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

PRESSURE POISSON FRACTIONAL-STEP SCHEMES FOR INCOMPRESSIBLE TWO-PHASE FLOWS: ELIMINATING ARTIFICIAL BOUNDARY CONDITIONS AND INF-SUP COMPATIBILITY RESTRICTIONS

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Key Words: *Split-step schemes, Fractional-step methods, Two-phase flow, Finite Element Method, Incompressible flow.*

Due to discontinuities in fluid parameters and flow quantities, incompressible fluid flows with more than one phase impose various difficulties to standard numerical methods. Moreover, the different natures of the unknowns – velocity, pressure and discontinuity marker – can be a challenge when designing efficient solution processes. Although coupled solvers are sometimes used [1], so-called *projection methods* are more popular in numerical practice [2]. These algorithms decouple the pressure, velocity and density/levelset/colour-function approximations in time, allowing a simpler, more efficient solution of the individual equations. When a finite element discretisation is used, however, such algorithms have an inherent drawback: we must settle for either spurious pressure boundary layers or an LBB compatibility restriction on the discrete pressure and velocity spaces. In this context, we present here a novel approach to deal with these issues in a simple, efficient way. The basis for our split-step framework is a pressure Poisson equation (PPE) with fully consistent boundary conditions, enforcing incompressibility without the need for Leray projections. More specifically, we extend our recent variable-viscosity PPE [3] to flows with also *non-constant density*. This contribution will present both the basic steps and ingredients of our approach and numerical tests showcasing its potential.

REFERENCES

[1] Landet, T., Mardal, K.-A. and Mortensen, M. Slope limiting the velocity field in a discontinuous Galerkin divergence-free two-phase flow solver. *Computers and Fluids* (2020) **196**: 104322.

[2] Guermond, J.-L. and Quartapelle, L. A projection FEM for variable density incompressible flows. *Journal of Computational Physics* (2000) **165**: 167-188.

[3] Pacheco, D.R.Q., Schussnig, R. and Fries, T.-P. An efficient split-step framework for non-Newtonian incompressible flow problems with consistent pressure boundary conditions. *Computer Methods in Applied Mechanics and Engineering* (2021) **382**: 113888.