ScienceDirect

Materials Today: Proceedings

Volume 64, Part 1, 2022, Pages 731-736

An investigation of the effects of hot rolling on the microstructure and mechanical behavior of nano-sized SiC particulates reinforced Al6063 alloy composites

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https://doi.org/10.1016/j.matpr.2022.05.197

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Abstract

This study investigated the properties of aluminum alloy composites reinforced with nano-SiC particles produced by stir casting and hot rolling at a temperature of 5500C. Microstructural analysis reveals that nano SiC particles are uniformly distributed with good bonding to the alloy Al6063. The nano SiC particles align in a rolling direction, and the volume phase was analysed as per ASTM standards. It was observed that due to grain refinement the porosity was reduced due to the inclusion of nano Sic. The tensile strength and hardness of synthesised hot rolled composites significantly increased owing to enhancement of grain refinement and reduction in porosity.

Introduction

Aluminium metal matrix composites have been used for the last three decades due to their lightweight, ductile, and the high strength-to-weight ratio [1]. In contrast to the many alloy series, Al 6xxx series alloys are primarily used as heat-treatable alloys, and these alloys exhibit poor wear resistance [2]. From the light of the literature, it is inferred that the preferred ceramic reinforcements for the Aluminium based MMC are SiC, TiC, B_4C, TiB_2, BN, and Al2O3 etc. The addition of low density ceramic particle could improve the wear characteristic by without affecting the parent Al composite behavior. Al based MMCs are fabricated using various manufacturing techniques based on the production rate and its application. The powder metallurgy is simple and effective technique for fabricating small scale or typical products in macro and micro levels. As a way of improving wear resistance properties, ceramic particles are added to the alloy and intermixed to make composite materials, such as boron carbide and silicon carbide [3]. This type of composite material has a small thermal expansion coefficient hence it is used in the aerospace and electronics industries where weight reduction is the deciding factor [4]. Metal matrix composites made from aluminum were prepared by liquid phase and solid phase manufacturing methods. Due to its low cost, liquid manufacturing processes are attractive as opposed to solid manufacturing processes, and the homogeneous distribution of reinforcement within the matrix materials exhibits significant physical properties because it involves effective mixing [5]. During the manufacturing of casting process, the defects such as blowholes, cavities, shrinkage and porosities are common and removing of these defects are very important to get mechanical properties [6]. Consequently, the developed composite materials are subjected to secondary forming processes, such as rolling, extrusion, and forging that improve matrix and reinforcement bonding as well as uniform distribution of reinforcement particles, as well as be transformed into

deformed structures that significantly improve processing properties [7].In preparation of metal sheets rolling process is most widely used in the manufacturing industries i.e. roofing panels, automobile bodies, refrigerator, construction materials and rail tracks [8].It was observed that Cold rolling reduces strength and strain along the rolling direction, whereas hot rolling increases strength. Based on the observed microstructural changes caused by the cold rolling and the T6 heat-treatment operations, and particularly the redistribution and damage of SiCp, these behaviors can be explained. As cold rolling damages components and internal microstructure, the study carried out hot rolling on the particulates to minimize the damage [9]. The study of the hot rolling process on composite materials aims to improve the mechanical properties of Aluminium Silicon carbide composites, which have many industrial applications. An investigation of the influence of hot rolling and annealing on the degree of grain refinement of Al-5Ti-B master alloys found that the mean particle size of the alloy decreased with the percentage reduction at any given rolling temperature [10]. The effect of reduction in rolling temperature conducted at 400°C on the tensile properties of Al6061/ABO whisker composites, which led to fine-grain alignment along the roll direction, as well as improvements in mechanical properties like tensile strength with an increase in reduction percentage [11]. It has been observed a significant improvement in mechanical properties and wear resistance of Al2024 alloy composites when B_4C nanoparticles were added to the matrix by mechanical milling followed by extrusion [12].

In reviewing the literature, it was found that a considerable amount of work has been performed in the study of mechanical properties and morphological study in the nano particle reinforcement especially in the aluminum composites but some adequate works were done by the researches. The effect of hot-rolling on the microstructural and mechanical properties of aluminum alloy-based nanocomposites. In light of the aforementioned, the purpose of the current study is to develop a metal matrix composite containing nano SiCp as reinforcements in the Al6063 alloy matrix using a stir casting method followed by hot rolling, with the aim of obtaining a high strength composite material. The effect of hot-rolling on microstructure and mechanical properties of synthesized aluminium nanocomposites will be investigated and compared with by varying weight proportions of ceramic strengthening particulates.

Section snippets

Selection of matrix and reinforcement

The Al6063 material is considered for this study, which is most widely used for the structural work because of its better mechanical characterization, because of that Al6063 is referred as architectural alloy. Its mechanical property is superior in shape with structural formation and also high corrosion resistance with good surface finish [13].

In Table 1, the elemental composition of the Al6063 matrix alloy used in this study is shown.

Silicon carbide nanoparticles are used as reinforcing…

Microstructure of nano SiCp reinforced Al6063 alloy composites

In this experimental study, the polished surfaces of the hot-rolled composites were etched with Keller's reagent and their microstructure was examined by an optical microscope. A standard ASTM-E562 and E1245 test process were used to analyze volume and phase analysis [15]. In the microstructure of the sheet, the SiC particulate was distributed uniformly throughout the matrix phase. During rolling, equated grains were formed with an average grain size of 20 μm. After the rolling process, the…

Conclusion

In this investigation the nano SiCp of varying weight proportions was synthesized by using the stir casting method and it was hot rolled to minimize the demerits of the casting defects and its microstructure with the mechanical properties were analyzed.

- From the microstructure study, it was observed that the reinforcement particles are aligned in the direction of metal flow after the hot rolling process.…

- Due to the presence of SiC nano-particles, the composites display smaller grains compared to…

…

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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