

## A HYBRID MULTIGRID METHOD FOR THE STEADY-STATE INCOMPRESSIBLE NAVIER-STOKES EQUATIONS \*

MICHAEL PERNICE<sup>†</sup>

**Abstract.** Multigrid methods for solving the steady-state incompressible Navier-Stokes equations require an appropriate smoother and coarse grid solution strategy to be effective. Classical pressure-correction methods, such as SIMPLE and SIMPLER, are widely used as solvers in engineering analysis codes, but can also be used as effective multigrid smoothers. An inexact Newton method preconditioned by a linear multigrid method with a pressure-correction smoother can serve as a coarse grid solver. A hybrid nonlinear multigrid scheme based on combinations of these components is described. A standard benchmark problem is used to demonstrate the effectiveness of SIMPLER smoothing and the impact an inexact Newton coarse grid solver has on the resulting nonlinear multigrid scheme.

**Key words.** multigrid, Newton-Krylov methods, pressure-correction methods, incompressible fluid dynamics.

**AMS subject classifications.** 65N55, 65H10.

---

\*Received May 25, 1999. Accepted for publication February 1, 2000. Recommended by J. Dendy. Work supported by Reaction Engineering International, Salt Lake City, Utah through funding from the Department of Energy Office of Energy Research under grant DE-FG03-96ER82268; the University of Utah Center for the Simulation of Accidental Fires & Explosions, funded by the Department of Energy, Lawrence Livermore National Laboratory, under subcontract B341493; and the University of Utah Center for High Performance Computing.

<sup>†</sup>Center for High Performance Computing, University of Utah, Salt Lake City, Utah 84112-9050.