Stress Analysis of Functionally Graded Beams Due to Thermal Loading

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Abstract

In this paper, axial stress analysis of a functionally graded beam (FGB) was performed analytically and numerically under thermal loading. In these analyses, three different FGBs were used. Material properties of these FGBs are varied depending on the power law function along the z axis while Poisson ratio was assumed to be constant along the z-axis. Analytical formulas were given for axial stress analysis along z axis. FGBs were analysed numerically using the ANSYS program. Analytical and numerical results of axial stresses were compared and observed to be in consistence with each other. Then, the effect of different FGB types on axial stress was investigated under thermal loading. After analytical and numerical calculations, it was concluded that the FGM type consisting of Ti-6Al4V/Al2O3 metal ceramic pair had the lowest axial stress values. The results are given in graphs.

Beams are used to transfer and support loads in many areas of the industry such as construction, machine construction, space and aerospace. With the developing technology, the resistance of these beams to mechanical-thermal loads has gained great importance and the functionally graded materials (FGMs) have been a good alternative material for this purpose. FGMs are kind of composite materials consisting of metal and ceramic pairs that can be produced by powder metallurgy method. Metal surface provides the stronger structure to carry the stress and the higher heat resistivity of the ceramic surface prevents heat transfer. There are many studies about FGMs in the literature. Arbind used a third-order beam theory based on a couple stress theory designed to perform the bending analysis of the FGM beam. They compared the results with the finite element method. Afsar have described an FGM disk consisting of a combination of Al2O3-Al material properties throughout the thickness. They developed an analytical formulation for the thermo-elastic analysis of this disc. Afshin have established equations to investigate the transient thermo-elastic analysis of an axisymmetric hollow cylinder made of FGM. They solved this equation by the separation method and compared finite element results with the analytical results.

Almitani has studied buckling characteristics of both nonlinear symmetric power function and sigmoid-law FGBs. Ben-Oumrane have made a formulation based on classical laminate beam theory, deformation theory, highgrade theories to perform the displacement and stress analysis of a sigmoid beam formed from the combination of Al and Al2O3. Benyamina performed the thermo-mechanical bending analysis of ceramic-metal FGM beam in their work. This analysis was performed by using refined exponential shear deformation plate theory. They compared the results with literature.

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