The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

A Time-Staggered CFD Scheme for Moist Air Variable Density Flow

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Keywords: *CFD, Compressible, Incompressible, Moist Air*

We present a conservative second order staggered time scheme for dry and moist variable density air flow implemented in the open source CFD solver code_saturne. The staggered time arrangement introduced by Pierce and Moin [1] is extended to finite volumes and discontinuous solutions. An Helmholtz equation is solved in order include the thermodynamical pressure variation and to remove the acoustic CFL restriction. The internal energy equation supplemented by a corrective source term based on the kinetic energy dissipation [2] is solved, allowing the scheme to be consistent with discontinuous solutions. The water phase change is treated by considering thermodynamical equilibrium. Dalton's law is used to compute the density and the temperature is obtained from the internal energy equation, solving with Newton's method in case of phase change. A numerical analysis is presented to insure the positivity of the thermodynamic variables, followed by the scheme verification and validation. First, dry air cases are presented: a natural convection and shock cases are used to verify its accuracy related to singularities and buoyancy effects. Moreover, a pressure cooker like system shows the scheme good reproduction of pressure variations and correct time error convergences rates. Finally, the moist air module is verified against analytical cases.

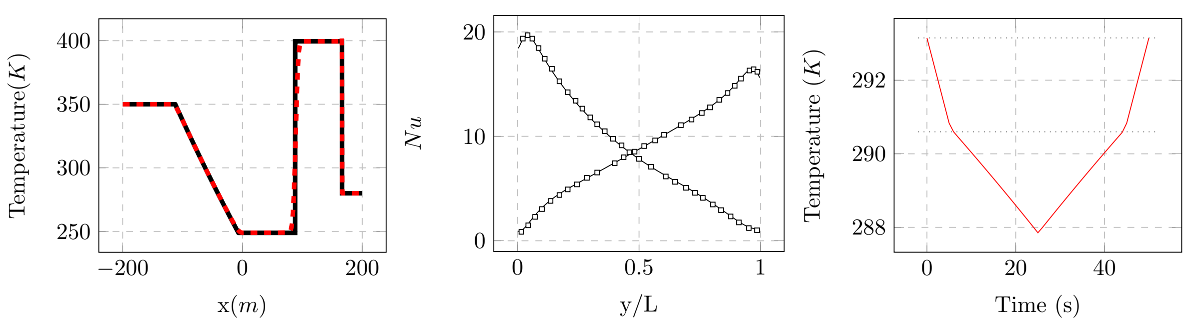

Figure 1: Left: Shock case result (–) Exact solution (–) Simulation. Centre: Convection case result. (o) Reference result (–) Simulation. Right: Moist air verification case result.

REFERENCES

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