An isogeometric approach for coupled thermomechanical problems at large strain

Lei Zhang†, Stéphane Lejeunes † and Dominique Eyheramendy†*

† Aix Marseille Univ, CNRS, Centrale Marseille, LMA
4 impasse Nikola Tesla CS40006
13453 Marseille, France
e-mail: dominique.eyheramendy@centrale-marseille.fr, web page: http:// www.lma.cnrs-mrs.fr

ABSTRACT

In this paper, we focus on the development of isogeometric models to tackle the simulation of elastomers under coupled thermomechanical complex loading and self-heating phenomena. We first investigate volumetric locking numerical issues existing for low order NURBS elements for incompressible or slightly compressible media. We investigate two fields displacement/pressure (*u-p*) IGA formulations for which the combinations of patches of degree p of type $(\boldsymbol{u}\, p_1^1, \boldsymbol{p}\, p_0^1)$ - subdivision of the patch for the velocity u- and $(\boldsymbol{u}\, p_0^2, \boldsymbol{p}\, p_0^1)$ –repetition of the inner knots for the patch for the velocity u- (see [1-2] for notations, [1] for a state of the art and e.g. [3] for examples of optimally convergent elements). The comparison between the two-fields mixed formulation and a strain projection method is lead at small and large strains (see [5] for a pure displacement formulation and [4] for an example of formulation at large strains). At last, we originally adopt a similar strategy for thermomechanical problem at small and large strains. In the context two-fields formulation, we investigate the numerical convergence of displacement/temperature IGA formulations. Thus, we investigate the choices of patches for two-fields formulation displacement/temperature (*u-T*) fields for IGA applied to thermoelasticity. Optimal convergences are obtained at small strains when thermomechanical coupling is not too strong for combinations $(\boldsymbol{u}\, p_1^1, \boldsymbol{T}\, p_0^1)$ and $(\boldsymbol{u}\, p_0^2, \boldsymbol{T}\, p_0^1)$. A formulation at large strain for a time dependent problem is investigated. Several numerical results for thermomechanical problems at small and finite strains are presented. At last, an incompressible visco-thermo-hyperelastic model is evaluated in the IGA framework with the proposed approach.

REFERENCES

[1] Lei Zhang, “Sur une approche isogéométrique pour problèmes multi-champs couplés en grandes déformations”, PhD Thesis report, Ecole Centrale Marseille, 2016 (in english).

[2] P. N. Nielsen, A. R. Gersborg, J. Gravesen, and N. L. Pedersen, “Discretizations in isogeometric analysis of Navier–Stokes flow,” Comput. Methods Appl. Mech. Eng., vol. 200, no. 45–46, pp. 3242–3253, 2011.

[3] A. Buffa, C. de Falco, and G. Sangalli, “IsoGeometric Analysis: New stable elements for the Stokes equation” Int. J. Numer. Methods Fluids, vol. 65, no. 11–12, pp. 1407–1422, 2011.

[4] C. Kadapa, W. G. Dettmer, and D. Perić, “Subdivision based mixed methods for isogeometric analysis of linear and nonlinear nearly incompressible materials,” Comput. Methods Appl. Mech. Eng., vol. 305, pp. 241–270, 2016.

[5] T. Elguedj and T. J. R. Hughes, “Isogeometric analysis of nearly incompressible large strain plasticity,” Comput. Methods Appl. Mech. Eng., vol. 268, pp. 388–416, 2014.