A MONOLITHIC APPROACH APPLIED TO THERMO-MECHANICALLY AND ELECTRO-THERMO-MECHANICALLY COUPLED PROBLEMS

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The application of the method of vertical lines in the case of quasi-static solid mechanics using inelastic material properties yields after the spatial discretization by means of finite elements a system of differential-algebraic equations (DAE-system). This is the case of thermo-mechanically coupled problems and electro-thermo-mechanical situations as well.

In this presentation the application of high-order time-integration methods and their pitfalls are discussed as well. First, analytical equations are developed to provide verification examples. Second, order investigations are discussed showing that for non-linear Dirichlet-boundary conditions in the heat equation an order reduction phenomenon occurs. This can be circumvented by a proposal of [1], where the boundary-conditions are integrated as well. The applications are small strain thermo-viscoplasticity, finite strain thermo-viscoelasticity using high-order DIRK-methods, see [2], and small strain thermo-electro-mechanics, which occurs in specific problems in field-assisted sintering problems, see [3].

REFERENCES

[1] I. Alonso-Mallo. Runge-Kutta methods without order reduction for linear initial boundary value problems. *Numerische Mathematik*, Vol. **91**, 577–603, 2002.

[2] T. Netz. *High-order space and time discretization scheme applied to problems of finite thermo-viscoelasticity*. PhD-thesis published as report no. 3/2013, Institute of Applied Mechanics, Clausthal University of Technology, Germany, 2013.

[3] S. Hartmann and S. Rothe. A Rigorous Application of the Method of Vertical Lines to Coupled Systems in Finite Element Analysis. In: Recent Developments in the Numerics of Nonlinear Hyperbolic Conservation Laws. (Eds.) Ansorge, R. and Bijl, H. and Meister, A. and Sonar, T., *Notes on Numerical Fluid Mechanics and Multidisciplinary Design*, Vol. **120**, 161-175, 2013.