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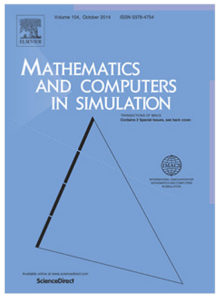

A case-study in open-source CFD code verification. Part II: boundary condition non-orthogonal correction

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A case-study in open-source CFD code verification. Part II: boundary condition non-orthogonal correction.

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Abstract

This investigation constitutes the follow-up to a previous work in which we applied the manufactured solution procedure to verify the OpenFOAM diffusion operator on different types of meshes. Theoretical convergence orders were observed for Poisson's equation solver on orthogonal hexahedral grids using several boundary conditions. We noticed that on non-orthogonal grids even slight mesh distortions reduce the theoretical second order convergence rate to first order. Our investigation showed that this loss in convergence order takes place when Dirichlet and/or Neumman boundary conditions are used on non-orthogonal meshes. In this paper, we introduce ways to achieve theoretical second order convergence accuracy, mainly based on applying non-orthogonal correction to Dirichlet and/or Neumann boundary condition schemes. A peculiarity was discovered for the Least-Squares gradient scheme that slightly affects second-order convergence, and which we attribute to the non-orthogonal correction at boundaries in the Least-Squares vector reconstruction library. The verification procedure is performed using the method of manufactured solutions for the Poisson equation and an analytical solution, the SIMPLE solver, for the Navier-Stokes equations. The average and maximum error norms were used to calculate the convergence rate. Comparative results are presented.

Keywords: Verification, manufactured solution, OpenFOAM, Poisson equation, Navier-Stokes equations.

1. Introduction

OpenFOAM®, a trademark of The OpenFOAM Foundation, is free, open source Computational Fluid Dynamics (CFD) software that is widely used in both industry and academia. The number of flow simulations based on this tool has grown considerably in recent years, particularly in academia. The theoretical foundation for OpenFOAM is the finite volume method (FVM), which is a well-known approach for solving a variety

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