Convergence of continuum damage for ductile failure processes

R. Larsson[1]*and A. Erturk[1],

[1] Division of Material and Computational Mechanics, Department of Industrial and Materials Science, Chalmers University of Technology, SE-412 96 Göteborg, Sweden, ragnar.larsson@chalmers.se

The paper compares two damage evolution models describing the degraded material response coupled to thermal softening for ductile failures. Continuum thermodynamics is used to represent the energy dissipation induced by the effective material response, thermal effects and damage evolution. The continuum damage evolution of Lemaitre type is focusing the degradation of the shear response, eventually leading to ductile shear failure. Here, the main prototype for the effective material is the Johnson-Cook model, accounting for deformation hardening, strain rate hardening and temperature degrading effects. Our incentive is to consider the convergence and stability properties in the FE-application considering both damage rate and gradient dependence in the fracture area production.

In the damage modeling we are concerned with:

1. the energy dissipation rate describing a damage coupled to plasticity driving dissipation to the fracture area production process. A special feature is the damage-driving dissipation rate, allowing for elastic and plastic contributions separated by a damage threshold for accumulation of inelastic damage-driving energy, [1].

2. the description of energy dissipation due to fracture area production, involving area production due to ”nucleation” and ”convection” of damage in the temporal evolution of the damage field [2]. The “gradient” fracture area production effect is obtained due to spatial growth of the damage field.

3. the formulation of a nonlocal condition for the damage threshold defining plasticity driven damage evolution. For isothermal conditions, the examples exhibit mesh convergent behavior when using the nonlocal damage threshold, [3].

In the application to a dynamic split-Hopkinson test and two quasi-static tensile test, the gradient damage model is compared to a corresponding rate dependent local model. It appears that the temporal damage evolution removes the pathological mesh dependence in the isothermal case and has a stable behavior without the additional gradient effect, [1].

References

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