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CO2 Fluid Properties Parametrization for Accurate Heat, Solubility and Transport Model

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As an alternative to water, supercritical carbon dioxide (CO2) has higher mobility and heat capacity to be used for heat extraction from geothermal reservoirs, while also trapping most of the injected CO2 underground to reduce carbon emissions and mitigate climate change. CO2 capture, utilization, and storage (CCUS) in geothermal reservoirs has become an attractive option for circular carbon economy models for governments and green energy business decision takers. Therefore precise fluid property parametrization and modeling workflows are essential for CCUS simulations to reach the right economic decisions.

CO2 injection in a saline aquifer is a multi-phase flow problem where scientists have to take into account the multi-component fluid flow and heat transport. For many multi-phase flow systems, viscosity plays an important role; hence it characterizes the fluids' resistance to flow (mobility) and the displacement rate of other fluids in the reservoir. In cases of injecting CO2 in thick, deep, saline aquifers, where the changes in pressure and temperature are considerably high, the viscosity of the injected fluid is also changing significantly in reservoir conditions. Moreover, the mutual solubility of CO2 and water has many obvious implications for long-term carbon sequestration and fluid-rock-heat interactions, which also changes with pressure and temperature. Therefore fluid properties, especially the viscosity and solubility of CO2, is critical to be prescribed precisely in the expected ranges of pressure and temperature of reservoir conditions.

We prescribed the CO2 viscosity based on the National Institute of Standards and Technology (NIST) database (https://webbook.nist.gov/chemistry/fluid/) and mutual solubility of CO2 and water based on the published laboratory experiments. We used the CMG STARS simulator as main solver, which has excellent performance in calculating heat exchange between fluids and rocks, and often is used to simulate thermal recovery processes in oilfields. To validate our results of viscosity and solubility inputs, we compare our model results with simulation results from compositional simulators CMG GEM and TOUGH2. These compositional simulators use their inbuilt libraries for fluid properties and their own interpolation algorithms (empirical relationships) for changing viscosity and solubility in defined P-T ranges. We then check the CO2 saturation and pressure results for different model scenarios in both CMG STARS, CMG GEM, and TOUGH2 to validate our main modeling approach in CMG STARS.

The comparison study and results show that our modeling technique achieves equivalent saturation and pressure values in the same injection production scenarios compared to verification simulators (CMG GEM and TOUGH2), where it outperforms by fully coupling the solubility and enthalpy. This modeling approach gives us the flexibility to prescribe fluid parameters that change at different pressure, temperature and brine concentrations. The model results reveal how the dense mixture of dissolved CO2 and formation brine moves in the reservoir and thus affects the reservoir's heat recovery scheme in long term.

Participation

In-Person

References

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