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Robust algorithms for stability analysis and flash calculation of reservoir fluids at constant moles, volume and temperature

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Accurate modeling and robust computation of the phase behavior is essential for optimal design and cost-effective operations in petroleum reservoirs as well as in petroleum processing plants, where we need to understand the fluid flow of partially miscible multi-component multi-phase mixture in free spaces or in porous media. Phase behavior calculation of fluid mixture consists of stability analysis and flash equilibrium calculation. The goal of the NVT stability analysis is to determine whether a phase is stable at specified volume, temperature, and mole numbers. If it is not stable, the NVT flash equilibrium calculation is to establish the composition and amount of each stable phase after phase splitting. Conventional algorithms for stability analysis and flash calculation are based on fixed-point iteration, Newton-type iteration, or their combination, and the convergence has never been guaranteed. In this work, we propose an energy-stable iterative method for NVT stability analysis and NVT flash equilibrium calculation. We consider fluid mixture modeled by the Peng-Robinson equation of state, and our proposed algorithm is an iterative algorithm motivated from the dynamics of two-phase fluid system with Fick's law of diffusion for multi-component fluids. The proposed iterative procedure is proven to be energy stable under certain conditions. Numerical examples are tested to demonstrate efficiency and robustness of the proposed method. We also discuss the extension of the algorithm to NVT flash in multiple spatial dimensions, which can be used to model the interface of nonzero thickness between two phases.

References

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