

Upscaling of Heterogeneous Core Plug Model Using Effective Medium Theory for Coreflooding Simulation

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Abstract

1. OBJECTIVE/SCOPE

Core flooding simulation is an important tool for studying the displacement efficiency and recovery potential of a recovery process. Most core flooding simulations are conducted on homogeneous models, but the presence of heterogeneity could cause a significant difference in the core flooding performance. This work introduces a geometric-based approach to building an upscaled carbonate core plug model that preserves good heterogeneity for coreflooding simulations.

2. METHODS, PROCEDURES, PROCESS

This work aims to offer a method to create upscaled heterogeneous core plug models in a cheap and efficient manner. The proposed workflow includes three main steps. The first step is using the effective medium approximation (EMA) method with pore geometries of CT images to build a digital rock model. Unlike previous works using empirical correlations to recalibrate permeability, the proposed method considers the grid connectivity in core flooding simulation so that the reconstructed model preserves good heterogeneity without nonphysical overshoots or undershoots. Second, we will evaluate the effective permeability of the upscaled model and simulate alternated water and polymer flooding to reproduce the recovery profile on a real carbonate core sample. In the end, a sensitivity analysis is performed to study the upscaling effect on numerical core flooding simulation.

3. RESULTS, OBSERVATIONS, CONCLUSIONS

The effective permeability of the reconstructed carbonate rock model agrees with the experimental measurement very well, and the simulation of alternated water and polymer flooding shows a consistent recovery profile with the lab experiment. Compared to the previous works, there is no need to use empirical correlations to recalibrate permeability. Moreover, we make no prior assumption on pore connectivity patterns to match the calculated permeability with the experimental measurement. The permeability distribution is reasonable without extremely high or low permeability values. This will ease the core flooding simulation on the reconstructed rock model, and consequently, the computational efficiency is also improved. With optimization of upscaling ratio, we can reach a balance between accuracy and efficiency, which allows us to accurately simulate the complicated flow behavior in a heterogeneous system within a reasonable time.

4. NOVEL/ADDITIVE INFORMATION

We propose a cheap and efficient approach to reconstructing core plug models based on pore geometries extracted from fine-scale CT images. The reconstructed model preserves good heterogeneity, which is very important in the accurate evaluation of core flooding performance. Moreover, the digital core model has fewer grid blocks by one to two orders of magnitude. This reduces the memory consumption and enables core flooding simulation completed within a reasonable time.