Multi-material interface schemes for ALE codes

A. J. Barlow
Atomic Weapons Establishment, Aldermaston, Reading, RG7 4PR, UK

CORVUS is a 2D multi-material Arbitrary Lagrangian Eulerian (ALE) hydrocode, which employs a staggered grid hydro scheme with the timestep split into separate Lagrangian and advection phases. It provides the option of two interface treatments Lagrangian slide lines (Barlow 2000) and a multi-material cell scheme (Barlow 1997). The multi-material cell scheme is used when material interfaces undergo high deformation. A volume of fluid (VOF) representation is used in the multi-material cells where the fractional cell volume and thermodynamic states are stored for each material component. The introduction of multi-material cells poses a number of problems. Most researchers have focussed on the issues assosciated with multi-material advection, such as how to reconstruct material interfaces and use the reconstructed interface in advecting state variables.

In contrast this paper is concerned with the treatment of multi-material cells during the Lagrangian phase. The main difficulties in this case are how to accurately determine the thermodynamic states of the individual material components and the nodal forces that such zones generate, given the lack of information about the velocity distribution within the multi-material cells. A new Lagrangian multi-material cell scheme has recently been developed by the author which addresses these issues and has been implemented in CORVUS (Barlow 2001). The scheme adjusts the volume fractions during each Lagrangian step in an attempt to emulate the behaviour of separate Lagrangian subzones. This provides an interface treatment that is accurate and robust for all types of grid motion from Lagrangian to Eulerian. It also provides a natural framework for introducing interface physics.

A key aspect of the new scheme is the sub-zonal model used to estimate the velocity of the constructed interface with respect to the frame of reference of each multi-material cell. It will be shown that this can be derived from the Lagrangian equations of motion by applying an approximate Riemann solver. The definition used for the average cell pressure in the new scheme will also be revisited and given further physical justification. Although the scheme was developed assuming a PdV update to increment the internal energy, it will also be shown that the scheme can also be used with a compatible work based internal energy update with minor modifications. The rest of the talk will then focus on the issues involved in extending the multi-material cell scheme to provide a consistent treatment of void closure and of elastic-plastic flow within multi-material cells.

References

Barlow AJ,Whittle J (2000) Mesh Adaptivity and Material Interface Algorithms. Chem. Phys. Reports 19(2) 233-258

Barlow AJ (1997) ALE in CORVUS. Proceedings of New Models and Numerical Codes for Shock Wave Processes in Condesed Media, Oxford,1997,581-596.

Barlow AJ (2001) A New Lagrangian scheme for multi-material cells. Proceeding of the European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS) Computational Fluid Dynamics Conference 2001 Swansea, Wales UK, 4-7 September 2001.