CRIMSON PUBLISHERS
Wings to the Research

Evolutions in Mechanical Engineering

ISSN: 2640-9690

Mini Review

Effects of Carbon Nanotube Dispersion on the Material Properties of Polymer Matrix Composites

Azadeh Tavousi Tabatabaei[1], Seyed Hossein Mamanpush[1]* and Bahareh Tavousi Tabatabaei[2]

[1]*Composite Materials and Engineering Center, Washington State University, USA*

[2]*Department of Engineering, Islamic Azad University, Iran*

***Corresponding author:** Seyed Hossein Mamanpush, Composite Materials and Engineering Center, Washington State University, Pullman, WA, 99163, USA

Submission: August 01, 2018; **Published:** September 11, 2018

Abstract

Carbon nanotubes (CNTs) constitute a prominent example of structural nanomaterials, with many potential applications due to their unique mechanical properties. Substantial improvements in mechanical properties of polymers have been attained through the addition of small amounts of carbon nanotubes. The way in which CNTs are distributed inside the matrix can be divided into two main categories namely: aligned and randomly distributed. Modeling of carbon nanotube dispersion in the polymer matrix is an important step for understanding the characteristics of composites. For modeling CNTs dispersion in the polymer, a numerical homogenization technique based on the finite element method (FEM) is used.

Introduction

The combination of extraordinary mechanical and physical properties makes CNTs prospective candidates for reinforcement of polymer matrix composite systems. Besides their extraordinary small size, CNTs are half as dense as aluminum, with a density of 1.33-1.4 g/cm^3. CNTs have Young's modulus of about 1TPa and tensile strength 20 times that of steel alloys. Tensile strength of single–walled carbon nanotubes (SWCNTs) is as high as 2GPa, which is much higher than that of high strength steels [1,2]. Models were developed based on the method presented in [3,4] to determine nanocomposite effective mechanical properties. the results of nanocomposite reinforced with randomly distributed nanotubes in the FEM model presented in Figure 1 and Table 1 & 2.

Table 1: Computed Young's moduli of randomly distributed CNT-reinforced nanocomposite.

E_z/E_m	E_y/E_m	E_x/E_m	E_m
1.03	1.027	1.021	100
1.041	1.038	1.037	90
1.055	1.049	1.045	70
1.093	1.07	1.05	50
1.121	1.133	1.108	30
1.185	1.146	1.132	20
1.231	1.178	1.168	10
1.31	1.293	1.289	3.2

Table 2: Poisson's ratios of randomly distributed CNT-reinforced nanocomposite.

E_m	υ_{xy}	υ_{xz}	υ_{yx}	υ_{yz}	υ_{zx}	υ_{zy}
100	0.2981	0.2981	0.2978	0.2937	0.2927	0.2982
90	0.2925	0.2978	0.2928	0.2989	0.2975	0.2942
70	0.2926	0.2926	0.2981	0.2908	0.2912	0.2998
50	0.2847	0.2858	0.2898	0.2871	0.2849	0.2851
30	0.2953	0.2883	0.2988	0.2892	0.2941	0.2953
20	0.2903	0.2844	0.2985	0.2906	0.2945	0.2991
10	0.2983	0.2933	0.2974	0.2992	0.2905	0.293
3.2	0.2888	0.2858	0.2905	0.2933	0.2912	0.295

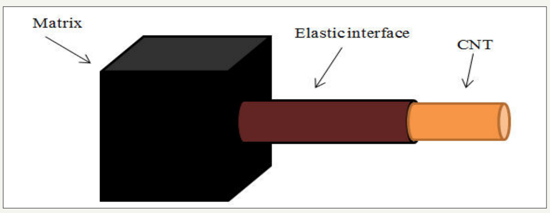

Figure 1: Schematic of the elastic interface model. A part of each component is shown.

The ratio of nanocomposite modulus to matrix modulus in the longitudinal direction, E_z/E_m, is equal to 1.310 in this case for the matrix with modulus of 3.2GPa. This is about 20% lower than the uniformly distributed CNT reinforced nanocomposite longitudinal modulus [3-5]. A comparison of the results with those obtained for the uniform distribution of straight CNTs indicates that strengthening is much more homogeneous in the randomly distributed CNT case. That is, the ratios of nanocomposite longitudinal and transverse moduli to matrix modulus are close in this case (at equal Em values). These results suggest that the random distribution of the CNTs reinforces the matrix in all three directions. In fact, in case of transverse moduli, the portions of CNTs that are oriented along the x- and y-directions contribute to the nanocomposite moduli in those directions.

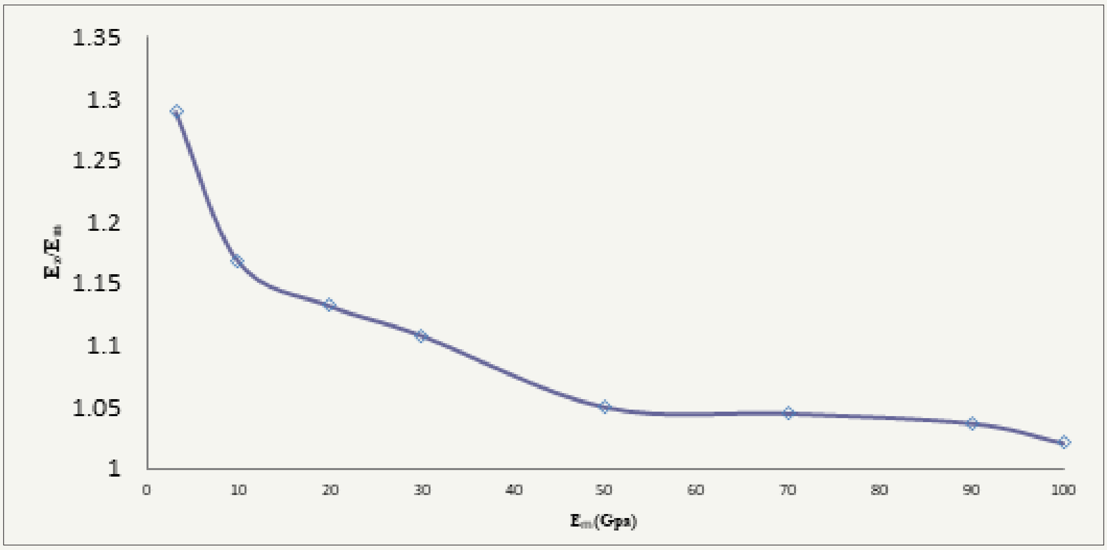

Figure2: Variation of E_z/E_m with matrix modulus for randomly oriented CNT-reinforced nanocomposite.

Nanocomposite longitudinal modulus decreases with increasing CNT inclination angle, thus limiting the overall effective modulus of the nanocomposite. The variation of nanocomposite longitudinal modulus to matrix modulus, E_z/E_m, with matrix modulus is shown in Figure 2. Note that the ratio of nanocomposite longitudinal modulus to matrix modulus decreases as the matrix modulus increases in this case as well.

References

1. Mamanpush SH, Li H, Englund K, Tabatabaei AT (2018) Recycled wind turbine blades as a feedstock for second generation composites. Waste Manag 76: 708-714.
2. Shaabani A, Afshari R, Hooshmand AE, Tabatabaei AT, Hajishaabanha F (2016) Copper supported on MWCNT-guanidine acetic acid@Fe_3O_4: synthesis, characterization and application as a novel multi-task nanocatalyst for preparation of triazoles and bis(indolyl)methanes in water. RSC Advances 6 (22): 18113-18125.
3. Mamanpush H, Golestanian H (2013) Effects of carbon nanotube dispersion on the mechanical properties of nanocomposites considering interface effect. International Journal of Current Life Sciences 4(8): 4366-4373.
4. Mamanpush H, Golestanian H (2014) Investigating the effects of carbon nanotube orientation on the macroscopic stiffness of nanocomposites. International Journal of Current Life Sciences 4(4): 1168-1174.
5. Mamanpush H, Golestanian H (2014) Evaluation of effective material properties of randomly distributed carbon nanotube composites considering interface effect. Indian J Sci Res 2(1): 132-142.

How to cite this article: Azadeh T T, Seyed H M, Bahareh T T. Effects of Carbon Nanotube Dispersion on the Material Properties of Polymer Matrix Composites. Evolutions Mech Eng . 1(3). EME.000512.2018. DOI: 10.31031/EME.2018.01.000512