Thermo-mechanical coupling in fiber-reinforced continua: Mixed finite element formulations and energy-momentum time integration

Dietzsch J.*, **Groß M.**† **and Flessing L.**††

Technische Universität Chemnitz
Professorship of applied mechanics and dynamics
Reichenhainer Straße 70, D-09126 Chemnitz

* julian.dietzsch@mb.tu-chemnitz.de † michael.gross@mb.tu-chemnitz.de

†† tmd@mb.tu-chemnitz.de

Key words: Mixed finite element method, higher-order energy-monentum scheme, fiber-reinforced material, polyconvex strain energy function, anisotropic thermoelasticity

Abstract: Our research activity is motivated by accurate dynamic simulations of fiber-reinforced materials in light-weight structures. In order to accomplish this, we have to take various steps. The material behavior is formulated with an anisotropic, polyconvex strain energy function. We combine different mixed element formulations (e.g. see Reference [1] or [2]) with a Galerkin time integrator as shown in Reference [3]. This reduces the volumetric locking effect of an incompressible matrix material as well as the locking effect due to stiff fibers. In addition, we increase the accuracy by using Galerkin-based higher-order time integrators. Since in long-term simulations a hugh energy error is a strong problem, we apply the mixed finite element formulations to an energy-momentum time integration scheme (see Reference [4]). In the next step, we extend the material formulation by adding a thermo-mechanical coupling as shown in Reference [5]. Here we also describe the directional heat conduction of the fiber. As numerical examples with multiple material domains and families of fibers serve cooks cantilever beam as in Reference [3] and a rotating heatpipe as in Reference [4]. The Dirichlet boundary conditions are modelled by the Lagrange-multiplier method (see Reference [5]) and as Neumann boundary condition a pressure distribution is used.

REFERENCES

[1] Schröder, J., Wriggers, P., Balzani, D. (2011) A new mixed finite element based on different approximations of the minors of deformation tensors. *Comput. Methods Appl. Mech. Engrg.*, 49:3583–3600.

[2] Schröder, J., Viebahn, V., Wriggers, P., Balzani, D. (2016) A novel mixed finite element for finite anisotropic elasticity; the SKA-element Simplified Kinematics for Anisotropy. *Comput. Methods Appl. Mech. Engrg.*, 310:475–494.

[3] Dietzsch J. and Groß M. (2018), MIXED FINITE ELEMENT FORMULATIONS FOR THE GALERKIN-BASED TIME INTEGRATION OF FINITE ANISOTROPIC ELASTODYNAMICS. *ECCOMAS conference ECCM-ECFD 2018* - 6th European Conference on Computational Mechanics (ECCM 6), Glasgow UK, 11-15 June 2018

[4] Groß, M., Dietzsch., J. (2017) Variational-based energy–momentum schemes of higher-order for elastic fiber-reinforced continua. *Comput. Methods Appl. Mech. Engrg.*, 320:509–542.

[5] Groß M., Dietzsch J. and Bartelt M. (2018), Variational-based higher-order accurate energy–momentum schemes for thermo-viscoelastic fiber-reinforced continua, *Comput. Methods Appl. Mech. Engrg.*, 336: 353-418, 2018.