عنوان مقاله:

Nonlinear Torsional Vibration Analysis of Nanorods in the Presence of Surface Energy Effect: Multi-Mode Galerkin Method

محل انتشار:

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خلاصه مقاله:

In this paper, the nonlinear torsional vibrations and internal resonances of nanorods are investigated by considering the surface energy effects. For this purpose, Hamilton’s principle is implemented to derive the nonlinear governing equation of motion based on the von-Kármán relations. Hamilton's principle includes the strain energy and the kinetic energy of the nanorod surface and bulk. The strain and kinetic energies of the nanorod bulk are obtained using the classical theory of elasticity, and those of the nanorod surface are obtained using the surface elasticity theory. The surface energy parameters, including the surface density and the surface Lame constants, are included in the equations by the surface elasticity theory. Then, the multi-mode Galerkin method is used to convert the partial differential equation of motion to an ordinary differential equation. The Multiple-scale method is employed to solve the governing equations of motion for fixed-free and fixed-fixed end conditions. To investigate the technique presented in this paper, circular nanorods made of aluminum and silicon have been used. The effect of surface energy parameters on the torsional frequencies of nanorods is investigated for different values of length, radius, frequency number, and amplitude of the nonlinear vibrations. In addition, the cases in which internal resonances occur are reported, and some numerical data are given. The results obtained in this research may be helpful for the better design of .nanoelectromechanical devices such as nano-bearings and rotary servo motors

کلمات کلیدی:

Nonlinear torsional vibration, Multiple-scale method, Internal resonances, Multi-mode Galerkin method, Surface energy