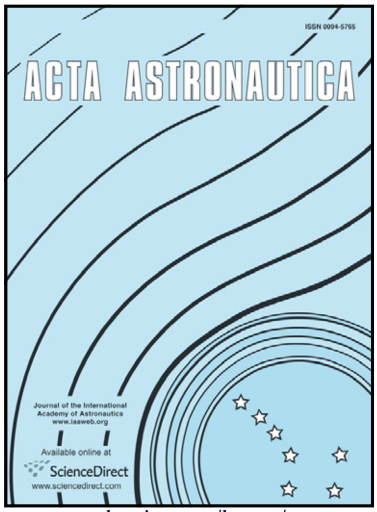
Author's Accepted Manuscript



www.elsevier.com/locate/actaastro

Nonlocal thermo-mechanical vibration analysis of functionally graded nanobeams in thermal environment

Farzad Ebrahimi, Erfan Salari

PII: S0094-5765(15)00131-9
DOI: http://dx.doi.org/10.1016/j.actaastro.2015.03.031
Reference: AA5399

To appear in: *Acta Astronautica*

Received date: 21 January 2015
Revised date: 23 March 2015
Accepted date: 27 March 2015

Cite this article as: Farzad Ebrahimi, Erfan Salari, Nonlocal thermo-mechanical vibration analysis of functionally graded nanobeams in thermal environment, *Acta Astronautica,* http://dx.doi.org/10.1016/j.actaastro.2015.03.031

Nonlocal thermo-mechanical vibration analysis of functionally graded nanobeams in thermal environment

Farzad Ebrahimi*,Erfan Salari

Department of Mechanical Engineering, Faculty of Engineering, Imam Khomeini International University, Qazvin, Iran

* Corresponding author email: febrahimy@eng.ikiu.ac.ir (F. Ebrahimi).

Abstract

In this paper, the thermal effect on free vibration characteristics of functionally graded (FG) size-dependent nanobeams subjected to various types of thermal loading is investigated by presenting a Navier type solution and employing a semi analytical differential transform method (DTM) for the first time. Two kinds of thermal loading, namely, linear temperature rise and nonlinear temperature rise are studied. Material properties of FG nanobeam are supposed to vary continuously along the thickness according to the power-law form and the material properties are assumed to be temperature-dependent. The small scale effect is taken into consideration based on nonlocal elasticity theory of Eringen. The nonlocal equations of motion are derived through Hamilton's principle and they are solved applying DTM. According to the numerical results, it is revealed that the proposed modeling and semi analytical approach can provide accurate frequency results of the FG nanobeams as compared to analytical results and also some cases in the literature. The detailed mathematical derivations are presented and numerical investigations are performed while the emphasis is placed on investigating the effect of the several parameters such as thermal effect, material distribution profile, small scale effects, mode number and boundary conditions on the normalized natural frequencies of the temperature-dependent FG nanobeams in detail. It is explicitly shown that the vibration behaviour of a FG nanobeams is significantly influenced by these effects. Numerical results are presented to serve as benchmarks for future analyses of FG nanobeams.

Keywords: Thermal effect, Free vibration, Functionally graded nanobeam, Eringen's nonlocal elasticity, DT method.

1. Introduction

Functionally graded materials (FGMs) are composite materials with inhomogeneous micromechanical structure. They are generally composed of two different parts such as ceramic with excellent characteristics in heat and corrosive resistances and metal with toughness. The material properties of FGMs change smoothly between two surfaces and the advantages of this combination lead to novel structures which can withstand in large mechanical loadings under high temperature environments.[1, 2] Presenting novel properties, FGMs have also attracted intensive research interests, which were mainly focused on their static, dynamic and vibration characteristics of FG structures.[3, 4] Since functionally graded structures are most commonly used in high temperature environment, in the last decade, beams and plates made of FGMs have found wide applications as structural elements in modern industries such as aeronautics/astronautics