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APPLICATIONS OF THE PARTICLE FINITE ELEMENT METHOD FOR 3D FLUID-STRUCTURE INTERACTIONS AND MULTIPHYSICS SIMULATIONS

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ABSTRACT

The present work focuses on the partitioned coupling between a structural solver based on the Finite Element Method (FEM) and a fluid solver based on the Particle Finite Element Method (PFEM) (Idelsohn, Oñate and del Pin, 2004) in order to simulate thermo-mechanical Fluid-Structure (FS) interactions involving free surface flows and large deformations of the solid. The coupling is performed by transferring nodal information (such as the heat flux, the mechanical load, the nodal temperature and the nodal displacement) between the two solvers, under the form of Neumann-Dirichlet boundary conditions imposed at the fluid-structure interface. When the solid and fluid meshes are non-matching at the interface, an interpolation technique is required to transfer the nodal data from one solver to another. In particular, the Radial Basis Function (RBF) interpolation is considered for its flexibility and its efficiency (Lacroix et al. 2024).

The use of different solvers aims at combining their individual potentials for simulating complex physics (such as phase change and free-surface flows on the fluid side, or rupture and contact mechanics on the solid side) while exchanging a minimum amount of information between the two solvers to achieve the coupling (Cerquaglia et al. 2019). The presentation starts with a brief introduction to the basic principles of the PFEM and the Neumann-Dirichlet partitioned coupling, followed by a discussion regarding the mesh-interpolation technique. Notably, the interpolation step and the detection of the FS interface is challenging when the boundaries of the fluid and of the solid evolve in their topology due to large deformations, rupture of finite elements or local mesh refinement. Finally, our presentation includes some examples of applications of the FPEM in friction melt bonding, water-jet cutting or frictional contact between debris in a pipe.