Unified stabilized formulation for thermally coupled fluid-structure interaction problems using the PFEM

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ABSTRACT

We present a unified stabilized formulation for solving the thermo-coupled mechanics in a general domain that may include compressible or quasi-incompressible solids, fluids or both. The global problem is solved via a mixed Velocity-Pressure Lagrangian formulation. For each time step the linear momentum and the continuity equations are solved iteratively until the achievement of the convergence using a Gauss-Seidel partitioned scheme.

Linear shape functions are used for both velocity and pressure fields. For the solution of incompressible materials the formulation is stabilized using the updated version of the Finite Calculus (FIC) technique presented and validated in [1].

The fluid is modelled using the PFEM [2] and a Newtonian quasi-incompressible model [3]. On the other hand, the solid is solved with the classical FEM using a hypoelastic constitutive law.

The unified formulation allows us the solution of FSI problems through a monolithic scheme in which solids and fluids are solved within the same linear system. This guarantees a strongly coupled solution to the FSI problem.

The coupling with the heat transfer is ensured through a staggered scheme [4], [5]. It will be shown that the PFEM-based unified formulation is suitable for solving thermal problems involving phase change of materials.

Several numerical examples are presented showing the validity of the unified PFEM-based formulation for solving coupled thermal-mechanical and FSI problems.

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