IMPLEMENTATION OF PRESSURE-CORRECTION ALGORITHM WITH AUSM INTO OPENFOAM

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Introduction

OpenFOAM is open source software that can solve a wide range of problems in continuum mechanics. The OpenFOAM package comes with ready made implicit solvers for compressible flows (sonicFoam, rhoSimplecFoam, etc.) which utilize the so called pressure correction approach, and one explicit solver (rhoCentralFoam) based on coupled solution of Euler or Navier-Stokes equations in conservative form. The recently presented paper [1] has involved own implementation of explicit AUSM method named explicitAUSMFoam. AUSM [2] is known as a simple, robust and first order accurate method. ExplicitAUSMFoam is well suited for calculations of transonic flows for its accurate capturing shocks, but the convergence behaviour requires impractically small time steps. Consequently, the acoustic terms were treated implicitly following the approach proposed by Dick and Nerinckx [3] and the system of equations became semi-implicit. The fully segregated pressure-correction algorithm was implemented (as implicitAUSMFoam) due restriction on perfect gas without heat transfer.

Results and conclusions

The implicitAUSMFoam was applied for solving 2D and 3D inviscid transonic flows through a GAMM channel. Figure 1 illustrates the geometry of channels. Inlet boundary conditions are: total pressure $p_0 = 100\,\mathrm{kPa}$, total temperature $T_0 = 293.15\,\mathrm{K}$ and homogeneous Neumann condition for velocity. At the outlet are: static pressure $p_2 = 73.7\,\mathrm{kPa}$ and homogeneous Neumann conditions for velocity and temperature. The rest of boundaries are non-permeable walls. The 2D numerical solution (Fig. 2) is compared with those obtained with explicitAUSMFoam, sonicFoam (PISO algorithm) and rhoSimplecFoam (SIMPLEC algorithm). Finally, it is obvious, that implicitAUSMFoam and explicitAUSMFoam give nearly identical results with better shock capturing than standard solvers. These first results confirm that our implementation of AUSM into OpenFOAM is effective tool for 2D as well as 3D transonic flow problems. The future developments aim to improve accuracy and compatibility with some boundary conditions.

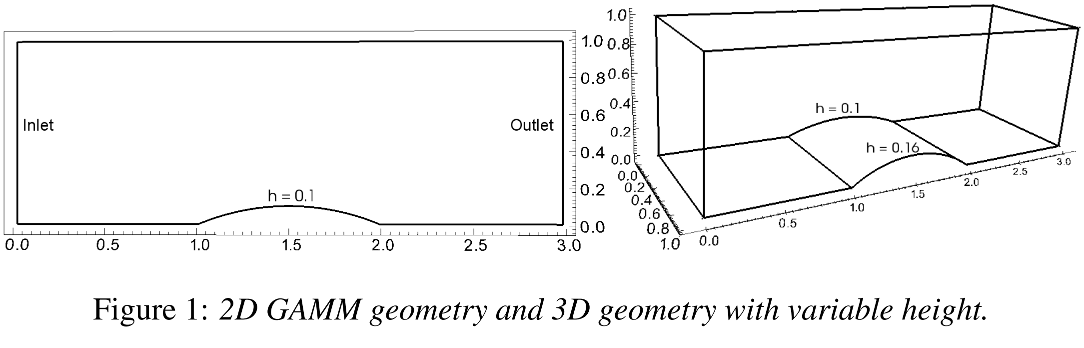

Figure 1: *2D GAMM geometry and 3D geometry with variable height.*

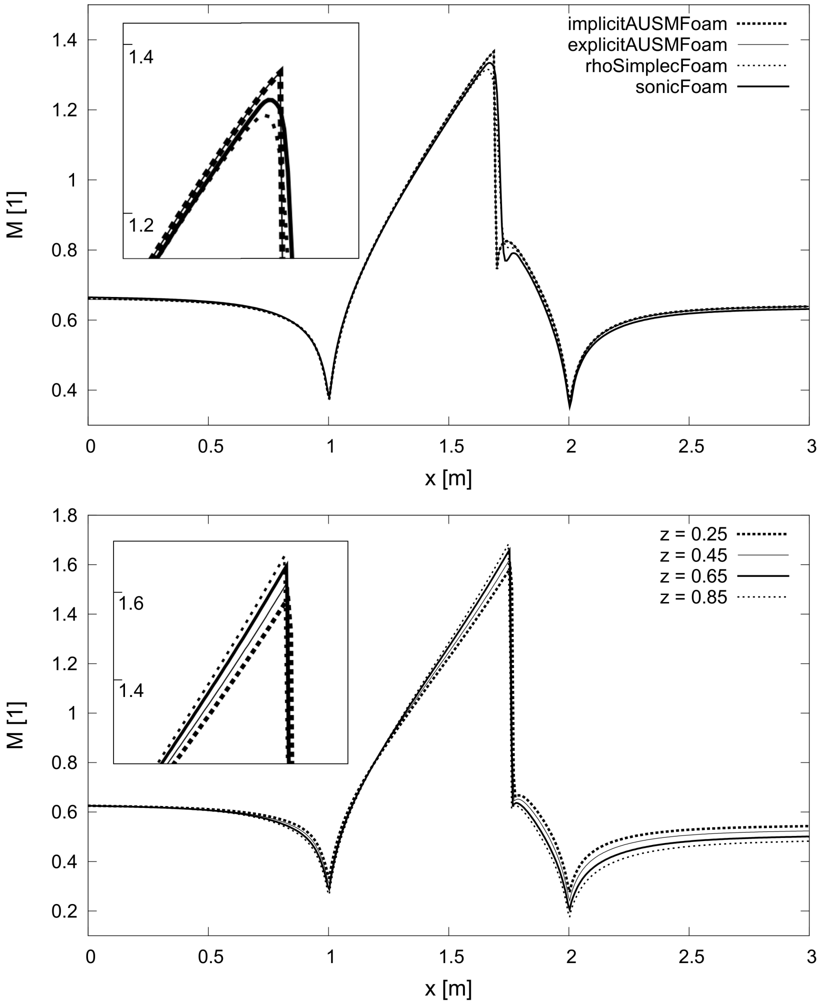

Figure 2: *Mach number distribution along a lower wall 2D channel (above, structured quadrilateral grid with 150x50 cells) and 3D channel (below, structured hexahedral grid 150x50x30 cells). First-order accurate in space and time.*

References

[1] Martin Kožíšek, Jiří Fürst, Implementation of Explicit Advection Upstream Splitting Method into OpenFoam. Topical Problems of Fluid Mechanics 2012, p. 65-66.

[2] M.-S. Liou, Mass flux schemes and connection to shock instability, JCP 160 (2000) 623-648.

[3] Krista Nerinckx, Jan Vierendeels, Erik Dick: Mach-uniformity through the coupled pressure and temperature correction algorithm, JCP 206 (2005).

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