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

AN ENERGY-PRESERVING UNCONDITIONALLY STABLE FRACTIONAL STEP METHOD ON COLLOCATED GRIDS

D. Santos[1], F.X. Trias[1], G. Colomer[1], A. Oliva[1]

[1]Heat and Mass Transfer Technological Center,
Technical University of Catalonia, C/Colom 11, 08222 Terrassa (Barcelona)
daniel.santos.serrano@upc.edu, francesc.xavier.trias@upc.edu
guillem.colomer@upc.edu, asensio.oliva@upc.edu

Keywords: *Collocated meshes, Gradient, FSM, Stability, Interpolation*

The solution adopted by most of the principal CFD codes such as OpenFOAM or ANSYS-FLUENT are finite-volume discretizations on unstructured meshes. These discretizations are usually preferred over staggered ones due to its simplicity, but some errors arise from this approach, such as an improper gradient formulation for pressure correction. Besides, many discretizations for the gradient operator have been proposed, but some of them do not conserve energy or lead to an unstable pressure gradient solution, especially for high aspect ratio meshes. In this framework, a continuous-mimicking property argument[1] is used to find a proper symmetry-preserving gradient. It turns out to be the same gradient found by Trias et. al. [2], adopted in order to achieve conservation of energy:

$$G = -\Omega_s^{-1} M^*, \tag{1}$$

where G is the cell-to-face discrete gradient operator, Ω_s is a diagonal matrix containing the staggered volumes and M is the face-to-cell discrete divergence operator. Then, a fully-conservative discretization method for unstructured grids proposed in [2] is used to study the stability of the pressure gradient[3]. Using the same notation as [2], the velocity correction reads:

$$\mathbf{u}_c^{n+1} = \mathbf{u}_c^p - \Gamma_{s\to c} G p_c, \tag{2}$$

where $\mathbf{u}_c$ is the collocated velocity, p_c is the cell-centered pressure, and $\Gamma_{s\to c}$ is the face-to-cell interpolator. The interpolation stability was studied in [3]. Finally, a new way of studying mesh rotations and its stability is introduced.

REFERENCES

[1] J. J. Kreeft, Mimetic spectral element method; a discretization of geometry and physics. *Doctoral thesis*, Fac. of Aerospace Eng., TU Delft, ISBN 9789461919281

[2] F. X. Trias, O. Lehmkuhl, A. Oliva, C.D. Pérez-Segarra, and R.W.C.P. Verstappen., Symmetry-preserving discretization of Navier-Stokes equations on collocated unstructured meshes. *Journal of Computational Physics*, 258:246–267, 2014.

[3] D. Santos, J. Muela, N. Valle, F.X. Trias, On the Interpolation Problem for the Poisson Equation on Collocated Meshes. *14th WCCM-ECCOMAS Congress 2020*, DOI: 10.23967/wccm-eccomas.2020.257