CHAPTER 3

FABRICATION

3.1 STIR CASTING

Most of the methods used for the manufacture of metal matrix composites are expensive and require skilled complicated operations. The liquid phase routes are more similar to conventional casting process and are economical for the manufacture of metal matrix composites. In addition, these casting processes enable to fabricate large complex near net shaped components. Hence liquid phase route (Stir casting) is chosen in this work. Stir casting setup motor and stirrer arrangement and crucible furnace are shown in Figure 3.1.

Figure 3.1 (a) Stir casting setup motor and stirrer arrangement and (b) crucible furnace
The metal matrix composites of Al6082 reinforced with SiC\textsubscript{p} were prepared in a crucible furnace. The fabricated stir casting set up is shown in Figure 3.2. The SiC\textsubscript{p} were pre oxidised at 650°C for 2 hours and poured into the liquid matrix stirred at a constant rate. The heat treatment was done in order to form a layer of SiO\textsubscript{2} on the SiC\textsubscript{p}, which improves the incorporation of the SiC\textsubscript{p} into the molten metal. The melt was stirred at a constant rate of 670 rpm for 10 minutes, after the addition of SiC\textsubscript{p} as found the optimum speed and time by Balasivanandha Prabhu et al (2006).

Figure 3.2 Stir casting setup

Magnesium was added to increase the wettability of the particulates found out by McKimpson and Scott (1989). Magnesium, which improves the wettability of SiC\textsubscript{p} with the Aluminium melt, is lost from the melt by oxidation, during melting and stirring of the alloy. In order to compensate for this loss and maintain the wettability of the alloy, magnesium was added to the molten metal before the start of stirring. After the continuous stirring, the melt was poured in to a permanent iron die mould to obtain
composites of size 17 mm diameter and 230 mm length after the sprue pins were removed. No evidence of macro casting defects was seen. The matrix metal was also cast in the same process to standardize the casting process. Front view of the casting mould and top view of the casting mould are shown in Figure 3.3 and casting mould cavity is shown in Figure 3.4.

![Figure 3.3](image1.png)  ![Figure 3.4](image2.png)

**Figure 3.3** (a) Front view of the casting mould (b) Top view of the casting mould

**Figure 3.4** Casting mould cavity
Three different weight fractions 5 %, 10 % and 20 % of SiC\textsubscript{p} by weight percentage of aluminium were fabricated. The average particle size for the study of the variation of percentage of particle was 22 \(\mu\text{m}\). Three different particle sizes of average particle sizes of 22 \(\mu\text{m}\), 12 \(\mu\text{m}\) and 3 \(\mu\text{m}\) were used to study the effect of variation of particle sizes. The composites are henceforth referred as Almmc22, Almmc12 and Almmc3 respectively. The weight fraction of the SiC\textsubscript{p} chosen to study the effect of particle sizes was 10 % by weight percentage of aluminium.

3.2 FORGING

The combination of high strength with light weight has lead to an expanding range of applications for forged aluminium which has more advantages than other methods of manufacturing. The characteristics of a relatively simple forged design often provide the desired weight and strength at low cost. When forged and heat-treated some common aluminium alloys exhibit some mechanical properties comparable with many grades of steel.

The ingots were then forged in a closed die forging to obtain composites of size 12 mm diameter and 230 mm length. The forging processes were performed at 500\(^\circ\) C as one step forging. DIN 2714 steel was used as a die material. A graphite based mixture was used as a high temperature lubricant. The flash materials were trimmed off from the forged materials. The forging specimens were polished in different stages to remove the roughness on the surface. It was seen that increasing particle volume fraction increases the instability regions (at which the fracture or defects are more likely) similar to result obtained by Narayana Murty and Nageswara Rao (1999).
3.3 AGEING HEAT TREATMENT

The final stage of the production process of a composite material with an aluminium alloy matrix usually includes a heat treatment process to modify the matrix microstructure by differential precipitation. A matrix of this class can be heat treated by solutionizing and ageing to modify the microstructure and mechanical properties. The age hardening characteristics of an alloy are generally modified by the introduction of reinforcement. These modifications are due to the manufacturing process, the reactivity between the reinforcement and the matrix and to the size morphology and volume fraction of the reinforcement.

The size, morphology and volume fraction of the reinforcement, are factors controlling the plasticity and the thermal residual stresses in the matrix. The sink effect due to interfaces introduced by the presence of the reinforcement may also play an important role in precipitation kinetics. The manufacturing process may lead to different microstructures, which would also modify the precipitation kinetics.

The reactivity between the reinforcement and the matrix during the high temperature solution treatment may lead to a modification of the composition of the matrix. If Silicon, Manganese, Magnesium are taken as the main alloying elements, the most important reaction phenomena will be due to the reactivity of magnesium with the reinforcement, which may lead to a decrease in the content of this element in solid solution and thus to a decrease in the amount of precipitate formed during ageing. Magnesium is highly reactive with silica in the temperature range 500° C-550° C and, to a lesser extent with alumina, whereas no reactivity is observed for the normal treatment conditions with other reinforcements such as Boron carbide and Silicon carbide.
The samples were artificially aged to T6 condition by solutionizing at 550º C for one hour followed by precipitation heat treatment at 178º C for 8.5 hours as suggested by P. Merle, (2000). The heat treatment furnace is shown Figure 3.5.

Figure 3.5  Heat treatment muffle furnace