Contribution ID: **795** Type: **Poster Presentation**

Retention Mechanism of Residual Oil in Different Pore-Throat Structures Under High-Flux Water Displacement Using Pore-Scale Two-Phase Flow Simulation Considering Dynamic Contact Angle

Thursday, 16 May 2024 15:05 (1h 15m)

Objectives/Scope（25-75words）
High-flux water displacement is one of the effective methods for low-cost development of mature oilfields. The wettability alteration under high-flux water displacement is the crucial reason for improving displacement efficiency, which makes complex flow characteristic in different pore-throat structures. The objective of this paper is to establish a high-flux water displacement pore-scale simulation method considering dynamic contact angle to determine the distribution pattern and retention mechanism of residual oil.

Methods/Procedures/Process (75-100words)
Firstly, the physical models of different pore-throat structures (200mD and 50mD) were constructed by the extraction of the casting thin-section images. Then, the pore-scale two-phase flow mathematic model coupling the Navier-Stokes equation and the Phase-Field equation was established to track the phase interface migration. Moreover, a dynamic contact angle equation was added to the model. Finally, the commercial software COMSOL is used to solve the model by finite element method (FEM). Especially, the injection rate set to 2.25×10-8m3/s, the simulation time of high-flux water displacement set to 800s (about 200PV), and the contact angle change rate set to π/1200 rad/s.

Results/Observations/Conclusions (100-200words)
The results show that the displacement efficiency after high-flux water displacement is significantly improved when considering the dynamic contact angle. For the high permeability reservoir (200mD) with large pores and better connectivity, the oil in small throats near the main streamlines started to be displaced when the contact angle drops to 4/9π. The cluster-type residual oil remain oil in the weak sweep area is partially driven out when the contact angle dropped to 1/3π. The residual oil saturation at 200PV is reduced by about 15% compared to that at 30PV (traditional water displacement experiment). There are three main streamlines parallel to the injection-production direction, and the residual oil is mostly cluster-type oil far from the main streamlines. For the low permeability reservoir (50mD) with narrower pores and poor connectivity, the residual oil saturation at 200PV is reduced by about 7% compared to that at 30PV. There is only one main streamline connecting the inlet and outlet, and the residual oil is widely distributed near the main streamline.

Novelty/Additive Information (25-75words)
In this paper, a pore-scale long-time simulation method was established by coupling a dynamic contact angle equation to characterize the retention mechanism of residual oil under wettability alteration during high-flux water displacement. The impacts of pore-throat structure and displacement flux on the distribution pattern of residual oil were analyzed, which could provide valuable insights for improving the oil recovery (IOR) of mature oilfields developed by water flooding.

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Session Classification: Poster

Track Classification: (MS12) Advances in computational and experimental poromechanics