Damage anisotropy

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ABSTRACT

The discussion concerns recent developments of the Perzyna’s type viscoplasticity by the Authors [5, 3, 6, 1, 7]. Apart from commonly known main features of the Perzyna model like: (i) invariance of the description with respect to any diffeomorphism (any motion of this model can be described), (ii) well-posedness of the evolution problem (there exist unique solution), (iii) rate sensitivity, (iv) finite elasto-viscoplastic deformations, (v) plastic nonnormality, (vi) dissipation effects, (vii) thermomechanical couplings or (viii) length scale sensitivity we would like to distinguish the new one that governs directional evolution of damage. The motivation, of such investigations lays in fact that although the problem of damage anisotropy description has been studied by many researches (cf. [4, 9, 8]) nevertheless, many of previous proposals have very often unclear physical foundations or their applications are limited to 1D or 2D problems, mostly under static conditions.

The model under consideration has a deep physical interpretation derived from analysis of a single crystal and a polycrystal behaviour ([5]). This constitutive structure is devoted for metallic materials under extreme loading conditions, which can produce strain rates up to $10^7 \text{s}^{-1}$ and temperatures up to melting point. The description of damage anisotropy by the model assumes the introduction of a second order microdamage tensor, with the interpretation that its Euclidean norm defines the scalar quantity called the volume fraction porosity or simply porosity [5] while its principal values are proportional to the ratio of the damaged area to the assumed characteristic area of the representative volume element [6], thus they indicate damage plane as one perpendicular to the maximal principal value of microdamage tensor [2].

The discussed material model is implemented into Abaqus/Explicit finite element code by taking advantage of a user subroutine VUMAT, which is coupled with Abaqus system. The Abaqus/Explicit utilises central-difference time integration rule along with the diagonal (“lumped”) element mass matrices. The implementation keeps the Lie objective rate.

There will be presented a numerical results for dynamic tension, shearing, twisting and spalling. All analyses are carried out as a 3D problems (the only possibility when damage anisotropy is considered) under adiabatic conditions assumption. In examples detailed analysis of damage anisotropy is presented, showing that we are able to predict correctly (both in space and time) damage initiation its directional evolution up to full fracture. Further tasks will be defined also.

References


