THE EFFECT OF MILLING TIME ON ALUMINUM- SILICON CARBIDE COMPOSITE

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To my beloved family

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In the name of God, the most Gracious, the most Merciful.

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ABSTRACT

Silicon carbide particle reinforced aluminum matrix composites have been developed over past few decades, owing to their excellent properties like light weight, wear resistance and high elastic modulus. Thus, the silicon carbide particle reinforced aluminum matrix composites are expected to have many applications in aerospace, automobile, aircraft and electronic industries. In this study, aluminum metal matrix composites contains two weight percentages of reinforcement particles were prepared by mechanical alloying. The main steps in mechanical alloying are milling, compacting and sintering. The experiments were performed on two composition of silicon carbide powder in the composite. The study presents the results of the influence of milling time on aluminum- silicon carbide composite and the effect of different weight percentage of silicon carbide in composite on hardness and microstructure of the composite. Aluminum and silicon carbide particles are mixed of different milling times 0, 40, 80, 120 minute. Digital image analyzer was used to characterize the composites. The effect of weight percentage of silicon carbide on hardness of composites was investigated by using Vickers hardness Test. Hardness of the composites increased with increasing silicon carbide addition in it.

ABSTRAK

Matriks komposit aluminum yang diperkukuh dengan zarah silikon karbida telah dibangunkan sejak beberapa dekad lalu kerana kecemerlangan sifat-sifat seperti ringan, tahan rintang dan modulus elastik yang tinggi. Oleh itu, matriks komposit aluminum yang diperkukuh dengan zarah silikon karbida dijangka mempunyai banyak aplikasi dalam aeroangkasa, kereta, kapal terbang dan industri elektronik. Dalam kajian ini, komposit matriks logam aluminium mengandungi dua peratusan berat zarah pengukuhan telah disediakan melalui pengaloian mekanikal. Langkah-langkah utama dalam pengaloian mekanikal ialah penghancuran, mampatan dan pensinteran. Eksperimen dijalankan ke atas dua komposisi serbuk silikon karbida dalam komposit. Kajian ini membentangkan hasil pengaruh masa pengisaran terhadap komposit aluminium-silikon karbida dan kesan peratusan berat yang berbeza daripada silikon karbida dalam komposit pada kekerasan dan struktur mikro yang telah dikaji. Zarah aluminium dan silikon karbida dicampur pada masa pengisaran yang berbeza; 0, 40, 80, 120 minit. Penganalisis imej digital digunakan untuk mencirikan komposit. Kesan peratusan berat silikon karbida pada kekerasan komposit dikaji menggunakan kekerasan Ujian Vickers. Kekerasan komposit meningkat dengan peningkatan silikon karbida di dalamnya.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

A composite material is a ‘material system’ composed of a combination of two or more micro or macro constituents that differ in form, chemical composition and which are essentially insoluble in each other. Aluminum-matrix composites are not a single material but a family of materials whose stiffness, strength, density, thermal and electrical properties can be tailored. The matrix alloy, reinforcement material, volume and shape of the reinforcement, location of the reinforcement and fabrication method can all be varied to achieve required properties. The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and ceramics. 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 (Mares, 2001).

1.2 Metal Matrix Composite

1.2.1 Metal Matrix Composite Definitions

A composite material is made by combining two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite you can easily tell the different materials apart as they do not dissolve or blend into each other.

Composite material is a mixture of two or more materials or phases of the same material, insoluble in one another, possessing properties which are superior to any of the component materials (Vencl & Rac, 2004).

1.2.2 Metal Matrix Composite Applications

Metal matrix composite (MMC) is engineered combination of the metal (Matrix) and hard particle/ceramic (Reinforcement) to get tailored properties. MMC's are either in use or prototyping for the space shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs, and a variety of other applications (Singla, et al., 2009).

1.3 Problem Statement

There are many methods used to reduce the size of materials to become powder but not all types can achieve the desirable size of fine powder. The common methods such as jaw crusher or hammering method, sometimes results in the material losses of its characteristics during size reduction process. High quality ball mills are potentially expensive and can grind mixture particles to as small as 0.0001 mm, enormously increasing surface area and reaction rates. However, normal ball mill is inexpensive and simple process, but it suffer from some defects such as occurring of wear, principally from the balls, but partially from the casing and this may result in the product being contaminated. Also soft or sticky materials may cause problems by caking on the sides of the mill or by holding the balls in aggregates (Bhatt & Agrawal, 2007).

In milling process, there are many different process variables that can be tuned in order to obtain a product with well-established properties: milling time, milling speed, size of grinding media, ball-to-powder ratio, controlled atmosphere, and so on. This fabrication method is thus simple but not trivial and it can be an attractive technology in nano-powder production (Russo et al., 2011; Singla et al., 2009).

Generally, nanoparticles synthesis requires the use of a device or process that handles these problems (Horikoshi & Serpone, 2013):

- Control of particle size, size distribution, shape, crystal structure and composition distribution
- Improvement of the purity of particles (lower impurities)
- Control of aggregation
- Stabilization of physical properties, structures and reactants
- Higher reproducibility
- Higher mass production, scale-up and lower costs

1.4 Research Objectives

1. To obtain (Aluminum -Silicon carbide) composite from mixing of the two powders and to study the effect of the milling time on particles size and distribution.
2. To study the effect of milling time on microstructure and mechanical properties of (Aluminum –Silicon carbide) composites.

1.5 Research Significance

Raw materials and often occur in sizes that are too big to be used, and therefore, there must be a reduction or changing in size however if the milled raw material is too fine and the dispersion of reinforcement material is not good. Different raw materials vary in shape and size, fragility and durability, and the product may vary from coarse powder for ease in different industries for different purposes. Fabrications of fine particles are being investigated increasingly in industry and academic research because of the applications on a large scale in all the fields of science and production.

1.6 Research Scope

The research aims to study the effect of ball milling on two selected materials. Different quantities of powder of Aluminum (Al) and Silicon Carbide (SiC) will be used to achieve the research goals. The ball mill machine PM 400 will

be used in the research experiments. The machine is designed to fabricate a small powder size estimated in hundreds of grams.

1.7 Research Organization

This research is organized into five chapters as follows. Chapter 2 explores the literature review. Chapter 3 explains the research methodology. The results and discussion are demonstrated in Chapter 4, while conclusions and recommendations are in chapter 5.

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