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Improvement in physical and mechanical properties of aluminum/zircon composites fabricated by powder metallurgy method

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ABSTRACT

Metal–matrix composites (MMCs) are known as the most useful and high-tech composites in our world as well as aluminum (Al) as the best metal for producing these composites. Combining aluminum and zircon ($ZrSiO_4$) will yield a material with the best corrosive resistance and mechanical properties like strength at high temperatures. Also, the abrasive wear behavior of these composites will be improved. In the present investigation, a study on aluminum/zircon composites has been carried out. Micro-structures of these composites in powder metallurgy conditions show different size distribution of zircon with different proportions in the composite. Also, there is a case-study about density and compressive strength and hardness of aluminum/zircon composites. The green specimens prepared by isostatic pressing of prepared powders with different zircon percentages, were sintered at two temperatures. These specimens were then investigated by different physical and mechanical testing methods to observe in which conditions the best properties would be obtained. The most improved compression strength was obtained with the specimen including 5% of zircon sintered at 650 °C.

1. Introduction

The one of the best properties of powder metallurgy for fabrication of composites can be obtained when the reinforcement is homogeneously dispersed in the matrix, as approved by experiment [1,2] and theoretical [3–5] studies. For composites fabricated by the powder metallurgy method, it is possible when the matrix-to-reinforcement particle size ratio is close to unity [6]. Particulate reinforced MMCs improved both mechanical and physical properties with increasing metal working characteristics and powder metallurgy processing is one of the methods proper for fabricating these materials [7].

MMCs are very important because of their high ratio of strength and weight, high Young modulus and high abrasive properties. Aluminum is one of the best materials for matrix because of its low density, high conductivity and high toughness [8]. Moreover, Al is cheaper than other light metals like magnesium (Mg). The other advantage of using Al as matrix of MMCs is its corrosion resistance which is very important for using composites in different environments. In contrast, Al does not have enough tensile strength for many applications. Because of this weakness, ceramic particles (e.g. zircon) can be added for better hardness and tolerating high temperatures [9]. Also, they can improve mechanical and tribological properties of the composite.

Zircon is a ceramic with high chemical stability and also for break the bonds significant energy is necessary for its reduction into zirconia and zirconium metal [10,11]. Its inherently high stability even at high temperatures, the energy needed, and the expensive process equipment required to reduce the orthosilicate compound, more research is presently focused on alternative economic uses [12,13].

However, composites with non-continuous reinforcement do not have improved mechanical properties as continuously reinforced composites do, but their production cost is lower, their processing methods are more adaptable to conventional ones and their performance is acceptable [14–17].

Particle reinforced metal–matrix composites have been considerably investigated in recent researches [18,19]. Generally, this type of composites is produced using stir casting methods, and there have been fewer investigations on producing them by

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