Coupled Thermoelastic response of Functionally Graded Cylindrical shells by using Galerkin method

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Abstract
This paper presents coupled thermoelastic response of cylindrical shells that made of functionally graded materials (FGMs) under thermal heat flux. A second-order shear deformation shell theory that accounts for the transverse shear strains and rotations is considered. The Galerkin method approach is used to transform the governing equations into a set of linear ordinary differential equations. The resulting system of equations is solved through a numerical integration scheme the shell is graded through the thickness assuming a volume fraction of metal and ceramic, using a power law distribution.

Keywords: Coupled thermoelastic, functionally graded materials, Galerkin method.

1. Introduction

The aerothermoelastic behavior of materials is an important factor in the design of space re-entry vehicles, high-speed aircraft and other modern engineering applications. As the name suggests, aerothermoelastic concerns elastic structures under the combined effects of aerodynamic, thermal loadings, inertial, and elastic forces. Librescu [1] has provided a general understanding of all the factors contributing to the occurrence and increase of the instability boundaries. An excellent overview of non-classical and classical thermal-structural models and computational methods for analysis of engineering structures was given by Tamma in chapter 4 of Ref. Hetnarski [2]. When the characteristic times of structural and thermal disturbances are of comparable magnitudes, the equations of motion of a structure are coupled with the energy equation and the solution of the coupled system of equations provides the stress and temperature fields in the plate. Bahtui and Eslami [3] presented the coupled thermoelasticity solution of functionally graded cylindrical shells. They employed the classical coupled theory of thermoelasticity, including the thermomechanical coupling and rotary inertia, a Galerkin finite element formulation in space domain and the Laplace transform in time domain are used to formulate the problem. Bagri and Eslami [4] analyzed generalized coupled thermoelasticity of disks based on the Lord-Shulman model. Manoach and Ribeiro [5] developed the accurate and time efficient numerical approaches to study geometrically nonlinear vibrations of moderately thick beams under the combined action of mechanicaland thermal loads. Daneshjoo and Ramezani [6] presented the non-classical dynamic coupled thermoelasticity analysis based on the Green–Lindsay model is carried out on a homogeneous isotropic and a laminated composite plate. Lateral thermal shock is applied, and then temperature and stress behaviors are presented for both the mentioned plates. They [7] carried out the response of homogeneous isotropic and laminated composite plates due to lateral loading and thermal shock have been investigated by the finite element method. Ng et al. [8] presented a flat-shell element for the active control of FG shells through integrated piezoelectric sensor/actuator layers. Sharma and Sharma [9] presented the thermoelastic response of thick axisymmetric solid plate subjected to sudden lateral loading and thermal shock. Pourtakdoust and Fazelzadeh [10] have worked on the nonlinear aerothermoelastic behavior of skin plate with wall shear stress effect. Jing-feng Gong et al. [11] describe thermoelastic analysis of functionally graded solids using a staggered finite volume method, A. H. Akbarzadeh et al. [12] presented coupled thermoelastisty functionally gradedplates based on the third-order shear deformation theory. The present work deals with the coupled thermoelasticity problem of a Titanium–Zirconia functionally graded cylindrical shell under gas flow. The material properties are graded along the thickness direction according to a volume fraction power law distribution.The governing equations are based on the first-order shear deformation plate theory, including the rotary inertia term. The Lord-Shulman linear thermoelastic theory is considered, and the Galerkin approach is used as a solution method.

2. Theoretical formulations

A functionally graded cylindrical shells of uniform thickness *h*, length l in the *x*-direction and angel θ in the