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Density Based Navier Stokes Solver for Transonic Flows

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Riemann Solver, Slope Limiter, Time Stepping, MRF/SRF, FSI/CHT

A new density based Navier-Stokes solver for laminar and turbulent transonic flows was developed. Such solvers are in general better suited for transonic and supersonic flows, as segregated pressure based ones which are available as standard solvers in OpenFOAM. A faster convergence and more accuracy are expected from this new type of solver. The solver is based on a generic Godunov flux type class in order to handle different Riemann solvers. Up to now two different flavours of Riemann solvers are implemented in OpenFOAM, the Roe [Roe81] and the HLLC scheme [BLG97].

A second order extension [WS95] was added to the Godunov flux class. Therefore additional slope limiters were implemented. Some one dimensional flux limiters like MinMod, vanLeer or vanAlaba were rewritten as slope limiter. Furthermore the multidimensional Barth-Jespersen [BJ89] and Venkatakrishnan [Ven95] slope limiters are available.

For a fast steady state convergence a second order low storage Runge-Kutta scheme with local time stepping [MJM89] was implemented. A dual time stepping approach [ALP93] for unsteady calculations was also introduced. Additionally new boundary conditions for subsonic inlets were needed for temperature and velocity, otherwise spurious pressure reflections were encountered.

Furthermore the SRF and MRF [LBL04] formulation for rotating turbomachineries were implemented. The *icoFsiFoam* solver was merged with this new flow solver in order to implement a new compressible transonic FSI solver. This new solver supports also thermal stresses. It could therefore also be used as a standalone transonic CHT solver.

For non rotating problems the flow solver was tested with two different numerical test cases [WC84] and [Ni82]. Figure 1 shows the Mach number distribution for the second test case. Additional tests were performed with the SRF and MRF implementation for rotating transonic turbomachines. A validation test case for the CHT/FSI version of the new solver will be also presented.

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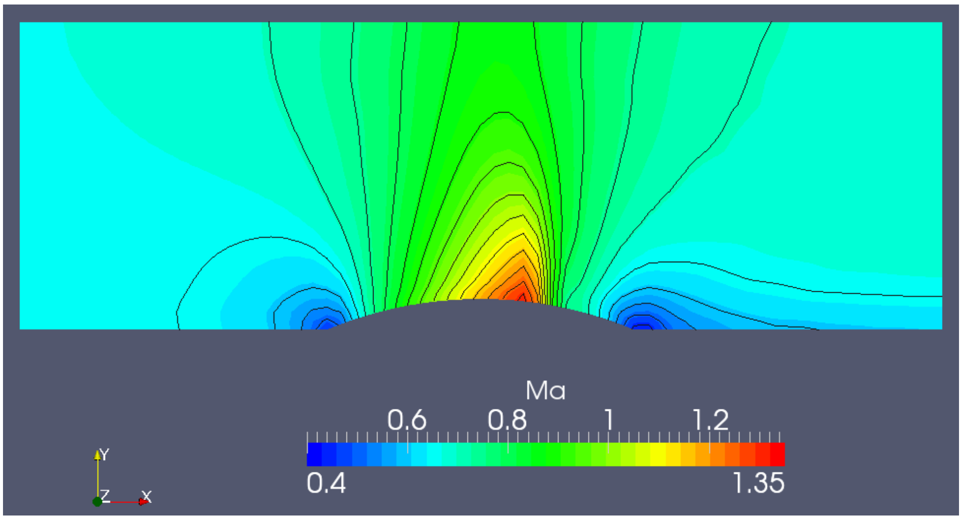

Figure 1: Bump Test Case

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