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Mechanical and wear behaviour of the Al-Mg-nano ZrC composite obtained by means of the powder metallurgy method

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Abstract. This work concentrates on the impact and contribution of zirconium carbide (ZrC) and magnesium to the mechanical and tribological properties of aluminium matrix composites. Distinctive weight portions of zirconium carbide, containing fixed weight fractions of magnesium and strengthening aluminium composites, were prepared utilising the entrenched cold-press sintering technique used in powder metallurgy. The uniform powder mixture was obtained by using planetary ball milling and it was then observed by using the scanning electron microscope technique. The hardness of the hybrid composite increased along with increase in the amount of the ZrC particle. The wear losses of sintered Al-Mg-ZrC composites were explored by directing sliding tests in pin-on-disc equipment. Hybridisation of reinforcements also decreased the wear loss of the composites at high sliding load and speed. This study reveals that the hybrid aluminium composite can be considered a unique material with high strength, low weight and wear resistance that will find their application in components to be used in the automobile and aero space engineering sectors.

Key words: aluminium, magnesium, zirconium carbide, wear and hardness.

1. Introduction

Aluminium matrix composites (AMCs) are a truly fascinating material because they manifest solid consolidation of properties such as, for example, high elastic modulus, wear resistance and tensile strength [1, 2]. Some of the most successful applications of AMCs in the automotive industry include connecting rods, pistons, brake rotors and cast engine blocks [3]. Metal matrix composites are manufactured by means of an extensive variety of strategies, including stir casting [4], plasma spraying [5], hot pressing [6], hot extrusion [7] and powder metallurgy (P/M) [8]. Among these, the powder metallurgy method has its own particular benefits. This strategy shows a tendency to accomplish uniform distribution of strengthening particles in the matrix when utilising the mechanical alloying process. Particle sizes of the strengthening material play a key role in the hardness property of the composite. The specimens prepared by means of the powder metallurgy method are always porous and thus decrease the strength of the sintered samples. However, hard nano reinforcements can be employed to improve mechanical properties and also to fill in the porous regions of composite specimens prepared by means of powder metallurgy [9]. In addition, ceramic particles such as SiC, TiC, WC, B_4C and ZrC are preferentially considered as a secondary strengthening phase in the metal matrix, hybridising the composite. This enhances the mechanical properties as well as wear resistance. Incorporation of the ceramic particles as reinforcement during strengthening of the composite may fail to introduce high hardness due to the fact that they will agglomerate by any conventional process. To overcome this, researchers found that ball milling is an efficient way of alloying ceramic particles with the aluminium matrix without any agglomeration [10, 11]. However, an aluminium matrix reinforced with magnesium (Mg) and zirconium carbide (ZrC) for improvement of wear and mechanical properties and prepared using powder metallurgy has not been reported to date. The main objective of this work is thus to evaluate and report on the combined effect of the higher hardness material (nano ZrC: 0–8%) and another material (MWCNTs: 4%) on reinforcement in the aluminium matrix for improvement of various mechanical and wear properties of composites prepared using the powder metallurgy method for tribological application.

2. Experimental procedure

2.1. Materials. Magnesium powder with average particle size of 60 μm and 400 nm ZrC powders were used as reinforcement materials while pure aluminium powder with average particle size of 60 μm was selected as the matrix material. Reinforcement materials have a massive impact on the wear as well mechanical behaviour of composites. Micrographs (Fig. 1a–c) of both reinforcements and matrix materials were examined through the SEM. Figure 1a shows that commercially purchased aluminium particles are irregular in shape, and that magnesium

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