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Fully-coupled Geomechanics and Flow with Embedded Meshes

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Geomechanical effects can have a first-order effect on production from naturally and hydraulically fractured reservoirs. Unstructured discrete fracture-matrix methods utilize conforming meshes with fractures represented by N-1 dimensional elements with local mesh refinement about them. Numerous coupled mechanics and flow models are employed on such mesh topologies. While these methods can offer attractive properties in terms of accuracy, they do rely on the availability powerful mesh generators. Moreover, their application to fracture propagation modeling requires mesh adaptivity. Embedded mesh methods on the other hand aim to couple independently constructed meshes for the matrix and fractures without the need for the meshes to conform. One timely challenge is the design of accurate and efficient numerical schemes for coupled mechanics and multiphase flow.
In this work, a hybrid discretization is proposed; pEDFM (projection-based embedded discrete fracture) is adopted for multiphase flow and is fully-coupled (monolithic) to an extended finite element method (XFEM) for geomechanics. Three aspects of the scheme are analyzed: accuracy, nonlinear solvability, and the efficacy of linear preconditioners for the resulting linearized residual systems. The grid refinement is performed to test the convergence rates for different physical variables (pressure, saturation and displacement). We use the block LDU factorization so that two different AMG (algebraic multigrid method) for XFEM and EDFM can be applied separately. AMG will be called whenever it is required by the outer loop solver, FGMRES.

References

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