A Screening Model for CO_2 Flooding and Storage in Gulf Coast Reservoirs Based on Dimensionless Groups

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Abstract

Concerns over global warming have led to interest in removing greenhouse gases, specifically CO2, from the atmosphere. Sequestration of CO2 in oil reservoirs as part of enhanced oil recovery (EOR) projects is one method that is being considered.

This paper first presents the scaling groups necessary to describe CO2 flooding for a typical line-drive pattern and then uses these groups in a Box-Behnken experimental design to create a screening model most applicable to candidate Gulf Coast reservoirs (Box and Behnken 1960). By generating oil recovery and CO2 storage curves, the model estimates the cumulative oil recovery and CO2 storage potential for a given reservoir. Past screening models—Rivas et al. (1992) and Diaz et al. (1996)—focused only on oil recovery and simply assigned qualitative rankings to reservoirs. Models that did include quantitative results, including CO2 Prophet (Dobitz and Prieditis 1994) and the CO2 Predictive Model (Paul et al. 1984), did not include the effects of dip. This model focuses on both oil recovery and CO2 storage potential, produces quantitative results for each, and includes the effects of dip.

This model quickly estimates the oil recovery and CO2 storage potential for a reservoir. Operators can quickly screen large databases of reservoirs to identify the best candidates for CO2 flooding and storage. The scaling groups also provide the basis for future models that may be more specific to other regions.

The results show that continuous CO2 flooding can be fully described using 10 dimensionless groups: aspect ratio, dip angle group, water and CO2 mobility ratios, buoyancy number, dimensionless injection and producing pressures, residual oil saturation to water and gas, and initial oil saturation. The effects of capillary forces and dispersion were secondary effects in this model and were not included in the scaling. Dimensionless oil recovery was effectively modeled with the dimensionless oil breakthrough time and the dimensionless recovery at three different dimensionless times, while CO2 storage potential was calculated only at the final dimensionless time. The reservoir-specific parameters discussed above were calculated from response surface fits. The scaling does not work as well at small buoyancy numbers; however, it is effective in the range of values typical of Gulf Coast reservoirs.