EFFICIENT INTEGRATION FOR THE SIMO-MIEHE MODEL WITH MOONEY-RIVLIN POTENTIAL

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A model of finite-strain visco-plasticity proposed by Simo and Miehe [1] is considered. The model is based on the multiplicative split of the deformation gradient, combined with hyperelastic relations between elastic strains and stresses. This model is a backbone of many advanced models of visco-elasticity and visco-plasticity. Therefore, its efficient numerical treatment is becoming increasingly important. Since the underlying evolution equation is stiff, implicit time integration is required. A discretization of Euler backward type yields a nonlinear system of algebraic equations. The system is usually solved numerically by Newton-Raphson iteration or its modifications. In the current study, a practically important case of the Mooney-Rivlin potential is analyzed. For this type of hyperelastic potential, the system of discretized evolution equations is reduced to a quadratic tensor equation; its solution is obtained in a closed form. Thus, in the general visco-plastic case, the problem is reduced to the solution of one scalar equation with respect to the unknown plastic strain increment. For vanishing static yield stress, a popular formulation of the finite-strain Maxwell fluid is obtained. For the Maxwell fluid, the corresponding numerical procedure is completely iteration-free [2]. In the case when the potential is of neo-Hookean type, the very simple explicit update formula from [3] is restored. It is shown that the new efficient approach exhibits the same accuracy as the Euler backward method with correction of incompressibility. The method is also compared numerically to the implicit time stepping based on the tensor exponential. None of the methods prevail in accuracy, but the new method is essentially more efficient and robust. It is unconditionally stable; it preserves the incompressibility and weak invariance under isochoric changes of the reference configuration.

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