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Effect of Wettability Alteration on Production Performance in Unconventional Tight Oil Reservoirs

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Abstract : In tight oil reservoirs, wettability alteration has generally been considered as an effective way to remove fracturing fluid retention on the surface of the fracture and consequently improved oil production. However, there is a lack of a reliable productivity prediction model to show the relationship between the wettability and oil production in tight oil well. In this paper, a new oil productivity prediction model of immiscible oil-water flow and miscible CO_2-oil flow accounting for wettability is developed. This mathematical model is established by considering two different length scales: nonporous network and propped fractures. CO_2 flow diffuses in the nonporous network and high velocity non-Darcy flow in propped fractures are considered by taking into account the effect of wettability alteration on capillary pressure and relative permeability. A laboratory experiment is also conducted here to validate this model. Laboratory experiments have been designed to compare the water saturation profiles for different contact angle, revealing the fluid retention in rock pores that affects capillary force and relative permeability. Four kinds of brines with different concentrations are selected here to create different contact angles. In water-wet porous media, as the system becomes more oil-wet, water saturation decreases. As a result, oil relative permeability increases. On the other hand, capillary pressure which is the resistance for the oil flow increases as well. The oil production change due to wettability alteration is the result of the comprehensive changes of oil relative permeability and capillary pressure. The results indicate that wettability is a key factor for fracturing fluid retention removal and oil enhancement in tight reservoirs. By incorporating laboratory test into a mathematical model, this work shows the relationship between wettability and oil production is not a simple linear pattern but a parabolic one. Additionally, it can be used for a better understanding of optimization design of fracturing fluids.

Keywords : wettability, relative permeability, fluid retention, oil production, unconventional and tight reservoirs
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