Performance Evaluation of CO_2 Huff-n-Puff Processes on Heavy Oil Recovery under Reservoir Conditions

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Abstract

Numerous efforts have been directed towards miscible and immiscible CO_2 flooding for conventional hydrocarbon reservoirs, but few attempts has been made to evaluate performance of CO_2 huff-n-puff processes in thin and deep heavy oil reservoirs, though they might especially be suitable and effective for those with poor interwell connections. In this study, experimental and numerical techniques have been developed to evaluate performance of CO_2 huff-n-puff processes and examine effect of supercritical CO_2 on heavy oil properties under reservoir conditions. Experimentally, viscosity reduction of heavy oil and interfacial properties between CO_2 and heavy oil have been quantified, while five cycles of CO_2 huff-n-puff processes have been conducted to determine oil recovery together with component variation of produced and residual oils. Theoretically, numerical simulation has been performed to identify the underlying mechanisms (i.e., swelling effect, viscosity reduction, interfacial tension reduction, solution gas drive, and light-components extraction) associated with the CO_2 huff-n-puff processes with respect to heavy oil recovery. CO_2 dissolution into heavy oil is found to effectively reduce heavy oil viscosity and interfacial tension, increase flow capability, and swell the heavy oil. In particular, CO_2 huff-n-puff processes are only effective in the first two cycles under the existing experimental conditions, while the effective sweep range is limited near the wellbore region, resulting in poor oil recovery in the subsequent cycles. As for produced oil, its viscosity, density, heavy component, and molecular weight of asphaltene are reduced, whereas, for the residual oil, they are increased, especially within the first half of the sandpack model from its inlet. The asphaltene component in the residual oil shows weak stability compared to that of the produced oil, while the ultimate oil recovery at the end of the fifth CO_2 cycle of huff-n-huff processes is measured to be 31.6%.

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