The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Particle Finite Element Method for 2D/3D Fluid-Structure Interactions, including Contact Interactions

M. Lacroix[1*], S. Février[1], R. Boman[2], J.-F. Remacle[3] and J.-P. Ponthot[2]

[1] University of Liège, Belgium, *martin.lacroix@uliege.be*, https://www.uliege.be
[2] University of Liège, Belgium, *jp.ponthot@uliege.be*, http://www.ltas-mnl.ulg.ac.be
[3] University of Louvain, Belgium, *jean-francois.remacle@uclouvain.be*, https://uclouvain.be

Keywords: *Particle Finite Element Method, Fluid-Structure Interaction, Free Surface Flows, Large Deformations of Solids, Contact Mechanics.*

The present work focuses on the simulation of 2D and 3D Fluid-Structure Interaction (FSI) problems involving fluid free surfaces, large deformations of solids including plasticity and solid-solid contact mechanics, incompressible and weakly compressible flows. The considered approach is the partitioned coupling between two independent solvers, one for the fluid and one for the solid. The two solvers are precompiled and wrapped in Python objects that are called by the coupling algorithm using the Dirichlet-Neumann paradigm [1]. In particular, the new fluid solver uses a Particle Finite Element Method (PFEM), an adaptive mesh-based Lagrangian algorithm allowing a straightforward tracking of the free surface and deformation of the fluid domain [2]. The solid solver uses a nonlinear finite element algorithm with an updated Lagrangian formalism [3]. In this work, the codes previously developed in [1, 2] have been extended for performing 3D FSI simulations. In addition, we enable a faster resolution of existing 2D problems as well as new test cases featuring an additional complexity. Notably, one of our main challenges is the numerical efficiency of the algorithms, where both the quality of remeshing procedure and the execution time of the codes are key factors for the reliability and accuracy of the solution. In addition to a discussion about the concepts presented above, this presentation will include, but will not be limited to, some examples and comparisons between 2D/3D FSI simulations such as the displacement and deformation of solid walls due an incident fluid flow or solid-solid contacts between debris in a pipe.

REFERENCES

[1] M.L Cerquaglia et al. "A fully Partitioned Lagrangian Framework for FSI Problems Characterized by Free Surfaces, Large Solid Deformations and Displacements, and Strong Added-Mass Effects". *Computer Methods in Applied Mechanics and Engineering*, Vol. **348**, 2005.

[2] S. Février. "Development of a 3D Compressible flow Solver for PFEM Fluid Simulations". Unpublished master's thesis, the University of Liège, Belgium, 2020.

[3] Metafor, a nonlinear finite element solver. MN2L group at the University of Liège. http://metafor.ltas.ulg.ac.be