Microstructure and properties of aluminium-aluminium oxide graded composite materials

F F Kamaruzaman[1], D M Nuruzzaman[2], N M Ismail[2], Z Hamedon[2], A K M A Iqbal[2] and A Azhari[2]

[1,2]Faculty of Manufacturing Engineering, University Malaysia Pahang, 26600 Pekan, Pahang Darul Makmur, Malaysia.

[1]Email: farafazira92@yahoo.com

Abstract. In this research works, four-layered aluminium-aluminium oxide (Al-Al_2O_3) graded composite materials were fabricated using powder metallurgy (PM) method. In processing, metal-ceramic graded composite materials of 0%, 10%, 20% and 30% weight percentage of ceramic concentration were prepared under 30 ton compaction load using a cylindrical die-punch set made of steel. After that, two-step pressureless sintering was carried out at sintering temperature and time 600ºC and 3 hours respectively. It was observed that the sintered cylindrical specimens of 30 mm diameter were prepared successfully. The graded composite specimens were analysed and the properties such as density, microstructure and hardness were measured. It was found that after sintering process, the diameter of the graded cylindrical structure was decreased. Using both Archimedes method and rule of mixture (ROM), he density of structure was measured. The obtained results revealed that the microvickers hardness was increased as the ceramic component increases in the graded layer. Moreover, it was observed that the interface of the graded structure is clearly distinguished within the multilayer stack and the ceramic particles are almost uniformly distributed in the Al matrix.

1. Introduction

At present, the demand for multifunctional composite materials is growing increasingly for advanced engineering applications. A new class of graded composite material is suitable for multiple functions and this metal-ceramic graded composite structure can be attained in a single component. Currently, variety of fabrication methods available for processing of these metal-ceramic graded composite materials, namely, centrifugal casting, thermal spraying and powder metallurgy [1-3]. Among these methods, powder metallurgy (PM) is widely used in order to meet the desired requirements and to produce the functional gradients which can also be tailored while providing the best use of each component [4-6]. The most challenging step within powder metallurgy technique is the sintering process. Due to the residual stress caused by the mismatches in thermal expansion and sintering between successive layers, cracks and camber are noticeable during sintering of these multi-layered graded composite materials [7].

In the recent past, several research efforts were carried out to investigate the behaviour of functionally graded materials (FGMs) of different combinations [8-14]. Mechanical responses and the structures of these composites significantly influenced by a number of factors such as powder characteristics, compaction load, metal-ceramic system, sintering temperature, number of layers and the consolidation process. Influence of reinforcements on the mechanical properties of functionally graded aluminium composites was investigated [15]. The obtained results revealed that the outer regions of the composites exhibit higher hardness than the middle and inner regions. The outer region