SiC) particulate type Metal Matrix Composites using LFC process. The rectangular expanded polystyrene (EPS) patterns are used in this LFC process instead of circular patterns. The LFC process quality is strongly affected by the elimination of degradation product which in turn depends on the process parameters such as sand grain size, coating grain size, pouring temperature and coating method. These four process parameters with three levels are considered for Taguchi's technique with L9 Orthogonal Array (OA) and the experiments were conducted. Density and tensile strength of the castings are considered as quality characteristics of the LFC process. From the ANOVA results, it reveals that the sand grain size and coating grain size mainly influence the casting quality. The optimal process parameters are sand grain size of AFS 50, coating grain size of 212µm, pouring temperature 800°C and coating method of brushing technique.

## Introduction

Cast Aluminium (Al) alloys are commonly used in automotive, aerospace, chemical and food industries due to their characteristics of low weight, high corrosion resistance and good cast ability etc. The specific properties of cast Al alloys are improved by alloying, grain refinement and heat treatment. In order to improve certain properties like wear resistance, stiffness and high temperature stability Al-MMCs are the ceramic in which continuous aluminium phase is combined with another phase of ceramic in the form of particulates, palates, whiskers or fibers [1]. These composites are obtained by impregnating high-strength fibers of stainless steel, boron, tungsten, molybdenum, graphite, Al2O3, SiC and Si3N4 etc with molten metal of aluminium, titanium, Ni and Cobalt etc.

The Evaporative pattern casting (EPC) is also known as LFC process. LFC process is an environment friendly precision casting process [2]. The LFC technology possesses for making complex components. LFC process is the typical polymer used in commercial applications. This process is also called as polycast, EPC and Full mould method. LFC process is an environment friendly process that offers an opportunity to produce more economically complex engineered shapes with improved surface finish and greater dimensional accuracy. It has been successfully used in GM for about year to produce aluminum casting for automotive and marine engine. The process is being used to produce heads, blocks, ductile Iron crankshafts, pipefitting and a wide variety of other parts at the present time [3]. In this process the main function of mould paints is to prevent metal penetration and mould/metal reactions [4]. With unbounded sand other factors are involved, for example the permeability to gaseous decomposition products of the pattern must be considered. Also the paint may act to some extent as a barrier; preventing the collapse of sand into the mould.

It has been noticed when casting aluminium, a Zircon flour base (ZrO2), binder of Colloidal Silica (O2Si) is coated on the surface of the casting. A reduced gas permeability and increase porosity occurs due to the process of pattern coating is reported in many researches [5], [6]. Many researches also used the kaolin and talc as the coating material [7]. The problem of metal penetration can be prevented by the process of coating the iron powder on Cast Iron material. During the initial and final solidification process temperature reduction occurs due to the size of the strip and the thickness of coating [8]. The parameters that affects the casting quality are coating materials and shell layer thickness [9]. Casting has been heavily discolored or even pitted by a carbonaceous deposit. This has occurred particularly near the top of castings of large sectional thickness. This is attributed to low permeability and work is proceeding to try to cure this problem, firstly by the use of more permeable paints and thinner coats, and secondly by using a very fine grained sand which allows the paint to be omitted altogether [10].

In the LFC process, usage of Zircon flour coating material is very costly. Use of refractory filler (Siliminite), binders (Dextrin and Bentonite), plumboco powder and other ceramic materials used in the coating for evaporative polystyrene is a welcome step in reducing the cost factor [11]. The coating process is carried out by applying fine coat of the combination of bentonite powder, plumboco powder, and quarry dust with the contribution of each 40%, 30%, 30% respectively. The

coating is done by the application of the coating mix uniformly on the pattern and sprue with the help of the brush. After the pattern is coated it is dried for 2hrs under 40°C in an oven [12].



## Section snippets

### Methods

In this current work, to study the effect of process variables A356/ 10% SiC composites by taguchi's design approach. …

### Pattern preparation and assembly

The circular shaped patterns are most widely used in researches and it is observed that the rate of blow holes are found to be higher [15]. In order to overcome the issue, the rectangular pattern is used as test pattern with dimensions 80 mmX20 mmX90 mm and is cut from expanded polystyrene (EPS) board with a bead size of 1 mm [16]. The required gating system includes size 20 mmX20 mmX100 mm of sprue, 20 mmX20 mm X20 mm of runner and 40 mmX40 mmX20 mm of sprue cup are cut separately. The pattern …

### Results

Nine castings were made as per L9 OA. Density and tensile strength of the castings was measured for standard specimen and tabulated in Table 4. The optimum process parameters are identified by density and tensile strength of the castings and considered as excellence characteristics [21], [22]. The investigational results were transformed into S/N (signal to noise) ratio to calculate the deviating excellence characteristics from the preferred one. The quality characteristics of density and …

### Percentage contribution

The percentage contribution indicates the relative power of a factor to reduce the variation. The indicated percentage contributions can be reduced precisely by controlling the factors. The percentage contribution of the sand grain size, coating grain size, pouring temperature and coating method is shown in Fig. 5 and Fig. 6. …

### Estimation of optimum performance characteristics

Once the experiments are conducted and the optimum condition is determined, one of two possibilities exists:

- The prescribed combination of factor level is identical to one …

…

## Conclusions

Castings of MMC (A356Al+SiC) were made using lost foam casting process and mechanical properties namely density and tensile strength of the castings were measured. Taguchi's technique with L9 Orthogonal Array was followed for the experimental investigation. In this investigation, an attempt has been made to make castings of Metal Matrix Composites (A356+SiC) using lost foam casting process and the effort was successful. In LFC process the utilization of rectangular slab results better …

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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