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INVESTIGATION OF THE MECHANICAL PROPERTIES OF AL-SIC MMC FABRICATED WITH DIFFERENT PARTICLE SIZE

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MUHAMAD KHALIL

Report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Engineering in Manufacturing Engineering

Faculty of Manufacturing Engineering

UNIVERSITI MALAYSIA PAHANG

June 2016

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Manufacturing Engineering.

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STUDENT'S DECLARATION

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LIST OF ABBREVIATIONS

Al   Aluminum

AMC   Aluminum Matrix Composite

MMC   Metal Matrix Composite

PM   Powder Metallurgy

SiC   Silicon Carbide

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ABSTRACT

Silicon carbide particle reinforced aluminum matrix (Al) composites have been developed over past few decades, owing to their excellent properties like lightweight, high elastic modulus and wear resistance. Thus, the silicon carbide (SiC) particle reinforced Al composites are expected to have many applications in aerospace, aircraft, automobile and electronic industries. In this study, aluminum metal matrix composites (AMC) containing different particle size of reinforcement particles were prepared by using powder metallurgy method. The main steps in powder metallurgy are blending, compacting and sintering. The experiments were performed on micro and nano size particles of silicon carbide powder in the composite. The study presents the results of experimental investigation on mechanical behavior of silicon carbide particle reinforced aluminum matrix. The influence of MMC micro and nano particles on the mechanical behavior was examined. The hardness and microstructure was studied. Optical Metallurgical Microscope was used to characterize the composites. The hardness was measured by vicker micro hardness testing machine as per the ASTM E384. The microstructure observation shows better distribution of particles in case of nano particles as compared to micro particles. The overall results showed that the MMC reinforced with SiC nano particles exhibited better mechanical properties then MMC reinforced with micro particles.

ABSTRAK

Sejak beberapa dekad yang lalu, silikon karbida dengan aluminium matrik telah di kompositkan kerana sifat-sifat cemerlang mereka, seperti ringan, modulus elastik yang tinggi dan rintangan yang berkesan. Oleh itu, silikon karbida komposit dengan aluminium mempunyai banyak aplikasi dalam bidang aeroangkasa, pengangkutan dan industri elektronik. Dalam kajian ini, komposit logam aluminium matrik yang mengandungi zarah yang berlainan saiz akan di hasilkan dengan menggunakan kaedah metalurgi. Langkah-langkah utama dalam metalurgi ialah mencampurkan, memadat dan pensinteran. Kajian ini telah dijalankan berdasarkan dua silikon karbida yang mempunyai zarah berbeza iaitu mikro dan nano saiz. Kajian ini akan mengkaji terhadap sifat-sifat mekanikal terhadap zarah silikon karbida yang dikompositkan dengan aluminium. Sifat-sifat mekanikal mikro dan nano yang dipengaruhi oleh MMCs dikaji. Kekerasan dan mikrostruktur dikaji. Mikroskop optik logam digunakan untuk mengkaji ciri-ciri komposit. Vicker mikro mesin digunakan untuk mengukur kekerasan seperti ASTM E384. Berdasarkan pemerhatian mikrostruktur, zarah nano menunjukkan pengedaran yang lebih baik berbanding dengan zarah mikro. Pengukuhan MMC dengan zarah nano silikon karbida mempamerkan sifat-sifat mekanikal yang lebih baik berbanding pengukuhan MMC dengan zarah mikro.

CHAPTER 1

INTRODUCTION

1.1   BACKGROUND OF STUDY

Composite materials are important engineering material due to their outstanding mechanical properties. Composite material that exists today can be classified into five classes. Metal Matrix Composite (MMCs) is two material composite and being one material. One being a material necessity and the other material is different. Each of the material retains its characteristics and structure but the composite possesses better properties. Due to the high cost and difficulty of processing these composites led to the development of discontinuously reinforced composites.

The familiar material used nowadays is aluminum matrix composite (AMCs) because it has a low melting point, low density, high stiffness, and corrosion resistance. AMCs widely uses in the field of automation because of their properties. Aluminum (Al) is an abundant, because of their properties are light and strong. The metal matrix, the reinforcement material, the volume of the reinforcement and the fabrication method can all be diverged to achieve required properties.

Referable to improvement in wear resistance, stiffness, hardness, strength and chemical compatibility with Al, Silicon Carbide (SiC) is regarded an ideal reinforcement. A significant reduction of the fracture toughness and ductility of the MMCs due to the incorporation of the ceramics SiC has been reported by (Samuel 1993). This reduction in toughness is attributed (Samuel 1993) to the inhomogeneous distribution of the SiC particles,

presence of voids and weak interfacial bonding of Al-SiC. SiC has a strong bonding because of the composed of tetrahedral of carbon and silicon atoms. Due the strong bond it will produce a very hard and strong material. The properties of SiC are low density, low thermal, low density and high hardness. That's why the MMCs is the familiarity material uses in the modern day in industry automation.

While using isotropic properties, the MMCs is easily adaptable in engineering design. MMCs have considered promising candidates to fill these needs. In particular, particulate MMCs have been preferred over continuously reinforced MMCs because they avoid problems such as fiber damage, microstructural non uniformity and fiber contact damage (Ram Prabhu, Varma et al. 2014). MMCs reinforced with ceramic have been developed and applied in numerous industrial applications from automobile to the recreation industries. MMCs have been used in various industries because of the high strain rate impact properties, high specific strength, high stiffness, high resistance and reduced weight. MMCs usually consists low density, compared with unreinforced it has a high strength, high stiffness and wear resistance. The advantages of composite material are to increase yield strength and stress, and improve corrosion resistance. To improve the Al metal, the SiC needs to composite with Al. MMCs generally consists of lightweight. SiC particles and Al matrix is the main composite in the preparation of MMCs because of the physical and chemical compatibility.

Therefore, the reinforcement of metal matrix composite can be fabricated by powder metallurgy (PM), ingot metallurgy (IM), and disintegrated melt deposition (DMD) method. In this study, the PM method is carried out to fabricated SiC particle reinforced Al MMC. The effect of weight percentage of the reinforced particles on mechanical behavior such as microstructure of the composites and hardness can be investigated. The PM method is generally preferred because of the advantages. Due to the advantages of the PM method the uniformity distribution of ceramic particle reinforcement is realized. Powder metallurgy is a forming process consist of producing metal powder, blending, compacting in dies and sintering. The PM method also capable producing a relatively economically specimen and wide variety of metal matrix composite. Basically, in the conventional PM production, after produced the raw material, there are three steps consists. Firstly, the raw material are mixing

and blending. Then the material are compact into the circle shape using die. The last steps of PM method is sintering. This process is to cause solid state bonding of the particles and strength which involves heating to a temperature below the melting point. Mixture refers, when the powders have same chemical composition but different chemistries being combine. After that, in compaction, the high pressure is applied to the powders to form the material into circle shape. After compaction, the green compaction are lacks strength and hardness. The sintering process is applied as a heat treatment on the compact to bond the particles.

1.2   PROBLEM STATEMENT

MMCs is one type of composite that combination of solid that consist of two or more different materials that will reinforcement together. Each composite can enhance the mechanical properties such as the hardness, tensile strength and yield strength. In this situation, the problem occurs when its structure of the composite material, aluminum (Al) and Silicon Carbide (SiC) is crack earlier due the increasing of particles. When particles increase the mechanical properties of Metal Matrix Composite (MMCs) will become reduces. The crack grows due the increasing of particles. In addition, by using the nano-sized SiC particle reinforcement, the hardness, strength and the yield strength of the composite increase. The MMCs fracture initially as the crack breaks the particle and propagate. Therefore, the overall mechanical properties of the MMC reduced. So the reduction of the size of the particle can be a solution to increase the life of MMC. This is because when it is below the critical level, particles will no longer fracture. (Taha et al 2003) described, after break up, the ductile Al matrix is able to flow between the particles. The SiC need to redistribute in a more homogeneous configuration. The SiC particle size and distribution, the voids must be understood to optimize the suitable parameters for various applications.

The uniformity or homogeneous distribution of particle is also very important to get a good mechanical response of the composite (Kung et al. 2009). There are many types of method that can be used to manufacture the Al-SiC MMC. Most of the methods have a nearly uniform distribution of the reinforcement particle within the matrix. However, there are still some small agglomerations between it (Saravanani et al. 2015). To reduce the agglomerations, the powder metallurgy method is used. This method can help to have a

REFERENCE

Aydemir, B., Cal, B. & Salman, S., 2011. the Advantages of New Generation Hardness Measurement Methods. , pp.337–344.

Bodukuri, A. K., K. Eswaraiah, K. Rajendar and V. Sampath (2016). "Fabrication of Al-SiC-B4C Metal Matrix Composite by Powder Metallurgy Technique and Evaluating Mechanical Properties." Perspectives in Science.

Cai, Z., C. Zhang, R. Wang, C. Peng, K. Qiu and Y. Feng (2015). "Preparation of Al–Si

Du, Y., A. B. Li, X. X. Zhang, Z. B. Tan, R. Z. Su, F. Pu and L. Geng (2015). "Enhancement of the mechanical strength of aluminum foams by SiC nanoparticles." Materials Letters **148**: 79-81.

El-Kady, O. and A. Fathy (2014). "Effect of SiC particle size on the physical and mechanical properties of extruded Al matrix nanocomposites." Materials & Design (1980-2015) **54**: 348-353.

H. Wang, R. Zhang, X. Hu, C. Wang, and Y. Huang, "Characterization of a powder metallurgy SiC / Cu – Al composite," vol. 7, pp. 43–48, 2007

Jiang, J. and Y. Wang (2015). "Microstructure and mechanical properties of the rheoformed cylindrical part of 7075 aluminum matrix composite reinforced with nano-sized SiC particles." Materials & Design **79**: 32-41.

Kumar, S. and V. Balasubramanian (2008). "Developing a mathematical model to evaluate wear rate of AA7075/SiCp powder metallurgy composites." Wear **264**(11-12): 1026-1034.

Magnani, G., G. Sico, A. Brentari and P. Fabbri (2014). "Solid-state pressureless sintering of silicon carbide below 2000°C." Journal of the European Ceramic Society **34**(15): 4095-4098.

Rahman, M. H. and H. M. M. A. Rashed (2014). "Characterization of Silicon Carbide Reinforced Aluminum Matrix Composites." Procedia Engineering **90**: 103-109.

Ram Prabhu, T., V. K. Varma and S. Vedantam (2014). "Effect of SiC volume fraction and size on dry sliding wear of Fe/SiC/graphite hybrid composites for high sliding speed applications." Wear **309**(1-2): 1-10.

Tan, Z., Z. Chen, G. Fan, G. Ji, J. Zhang, R. Xu, A. Shan, Z. Li and D. Zhang (2015). "Effect of particle size on the thermal and mechanical properties of aluminum composites reinforced with SiC and diamond." Materials & Design.

Samuel F. H.and Samuel A. M. (1993). Effect of heat treatment on the microstructure, tensile properties, and fracture behavior of permanent mold Al-10 wt pct Si-0.6 wt pct Mg/SiC/10p composite castings, *Metallurgical and Materials Transactions A* **25**, 2247-2263.

Thakur, S. K., K. S. Tun and M. Gupta (2010). "Enhancing Uniform, Nonuniform, and Total Failure Strain of Aluminum by Using SiC at Nanolength Scale." Journal of Engineering Materials and Technology **132**(4): 041002.

Schwier G, Teusel I, and Lewis MH (1997). Characterization of SiC powders and the influence of powder properties on sintering. Pure & Appl. Chem, 69 (6), pp. 1305-1316.

STaha, M.A., El-Mahallawy, N.A and El-Sabbagh, A. M. (2003). Behavior of Stir-Cast Al-Alloy Particulate-Reinforced Metal-Matrix Composites under Successive Hot Rolling. *Advanced Engineering Materials* **5**, 805-812

Suryanarayana, C. and N. Al-Aqeeli (2013). "Mechanically alloyed nanocomposites." Progress in Materials Science **58**(4): 383-502.

Zakaria, H. M. (2014). "Microstructural and corrosion behavior of Al/SiC metal matrix composites." Ain Shams Engineering Journal **5**(3): 831-838.