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Fabrication and Studieson Mechanical properties of Multi walled Carbon Nanotube Reinforced Aluminium 6061 hybrid composites.

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Abstract

Hybrid nanocomposites are based on aluminium alloy reinforced with different hybrid ratios of Graphite (1%, 2%, 3% &4 weight %) and Multi walled carbon nanotube (MWCNT) (fixed 2 weight %) nanoparticles were successfully mixed by using planetary ball mill and compacted by using novel technique powder metallurgy. The core of work, it is intended to develop and study the properties of Aluminium 6061(Al6061) /MWCNT/Graphite reinforced hybrid aluminium metal matrix composites. The fabricated specimens were characterized using Scanning Electron Microscope (SEM) with X-ray diffraction(XRD), and hardness test. it was observed that the MWCNT and graphite was fairly dispersed in the Al6061 metal matrix composites. The hardness of this composites is increased for 1% graphite and MWCNTs as compared with the aluminium 6061 alloy and hardness decreases with increases graphite percentages.

Keywords: *Aluminium 6061, MWCNT, Graphite, ball mill, Powder metallurgy, hardness.*

1. INTRODUCTION

Aluminium based reinforced metal matrix composites (MMC) have received considerable attention, because of their improved strength, high modulus and increased wear resistance over conventional aluminium alloys [1].

The research focused over the past decades on using carbon nanotubes (CNTs). Research have investigated on metal matrix composites with the core research as being aluminum and aluminium alloy [2,3], due to light weight, high strength composites, which are widely applied in the automobile and aerospace industries[4].

Carbon nanotubes is an ideal reinforcement, since it possesses extremely high modulus, strength, stiffness, low density and high specific surface[5]. The dispersion of the CNTs in the metal matrix is a key factor to improve the mechanical properties of CNT/Al metal matrix composites[6,7].

The fabrication of Al 6061/MWCNTs metal matrix composites using powder metallurgy route has emerged as promising route for the fabrication of MWCNTs reinforced MMC [8,9,10].However, very limited research has been done in the field of CNT-reinforced hybrid aluminium metal matrix composites[11].

2.MATERIALS AND METHOD

2.1. Materials

Aluminium 6061, in powder form 200 mesh size was used as a matrix material and its chemical composition is presented in table 1. The mechanical and physical properties of Al6061 presented in table 2. Al 6061 is a precipitation hardening aluminium 6061, containing magnesium and silicon as its major alloying elements. It has significant applications in aircraft, marine and automobile industries.

Table 1.1 Composition of aluminium 6061

Component	Al	Mg	Si	Cu	Fe	Zn	Mn	Ti	Cr
Amount(wt%)	balance	0.8-1.2	0.4-0.8	0.15-0.40	Max0.7	Max0.25	Max0.15	Max0.15	0.04-0.35

Table 1.2 Mechanical and Physical properties of aluminium 6061

Elastic modulus(Gpa)	Density(g/cc)	Poisson's ratio
70-80	2.7	0.33

As the reinforcement, the graphite particles with size of 100 micron and multi walled carbon nanotubewith the diameter of 20-30nm and length 10-30µm were used. carbon nanotubes were produced by chemical vapour deposition (CVD) by cheap tube(USA). The morphology of the as-received MWCNTs image of Transmission Electron Microscope (TEM) and X-ray diffraction (XRD) of Al6061 shown in Fig 1.1(a) &(b) .

Figure 1.1. a) TEM of MWCNTs

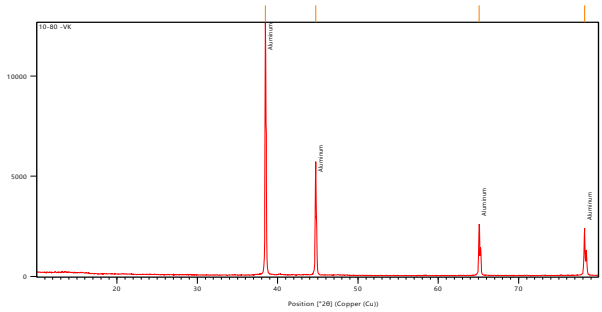

Figure 1.1: b) XRD result of Al6061 alloy powder

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2.2. Method

In the present work using powder metallurgy (P/M) technique. The hybrid composites has been fabricated using compacting die to compact the powders by using 40Ton capacity hydraulic press.

In order to achieve uniform dispersion of MWCNTs and Graphite in Al 6061matrix , 1 hours of mechanical milling in planetary ball mill of each powder was milled under the rotation speed of 200rpm. The ball mill andstain less steel balls were used as shown in fig 2 and fig 3, ball to powder ratio was set 10:1[12].

Figure1. 2. Planetary Ball mill

Fig 3. Ball mill Jar with steel balls

After blending, compaction the powders in to solid billet (green sintering).Thecompaction die and punch set is made of mild steel. It consists of circular hole of 20mm diameter and to obtain specimen as per ASTM E9 . The mixture is compacted at load of 90-120KN and the samples as shown in fig 4, The samples were prepared for various composition ranging from different weight percentages as detailed shown below table 1.3.

Figure 1. 4. Compacted specimens

Table1. 3 Different weight percentage of matrix and reinforcement.

Sample	Al6061	MWCNTs	Graphite
S1	100%	0%	0%
S2	97%	2%	1%
S3	96%	2%	2%
S4	95%	2%	3%
S5	94%	2%	4%

The specimens was subjected to sintering process for 8hours at temperature between 0.7 and 0.9 times the below melting temperature of the base metal (480^{o}C), then cooled in the furnace for 48hours. Samples were exmained for microstructre, using microscope, SEM and hardness test.

3. RESULTS AND DISCUSSIONS

3.1Microstructure

The fabrication of MMC with nanoparticles by powder metallurgy is usually difficult because of agglomeration phenomenon, which result in non uniform distribution and poor mechanicalproperties. In present work, an attempt has been made to prepare Al6061 mixing with reinforcement particles. The microstructure images of the Al 6061 with 2% MWCNTs and varying percentage of graphite particles at 1%, 2%, 3% &4% were shown in figure 1.5(a-e).

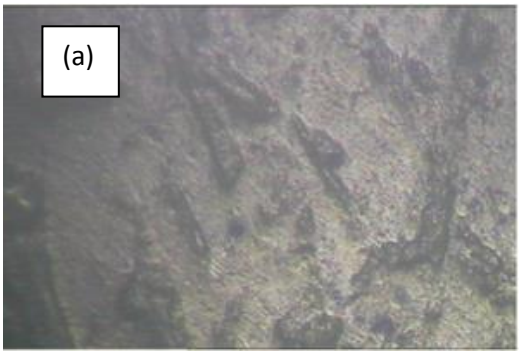

Figure 1.5a. Pure Al6061

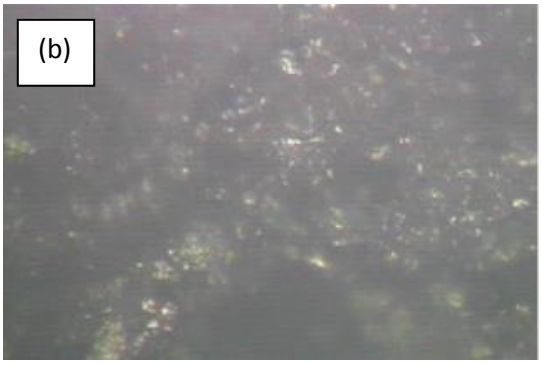

Figure 1. 5b.97%Al6061+2%MWCNTs+1%Graphite

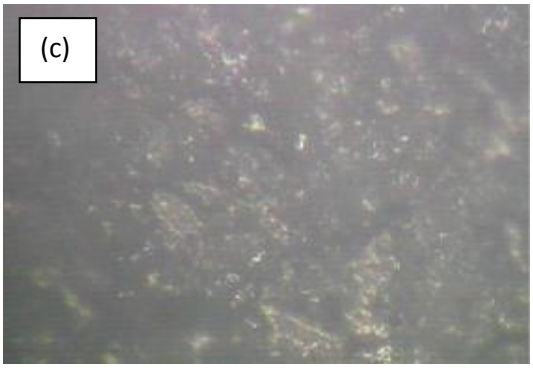

Figure 1. 5c. 96%Al6061+2%MWCNTs+2%Graphite

Figure 1. 5d. 95%Al6061+2%MWCNTs+3%Graphite

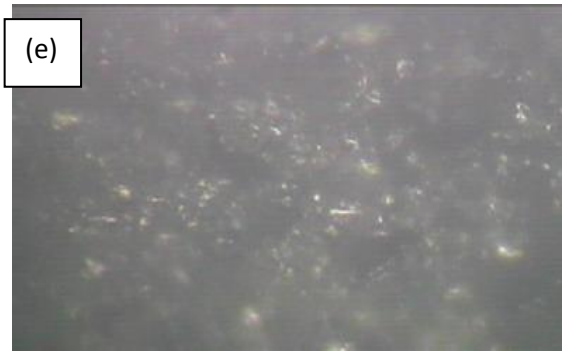

Figure 1. 5e. 94%Al6061+2%MWCNTs+4%Graphite

Figure 1.5.a-e showing the micrographs of Al6061 with and without MWCNTs and graphite particulates

The above Figure 1. 5 (a-e) shows micrographs of Al6061/MWCNTS/Graphite reasonably uniform distribution of MWCNTs/Graphite particles in the Al6061matrix. The micrographs of the hybrid composites clearly reveals the morphology of MWCNTs/graphite dispersed particles indicating porosity of irregular shape of sharp edges.

3.2 Scanning Electron microscope

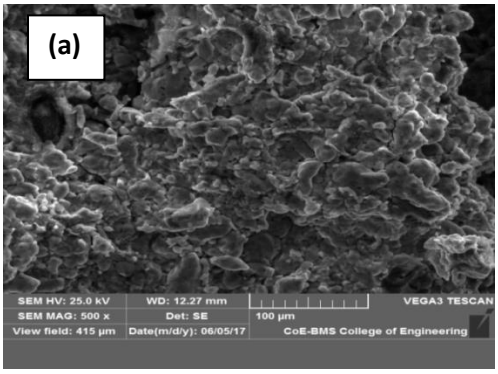

Figure 1.6a. Pure Al6061

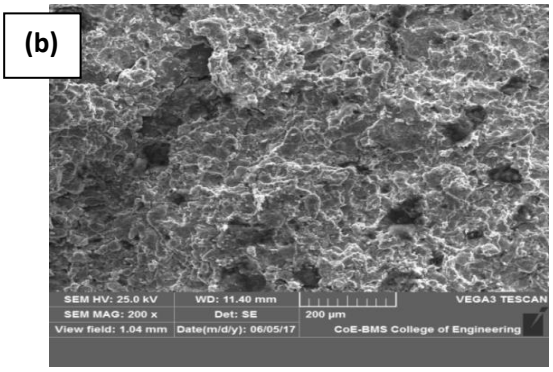

Figure1. 6b. 97%Al6061+2%MWCNTs+1%Graphite

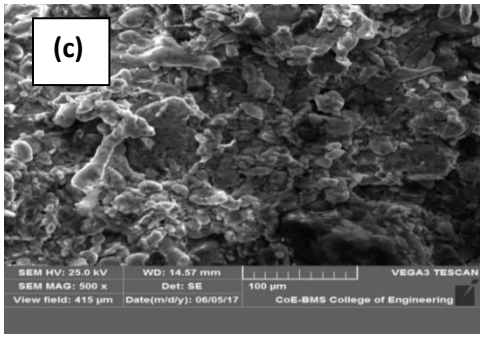

Figure 1. 6c. 96%Al6061+2%MWCNTs+2%Graphite

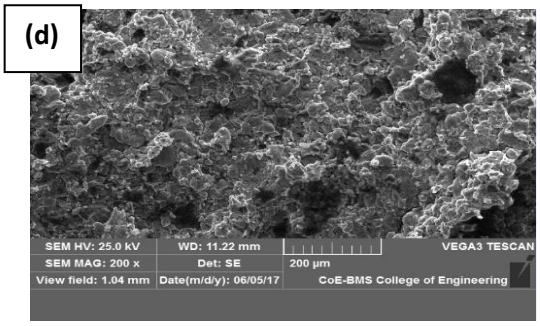

Figure1. 6d. 95%Al6061+2%MWCNTs+3%Graphite

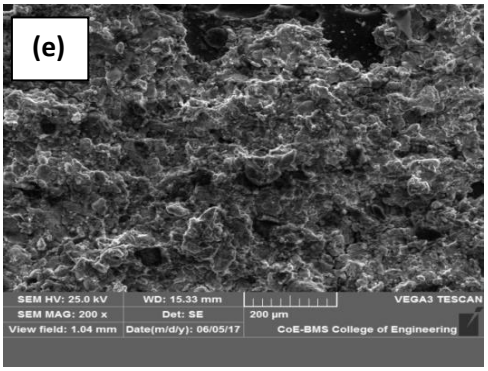

Figure 1. 6e 94%Al6061+2%MWCNTs+4%Graphite

The above Fig 6 (a-e) shows SEM micrographs shows that fairly uniform distribution of MWCNTs/Graphite in bas metal matrix composites.

3.3 Hardness

Brinell hardness test was conducted for measuring the hardness of the Al6061/MWCNTs/Graphite metal matrix composites. The hardness were measured on the polished samples using ball indenter 5mm diameter with a load of 250kgf. The hardness values were measured in three locations and the average values were considered for all specimens, as shown in below table1. 4.

Table1. 4. Brinell hardness valuesof Al6061/MWCNTs/Graphite

Sample	Weight percentage of reinforcement	Hardness (BHN)
S1	100%Al6061+0%MWCNs+0%Graphite	31.2
S2	97%Al6061+2%MWCNTs+1%Graphite	36
S3	96%Al6061+2%MWCNTs+2%Graphite	33.5
S4	95%Al6061+2%MWCNTs+3%Graphite	32.1
S5	94%Al6061+2%MWCNTs+4%Graphite	31.6

Hardness of the specimen of Al6061/MWCNTs/Graphite fabricated MMC were determined by using BHN apparatus as per ASTM B925. The figure 1. 7 shows the variation of BHN for Al6061 /MWCNTs/Graphite developed for various weight percentages of MWCNTs and graphite as compared to Al6061. The hardness increases for 1% graphite and MWCNTs compared to base metal matrix composites, later increases with percentages of graphite results in decreaese in hardness of the composites.

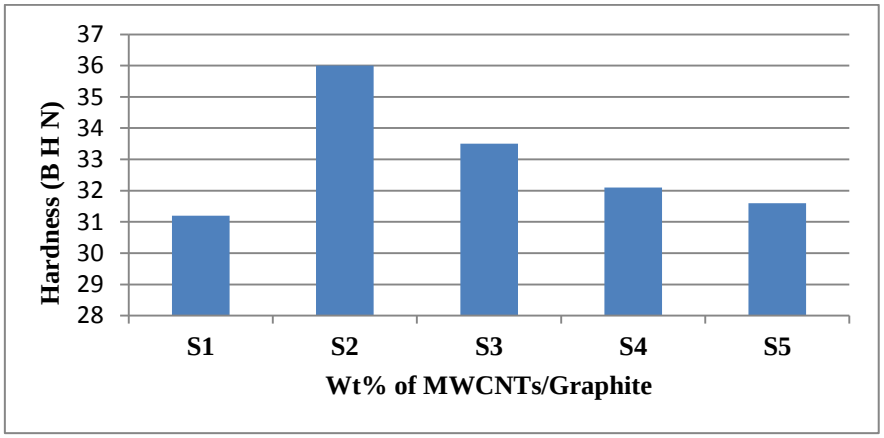

Figure 1. 7. Showing the variation in hardness of Al6061 before and after addition of different Wt% of MWCNTs/Graphite particulates.

4. CONCLUSION

Al6061reinforced MWCNTs/Graphite metal matrix composites developed successfully by powder metallurgy technique and evaluation of characterization and hardness test has led to following conclusions.

- The metal matrix composites of Al6061 with 2% percentage of MWCNTs and 1%,2%,3% &4% of graphite particulates were successfully blended using planetary ball mill.
- Based on metallographic and SEM examination of composites found that fairly uniform distribution of MWCNTs and graphite particles in base matrix and agglomeration were found.
- The hardness of the prepared composites increases for 2% MWCNTs and 1% Graphite and hardness decrease with increase of graphite percentage.
- It is observed that, increases the addition of graphite more than 2%particles to composites, the compactness of the material is quiet non uniform due to porosity and forming few clusters.

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