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Geometric/microstructural imperfection sensitivity in the vibration characteristics of geometrically non-uniform functionally graded plates with mixed boundary conditions

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ABSTRACT

In the present article, the vibration response of geometrically imperfect functionally graded material (FGM) plates with geometric discontinuities and microstructural defects have been investigated. The structural kinematics used in the present study is based on logarithmic shear-strain function. A refined generalized porosity model has been developed to encompass even and uneven types of porosity models available in the literature. The geometric discontinuities have been assimilated in terms of a circular cut-out of different sizes at the center of the plate. To incorporate the geometric imperfection, a generic function has been used. A C^0 continuous isoparametric finite element formulation has been used to attain the results whereas the accuracy of the present solution has been confirmed by comparing the results with the available literature. The analysis reveals that after a specific cutout radius, the FGM plates exhibit the nonlinear vibration characteristics. It has been observed that the influence of boundary conditions, cutout dimensions, geometric imperfections, and porosity inclusions on frequency parameters are significant. Most of the results presented in this paper are novel and may be treated as benchmark results for future reference.

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KEYWORDS
Functionally graded material; geometric imperfection; porosity inclusions; cutout size; unconventional boundary constraints

1. Introduction

Heterogeneous composite materials exhibiting smooth and continuous variation in mechanical properties in any desired direction are called Functionally Graded Materials (FGMs). In 1972 Bever and Duwez for the first time termed the concept of Functionally graded materials, but was majorly conceptualized in 1984 by a group of aerospace scientists in Japan (Koizumi 1997). Because of their ability to serve various purposes according to the required applications and working environment, in many engineering and other diverse areas including optoelectronics, chemical science, biomedicine, nuclear science, aeronautical, mechanical and civil industries consider FGMs as advanced high technological material (Uymaz and Aydogdu 2007; Shahrjerdi et al. 2010; Hu and Zhang 2011). The ceramic composition in Ceramic- metal FGMs displays properties of efficient thermal and corrosion resistance which help protect the metal from corrosion and oxidation (Gupta and Talha 2018a; Yan, Chen, and Liou 2020). FGMs consisting of metallic and ceramic components are known to enhance the properties of thermal barrier systems because cracking of which is often observed in conventional multi-layer systems can be circumvented due

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