

# Study of Mechanical and Wear Properties of Multi Walled Carbon Nano Tubes (MWCNT's) Reinforced Epoxy Based Composites at Elevated Temperature

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**ABSTRACT:** Composite material is a combination of two or more materials to form a new material system with enhanced material properties. Nano Composite materials are formed by reinforcing carbon Nano tubes in a matrix, which are mostly structural. The main objective of the project is to determine the various mechanical properties of the Nano composite material composed of multi walled carbon Nano tubes blended in various quantities with the specified amount of epoxy as a matrix. The technique involved in fabricating is hand layup method and the required amount of specimen is cut down according to ASTM standards. Tensile, impact and hardness tests have been conducted for 0.25 , 0.50 , 0.75, 1.0, 1.25 weight percentage of Multi Walled carbon Nanotubes in epoxy composites. The results show that as the percentage of Multi Walled carbon nanotubes in epoxy increases the mechanical properties of composites is improved in different conditions.

**KEYWORDS:** Composites, Multi walled Nano tubes [MWCNT], Epoxy resin

## I. INTRODUCTION

Composite material is a combination of two or more materials to form a new material system with enhanced material properties. Nano Composite materials are formed by reinforcing carbon nano tubes in a matrix, which are mostly structural. Matrix material provides support for the fibers and assists the fibers in carrying the loads. It also provides stability to the composite material. The major functions of the matrix material are to hold the fibers together, protecting the fibers from environment, distributing the loads evenly between fibers so that all fibers are subjected to the same amount of strain etc. The most common advanced composites are Polymer Matrix Composites (PMC's) consisting of a polymer (e.g., epoxy, polyester, urethane) reinforced by thin diameter fibers (e.g., graphite, aramids, boron). For example, graphite/ epoxy composites are approximately five times stronger than steel on a weight-for-weight basis.

**The work was carried according to the following steps:**

1. Materials procurement.
2. Fabrication of the composites.
3. Preparation of test material according to ASTM Standards.
4. Testing the specimens for mechanical properties at elevated temperature.

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Multi-Walled Carbon Nanotubes (MWCNTs) were used as the reinforcement in an epoxy resin with weight percentages (0.25, 0.5, 0.75, 1.0, 1.25) wt.%, respectively, by using direct mixing processes to prepare (epoxy/MWCNTs) nanocomposites. The ultrasonic mixing process was used to disperse the nanotubes into the epoxy resin system. The results show improvement of the mechanical properties with an increase in the percentage weight less than 2% and then a decrement with a further increase in the MWCNTs content. The results show that long carbon nanotubes have mechanical properties better than short carbon nanotubes.

## II. LITERATURE REVIEW

[1] Pascault J.P et al., observed the behaviour of Nano carbon fiber and carbon tubes. It might be turbostratic or graphitic relying on forerunner to make the fibre or have a cross breed structure with both graphitic and turbostratic parts exhibit. Carbon strands got from mesophase pitch are graphitic after warmth treatment at temperatures surpassing 2200 °C. Turbostratic carbon filaments have a tendency to have high elasticity, while warm treated mesophase-pitch-inferred carbon strands have high Young's modulus (i.e., high firmness or protection from augmentation under load) and high warm conductivity.

[2] Dr.Chandramohan et al., conducted a research on epoxy resin polymers reinforced with natural fibers like Sisal, Banana and Roselle and three hybrid combinations of any two fibers. Tensile and hardness tests were conducted on all the three specimens. The hybrid composites showed better performance. Less elongation and fiber pull out and brittle nature of fracture were observed in fiber based composites while more elongation, fiber pull out and partial brittle nature of fracture were observed in hybrid composites.

[3] Allaouiet.al., observed that Small quantity addition can modify considerably the mechanical and electrical behavior of a soft polymer matrix. The exceptional mechanical properties, the high aspect ratio and the good conductivity of MWNT have been used to improve the performance of a rubbery epoxy matrix Nano composite. Enhancement has been obtained with CVD MWNT and simple process. The non-homogeneity of CNTs may have a less effect on their electrical properties. The results of this study suggest that it would not be helpful to use high CNTs concentrations to improve the mechanical properties of composites if they are in random distribution.

[4] E. Hammel a et al., concluded that Carbon nano-fibers and nanotubes are promising to revolutionize several fields in material science and are suggested to open the way into nanotechnology. Further market development will depend on material availability at reasonable prices. Reasonably low temperatures and yields of up to several g/m<sup>2</sup> min at more than 70% carbon gas-to-fiber conversion rates allow considerable cost reductions. Polymer composites have been prepared by dispersion of CNFs into polymer matrices applying intensive shear via extrusion. In polypropylene the application of less than 10 wt.%. CNFs reduced the volume resistivity from >10<sup>13</sup> X-cm to a value of 10<sup>5</sup> X-cm. Different sizing of fibers is normally used for nylon, polycarbonate and other high temperature applications. It is the development and volume production of a single carbon Nano-fiber type which can be used in the wide range of systems beyond, but not restricted to polymer composites


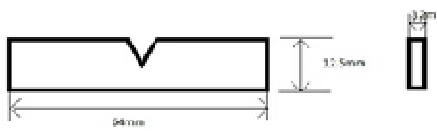

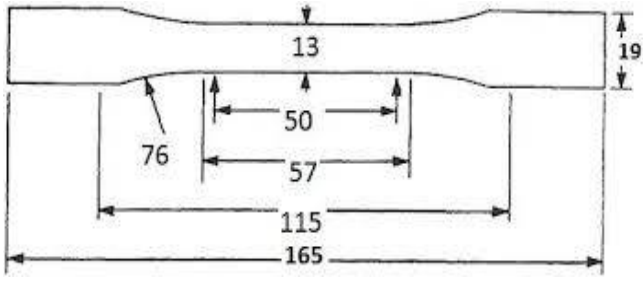

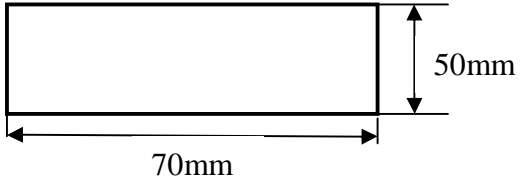
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### III. TEST SPECIMENS

<b>Impact test specimen-ASTM D256</b>	<b>Impact test specimen dimensions</b>
	
<b>Tensile test specimen- ASTM D-638</b>	<b>Tensile test specimen Dimensions</b>
	
<b>Hardness test specimen-ASTM D2240</b>	<b>Hardness test specimen dimensions</b>
	
<b>Figure 1 : Test Specimens and its dimensions</b>	

## IV. EXPERIMENTAL RESULTS

### 1. Effect of temperature on tensile strength of MWCNT-Epoxy composites

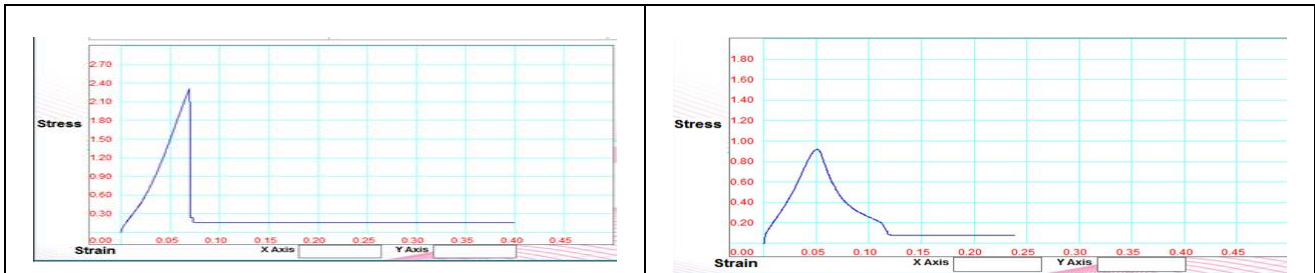


Figure 2: Stress Strain curves for 0.5gm MWCNT-Epoxy at 60°C and 80°C

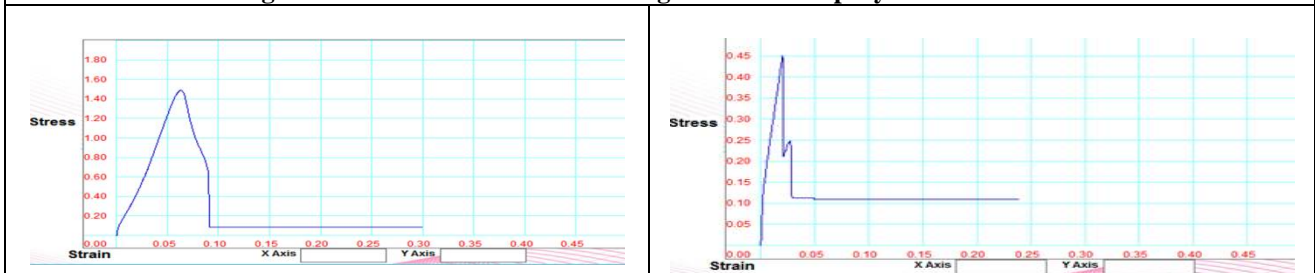


Figure 3: Stress strain curve for 1.0gm MWCNT-Epoxy at 60°C and 80°C

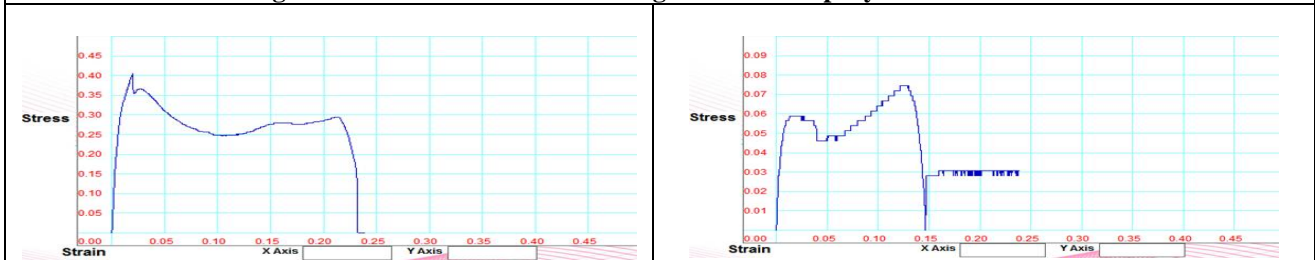


Figure 4: Stress strain curve for 1.5gm MWCNT-Epoxy at 60°C and 80°C

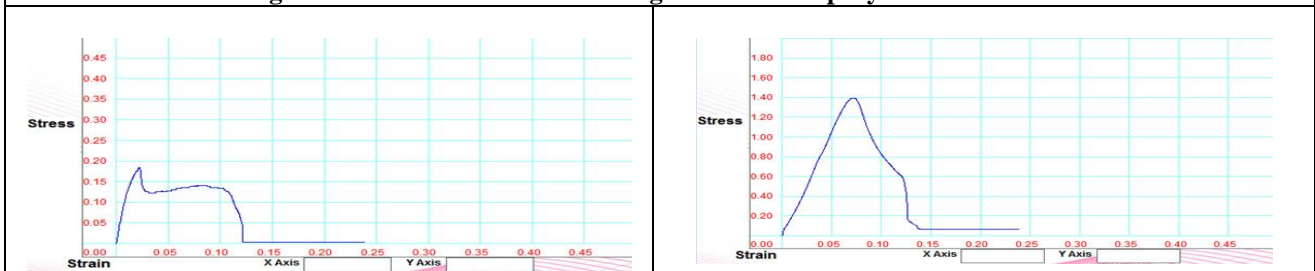


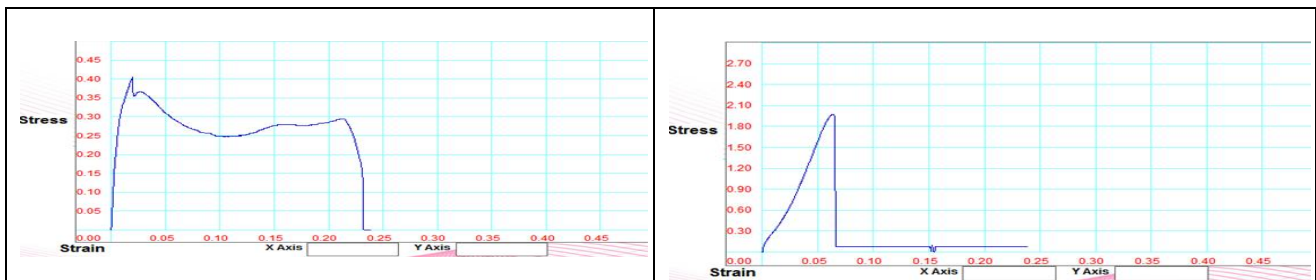
Figure 5: Stress strain curve for 2.0gm MWCNT-Epoxy at 60°C and 80°C

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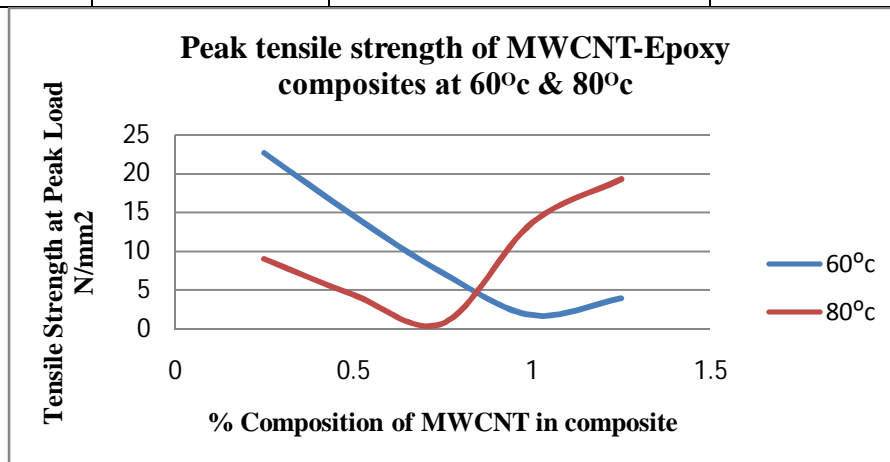
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**Figure 6: Stress Strain curves for 2.5gm MWCNT-Epoxy at 60°C and 80°C**

<b>Table 1: Peak tensile strength of MWCNT-Epoxy composites at 60°C &amp; 80°C</b>			
Specimen No.	% composition of MWCNT in composite	Tensile strength at peak load N/mm <sup>2</sup>	
		Temperature (°C)	
		60°C	80°C
<b>1</b>	0.25	22.714	9.03
<b>2</b>	0.50	14.614	4.427
<b>3</b>	0.75	7.235	0.729
<b>4</b>	1.0	1.81	13.684
<b>5</b>	1.25	3.974	19.318



**Figure 7 : Variation of tensile strength with respect to increase in wt % of MWCNT in epoxy**

From the above table 1 and figure 7 it is clear that as the temperature increases, the tensile strength of the specimen decreases. We also observe that as the percentage of MWCNT increases from 0.75 to 1%, the tensile strength increases significantly with increase in temperature (at 80°C)

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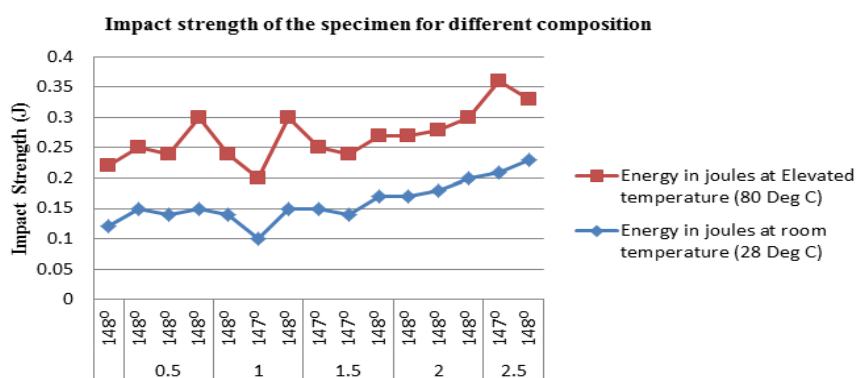
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Hence it is clear that by increasing higher percentage of MWCNT's, the tensile strength of the composites can be improved.

## 2. Impact Test Results:

Table 2 : Impact strength of the specimen for different composition			
Composition of MWCNT in Epoxy (grams)	Angle in degrees	Energy in joules at room temperature (28 <sup>o</sup> C)	Energy in joules at Elevated temperature (80 <sup>o</sup> C)
0.5	148 <sup>o</sup>	0.12	0.1
	148 <sup>o</sup>	0.15	0.1
	148 <sup>o</sup>	0.14	0.1
1.0	148 <sup>o</sup>	0.15	0.15
	148 <sup>o</sup>	0.14	0.1
	147 <sup>o</sup>	0.1	0.1
1.5	148 <sup>o</sup>	0.15	0.15
	147 <sup>o</sup>	0.15	0.1
	147 <sup>o</sup>	0.14	0.1
2.0	148 <sup>o</sup>	0.17	0.1
	148 <sup>o</sup>	0.17	0.1
	148 <sup>o</sup>	0.18	0.1
2.5	148 <sup>o</sup>	0.2	0.1
	147 <sup>o</sup>	0.21	0.15
	148 <sup>o</sup>	0.23	0.1



**Figure 8: Variation of impact strength on various percentage of MWCNT's**

From the above table 2 and figure 8 it is clear that as the temperature increases, the Impact strength of the specimen at 60<sup>o</sup>C increases. We also observe that as the percentage of MWCNT increases from 0.5 to 2.5%, the impact strength significantly retains its properties with increase in temperature (at 80<sup>o</sup>C)

Hence it is clear that by increasing higher percentage of MWCNT's, the impact strength of the composites can be improved.

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### 3. Effect of temperature on hardness of MWCNT-Epoxy composites:

Table 3: Effect of temperature on hardness of MWCNT-Epoxy composites				
Composition of MWCNT in Epoxy (grams)	Temperature ( °C )			
	30	60	80	100
Shore-D Hardness no.				
0.5	98	71	50	42
1.0	98	78	59	44
1.5	95	78	60	45
2.0	101	78	60	48
2.5	103	86	68	53

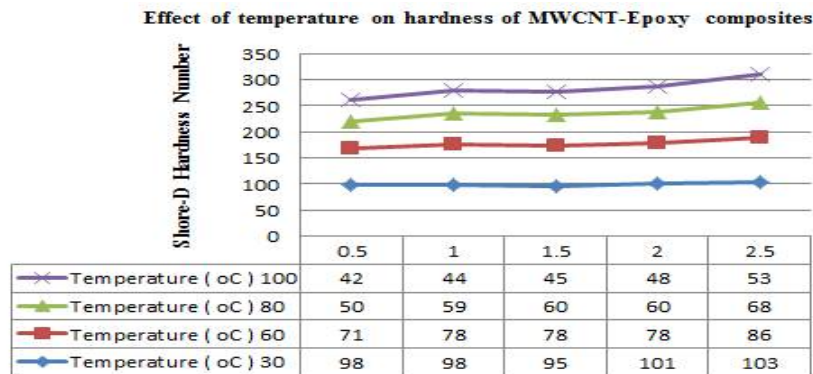


Figure 9: Variation of Hardness on various percentage of MWCNT's

Hardness test has been conducted for temperatures 30°C, 60°C, 80°C and 100°C. It has been noted that

- As the temperature is increased hardness of the specimen decreases
- As the composition of MWCNT in 200g of Epoxy resin is increased and keeping the temperature constant, the hardness of the specimen increases.

### V. SEM MORPHOLOGY

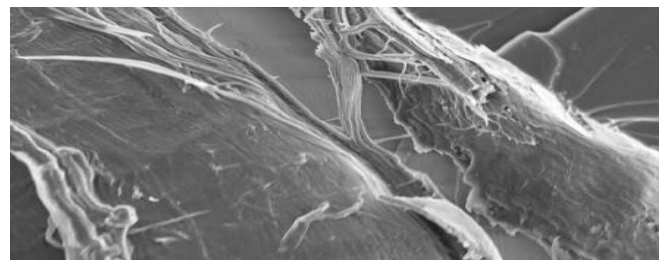
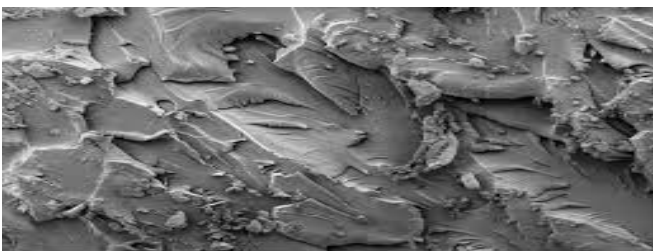


Plate1: SEM micrograph (500 X Magnification) of MWCNT-Epoxy composite with subjected to Tensile test

Plate 2 : SEM micrograph(500 X Magnification) of MWCNT-Epoxy composite with subjected to Impact test

Figure 10: SEM Morphology of MWCNT-Epoxy composite for tensile and impact test

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From Figure 10 the Plate 1 is showing SEM micrographs for the tensile specimen having 2.5% MWCNT at the junction of failure. From SEM micrograph, it is seen that the specimen has failed due to brittle fracture from the ER matrix. Since the interfacial area between ER matrix and MWCNT loading is larger, the above mentioned phenomenon occurs. Plate 2 shows SEM micrographs for impact specimen having 2.5% MWCNT which are seen as dark spots. Small hair like structure in large scale on the surface of the specimen represents MWCNT's randomly distributed over the entire surface of the specimen.

## VI. CONCLUSION

### The present study and analysis of results had led to the following conclusions

In the present study an attempt was made to observe the effects of multi walled carbon Nano tubes reinforcing with epoxy based composites. The following observations were made by varying percentages (0.5,1,1.5,2,2.5) of MWCNT on mechanical properties of composites at elevated temperature.

1. As the temperature increases, the tensile strength of the specimen decreases. With the increasing percentage of MWCNT from 0.75 to 1%, the tensile strength increases significantly with increase in temperature (at 80<sup>0</sup> C). Hence it is clear that by increasing higher percentage of MWCNT;s, the tensile strength of the composites can be improved.
2. The impact strength of the specimen has not shown noticeable changes in the mechanical properties of the composites and remains almost constant for all the proportion of MWCNT.
3. As temperature of the specimen increases the hardness of the specimen decreases. Therefore by increasing the percentage of MWCNT's and by keeping temperature constant, the hardness of the specimen can be improved.
4. From the above details, we can conclude that the mechanical property of the MWCNT-Epoxy composite can be improved by increasing the percentage of MWCNT.

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