ABSTRACT

Since the early 1960s, there is a demand for new and improved engineering materials with the advance of modern technology and the interest in the areas of aerospace and automotive industries has led to a rapid development of metal matrix composites. The high demand on materials for better overall performance has led to extensive research and developmental efforts in the field of composites. Among the composites, the aluminium based metal matrix composite materials are widely used. To meet this emerging need, innovations in materials processing enabled achieving an enhancement in stiffness, realization of a high strength-to-weight ratio, an improvement in wear resistance, and maintaining strength at elevated temperatures (Jayamathi et al 2004; Rajan et al 1998).

Aluminium based metal matrix composites have been one of the key research areas in materials science for the last few decades. Most of the work has been dealing with aluminium matrix and SiC reinforcement for achieving requiring the light weight in combination with high strength and stiffness. This is because aluminium is lighter in weight, which is the first requirement in most of the industries. In addition, it provides impressive strength improvement, as the thermal expansion coefficient of Al matrix composites can be adjusted by using silicon carbide, carbon and boron carbides (Lindroos 1995).
The properties of a metal matrix composite material are strongly influenced by the distribution of particles in the matrix, and the behavior of the interface region between the matrix and the reinforcement. The interface or interphase region has a great deal of importance in determining the ultimate properties of metal matrix composites. The main function of the interface region is transfer efficiency of stress from the matrix to reinforcement is the fundamental importance in determining the mechanical properties of metal matrix composites. High bond strength is required at the interface for the transfer the effective load. A perfect bond is usually formed by the reaction between the matrix and the reinforcement. The formation of a good interface bonding is important to all composite systems. The bonding strength has a close relationship with the interface bond-interface structure - interface compounds in the composite materials.

The distribution of particles and formation of good interfacial bonding between the matrix and the reinforcement is well controlled by the process parameters. So it is essential to study the effect of the process parameters on particle distribution and interface bonding quality. To achieve the desired properties, these problems must be overcome. In the last few years, considerable work has been done on the nature of interfaces in metal matrix composites and their influence on their mechanical properties. These research works have been done by numerical methods to reveal the effect of the interface bonding on the composites, and some investigators attempt to find the bonding strength numerically.

This research work mainly demonstrates the influence of the process parameters such as the temperature, process hold time, and the composition of the matrix. The processing parameters are interconnected to
each other in the distribution of particles in the matrix and formation of a good interface bond between the matrix and the reinforcement. The objective of this research is to study, how the process parameters influence the distribution of particles and formation good interface bonding, and how it enhances the mechanical properties.

In order to demonstrate the influence of the processing temperature and holding time on the effective distribution of particles in the matrix, the Al-11.2Si / 10% SiCp composite materials were fabricated through the stir casting process with different processing temperatures and different holding times. The average size of the reinforcement is 40 microns, and it was preheated to 1000°C before being added to the melt. The stirring speed was maintained at 450 rpm throughout the process. The particle distribution was analyzed by an optical microscope and a scanning electron microscope. The mechanical properties of the composites were evaluated by the tensile, hardness and impact tests.

In order to understand the influence of the processing parameters i.e., processing temperature, and holding time on the interface bonding behaviour, the interface of Aluminium / Silicon carbide was developed by the diffusion bonding process. The liquid Al melts infiltrated on the SiC plates. Monolithic α-SiC plates (7 × 75 × 100 mm³) were prepared by the sintering process. The experiments were conducted at different processing temperatures with different holding times. The bonded region was cut from the Al-SiC bonded samples, and the interface regions were evaluated by the Scanning Electron Microscope. The intermetallic composition of the interface region was analyzed by using the energy dispersive spectroscopy. The tensile strength of the bonded samples were evaluated by FIE tensile machine. The
microhardness was measured in the interface region using the Wilson Wolpert vicker hardness tester with 500g load at different locations across the interface region. Two different aluminium alloys which contain different percentages of Si were used for the study, to investigate the effects of the Si element on the interface chemistry.

The research results revealed that particles were distributed in the matrix uniformly at 750-800°C for higher holding time. The ultimate strength and hardness strength of Al/SiCp composites are associated with particle distribution. The structural morphologies of the interface in the Al/SiC are mainly altered by the presence of interfacial elements (Si) at the interface region. The higher concentration of the Si in matrix region near the interface alters the interface bonding characteristics of the Al/SiC. The hardness values increase near the interface region in the matrix due to presence of the Si and C elements.

Microstructure based finite element analyses were made to evaluate the interfacial behavior as well as interface failures. The microscopic and macroscopic response of the microstructure has been studied from two dimensional microstructure based finite element analyze. Failures such as particle fracture, interfaces decohesion and matrix yielding have been quantified from the model, and thermal stresses and thermal strains were analyzed by using a three dimensional FEA model. The models also analyse the effects of particle clustering on the mechanical of the microstructure. The results obtained from the finite element analysis have been compared with the experimental results.