Nonlinear Analysis of Piezoelectric Energy Harvesters Considering Direct Excitation and Parameter Excitation

Abstract. In this paper, a cantilever piezoelectric energy harvester of nonlinear beam model based on Hamilton's Principle is established. A piezoelectric device made of a bimorph cantilever beam which is fixed at one end is subjected to horizontal and vertical excitation. Based on the Euler-Bernoulli thin beam with inextensible deformation, the model further considers the effects of geometric nonlinearity and damping nonlinearity. The reduced-order nonlinear partial differential equations of motion with electromechanical distributed coupling parameter are derived by using the Galerkin method. The equations of motion of the energy harvester are solved by using the method of multiple scales. The fundamental first-order resonance response is analyzed and the amplitudes of fundamental transverse deflection, output voltage and output power are determined. The major effects of excitation, linear damping coefficient, nonlinear damping coefficient, impedance, nonlinear electromechanical coupling coefficient on transverse deflection, voltage and power are analysed. The result shows that the linear damping coefficient and resistance affect the initial threshold of parametric excitation. The combination of parametric excitation and direct excitation give full play to the advantages of parametric excitation and improve the energy conversion efficiency of the energy harvesting system.