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Experimental Investigation of Aluminium alloy with MWCNT Composite to increase the Mechanical Properties by Stir Casting Method

Sankara Narayanan.S and Manickavasaham.G and Moorthy S3
1: PG Scholar, Department of Mechanical Engineering, University College of Engg , BIT Campus
2: PG Scholar, Department of Mechanical Engineering, University College of Engg , BIT Campus
3: Assistant Professor, Department of Mechanical Engineering, Shivani Engg College

Abstract— In many manufacturing industries light weight components are produced using aluminium composite materials.But they lack good machinability and possess poor mechanical strength. In this paper , we are presenting the fabrication of Al6061 alloy composite with multiwall carbon nanotubes (MWCNT) by Stir casting process techniques. In this experiment Al6061 alloy as a matrix and multiwall carbon nanotubes (MWCNT) as reinforcement for metal matrix composites to investigate the mechanical properties of the fabricate Composite. The amount of materials are calculated by the materials were properly mixed using mass and volume fraction formula. The Sample is prepared for one composition (i.e., 1wt %) investigation on microstructure, using optical microscope and SEM were done. The strength and machinability were also calculated.

Keywords: Multiwall Carbon Nanotube(MWCNT), Al6061, Stir casting, mechanical properties, SEM

1. INTRODUCTION

Many Engineering applications in the field of aerospace engineering, automobiles, electronic equipment etc require very light material with good mechanical properties. Aluminium based metal matrix composites with carbon nanotube reinforcement can be a solution for such applications. It satisfies the requirement of light weight with very good strength. This study focuses on preparation of aluminium metal matrix composites with CNT reinforcements for various composition and study of its mechanical properties. Al 6061 alloys have been widely used as structural materials in aeronautical industries due to their attractive comprehensive properties, such as low density, high strength, ductility, toughness and resistance to fatigue. In this study, carbon nanotube (CNT) reinforced aluminium alloy 6061 (Al6061) composite was synthesized by stir casting process. Mechanical alloying was used to stir casting the CNTs in the matrix phase. The effects of the processing temperature (6000C, 6200C and 6400C) on the microstructure, hardness, fracture surface and composition of the Al6061–MWCNT composite were investigated. Stir casting was used to 1 wt% MWCNT in aluminum (Al6061). Despite the success of stir casting for CNTs in Al 6061 material, Carbon nanotubes are the ultimate carbon fibres because of their high Young‘s modulus of ≈ 1 TPa which is very useful for load transfer in nanocomposites. In the present work, CNT/Al nanocomposites were fabricated by the stir casting technique and after moulding the nanocomposites bright field scanning electron microscopic (SEM) studies were carried out. From the SEM images so obtained, a novel method of ascertaining the Young‘s modulus of multi-walled carbon nanotubes is worked out, which turns out to be 0·9 TPa. The microstructure characteristics and the distribution of carbon nanotubes in the aluminum matrix were investigated. Nanometer-sized carbon cones were generated by vapor condensation of carbon atoms on a graphite substrate and were analyzed by scanning tunneling microscopy (STM) Carbon nano-tubes are a new form of carbon with unique electrical, mechanical properties[1] and electronic properties[2]. The purified nanotube examined in the present study is a clean‘ semiconductor almost without magnetic impurity and is doping inactive. The low frequency vibrational modes and the structural rigidity of long graphitic carbontubules consisting of 100, 200, and 400 atoms were studies [3]. Scanning tunneling microscopy (STM) has been used to investigate the structure and electronic properties of carbon nanotubes produced from a discharge between graphite electrodes[4]. In addition, bias-voltage dependent imaging studies indicate that the nanotubes are semiconductors.The tensile and bending stiffness constants of ideal multi-walled and single-walled carbon nanotubes are derived in terms of the known elastic properties of graphite. C.-H. Kiang et.al.[5] have investigated that a variety of carbon structures are produced in an electric arc discharge with an anode composed of carbon, cobalt,andsulfur. Single and multiple layered carbon nanotubes, as well as partially filled nanowires and bamboo-shaped carbon compartments, are found in different regions of the soot inside the chamber. Sulfur plays an important role in forming these carbon nanomaterialsThe room-temperature single-electron transistors are realized within individual metallic single-wall carbon nanotube molecules[6]. Jean-Paul Salvetat et.al.[7] have investigated that a condensed review of mechanical properties of carbon nanotubes is given. Theory as well as experiments is examined with a view to extracting the fundamental elements that should allow the reader to build his own perspective of the subject. R. Byron Pipesa et.al[8] have investigated that an investigation of the effective mechanical properties of large arrays of carbon nanotubes assembled in helical geometries of circular cross-section is undertaken following two approaches. Ray H. Baughman et.al.[9] have investigated that Many potential applications have been proposed for carbon nanotubes, including conductive and high-strength composites; energy storage and energy conversion devices; sensors; field emission displays and radiation sources; hydrogen storage media; and nanometer-sized semiconductor devices, probes, and interconnects.Suneel D et.al.[10] have investigated that Aluminum structural components find numerous applications in aerospace and defense industries.The study involves preparation of CNT reinforced Al6061metal matrix Composites by stir casting technique.

II. MATERIALS AND METHODS

Reinforced Al6061-CNT composites were manufactured by stir casting technique.Al6061 material as a matrix and Multiwalled Carbon NanoTubes as reinforcement. The properties of MWCNTs (Nanoshel LLC ,USA) and Al6061 are given in Table.1 and 2.

Table.1 Properties of Mutiwalled Carbon Nano Tube

Properties	Values
Diameter	20-30nm
Length	3-8um
Purity	>98%(MWCNT)
Real Density	1-2g/cm2

Table.2.Typical properties of Al6061

Component	Amount (Wt. %)
Aluminium	Balance
Magnesium	0.8-1.2
Silicon	0.4-0.8
Iron	Max.0.7
Copper	0.15-0.40
Zinc	Max.0.25
Titanium	Max.0.15
Manganese	Max.0.15
Chromium	0.4-0.35
Others	0.05

A. Methods

Al6061 and multiwall carbon nano tubes (20-30 nm) were properly mixed for composition using stir casting process Stirrer speed of 300rpm was used to mix the MWCNT added for casting process.

B. Preparation of composite

The CNT powder was initially purified to remove the impurities like graphite, amorphous carbon etc. by adding concentrated Nitric acid, filtering and washing with de-ionized water followed by drying at 1200 C. In stir casting process, MWNT of 0 wt%,1 wt%, was mixed with Al6061 for 20 min at 300 rpm to get uniform mixing in the crucible. The mixture of a particular weight percentage of MWCNT and Al6061 was molded in the pattern Fig,1,2 and 3)

Fig 1. MWCNT

Fig 2. Molten metal poured in pattern

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Fig3.component

III. Experiment, Results and discussions

Micro structural characterization studies were conducted on unreinforced and reinforced samples using scanning electron microscope. The composite samples were metallographically polished prior to examination. Characterization is done in etched conditions. Etching was accomplished using Double etchant reagent. The SEM micrographs of composite and wear debris were obtained using the scanning electron microscope. The images were taken in both secondary electron (SE) and back scattered electron (BSE) mode according to requirement. Microscopic studies to examine the morphology, micro structure were done by a JEOL 6480 LV scanning electron microscope (SEM) equipped with an energy dispersive X-ray (EDX) detector of Oxford data reference system. Micrographs are taken at suitable accelerating voltages for the best possible resolution using the secondary electron imaging.The casting procedure was examined under the optical microscope to determine structure .A section was cut from the castings. It is first belted grinded followed by polishing with different grade of emery papers. Then washed and polished in clothes and again washed, dried and etched with Double etchant solution and then examined though optical microscope (Fig 4).

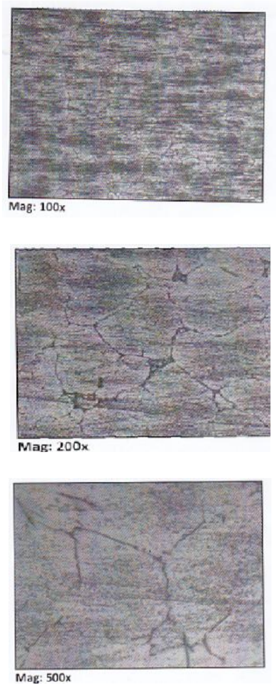

Fig 4. Optical Micrograph of MWCNT

Bulk hardness measurements were carried out on the base metal and composite samples using standard Brinnel hardness test to investigate the influence of particulate weight fraction on the matrix hardness. Load applied was 150kgs and indenter was a steel ball of 1/16" diameter.Hardness values are shown in Table 3.

Table3. Hardness values of specimens

Sl.No.	Load (Kg)	Al 6061+0%MWCNT In HRA	Al 6061+ 1%MWCNT In HRA	Average value in HRA
1	60	57 59	72 73	72.5
2	100	61 62	77 78	77.5
3	150	62 63	73 74	73.5

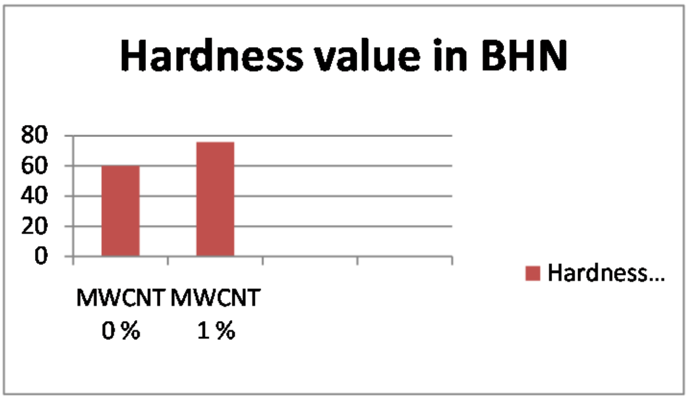

Fig 5. The bar chart for Hardness value comparision.

Fig.5 shows the bar chart of comparison of hardness of matrix alloy and the composites. The composite found to be harder than the matrix alloy, and the hardness increases with increase in percentage of Carbon Nano Tube (MWCNT).

Table.4 Tensile Test value of the specimen.

Sl.No.	Test Parameters	Al 6061+ 0% MWCNT	Al 6061+1%MWCNT
1.	0.2% Proof Stress(Mpa (or)N/mm2)	80	110.20
2.	Ultimate Tensile Strength(Mpa (or)N/mm2)	140	189.49
3.	%Elongation in 50mm dia (%)	10	9

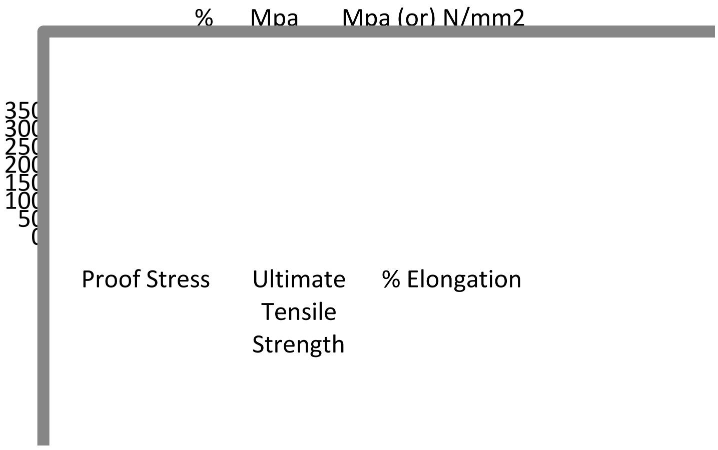

Fig 6. The bar chart of Tensile strength comparison

From the bar chart it was observed that the theoretical and experimental density increases with an increase in weight percentage of MWCNT in the composites. This is due to agglomeration of MWCNT in theAl6061 matrix. Tensile strength increases remarkably with an increase in weight percentage of MWCNT in the composites.

IV. CONCLUSION

Al6061alloy as matrix mixed with MWCNT in weight percentages of 1 % wt as reinforcement were produced through Stir casting route. The specimens were moulded successfully and subjected to evaluate the behavior of microstructure and mechanical properties of MMc‘s. From the investigation, following points are arrived.

- Hardness of Al6061-MWCNT composite is greater than Al6061.
- Micrograph shows good bonding between matrix and reinforcement.
- Al6061-MWCNT composite showed ductile property where as Al6061 were brittle.
- . Young‘s Modulus increases remarkably with the increase in Reinforced particulate (MWCNT).
- Tensile strength increases with the addition of MWCNT but compressive strength decreases with the addition of MWCNT.

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