ScienceDirect

Materials Today: Proceedings

Volume 27, Part 2, 2020, Pages 1530-1534

Influence of microstructure and mechanical properties of TiC reinforced magnesium nano composites

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https://doi.org/10.1016/j.matpr.2020.03.176

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Abstract

In the present study, an effort has been made to synthesize TiC reinforced magnesium nanocomposites by varying its weight percentage (3%, 6% and 9%) using powder metallurgy for marine applications. The compaction pressure was maintained at 350 MPa for 15 min at 250 °C followed by sintering process. Sintering temperature was maintained at 650 °C in argon protected atmosphere for 8 hrs. Optical microscope and scanning electron microscopy (SEM) have been used to study the microstructure of magnesium nanocomposites. Vickers micro hardness test and ASTM-E9 standards have been used to evaluate the hardness and compressive properties of magnesium nanocomposites. The microstructure of synthesized magnesium nanocomposites revealed that the reinforcement particles are homogeneously distributed in the magnesium matrix without indication of cluster and they appeared as a lamellar precipitates during diffusion. The increase in percentage of reinforcement increases its compressive strength and hardness of magnesium nanocomposites due to the inclusion of stiffer and stronger reinforcement in matrix alloy. B117 salt spray technique was utilized to study the corrosion behavior of magnesium nanocomposites. It has been observed that the corrosion properties of magnesium nanocomposites significantly increased to a maximum of 46% compared with monolithic AZ91D magnesium material.

Introduction

Owing to its low density, high specific strength and stiffness, good damping capacity, the utilization of magnesium and its alloys have been primarily used in various industries such as aerospace, automotive and marine industries for subsea applications [1]. Moreover it has unique properties such as excellent castability, machinability, electromagnetic shielding and comparable melting temperature with aluminum metal matrix composites. However, its engineering applications the utilization of magnesium and magnesium alloys are limited. This is due to the fact that they possess low elastic modulus, low ductility and low corrosion resistance [2]. In order to overcome such limitations, inclusion of suitable reinforcement and alloying elements with magnesium has been used to enhance its mechanical properties. The research works on magnesium based composites have been limited due the difficult in synthesizing of magnesium; hence these materials are pyrophoric nature and its forms oxide when it is exposed to atmospheric temperature. However, with respect to some specific applications, researchers have utilized the reinforcement such as SiC, Al2O3, B4C, TiO2, Aln, TiN, Y2O3, Fly ash, Graphite and CNT for synthesizing magnesium matrix composites [3]. In the present work Titanium carbide has been used as reinforcement for synthesizing magnesium alloy composites. It is also noted that the elementary and physical properties such as toughness and elastic modulus of TiC is around 400GPa and a shear modulus of 188GPa is most significant factors that are essentially need for marine application. It has been also inferred that the inclusion of TiC tends to increase its tensile strength, hardness, ductility, wear resistance of magnesium alloy. The effect of nano sized TiC (0.58, 0.97, and 1.98 vol%) reinforced magnesium composites using disintegrated melt deposition (DMD) method. It was observed that the tensile strength (54%) and compressive strength (47%) of magnesium composites increased compared with pure magnesium [4]. The wear performance on TiC (56%vol) reinforced magnesium composites was synthesized using pressure less infiltration method. It was found that the wear rate significantly improved compared to monolithic materials. However, an increase in the applied load beyond certain limit tends to decrease the wear resistance characteristics and make it not suitable for automobile braking system. Hence it was concluded to reduce particulate concentration on magnesium matrix composites [5]. TiC reinforced magnesium composites using semi solid slurry stirring techniques. It was observed that addition of 10% volume of TiC increases the mechanical properties such as hardness, wear resistance and ultimate tensile strength compared to unreinforced magnesium alloy [6]. From the literature studies it has been found that only limited studies have been carried out on synthesizing of TiC reinforced magnesium composites and moreover its mechanical properties have not been characterized entirely for many applications. Considering these extensive literature, an attempt has been made to synthesis TiC of particle size (<200 nm) reinforced AZ91D magnesium by varying its wt% (3%, 6% and 9%) using powder metallurgy technique and to assess the mechanical properties towards marine applications.

Section snippets

Experimental methodology

The synthesizing of magnesium nanocomposites are usually processed by liquid or solid phase method. In liquid phase method, it is essential to obtain uniform distribution of reinforcement prior to casting. However, during synthesis of liquid metallurgy method, porosity cannot be minimized which results in reduction in properties of metal matrix composites. To overcome such limitations, solid phase method has been used in the current study. This method involves the mixing of metal powder and…

Microstructure of TiC reinforced magnesium composites

Optical microscope has been used to study the microstructure features and the distribution of TiC reinforcement in magnesium alloy matrix composites. From the microstructural analysis as depicted in Fig. 2 (a-c) shows that the reinforcement particles are uniformly distributed throughout the cross sections without indication of cluster. It has been also observed that the magnesium powder has been sintered effectively with good fusion along with the formation of secondary phases. The fusion of…

Conclusion

1. The magnesium matrix composites reinforced with nano sized TiC particles of varying 3%, 6% and 9 wt% has been effectively synthesized using powder metallurgy method. Microstructural characterization illustrates that the distribution of Tic reinforcement particulates is relatively homogeneous throughout the magnesium alloy matrix.…
2. On compressive loading, the addition of 3%, 6% and 9% TiC has led to an increase its compressive strength. This is due to the fact that, that the addition of stiffer…

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