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Synthesis, Processing and Finite Element Analysis of CNT Based Polymer Composites

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Abstract. One of the most reverting materials with atypical properties is Carbon Nanotube. The magnificent possessions of Carbon nanotubes have engrossed many in nano science and nanotechnology manifesto, though nanotubes are very favourable in a wide range of province. Its entreaty discrete nanotube for wide range has been bounded. To enhance its practical applications, piles of nanotube materials have lately allured attentions especially by evolution of polymer amalgamation. Finite Element Analysis (FEA) is the contemporary analysis hub for this method, which is used to examine the astounding properties of CNT, based polymer fusion. The present review focus on the methods of Finite Element Analysis (FEA) used to analyse these extraordinary properties of CNT based polymer composites with ANSYS and ABAQUS software.

Keywords: Composite Materials, Carbon Nanotube, Finite Element Analysis

INTRODUCTION

The material that has numerous properties like flexibility, low density, reasonable strength, easy processibility is polymer [1-4]. Properties of nano-scale particles have been described as filler material for polymers for creation of high performance composites with better properties. Carbon nanotube with a one-dimensional carbon fiber with an aspect ratio of more than 1,000 relative to other carbon materials including steel, graphite and Fuller. No other item had shown the mixture of these exceptional thermal, mechanical, and electronic properties. Its usage ability as an innovative filler that combines improved physical and chemical characteristics in polymers makes CNT an excellent choice for use in a wide variety of applications. Its effective ability as an innovative filler that combines improved physical and chemical properties in composites makes CNT an excellent choice for use in a large range of applications. The nanotube reinforced polymer composites were found as one of the most capable materials for the development of scientific and technical application areas. Work in the field of Nano composites has shown that the special properties of nanoparticles in conjunction with the traditional reinforcement contribute to inherent advantages. CNT 's outstanding electrical , mechanical and thermal properties make it the best alternative as a filler in composites made from light polymer. Nanotube-enhanced polymer composites have become important structural materials not only in the weight-sensitive aerospace industry but also in the military, naval, civil engineering, industrial, rail and sports goods industries due to their high basic rigidity and strong strength. Various Nano composites were created by incorporating CNT into a range of polymeric materials.

It is a flexible and high elastic natural material, though these properties are not sufficient for many engineering applications. Consequently many of them were enduringly looking over for new type of polymeric material with higher properties [3,4]. Many attempts in blending of various class with polymer where tried, to find a new material with absolute properties. Nevertheless, by blending it have only minor in its physical property which were been still scare for engineering application [5]. Regardless of the strength and rigidity of composites is proportion of their weight is equal to the metals. This material is also commonly used in aviation and sports equipment. Preparation of

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such materials is very difficult, thus, small composites reinforced with fibres or particles have been developed [6]. The characteristic fragment fillers were used [7]. The typical fragment fillers used were Silica, Carbon black, metal particles etc. Large amount of fillers loading was required to get required mechanical property. Hence, it is cost effective and difficult to handle. [8-10].

Already CNT-consisting epoxy composites have generated considerable attention. CNT may be designed with length-to - diameter ratios that are substantially superior to any other substance, supplying them with excellent electrical, mechanical, and thermal properties. Consequently, the usage of CNT as an innovative buffer in multiple science and engineering applications provides wonderful prospects. The new composite materials which is gathering significant notification both academic and industrial area is polymer Nano composites. Nano-fillers which are of only a few nanometre in dimension are used to strengthen the matrix [11-13]. The nano-filler exhibit intensity toughness without abandonment stiffness [14-16]. It has mechanical properties like greater thermal and oxidative stability and better barrier. These composite has unique properties like self-extinguishing behaviour. The most promising nano-filler till date is carbon nano-tube (CNT) because of its remarkable mechanical and electrical properties [17-19].

CNT BASED NANO POLYMER COMPOSITES

The long cylinder of molecular bonded carbon atoms that own astounding mechanical and electrical properties is CNTs. Basically it has Single wall carbon nanotubes (Fig.1.a) (SWCNT), Double wall carbon nanotubes (DWCNT) and Multi wall carbon nanotrubes (Fig.1.b) (MWCNT). SWCNT is cylindrical in structure [20] and MWCNT [21] is made of coaxial cylinders which has interlayer spacing adjacent to that to interlayer distance in graphite in 0.34nm. The size of the cylindrical structure is few nanometer in diameter ad its end is round off with half of a fullerenes molecule, also this cylindrical can be tens of microns long. In 1978 it was discovered by M. Endo who working in University of Orleans in France. However, Iijima [20] first reported actual interest in CNTs in 1991. The field flourishes only after first polymer composites conglomeration using CNT as filler was announced by Ajayan et.al [22]. The contemporary experimentation has enrapt on developing the quality of catalytically produced nanotubs[23, 24].

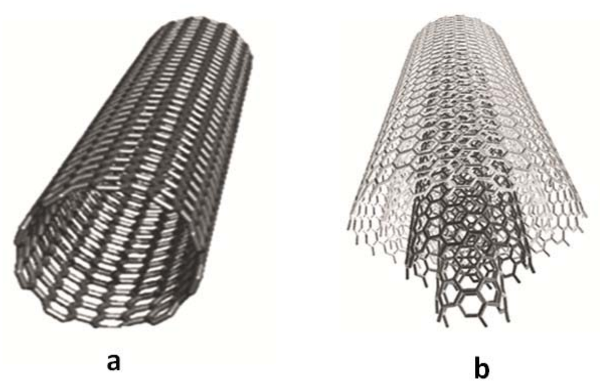

FIGURE 1. (a) Schematic diagrams of single-wall carbon nanotube [SWCNT] and (b) multi-wall carbon nanotube [MWCNT]

DIFFERENT TYPES OF FINITE ELEMENT METHOD

Throughout the last twenty years, many modifications have been introduced to improve the mechanism of way to solve and expand the usefulness of finite element analysis to a wide range of issues. Any of the critical ones currently in use include: Expanded Finite Element Process (XFEM)-The Bubnov-Galerkin method involves continuity of the separations of elements. Discontinuities include problems such as collision, fracture, and toured injury. To overcome this deficiency, XFEM was born in the 1990s. XFEM approaches Heaviside Phase Functions by the extension of the shape functions. Extra degrees of freedom are granted to the nodes near the discontinuity point, so that hops can be allowed. The General Finite Element Method (GFEM) was also introduced concurrently with XFEM in the 1990's. It mixes the features of standard FEM methods with mesh less ones. Form functions are mainly characterized in global coordinates and further compounded by partition-of-unity to construct functions of the elementary local form. One of the benefits of GFEM is the lack of re-meshing of singularities. Mixed Finite

Element Method (MFEM) is intended to solve many problems, such as touch or incompressibility, the use of Lagrange multipliers to enforce constraints.

RESULT AND DISCUSSION

In this paper, we have to discuss the literature of some paper to analyse the CNTs properties are to be analysed. Now a days various FEA software are used for analyzing the CNT polymer composite like MARC, FEAST, ABAQUS. SOLIDWORKS, ANSYS, CATIA. Here we are follow the FEA analysis using ANSYS and ABAQUS software.

Michael Schieboldet al. [25] State a multi-scale approach using solid equivalent cylinders to model CNT polymer composites. Under the proposed assumptions, the material characteristics of a CNT are observed well for the vertical tube and the cylinder using the FEA simulation process. The standard pressures and tension system for the cylinder leads to failures in the resulting material characteristics. Subsequently, the equivalent solid cylinder is better suited than the circular tube for CNT polymer composite FE simulations and the reported strength is well in accordance with the finding of MT homogeneity. Figure 2 shows the error details of the radial compression without fixed axial position. [26, 27]

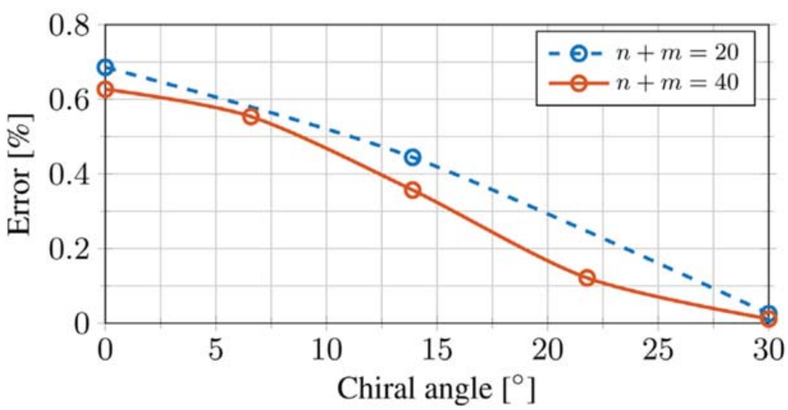

FIGURE 2. Strain energy error of the equivalent solid cylinder for a radial compression without fixed axial position.

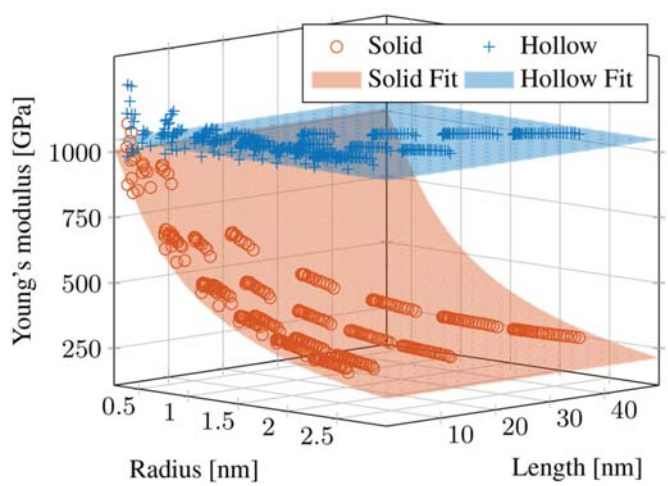

FIGURE 3. Fits of the Young's moduli *Ez*of equivalent cylinders for different radii and lengths

Dilip Banerjee et al. [28] states the stress analysis was performed using the finite element method of a single-walled carbon nanotube polymer matrix composite. For the 3-phase composites, possessions of variations in both Young's modulus and interphase thickness on composite mechanical property were analysed as shown in the Fig. 3.

Stress distribution of SWCNT mechanism in polymer has also been studied. The composite elastic moduli measured using the present methods are in good agreement with the ones mentioned in the literature.

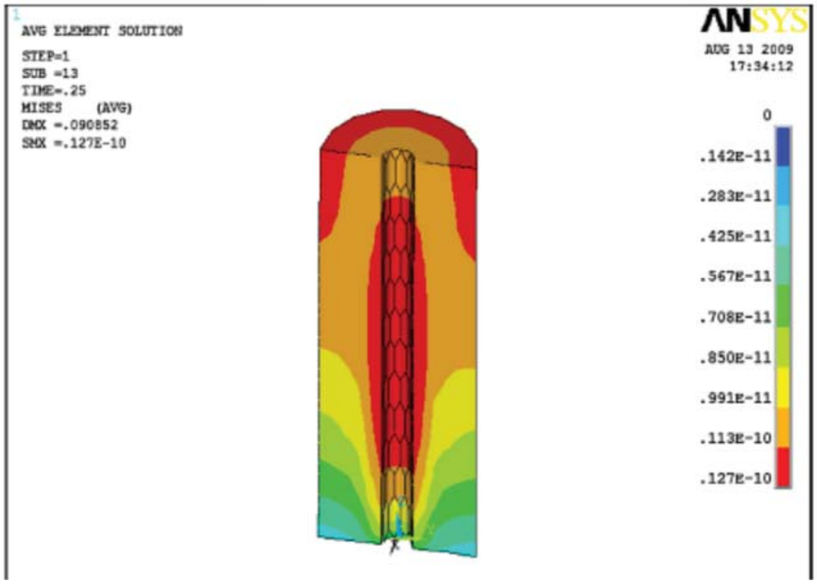

FIGURE 4. Von Mises equivalent stress in the 2-phase polymer/SWCNT composite

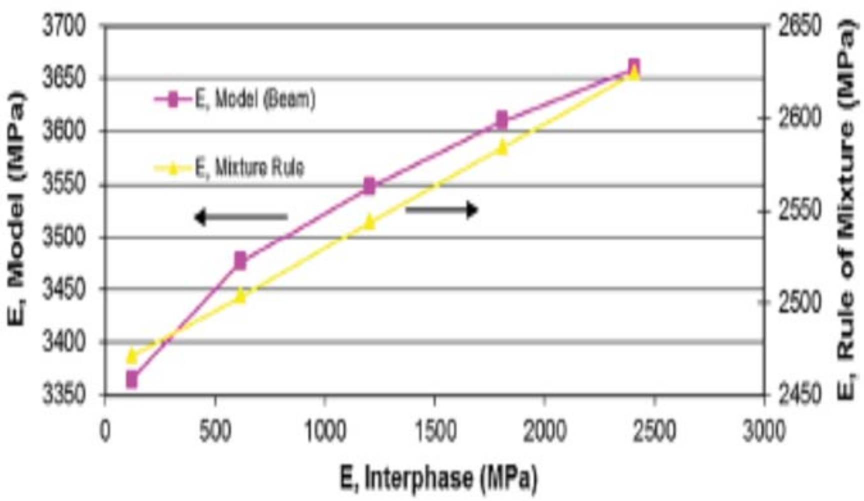

FIGURE 5. Dependence of composite modulus on Young's modulus of the interphase thickness of 8.007 nm

Anuj Kumar Singh et al.[29] investigated with ABACUS. As a result, compression in the hexagonal RVE increases the stress of Von Mises by 15 for every cent with lengthy CNT. The Fig. 5 shows the young's modulus relation with the thikness. Likewise, the transformation in Von-mises stress from mechanical to thermo-mechanical loading is discovered to be 35 per cent for hexagonal RVE with short CNT inside the RVE. The Fig. 4 shows Vonmises equivelant sresses of polymer/SWCNT composite. The results suggest that in the case of short CNT in the matrix, the long CNT increases the thermal conductivity rather than the short CNT because of a higher volume fraction of 6.2 per cent relative to 2.6 percent. It was found that for bending work the bending deflection was greatly influenced by the CNT current capacity, the width-thickness ratio and the border state. However, the fraction of the CNT amount can have a marginal effect on the core axial stress. For the active vibration control, both the CNT volume percentage and the width-to - thickness ratio get a marked effect on the normal vibrations and vibration structural response of the CNTRC layer. Table 1. Shows the details of increase in the stress and thermo-mechanical strain of Long and short CNT composites.

TABLE 1. Comparison of long and short CNT under thermo-mechanical loading.

S.No	CNT Type	Von mises Stress (nN/nm^2) by:		Increase in stress (%)	Total thermo-mechanical strain
		Mechanical Loading	Thermo- Mechanical Loading		
1	Long CNT (100 mm)	16.5	19	15	0.1363
2	Short CNT (50 mm)	13.4	18.11	35	0.1732

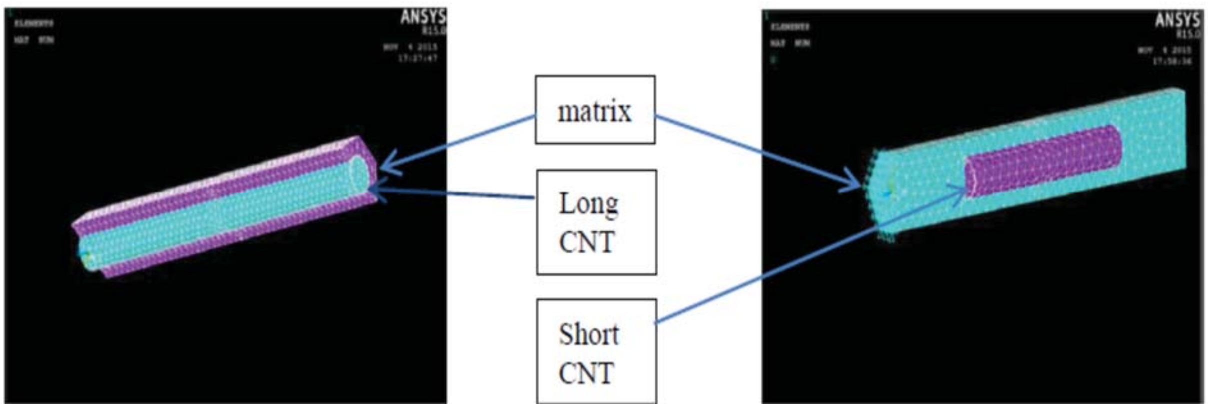

FIGURE 6. Hexagonal RVE with a long continuous CNT

FIGURE 7. Hexagonal RVE with a short continuous CNT

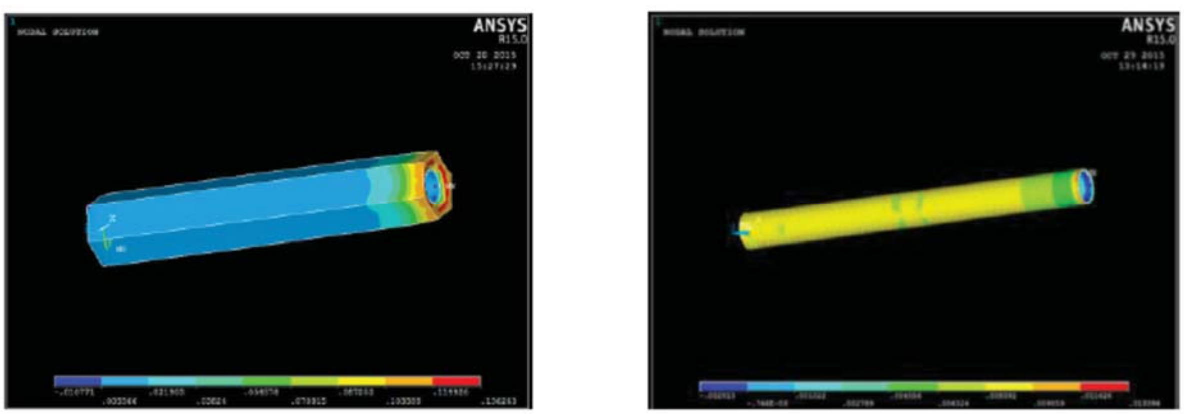

FIGURE 8. Plot of total thermo-mechanical strain in Hexagonal RVE with long CNT(a)RVE;max strain =0.13623 (b)CNT;max strain =0.013394

Ping Zhu et al. explain, bending and free vibration analyses of carbon nanotube- Hence prove to be better reinforcement for the nano composites subjected to thermo-mechanical loading reinforced composite plates are investigated by a finite element modal. Figure 6, 7 and 8 shows the analysis results of long and short CNT for thermo mechanical strain. Figure 9 shows the details of the free vibration mode shapes of a SSSS square CNTRC plate.

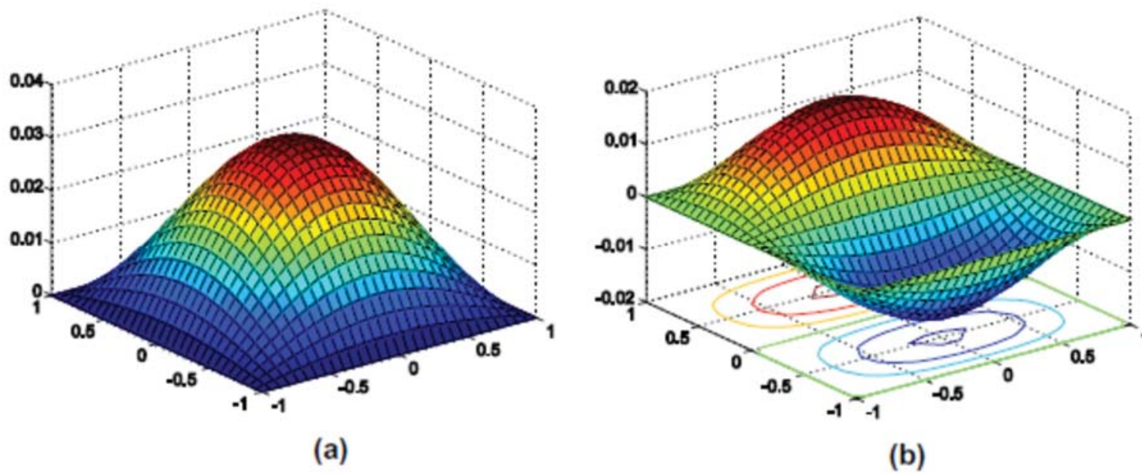

FIGURE 9. The free vibration mode shapes of a SSSS square CNTRC plate.
(a) 1st Mode (m = 1, n = 1); (b) 2nd Mode (m = 1, n = 2);

CONCLUSIONS

The Finite Element approach is used to measure the elastic module and natural frequency of the CNT reinforced composite material. The similarly solid cylinder is better suited for CNT polymer composite FE simulations than the hollow cylinder and the measured stiffness is well in agreement. Bending and free vibration measurement, CNT volume fraction, width to thickness ratio and boundary condition Since of greater volume fraction, the long CNT's boost the thermal conductivity more compared to the short CNT's. For the nano composites subjected to thermo-mechanical testing, even stronger strengthening

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