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Influence of Mechanical and Geometric Characteristics on Thermal Buckling of Functionally Graded Sandwich Plates

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Functionally graded materials (FGM) are a new range of composite materials having a gradual and continuous variation of the volume fractions of each of the constituents (in general, metal and ceramic) in thickness, which accordingly causes changes in the overall thermomechanical properties of the structural elements they constitute. The interest of this work is the use of a high-order plate theory for the study of thermal buckling of FGM plates resting on Winkler-Pasternak type elastic foundation. The present method leads to a system of differential equations, where the number of unknowns is five. The material properties of FGM plate such as Young's modulus and coefficient of thermal expansion are assumed to be variable through the thickness according to the Mori-Tanaka distribution model. The thermal loading is assumed to be uniform, linear and nonlinear through the thickness of the plate. A parametric study is thus developed to see the influence of the geometric and mechanical characteristics, in particular, the geometric ratio (*a*/*b*), thickness ratio (*a*/*h*) and the material index (*k*), as well as the impact of the Winkler and Pasternak parameters on the critical buckling load.

Keywords: Functionally graded materials (FGM), High order theory, Mori-Tanaka model, Elastic foundation, Thermal buckling.

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1. INTRODUCTION

Functional graded materials (FGM) are a class of composites in which the material properties change gradually in one or more Cartesian directions [1]. This class of composite materials has attracted considerable attention in the engineering community, especially in high temperature applications such as nuclear reactors, aerospace and energy industries [2]. Over the past two decades, many research reports have been published on thermal stress, failure, thermomechanical response, buckling, free vibration, etc. of structural elements in FGM [3].

Due to the importance and wide technical applications of FGM structures, they have been addressed by many researchers [4]. Reddy [5] studied the third-order plate shear deformation theory (TSDT). Touratier [6] elaborated the sinusoidal shear plate strain theory (SSDT), and Karama [7] developed the exponential shear plate strain theory (ESDT). Sankar and Tzeng [8] obtained an elasticity solution for FGM beams with exponential variation of properties subjected to transverse loads. Kapania and Raciti [9] provided a detailed review of shear deformation theories used for static, vibration and buckling analysis of beams and plates.

2. GEOMETRIES AND MATERIALS

Consider an FGM plate of thickness h, length a, and width b, mentioned with respect to the rectangular Cartesian coordinates (x, y, z). The x-y plane is taken to be the mid-plane of the undeformed plate plane and the z-axis is perpendicular to the x-y plane (Fig. 1).

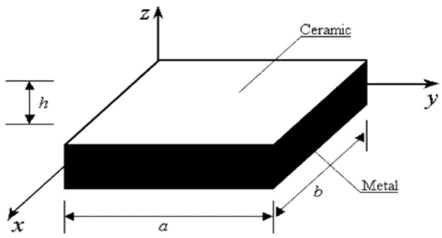

Fig. 1 – FGM plate geometry

According to the Mori-Tanaka homogenization scheme, the material properties of the FGM plate are given by:

$$E(z)=\frac{E_m+(E_c-E_m)V_c}{1+(1-V_c)(E_c/E_m-1)(1+\nu)/(3-3\nu)},$$
$$\alpha(z)=\frac{\alpha_m+(\alpha_c-\alpha_m)V_c}{1+(1-V_c)(\alpha_c/\alpha_m-1)(1+\nu)/(3-3\nu)}, \quad (2.1)$$

where E_m and E_c are the corresponding properties of metal and ceramic, respectively, and k is the material parameter. The volume fractions of the ceramic constituent V_c and the metallic constituent V_m can be written in the form [10]:

$$V_c=(z/h+1/2)^k,\ V_m=1-V_c. \quad (2.2)$$

2.1 Displacement Field

The displacements of a material point located at (x, y, z) in the plate can be written [11]:

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