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.