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Construction mechanism of a dispersed particle gel strengthened alkali/surfactant/polymer as a novel combination flooding system for enhanced oil recovery

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Abstract

During the long-term water flooding phase, the oil recovery operation becomes more difficult due to the reservoirs' permeability, which increases considerably during the oil field development process. In general, to ameliorate the conditions for good enhanced oil recovery, it necessary to improve the displacement efficiency of displacement agents and improve sweep efficiency. Therefore, the alkali/surfactant/polymer combination flooding system techniques have been the required solution for enhanced oil recovery. However, in porous media, the reservoir temperature and salinity, the sheer deterioration, and the dilution effect affected the viscosity and viscoelasticity of the alkaline-surfactant-polymer combination's flooding systems. In addition, on the polymer molecular, the negative alkali ion neutralizes and forming a band molecule structure. The polymer's molecular structure is transformed and changed. Consequently, the polymer solution's viscosity and viscoelasticity are decreased. Our group's previous studies reported that the dispersed particle gel prepared by shearing bulk gel has excellent characteristics, such as softness, viscoelasticity, high-temperature tolerance, thermal stability, and high expansion. The dispersed particle gel can plug the high permeability zones through aggregation in pores and throats and can also effectively improve the profile control through direct plugging or bridging across pore throats in the formation.

The addition of dispersed particle gel to strengthened the alkali/surfactant/polymer combination flooding system interleaves in the three-dimensional network structure and has a synergistic viscosity increase effect by increasing the combination flooding system's stability in the solution.

The effect of the interfacial tension and viscosity on the combination flooding system was investigated. The results indicate that, the dispersed particle gel strengthened alkali/surfactant/polymer combination flooding system has a comfortable network structure and higher viscosity and viscoelasticity. The aging time and salinity affected the capacity of the interfacial tension reduction of the system. The increase in interface elasticity produces significantly positive effects on the combination flooding system stability. The interfacial tension decreased to an ultralow level, and the reaction of those actions in the system make the viscoelasticity and rheological property of the dispersed particle gel strengthened alkali/surfactant/polymer flooding system performant. Therefore, the dispersed particle gel strengthened alkali-surfactant-polymer flooding technology have the ability and good reaction to be developed as a new type of the combination flooding technology for enhanced oil recovery.

In recent years, a newly developed dispersed particle gel (DPG) has attracted significant attention because of its excellent properties and a good application prospect in an enhanced oil recovery process. The preparation method is convenient and easy to scale up for the field application. The dispersed particle gel with sizes ranging from submicron to micron can block the high permeability layers by accumulating in large pore spaces or directly plugging small pore throats. Furthermore, the dispersed particle gels can achieve in-depth profile control due to the elastic deformation and migration into the reservoir's porous media. These characteristics have demonstrated great potential for the dispersed particle gels to strengthen the alkali/surfactant/polymer combination flooding system. The polymers used are the principal sources of viscosity in the system; the surfactant and alkaline produce the synergistic effect by generating the ultralow oil-water interface tension. The added dispersed particle gel has a synergistic viscosity increase effect, temperature tolerance, and thermal stability. However, the combined flooding system suffers from the surfactant

loss and chromatographic separation that affect the chemical components' synergistic effect for enhanced oil recovery. In this paper, the chromatography separation effects linked to a new method of oil displacement mechanism based on the dispersed particle gel strengthened Alkali/Surfactant/Polymer as a novel combination flooding system was investigated. The addition of dispersed particle gel in the Alkali/Surfactant/Polymer combination flooding system could interleave in the system's network structure and increase the viscosity stability by strengthening the flooding system to improve the oil recovery capacity. The novel dispersed particle gel strengthened alkali/surfactant/polymer flooding systems have a high displacement efficiency and a better-swept volume capacity considering the oilfield requirement for the enhanced oil recovery process. The effects of polymer, surfactant, alkaline, and dispersed particle gel concentration on the combination flooding system were evaluated, furthermore the impact of external factors on the system such as salinity; aging time was described. The results showed that the effects of external factors aging time and salinity slightly affected the system's interfacial reduction capacity. The increase in interface elasticity produced significantly favorable effects on system stability. For the displacement mechanism, when the dispersed particle gel strengthened alkali/surfactant/polymer combination flooding system moved in a porous medium, the dispersed particle gel passed through the pore throat directly or by deformation depending on the system's pressure variation.

Furthermore, the phase separation was formed due to the combined component's effects, resulting in the differential migration between the systems, which led to different degrees of chromatographic separation phenomenon to affect the displacement mechanism. As we can see in the micro visualization simulation experiment, the residual oil interacted with Alkali molecules and form the in-situ surfactant, which makes the remaining oil emulsified, as well the surfactant adsorbed by DPG particles, make the crude oil emulsified and get enhanced. The chromatography and micro visualization experiments results of the dispersed particle gel strengthened alkali/surfactant/polymer combination flooding system indicated a favorable application of the system in an enhanced oil recovery process.