Influence of Squeeze Casting Process Parameter on Al/SiCp Metal Matrix Composite

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Abstract. There are so many casting processes available in the manufacturing industry world. Each method has its distinguished pros and cons. The main drawback of the conventional casting process, such as high pressure die casting, is the presence of air, wrinkles and porosity. Casting without these defects is really challenging and leads to tailor the new innovative processing method. To develop the quality and integrity of the process the suitable technique is considered as squeeze casting. This method is versatile and exhibits unique properties since many automobile manufacturing industries have incorporated it. Squeeze cast component can have superior mechanical, micro, and microstructural characteristics of features compared with traditional casting techniques as it alleviates voids and blowholes. The current study focuses on the effect of process parameters of squeeze casting towards the mechanical properties of Al/SiCp materials. Volume addition of 10% SiCp to the molten aluminum metal to pour into the preheated die is performed in the laboratory. Cylindrical cast samples are cut into pieces as per the dimensions to carry out material characterization.

Keywords: Aluminium, Squeeze Casting, Composites, Microstructure

1. Introduction

The preparation of lightweight components is playing a major role in high precision industries. The weight reduction ratio would help to develop many advanced materials. Now all advanced materials have been used in commercial applications. The preparation of such metal matrix composites playing a crucial role. Manufacturing of metal matrix composite is broadly classified into three main categories, namely viz solid, liquid, vapor state methods [1,2]. Conventional casting techniques can lead to defects such as porosity, blowholes, and pores. Therefore, it is necessary to eliminate these defects to increase the strength of the materials[3]. Squeeze Casting is recently developed and receiving much attention by a researcher to get high mechanical strength materials. Elimination of defects is possible in this method due to the introduction of pressure on molten metal till the end of solidification by maintaining contact between the surface of the die and liquid metal. In precise terms, it is said to be squeeze casting is an amalgamation of both the casting and forging process [4].

In automotive and aircraft industries, the need to produce aluminum-based metal matrix composite is increasing due to its improved lightweight and high strength weight ratio. The weight reduction ratio would help to support the material, and at the same time, the consumption of energy has also been
reduced [5]. On further, it could be easy to get improved stiffness by reinforcing SiC or other abrasive particles [6]. As such, it is paramount importance to incorporate the particles in the melt and control the process parameters [7]. Current work includes the use of an aluminum alloy of A356 is reinforced with Silicon carbide 40.5µm size.

2. Experimental work
A 60 tone hydraulic press is used, as shown in Fig.1. The experimental set up is designed to tolerate high pressure of the melt and die. The design of the punch is required much attention because it has a catching mechanism to get a desired near net shape in squeeze casting. The punch and die set up is made up of H13 tool steel.

The material composition of Al (A356) alloy is shown in Table 1. A measured quantity of SiC is preheated to 10000C throughout the experimentation. The Al (A356) is melted in a furnace at a different temperature. A constant stirrer does stirring after pouring SiCp into the molten metal, and the melt (molten aluminium and SiCp) is poured into a die measuring 50mm inner diameter and 150mm height. Applied pressure is kept constant for 100 MPa throughout the experiment. The samples are squeezed into the size of 100mm in height and 50mm in diameter. The experimental condition is shown in Table 2.

Table 1. A356 alloy and its elements

|   | Si   | Fe | Cu | Mn | Mg   | Zn | Ti | Al   |
|---|------|----|----|----|------|----|----|------|
|   | 6.5-7.5 | 0.2 | 0.2 | 0.1 | 0.25-0.45 | 0.1 | 0.2 | Balance |

Figure 1. Experimental Setup for Squeeze Casting Cylinder Setup

Figure 2. Details of the Tensile Specimen (All dimensions are in mm)
Table 2. Casting Parameters

| Sl No | Melt Temperature (°C) | Die Temperature (°C) | Pressure (MPa) |
|-------|------------------------|----------------------|----------------|
| 1     | 800,825,850,875        | 350                  | 100            |

3. Results and Discussion

3.1. Ultimate Tensile Strength

A dog bone shape is prepared as per the ASTM Standard D3039. The influence of melt temperature is taken into account to explore the ultimate tensile stress of squeeze cast specimen, as shown in Fig.3. The sample is prepared from the center of the cast specimen. It can be concluded as melt temperature at 850°C is giving good tensile strength due to the formation of smaller grain size [8]. In this study, the melt temperature at 800°C, the tensile strength is 240 MPa, and it is maintained up to 825°C, and then the value is reached 255MPa. The value is maximum at this temperature (850°C), and then the value is decreased at 875°C. The tensile strength values are taken from the average value of three experiments. At higher temperatures, the melt can flow quickly, which may cause improper particle orientation, and a group of particles would have settled in one region. This may be the cause of the decrease in the value of tensile strength at 875°C.

![Figure 3. Tensile Strength of Various Melt Temperatures](image)

3.2. Hardness

Fig.4 shows the influence of melt temperature on the hardness of the squeeze cast specimen when the applied pressure is 100 MPa. Although hardness value is strongly dependent on the effect of melt temperature, which is taken into account in this research work. The hardness sample was also reserved in the center of the squeeze cast sample. Each 10 mm of three indentation values are averaged, and it has been plotted in the graph. From the graph, it can be said that melt temperature also has influence over the hardness value, and it has a decreasing trend as temperature increases. Here even above 850°C, the values are decreased; this may occur due to improper distribution of particles. Also, it is noted that at low temperatures (800°C), the particles were not homogeneous. The values are almost close in agreement with base alloy [9].
Figure 4. Hardness Distribution of Various Melt Temperatures

3.3. Microstructure
An optical microscope is utilized to know about the silicon carbide distribution. Though the SiC cluster is formed at 800°C of melt temperature, grain size for 800°C and 850°C is about 1.245 microns and 1.502, respectively. As shown in Fig 5,6, the fine dispersion of silicon carbide particulate is dependent on stirring speed and time. It is demonstrated that at 800°C, the particle distribution was not uniform. Still, the value of tensile strength is reasonable. Further increasing the temperature, there is increasing the value because of uniform distribution[10,11]. It is clearly shown in Fig.6.

Figure 5. Microstructure of Al/SiC squeeze cast component at 800 0C.

Figure 6. Microstructure of Al/SiC squeeze cast component at 850 0C.

4. Conclusions
The mechanical properties of the newly developed metal matrix composite are studied, such as the tensile strength and microhardness. In the above experimental work, the following points were concluded

- The metal matrix composite is prepared with 800,825,850 and 875°C of melt temperatures, die temperature is 350°C with the pressure of 100MPa, respectively all were subjected to prepared by squeeze casting method.
• It is observed that the tensile strength and hardness values of the developed composites are higher at the temperature of 850°C.
• From the microstructural analysis, the varying melt temperatures revealed a homogeneous particle distribution at 850°C. This observation has clearly shown that the optimum and recommended temperature is 850°C.
• It is clearly shown that the melt temperature has influenced the properties of the prepared composites.

5. References
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