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

SIMULATION OF HIGH-VELOCITY IMPACT IN FLUID-FILLED VESSELS WITH ADAPTIVE SPH-FE COUPLING

Martin Sauer, Uwe Scheffer,
Klaus Thoma

Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institute (EMI)
Eckerstrasse 4, 79104 Freiburg, Germany
e-mail*:* *martin.sauer@emi.fraunhofer.de*, www.emi.fraunhofer.de

Key Words: *Meshless Methods, SPH, Impact, Fluid-Structure Interaction, Hydraulic Ram.*

ABSTRACT

Although conventional SPH algorithms have drawbacks such as tensile instability and difficulties in boundary conditions, they are useful for specific purposes and therefore also implemented in commercial codes. One of these specific purposes is the application in hypervelocity impact computations, see eg. [1], for development of shielding structures for satellites or space stations against micrometeorite and debris impact.

Recently, Johnson & Beissel have shown applications of an adaptive coupling of SPH Particles and Finite Elements in the sense that deformed elements are replaced by particles. This has been shown to be useful for several impact and penetration problems: pure Finite Element simulations suffer from the necessity of eroding elements at some level of deformation, and pure SPH Simulations suffer from long computation times and sometimes stability problems. A similar form of coupling has been presented by Sauer in [3]. It was successfully used e.g. in [4] for the mesomechanical simulation of crushing aluminum foams.

In the current paper, the applicability of the method to high-speed impact of projectiles on water-filled vessels is investigated. In such problems, a hydraulic ram occurs which may lead to a rapid destruction of the vessel's hull. In order to get a good representation of the real physical effects in a simulation, it is essential to model the correct transfer of momentum from the projectile to the fluid. Three different modeling strategies, which are all implemented in EMI's own research code SOPHIA, are being explained and compared with each other and with experimental results:

1) Lagrangian Finite Elements in combination with an erosion algorithm for vessel hull, fluid and projectile
2) Lagrangian Finite Elements with an erosion algorithm for vessel hull, fluid and projectile, eroded elements are replaced by mass points which only interact with Finite Element surfaces
3) Lagrangian Finite Elements with adaptive conversion to SPH particles for vessel hull, fluid and projectile.

These three strategies are assessed in terms of the quality of the results, robustness and computational efficiency.

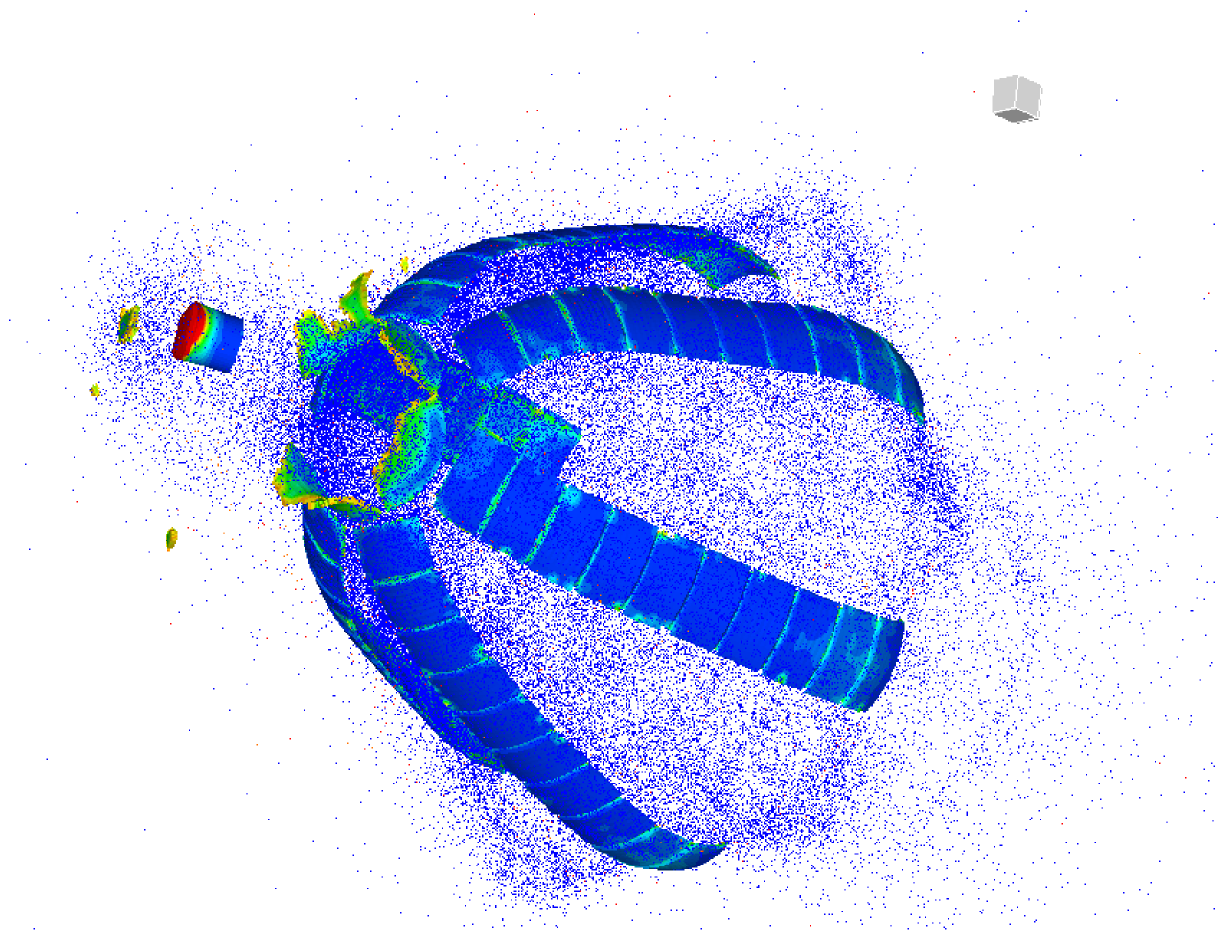

Figure: Impact on a water-filled, pre-notched container, simulated with FE/SPH adaptivity.

REFERENCES

[1] S. J. Hiermaier, W Riedel, R A Clegg, C J Hayhurst, *Advanced Material Models for Hypervelocity Impact Simulations*, Final Report, ESA/ESTEC Contract No. 12400/97/NL/PA(SC), 1999.

[2] G. R. Johnson, R. A. Stryk, "Conversion of 3D Distorted Particles During Dynamic Deformation", *International Journal of Impact Engineering* **28,** pp. 947-966, (2003).

[3] M. Sauer, S. Hiermaier, J. Peter, K. Thoma, "Modelling the Continuum/Discrete Transition using Adaptive Meshfree Methods", *Proceedings of the Fifth World Congress on Computational Mechanics*, WCCM V, Vienna, Austria, 07.-12.07.2002. http:\\wccm.tuwien.ac.at

[4] M. Wicklein, K. Thoma, "Numerical Investigations of the Elastic and Plastic Behaviour of an Open-cell Aluminium Foam", *Materials Science and Engineering*, **A 397,** pp. 391-399, (2005).