Solving the Linear Equation in Reservoir Simulation

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Reservoir simulation has progressed significantly over the last twenty years and is becoming increasingly sophisticated, so that solving the linear equations arising in Newtons step is more and more challenging. Simulators nowadays generate Jacobian matrices with a much more complex structure than the constant-bandwidth fixed-block size structure, and with a much more complex physic involved. Solver dedicated to reservoir simulation needs to take into account the particular issues of reservoir simulation, as anisotropy, important heterogeneities, flow barriers, lack of symmetry An overview of features that increase the Jacobian complexity is given. Point-Gauss Siedel has been the first used technique to solve the linear system, but due to aspect ratio, Line-Gauss Siedel with additive correction has been proven much more efficient in reservoir simulation, but still couldnt handle flow barriers. Cheshire and Appleyards Nested Factorization is highly analogous to those techniques, but ensures that material balance is preserved exactly within each plane of the reservoir and not only globally on the complete grid. This is the reason why Nested Factorization is a much powerful approximation to handle flow barriers and has been the standard solution, used as a preconditioner of any Krylov space methods, for solving the reservoir simulation linear system in reservoir simulators developed in the past. New generation simulator taking into account massive parallel computer structure, solver research has been dedicated upon that during last decade. John Wallis Constant Pressure Residual technique (CPR) is a two-stages preconditioner where pressure is solved alone during the first stage, improving efficiency over large and very heterogeneous cases. Indeed, pressure has an elliptic behavior while other variables are much more hyperbolic, so using two different preconditioning techniques makes sense. Parallel CPR with Adaptive Multi Grid (AMG) for first stage and Incomplete LU factorization (ILU) for second stage is becoming the standard solution for large grids.

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