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An Assessment of Some Solvers for Saddle Point Problems Emerging from the Incompressible Navier–Stokes Equations

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Abstract

Efficient incompressible flow simulations, using inf-sup stable pairs of finite element spaces, require the application of efficient solvers for the arising linear saddle point problems. This paper presents an assessment of different solvers: the sparse direct solver UMFPACK, the flexible GMRES (FGMRES) method with different coupled multigrid preconditioners, and FGMRES with Least Squares Commutator (LSC) preconditioners. The assessment is performed for steady-state and time-dependent flows around cylinders in 2d and 3d. Several pairs of inf-sup stable finite element spaces with second order velocity and first order pressure are used. It turns out that for the steady-state problems often FGMRES with an appropriate multigrid preconditioner was the most efficient method on finer grids. For the time-dependent problems, FGMRES with LSC preconditioners that use an inexact iterative solution of the velocity subproblem worked best for smaller time steps.

Keywords: linear saddle point problems, inf-sup stable pairs of finite element spaces, UMFPACK, flexible GMRES, coupled multigrid preconditioners with Vanka smoother, Least Squares Commutator preconditioners

1. Introduction

Inf-sup stable finite element methods are a popular approach for the spatial discretization of incompressible flow problems. Within a Picard or Newton-type

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