Abstract

Beams are essential components of all types of structures. Beams can be used to idealize or represent various structural elements, like, cutting tools, robotic arms, wind mill blades, helicopter rotor blades, heart valves, and many more. The notion of functionally graded materials (FGM) emerged in an attempt to design a new type of particulate composite material as an alternate to the standard fibrous composites due to their frequently occurring delamination failure. So, it is anticipated that using beams with functionally graded materials will increase their dependability and safety. As functionally graded materials are all customized materials so it is necessary to investigate the behaviour of functionally graded beams thoroughly with all types of variations in gradation parameters for the process of design and development. This study examines the deformation and stress behaviours of a functionally graded (FG) material beam under mechanical as well as thermo-mechanical loading circumstances.

To analyse behaviour of an FG beam thoroughly a new type of unified higher order beam theory has been derived in context of Third order Shear Deformation Theory (TSDT). To take into account of the influence of non-linearity on the beam behaviour, von-Karman principle has also been integrated into the formulation. Adaptation of principle of stationary total potential through von-Karman's principle has enabled to incorporate higher order terms (up to 6^{th} order) to examine behaviour of beams more minutely for various cases of material gradations under different mechanical and thermo-mechanical loads. The material's properties, such as its modulus of elasticity, stiffness, coefficient of thermal expansion, and thermal conductivity, have been assumed to vary over the thickness of the beam but Poisson's ration has been taken constant.

Standard problems from few previous works [33, 128] have been solved using the mathematical model developed in the present work under mechanical load as well as thermo-mechanical load to determine transverse deflection, axial stress and shear stress. It has been observed that the results of transverse deflection and axial stress have been validated with the results of the work from the base papers [33, 128] under mechanical and thermal load both. But it has also been observed that result of shear stress differs considerably with the results determined by the authors in [33] and [128]. It has been concluded that due to incorporation of 6^{th} order derivative in the mathematical model this difference in shear stress has been appeared because in the mathematical model derived by the authors of [33] and [128], up to 4^{th} order derivative appeared.

In the present work it has also been experienced that analysis of FG beams with dimensional discontinuities is not possible with analytical method. For this reason, FEA codes have been developed to analyse FG beams with circular and elliptical holes under static loadings.