PRECONDITIONED ITERATIVE METHODS BASED ON DUAL VARIABLE REDUCTION FOR SOLVING THE THREE-DIMENSIONAL POTENTIAL FLUID FLOW PROBLEM.

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Abstract: In this contribution we consider symmetric indefinite saddle-point problems arising from mixed-hybrid finite element discretization of the stationary fluid flow problem. We propose solution techniques based on computation of the null-space basis of the whole or of a part of the left lower off-diagonal block in the system matrix. Such solution techniques are mainly motivated by the need to solve a sequence of such systems with the same mesh but different material properties.

The general framework of dual variable methods covers a couple of approaches. On one hand, a fundamental cycle null-space basis of the whole off-diagonal block based on the spanning tree of an associated graph can be constructed. Note that at the continuous level, such basis can be obtained from curls of appropriate vector potentials. It is shown that this basis may be theoretically rather ill-conditioned. On the other hand, the orthogonal null-space basis of its sub-block that enforces continuity over faces be easily constructed. In the former case, the resulting projected system is symmetric positive definite and so the conjugate gradient method can be applied. The projected system in the latter case remains indefinite and the preconditioned minimal residual method should be used. Rates of convergence in these cases are discussed and the efficiency of preconditioned solvers is compared in numerical experiments. The whole solution strategy based on transformation to the system for dual variables is also compared with other approaches. The comparison indicates that the dual variable approach can be better than primal solution strategy for systems with ill-conditioned hydraulic permeability tensor.

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