Computational procedure for anisotropic elastoplasticity at finite strains

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ABSTRACT

We present a theory and the corresponding computational model for anisotropic plasticity at large elastic and plastic strains. The model uses logarithmic strains and his work conjugated "generalized Kirchhoff" stresses in the intermediate configuration, considering the material anisotropy in both the elastic and plastic components.

The formulation solves the so-called "rate issue" employing a corrector rate of elastic strains, yielding an additive decomposition in the logarithmic strain space, both in the continuum theory and in the algorithmic implementation. The resulting framework is closely related to the equivalent additive one at small strains, and it is similar to one recently employed in viscoelasticity [1]. This decomposition is compatible with the multiplicative decomposition. The dissipation equation may be seamlessly formulated in any work-conjugate stress-strain pair, resulting in the same invariant dissipation [2]. The skew-symmetric flow is naturally fully uncoupled from the symmetric one. The result is a plastic isochoric flow that avoids the use of additional hypotheses about the plastic spin and without the presence of the Mandel stress tensor. It also avoids the use of the exponential integration rule typically used at finite strains. For the particular case of isotropy, the formulation recovers the computational model from Simó using a conventional flow rule instead of one based on the Lie derivative.

The formulation is valid both for metals and soft materials, because it allows for the use of arbitrary elastic stored energies and large elastic strains. The stress-point integration algorithm is just a backward-Euler integration of the corresponding continuum setting. The local computational algorithm [3] iterates in the elastic strains and the scalar equivalent plastic strains. Remarkably, the resulting numerical tangent closely resembles the continuum one, and that of the formulation at small strains. We compare the finite element results of our model to predictions from other models in the literature.

REFERENCES

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