14th World Congress on Computational Mechanics (WCCM)
ECCOMAS Congress 2020
19–24 July 2020, Paris, France

ENERGY-PRESERVING DISCRETISATION FOR LES/DNS WITH UNSTRUCTURED COLLOCATED GRIDS IN OPENFOAM

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Key Words: Finite volume, unstructured, symmetry-preserving, numerical dissipation, projection, PISO

Given its advantages for complex solution domains, the unstructured finite volume collocated grid approach is widely used in industry in codes such as ANSYS-FLUENT, STAR-CCM+, OpenFOAM® and Code-Saturn. In such codes, the pressure Poisson equation is standardly solved using a compact stencil. This compact stencil suppresses the well-known checkerboard problem. However, the application of the compact stencil in the pressure Poisson equation introduces a kinetic energy conservation error of $O(\Delta t \Delta h^2)$, causing a reduction of the order of accuracy of the applied temporal schemes to first order. Furthermore, for typical LES mesh resolutions, the introduced numerical dissipation is larger than the SGS dissipation rate, making explicit LES modelling not effective [1].

Improved numerical methods are used in the present study in order to eliminate the introduced numerical dissipation. As the base method, we use the symmetry-preserving discretisation of [2], which we implemented in OpenFOAM. Next, this base method is extended by implementing a family of explicit and diagonally implicit Runge-Kutta temporal schemes. Furthermore, we assess the application of more accurate variants of the standardly used predictor steps in the applied projection method for explicit time integrations and the applied PISO method for implicit time integration. In addition, we use a modified PISO approach based on a pressure correction instead of the total pressure. It is shown that a pressure correction-based PISO approach reduces the numerical dissipation significantly. Results are presented for the Taylor-Green vortex, lid-driven cavity flow, and turbulent channel flow. The presented methods and their ability to reduce numerical dissipation on collocated unstructured meshes is deemed a relevant contribution towards successful industrial application of LES or DNS to real-world problems.

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