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How to Predict CO2 Foam Propagation Distance by Using Bubble Population Balance Model

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Although foams are known for effectively reducing gas mobility and enhancing oil recovery in many field applications, it is still not clear how far the injected fine-textured foams will propagate into the reservoirs. Lacking such a knowledge makes the design of foam field treatments difficult and often unreliable. The purpose of this study is to investigate CO2 foam propagation distance as a function of injection foam quality and injection total rate by using bubble population balance model. This study is believed to cover the steps needed from the pore-scale to field-scale events.

In order to meet the purpose, this study performs the following tasks: (i) fitting bubble population balance model to lab coreflood experiments and determining model parameters; (ii) establishing the mathematical framework to determine foam propagation distance during EOR processes; and (iii) characterizing foam propagation distance at different injection strategies. The laboratory data consists of three foam states (weak-foam, strong-foam, and intermediate states) as well as two different flow regimes (high-quality and low-quality regimes) of the strong-foam state.

The mobilization pressure gradient is one of the key model parameters to distinguish gaseous CO2 foams from supercritical CO2 foams. It is because, the mobilization pressure gradient being proportional to the interfacial tension, supercritical (or dense) CO2 foams exhibit much lower mobilization pressure gradient compared to gaseous CO2 foams, often with a couple of orders of magnitude difference.

The results show that the presence of three different foam states as well as two different strong-foam flow regimes (high-quality and low-quality regimes) plays a key role in model fit and field-scale propagation prediction. More specifically, this study finds that supercritical CO2 foams can propagate a few hundreds of feet easily, which is a few orders of magnitude higher than gaseous CO2 foams. For dry foams (or, strong foams in the high-quality regime), higher injection gas fractions result in shorter foam propagation distance, while for wet foams (or, strong foams in the low-quality regime) the propagation distance is not really sensitive to injection gas fractions. In addition, the higher injection rates (or pressures), the farther foams propagate – such an effect is shown to be much more pronounced for dry foams.

References

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