Compressible Flow Turbomachinery Simulations with OpenFOAM

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Computational Fluid Dynamics (CFD) simulations allow researchers to acquire knowledge of the turbomachinery internal flow. OpenFOAM is an open source library for Computational Continuum Mechanics in which several CFD solvers are implemented. Being cost-free and allowing one to modify the code are important reasons that make OpenFOAM attractive to researchers. However, there is little work published about the use of OpenFOAM in turbomachinery, particularly regarding compressible flow. In this paper, a methodology to run compressible turbomachinery calculations with OpenFOAM is proposed.

In order to deal with compressible flow, a segregated compressible solver is developed from a merged PISO-SIMPLE incompressible solver with sliding mesh capability. Moreover, some enhanced features as variable under relaxation factors and variable tolerances, which improve the convergence behavior of the case, are also applied. The new solver is compared with other compressible solvers in a benchmark problem to evaluate its performance.

The different available boundary conditions are assessed. Multiple Reference Frame and Sliding Grid simulations are performed with the developed compressible solver. Both strategies are used in combination with the General Grid Interface included in the OpenFOAM-extend project. A comparison between simulations computed with the new solver with their equivalent in ANSYS-Fluent is also addressed. The results are analyzed qualitatively, using velocity vectors and fluid variables contours, and quantitatively, providing surface integrations (torque, surface averages, mass flow, etc.). Finally, the issue of parallel performance is addressed. In light of these results, the described methodology can be used for the characterization of turbomachinery working under compressible flow conditions.

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