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A POSITIONAL PFEM FORMULATION FOR SOLVING FREE SURFACE FLOW AND FSI PROBLEMS

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Abstract. There are two mainly used approaches for coupling solid and fluid, the moving mesh and nonmoving mesh methods. In the first approach, arbitrary Lagrangian–Eulerian or space–time methods are employed to allow fluid mesh to deform and follow the moving structure, however such methods are not able to handle directly problems with very large displacements causing topology changes (TC) in the flow domain, like waves breaking over structures. In the second approach, immersed-boundary methods are used to allow the structure to move over a mesh that is not following the interface, being a practical way in flow problems with TC, however, it might involve numerical problems due to the conditions imposed at the immersed boundary. A more recent alternative is the particle-finite element method (PFEM), associating a Lagrangian finite element modeling of the fluid to particle method. The positional finite element method, developed in the same academic environment where this project is proposed, uses a total Lagrangian framework and naturally includes the geometric non linearity effects due to the use of nodal positions as main variables instead of displacements. Such formulation seems ideal for association with particle concepts, considering particle positions as main variables. Thus, we propose to model the fluid also using a Lagrangian framework by considering it as a set of particles which interaction forces are computed through positional finite element method each time step. To make it possible, a new mesh must be periodically constructed based on particles positions and the Lagrangian reference must be updated. Finally, a Dirichlet-Neumann coupling scheme can be employed with no need of extra techniques since the motion of both fluid and solid domain is described by means of a Lagrangian reference.

Keywords: Fluid-structure interaction, Free surface flow, Particle finite element method, Positional finite element method.