A NEW APPROACH FOR MULTI-MATERIAL CELLS IN CELL-CENTERED HYDRODYNAMICS

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We present a new method of treating multi-material cells in a cell-centered hydrodynamic (CCH) formulation [1, 2] suitable for simulating compressible flows on 3D unstructured meshes and involving materials with constitutive models. At each node a multi-material, multidirectional Riemann-like problem is solved incorporating contributions from each of the cell corners adjacent to the node. While CCH methods typically use constant or linear reconstructions, we use a full quadratic polynomial to represent the material stress field in the cell, constructed using only information from face-neighboring cells. A quadratic polynomial is created for each material in the cell. There are two common approaches for reconstructing the velocity and stress fields in a multimaterial cell. The first approach reconstructs the volume-fraction average fields. The second approach reconstructs the fields for each material present in the cell. We propose a hybrid approach that combines these two approaches together. In this work, the higher-order polynomial reconstructions incorporate a discrete Mach number as a smoothness indicator [3] to reduce the reconstruction towards a piecewise constant field near discontinuities preventing artificial extrema. The accuracy and robustness of the new multi-material CCH approach is demonstrated by simulating a suite of 3D Cartesian test problems, each involving two materials on a non-conformal mesh, including the Sod, Sedov, and triple point problems for gas dynamics, as well as the Verney spherical compression problem for solid dynamics.

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