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Effect of *TiC* addition on the mechanical properties and microstructure of Al-Si alloy

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Abstract

This study is focused on the development and characterization of a stir cast Al-Si alloy reinforced with titanium carbide nano-particles. The composite was developed using the stir casting method and the casted samples were prepared with TiC nano-particle at 0.4 (B1), 0.8 (B2), 1.2 (B3), 1.6 (B4) and 2.0 (B5) wt. % of the entire composition, as well as a control sample, and thereafter subjected to tensile and hardness tests. It was noticed that none of the samples at the chosen concentrations brought about a greater hardness value than that of the control sample (Sample A), however they all show a positive trend with an increase in the % wt. of reinforcement bringing about a possibility of increase in the hardness value. This suggests that a further increase above 2.0% of the reinforcement should bring about an increase in hardness above that of the base Al-Si alloy. On the other hand, the tensile strength was significantly increased upon reinforcement. B5 exhibited the highest tensile strength by displaying a transition from needles/plate-like to globular/fibrous morphology.

Introduction

The modification of materials and material properties with the use of nanoparticles has attracted widespread attention especially in the area of strength and stiffness improvement. Al–Si cast alloy is an encouraging material used primarily in automobile industry due to their great strength-to-weight ratio, exceptional castability and worthy mechanical properties. Such alloys blend outstanding mechanical characteristics and strong resistance to corrosion with fine castability [1], [2], [3], [4]. The need for enhancement of properties of Al-Si based alloys has expressed importance due to the fact that at least 90% of aluminium castings are based on aluminium–silicon today. Being a binary alloy providing exceptional castability at low cost, aluminium–silicon based alloys are commonly used in numerous industries like for instance, the automotive industry [5]. Aluminium-based metal matrix composites and aluminium–silicon alloys have found usage in the production of a number of automotive engine machineries [6]. Based on these recent growths, there is a demand for composite materials possessing great chemical and mechanical characteristics including toughness, improved corrosion resistance and high hardness [7]. Recently, researches on metal matrix composites (MMC) suggest that these materials display advantageous industrial applications owing to their high resistance to elevated temperature and greater strength-to-weight ratio. These prompted researchers to focus on the development of reduced-cost products, especially metal matrix composite, which have improved features [8].

The utilization of Al-based cast alloys is currently on the increase. Although they possess great corrosion resistance accompanied with outstanding mechanical properties, the effect and contribution of reinforcement with nanoparticles however has not been extensively explored. Al-Si alloys lack adequate corrosion resistance and strength amongst other properties. The combination of strength and ductility has warranted the production of great strength Al-Si alloys with noteworthy ductility in the recent times [9]. The aim of this research is to significantly improve certain properties of stir cast Al-Si alloys with the use of Titanium Carbide (TiC) nanoparticles modifiers. The research is further aimed at comparing the viability and benefits that the use of the selected nanoparticles has on Al-Si alloys and their properties.

Section snippets

Materials

The materials (Aluminium, TiC nanoparticles) used for this work were purchased from the local market in Nigeria. The materials were taken to the foundry department where stir casting was done using a crucible furnace. TiC was added to the aluminium matrix composite according to the proportion listed in Table 1. After casting, the as-cast material was machined into different small circular pieces in preparation for the tests as well as a standard tensile sample specification on which the tensile

Brinell hardness values

From Fig. 2, it was observed that the control sample has the highest Brinell hardness value of 21.89 MPa indicating that the addition of TiC at the selected concentrations failed to bring about an increase in the hardness of the sample. An explanation for this lies in the fact that aluminium matrix composites, being mostly reinforced with ceramics, have low toughness in comparison to the unreinforced aluminium and alloys [10]. However, a positive trend is noticed with a deviation in sample B4

Conclusions

In this study, a metal matrix composite was developed from the alloy of aluminium and silicon reinforced with titanium carbide (TiC) making use of several material testing techniques. From the experiments concluded matched with experimental results, specific material properties like tensile strengths were enhanced with some superior to the monolithic material. Although precise material properties like hardness were not seen to progress by a large margin, it is suggested that upon further

CRediT authorship contribution statement

O.O. Joseph: Conceptualization, Writing - review & editing. **A.S. Afolalu:** Visualization, Investigation. **A.A. Abioye:** Visualization, Investigation. **S.E. Agbo:** Investigation, Data curation. **S.F. Olatunde:** . **O.S. Omotehinwa:** Investigation, Data curation.

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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