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Nonlinear Vibration of FG beams subjected to parametric and external excitations

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Abstract

In this paper, the principal resonance and parametric vibration of functionally graded (FG) beams are investigated. The theoretical formulations and governing partial deferential equations of motion are derived based on the Hamilton's principle, Euler-Bernoulli beam theory, and von Kármán geometric nonlinearity. The Galerkin technique and the static condensation method are employed in order to convert the nonlinear partial differential equations into a set of nonlinear ordinary differential equations. The nonlinear frequency-response of FG beams is investigated using the method of multiple scales. The magnitude and frequency of parametric excitations are analyzed by numerical integration results. The effects of different parameters on the nonlinear response are also investigated. Moreover, the period-2 and chaotic motions of FG beams are found by numerical simulation.

Keywords: Functionally graded; Beam; Nonlinear vibration

1. Introduction

Functionally Graded Materials (FGMs) are inhomogeneous composites in which the mechanical properties vary gradually and continuously across any desired spatial direction, thus alleviate the stress concentrations found in laminated composites. Due to this characteristic, FGMs have found many potential applications in ship building, space vehicles, aircrafts, nuclear reactors, biomedical, and civil structures (Liew et al., 2011; Carrera et al., 2011; Shen and Wang, 2015; Sofiyev and Kuruoglu, 2016; Duc,

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