World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:9, No:12, 2015

Nonlocal Beam Models for Free Vibration Analysis of Double-Walled Carbon Nanotubes with Various End Supports

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Abstract : In the present study, the free vibration characteristics of double-walled carbon nanotubes (DWCNTs) are investigated. The small-scale effects are taken into account using the Eringen's nonlocal elasticity theory. The nonlocal elasticity equations are implemented into the different classical beam theories namely as Euler-Bernoulli beam theory (EBT), Timoshenko beam theory (TBT), Reddy beam theory (RBT), and Levinson beam theory (LBT) to analyze the free vibrations of DWCNTs in which each wall of the nanotubes is considered as individual beam with van der Waals interaction forces. Generalized differential quadrature (GDQ) method is utilized to discretize the governing differential equations of each nonlocal beam model along with four commonly used boundary conditions. Then molecular dynamics (MD) simulation is performed for a series of armchair and zigzag DWCNTs with different aspect ratios and boundary conditions, the results of which are matched with those of nonlocal beam models to extract the appropriate values of the nonlocal parameter corresponding to each type of chirality, nonlocal beam model and boundary condition. It is found that the present nonlocal beam models with their proposed correct values of nonlocal parameter have good capability to predict the vibrational behavior of DWCNTs, especially for higher aspect ratios.

Keywords : double-walled carbon nanotubes, nonlocal continuum elasticity, free vibrations, molecular dynamics simulation, generalized differential quadrature method
Conference Title : ICMMME 2015 : International Conference on Mechanical, Materials and Mechatronics Engineering
Conference Location : Paris, France
Conference Dates : December 30-31, 2015