Conference in Numerical Analysis 2014 (NumAn 2014)
September 2-5, 2014
Chania,Greece

A MultiGrid accelerated high-order pressure correction compact scheme for incompressible Navier-Stokes solvers

V.G. Mandikas[a], E.N. Mathioudakis[a], G.V. Kozyrakis[b,c], J.A. Ekaterinaris[d] and N.A. Kampanis[b]

[a]Applied Mathematics and Computers Laboratory, Technical University of Crete, University Campus, 73132 Chania, Hellas

[b]Institute of Applied and Computational Mathematics, Foundation for Research and Technology - Hellas, 70013 Heraklion, Crete, Hellas

[c]Department of Marine Sciences, University of the Aegean, University Hill, Mytilene 81100, Hellas

[d]Department of Aerospace Engineering, Daytona Beach College of Engineering, Embry-Riddle Aeronautical University, 600 S. Clyde Morris Blvd., Daytona Beach FL 32114, USA

bmandikas@science.tuc.gr, manolis@amcl.tuc.gr
gkoz@iacm.forth.gr, ekaterin@iacm.forth.gr
kampanis@iacm.forth.gr

Abstract

A high-order accurate compact finite-difference numerical scheme, based on multigrid techniques, is constructed on staggered grids in order to develop an efficient incompressible Navier-Stokes solver. The enforcement of the incompressibility condition by solving a Poisson-type equation at each time step is commonly accepted to be the most computationally demanding part of the global pressure correction procedure of a numerical method. Since the efficiency of the overall algorithm depends on the Poisson solver, a multigrid acceleration technique coupled with compact high-order descretization scheme is implemented to accelerate the iterative procedure of the pressure updates and enhance computational efficiency. The employment of geometric multigrid techniques on staggered grids has an intrinsic difficulty, since the coarse grids do not constitute part of the finer grids. Appropriate boundary closure formulas are developed for the cell-centered pressure approximations of the boundary conditions. Performance investigations demonstrate that the proposed multigrid algorithm can significantly accelerate the numerical solution process, while retaining the high order of accuracy of the numerical method even for high Reynolds number flows.

Key words: Global pressure correction, Poisson type equation, Incompressible Navier-Stokes equations, High-order compact schemes, staggered grids, Geometric MultiGrid techniques.