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Strain gradient thermoelastic Kirchhoff-Love plate model: Variational formulation and isogeometric analysis

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In this contribution, we first focus on the variational (or weak) formulation of the Kirchhoff-Love plate model in the framework of first strain (second displacement) gradient thermoelasticity [1]. Within this theory the Helmholtz free energy contains not only strains, strain gradients and temperature, which was so far the stem of the gradient thermoelastic material model, but also temperature gradient. Next, the weak form of the generalized plate model is discretized with the NURBS-based isogeometric Galerkin method [2] which is implemented in the framework of user elements of the commercial finite element software Abaqus [3]. Finally, we consider thin plate structures which are constructed by extrusion of 2D triangular lattice trusses [4]. Mechanically induced bending response is found to be size-dependent whereas thermally induced bending response remains independent on the plate size [5]. The behaviour of the plate with triangular cell microstructure is perfectly captured by the generalized thermoelastic plate model, which approves the importance of the temperature gradient in the free energy expression. Numerical simulations have been performed by utilizing standard finite elements for modeling the lattice plate structures and user-defined isogeomtric elements for modeling the generalized Kirchhoff-Love plate problem.

REFERENCES

[1] S. Khakalo, J. Niiranen, On constitutive laws in second gradient thermoelasticity: Thermodynamics and experimental evidence, in preparation

[2] T. J. R. Hughes, J. A. Cottrell, Y. Bazilevs, Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement. *Computer Methods in Applied Mechanics and Engineering*, 194, 4135-4195, 2005

[3] S. Khakalo, J. Niiranen, Isogeometric analysis of higher-order gradient elasticity by user elements of a commercial finite element software, *Computer-Aided Design*, 82, 154-169, 2017

[4] S. Khakalo, V. Balobanov and J. Niiranen, Modelling size-dependent bending, buckling and vibrations of 2D triangular lattices by strain gradient elasticity models: applications to sandwich beams and auxetics, *International Journal of Engineering Science*, revised, 2018.

[5] S. Khakalo, J. Niiranen, Strain gradient thermoelastic Kirchhoff-Love plate model: Variational formulation and isogeometric analysis, in preparation