Foam Barriers Against Gas Coning:
Physical-Model and Mechanistic Simulation Study

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Abstract:

Gas coning contributes to unfavorably high gas/oil ratio (GOR) in reservoirs with a gas cap. We investigate a novel treatment technology, currently under consideration for a field trial, for prevention of gas coning with an integrated experimental and simulation study. Experiments with oil-miscible foamer solution are performed in a partially scaled physical reservoir model that includes a gas cap. Companion mechanistic simulations are conducted with a multidimensional, multicomponent reservoir simulator incorporating a foam-bubble population balance. This simulator directly includes the kinetics of foam generation and coalescence and the role of bubble texture in reducing gas mobility.

Rapid foam generation and the formation of a barrier to gas production is demonstrated experimentally within the physical sector model and predicted numerically in zones saturated with a light-hydrocarbon, oil-miscible foamer. The barrier to gas coning is persistent and robust. Back production of surfactant occurs, but does not preclude foam barrier creation and maintenance. Further, we show experimentally and confirm numerically that gravity-assisted initial placement of the foamer near the gas/oil contact is feasible with a miscible injectant.

The mechanistic foam simulator utilizes physically-based parameters and equations to describe foam formation and propagation. Thus, the results and methods described lead to reservoir-scale predictions of process efficiency, screening of critical parameters for field application, and provide a powerful engineering tool for the design of foam-based, deep-penetration production well treatments. Critical parameters for field application are absolute reservoir permeability, the ratio of vertical to horizontal permeability, oil and injectant density and viscosity, oil zone thickness, and foam strength.

Technical Contributions:

1. The experiments verify each step of a process for creating deep-penetrating foam barriers using a field-ready foamer and a physical model partially scaled to reservoir dimensions.

2. The mechanistic foam simulator matches the complex foam generation, coalescence, and flow mechanisms in a well-controlled, multidimensional, porous-medium experiment.

3. The combination of experiments and mechanistic simulation form a good basis for predicting foam-process efficiency.

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