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Axisymmetric nonlinear vibration analysis of sandwich annular plates with FG-CNTRC face sheets based on the higher-order shear deformation plate theory

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Abstract

In this paper, a comprehensive numerical study is presented on the large-amplitude free vibration of sandwich annular plates integrated with functionally graded carbon nanotube-reinforced composite (FG-CNTRC) face sheets resting on elastic foundation. The sandwich plate is made of a homogeneous core and two FG-CNTRC face sheets whose material properties are estimated through a micromechanical model. Since the fundamental vibrational mode shapes of annular plates are axisymmetric, the governing equations are derived assuming the axisymmetric formulation. For this purpose, the quadratic form of total potential energy of the structure is presented based on the higher-order shear deformation theory (HSDT) of plates along with von-Karman nonlinear kinematic relations. The numerical differential and integral operators are then employed to discretize the energy functional in space and time domains. Finally, using the response of linear analysis and applying the pseudo-arc length continuation method, the nonlinear frequencies are obtained. After validating the results of proposed approach, detailed numerical results are given to analyze the effects of geometrical and material parameters on the nonlinear vibration of FG-CNTRC sandwich annular plates.

Keywords: Nonlinear vibration, Sandwich annular plate, FG-CNTRC, numerical approach

1. Introduction

In the engineering applications, there are many different shapes of plate structures made of a wide range of material properties. Static and dynamic behaviors of homogeneous and inhomogeneous plates with rectangular, quadrilateral and circular shapes have been widely studied in the literature. Especially, due to their widespread usages in civil, mechanical, and aerospace engineering, the annular plates have received considerable attention among scholars.

Sandwich plate structures have some important features such as high bending rigidity, low specific weight and good energy-absorbing capacity, which make them suitable candidates for load-bearing purposes in aerospace vehicles, aircrafts and transportation systems [1, 2]. Conventional sandwich-

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