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Vibration analysis of functionally graded carbon nanotube-reinforced composite sandwich beams in thermal environment

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Abstract. Thermo-mechanical vibration of sandwich beams with a stiff core and face sheets made of functionally graded carbon nanotube-reinforced composite (FG-CNTRC) is investigated within the framework of Timoshenko beam theory. The material properties of FG-CNTRC are supposed to vary continuously in the thickness direction and are estimated through the rule of mixture and are considered to be temperature dependent. The governing equations and boundary conditions are derived by using Hamilton's principle and are solved using an efficient semi-analytical technique of the differential transform method (DTM). Comparison between the results of the present work and those available in literature shows the accuracy of this method. A parametric study is conducted to study the effects of carbon nanotube volume fraction, slenderness ratio, core-to-face sheet thickness ratio, and various boundary conditions on free vibration behavior of sandwich beams with FG-CNTRC face sheets. It is explicitly shown that the vibration characteristics of the curved nanosize beams are significantly influenced by the surface density effects.

Keywords: free vibration; sandwich beam; FG-CNTRC; thermal environments

1. Introduction

The use of sandwich structures is growing very rapidly all over the world and has received increasing attention due to their superior characteristics. The need for high performance and low weight structures makes sandwich construction one of the best choices in aircrafts, space vehicles and transportation systems. Functionally graded materials (FGMs) are composite materials with inhomogeneous micromechanical structure in which the material properties change smoothly between two surfaces and leads to a novel structure which can withstand large mechanical loadings in high temperature environments (Ebrahimi and Salari 2015). Presenting novel properties, FGMs have also attracted intensive research interests, which were mainly focused on their static, dynamic and vibration characteristics of FG structures (Ebrahimi and Rastgoo 2008a, b, c, Ebrahimi 2013, Ebrahimi *et al.* 2008, 2009a, b, 2016a, Ebrahimi and Zia 2015, Ebrahimi and Mokhtari 2015, Ebrahimi *et al.* 2015, Ebrahimi and Salari 2015, Ebrahimi and Salari 2015, Ebrahimi and Jafari 2016, Ebrahimi and Barati 2017a, b, Ebrahimi *et al.* 2017, Ebrahimi *et al.* 2017, Ebrahimi and Salari 2017).

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