Micromechanical Modelling of Ductile Damage via a Cohesive-Volumetric Approach

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ABSTRACT

The present work addresses the modelling and the simulation of crack initiation and propagation in ductile materials which failed by void nucleation, growth and coalescence. One of the current research frameworks on crack propagation is the use of the cohesive-volumetric approach where the crack growth is modelled as decohesion of two surfaces in a continuum material. In this framework, the material behavior is characterized by two constitutive relations - the volumetric constitutive law relating stress and strain, and a traction-separation law across a two-dimensional surface embedded in the three-dimensional continuum. Several cohesive models have been proposed for the simulation of crack growth in brittle materials. However, the application of cohesive models in modelling crack growth in ductile materials is still an open field. One specific idea developed in this field consist in determining the traction separation for ductile materials based on the behavior of a continuously-deforming unit cell failing by void growth and coalescence [1]. Following this method, the present work proposes a semi-analytical cohesive model for ductile materials based on a micromechanical approach. The strain localization band prior to ductile failure is modelled as a cohesive band and the Gurson-Tvergaard-Needleman plasticity model (GTN) [2] is used to describe the behavior of the cohesive band and to derive a corresponding traction separation law. The numerical implementation of the model has been performed using the Non-Smooth Contact Method (NSCD) where cohesive models are introduced as mixed boundary conditions between each volumetric finite element [3]. The present approach is applied to the simulation of crack growth in standard ferritic steel and validated by comparison with available experimental data. In a future work, it is planned to apply this approach to simulate the cracking of porous nuclear ceramics such as uranium dioxide fuels during postulated accident conditions.

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