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Impact of the homogenization models on the thermoelastic response of FG plates on variable elastic foundation

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Abstract. This paper presents a theoretical investigation on the response of the thermo-mechanical bending of FG plate on variable elastic foundation. A quasi-3D higher shear deformation theory is used that contains undetermined integral forms and involves only four unknowns to derive. The FG plates are supposed simply supported with temperature-dependent material properties and subjected to nonlinear temperature rise. Various homogenization models are used to estimate the effective material properties such as temperature-dependent thermoelastic properties. Equations of motion are derived from the principle of virtual displacements and Navier's solution is used to solve the problem of simply supported plates. Numerical results for deflections and stresses of FG plate with temperature-dependent material properties are investigated. It can be concluded that the proposed theory is accurate and simple in solving the thermoelastic bending behavior of FG thick plates.

Keywords: quasi-3D solution; FG thick plates; homogenization models; temperature-dependent material; thermo-mechanical bending

1. Introduction

In modern industries, the use of advanced composite materials in engineering applications are increased because of their ability to control and to withstand stresses caused by thermo-mechanical loading. Functionally graded materials (FGM) belong to this new generation of advanced composite materials in which the thermal and mechanical properties change gradually in one or more directions according to the volume fraction of its constituent materials (Lal *et al.* 2017, Almitani 2018, Rezaiee-Pajand *et al.* 2018, Bessaim *et al.* 2018, Faleh *et al.* 2018, Ahmed *et al.* 2019, Akbaş 2019, Sayyad and Ghumare 2019, Fenjan *et al.* 2019a, Ramirez *et al.* 2019, Esmaeili and Beni 2019, Ahmed *et al.* 2019, Al-Maliki *et al.* 2020,Gafour *et al.* 2020, Kar and Panda 2020). With the massive application of FGM in modern technologies such as energy sources, aerospace, automotive, nuclear reactor, mechanical, nanostructures, civil, electronic and shipbuilding industries (Sedighi *et al.* 2015, Batou *et al.* 2019, Chaabane *et al.* 2019, Berghouti *et al.* 2019, Salah *et al.* 2019, Hellal *et al.* 2019, Boulefrakh *et al.* 2019, Tlidji *et al.* 2019, Boukhlif *et al.* 2019, Balubaid *et al.* 2019, Al-Maliki *et al.* 2020, Kaddari *et al.* 2020, Rahmani *et al.* 2020), many researchers have focused on the study and development of theories relating to the behavior of FG structures and particularly thermo-mechanical analysis. Various FGM plate theories have been developed to predict the structures behavior in the past decades, such as classical plate theory (CPT), the first shear deformation theory (FSDT) and the High order Shear Deformation plate Theory (HSDT). The FSDT was used by Cong *et al.* (2015) to investigate the nonlinear stability of eccentrically stiffened moderately thick FG plates with temperature-dependent material properties subjected to in plane compressive and thermo-mechanical load. In the same framework, Ping *et al.* (2014) have employed the local meshless method with moving Kriging interpolation for geometrically nonlinear analysis of functionally graded plates in thermal environments. By using the third order shear deformation theory (TSDT), the same researchers (Cong *et al.* 2017) studied the nonlinear dynamic response of stiffened FGM plate in thermal medium subjected to mechanical and thermal loads. They consider the temperature-dependent materials properties. Ghiasian *et al.* (2014) investigated the thermal buckling of shear deformable temperature-dependent circular/ annular FGM plates. Zhu *et al.* (2014) analyze the thermomechanical behavior of moderately thick FGM plates using a local meshless method with Kriging interpolation technique. Trinh *et al.* (2017) studied the static bending, buckling and free vibration of FG sandwich microplates subjected to thermomechanical loading on the base of the modified couple stress theory by using Navier solutions. Li *et al.* (2016, 2017) use the four-variable refined plate theory to investigate the thermomechanical bending of FG sandwich plates. Using the HSDT, Kar *et al.* (2016) studied the linear/nonlinear deformation of FG

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