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A Multigrid Coupled DEIM Method for High-Efficient Simulation of Compressible Gas Porous Flow

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Abstract: In natural gas engineering, the numerical simulation plays a significant role in the exploration, production and optimization of natural gas reservoir. However, numerical simulations of compressible gas flow in porous media are always expensive due to the gas compressibility and nonlinear properties. To save the computational cost, in this work we present a multigrid coupled discrete empirical interpolation method (MG-DEIM) to speedup the simulation of compressible gas porous flow. In this MG-DEIM framework, the core idea is that the multigrid method based on the full approximate scheme (FAS) is used to solve the flow equation (a pressure equation); for the gas equation of state (EOS) that describes pressure as a function of temperature and volume, the discrete empirical interpolation method [1, 2] is applied to reduce the model order substantially in which the gas EOS is only solved on selected interpolation points. The computational efficiency and numerical accuracy of MG-DEIM method are carefully tested and validated by an unsteady compressible gas flow in the porous medium considering the Peng-Robinson (P-R) EOS. Results show that compared to conventional approaches, the MG-DEIM method offers an attractive speedup without sacrificing the accuracy obviously. In addition, the effects of restriction operator, smooth number and the number of interpolation points on computational speedup are investigated in detail.

Keywords: Multigrid; DEIM; Compressible gas flow; Porous media; P-R EOS

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