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Simultaneous optimization of the tensile strength, bending strength, hardness and wear resistance of W—Cu composite produced by sintering process

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ABSTRACT

In this research, the mechanical properties of tungsten-copper (W—Cu) composite fabricated by the sintering technology were optimized by design of experiments. The parameters of sintering temperature, sintering time and weight percentage of copper were selected to optimize the tensile strength, bending strength, wear resistance and hardness of the W—Cu composite using the response surface method combined with desirability process. The microstructure of the W—Cu composite was also examined by SEM, TEM, XRD and EDS analyses. The results showed that a rise in the sintering temperature from 1000 to 1150 °C improved the tensile strength of W—Cu composite, while a rise in the sintering temperature from 1150 to 1300 °C deteriorated the tensile strength. Moreover, the bending strength, wear resistance and hardness of the W—Cu composite continuously enhanced with the increase of sintering temperature from 1000 to 1300 °C. An increase in the amount of Cu from 20 to 40 wt% resulted in a reduction in the wear resistance and hardness of the W—Cu composite, while the increase of Cu content improved the tensile and bending strengths. It was also showed that mechanical properties of the W—Cu composite can be improved simultaneously by using 23 wt% Cu at sintering temperature of 1220 °C and sintering time of 2.5 h.

1. Introduction

Tungsten-copper (W—Cu) composites are considered as advanced materials because of good electrical and thermal properties of copper and also the low thermal expansion coefficient and high melting temperature of tungsten [1]. These composites, which are produced in various percentages of copper (15–50%), have found diverse applications in different industries, such as electrical and aerospace industries [2]. Moreover, due to the high corrosion resistance of copper, they also have good potential for marine applications such as engines, components of rockets, torpedoes, pump impellers and heat exchangers [3]. These composites are mainly produced by powder metallurgy due to the presence of tungsten phase [4]. However, it is well understood that the production of W—Cu composites is difficult because of insolubility of W and Cu, as well as the low melting point of Cu (1083 °C) compared to that of W (3410 °C) [1]. The production method of W—Cu composite usually depends on the desired properties and also the percentage of copper. The liquid phase sintering method is used for composites that have a high percentage of copper, while the infiltration process is used to prepare composites that have a low percentage of copper and thus have high strength and hardness [5]. In this study, the liquid phase sintering was used to produce W—Cu composite due to the high percentage of copper and high processing temperature of tungsten. The main advantage of liquid-phase sintering is the capability to attain good density with low porosity.

Recent researches have shown that decreasing the size of powder

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