8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

FLUID-STRUCTURE INTERACTION SIMULATION OF SHOCK WAVE IMPACT ON SOLID STRUCTURES

Ralf Deiterding
Oak Ridge National Laboratory
P.O. Box 2008 MS 6367, Oak Ridge, TN 37831-6367, U.S.A.
deiterdingr@ornl.gov and http://www.csm.ornl.gov/∼r2v

Key Words: *Hyperbolic Problems, Fluid-Structure Interaction, Wave Propagation Methods*

ABSTRACT

The impact of shock waves on solid materials can cause large structural deformations, fracture and fragmentation. Coupled fluid-structure interaction simulations are very challenging, because numerical methods have to cope with complex topology evolutions. We present an approach to coupling that uses a level set function for implicit geometry representation and is particularly robust [1,2].

The compressible fluid flow is simulated with a high-resolution shock-capturing Cartesian finite volume upwind method in Eulerian coordinates that considers the solid as a moving embedded body based on the current level set information. The structural response is calculated with problem-specific finite element schemes in Lagrangian coordinates. A loosely coupling temporal splitting method is applied to update the boundary's positions and velocities between time steps. The Eulerian finite volume scheme is incorporated into a parallel structured dynamic mesh adaptation algorithm that allows very fine local resolutions to capture the near-body interaction and incoming waves in the fluid at minimal computational costs (see [1] for details).

After presentation of several verification and validation examples driven by shock and detonation waves in gases, we focus particularly on the additional challenges from considering shocks in liquids instead. We detail the derivation of a positivity preserving multiphase wave propagation scheme, including simple cavitation modeling, that enabled the reliable computation of thin aluminum plates ruptured by water hammer [2,3]. Further on, we report on first efforts in simulating the elastic deformation of the mercury-filled target vessel of Oak Ridge National Laboratory's Spallation Neutron Source (SNS). In the SNS target, a strong shock wave is created by thermal expansion of mercury whenever the pulsating high energy proton beam penetrates the target to induce the nuclear spallation reaction. Accurate simulation of the consequences of these shock waves have turned out to be crucial for structural design and particular cavitation control.

REFERENCES

[1] R. Deiterding, R. Radovitzky, S. P. Mauch, L. Noels, J. C. Cummings, and D. I. Meiron. “A Virtual Test Facility for the efficient simulation of solid materials under high energy shock wave loading”, *Engineering with Computers*, Vol. **22(3-4)**, 325–347, 2006.

[2] F. Cirak, R. Deiterding, and S. P. Mauch. “Large-scale fluid-structure interaction simulation of viscoplastic and fracturing thin shells subjected to shocks and detonations”. *Computers & Structures*, Vol. **85(11-14)**, 1049–1065, 2006.

[3] R. Deiterding, F. Cirak, S. P. Mauch, and D. I. Meiron. “A virtual test facility for simulating detonation-induced fracture of thin flexible shells”. *Int. J. Multiscale Computational Engineering*, Vol. **5(1)**, 47–63, 2007.