UNIVERSITI TEKNOLOGI MARA

FRACTURE BEHAVIOUR OF DIFFERENT VOLUME FRACTION OF ALUMINA (Al_2O_3) REINFORCEMENT METAL MATRIX COMPOSITE

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ABSTRACT

Metal Matrix Composites (MMCs) are engineering materials in which a hard ceramic component is dispersed in a ductile metal matrix in order to obtain characteristics that are superior to those of the conventional monolithic metallic alloys. Due to the superior properties, MMCs are used in aerospace, automotive and other structural applications. Study on the fracture behaviour of the MMCs is necessary. Different percentage by volume (vol.%) of particulate alumina (Al_2O_3) reinforced aluminium alloy (Al 6061) with 5 vol.%, 15 vol.% and 25 vol.% are produced by powder metallurgy method. These samples were then subjected to compressive deformation test in order to investigate the fracture behaviour of the MMCs. Microstructure analysis on the individual sample before and after testing was performed under scanning electron microscopy. It is observed that the small particles measuring below 5 μm in size exhibited strong interfacial bonding with the matrix. The particles below 20 μm to 5 μm in size have shown fracture and debonding at interface. The large particles larger than 20 μm in size have revealed severe fractures and particles pull-out. Intergranular microcracks were observed propagated through and ended at the edge of the small cluster. Intergranular microcracks were only observed at the edge of the large clusters. The fracture initiation in the 5 vol.% and 15 vol.% Al_2O_3 MMCs is dominated by radial direction displacement, while in 25 vol.% Al_2O_3 MMCs it is dominated by tangential displacement. A non-linear stress-stain profile and an increase of modulus with an increase of vol.% of Al_2O_3 are obtained. The fracture behaviour was explained by relating the microstuctures, stress-strain profiles, modulus and displacement directions of the undeformed and deformed MMC samples. Some understandings on the fracture behaviour of different vol.% of Al_2O_3 reinforcement MMCs have been established.

Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

In the event that my thesis be found to violate the conditions mentioned above, I voluntarily waive the right of conferment of my degree and be subjected to the disciplinary rules of Universiti Teknologi MARA.

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CHAPTER 1

INTRODUCTION

Increasing demands on materials with high strength and stiffness with properties attainable at elevated temperatures have encouraged the development of the advanced composites [1]. A composite is produced when two materials are combined to produce a blend of properties that cannot be obtained in the original materials. In designing composite materials, engineers and scientists have combined various metals, ceramics and polymers to produce a new generation of materials.

Three categories of composites can be identified based on the type of the matrix material; polymer-matrix composites (PMCs); metal-matrix composites (MMCs) and ceramic-matrix composites (CMCs). PMCs have attractive features such as the ability to be processed at low temperatures, exceptional specific mechanical properties and good resistance to corrosion. These characteristics have led PMCs to be widely used in the transport, electrical, construction, sporting good, medical and aerospace industries. CMCs have the attribute of improved toughness when used at high temperatures as load-bearing elements, however they involve high temperature processing and poor machinability. MMCs provide high temperature operating limits than their base metal and they can be tailored to give improved strength, stiffness, thermal conductivity, abrasion resistance, creep resistance and dimensional stability as reported in [2]. However, MMCs have some drawback, such as low fracture toughness and low ductility. Compared to PMCs, MMCs can be used at higher temperatures, while compared to CMCs they have improved fracture toughness and superior manufacturability.