A CARTESIAN GRID METHOD FOR MULTIMATERIAL IMPACT, PENETRATION, AND VOID COLLAPSE

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Computer codes used in the study of high-speed impact can roughly be classified as Eulerian or Lagrangian, depending on whether the material flows through a fixed mesh or, the mesh follows the deformation of the solid. Both approaches have been used under the broad classification of *hydrocodes* to investigate large deformation problems involving high-speed multimaterial interactions. The advantages and disadvantages of each approach have been comprehensively reviewed by [1].

We present an Eulerian, *sharp interface*, fixed Cartesian grid method for the numerical simulation of high-speed multimaterial impact, in particular, the response of elasto-viscoplastic solids to projectile impact, shocks and detonation. The conservation of mass, momentum, and energy equations along with evolution equations for deviatoric stresses and equivalent plastic strain are cast in Eulerian conservation law form. The equation of state for pressure is the Mie-Gruneisen equation and the material models considered are the Prandtl-Reuss and Johnson-Cook models. For the range of materials and impact velocities of interest, eigenvalue analysis indicates that the resulting system of equations is hyperbolic. Due to large strain rates and gradients arising from the propagation of elasto-plastic waves, it is necessary to employ shock-capturing schemes that provide stable solutions in the presence of the moving boundaries. We use high-order accurate ENO [2] shock-capturing schemes along with a particle level set technique [3] to evolve sharp immersed boundaries. The proposed numerical technique shows the ability to handle collisions between multiple level sets and accurate computation of fluxes at the immersed boundaries without resorting to subcell resolution. We demonstrate that the method is simple, can be extended to three-dimensions and is capable of tackling the following physical phenomena encountered during impact:

- Nonlinear wave-propagation and the development of shocks in the materials.
- Elasto-plastic behavior of the shocked material, including rate-dependent plasticity through the radial return algorithm.
- Large deformations, including changes of topology during perforation of targets and collapse of voids.

Results of calculations for axisymmetric Taylor bar impact and penetration of a Tungsten rod into steel plate show excellent agreement with moving finite element solutions. Qualitative agreement with literature is shown for void collapsing process in an impacted material containing a spherical void.

References

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