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UNIFIED LAGRANGIAN FORMULATION FOR FLUID-STRUCTURE INTERACTION PROBLEMS WITH THERMAL COUPLING USING PFEM

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We present a unified Lagrangian formulation for fluid-structure interaction (FSI) problems. The fluid is modelled using the PFEM [1] and a quasi-incompressible formulation [2]. The fluid and the solid have the same unknown variables, the same time integration scheme and the same solution strategy. In this way, it is possible to solve the FSI problem by a monolithic scheme and without the risk of having ill conditioned matrices. The pressure and velocity fields are interpolated using linear shape functions. Therefore, a stabilization of the Navier-Stokes equations is needed. In this work, a new version of the FIC stabilization technique [2] is used. The unified formulation with PFEM can be easily coupled with a heat transfer problem for the analysis of thermal-mechanical problems in fluids, solids and FSI.

The formulation has been tested first solving fluid and solid problems separately. The fluid solver has been verified, both in 2D and 3D, simulating typical problems for free surface flows, as the sloshing of water in a rectangular tank, the collapse of a water column against a rigid step or multiple dam breaks. The numerical results have swown a good agreement both with the anaytical solutions and the experimental results. Furthermore, it has been shown that the method guarantees the conservation of mass of the fluid domain also in critical free surface problems.
The solid formulation has been verified in a huge number of large displacements 2D and 3D dynamic problems, as the benchmark test presented in [3]. In all the analyzed problems, the numerical results converge to the expected solutions.

The efficiency of the unified algorithm for FSI problems has been checked in various sample cases, such as the collapse of a water column on elastic object solved in [5] or the fall of a nylon ball into a water tank [6]. The comparison of the numerical results with

the reference ones is totally satisfactory, in 2D as in 3D.

Concerning the thermal coupling, the simple problems have been solved showed the potentiality of the unifed formulation with PFEM to solve FSI problems coupled with heat transer for modelling the melting of solids.

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