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A comparison of preconditioners for industrial incompressible flows

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ABSTRACT

We consider solution methods for large systems of linear equations that arise from the finite element discretization of the incompressible Navier-Stokes equations. These systems are of the so-called saddle point type, which means that there is a large block of zeros on the main diagonal. To solve these type of systems efficiently, several block preconditioners have been published. These type of preconditioners require adaptation of standard finite element packages. The alternative, is to apply a standard ILU preconditioner, in combination with a suitable renumbering of unknowns. We introduce a reordering technique for the degrees of freedom, which makes the application of ILU relatively fast. The resulting method is denoted as SILU (Saddle point ILU).

We compare the performance of SILU with some block preconditioners. The performance appears to depend on grid size, Reynolds number and quality of the mesh. For medium sized problems, which are of practical interest, we show that the reordering technique is competitive with the block preconditioners. Its simple implementation, makes it worthwhile to implement in standard FEM software.

In large sized problems, in combination with stretched grids, the block preconditioners have a better convergence behavior. In this paper we consider the following block preconditioners: the pressure convection diffusion (PCD), least squares commutator (LSC), and augmented Lagrangian based (AL) preconditioners. We also include SIMPLE(R) preconditioners in our comparison.

We first compare these preconditioners for academic problems generated by the IFISS package. Thereafter, we compare the best preconditioners for industrial problems using the SEPRAN FEM package.

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