thermal buckling behavior of functionally graded cylindrical shells using Newmark and FEM method

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ABSTRACT

Based on tree-order shear deformation theory and von Karman-type of kinematic nonlinearity, this paper investigates nonlinear mechanical and thermal buckling analysis of functionally graded (FG) cylindrical shells with various boundary conditions. Material properties of the constituent components of the FG shell are assumed to vary continuously according to the simple power-law and Mori-Tanaka distributions along the thickness direction. In order to find the critical buckling load, the axial compressive load and thermal gradient are applied to the shell incrementally so that in each load step the incremental form of governing equations are solved by newmark method combined with the finite element (FE) discretization technique.The critical mechanical buckling load is determined based on compressive load–displacement curve by adding the incremental displacements in each load step to the displacements obtained from the previous ones. The results reveal that for the higher ratios of radius-to-thickness there are not any significant difference between the results for various range of length-to-radius ratios and grading indices. It is also observed that at high radius-to-thickness ratios, not a major difference of critical thermal load is identified between clamped and simply supported boundary conditions.

Keywords: Newmark -FEM method-cylindrical shell

1. INTRODUCTION

Functionally graded materials (FGMs) have the advantage of their ability to withstand high temperature gradients unlike fiber matrix composites, which show mismatch of mechanical properties across an interface of two discrete materials bonded together and resulting in debonding at high temperatures in some cases [1]. Typically these materials are made from a mixture of ceramic and metal in which the ceramic constituent of the material provides the high temperature resistance; on the other hand, the FGMs is toughened and strengthened by the metallic composition. FGMs are designed so that material properties vary smoothly and continuously through the thickness from the surface of a ceramic to that of a metal on the other surface. In functionally graded (FG) cylindrical shells play the important role in the aerospace structural systems such as supersonic and hypersonic aircrafts, rockets, satellites, and nuclear components. Despite the evidentimportance of circular cylindrical FG shells in various industries, investigations on the buckling behaviors of these structures are still limited in number in comparison with the structures of plate or other kinds of shells. The dynamic thermoelastic response of FG cylinders and plates is presented by Reddy and Chin [2]. Li and Batra [3] studied the buckling behavior of axially compressed simply supported thin circular cylindrical shells with functionally graded middle layer. Buckling behaviors of FG cylindrical shells subjected to pure bending load were investigated by Huang et al. [4]. Shariyat [5] analyzed the dynamic buckling of apre-stressed, suddenly-heated imperfect FGM cylindrical shell and dynamic buckling of a mechanically-loaded imperfect FGM cylindrical shell in thermal environment, with temperature dependent properties. Based on the nonlinear large deflection theory of cylindrical shells as well as the Donnell assumptions, Huang and Han [6] present nonlinear buckling and postbuckling analyses for axially compressed functionally graded cylindrical shells using the Ritz energy method. Huang and Han [7] considered the buckling behaviors ofaxially compressed functionally graded cylindrical shells with geometrical imperfections using Donnell shell theory and the nonlinear strain-displacement relations of large deformation. Shahsiah and Eslami [8] carried out the buckling analysis of functionally graded cylindrical shells under two types of thermal loads with simply supported boundary conditions based on the first-order shell theory and the Sanders kinematic equations. A formulation for the free vibration and buckling of FG cylindrical shells subjected to combined static and periodic axial loadings are presented by Ebrahimi and Sepiani [9] based on first-order shear deformation theory (FSDT) and the classical shell theory (CST). Shen [10] studied the postbuckling analysis for an FG thin cylindrical shell of finite length subjected to external pressure and thermal environments. Shen and Noda [11] reported the e postbuckling analysis of shear deformable FG cylindrical shells of finite length subjected to combined axial and radial mechanical loads in thermal