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Mechanical Characterization of Aluminium 6061-Carbon Nanotube Metal Matrix Composites

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ABSTRACT

Composite materials play a vital role at the present industry sector. Metal matrix composites are light weighted, more strong and extremely hard which are useful in industries like aerospace, motor vehicles, mechanical tools & manufacturing sector. Mixing of carbon nanotubes and aluminium 6061 was done using manual stir casting process. It is one of the simple and widely used process in which aluminium 6061 was melted at high temperature in a furnace and then the reinforcement carbon nanotubes were mixed into it by mechanical stirring. Several specimens were prepared by taking 0,1,2,4,6,10 gm of CNT in 1kg of aluminium 6061. Hardness and Wear tests were conducted on the specimen including SEM analysis. The Experimental investigation involves proper mixing of the reinforcement and the maximum allowable length to weight ratio of the CNT's on SEM. The intent of this work is to measure the Hardness and Wear resistance. It was found that on increasing the weight of reinforcement the composite could withstand more loads. In wear test it is found that more the percentage of CNT in the composite the less was the wear. The load and speed in the wear test was kept as 5 kg and 1000 rpm.

Keywords: *MMC, CNT, SEM, Characterization.*

1. INTRODUCTION

Single and multi-wall carbon nanotubes have created tremendous expectations as strengthening additives for metallic, ceramic and polymer composites due to their high strength and stiffness. Metal matrix/CNT composites (MM/CNT) have a great potential in load bearing applications and packaging due to their high specific strength, high thermal conductivity and low thermal expansion. These properties are advantageous in advanced applications like aerospace and automotive structural members where a lower weight leads to savings in energy. In recent years, much research has been focused on the development of CNT reinforced Al matrix composites, because Al matrix composites have been wide prospects of applications in aviation, spaceflight and automobile industries [1].

CNT's have a Young's modulus of 1TPa, making them ideal reinforcements for composite materials. It is important to understand the relevant

strengthening mechanisms involved in CNT/Al composites, in order to produce optimized composites [1]. The carbon nanotubes having excellent chemical stability due to their seamless cylindrical graphite structure are an exceptional candidate for the reinforcement in aluminium matrix [2]. The quality of dispersion, however, is a crucial factor which determines the homogeneity and final mechanical properties of these composites [3].

Carbon nanotubes are allotropes of carbon with a cylindrical nanostructure. Nanotubes have been constructed with length-to-diameter ratio, significantly larger than for any other material. Owing to their extraordinary thermal conductivity and mechanical and electrical properties, carbon nanotubes find applications as additives to various structural materials. For instance, nanotubes form a tiny portion of the material(s) in some (primarily carbon fibre baseball bats, golf clubs, car parts or Damascus steel).

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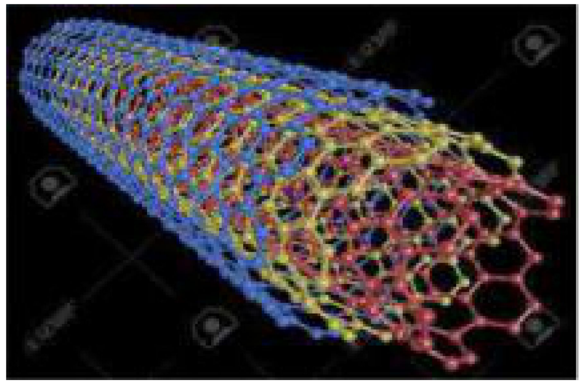

Fig1: Structure of multi walled CNT

Aluminium 6061 sourced from bauxite ore, the material is refined into aluminium oxide rehydrate(alumina) using the Bayer process and then reduced via smelting process into metallic aluminium. Alloy 6061 is one of the most widely used alloy in 6000 series. This standard structure alloy one of the most versatile of the heat treatable alloys, is popular for medium to high strength requirements and has good toughness characteristics. Applications range from transportation components to machinery and equipment applications to recreation products and consumer durables. Alcoa produces 6061 for use in standard and custom shapes, rod and bar products and seamless and structural pipe and tube. Alloy 6061 has excellent corrosion resistance to atmospheric conditions and good corrosion resistance to sea water. This alloy also offers good finishing characteristics and response well to anodizing [5].

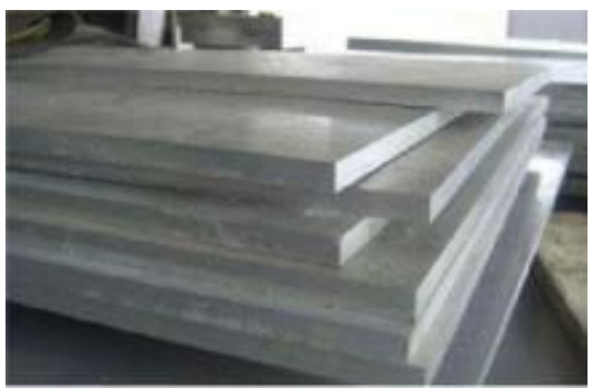

Fig 2: Aluminium 6061

2. Experimental Details

The carbon tubes in nanoscale (1nm) are mixed in aluminium 6061 by stir casting method. This process has been employed to produce discontinuous particle reinforced metal matrix composites from decades. The main problem in this process is to obtain sufficient wetting of particle by liquid metal to get a homogenous dispersion of the particles. In this current study, aluminium metal matrix composites were fabricated by different processing temperatures with different holding time to understand the influence of process parameters on the distribution of particle and the resultant mechanical properties. The distribution is examined by microstructure analysis.

In the present study Al6061alloy-Carbon nanotube composite is prepared by stir casting technique. The various proportions of Carbon Nanotubes like 0 wt%, 0.2wt%, 0.4wt%, and 0.6% & 1wt% volumes are tried and castings are prepared. Al6061alloy is melted in the furnace to a temperature of 720^{o}C & then Carbon Nanotubes (MWCNT) which is in the powdered form(1nm) is poured slowly, simultaneously stirrer is made to rotate at an optimum speed of 450 rpm for a period of 5-10 minutes, then the melt is degassed by passing Nitrogen gas. Finally, the molten

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metal is poured into the finger metal mould. The mould is coated with chalk powder to prevent adhering of the molten metal into the surface of the mould. The cast samples are then subjected to heat treatment. The solidified metal is removed from the die & is subjected to heat treatment where solutioning is done at $590^{o}C$ for a period of 10 hours and then it is immersed in hot water maintained at $100^{o}C$ and allowed it to cool for 12 hours. And finally ageing is done at $175^{o}C$ for a period of 5 hours, then the samples for tensile and wear tests were prepared according to ASTM standards.

SPECIMEN DETAILS:

Table 2.1: Number of specimens were prepared in stir casting process to the below shown composition.

Weight of Aluminium 6061(gram)	% variation of CNT by weight (Gram)	No. of Compressive specimens	No. of Wear specimens	No. of Hardness specimens
1000	0	1	1	1
1000	2	3	3	3
1000	4	3	3	3
1000	6	3	3	3
1000	10	3	3	3

3. RESULTS AND DISCUSSIONS

SEM Analysis:

FOR 0% CNT

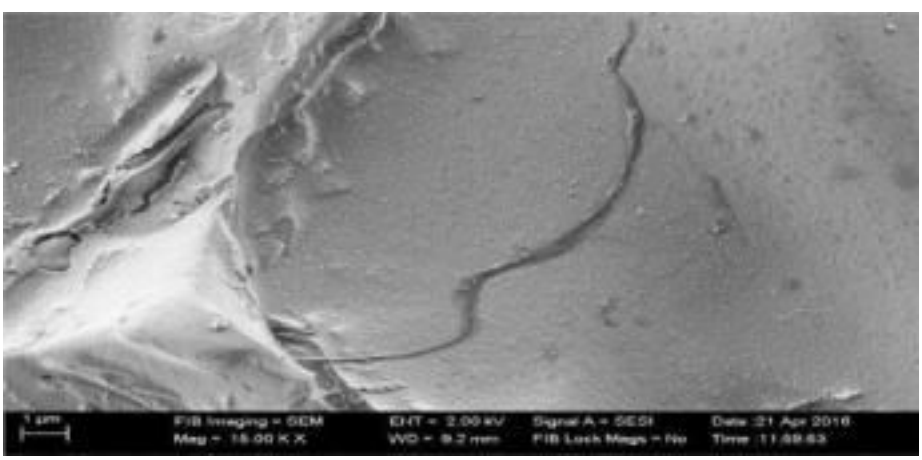

Fig 3.1: At 15000x magnification of 0% CNT in 1kg of aluminium 6061

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FOR 0.2% CNT

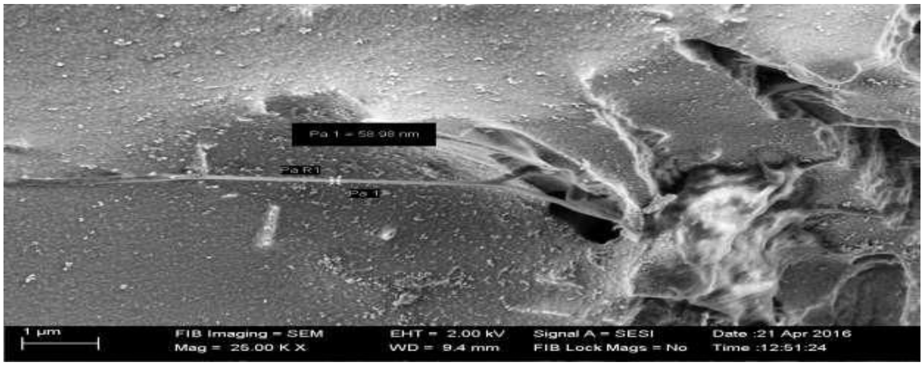

Fig 3.2: At 15000x magnification of 0.2% CNT in 1kg of aluminium 6061

FOR 0.4% CNT

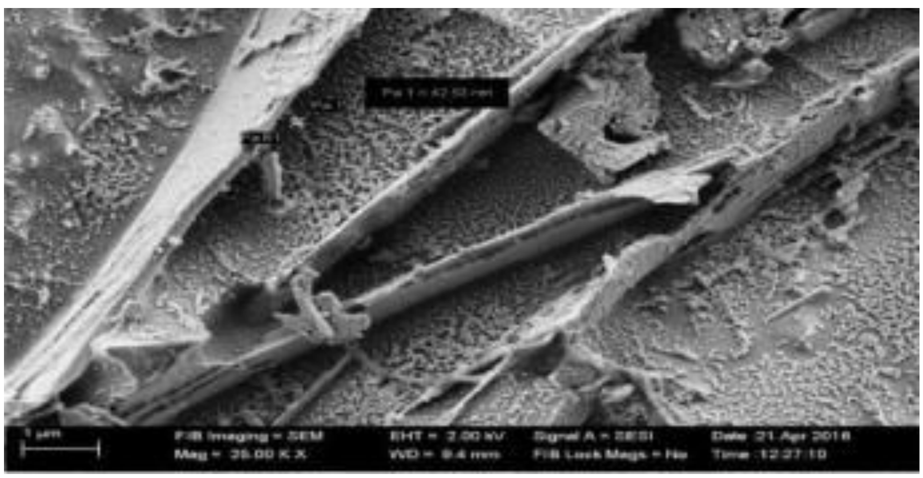

Fig 3.3 At 25000x magnification of 0.4% CNT in 1kg aluminium 6061

FOR 0.6% CNT

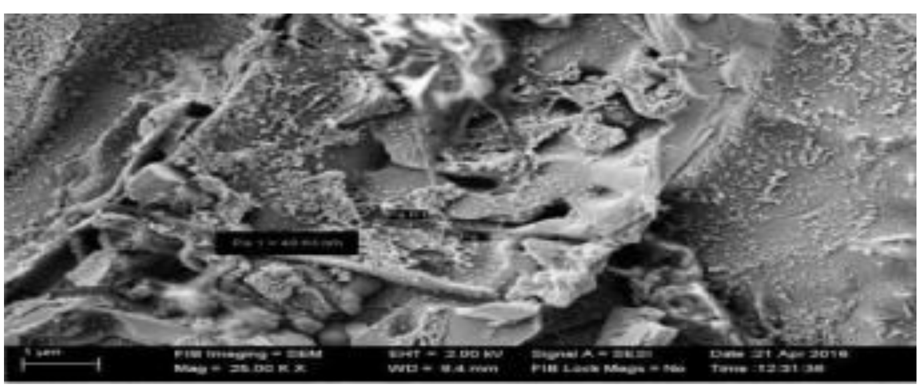

Fig 3.4 At 25000x magnification of 0.6% CNT in 1kg aluminium 6061

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WEAR TEST

Typical Pin on disk machine is used with pin diameter 8mm and 25mm length and the disc with 180mm diameter and 12mm thickness. Initially the disc is grounded to get a roughness of 0.8micrometer.

Table: 3.1: Effect of Sliding Time on Wear Loss on Al6061 and 0.6 % by wt.CNT

Wt Al + % of CNT	Wear loss in Microns for various Loads		
	5N	10N	15N
Al 1000	147.86	189.63	176
Al 1000 + 0.2% CNT	142.77	176.59	163.84
Al 1000 + 0.4% CNT	137.45	169.12	157.46
Al 1000 + 0.6% of CNT	129.69	149.58	136.89

HARDNESS TEST

The Brinell hardness test consists of indenting the test material with a 4 mm diameter hardened steel or carbide ball subjected to a load of 500 kg. The full load is normally applied for about 10 to 15 seconds. The diameter of the indentation left in the test material is measured with a low powered microscope. The Brinell hardness number is calculated by dividing the load applied by the surface area of the indentation. The Extruded specimens were subjected to Brinell Hardness Test and the BHN are tabulated as shown in the below Table3.2

Table: 3.2 Effect of BHN on Extruded Specimen

Wt % of CNT	Hardness (BHN)
Al 1000	35
Al 1000 + 0.2% CNT	39
Al 1000 + 0.4% CNT	44
Al 1000 + 0.6% of CNT	58

CONCLUSION

Al6061 metal matrix composites reinforced with carbon Nano tubes was successfully fabricated by stir casting. The microstructure of the carbon Nanotubes reinforced composite showed a reasonably uniform distribution of particles

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and good interracial bonding of dispersed particles with al6061 matrix alloy. There is a good interfacial bonding between Al6061alloy and carbon nanotube metal matrix which improves the hardness of the composites and also the wear behavior of the composites. Wear behavior of 6061Al alloy and its composites was carried out successfully by friction and wear monitor. The carbon Nano tubes content in Al6061 alloy plays a significant role in increasing the wear resistance of the material.Al6061 with 0.6% MWCNT has high resistance as indicated by lowest wear. Thewear loss tends to decrease with increasing particles volume, which confirms that addition of MWCNT is beneficial in reducing the wear loss of the composite. In adhesive wear, the material loss for Al6061-MWCNT composites is lower when compared to the Al6061 matrix alloy. Wear loss increases with increasing sliding distance due to the work hardening of the surface leading to abrasion wear

REFERENCES

1. *Ray H.Baughman,AnwarA.Zakhidov,walt A de Heer “carbon nanotubes-the Route toward Applications”Science Vol297, (2002)pp. 787-792*
2. *I. Sridhar Karthic R. Narayanan “Processing and characterization ofMWCNT reinforced aluminum matrix composites” J Mater Sci 44(2009) pp.1750–1756*
3. *K. Singhal, RenuPasricha, Satish Teotia, Girish Kumar and R.B. Mathur (2011) “Fabrication and characterization of Al-matrix composites reinforced with amino-functionalized carbon nanotubes” Composites Science and Technology vol.72, pp.103–111.*
4. *A.M.K. Esawi, K. Morsi, A. Sayed, M. Taher and S. Lanka (2010) “Effect of carbon nanotube (CNT) content on the mechanical properties of CNT-reinforced aluminium composites” Composites Science and Technology vol.70, pp.2237–2241.*
5. *C. Parswajinan, B. VijayaRamnath, C. Elanchezhian, S. V. Pragadeesh, P.R. Ramkishore, V.Sabarish (2014) “Investigation on Mechanical Properties of Nano Ferrous Composite” Procedia Engineering vol.97, pp.513-521*
6. *S. R. Malik, M. A. Maqbool,S. Hussain, H. Irfan ―carbon Nano tubes:Description,Properties and Applications‖ J Pak Mater Soc 2008; 2 (1).*
7. *Kwon, park, Silvain, kawasaki, Investigation of carbon nanotube reinforced aluminium matrix composite materials, Compos. Sci. Technol. Vol 70 (No. 3),2010, p 546-550.*
8. *Esawi, Morsi, Sayed, Taher, Lanka. Effect of Carbon nanotube(CNT) content on the mechanical properties of CNT-reinforced aluminium composites, Composite Science and Technology (vol 70), 2010, 2237-2241.*