

The effect of mechanical stirring on microstructure of CNT reinforced aluminium matrix composite

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ABSTRACT – Aluminium matrix composite has escalating demands especially the alluminium-silicon alloy composites in aerospace and automotive parts due to the properties of the materials whilst, CNT is a superior material used as reinforcement. Effect of mechanical stirring process on the microstructure of A356 metal reinforced with 0.5 wt% MWCNT is studied. MWCNT and 0.5 wt% Mg granules premix were injected into the metal matrix at a semisolid temperature of 650°C. As observed under optical microscopy (OM) and FESEM, the results show a non-dendritic structure is formed after the medium speed mechanical stirring of 500 RPM for 10 minutes. Moreover, this approach helps to produce a homogenous distribution of the CNT in A356 matrix, hence improved the mechanical properties of the samples.

1. INTRODUCTION

Aluminium metal as the matrix material reinforced with reinforcing agents produces a type of composite known as aluminium matrix composite (AlMC) which is applied in innumerable applications such as in aerospace, airframes of both land and water vehicles and more [1]. CNT is well known to function as reinforcing agent in enhancing mechanical properties as loads are transferred from the metal matrix to the CNT which is known as fine-grain strengthening [2]. A lightweight metal combined with high stiffness and strength properties is desired [3] and this is the justification that evokes the interest of researcher on such composite material.

Agglomeration of CNT tend to occur in metal matrix composite and as the vol% CNT increases, the size and cluster of CNT increases [4] thus having a major impact on the composites' mechanical properties [5].

As the primary A356 ingot morphology have those dendritic arm structures, brief mechanical stirring below liquidus temperature may result in the formation of semisolid slurries with non-dendritic structure [5]–[7].

2. METHODOLOGY

As-cast A356 alloy is used as the metal matrix. The composition by weight percentage (wt %) is as depicted in Table 1.

Table 1 Composition by weight percentage (wt %) of A356 alloy.

Element	Wt %.
Al	Balanced %
Si	6.5
Cu	0.2
Mg	0.2
Mn	0.3
Zn	0.1
Ni	0.1
Fe	0.5
Pb	0.1
Ti	0.2

Multi-walled carbon nanotubes with purity of more than 95%, having outside diameter of between 20-40 nm, inside diameter of between 5-10 nm and length of between 10-30 µm functioned as reinforcing particles and are produced by Sigma-Aldrich.

0.5 wt% MWCNT powder was premixed and encapsulated in aluminium foil with Mg granules; the wetting agent. 400 g of the alloy was fully melted by heating it, up to 700°C and was subsequently cooled down to a constant temperature of 650°C in the induction furnace before the encapsulated premix was put into a plunger and was injected into the bottom area of the molten alloy in the crucible.

Next, using a mechanical stirrer equipped with a three-blade impeller, the mixture was stirred at medium speed of 500 rpm for 10 minutes and then immediately poured into a mould preheated at 150°C.

After the produced moulded samples have cooled down at room temperature, the samples were sectioned and prepared according to metallographic procedure standard. The sectioned samples were ground on 400, 600, 800 and 1200 grit size paper respectively before polished using 6 µm, 3 µm and 1 µm diamond paste. The polished samples were then etched using Kellers solution for 10 seconds.

The prepared CNT reinforced aluminium matrix composite samples were examined for the microstructure using an optical microscope (OM). As-

received A356 alloy was used as a reference.

3. RESULTS AND DISCUSSION

The microstructure of as-received A356 ingot observed under optical microscopy (OM) is as shown in Figure 1 in which the alloy has dendritival arm structure, common in α -Al morphology.

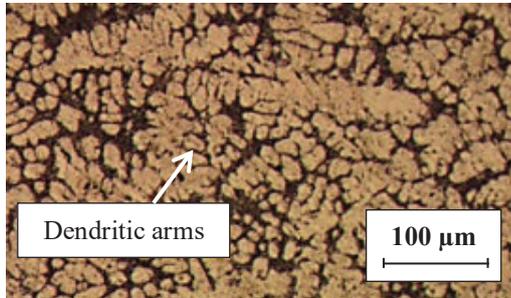


Figure 1 Microstructure of as-received A356 image by OM at magnification x500

Figure 2 exhibits the microstructure of CNT reinforced aluminium matrix composite after mechanically stirred. The microstructure appears in non-uniform rosette-like structures as the dendritic arms structure are broken up as a result of being subjected to external mechanical force.

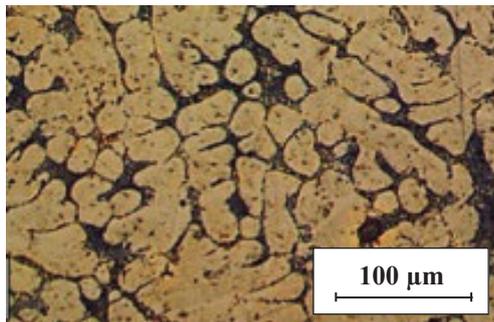


Figure 2 OM microstructure image of mechanically stirred CNT reinforced aluminium metal matrix

Observed from FESEM, Figure 3 shows that MWCNT does not agglomerate. The constant mechanical stirring after the addition of reinforcing agent into the bottom part of crucible resulted in a homogenous distribution of MWCNT throughout the molten metal matrix.

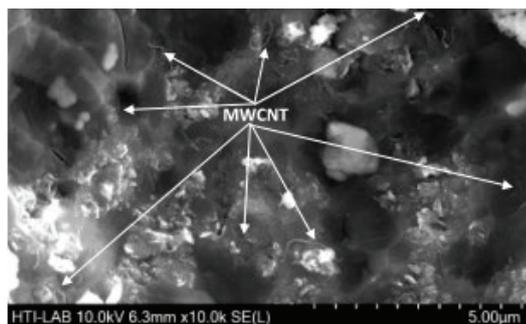


Figure 3 FESEM image of homogenous MWCNT dispersion in A356 matrix

4. CONCLUSIONS

Fabrication of CNT reinforced aluminium matrix composite with 0.5wt% MWCNT by mechanical stir casting was successfully done and this study concludes that:

- (1) At medium rotation of 500 rpm mechanical stirring process during stir casting of alloy, the α -Al dendritic microstructure evolved to a rosette-like structure.
- (2) MWCNT is homogenously distributed throughout the A356 alloy matrix due to the constant medium speed of the mechanical stirring process as observed from the FESEM image.

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