

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

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*TO MY BELOVED PARENTS FOR  
THEIR ENDLESS LOVE AND SUPPORT*

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Eventually, I hope that this report will be advantageous in future.

## 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 (compcasting technique) untuk mengkaji peningkatan kebolehasahan 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 langsung antara sifat mekanikal dan pengagihan seragam silikon karbida dalam matrik aluminium. hasil kajian daripada ujian mekanikal dan mikrostruktur menunjukkan penambah 1% Mg mempertingkatkan kebolehasahan komposit aluminium/SiC.

## TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABALES	x
	LIST OF FIGURES	xi
	LIST OF APPENDICES	xv
<b>1</b>	<b>INTRODUCTION</b>	<b>16</b>
1.1	Introduction	16
1.2	Research problem	19
1.3	Research Question	19
1.4	Research Objective	20
1.5	Limitation to the study	20
1.6	Scope of the Study and Limitation	21
<b>2</b>	<b>LITERATURE REVIEW</b>	<b>22</b>
2.1	Past studies relevant to our study	22
2.2	Metal Matrix Composites	37

2.2.1	Introduction to composite materials	37
2.2.2	Metal matrix composites(MMCs)	38
2.2.3	Materials selection	40
2.2.3.1	Property development	40
2.2.3.2	Interface	42
2.2.3.3	The Al-SiC System	43
2.2.4	Fabrication processes	45
2.2.4.1	Solid state processes	46
2.2.4.2	Semi-solid state processes	47
2.2.4.3	Liquid state processes	48
2.2.5	Stir casting	49
2.2.6	Impeller design	50
2.2.7	Distribution of reinforcing particles	52
2.2.7.1	Distribution in the liquid as a result of mixing	53
2.2.7.2	Distribution in the liquid after mixing	53
2.2.7.3	Redistribution as a result of solidification	54
2.2.8	Characterization of reinforcement distribution in MMCs	56
2.3	Aluminum Alloys	57
2.3.1	Introduction to aluminum and aluminum alloys	57
2.3.2	Classification of Aluminum-based Material	58
2.3.3	Wrought Aluminum Alloys	59
2.3.4	Cast Aluminum Alloys	59
2.4	Silicon Carbide (SiC)	62
2.5	Application of silicon carbide	63
2.6	Definition of Metal Matrix composites	64
2.7	Definition of Mechanical properties	65
2.7.1	Definition of Tensile Testing	65
2.7.2	Definition of Metal Hardness	65
2.8	Definition of volume fraction of reinforcement (SiC)	66
2.9	Definition of surface treatment of SiC	66
2.10	Definition of weight fraction of SiC	66
2.11	The role of addition of Mg into Melt	67

<b>3</b>	<b>RESEARCH METHODOLOGY</b>	<b>68</b>
3.1	Definition of the research method	68
3.1.1	Materials	69
3.1.2	Compo casting Procedure	73
3.1.3	Micrograph Observation	79
<b>4</b>	<b>RESULT AND ANALAYSIS</b>	<b>87</b>
4.1	Introduction to Results	87
4.1.1	Micrograph Observations of as cast MMCs	87
4.1.2	Tensile Properties of the as cast MMCs	94
4.1.3	Hardness of the as cast MMCs	109
4.2	Answering research questions	110
4.2.1	Answering research question no.1 regarding to the conducted tests 110	
4.2.2	Answering research question no.2 regarding to the conducted tests 111	
4.2.3	Answering research question no.3 regarding to the conducted tests 111	
<b>5</b>	<b>CONCLUSION AND RECOMENDATION</b>	<b>113</b>
5.1	Conclusion	113
5.2	Recommendation to management	114



## LIST OF TABALES

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Mechanical properties of composites(Robi, et al., 1991)	23
2.2	Summary of Microstructure and Tensile Properties of A356 Al/SiCp Composites(Baik, et al., 2006)	25
2.3	Mechanical properties of PMMCs from the Al-SiC system produced by various fabrication routes	45
2.4	Terminology of cast aluminum alloys ( Hiroyuki Toda et al, 2000)	61
2.5	National designation of aluminum silicon alloy	61
2.6	Main properties of Silicon Carbide	63
3.1	Chemical Analysis of A356 alloy matrix(%)	70
3.2	Thermal properties of A356 alloy (Clyne & Withers, 1995)	70
3.3	The suggestion weight for Al/20wt.% SiCp	72
3.4	The weight fraction of Al/20wt.% SiCp	73
3.5	Materials for wettability experiments	74
3.6	The suitable etching solution for several metals	83
4.1	Mechanical properties of 20% SiCp/Al composites	96
4.2	Table related to Research questions	112

## LIST OF FIGURES

<b>FIGURE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
1.1	A comparative evaluation of different techniques used for PMMCs fabrication(Hashim, et al., 2002)	18
2.1	Model of the first research	23
2.2	Model of the second research	25
2.3	Model of the third research	27
2.4	Model of the fourth research	28
2.5	Model of the fifth research	29
2.6	Flow curves in tensile deformation of composites(Mazahery & Shabani, 2012)	29
2.7	Variation of hardness as function of volume fraction of	30
2.8	Variation of yield strength as function of volume fraction of Nano SiC particulates (Mazahery & Shabani, 2012)	30
2.9	Variation of ultimate tensile strength as function of volume fraction of Nano SiC particulates(Mazahery & Shabani, 2012)	31
2.10	Variation of elongation as function of volume fraction of Nano-SiC particulates(Amirkhanlou, Ketabchi, Parvin, Khorsand, & Bahrami, 2013)	31
2.11	Model of the sixth research	32
2.12	Model of the seventh research	33
2.13	Model of the present research or our research	35
2.14	Classification of composites depending on size and shape of reinforcement(Tzamtzis, 2011).Long fibre, short fibres and particles from left to right respectively	38
2.15	Schematic diagram of a liquid drop on a solid surface showing interfacial forces and wetting angle (Tzamtzis, 2011)	43

2.16	Schematic illustration of MMC mixing set-up during the stir casting process (Tzamtzis, 2011).	50
2.17	Different designs of mechanical stirrers (Chichili & Ramesh, 1995).	52
2.18	A schematic illustration of the forces acting on a particle in the vicinity of the solid–liquid interface (Stefanescu, et al., 1988).	55
3.1	Cutting machine used to sectioning of Aluminum ingot	71
3.2	Aluminum ingots after sectioning to small pieces	71
3.3	Set up used to conducting compocasting method	74
3.4	Stirrers used to mixing slurry of composite	76
3.5	Introducing of SiC into the aluminium melting in semi solid state with the help of drilling	76
3.6	Mild steel mould	77
3.7	Ultrasonic machine used to cleaning SiC with the helping of acetone	78
3.8	Magnesium in the form of powder	78
3.9	The specimen dimension for micrograph observation	79
3.10	Hot mounting machine	80
3.11	The BUEHLER grinder machine	81
3.12	Automatic polishing machine	81
3.13	Etching solution	82
3.14	Optical microscope used to micrograph observation	83
3.15	Geometry of tensile testing specimen	84
3.16	Vickers hardness test machine	86
4.1	Microstructure of cast Al/as-received SiC composite with magnification 50x(A) and 100x(B)	88
4.2	Microstructure of cast Al/as-received SiC composite with magnification 100x(A) and 200x(B)	89
4.3	Microstructure of cast Al/surface treated SiC composite with magnification 50x	91
4.4	Microstructure of cast (Al/surface treated SiC+Mg) composite with magnification 50x	93

4.5	Tensile strength of the as cast aluminum alloy and Al/SiC composites	97
4.6	Percentage of elongation with respect to composite synthesis materials	98
4.7	Fractograph of Al/untreated SiC composite at 40X magnification by SEM after tensile testing which shows the crack propagation in the ductile matrix	99
(B)		101
4.8	Field emission Scanning electron microscopy(FESEM) of the Al/SiC composite with the unreacted matrix-reinforcement interface showing (A) The tensile fracture surface morphology and (B) a higher magnification view of the particle-matrix interfacial decohesion observed on the fracture surface	101
4.9	Fractograph of Al/Treated SiC composite at 100X magnification by SEM after tensile testing which shows the crack propagation along the SiC clusters	102
4.10	Field emission scanning electron(FESEM) micrograph of the Al/Treated SiC composite with the react matrix-reinforcement interface showing (A): Tensile fracture surface morphology,(B): a higher magnification view of the SiC particle breakage observed on the fracture surface.	104
4.11	Fractograph of( surface treated SiC+Mg) composite at 40X,100X magnification respectively by SEM after tensile testing which shows intergranular movement	106
4.12	Field emission scanning electron microscopy(FESEM) micrograph of (A) Voids of varying size intermingled with dimples reminiscent of locally (B) Operating ductile fracture mechanism	108
4.13	Variation in hardness with respect to section of the as cast aluminum alloy composite castings reinforced with different composite constituents	110

**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

**LIST OF APPENDICES**

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
A-B-C	(A)EDX result of as cast Al/as-received SiC composite which is achieved by feSEM (B) EDX result of as cast Al/oxidised SiC composite which is achieved by feSEM (C) EDX result of as cast Al/(oxidized SiC+Mg) composite	122-124

## 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  $24 \times 10^{-6}/^{\circ}\text{C}$  and  $4 \times 10^{-6}/^{\circ}\text{C}$ , 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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