Micromechanical Modelling of Ductile Damage with 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 cohesive-volumetric approach where the crack growth is modelled as a 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. On the other hand, the application of cohesive models in modelling crack growth in ductile material is still a relatively open field. One idea developed in the literature is to identify the traction separation for ductile material based on the behavior of a continuously-deforming unit cell failing by void growth and coalescence. Following this method, the present study proposed a semi-analytical cohesive model for ductile material 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) is used to model the behavior of the cohesive band and derived a corresponding traction separation law. The numerical implementation of the model is realized using the non-smooth contact method (NSCD) where cohesive models are introduced as mixed boundary conditions between each volumetric finite element. The present approach is applied to the simulation of crack growth in nuclear ferritic steel. The model provides an alternative way to simulate crack propagation using the numerical efficiency of cohesive model with a traction separation law directly derived from porous continuous model.

Keywords : ductile failure, cohesive model, GTN model, numerical simulation
Conference Title : ICFM 2018 : International Conference on Fracture Mechanics
Conference Location : Oslo, Norway
Conference Dates : June 24-25, 2019