PIMPLE ALGORITHM AND PARTITIONED FSI SOLVERS

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Fluid-Structure Interaction (FSI) simulations are often confronted with numerical stability problems especially in the case of strong interactions between fluid and solid, typically found when an incompressible fluid is interacting with light solids. The numerical instability usually grows with factors influencing the nature of the interactions–decreasing ratio of the fluid-to-solid density, increasing fluid viscosity and decreasing solid stiffness.
The reduced time step size as well leads to increased numerical instability. However, small time step sizes are an issue in problems with huge length scale differences in the flow domain where the stability of the flow solver is limited by the Courant number. The time step size imposed by the flow solver can introduce a hard limit on the whole FSI simulation especially when transient effects over long times are being investigated.
The usual solution for the partitioned FSI solvers necessitates a strong coupling between the fluid flow and structure modules. In this context the FSI problem can be viewed as a fix-point problem of the interface position and such be solved by fix-point iterations. The Aitken relaxation is often used to improve stability and convergence of the strong coupling. The implementation of the strong coupling in the OpenFOAM solvers is based on the PIMPLE algorithm loop that enables more passes over not fully converged solutions per time step. However there is much more potential hidden in the implementation of the PIMPLE algorithm in the current, foam-extend-3.2, partitioned OpenFOAM solvers.
The paper presents an improved implementation of the PIMPLE algorithm for the partitioned FSI solvers that:

- increases the numerical stability of the FSI simulation
- improves the FSI convergence
- overcomes the Courant number limitation imposed on the flow solver

The proposed algorithm has been used to stabilize the transient FSI simulation of a hydrodynamic bearing system where length scales differences in orders of magnitudes can be found.

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