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HOMOGENIZATION OF MATERIAL PROPERTIES OF THE FGM BEAM AND SHELL FINITE ELEMENTS

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Important classes of structural components, where a functionally graded material (FGM) is used, are beams and shells. FGM beams and shells play an important role not only in structural applications, but there are many applications in design of thermal-elastic, electric-thermal or electric-thermal-structural systems (e.g. MEMS like sensors and actuators, and other mechatronic devices). In all these applications, using new materials like FGM can greatly improved the efficiency of a system. FGM is built as a mixture of two or more constituents which have almost the same geometry and dimensions. From a macroscopic point of view, the FGM is isotropic in each material point but the material properties can vary continuously or discontinuously in one, two or three directions. The variation of macroscopic material properties can be caused by varying the volume fraction of the constituents or with varying of the constituents material properties (e.g. by a non-homogeneous temperature field).

For multiphysical analysis the new beam and shell finite elements are established, e.g. [1], [2]. In most research publications the transversal variation (with respect to the beam height or the shell thickness) of material properties is considered. The effective material properties, obtained by homogenization, are introduced within the finite element equations. The real material properties are homogenized by several methods. The mixture rules and the laminate theory are predominantly applied [3].

In the proposed contribution, the homogenization techniques of spatial varying (continuously or discontinuously, symmetrically or asymmetrically) material properties are proposed. The effective longitudinal varying electric, thermal and elastic material properties are derived by the extended mixture rules and the laminate theory for modal and multiphysical analyses of FGM beams and shells.

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