Dynamic fracture and spallation via hyperbolic models of hyperelastic solids

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February 3, 2017

A mathematical model for an arbitrary number of interacting hyperelastic solids undergoing large elastic-plastic deformations is derived. The specific energy of each solid is given in separable form: it is the sum of a hydrodynamic part of the energy depending only on the density and entropy, and an elastic part of the energy which is unaffected by the volume change. In particular, it allows us to naturally pass to the fluid description in the limit of vanishing shear modulus [1-3].

The Eulerian numerical method, called diffuse interface method, is developed. The method considers the interface cells as an artificial mixture zone through which the interface conditions must be satisfied. Thus, the interface between a solid and a fluid is a diffuse zone, but this diffusion is negligible for a short time interval. The main advantage of this approach is to solve the same equations with the same numerical scheme in the whole computational domain including the vicinity of the interfaces. The boundary conditions at the interfaces are included naturally in the model formulation. In spite of a large number of governing equations ($15 \times N$, where N is the number of solids), the model has a quite simple mathematical structure: it is a duplication of a single visco-plastic equations augmented by a micro-structure modelling in the interface zone. The model is well posed both mathematically and thermodynamically: it is hyperbolic and compatible with the second law of thermodynamics.

The modelling of the spallation process in metals is, in particular, presented.

This is a joint work with N. Favrie, S. Hank, S. Ndanou and J. Massoni.

References

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