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An enhanced finite volume based solver for thermoelastic materials in fluid-structure coupled problems

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Fluid-structure interaction (FSI) problems can be solved numerically by partitioned algorithms in which the structure is described by a Lagrangian approach whereas a conforming mesh with an Arbitrary Lagrangian-Eulerian formulation is employed for the fluid. An enhanced finite volume structural solver, with emphasis on convergence acceleration of the linearized system resolution, is proposed to be used in the semi-implicit partitioned FSI method [1]. In this manner, a common finite volume framework is used for both domains, ensuring a consistent coupling strategy and a conservative resolution of the governing equations.

The 3D thermoelasticity equations of the solid are solved with a parallel computing platform, which uses the trapezoidal rule for the time integration and a second-order cell-centred scheme for the spatial discretization. The displacements in the vertices are obtained by linear interpolation and used to directly evaluate the gradient and stresses on the cell faces, and to move the mesh in case an Updated Lagrangian approach is followed. The linearized system resolution can be addressed by two different procedures. The first relates to the segregated method, which has been traditionally adopted in finite-volume solid solvers, but with the addition of a relaxation technique. The second methodology is based on the work developed in [2], where the displacement inter-component dependencies are collected in a unique block-coupled system to speed up the solution convergence.

The work first presents a comprehensive description of the thermoelastic model. Then, the two linear system arrangements are tested with typical elastic benchmarks [2] with an extension to transient conditions, showing significant savings in computational time without compromising the solution accuracy. This is of great importance taking into account the fluid-structure iterative resolution involved in partitioned algorithms.

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