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Analysis of mechanical properties enhancement on composites of AA7175 by multi walled carbon nano tube (MWCNT)

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Highlights

- AA7175/ MWCNT was synthesised using stir casting method.
- 3 wt% of MWCNT increases the yield strength of composites.
- Increase of MWCNT decreases the percentage of elongation.
- Ultimate tensile strength decreases for 4 and 5 wt% of reinforcement.

Abstract

Developed to meet the demands of appealing contemporary materials, nanocomposites are polyphase materials that include a matrix and nano-reinforcement. The major types of nanocomposites are as follows. They are categorized as fiber-reinforced nanocomposites, laminar nanocomposites, and particulate nanocomposites based on the reinforcing component, whereas they are classed as metal matrix, ceramic matrix, and polymer matrix nanocomposites based on the matrix ingredient. Due to its advantages over polymer and ceramic matrix, metal matrix nanocomposites (MMNCs) are the most common type of nanocomposites employed in industrial applications. To improve the physical, mechanical, thermal, and electrical properties of conventional materials, nanocomposites are often formed by reinforcing nanoscale tubes, fibres, particles, or sheets. To keep up with technological advancements, drive market changes, and bridge technological gaps by revolutionizing the product, innovative nanocomposites must be used in advanced engineering applications. The high-strength, light-weight aluminium alloy matrix nanocomposites (AMNCs) are able to replace traditional materials to a greater extent in cutting-edge applications including the automotive, aircraft, marine, defense, leisure, and electronic industries. In this study deals with the property enhancement analysis by means of the assistance of Multi Walled Carbon nano tube (MWCNT) nano particles encouragement in AA7175 aluminium alloy. The main focus of this investigation on the tensile related mechanical properties such as tensile strength, percentage of elongation and yield strength. The composites were created with the mass fractions of 5.0 wt%, 4.0 wt%, 3.0 wt%, 2.0 wt% and 1.0 wt% of MWCNT with 95.0 wt%, 96.0 wt%, 97.0 wt%, 98.0 wt% and 99.0 wt% of AA7175 aluminium alloy. These composite mechanical properties were compared with the pure AA7175 aluminium alloy. Among the comparison of these composites values 3.0 wt% of MWCNT produce the greater results on the considered composites. The composite sample recorded high Ultimate Tensile Strength of 431.12 MPa, low Percentage of elongation of 9.58% and high Yield strength of 396.63 MPa.

Introduction

Aluminium alloy material research based on the augmentation of the characteristics by way of adding the different materials as composites [1]. This aluminium seven series contains the aluminium alloy with magnesium, Zink and Copper. Based on these materials combination variations the series number will be varied [2]. Specifically, AA7175 alloy is used in critical geometrical structure in the aerospace as well as marine parts because of its advanced strength [3]. Due to their high strength-to-weight ratio, strong creep and chemical resistance, and quick and affordable manufacturing techniques, alloys and composites based on aluminum are frequently utilized in the aerospace, automotive, marine, and defense industries [4]. However, their use in load bearing and abrasion applications is restricted by their increased coefficient of thermal expansion (CTE), weak hardness, and poor wear performance. To enhance its qualities, the Al matrix must therefore constantly be strengthened with appropriate ceramics like SiC, Al_2O_3, TiO_2, and B_4C [5]. However, using micro-sized reinforcements hasn't always been able to deliver the necessary strength in many situations. In order to reinforce the cermet in accordance with applicational criteria, researchers have preferred to focus on nanoparticles that require unique reinforcing processes, such as the Orowan mechanism, thermal discrepancy, and load transfer mechanisms.

The reinforcement of aluminium alloys employing single reinforcements like SiC and TiO_2 has been the subject of extensive investigation [6]. According to Bobic et al., the synthesis of aluminium carbide as a result of the reaction between SiC and aluminium alloys at high temperatures boosted the mechanical qualities of cermet but failed to increase its corrosion resistance [7]. Similar to this, TiO_2 nanoparticles have shown to improve the base alloy's wear resistance and density while significantly lowering thermal expansion [8]. According to a number of reports, one reinforcement is insufficient to improve all the attributes of aluminium alloys. In order to improve the various properties of the alloys, a hybrid composite may be a good alternate strategy.

Many studies have examined the impact of adding extra reinforcements to the aluminium alloys and have successfully improved characteristics. The UTS and hardness of the cermet increased by 60.1% and 80% in comparison to the base alloy and by 17.4% and 13.7% in SiC reinforced cermets, according to Kannan et alcomparison.'s of the composite Al7075/SiC with and without Al_2O_3 reinforcement produced by stir casting [9]. The wear resistance of hybrid cermet (SiC/Al_2O_3) was also reported by Altinkok et al. to have enhanced greatly from that of a single composite due to the tiny particle and interfacial bonding strength of alumina, which toughened the cermet [10].

According to studies, the hardness and other mechanical properties of cermets may have increased due to hard reinforcements and other reinforcing mechanisms, which are the main cause because they cause the dislocation density of the cermets to rise along with the reinforcing particles to accumulate in molten alloys [11]. The properties of materials like ultimate tensile strength, hardness, density, stiffness, high specific strength, cheap cost per specimen, enhanced stability of dimensions, wear resistance, etc. can all be improved by these nanocomposites. Aluminum and its alloys can be used in particle-reinforced nanocomposite to create materials with the necessary mechanical characteristics [12].

However, the manufacturing methods used with the alloys also affect the general characteristics of hybrid cermets [13]. Infiltration or casting processes are just two of the fabrication methods used to create hybrid cermets. However, because casting processes are more affordable, quick to build structures, and easier for mass production, they are becoming more popular than infiltration.

The use of molten metal as the casting medium is more frequently used in casting processes including stir casting, compo casting, squeeze casting, and more recent techniques like Rheo or vacuum die casting [14]. However, adding oxide powders to molten metals causes the powders to form clusters, accumulate, and be distributed unevenly throughout the surfaces [15]. Numerous researchers have developed various methods, including impellers, stirrers, and ultrasonication procedures before to production, to get around this prevalent issue with stir casting techniques. Rheo-casting methods were used in place of stir casting methods to reduce cavitation on alloys, which was then improved by the ultrasonication process [16].

With the aid of a magnetic stirrer, Shamsipour et al. investigated the fractures on several casting techniques used to create Al/Al2O3-based cermets and found that compo casting produced fractures with fewer and more uniform distributions than sand casting [17]. But because the economics of mass production were compromised, electromagnetic stirrers were also used to address the issues with magnetic stirrers. By using electromagnetic stirrers to create aluminium matrix nanocomposites and optimising the conditions that produced superior wear behaviour, Shamsipour et al. were able to get around this issue [18]. Further research revealed that utilising electromagnetic stirrers caused the intermetallic particles to be equally distributed throughout the Al-Si metal matrix with lower stress concentration locations [19].

However, there have been a few studies that claim that even with these methods, the lack of external pressure made it difficult for ultrasonic assisted double casting processes to completely remove porosity. In order to demonstrate that the surfaces had evident microstructural refinement and reduced porosity, Hajjari et al. used external pressure to fabricate hybrid Al alloys using squeeze casting. Particles were dispersed across the surfaces, but not uniformly enough [20].

Nano materials are the one of the most important material in the current situation [21]. MWCNT is one of the types of carbon nano tube with number of single walled structure. The thermal properties of the materials can be increased with the help of this MWCNT [22]. The stir casting method is most commonly using method for producing aluminium composites [23]. With best our knowledge the AA7175 aluminium alloy properties reinforcement with MWCNT nor reported in the literature so far. The unanswered questions are is there any significant properties improvements by reinforcing the MWCNT reinforcement in AA7175 aluminium alloy? In particularly tensile properties? If such reinforcement improves tensile properties by reinforcing MWCN, how much quantity of reinforcement could be made to maximize the tensile properties? This experimental investigation addresses such research gap by novel reinforcement of MWCNT in the matrix of AA7175 aluminium alloy. This investigation aims to optimize the reinforcement of MWCNT in AA7175 aluminium alloy matrix by preparing various nanocomposite samples (by varying percentage of reinforcement) and to be tested to maximize tensile properties. In this study deals with the major properties like tensile strength, percentage of elongation and yield strength. All these tests were done with the help of the universal testing machine with computerized system.

Section snippets

Experimental procedure

As per Table 1 composites were created with the percentage deviation of MWCNT nanoparticle mass fractions with the AA7175 aluminium alloy. In composites Aluminium alloy mass fractions were increasing from 95.0 wt% to 99.0 wt% with decreasing mass fractions of MWCNT from 5.0 wt% to 1.0 wt%). These composites were produced by the stir casting technique. Initially the powdered form of the considered materials was mixed separately as per the proportion mentioned in the Table 1. In the beginning,

Results and discussion

The average values of the specimens tested are provided in Table 2. The results for ultimate tensile strength are compared in Fig. 1. The error bars are displayed at 95% CI, or 5%. The AA7175 composite has a strength of 376.00 MPa, AA7175 95 wt% + MWCNT 5 wt% has a strength of 391.04 MPa, and AA7175 96 wt% + MWCNT 4 wt% has a strength of 410.59 MPa. The ultimate tensile strength of the AA7175 97 wt% + MWCNT 3 wt% composite is 431.12 MPa, the AA7175 98 wt% + MWCNT 2 wt% composite is 418.19 MPa,

Conclusions

This study presented the influence of MWCNT reinforcement effects in the AA7175 aluminium alloy matrix. The composite samples prepared with different weight fraction of MWCNT reinforcement on AA7175 aluminium alloy matrix. The effect of reinforcement was evaluated by means of the responses like tensile strength, percentage of elongation and yield strength. From the experimental results following findings were obtained.

- The MWCNT create the significant influence on the mechanical property

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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