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Mixed finite element formulations and energy-momentum time integrators for thermo-viscoelastic gradient-based fiber-reinforced continua

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Nowadays, fibre-reinforced materials and their accurate dynamic simulation play a significant role in the construction of lightweight structures. On the one hand, we are dealing with locking of the matrix material as well as the fibres, thermal expansion, the directed heat conduction through the fibres and viscoelastic behaviour in such materials. The material reinforcement is performed by fiber rovings with a separate bending stiffness, which can be modelled by second order gradients. On the other hand, we also want to perform accurate long-term simulations. In this presentation, we focus on numerically stable dynamic long-time simulations with locking free meshes, and thus use higher-order accurate energy-momentum schemes emanating from mixed finite element methods. We adapt the variational-based space-time finite element method in Reference [1] to the material formulation, and additionally include independent fields to obtain well-known mixed finite elements [2, 3]. As representative numerical example, Cook's cantilever beam and a rotating heatpipe is considered. We analyse the spatial and time convergence, the conservation properties, the effect of the thermal conduction of the fibres, the physical dissipation and the influence of the second order gradient formulation.

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