Multi-temporal space-time integration for dissipative solids under cyclic failure conditions - COMPLAS 2019

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ABSTRACT

The theory of generalized standard materials and its variational reformulation [1] provide a consistent framework for the description of the dissipative processes involved in material failure. The conventional numerical approach to the underlying evolution problems is based on step-by-step procedures, which may result in intractable computational costs for cyclic loading conditions.

Several methods have been proposed in the literature to reduce computational efforts under cyclic conditions, typically based on classical formulations with a local description of internal variables. A well-established example is the LATIN method [2, 3], where the full time history of the displacements and internal variables is computed in each iteration. While the method is able to handle strong non-linearities, its intrusive nature renders the numerical implementation of complex material models a cumbersome task. On the other hand, non-intrusive procedures have been proposed based on cycle jumping [4, 5], where step-by-step calculations are performed for a reduced number of cycles, with an adaptive extrapolation of the internal variables in between. While the simplicity of these methods is appealing, the definition of the jump size is far from trivial, and small jumps are required for highly non-linear temporal evolutions.

Herein, we propose a multi-temporal numerical approach intended to describe failure in materials undergoing cyclic plasticity and fatigue. The point of departure is the variational formulation of dissipative solids and the staggered solution strategy for the Euler-Lagrange equations. However, as in the LATIN method, the full time history is computed in each iteration. For this purpose, space-time proper generalized decomposition with multiple time scales is performed, which suggests possibilities for significant reductions in computational cost and can be, in principle, applied to a general class of models with internal variables. Benchmark problems that present ratcheting and shakedown mechanisms are addressed to show the capabilities of the proposed methodology.

REFERENCES