Materials and Design 32 (2011) 1031–1038

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Technical Report

The effect of production parameters on microstructure and wear resistance of powder metallurgy Al–Al_2O_3 composite

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ARTICLE INFO

Article history:
Received 23 March 2010
Accepted 13 July 2010
Available online 16 July 2010

ABSTRACT

Aluminum matrix composite is one of the most conventional types of metal matrix composites. This paper deals with the effect of production parameters on wear resistance of Al–Al_2O_3 composites. Alumina powder with a particle size of 12, 3 and 48 μ and pure aluminum powder with particle size of 30 μ were used. The amount of added alumina powder was up to 20%. Ball milling was utilized to blend the powders. The range of sintering temperature and time were 500, 550 and 600 °C and 30, 45, 60 and 90 min respectively. It was found that increasing sintering temperature results in increasing density, hardness and wear resistance and homogenization of the microstructure. However at certain sintering temperatures and time, considerable grain growth and reduction of hardness value occurred, leading to the degradation of wear resistance. The results showed that at high alumina content, relative density of the composite increases. However, after raising the particle size of alumina, relative density initially increases and then drops to lower values. Increasing weight percent of alumina powder leads to higher hardness and consequently improves the wear resistance of Al–Al_2O_3 composite. The use of fine alumina particles has a similar effect on hardness and the wear resistance. Finally, a finer grain size was observed, at high amount and low size of the reinforcement particle.

1. Introduction

There is an increasing trend towards using composite materials in order to achieve better performance in engineering materials. Thus, production and application of metal matrix composites (MMC) have increased in recent years [1]. Al–Al_2O_3 MMC, has been of greater importance due to superior mechanical properties and excellent wear resistance, under various applications [2]. Aluminum matrix composites have made numerous applications in aerospace, automotive, military and electronic industry due to low density, high toughness and high corrosion resistance [3,4].

Low wear resistance of pure aluminum is a serious drawback in using it in many applications. Addition of ceramic particles to aluminum matrix would improve the strength, hardness, wear resistance and corrosion resistance of the matrix [5,6]. Particle reinforcements are more favorable than fiber type, due to better control of microstructure and mechanical properties, by varying the size and the volume fraction of the reinforcement [3]. Al_2O_3 is the most popular among ceramic particle reinforcement after SiC particles. Al_2O_3 has higher thermal stability compared to SiC, since it does not react with the metal matrix at high temperatures and does not produce brittle phases [1].

Powder metallurgy is considered as a good technique in producing metal–matrix composites. An important advantage of this method is its low processing temperature compared to melting techniques. Therefore, interaction between the matrix and the reinforcement phases is prevented. On the other hand, good distribution of the reinforcing particles can be achieved [4]. Another advantage of powder metallurgy technique is in its ability to manufacture near net shape product at low cost [7].

In this research, uniaxial pressing was used to produce composite sample. The effects of sintering time and temperature, weight percent and size of reinforcement particles on wear properties, microstructure, relative density and hardness of samples were studied. The optimum condition of processing parameters and the key strengthening mechanisms can be extracted from this study.

2. Materials and experimental procedures

In this investigation, aluminum powder with purity of 99.97% and the average particle size of 30 μm and three types of alumina powder with average particle size in the range of 3–48 μm were used in the range of 0–20 wt.%. The densities of aluminum and

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doi:10.1016/j.matdes.2010.07.016