



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**INVESTIGATION ON THE EFFECT OF MATRIX VARIATION TO
THE MECHANICAL PROPERTIES OF METAL-METAL
COMPOSITE**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) with Honours.

by

NORASHSIKIN BINTI MOHD ARSAD

FACULTY OF MANUFACTURING ENGINEERING

2009


UNIVERSITI TEKNIKAL MALAYSIA MELAKA
BORANG PENGESAHAN STATUS TESIS*

**JUDUL: INVESTIGATION ON THE EFFECT OF MATRIX VARIATION TO THE
MECHANICAL PROPERTIES OF METAL-METAL COMPOSITE**

SESI PENGAJIAN: 2/2008-2009

Saya NORASHSIKIN BINTI MOHD ARSAD

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:


(TANDATANGAN PENULIS)


(TANDATANGAN PENYELIA)

Alamat Tetap:
Peti Surat 60034,
91010 Tawau,
Sabah.

Cop Rasmi: **MOHAMAD HAIBIR BIN MASLAN**
Tutor
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka


Tarikh: 22 May 2009

Tarikh: 22 May 2009

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.


DECLARATION

I hereby, declared this report entitled “Investigation on the Effect of Matrix Variation to the Mechanical Properties of Metal-metal Composite” is the results of my own research as cited in references.

Signature : 
Author's Name : Norashsikin Binti Mohd Arsad
Date : 22 May 2009

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Materials) with Honours. The member of the supervisory committee is as follow:



(En. Mohamad Haidir Bin Maslan)

MOHAMAD HAIDIR BIN MASLAN
Tutor
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

ABSTRACT

Metal-metal composite is a new invention method to produce a material which has significant increases in elastic modulus (stiffness), wear resistance, strength and weight savings. In this study, investigation on effect of different matrix (Aluminium 2024 and Stannum) on the properties of the metal-metal composites is studied. In this project, Aluminium 2024 reinforced low carbon steel and Stannum reinforced low carbon steel were fabricated by using pressureless metal infiltration. This is a new method of liquid state to produce metal-metal composites. The best compounding formulation of composite was found at weight percentage (wt %) with 60 wt% of matrixes material (i.e., Aluminium 2024 and Stannum) with 40 wt% of reinforcement (Low Carbon Steel). The mechanical test such tensile test and charpy impact test were conducted under ASTM D3552 and E23 standard to compare the toughness, tensile strength and modulus of elasticity between the two matrixes (Aluminium 2024 and Stannum). The results showed Aluminium 2024 reinforced low carbon steel composite, shows that improvement in term of mechanical properties (i.e., tensile strength and impact strength) compared to Stannum reinforced low carbon steel. The presence of interphase-interface between matrix and reinforcement were observed under Scanning Electron Microscope (SEM) and Fractography analysis was carried out to study the microstructure characteristics related to the fracture surface materials.

ABSTRAK

Komposit logam-logam adalah kaedah penemuan baru untuk menghasilkan sesuatu bahan komposit yang berupaya meningkatkan sifat kekakuan, ketahanan kehausan, kekuatan dan mempunyai berat yang ringan. Dalam kajian ini, penyiasatan terhadap matriks yang berbeza iaitu Aluminium 2024 dan Timah ke atas metal-metal komposit telah dipelajari. Dalam projek ini, penghasilan komposit Aluminium 2024 diperkuat keluli berkarbon rendah dan komposit Timah diperkuat keluli berkarbon rendah telah dihasilkan melalui kaedah baru dalam keadaan cecair iaitu *Pressureless Infiltration*. Formula sebatian terbaik komposit didapati pada peratusan berat (wt %) dengan 60 wt% matriks (Aluminium dan Timah) dan 40 wt% tetulang (keluli berkarbon rendah). Setelah komposit itu terhasil, ujian mekanikal seperti ujian tegangan dan ujian hentaman dilakukan di bawah ASTM D3552 dan piawaian E23 untuk membandingkan keliatan, kekuatan tegangan dan modulus kekenyalan di antara dua matriks yang berbeza iaitu matriks Aluminium 2024 dan matriks Timah. Seperti yang telah dijangkakan, keputusan menunjukkan bahawa Aluminium 2024 diperkuat keluli berkarbon rendah telah meningkatkan sifat-sifat mekanikal (kekuatan tegangan dan kekuatan hentaman) jauh lebih baik berbanding Timah diperkuat keluli berkarbon rendah. Kewujudan antaramuka-antarafasa di antara matriks dan tetulang diperhatikan dengan menggunakan Mikroskop Pengimbas Elektron (SEM) dan analisis fractografi telah dilakukan untuk mengkaji dan mempelajari karakteristik permukaan spesimen yang telah retak.

DEDICATION

For all your advice and encouragement, this thesis is gratefully dedicated to my beloved family (Mr. Mohd Arsad Osman and Mrs. Normah Binti Sulaiman) and friends. Thank you very much for their continuous support and effort towards the publication of this thesis.

ACKNOWLEDGEMENT

Firstly, Syukur Alhamdulillah and all praises of Allah S.W.T which lead me to accomplish this final year project in a course of BMFG 4913 and BMFG 4923 (PSM 1&2).I would like to express my big appreciation and sincere gratitude to my supervisor, Mr. Mohamad Haidir Bin Maslan and to my examiner Dr.Azizah Binti Shaaban for their encouragement, ideas and support and for their irreplaceable unfailing patience, guidance throughout this project research. Their knowledge and experience really inspired and spurred myself.

Last but not least, to technician lab members and whom those involve in completing this projects who have been helping together to give idea and any flourishing suggestions, a special thanks for their sincerely and co-operations. Also big thanks for my family as well as friends and all technicians without their wise counsel and dependable assistance this project research would not have been possible. Thank you, very much.

TABLE OF CONTENTS

| | |
|---|----------|
| Abstract | i |
| Abstrak | ii |
| Dedication | iii |
| Acknowledgement | iv |
| Table of Content | v |
| List of Tables | ix |
| List of Figures | x |
| List of Abbreviations Symbols, Specialized Nomenclature | xiv |
| | |
| 1. INTRODUCTION | 1 |
| 1.1 Research Background | 1 |
| 1.2 Problem Statements | 2 |
| 1.3 Objectives | 3 |
| 1.4 Scope of study | 3 |
| 1.5 Research Question | 4 |
| 1.6 Hypotheses | 4 |
| | |
| 2. LITERATURE REVIEW | 5 |
| 2.1 Composites | 5 |
| 2.1.1 Introduction | 5 |
| 2.1.2 Composites Properties | 6 |
| 2.2 Matrix | 9 |
| 2.2.1 Metal Matrix Composites (MMC) | 10 |
| 2.3 Metal Matrix Composites Processing | 12 |
| 2.3.1 Liquid state methods | 12 |
| 2.3.1.1 Squeeze Casting | 12 |
| 2.3.1.2 Melt Stirring | 13 |
| 2.3.1.3 Pressureless Metal Infiltration | 14 |
| 2.3.1.4 Spray Co-Deposition | 15 |

| | | |
|-----------|---|-----------|
| 2.3.2 | Solid State Methods | 16 |
| 2.3.2.1 | Diffusion Bonding of Foils | 16 |
| 2.3.2.2 | In – situ Processing | 16 |
| 2.3.2.3 | Powder Blending and Consolidation | 17 |
| 2.3.3 | Vapour State Method | 18 |
| 2.3.3.1 | Chemical Vapor Deposition | 18 |
| 2.4 | Characteristic of Metal Matrix Composites | 19 |
| 2.4.1 | Previous Research on Metal Matrix Composites | 20 |
| 2.4.2 | Polymer Matrix Composite (PMC) | 22 |
| 2.4.3 | Ceramic Matrix Composite (CMC) | 23 |
| 2.5 | Reinforcements | 24 |
| 2.5.1 | Low Carbon Steel (Reinforcement) | 26 |
| 2.6 | Aluminium Matrix Composites (AMC) | 27 |
| 2.6.1 | Introduction to Aluminium Matrix Composites | 27 |
| 2.6.2 | Aluminium 2024 | 28 |
| 2.6.3 | Previous Research on Aluminium Matrix Composite | 30 |
| 2.7 | Stannum (Tin) | 31 |
| 2.8 | Interphase and Interface | 31 |
| 2.8.1 | Types of Bonding | 33 |
| 2.8.1.1 | Mechanical Bonding | 34 |
| 2.8.1.2 | Chemical Bonding | 35 |
| 3. | METHODOLOGY | 37 |
| 3.1 | Introduction | 37 |
| 3.2 | Process sequence in this project | 38 |
| 3.3 | Methodology of parameter consideration | 39 |
| 3.3.1 | Parameter consideration | 39 |
| 3.3.2 | Sample Preparation | 40 |
| 3.4 | Methodology of mould fabrications | 41 |
| 3.4.1 | Process flow of fabricating mould | 42 |
| 3.5 | Methodology of composite fabrications | 43 |

| | | |
|-----------|---|-----------|
| 3.5.1 | Procedure of composite fabrications | 43 |
| 3.5.2 | Process flow of composite fabrications | 47 |
| 3.6 | Specimen Fabrications | 48 |
| 3.6.1 | Flow Chart of the Sample Fabrication Process | 49 |
| 3.7 | Methodology mechanical properties testing and analysis | 49 |
| 3.7.1 | Tensile test | 50 |
| 3.7.2 | Impact test | 52 |
| 3.7.3 | Matrix-reinforcement boundary observation analysis | 54 |
| 4. | RESULTS | 55 |
| 4.1 | Introduction | 55 |
| 4.2 | Tensile Test Result | 55 |
| 4.2.1 | Aluminium 2024 reinforced low carbon steel | 56 |
| 4.2.2 | Aluminium 2024 | 57 |
| 4.2.3 | Stannum reinforced low carbon steel | 58 |
| 4.2.4 | Stannum | 59 |
| 4.3 | Charpy Impact Test Result | 61 |
| 4.3.1 | Aluminium 2024 reinforced low carbon steel | 61 |
| 4.3.2 | Aluminium 2024 | 62 |
| 4.3.3 | Stannum reinforced low carbon steel | 62 |
| 4.3.4 | Stannum | 63 |
| 4.4 | Result for Scanning Electron Microscopy (SEM) | 64 |
| 4.4.1 | SEM of Aluminium 2024 reinforced low carbon steel | 64 |
| 4.4.2 | SEM of Stannum reinforced low carbon steel | 65 |
| 5. | DISCUSSION | 66 |
| 5.1 | Introduction | 66 |
| 5.1.1 | Composites enhanced the mechanical properties of the material | 66 |
| 5.2 | Mechanical Properties: Tensile Strength | 68 |
| 5.2.1 | Data Analysis for Tensile Strength | 69 |
| 5.3 | Mechanical Properties: Impact Strength | 71 |
| 5.3.1 | Data Analysis for Impact Strength | 72 |
| 5.4 | Fractography Analysis | 73 |

| | | |
|----------------------|---|-----------|
| 5.4.1 | Fractography analysis of tensile surface fracture | 74 |
| 5.4.2 | Fractography analysis of impact surface fracture | 76 |
| 5.5 | Matrix-Reinforcement Boundary Observation | 77 |
| 5.5.1 | Aluminium 2024 reinforced low carbon steel | 77 |
| 5.5.2 | Stannum reinforced low carbon steel | 80 |
| 6. CONCLUSION | | 82 |
| 6.1 | Conclusion | 82 |
| 6.2 | Recommendation | 83 |
| REFERENCES | | 85 |
| APPENDICES | | |
| A | Gant Chart for PSM 1 | 90 |
| B | Gant Chart for PSM 2 | 91 |
| C | Machines | 92 |
| D | Part of Composites Mould | 93 |

LIST OF TABLES

| | | |
|-----|---|----|
| 2.1 | General combinations of matrix and strengthener in MMC | 10 |
| 2.2 | Properties of Matrix Materials | 12 |
| 2.3 | Advantages & disadvantages of MMCs over PMCs | 19 |
| 2.4 | Types of reinforcements materials and its examples | 24 |
| 2.5 | Composition of Aluminium 2024 | 29 |
| 3.1 | Overall dimension details for tensile specimen test | 51 |
| 4.1 | Tensile Test Result for Aluminium Reinforced Low Carbon Steel | 57 |
| 4.2 | Tensile Test Result for Aluminium 2024 | 58 |
| 4.3 | Tensile Test Result for Stannum Reinforced Low Carbon Steel | 59 |
| 4.4 | Tensile Test Result for Stannum | 60 |
| 4.5 | Impact Test Result for Aluminium Reinforced Low Carbon Steel | 61 |
| 4.6 | Impact Test Result for Aluminium 2024 | 62 |
| 4.7 | Impact Test Result for Stannum Reinforced Low Carbon Steel | 63 |
| 4.8 | Impact Test Result for Stannum | 63 |
| 5.1 | Young Modulus and Ultimate Strength of Aluminium and Stannum | 70 |

LIST OF FIGURES

| | | |
|-------|---|----|
| 2.1 | Formation in composites material | 6 |
| 2.2 | Properties of the composite based on the properties of the component materials | 7 |
| 2.3 | Stress-Strain curves for Composite | 8 |
| 2.4 | Stress-Strain curves for a monolithic metal | 8 |
| 2.5 | Squeeze Casting | 13 |
| 2.5a | Squeeze Casting: Insert Perform Into Die Cavity | 13 |
| 2.5b | Added Precise Quantity of Molten Metal | 13 |
| 2.5c | Close Die and Apply pressure | 13 |
| 2.5d | Remove Ram | 13 |
| 2.5e | Extract Component | 13 |
| 2.6 | Melt Stirring Method | 14 |
| 2.7 | Pressureless Infiltration Process | 15 |
| 2.8 | Spray Co-deposition Production of SiC Particulate Reinforced Metal | 15 |
| 2.9 | Diffusion Bonding Process | 16 |
| 2.10 | Diagram of Induction Heating Used for Unidirectional Solidification | 17 |
| 2.11 | Chemical Vapor Deposition Unit | 18 |
| 2.12 | Fiber Orientation | 25 |
| 2.12a | Fibers are in one direction, the composite is called unidirectional | 25 |
| 2.12b | Fibers oriented in all directions, it has randomly oriented fibers | 25 |
| 2.12c | Orthogonal or bidirectional fiber | 25 |
| 2.12d | Layers oriented in different directions | 25 |
| 2.13 | Dependence of properties based on fiber and loading stress orientations | 26 |
| 2.14 | Schematic diagram of the fiber-matrix interphase and some of the factors that contribute to its formation | 33 |
| 2.15 | Interlock of mechanical bonding | 35 |
| 2.16 | Chemical Bonding | 35 |

| | | |
|------|---|----|
| 3.1 | Step in processing sequences of producing metal-metal Composites | 38 |
| 3.2 | Parameter (Aluminium 2024 and Stannum) involve in this project | 39 |
| 3.3 | Aluminium Bar | 40 |
| 3.4 | Stannum Rod | 40 |
| 3.5 | Low Carbon Steel in geometry of rod | 41 |
| 3.6 | Composite mould which is consists of bottom and cavity | 42 |
| 3.7 | Process sequence of fabricating mould of composites | 42 |
| 3.8 | Composites mould consists of base mould and cavity | 43 |
| 3.9 | Preparation of mould and raw material | 44 |
| 3.10 | Melting process of matrix material | 44 |
| 3.11 | Pouring molten matrix on top of reinforcement | 45 |
| 3.12 | Sample of Aluminium 2024 reinforced low carbon steel | 45 |
| 3.13 | Removing composites from mould | 46 |
| 3.14 | Surface finishing process by milling machine | 46 |
| 3.15 | Process flow of composite fabrications | 47 |
| 3.16 | Tensile Test Specimen | 48 |
| 3.17 | Charpy Impact Test Specimen | 48 |
| 3.18 | Flowchart of Sample Fabrication Process | 49 |
| 3.19 | The Overall Dimension of Tensile Test Specimen According to the ASTM D3552-Design Type D Straight Sided | 50 |
| 3.27 | Sample is clamped tightly using Universal Tensile Machine | 51 |
| 3.29 | Notched impact's specimen: 45° notch angle & 2.54 mm depth of notch | 52 |
| 3.30 | Charpy Impact Test Specimen according to ASTM E23 Type a Design | 53 |
| 3.31 | Impact Tester Machine | 53 |
| 3.32 | Scanning Electron Microscopy (SEM) | 54 |
| 3.33 | Mounted of specimens on SEM stubs | 54 |
| 4.1 | Stress-strain graph for Aluminium 2024 Reinforced Low Carbon Steel | 56 |
| 4.2 | Stress-strain graph for Aluminium 2024 | 57 |
| 4.3 | Stress-strain graph for Stannum Reinforced Low Carbon Steel | 59 |
| 4.4 | Stress-strain graph for Stannum | 60 |
| 4.5 | SEM for Aluminium 2024 Reinforced Low Carbon Steel at | |

| | | |
|------|--|----|
| | 150 X magnifications | 64 |
| 4.6 | SEM for Stanum Reinforced Low Carbon Steel at 150 X magnifications | 65 |
| 5.1 | Comparison of tensile strength between composites and monolithic material | 67 |
| 5.2 | Comparison of impact strength between composites and monolithic material | 68 |
| 5.3 | Comparison properties between Aluminium 2024 reinforced low carbon steel and Stannum reinforced low carbon steel | 68 |
| 5.4 | Experimentally results of data properties for Aluminium 2024 and Stannum | 70 |
| 5.5 | Comparison properties between Aluminium 2024 reinforced low carbon steel and Stannum reinforced low carbon steel | 71 |
| 5.6 | Fracture surface of Aluminium 2024 reinforced low carbon steel | 74 |
| 5.7 | Reinforcement pulls out from the matrix (Stannum Reinforced low carbon steel) | 75 |
| 5.8 | Impact fracture for Stannum reinforced low carbon steel | 76 |
| 5.9 | Impact fracture for Aluminium 2024 reinforced low carbon steel | 76 |
| 5.10 | The matrix-fiber interface observation through the Scanning Electron Microscopy (SEM) at 150 X magnifications | 77 |
| 5.11 | Schematic representation of metal substrate surface regions | 79 |
| 5.12 | The matrix-fiber interface observation through the Scanning Electron Microscopy (SEM) at 150 X magnifications | 80 |

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

| | | |
|-------------------------|---|--|
| % | - | Percent |
| μ | - | Coefficient of friction |
| $^{\circ}\text{C}$ | - | Degrees Celsius |
| $^{\circ}\text{F}$ | - | Fahrenheit |
| 150 x | - | 150 times magnification |
| Al | - | Aluminium |
| Al_2O_3 | - | Aluminum Oxide |
| AMCs | - | Aluminum matrix composites |
| ASTM | - | American Society for Testing and Materials |
| CFs | - | Carbon fibers |
| CMC | - | Ceramic Matrix Composites |
| Cu | - | Copper |
| <i>D</i> | - | Diameter |
| <i>E</i> | - | Modulus of Elasticity |
| eg. | - | Example |
| et al. | - | Et alia (and others) |
| etc. | - | Et cetera |
| GPa | - | Giga Pascal |
| HDPE | - | High Density Polyethylene |
| i.e., | - | That is |
| J | - | Joule |
| LDPE | - | Low Density Polyethylene |
| M | - | Mega |
| mm | - | milimeter |
| MMC | - | Metal Matrix Composites |
| MPa | - | Mega Pascal |
| Pa | - | Pascal |

| | | |
|------------------|---|------------------------------------|
| PMC | - | Polymer Matrix Composites |
| s | - | Second |
| SEM | - | Scanning Electron Microscopy |
| Sn | - | Stannum |
| UTM | - | Universal Tensile Machine |
| V | - | Volume fraction of component |
| wt% | - | Percent of weight fraction |
| ZrO ₂ | - | Zirconium Oxide |
| σ | - | Tensile Strength |
| σ_f | - | Tensile Strength of the Fiber |
| σ_y | - | Yield Strength, |
| τ_c | - | Shear yield Strength of the Matrix |
| τ_i | - | Interfacial shear strength |

CHAPTER 1

INTRODUCTION

1.1 Research Background

A composite is a combination of two or more material that can be arranged to be reinforcement or matrix. The matrix is a percolating “soft” phase with in a general excellent ductility, formability, and thermal conductivity in which are embedded the “hard” reinforcements (high stiffness and low thermal expansion). The combination forms a useful material to increase the properties of materials. The chemical reaction between reinforcement and matrix form an interface and interphase that separating them insoluble in each other.

Metal matrix composites with aluminum as the matrix material have been heralded as the next great development in advanced aluminum material for at least 20 years. Aluminium metal matrix composites are one of several classes of advanced materials which are expected to play a significant role in the development of future aerospace, automotive and military applications.

Reinforcement that had been used in this investigation was a low carbon steel. When combined with an aluminum matrix, the resulting material has significant increases in elastic modulus (stiffness), wear resistance, strength and fatigue resistance.

Pressureless metal infiltration is a process to produce the composite. By using different matrix of Aluminium 2024 and Stannum reinforced with rod low carbon steel, the mechanical properties of different matrix can be compared to study the material properties. Tensile test, Charpy impact test and matrix-reinforcement boundary observations were conducted under ASTM standard to obtain the mechanical properties of this composite material. Besides, the study of the surface between matrix and reinforcement were also facilitated to observe the bonding that developed from physical or chemical interactions, interfacial frictional stress and thermal stresses.

1.2 Problem Statements

Nowadays, metal-metal composites has not been paid much attention and used extensively in industry although it has excellent mechanical and thermal properties (Hassan *et al.*, 2008). The attractive physical and mechanical properties that can be obtained with this composites, such as high specific modulus, strength, and thermal stability, high impact strength and have been documented extensively. However, there is no detailed information can be found for this metal-metal composite which is used reinforcement and matrix as backbone for building structure. This project will investigate the effect of different matrix (Aluminium 2024 and Stannum) on the properties of the metal-metal composites it is a research developed to study the mechanical properties of Aluminium 2024 and Stannum. These matrixes (Aluminium 2024 and Stannum) will continuously reinforce with low carbon steel in geometry of rod. This reinforcement is embedded into the different matrix (Aluminium 2024 and Stannum) separately and their mechanical properties are compared and analyzed. It emphasizes the study on mechanical behavior of different effect of matrix which is Aluminium 2024 and Stannum in metal matrix composites. This project also using the pressureless metal infiltration which is a liquid state method to produces this metal-metal composite.

1.3 Objectives

There are few reasons to accomplish this project, which are:

- (a) To investigate the mechanical properties of Aluminium 2024 and Stannum in metal-metal composites.
- (b) To compare the mechanical properties effect of different matrix Aluminium 2024 and Stannum reinforced with low carbon steel.

1.4 Scope of Study

The emphasis of this report is on the establishment of studies on investigation effect of different matrix (Aluminium 2024 and Stannum) on the properties of the metal-metal composites. The comparison between the two different matrixes was investigated in order to acquire the mechanical properties. Besides, pressureless metal infiltration which is a liquid state method is using to produce this metal-metal composite. The mechanical properties was obtained via tensile test and charpy impact test conducted under ASTM standard to determine the toughness, tensile strength, yield strength and modulus of elasticity. The matrix-reinforcement boundary is observed using SEM (Scanning Electron Microscope) to understand and analyze the interphase-interface between reinforcement and matrix and physical properties. Fractography analysis was carried out to study the microstructure characteristics related to the fractured surface materials.

1.5 Research Question

- (a) What is the effect of mechanical properties when using different matrix?
- (b) Which matrix (Aluminium 2024 or Stannum) will increase the mechanical properties of metal-metal composites?
- (c) What will be formed when matrix and reinforcement are insoluble in each other?

1.6 Hypotheses

Different uses of matrix material such as Aluminum 2024 and Stannum with the same reinforcement (low carbon steel) will results a different effect behaviors and mechanical properties of a composite material. It was predicted that Aluminium 2024 matrix composites reinforced with low carbon steel will increase the mechanical properties of the metal-metal composites compared to copper matrix composites because Aluminium 2024 is quite attractive due to its low density, its capability to be strengthened by precipitation, its good corrosion resistance, high thermal and electrical conductivity, and its high damping capacity. In addition, processing Aluminium 2024 is more practical for their isotropic mechanical properties (higher than their unreinforced alloys) and their low costs (cheap processing routes and low prices). The chemical reaction between reinforcement and matrix form an interface and interphase that separating them insoluble in each other.

CHAPTER 2

LITERATURE REVIEW

2.1 Composites

2.1.1 Introduction

The term “composite” broadly refers to a material system that composed of a discrete constituents (the reinforcements) distributed in a continuous phase (the matrix) which derives its distinguishing characteristics from the properties of its constituents, from the geometry and architecture of the constituents, and from the properties of the boundaries (interfaces) between different constituents, as depicted in Figure 2.1. Composite materials are usually classified on the basis of the physical or chemical nature of the matrix phase such as polymer matrix composites (PMC), metal matrix composites (MMC) and ceramic matrix composites (CMC).

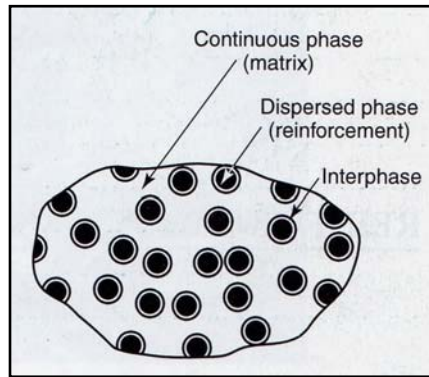


Figure 2.1: Formation in composites material (Helsel and Liu, 2001)

2.1.2 Composites Properties

Composites consist of two major parts in its constituent which is matrix and reinforcement. According to Matthews and Rawlings, (2002), each of materials (i.e. matrix and reinforcement) must exist of more than 5 wt% to be classified as composites material. The purposed of introduced the composites material is to improve the properties that have been performed by monolithic material. Thus, the composite is expected to improve the mechanical characteristics such as stiffness, toughness, ambient and high-temperature resistance (Callister, 2003).

The final properties of a composite with strengthener in fiber form are determined by fiber content, matrix material, fiber material, fiber orientation, and to a smaller extent by the fiber length and distribution in the composite. The reinforcing effects of the fiber in the composite are best explained by the rule of mixtures. In this rule, the properties of the composite depend directly on the volume fractions of each component in the mixture and the respective properties of the fiber and the matrix.

$$\sigma_c = \sigma_f V_f + \sigma_m V_m \quad \text{and} \quad E_c = E_f V_f + E_m V_m \quad \longrightarrow \quad \text{Rules of Mixtures}$$

Where σ = Strength of the material, V = Volume fraction of component, E = Modulus of elasticity of the material. The subscripts c is for the finished composite, f is for the fiber,