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Microstructure and mechanical properties of AZ91D/Si_3N_4 composites using squeeze casting method

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Highlights

- Si_3N_4 microstructure was spread out evenly, and there were no remaining pores.
- Hardness of the nano composites significantly improved due to impeded dislocation motion.
- The load distribution between the immixture is extreme, and thus tensile strength is significantly higher due to the effect of grain refinement.
- Due to strong interfacial bonding strength, the dispersion strengthening particles between the intermixtures compressive

strength significantly improved.

- The pitting corrosion occurred under saltwater circumstances due to the presence of NaCl.

Abstract

The material utilized in the aerospace and automotive industries must be capable of withstanding significant loads while maintaining a minimal structural weight. In pursuit of novel lightweight materials for industrial applications, magnesium is quickly displacing aluminum-based alloys. In this study, a magnesium (AZ91D) matrix composite reinforced with nano ceramic silicon nitride (Si_3N4) of varying weight proportion (2 wt%,4 wt% and 6 wt%) was synthesized using vacuum stir casting method. The microstructural study of uniform distribution of nano Si_3N_4 particles are revealed by an optical microscope. Micro hardness (26.8%) and tensile strength (32.12%) increased with increasing weight percentages of Si_3N_4 particles in a magnesium alloy matrix, whereas percentage of elongation decreased (6.52%). With an increase in weight% of Si_3N_4 particles in the magnesium matrix, the porosity of composites decreased (1.02%) and density of composites increased to minimum (0.06%). The corrosion characteristics were examined using B117 salt spray test. The test illustrated that an increase in percentage of reinforcement accelerates corrosion resistance (17.52%) due to induced segregation, dislocation, and micro crevice formation. Based on the results, it can be concluded that the manufactured composite can be employed in a variety of industrial applications where lighter structural materials are required.

Introduction

As weight reduction becomes a key issue for the automotive and aerospace industries, researchers are now focusing on lightweight materials [1].Magnesium and its alloys have attracted considerable interest due to its low density, great machinability, castability, and high specific strength, making it the most popular choice for lightweight structural metallic applications [2].µm-sized reinforcing particles, often ceramic or carbon-based, have been used as one of the most cutting-edge methods to improve the mechanical characteristics of magnesium light alloys [3]. As a consequence of the micron sized reinforcement, Mg-MMCs have significant limits, such as inferior ductility and toughness characteristics, compared to unreinforced magnesium alloys. This is because larger particles serve as micro concentrators of stress, inducing cleavage in the particle [4].Nonetheless, significant progress has been made in the production of appropriate composite materials, such as those in which reinforcing nanoparticles are well-dispersed in a magnesium metal matrix[5].Nanoparticle reinforcement in a magnesium metal matrix has the potential to significantly increase the matrix's strength, hardness, and wear resistance by means of new and different strengthening methods[6].One fundamental requirement for obtaining nanocomposite materials with enhanced material characteristics is to achieve an adequate dispersion of the reinforcing particles within the metal matrix via a suitable manufacturing method [7].The poor wettability and large surface to volume ratio of ceramic nanoparticles with the metal matrix make it difficult to uniformly distribute nano-sized particles in the metal matrix using liquid metallurgical procedures [8].Tensile characteristics of AZ91D/SiC composites made using stir casting aided by ultrasonic treatment, and the effect of SiC particles of varying sizes dispersed throughout the AZ91D matrix. Compared to monolithic AZ91D alloys, AZ91D/SiC composites containing micron-size SiC particles exhibit greater yield strength, ultimate tensile strength, and young's modulus. However, elongation is drastically reduced due to particle cracking and void formation at the particle/matrix interface [9]. Incorporating SiC nanoparticles into pure magnesium increased its yield strength, ultimate tensile strength, and ductility compared to a pure magnesium matrix supplemented with 10vol% of micron-sized SiC particulates [10]. Porosity, particle cluster, interfacial interactions, and oxide inclusions are some of the structural flaws that might emerge from using a traditional casting procedure. Squeeze casting was used to produce flawless castings [11]. Magnesium and its alloy casting has seen a lot of growth and study during the past two decades [12].

Unfortunately, there is relatively little research on the production and characterization of magnesium alloy-based composites using squeeze casting technique. The novelty of this study is that it used the squeeze casting process to make silicon nitride reinforced magnesium alloy composites with varied weight proportions, and its microstructure mechanical characteristics were examined where weight reduction is considered to be a prime factor.

Section snippets

Materials and methods

Owing to its enhanced strength, Excellent castability, atmospheric stability, and exceptional resistance to saltwater corrosion, AZ91D alloy was widely used to manufacture magnesium alloy nano composites by the squeeze casting method; its chemical composition is indicated in Table 1.

As reinforcement for the fabrication of magnesium nanocomposites, commercially available primarily α phase silicon nitride particle size 60 nm from Sigma-Aldrich is used due to its high strength, hardness,

Microstructure

Nano composites of magnesium with a highly ordered structure are studied using an optical microscope. Fig. 1, Fig. 2, Fig. 3 depicts the results of a visual evaluation of as-cast and etched synthesis composites with varying percentages of its weight. In terms of microstructure, it was found that the strengthening particles are dispersed evenly throughout the matrix alloy, with no clustering apparent. Also, the grains of primary magnesium are visible and appear to be finer in the greater

Conclusions

In the current study, a nano silicon nitride-reinforced AZ91D magnesium alloy was synthesized by changing the weight proportions of its constituent elements using the squeeze casting technique. The wettability between the mixtures was enhanced, and as a result, the mechanical characteristics of nanocomposites were greatly enhanced, as deduced below.

1. Si_3N_4 microstructure was spread out evenly, and there were no remaining pores.
2. Hardness of the nano composites significantly improved due to impeded

Scope and future

In the present investigation silicon nitride reinforced magnesium composites was synthesized using squeeze casting method and its microstructure and mechanical properties was investigated. It was observed that it has significant bonding strength between interface and its mechanical and corrosion properties was also increased. Further in the present investigation only 2 to 6wt% of reinforcement was utilized and it was found no agglomeration occurs. Hence by increasing the weight percentage more

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References: (34)

L. Tharanikumar *et al.*
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An investigation on wear properties of SiC/WC strengthened aluminium alloy hybrid composites
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