11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

BUCKLING BEHAVIOR OF SINGLE-WALLED CARBON NANOTUBES SUBJECTED TO COMBINED LOADING IN NANOTUBE-POLYMER COMPOSITES

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Key Words: *Buckling, Single-walled carbon nanotube, Nanotube-reinforced composites.*

Carbon nanotubes (CNTs) are one-dimensional nanostructures that have attracted considerable attention in various branches of nanoscience and nanotechnology [1]. Their extraordinary mechanical, electronic, transport, and thermal properties have made them ideal materials for designing various types of nano-scale devices and also as reinforcement fibers in composites [2]. Carbon nanotube-reinforced composites have advanced mechanical properties such as high strength, high stiffness and light weight which can be applied as layers in advanced laminated structures [3]. When the CNTs are used in the nano-composite materials, CNTs may undergo a combination of different loads simultaneously. However, few results can be found related to the buckling of single-walled carbon nanotubes subject to combined loads in literature. Elastic buckling of the SWCNTs under combined loading has been investigated by using the ANSYS software in Ref. [4]. Recently, Motevalli et al. [5] employed molecular dynamics simulation (MD) to compute the behavior and deformation properties of the CNTs under combined application of compression and torsion. More recently, MD simulation has been used to investigate the effect of hydrostatic pressure on the axial buckling of the SWCNTs [6]. In the aforementioned studies, the effects of curvature-induced elastic anisotropy are usually not accounted. It is well known that there are obvious evidences such as chirality-dependent Young and shear moduli and coupling of extension and twist, show that SWCNTs exhibit remarkable chirality induced anisotropic elastic properties which should not be neglected in some cases.

Motivated by these ideas, in the present work an anisotropic elastic shell model is developed to obtain a deeper understanding on the buckling behavior of SWCNTs with arbitrary chirality subjected to combined loading in the nanotube-reinforced composites. Analytical solution and buckling characteristics of anisotropic SWCNTs are presented by using the Flügge shell theory and complex method. The Flügge theory is known as a highly reliable theory that can be used for most shapes regardless of the size of their cross-sectional radius. Furthermore, anisotropic material properties of SWCNTs are obtained by the closed-form expressions developed in Ref. [7] using a molecular mechanics model. Based on the present model, a relationships between the critical pressure and axial stresses is established, which can be used for determining the stress limits when designing practical carbon nanotube-based systems in which combined loads may be applied. To validate the accuracy of the results of this analysis, the results are compared with solutions found in the literature. It shows that the present model is accurate and appropriate for prediction of the buckling behavior of SWCNTs.

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