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Size-dependent thermal stability analysis of embedded functionally graded annular nanoplates based on the nonlocal elasticity theory

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Abstract

In the present investigation, bifurcation-type buckling characteristics of heated functionally graded (FG) annular nanoplates resting on an elastic foundation and subjected to various types of thermal loading are carried out by presenting an exact analytical solution for the first time. Three kinds of frequently used thermal loading, i.e. uniform temperature rise, linear and nonlinear temperature distribution through the thickness direction are considered. Thermo-mechanical properties of FG nanoplate are supposed to vary smoothly and continuously throughout the thickness based on power law model whereas the Poisson's ratio is held constant. Eringen's nonlocal elasticity theory is exploited to describe the size dependency of nanoplate. Using the principle of virtual displacements, the equilibrium equations together with corresponding boundary conditions are obtained for the thermal buckling analysis of FG annular nanoplates including size effects. The pre-buckling analysis is performed and the proper boundary conditions are chosen to assure the existence of bifurcation-type buckling. Also, the nonlocal stability equations of FG annular nanoplate are derived by using the adjacent equilibrium criterion and they are solved by applying an exact asymmetrical solution. Moreover, in following a parametric study is accompanied to examine the effects of the several parameters such as nonlocal parameter, various temperature distributions, thickness to outer radius ratio, power law index, inner to outer radius ratios and elastic medium parameters on the critical buckling temperatures of the size-dependent FG nanoplates in detail. It is found that the small scale effects and thermal loading have a significant effect on thermal stability characteristics of FG annular nanoplates.

Keywords

FG annular nanoplates; Nonlocal theory; Thermal bifurcation buckling; Size effects; Exact analytical solution.

1. Introduction

Functionally graded material (FGM) is a composite material varying its microstructure from one material to another with a specific gradient, resulting in corresponding changes in the effective material properties (including elasticity modulus, thermal expansion coefficient and thermal conductivity) of the material. The FG materials can be designed to produce an optimum distribution of component materials for specific function and applications. Typically, FG materials are made of a mixture of two materials, mainly

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