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Numerical study on the nonlinear resonant dynamics of carbon nanotube/fiber/polymer multiscale laminated composite rectangular plates with various boundary conditions

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Abstract.

This work deals with the numerical investigation of the geometrically nonlinear resonant dynamics of carbon nanotube/fiber/polymer multiscale laminated composite (CNT-FPMLC) rectangular plates with different boundary conditions. It is assumed that a uniform distributed harmonic excitation load in the transverse direction is applied to the CNT-FPMLC plates. The material properties of multiscale composite are estimated by means of the fiber micromechanics and Halpin-Tsai relations. Furthermore, it is assumed that the carbon nanotubes (CNTs) are distributed uniformly and oriented arbitrarily through the epoxy resin matrix. Based upon the Mindlin plate theory and using the von Kármán hypotheses, the governing equations of motion for the in-plane and out-of-plane motions including the effects of geometric nonlinearity, rotary inertia and shear deformation are achieved by means of the Hamilton's principle. In the solution process, the nonlinear partial differential equations of motions and associated boundary conditions are discretized via the generalized differential quadrature (GDQ) and afterward converted into a Duffing-type nonlinear time-varying set of ordinary differential equations via a numerical Galerkin approach. Then, the time periodic discretization method and the pseudo-arc length continuation technique are employed to solve the obtained equations in order to achieve the frequency-response curves associated with nonlinear free and forced resonances for the CNT-FPMLC rectangular plates with various edge supports. Finally, the influences of important design parameters including the weight percentage of single-walled and multi-walled CNTs, volume fraction of fibers, CNT aspect ratio, plate geometry and boundary conditions on the nonlinear resonant dynamics and linear natural frequencies of CNT-FPMLC rectangular plate are investigated in the numerical results.

Keywords: Nonlinear resonant dynamics; Multiscale laminated nanocomposite plates; Carbon nanotubes; Numerical study.

1. Introduction

The remarkable mechanical and physical properties of carbon nanotubes (CNTs) [1-3] including single and multi-walled ones (SWCNTs & MWCNTs) make them excellent candidates in various industrial and engineering applications. Some superior characteristics of CNTs include high strength and stiffness, low density and high aspect ratio as well as the excellent electronic and thermal

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