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Analysis of Thermal Effect on Functionally Graded Micro-Beam via Mixed Finite Element Method

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Abstract : Studies concerning the microstructures are becoming more important as the utilization of various micro-electro mechanical systems (MEMS) are increasing. Thus in recent years, thermal buckling and vibration analysis of microstructures have been subject to many investigations that are utilizing different numerical methods. In this study, thermal effects on mechanical response of a functionally graded (FG) Timoshenko micro-beam are presented in the framework of a mixed finite element formulation. Size effects are taken into consideration via modified couple stress theory. The mixed formulation is based on a function which in turn is derived via Gateaux Differential scientifically. After the resolution of all field equations of the beam, a potential operator is carefully constructed. Then this operator is used for the manufacturing of the functional. Usual procedures of finite element approximation are utilized for the derivation of the mixed finite element equations once the potential is obtained. Resulting finite element formulation allows usage of C_0 type simple linear shape functions and avoids shear-locking phenomena, which is a common shortcoming of the displacement-based formulations of moderately thick beams. The developed numerical scheme is used to obtain the effects of thermal loads on the static bending, free vibration and buckling of FG Timoshenko micro-beams for different power-law parameters, aspect ratios and boundary conditions. The versatility of the mixed formulation is presented over other numerical methods such as generalized differential quadrature method (GDQM). Another attractive property of the formulation is that it allows direct calculation of the contribution of micro effects on the overall mechanical response.

Keywords : micro-beam, functionally graded materials, thermal effect, mixed finite element method
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