A coupled finite volume solver for the solution of laminar and turbulent incompressible flows

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Abstract

This work reports a newly developed fully coupled pressure-based algorithm for the solution of laminar and turbulent incompressible flows exploiting OpenFOAM topology and operators.

The implicit pressure-velocity coupling is accomplished by deriving a pressure equation in a procedure similar to a segregated pressure correction SIMPLE algorithm, using the Rhie-Chow interpolation technique and assembling the coefficients of the momentum and continuity equations into one diagonally dominant matrix. This procedure eliminates the pressure correction step of the SIMPLE-like algorithm, consequently the calculation time can be reduced with much faster convergence speed and much higher relaxation factors.

The extended matrix of continuity and momentum equations is solved simultaneously using an external tool based on PETSc libraries.

Turbulence is modeled by means of the k-ωSST model and energy equation is solved as well.

The behavior of the coupled approach is compared to the segregated approach and experimental data both in laminar and turbulent regimes. Test cases were chosen among the most common test cases for code and turbulence modeling validation, including 3D tests for heat transfer analysis. Performance are analyzed in terms of computational costs, convergence speed and accuracy of results.

The test results demonstrate superior convergence for both laminar and turbulent flow simulations at the expense of increasing peak memory usage.

Key words: Solver, coupled, pressure-based

References

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The authors suggest that this work is presented in one of the following sessions, in order of significance:

1. New Solvers