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A thermo-coupled constitutive model for semi-crystalline polymers at finite strains: Application to varying degrees of crystallinity and temperatures

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Thermoplastic materials are widely used for thermoforming and injection moulding processes, since their low density in combination with a high strength to mass ratio are interesting for various industrial applications. Semi-crystalline polymers make up a subcategory of thermoplastics, which partly crystallize after cool-down from the molten state. During the thermoforming process, residual stresses can arise, due to complex material behavior under different temperatures and strain rates. Therefore, computational models are needed to predict the material response and minimize production errors.
This work presents a thermomechanically consistent phenomenological material formulation at finite strains, based on [1]. In order to account for the highly nonlinear material behavior, elasto-plastic and visco-elastic contributions are combined in the model formulation. To account for the crystalline regions, a hyperelastic-plastic framework is chosen, based on [2, 3]. A nonlinear kinematic hardening of Arruda-Boyce form is incorporated in the formulation, as well as a non-associated plastic flow. The material parameters depend on both, the temperature as well as the degree of crystallinity. A comparison to experiments with varying degrees of crystallinity and temperatures is presented, where a special blending technique ensures stable crystallinity conditions.

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