THE WETTABILITY ENHANCEMENT OF SIC PARTICLES IN CAST ALUMINUM A356 MATRIX COMPOSITES

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TO MY BELOVED PARENTS FOR

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ABSTRACT

A study has been conducted using compocasting technique to investigate the wettability enhancement of SiC in aluminum matrix composite. Aluminum matrix composite reinforced with SiC is produced by the addition of 1% Mg powder which have impact on a uniform distribution of SiC in the Aluminum matrix. In addition, it is worthwhile to mention that there is mutual relationship between a uniform distribution of SiC in the aluminum matrix and mechanical properties. The findings show that there are some important determinants, which have strong influence on a uniform distribution of SiC in the Aluminum matrix such as surface treatment of SiC, addition of alloy elements including Mg and other elements, particle size, percentage of Mg, stirring speed and stirring method and solidification rate. Among of mentioned determinants, the results show that addition of Mg into melt is the salient predictor. In addition, there is a direct relationship between mechanical properties and a uniform distribution of silicon carbide inside the aluminum matrix. Result from the mechanical testings and the microstructural show that the addition of 1% Mg improves the wettability of the aluminum/SiC composites.

ABSTRAK

kajian ini dijalankan dengan menggunakan teknik (compocasting technique) untuk mengkaji peningkatan kebolehbasahan SiC dalam komposit matrik aluminium. Komposit matrik aluminium diperkuatkan dengan SiC adalah dihasilkan dengan tambahan 1% Mg serbuk yang mempunyai impak ke atas pengagihan seragam SiC dalam matrik aluminium. tambahan itu, terdapat hubungan bersama antara pengagihan seragam SiC dalam matrik aluminium dan sifat mekanikal. hasil kajian ini menyatakan terdapat beberapa penentu yang penting,yang mempunyai pengaruh yang kuat ke atas taburan seragam SiC dalam matrik aluminium seperti rawatan permukaan SiC, penambah elemen aloi termasuklah Mg dan elemen lain, saiz zarah, peratusan Mg, Kelajuan kacau dan kaedah dan kadar pemejalan. antara penentu yang disebutkan, keputusan menunjukkan penambah Mg ke lebur adalah peramal yang penting. di samping itu, terdapat hubungan lansung antara sifat mekanikal dan pengagihan seragam silikon karbida dalam matrik aluminium. hasil kajian daripada ujian mekanikal dan mikrostruktur menunjukkan penambah 1% Mg mempertingkatkan kebolehbasahan komposit aluminium/SiC.

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LIST OF ABBREVIATIONS

SiCp	Silicon Carbide Particulate
MMCs	Metal Matrix Composites
UTS	Ultimate tensile strength
PMMCs	Particulate metal matrix composites
AMCs	Aluminum matrix composites
AL	Aluminum
Mg	Magnesium
Sic	Silicon carbide

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In the competitive area of the technology and during the past decades MMCs have received substantial attention because of their improved strength, high elastic modulus, low specific density and increased wear resistance over conventional base alloys. The wide scale introduction of MMCs has been increasing simultaneously with the technological development (Miracle, 2005). A composite material is engineering combination of metal (matrix) and hard particles/ceramics(Reinforcement) that differ in form, chemical composition and which are essentially insoluble in each other to get tailored properties (Singla, Dwivedi, Singh, & Chawla, 2009) . The aim of involved in designing metal matrix composite materials is to combine the desirable attribute of metals and ceramics. The addition of high strength, high modulus refractory particles to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement. Metals have a useful combination of properties such as high strength, ductility and high temperature resistance, but sometimes have low stiffness, whereas ceramics are stiff and strong, though brittle. Aluminum and silicon carbide, for example, have very different mechanical properties: Young's moduli of 70 and 400 GPA, coefficients of thermal expansion of $24 \times 10^{-6}/℃$ and $4 \times 10^{-6}/°C$, and yield strengths of 35 and 600 MPa, respectively.(Mazahery & Shabani, 2011)

Many researchers have been conducted on aluminum matrix composites (AMCs) in commercial laboratories and small businesses. Because of these activities,

many new AMCs applications have been established, and most of these have found insertion within the commercial sector. Important AMCs applications in aerospace, automobiles and infrastructure industries are enabled by functional properties including high structural efficiency, excellent wear resistance, and attractive thermal and electrical characteristics. (Mazahery & Shabani, 2011). In general, the solidification synthesis of metal matrix composites involves producing a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt, obtaining a suitable dispersion. The next step is the solidification of the melt containing suspended dispersoids under selected conditions to obtain the desired distribution of the dispersed phase in the cast matrix. Among discontinuous metal matrix composites, stir casting is generally accepted as a particularly promising route, currently practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production especially for Aluminum-SiC composites and allows very large sized components to be fabricated.(Hashim, Looney, & Hashmi, 2002) . Figure 1.1 indicates a comparative evaluation between different techniques of producing PMMCs. There are however problems associated with the production of reinforced composites, one of significance being the difficulty of achieving a homogeneous distribution of reinforcement in the metal matrix, essential for optimum mechanical properties. This problem is common to most production routes, including the stir casting process, which using particle reinforcement, offers the possibility of producing relatively complex shaped composites. Therefore, that it is important to identify and control casting process parameters relevant to reinforcement distribution in order to achieve a good quality composite.

Method	Range of shape and size	Metal yield	Range of volume fraction	Damage to reinforcement	Cost
Liquid metallurgy (stir casting)	wide range of shapes; larger size; up to 500 kg	very high, >90%	up to 0.3	no damage	least expensive
Squeeze casting	limited by preform shape; up to 2 cm height	low	up to 0.45	severe damage	moderately expensive
Powder metallurgy	wide range; restricted size	high		reinforcement fracture	expensive
Spray casting	limited shape; large size	medium	0.3–0.7	-	expensive
Lanxide technique	limited by pre-form shape; restricted size	-	-	-	expensive

Figure 1.1 A comparative evaluation of different techniques used for PMMCs fabrication(Hashim, et al., 2002)

To summarize, we can state that there were some previous studies in this research area conducted with different authors in different countries such as Iran, India and Iraq. As the nature of every empirical study, each of previous studies had its own results.

We can mention that there are some important factors such as surface treatment of SiC, addition of Mg into melt, volume fraction of SiC, weight fraction of SiC and stirring method, which affect achieving a homogeneous distribution of reinforcement in the matrix regarding to previous studies. In addition, it will be related to the mechanical properties such as hardness and tensile behavior.

In the present study, first, we discuss the previous studies related to our research and we will define important factors and the method of this research that is stir casting. Finally, we will bring into discussion the results of research in order to knowledge contribution in this research area.

1.2 Research problem

Nowadays, one of the major challenges when processing MMCs is achieving a homogeneous distribution of reinforcement in the matrix as it has a strong impact on the properties and the quality of the material.

Due to this challenging issue in this present research, we have come up to conduct a research in order to achieve a uniform distribution of reinforcement within the matrix. Therefore, through this research, we will fill up this knowledge gap in Malaysia in order to knowledge contribution.

Stir casting is a widely used technique of producing Al matrix composites that are reinforced by micro ceramic particles. However, there are some problems associated with stir casting of AMCs such as:

Poor wettability and heterogeneous distribution of the reinforcement material. When the particles are wetted in the metal melt, they will tend to sink or float to the molten melt due to the density differences between the reinforcement particles and the matrix alloy melt, so that the dispersion of the ceramic particles is not uniform and the particles have high tendency for agglomeration and clustering. In order to achieve the optimum properties of the metal matrix composites, the distribution of reinforcement material in the matrix should be uniform.

1.3 Research Question

Referring to the problem statement and the important factors, which can affect our research problem in this empirical study, we have to formulate research questions. Something into consideration is that, the research questions should be clear, specific and possible to answer. Therefore, we have formulated following research questions in order to reach our research objective.

- What are the most significant factors, which have a great impact on achieving a uniform distribution of SiC in the Aluminum matrix?

- Which one of the factors is the salient factor for achieving a uniform distribution of SiC in the Aluminum matrix?

- What is the relationship between distribution of SiC in the Aluminum matrix and mechanical properties?

1.4 Research Objective

Referring to the problem statement of the research, the research objectives will be to answer research questions:

- To study the microstructure and mechanical properties of Al A356/SiC composites made by stir casting.

- To determine the most significant factors which have a great impact on achieving a uniform distribution of SiC in the Aluminum matrix.

- To determine the most significant factor for achieving a uniform distribution of SiC in the Aluminum matrix.

- To determine the relationship between distribution of SiC in the Aluminum matrix and mechanical properties.

1.5 Limitation to the study

Regarding to the research problem of this empirical study, from the theoretical knowledge and review of previous studies with the same problem statement that is achieve a uniform distribution of reinforcement within the matrix, we can state that previous studies have been conducted with different methodology.

One of the limitations to this study has been the selection of method, because the method and the equipment such as furnace and so on should be provided for the researcher in order to conduct the research, because due to lack of necessary equipment, the research study is not applicable.

1.6 Scope of the Study and Limitation

Referring to the problem statement, there are some significant issues in the viewpoint of the scope of the study of this research, based on the previous studies, which will be stated in more details in chapter 2, there have been some research studies in this research area in India, Iran and Iraq and so on. Therefore, we have been stimulated to conduct this research study in Malaysia. Therefore, we can state that the scope of the study and our empirical study are as followings:

- Literature study on stir cast Al/SiCp composites.
- Selection of Aluminum A356 and Silicon Carbide(SiC)
- Preparing Al/SiC composites by stir casting process
- Preparing Microstructure (OM, SEM observation) and Mechanical (Hardness, Tensile testing) examination.
- Data collection and Analysis

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