A New Approach To Improve Linear Solver Performance for a Fully Implicit Coupled System of Reservoir and Surface Network

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Abstract

In a fully-integrated reservoir and surface-facilities simulator, the overlapping multiplicative Schwarz method was chosen to solve the coupled system, using the perforated grid blocks as the overlapping layer. In many cases, it was found that this overlapping approach did not improve the global linear-solver performance, and the matrix for the extended-surface network, which included the perforated grid blocks, was much larger, denser, and lost its original tree structure, which taxed the linear solver for the network. Furthermore, the pressure solver for the reservoir domain was totally decoupled from the network domain. Such a loose coupling in the pressure solution led to disappointing performance. In most cases, the accuracy of the pressure solution across the reservoir and surface network directly determines the performance of the global linear solve, so it is crucial to define an appropriate global pressure matrix to represent the flow exchange between these two domains.

Taking advantage of new formulations for a generalized network model of wells and facilities, in which node-based variables, pressure, and component compositions are chosen as the primary variables, instead of mixed-node and connection-based variables, algebraic methods are designed to reduce the full-system matrix, involving pressure and component masses for the reservoir domain and pressure and component compositions for the network domain, to a pressure-only matrix. This global pressure matrix works as the first-stage preconditioning matrix in a two-stage solution method. For the reservoir domain, a widely-used IMPES-like reduction method was implemented. This paper focuses on methods to construct the pressure matrix for the network domain and coupling matrices between those two domains.