International Journal of Mechanical Engineering

Young’s Modulus of Elasticity of Carbon Nanotube (CNT)

Dr.Kanchan Kumar [1]

[1] Assistant Professor, Dept. Physics, Mahila Mahavidyalaya Godda, Jharkhand, India.

***Abstract* -** CNTs have numerous features and applications [1]which are to be remarked on its structures and simulation of interactions on atomicity. In this present article it is assessed on its Young’s Modulus of elasticity calculated concentrating on weak interaction method. Although it was calculated on atomicity up to 0.1 to 1.7 T Pa[2] and average value 1.0 to 1.2 T Pa [3]. Our main focus is concentrated on weak interaction method how to decrease the diameter of Nanotube. It leads to predict a new design fabric to emerge in market providing much more durable as well as stronger as if with continuous elastic maintenance. A virtual calculation has been done for different orders of atomicity in weak interaction method.

Keywords : *Nanotube, weak interaction, fabric, Modulus of elasticity single wall nanotube, Multiwall nanotube.*

INTRODUCTION

Carbon nanotube is the thinnest material ever increasing in the world based on rolled-up grapheme layers [4]. It has unique and remarkable properties to fascinate the world. The excellent mechanical properties of graphene are advantageous for all durable electronic applications. In this present article it is also used the previous concept that the properties of nanotube change on change of structure. The structural properties vary in interaction and type of contact with change in diameter. Young’s modulus of elasticity is discussed on diametric variation depending on orders of atoms. It is also theoretically and virtually shown graphical variation in force and strain for Single Walled Nanotube and compared to Multiwalled nanotube. The article tried to predict some future aspects targeting to design a new fabric.

THEORY AND TECHNIQUE

CNTs have several remarkable features to see around as to intend to develop mechanism an extended model based on modulus of elasticity at constant Physical condition. “In weak interaction nanotube diameter [5]goes on decreasing and Modulus of elasticity [8] increases”. Young’s Modulus of elasticity for carbon nanotube with area of cross section A is given as.

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}}$$

$$Y = \frac{F}{A} \cdot \frac{L}{l}$$

$$Y = \frac{mgL}{\pi r^2 l} \qquad (1)$$

Where L =original length, l = change in length i.e. negligible irrespective of diameter.

*r = radius of tube and d_t be the diameter of the nano-tube.

Then, r = $\frac{d_t}{2}$

From equation (1) $Y = \frac{mg}{\pi} \cdot \frac{1}{\left(\frac{d_t}{2}\right)^2} \cdot \frac{L}{l}$

$$\mathrm{Y} \quad = \frac{4mg}{\pi d_t^2} . \frac{L}{l} \; \ldots \tag{2}$$

$$\text{Let } \frac{L}{l} = \text{s.} \;\; \ldots\ldots \tag{3}$$

$$\mathrm{Y} = \frac{4mg}{\pi d_t^2} . s \tag{4}$$

- Since $d_t = (□^3/□)a_{c\text{-}c} \sqrt{}(m^2+mn+n^2)$ (5)
- Where $a_{c\text{-}c}$ is the distance between neighbouring carbon atoms in the flat sheet.

It means, $□^3/□$=0.0783 nm i.e $□^3/□$ is a symbol for basic nano scale [6].

$$\mathrm{Y} = \frac{4mgS}{\pi(□^3/□)^2 a_{c-c}^2 \;\; (\sqrt{m^2+mn+n^2})^2} \tag{6}$$

If weak interaction is set up such that atomic diameter goes on decreasing, as a result Young's modulus of elasticity increases as it is theoretically independent of temperature[7].

If we consider $\frac{4mgs}{\pi}$ = K = constant (7)

From equation (6)

$$\mathrm{Y} = \frac{\boldsymbol{K}}{\boldsymbol{d_t}^{\mathbf{2}}} \quad . \tag{8}$$

RESULT AND DISCUSSIONS

From the above derived formula of Young's modulus of elasticity it is vivid that Modulus depends on diameter of the tube, d_t.

Now for different values of m and n, d_t is calculated and corresponding Young's modulus of elasticity, Y is calculated using equation (8).

d_t = 0.0783 $a_{c\text{-}c}$ $\sqrt{}(m^2+mn+n^2)$ = o(omicron) $\sqrt{}(m^2+mn+n^2)$

d_t^2 = $(0.0783)^2(m^2+mn+n^2)$ = o^2 (m^2+mn+n^2)

Where, o(omicron) = 0.0783 $a_{c\text{-}c}$

$d_t = o. \sqrt{}(m^2+mn+n^2)$

For (m, n) = (1, 1)

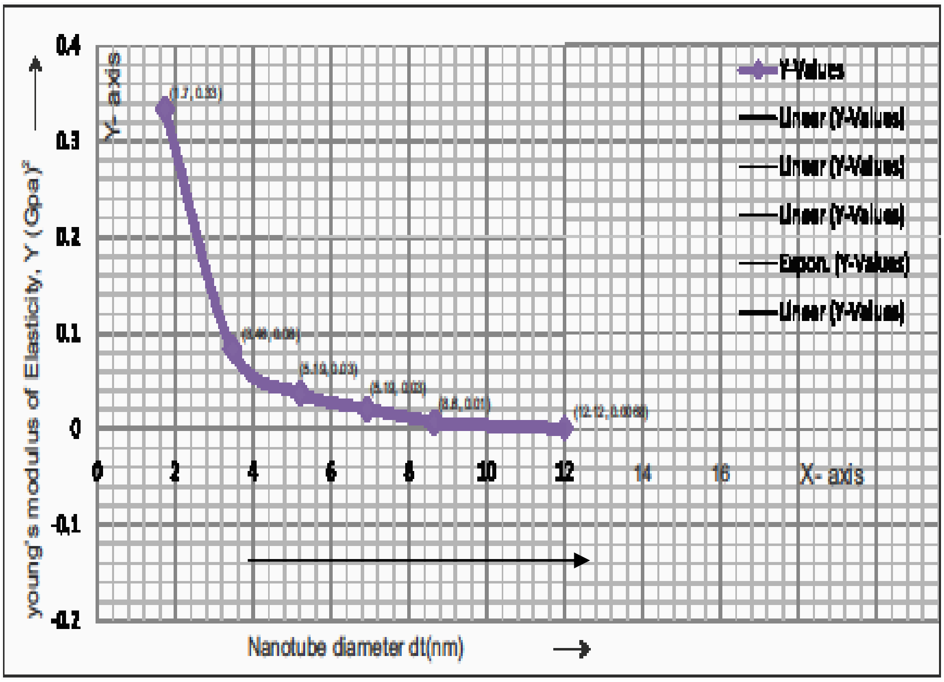
$d_t = o. \sqrt{}(1^2+1.1+1^2) = \sqrt{3} \;.\; o = 1.732.\; o$

Table 1

S.N.	CNT(m, n)	d_t(in nanolength)	d_t^2(o^2)	Y=$\frac{K}{d_t^2}$ (in $(GPa)^2$
1	(1, 1)	1.732	2.9998	0. 3333
2	(2,2)	3.46	11.9716	0.0835
3	(3, 3)	5.196	26.9984	0.0370
4	(4,4)	6.928	47.9971	0.0208
5	(5, 5)	8.66	74.9956	0.0133
6	(6, 6)	10.392	107.9936	0.0092
7	(7,7)	12.124	146.9913	0.0068
8	(8,8)	13.856	191.9887	0.0052
9	(9, 9)	15.588	242.9857	0.0041

Graph-1 the graph between nanotube diameter and Young's Modulus of elasticity is shown with correct labeling.

Nature



Nanotube diameter d_t(nm)

Fig: (1) graph between nanotube diameter d_t(in nanolength) along X axix and Young's Modulus of elasticity, Y along Y-axix for singleWalled nanotube.

It is now clear that Young's modulus of elasticity, Y increases as diameter of the tube is made to decrease through weak interaction method.

In the derivation it is assumed that equal no. of atoms (m=n) interact in singlewalled nanotube. However, Multiwalled nanotube(MWNT) have least possibility to interact in order of m=n. hence, nanotube diameter d_t is calculated through unequal pair of atoms.

For (1,2) = $o.\sqrt{(1^2+1.2+2^2)}$

= $o.\sqrt{(1+2+4)}$

= $o.\sqrt{7}$

= $o.2.64$

And in similar way for other orders we have-

Table 2

S.N	CNT(m, n)	d_t(in nanolength)	d_t^2(o^2)	Y=$\frac{K}{d_t^2}$ (in $(GPa)^2$
1	(1, 2)	2.64	6.969	0.1434
2	(2, 3)	4.35	18.922	0.0528
3	(4, 5)	7.81	60.996	0.0163
4	(6,7)	11.26	126.787	0.0078
5	(8, 9)	14.73	216.972	0.0046
6	(10, 11)	18.19	330.876	0.0030
7	(12, 13)	21.656	468.982	0.0021
8	(15, 17)	27.730	768.952	0.0013
9	(19, 21)	34.655	1200.96	0.0008
10	(23, 25)	40.743	1659.74	0.0006

Graph:2 Nature of Graph of MWNT

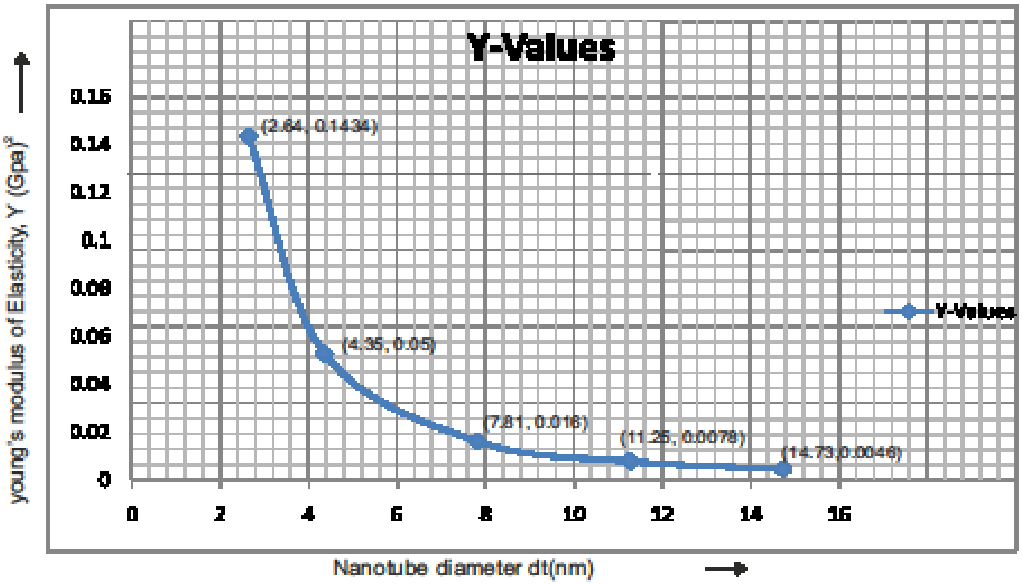


Fig: (*2*) *graph between nanotube diameter* d_t*(in nanolength) along X axix and* Young's Modulus of elasticity, Y along Y-axix for Multiwalled nanotube.

The graphical variations between modulus of elasticity Y and diameter $d_t$draw the following points:

1. The diameter decreases as the number of interacting atoms decreases and vice versa.
2. Young's modulus of elasticity Y increases as the tube diameter decreases.
3. Modulus of elasticity is greater for single walled nanotube than Multiwalled nanotube.

Uses:

1. 1.This method is applicable to turn the material for more elastic and its long lasting.
2. it is independent of environmental factor such as temperature, pressure and humidity.
3. it can be used in filter of contaminated water comparatively long days.
4. A new I.C. can be fabricated with high modulus of elasticity.

CONCLUSION

Weak interaction method is appropriate and relevant method to calculate Modulus of elasticity of carbon nanotube for single walled nanotube (SWNT) and Multiwalled nanotube (MWNT). Theoretical and virtual calculations provides tube diameter decreases on just managing with small ordered atomic interactions and hence Modulus of elasticity goes on increasing. It has been obvious that modulus of Single wall nanotube is greater than Multiwalled nanotube. In prediction it is ensured that a new fabric can be constructed for high Modulus of elasticity.

ACKNOWLEDGEMENT

I thank the Great Nobel Prize winner S.Iijima's works on carbon nanotube [4] and Work of Feras G.Alzubi and Ronald Cosby Kuwait institute for scientific Research centre. I am also thankful to Prof. Abdus Sattar, H.O.D, Dept. of Physics S.K.M.U. Dumka who inspired me to work continuously to seek innovative thought and achieve new result.

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