Abstract

Laminated composite shell panels have gained popularity in high-performance products that need to be lightweight such as aerospace, marine and modern automotive components. The main reasons for this trend are outstanding mechanical properties of composites, such as high strength/stiffness to weight ratio, good thermal properties, etc. The external skin made of composites of the high speed aircrafts, rockets and launch vehicles normally having geometry of shell panel are subjected to intense thermal load due to the aerodynamic heating during their service life and the structural responses are affected considerably due to that. They are very often subjected to large amplitude vibration, buckling and post-buckling and post-buckled vibration due to extreme thermal loading conditions, which has significant effect on the nonlinear structural response. The basic geometry of the panel may alter due to the large deformation which adversely affects the stiffness and geometry of the structures. In order to increase the life of laminated structures and to maintain their original geometry in elevated thermal environment shape memory alloy (SMA) has great potential. The investigations considering these effects are not sufficient enough and hence, it is required to take into account the geometric and material nonlinearity arising in such flexible structures in thermal environment especially structures having severe geometric nonlinearity. In this study, a general nonlinear mathematical model is developed for laminated composite shell panels embedded with and without SMA fibres at elevated temperature based on the higher order shear deformation theory. The geometric nonlinearity is modelled in Green-Lagrange sense. The material nonlinearity in SMA due to temperature variation is incorporated via, a marching technique. The system equations are developed which include all the higher order term arising in the nonlinear formulation. A suitable nonlinear finite element model combined with direct iterative method is proposed and implemented for obtaining the solution of the nonlinear system equations. The effects of different parameters on the nonlinear vibration, thermal post-buckling and nonlinear free vibration of thermally post-buckled composite shell panel with and without SMA are studied in details. The comparison studies indicate the necessity and importance of the present study. New results are also presented. A design based upon such analysis would certainly be very useful for the researchers and designers.

Keywords: laminated shell panel, Green-Lagrange nonlinearity, HSDT, nonlinear FEM, nonlinear vibration analysis, buckling and post-buckling, post-buckling vibration analysis, shape memory alloy, thermal environment.