Improvement of Sweep Efficiency in Gas Flooding

DE-FC26-04NT15535

Goal

The goal of this work is to evaluate sweep efficiency of various miscible flooding processes in a laboratory model, develop numerical tools to estimate sweep efficiency at the field scale, and identify solvent composition, mobility control method, and well architecture that improve sweep efficiency.

Performer

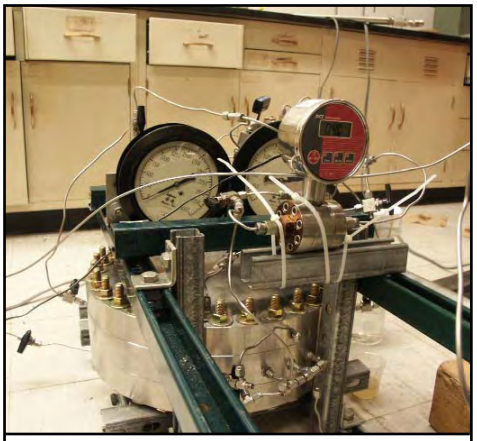
University of Houston
Houston, TX

Results

A high-pressure quarter five-spot cell has been constructed in this work to conduct multicontact miscible water-alternating-gas (WAG) displacements at reservoir conditions. Multicontact miscible solvents are identified by conducting slimtube experiments for a medium-viscosity oil (78 cp). Coreflood experiments were conducted to determine microscopic displacement efficiency as a function of WAG ratio. Quarter five-spot experiments are conducted to infer sweep efficiency in a 3-D geometry at the laboratory scale. WAG improves the microscopic displacement efficiency compared with a program of continuous gas injection followed by waterflood in corefloods. WAG improves the oil recovery and thus sweep efficiency in the quarter five-spot over the continuous gas injection followed by waterflood. Gas breakthrough is delayed by WAG injection. A decrease in the slug size improves the sweep. Above minimum miscibility pressure (MMP)—as the reservoir pressure decreases—the gas-flood followed by waterflood recovery increases, possibly because of high oil viscosity. An inverted nine-spot improves gas-flood oil recovery slightly vs. a five-spot. In WAG floods as the total solvent injected drops, so does oil recovery, but not very drastically. Use of a horizontal production well lowers the sweep over a vertical production well during both continuous gas injection and WAG floods.

Benefits

The experimental data on sweep efficiency help evaluate multicontact miscible flooding processes at the laboratory scale. Reservoir simulators should be tuned to such experiments before being used for field-scale process optimization. The methodology developed in this project would help improve miscible oil recovery projects.



Front view of the quarter 5-spot high-pressure cell.

Background

Miscible and near-miscible gas flooding has proven to be one of the few cost-effective enhanced oil recovery techniques in the past 20 years. The sweep efficiency of such processes often is not high because of the adverse viscosity ratio and density difference between the solvent gas and the oil, as well as the reservoir heterogeneity. WAG processes often are used to improve sweep efficiency. Foams and direct thickeners have been developed but not used routinely in the field. The effect of new well architectures on sweep efficiency is poorly understood. As the scope of miscible flooding is being expanded to medium-viscosity oils in shallow sands in Alaska and shallower reservoirs in the Lower 48, there are questions about sweep efficiency in near-miscible regions. This project is aimed at evaluating the sweep efficiency of various miscible flood processes at the laboratory scale.

Summary

This project is aimed at evaluating the sweep efficiency at the laboratory scale, developing numerical tools to estimate sweep efficiency at the field scale, and identifying parameters to improve sweep efficiency.

The major achievements of this project to date are the:

- Construction of a high-pressure quarter five-spot model.
- Evaluation of sweep efficiency for WAG floods for one Alaskan oil and solvent.
- Streamline simulation of WAG floods with three-hydrocarbon-phase behavior.
- Evaluation of the effect of horizontal wells on sweep efficiency.
- Evaluation of the effect of slug size on sweep efficiency.
- Evaluation of the effect of amount of solvent on sweep efficiency.
- Evaluation of the effect of well pattern on sweep efficiency.
- Inclusion of compressibility in compositional streamline simulation.
- Inclusion of gravity in compositional streamline simulation.

Current Status (February 2007)

The project is in its second year. Researchers have completed four subtasks: slimtube tests, high-pressure model construction, corefloods, and one-dimensional compositional modeling. Three-dimensional modeling of the sweep efficiency of gas/WAG floods is in progress. Applications of other oil/solvent systems, foams, and field-scale modeling will be conducted during 2007.

Funding

This project was selected in response to DOE's Oil Exploration and Production solicitation DE-PS26-04NT15450, February 2004.

Publications

Lewis, E., Dao, E.K., and Mohanty, K.K., "Sweep Efficiency of Miscible Floods in a High Pressure Quarter Five-Spot Model," SPE 102764, SPE Annual Technical Conference and Exhibition, San Antonio, TX, September 24-27, 2006.

Dao, E.K., Lewis, E., and Mohanty, K.K., "Multicontact Miscible Flooding in a High-Pressure Quarter Five-Spot Model," SPE 97918, SPE Annual Technical Conference and Exhibition, Dallas, TX, October 9-12, 2005.

Bhambri, P., and Mohanty, K.K., "Streamline Simulation of Four-Phase WAG Processes," SPE 96940, SPE Annual Technical Conference and Exhibition, Dallas, TX, October 9-12, 2005.

Kumar, K., Dao, E., and Mohanty, K.K., "AFM Study of Mineral Wettability with Reservoir Oils," Journal of Colloid and Interface Science, 289, 2005, pp. 206-217.

Project Start: October 1, 2004
Project End: September 30, 2007

Anticipated DOE Contribution: $618,017
Performer Contribution: $157,634 (20 percent of total)

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