Effect of Varying Wt% of TiC on Mechanical and Wear Properties of RZ5-TiC In-Situ Composite

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ABSTRACT

The purpose of this article is to enhance the mechanical properties and wear resistance of the RZ5 alloy used in the aerospace application by adding TiC particles. The present study discusses processing of in-situ RZ5-TiC composite fabricated by self-propagating high temperature (S.H.S.) method and its wear behavior. The effects of TiC particle on mechanical and microstructural properties of the composite are studied. The wear test is performed by varying the sliding distance and applied load. The composite is characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). The results exhibited the properties like strength and hardness of RZ5-10wt%TiC composite has been increased considerably, while grain size is decreased as compared to the RZ5 alloy. The fractography indicated mixed mode (quasi-cleavage and ductile feature) failure of the composites. The wear results showed improvement in wear resistance of the composite. The FESEM showed dominate wear mechanisms are abrasion, ploughing grooves.

KEYWORDS

Composite, In-Situ, MMC, Reinforcement, Tensile Strength, Wear

INTRODUCTION

Magnesium is one of the lightest metallic materials (35% lighter than aluminum and 78% lighter than steel) available for engineering application (Wang, Jiang, Li, & Wang, 2003; Guan, Wang, Li, & Jiang, 2004). Due to the light weight and adequate structural strength, magnesium alloys are considered as the potential materials for reducing the specific weight of the engineering components, especially in aerospace industries by replacing heavier materials such as steel and aluminum alloys (Sohn, Euh, Lee, & Park, 1998; Natarajan, Krishnaraj, & Davim, 2015). Over the years, the magnesium matrix composites (MMC) have been produced through various routes such as stir casting, powder metallurgy and squeeze casting (Gui, Li, & Han, 2003; Luo, 1995; Zhang, Fan, Wang, & Zhou, 2000). The stir casting route of composite synethetization is preferred by many because of low cost and high production rate (Ray, 1993).

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In ex-situ fabrication of magnesium based MMC, many investigators have utilised SiC as reinforcement. Based on scanning electron microscopy (SEM) results, Saravanan et al. (2000) opined that no reactions took place between pure Mg and SiC during stir casting at 700°C. It has been reported that, during the synthesis, magnesium does not react with SiC. The properties of the composite degraded due to the phase Mg17Al12. The ultimate tensile strength increased from 175 MPa to 203.1 MPa has been observed (Contreras, Angeles-Chávez, Flores, & Perez, 2007). Moreover, it has also been reported that at a temperature higher than 680 ºC the MgC2 phase is not stable. It is well known that wetting characteristics of reinforcement and matrix during synthesis of MMC play an important role in overall quality characteristics. The aluminum as a matrix material generally has exhibited better wetting characteristics than magnesium for ceramic reinforcements such as TiC and SiC (Contreras et al., 2007).

Chen et al. (2005) synthesized AZ91-TiC composite using a preform prepared from titanium and carbon at 800°C. This method confirmed the formation of the TiC by XRD. The Cao et al. (2008) and Wang et al. (2006) achieved in-situ reaction of titanium and carbon in molten magnesium at 800 ºC. More recently, Shamekh et al. (2012) used infiltrated preform of Ti-B,C powder with AZ91 in order to fabricate magnesium MMC reinforced with TiC-TiB. Although, different reaction products of Mg-B and Ti-B such as MgB6, TiB2, TiB, Ti2B, and even TiC and Ti2AlC were detected, no evidence of reaction of magnesium and titanium or carbon was observed.

Contreras et al. (2004) processed 56 vol.% TiC-Mg MMC through mechanical alloying route by infiltrating molten magnesium into porous TiC preforms at temperatures of 850 ºC to 950 ºC under argon shielding atmosphere. The reaction forms TiC, TiB2 and third form Ti2AlC. They observed that the ultimate tensile strength increased from 175 MPa to 200 MPa and hardness from 183 to 194 VHN. Among all the Mg alloys, the ZE41 is a established alloy that contains Zn, rare earth such as Zr, has decent mechanical properties at room and elevated temperatures due to the solution and precipitation hardening. It has been widely used in aircraft gearbox and generator housings, and military helicopter components (López, Torres, Taltavull, & Rams, 2013; Trojanová, Gärtnerová, Lukáč, & Drozd, 2004).

Q. F. GUAN and H.Y. Wang (2004) used Aluminum material and high weight percentage (20-50) Ti-C preform in molten magnesium alloy to form Mg-TiC composite. In XRD analysis and found that extra peak of aluminum and TiAl. No significant increase in extra peak of the tensile strength as the ultimate tensile strength is increased from 162 to 185 MPa and hardness from 61.5 to 83.5 BHN of TiC strengthened AZ91. Likewise, Q.C. Jiang (2003) used Al-TiC master alloy as powder form in molten magnesium. The high 10% volume faction of TiC was used to form Mg-TiC and for that the ultimate tensile strength is increased about 160 to 214 MPa and hardness from 60 to 83 BHN. However, % elongation is reduced from 9 to 4 for 10 vol% TiC strengthened AZ91.

Towle et al. (1994) reported the effect of the saffil fiber reinforcement distribution in RZ5 MMC obtained through liquid metal infiltration. They observed that the RZ5 MMC properties improved in tension as well as in compression for parallel distributed fiber arrays.

The Mg alloys have been in use for a variety of structural applications. On the other hand, low mechanical properties at high temperatures and low corrosion resistance are their major drawbacks (Cabibbo, 2011). One can improve the mechanical properties of a ZE41 alloy like tensile strength, creep resistance, wear resistance and stiffness by reinforcing ceramic particles such as TiC (Trojanová, Száraz, Chmelík, & Lukáč, 2010).

In the present work, RZ5 magnesium alloy is reinforced with 10wt% TiC through stir casting self-propagating high temperature (S.H.S) method. The purpose of the present work is to investigate the effect of titanium carbide (TiC) on the mechanical properties of RZ5-TiC metal matrix composite. The wear analysis of the RZ5-10wt%TiC composite is also studied.
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