Modelling of spallation in ductile metals using an explicit enriched finite volume scheme combined to a cohesive zone model

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ABSTRACT

Spallation is a damage and failure process occurring under shock loading. During a plate impact experiment, a projectile hits a target: shock waves propagate in both materials and then reflect in rarefaction waves on material boundaries. Their interaction induces a brutal tension in the material and triggers void nucleation, growth and coalescence, leading to spallation. Since the shock loading induces strong compression in materials, their compressible behavior has to be considered through an equation of state. A Finite Volume (FV) discretization is also convenient to capture the density variation along shock propagation.

This work aims at simulating the failure resulting from such a plate impact in ductile metals ($\approx 300\,m.s^{-1}$). The waves propagation is calculated by the FV explicit dynamics Wilkins scheme [1]. Finite Element failure treatments have thus been adapted on the FV discretization. The damage process leading to spallation is represented by a ductile cohesive zone model, following [2]. Failure is simulated by a displacement jump inside the material continuum, using the phantom node method, which is based on Hansbo & Hansbo formalism [3], to allow a discontinuity creation and treatment independent on mesh characteristics. Note that this approach is in fact equivalent to the Heaviside enrichment of the eXtended Finite Element Method (XFEM) [4] with different meaning of the degrees of freedom [5]. The combination between cohesive model and enrichment enables to simulate material degradation and the spall opening without any *a priori* assumptions on the fracture path.

The adaptation of the enrichment method and cohesive zone model into the 2D Wilkins scheme are presented in this work. Influence of the cohesive model on the material degradation representation is discussed, regarding different meshes. Finally, results from simulation are compared with experimental free surfaces velocities, illustrating the relevance of the proposed model to simulate a plate impact experiment.

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