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THREE-DIMENSIONAL THERMOPIEZOELECTRIC ANALYSIS OF LAMINATED AND FUNCTIONALLY GRADED PLATES AND SHELLS BY A SAMPLING SURFACES METHOD

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Summary: Three-dimensional (3D) analysis of piezoelectric laminated and functionally graded plates and shells has received considerable attention during past years. There are at least four approaches to 3D exact solutions of thermoelectroelasticity for piezoelectric plates and shells, namely, the Pagano approach, the state space approach, the series expansion approach and the asymptotic approach. These approaches were applied efficiently to 3D exact solutions for laminated piezoelectric plates and shells in many contributions.

In a present work, we invoke a new approach based on the method of sampling surfaces (SaS) proposed recently by the authors for piezoelectric laminated and functionally graded plates and shells under electromechanical loading [1-4] and extend it to the thermopiezoelectric shell formulation. As SaS, we choose inner surfaces inside the layers parallel to the middle surface and introduce temperatures, electric potentials and displacements of these surfaces as basic shell variables. Such choice of unknowns with the consequent use of Lagrange polynomials in the thickness direction permits the presentation of governing equations of the thermopiezoelectric shell formulation in a very compact form.

It is worth noting that the developed approach with equally spaced SaS does not work properly with Lagrange polynomials of high degree because of the Runge's phenomenon, which yields the wild oscillation at the edges of the interval when the user deals with specific shell metric functions. If the number of equally spaced nodes is increased then the oscillations become even larger. However, the use of Chebyshev polynomial nodes as SaS coordinates allows one to minimize uniformly the error due to Lagrange interpolation. As a result, the SaS formulation can be applied efficiently to the solution of 3D thermopiezoelectric problems for laminated and functionally graded plates and shells with a specified accuracy utilizing the sufficient number of SaS. This is due to the fact that the analytical solutions based on the SaS formulation asymptotically approach the 3D exact solutions of thermopiezoelectricity as the number of SaS goes to infinity.

References

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