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Enhancing Oil Recovery from Carbonate Reservoirs with Nanoparticle-Assisted Foams

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Due to its benefits of miscibility and diffusivity with oil, which results in recovering most of the oil within its swept zone, gas EOR is typically used to reduce decline in oil production. However, gravitational segregation, gas channeling, and viscous fingering are frequent occurrences during gas EOR operations. This results in a low mobility ratio and poor volumetric sweep efficiency, which adversely affect oil production, particularly in highly heterogeneous deposits. Foaming the injected gas, either by generating it in-situ or by alternating injection cycles of foaming solution with the gas, is a typical technique for preventing these issues. In order to reduce fingering, foams are generated to flow deeply within the formation layers. Furthermore, foams migrate into relatively small pores to block highly permeable layers and divert gas flow to establish a more uniform propagating front. This is key to improving volumetric sweep efficiency. With all these beneficial qualities of foam, it must remain stable in the porous media to produce positive results. Nanoparticles are positioned to be the focus of research related to foam stabilization, even under harsh reservoir conditions. In addition to increasing stability, surfactants and nanoparticles enhance foam EOR by the combination of their abilities to alter wettability, decrease IFT, decrease oil viscosity, and mitigate asphaltene deposition. In this work, a more specific and realistic foam investigation was carried as it was designed for an existing carbonate geological deposit, located in Volga-Ural region, Russia. In this work, a more specific and realistic foam investigation was carried as it was designed for an existing carbonate geological deposit, located in Volga-Ural region, Russia. An advanced technique of high-pressure microscopy (HPM) was used to examine the stability of N_2 and CO_2 foams at reservoir conditions in the presence and absence of nanoparticles. The experiments were carried out at vapor and supercritical conditions. Furthermore, core flooding studies were performed to investigate their effect on oil displacement and mobility control in both real and artificial core samples. Our results indicated that foams produced at 80% quality were more stable than foams produced at 50% quality because the bubble size was significantly smaller while bubble count was higher. Additionally, foams under supercritical conditions (sc) exhibited greater stability than foams under vapor conditions. This is because at supercritical conditions, gases have a density similar to that of liquids and this helps to strengthen the foam lamella by enhancing the intermolecular contacts between the gas and the hydrophobic part of the liquid phase. In the core flooding experiments, an initial displacement efficiency of 48.9% was recorded for scCO_2 and the use of foam allowed us to increase the total displacement efficiency up to 89.7% in the artificial core model. In the real core model, CO_2 foam injection increased oil recovery during CO_2 injection from 37.7% to 66.6%. The results of this study showed that nanoparticles-enhanced foams have the beneficial potential for EOR purposes and for the mitigation of early gas breakthrough which was noticed after injecting about 0.14 PV during scCO_2 injection.

Participation

In-Person

References

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