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A MICROSTRUCTURALLY BASED CONSTITUTIVE MODEL FOR SHAPE-MEMORY POLYMERS FORMULATED IN THE LOGARITHMIC STRAIN SPACE

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As compared to other shape memory materials, shape memory polymers (SMP's) have a number of distinctive properties such as well adjustable glass transition temperature, relatively large elastic strains and low density. Reliable modeling capabilities are essential to exploit the potential of SMP's in a wide spectrum of applications, ranging from deployable structures to biocompatible/biogradable stents. This work focuses on predictive modeling of thermally induced shape memory phenomenon observed in SMP's and proposes a fully-coupled thermo-mechanical constitutive model including its finite element implementation at finite strains.

The presented framework is essentially an extension and a proper adaptation of a recently proposed model for mechanical behaviour of polymers well below the glass transition temperature, under isothermal conditions, [1]. In the context of shape-memory effect, the key component of this model is the 'transformational' plastic energy density which evolves with deformation and acts as a potential for back stresses that drive the thermal recovery from the plastically deformed state upon heating above the glass transition temperature (θ_g). Under thermodynamically favorable conditions, the latent 'transformational' plastic energy stored in the plastified regions is activated and the evolving back stresses restore the undeformed state of the material naturally, as opposed to some of the existing models in the literature, e.g. [2].

On the algorithmic side, an additive kinematical decomposition in logarithmic strain space is adhered which a priori avoids the difficulties and assumptions associated with the fictitious intermediate configuration of multiplicative decomposition. Furthermore, additive decomposition kinematics leads to a highly efficient algorithmic formulation, which allows the straight forward extension of well established small-strain inelastic stress update algorithms to finite strains with purely geometrical pre- and post-processing operators.

Qualitative and quantitative prediction capabilities of the proposed framework are demonstrated by means of illustrative examples.

REFERENCES

[1] C. Miehe, S. Göktepe, J. Mendez, Finite Viscoplasticity of Glassy Polymers in the Logarithmic Strain Space, International Journal of Solids and Structures, vol. **46**, 181–202, 2009.

[2] S. Reese, M. Böl, D. Christ, Finite Element-based Multi-phase Modelling of Shape Memory Polymer Stents, Computer Methods in Applied Mechanics and Engineering, Vol. **199**, 1276–1286, 2010.