Ductile fracture modelling using the Thick Level Set approach

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ABSTRACT

In this work, the Thick Level Set approach, originally introduced in [1] to model quasi-brittle failure, is applied to ductile damage modelling. As a target model to regularize, we use a version of the Gurson-Tvergaard-Needleman (GTN) model based on a logarithmic finite strain formulation, described in [2]. In the previous publications on the quasi-brittle case, the damage variable was regularized, whereas for the ductile failure, we regularize the hardening variable. Prior to local softening, the evolution of plasticity is purely local; non locality is triggered only when softening arises. This is represented by two hardening variables instead of one: a “classical” local one, which is at first the only one evolving. Then, when softening is detected, the non local hardening variable starts to increase. The later is non local in the TLS sense, that is it is expressed in terms of a level set function. It allows to introduce a characteristic length, and therefore to avoid mesh dependency. Note that the evolution of this non local hardening variable is a problem of dimension $n-1$ (n being the dimension of the problem), which is interesting in terms of CPU time.

Ductile fracture is characterized by large plastic strains before the apparition of macro-cracks, which may cause some strong element distortions. Therefore, the last development of the TLS [3] are used to represent these cracks with a cohesive zone. The idea is to introduce a cohesive crack before the total failure of the bulk, to avoid large strains.

Finally, three phenomenon contribute to the dissipation:

- A bulk, local evolution of the hardening variable
- A bulk, non local evolution of the hardening variable in in the softening part of the structure, with finite plastic strains
- A surface dissipation on the cohesive zone, with a plastic displacement jump

The equations of the model will be presented and discussed in 1D. Finally, some 2D illustrations will conclude the presentation. It will be shown that having non locality reduced to a problem of dimension $n-1$, as well as the use of a particular explicit algorithm used to integrate the constitutive equations, allow low computing times.

REFERENCES

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