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Application of CO_2-Saturated Water Flooding as a Prospective Improved Oil Recovery and CO_2 Storage Strategy: Experimental and Simulation Study

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Abstract

In this study, prior to flooding tests a number of CO_2 solubility measurement tests for CO_2–oil and CO_2–brine systems were conducted in order to determine the effect of operating conditions on the capacity of reservoir fluids to dissolve the injected CO_2. Next, series of flooding experiments were carried out using unconsolidated sand-pack, synthetic brine, and real Bakken light crude oil to investigate the performance of CO_2-saturated water injection as a potential strategy for improving light oil recovery and at the same time permanent CO_2 storage. Both solubility and flooding tests were performed at various operating pressures in the range of P = 0.7 MPa to 10.3 MPa and two constant operating temperatures of T = 25 °C and 40 °C.

According to the results of CO_2 solubility measurement tests at constant temperatures, an increase in CO_2 solubility values was observed for both CO_2–brine and CO_2–oil systems when the equilibrium pressure increases. Furthermore, it was revealed that for both aforementioned systems, the solubility of CO_2 reduces when temperature increased. In terms of oil recovery, it was found that the ultimate oil recovery factor of CO_2-saturated water flooding is consistently more than that of conventional water flooding leading this technique to be a more viable option as a means of improved oil recovery technique. In this study, flooding tests conducted at pressure of P = 10.3 MPa and temperature of T = 25 °C, verified that injection of CO_2-saturated water resulted in improving the conventional water flooding oil recovery factor by about 19.0% and 12.5% of OOIP for secondary and tertiary scenarios, respectively. From CO_2 storage point of view, it was revealed that mixing CO_2 with injected water noticeably provides permanent, safe, and practical CO_2 storage together with considerable oil recovery improvement in light oil systems.

It was also found that introducing CO_2 to the oil reservoirs through injection water provides great opportunity to lock large quantity of CO_2 inside the porous medium with high retention factor. Results of this study showed that both secondary and tertiary scenarios of CO_2-saturated water flooding are favourable with the storage capacity between 34% to 45% of the injected CO_2 in the sand-pack model.