Coupling of non-Newtonian meshless flow with structural solver

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ABSTRACT

Lagrangian and meshless methods are often employed to simulate violent flows with complex free surface evolutions. Therefore, they are naturally capable of coupling with structural solvers to simulate nonlinear fluid–structure interactions (FSI) with large deformations. Moreover, non-Newtonian fluids and granular flows may be simulated as continuums with large time steps in the meshless Lagrangian context. Therefore, the aim of this study is to investigate the coupling process of non-Newtonian meshless Lagrangian methods and Finite Element Method (FEM) solvers.

The coupling process is based on a validated Lagrangian Differencing Dynamics (LDD) flow solver, but it can be applied to any mesh-free Lagrangian solver. The flow solver is volume–conservative, second–order accurate, and works directly on triangulated geometry. The solver is implemented in a way that particles adjacent to walls are projected onto them, and boundary conditions for the pressure and velocity are imposed on those projections. This makes transferring of the deformed geometry straightforward. As the adjacent fluid particles lie along projections' wall normals, the advantage of straightforwardly obtaining normal and tangential stresses along walls is discussed. Moreover, appropriate boundary conditions for the pressure and velocity equations are also discussed, which need to be imposed on dynamically deforming walls.

preCICE, an open-source coupling library, is used to set-up partitioned bidirectional coupling of flow and the open-source FEM solver, named CalculiX. During the simulation the structure motion is imposed, the fluid stresses on the structure are applied in the structural equations-of-motion, and the deformations are brought back to the fluid solver. The coupling is validated by simulating viscoelastic fluid in a cavity with deformable walls, and by simulating a dam break with elastic gate clamped at one end and a non-Newtonian fluid.

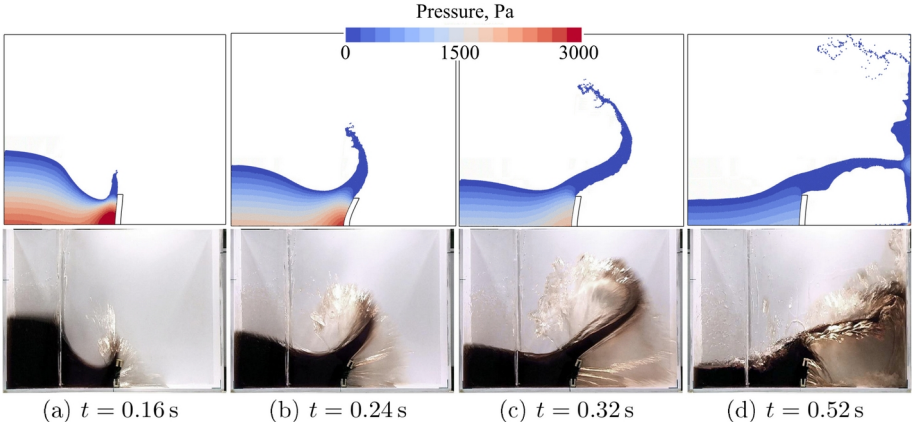

Figure 1. Snapshots of a FSI dam-break experiment. Numerical solution is plotted with pressure contours (top row), and the obtained free surface shape and obstacle deformation are compared to the experimental images (bottom row).

REFERENCES

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