Abstract

A three-dimensional approach based on linear elasticity theory is developed to study free vibration and thermal buckling of rectangular functionally graded material (FGM) plates. The three displacement components of the plate are expanded by a triplicate series of Chebyshev polynomials which are multiplied by appropriate boundary functions. A set of boundary functions is established for the different mechanical supported conditions of the plate. By using Ritz method, the problems of free vibration and thermal buckling of FGM plates reduce to an eigen-value problem from which the free vibration frequency and critical temperature can be determined. As there is no hypothesis along the thickness of the plate in the present approach, the three-dimensional solutions can be obtained. The convergence studies show that the present approach is valid and efficient in analyzing the rectangular FGM plates. Comparisons with the limited results from other studies were made and showed good agreement.

The proposed approach was used to investigate free vibration of FGM plates and FGM sandwich plates, free vibration of FGM plates and FGM sandwich plates subjected to uniform, linear and nonlinear distribution of temperature across the thickness, and thermal buckling of clamped FGM plates.The typical power-law distribution FGMs made of ceramic/metal style – alumina/aluminum and Si_3N_4/SUS304 – are considered in the study. Sandwich plates composed of homogeneous core with FGM facesheets and FGM core with homogeneous facesheets are also considered.

Extensive parametric studies were made to FGM plates and FGM sandwich plates with different combinations of support conditions on the edges, thickness-side ratios, aspect ratios, volume fraction indices, thickness layer proportions and temperature distributions across the thickness.

The studies show that the fundamental frequency parameters decrease with the

increase of volume fraction index κ for FGM plates. Moreover, the thin plates are slightly more sensitive than the thick plates to material rigidity. The vibrational frequency parameters decrease with the increase of the temperature. The temperature change affects the lower modes more significantly than higher modes and the plates of volume fraction $\kappa = 10$ are more sensitive to the temperature change than those of $\kappa = 1$. The uniform temperature distribution affects the vibrational frequencies more significantly than the linear and nonlinear temperature distributions and the effects of linear and nonlinear temperature distributions are close. The temperature effects on different mechanical boundary conditions are listed in the rank of intensity from high to low: CCCC, FCFC, SCSC, SSCC, SSSS.

For clamped FGM plates, the critical temperature increases with the increase of the thickness of the plate. The critical temperature under nonlinear temperature rise field is higher than that under linear temperature rise field and the critical temperature under linear temperature rise field is higher than that under uniform temperature rise field. It is seen that the critical temperatures decrease with the increase of volume fraction index κ and aspect ratio a/b.

The present three-dimensional approach is a valid and high efficient approach in analyzing the rectangular FGM plates. The thesis presents a comprehensive study of free vibration of FGM plates and FGM sandwich plates, vibration of FGM plates and FGM sandwich plates in thermal environment and thermal buckling of clamped FGM plates.