Effect of Oil Type on the Performance of Carbonated Water Injection for Enhanced Oil Recovery under Consistent Operating Conditions

Samia Mohammed AL-Riyami

Abstract

Hydrocarbon liquid production from the existing oil fields should increase in the coming years to cover the sharp increase in the world demand of fossil fuels. The ultimate recovery governed by immiscible gas injection or water flooding is limited primarily by three factors: (1) displacement efficiency of the injection fluid in rock volume that is swept, (2) volumetric sweep of the injection fluid, and (3) capture of the displaced oil at producing wells. In recent decades, lot of effort has been spent on studies and developments of enhanced oil recovery (EOR) processes. Injection of CO_2 is one of the most proven EOR methods because CO_2 has the ability to mix with the oil, cause oil swelling, make it lighter and therefore easily displace it towards producing wells. It enables the oil to flow more freely within the reservoir and detach from the rock surface. However, CO_2 injection often results in low macroscopic sweep efficiency due to unfavorable mobility ratio.

In order to address low microscopic sweep issues of water flooding along with poor macroscopic sweep problems of CO_2 flooding and maximize the oil recovery, Carbonated Water Injection (CWI) has been developed. CWI is proved to be one of the most attractive EOR option in field under water flooding process as large amounts of CO_2 can be dissolved in water, then transferred from the injected water to the oil phase. CWI reduces the problem of mobility contrast between CO_2 and oil, controls gravity segregation and eliminates gas fingering, improves the sweep efficiency, delays the breakthrough of CO_2 and increases the recovery of water flooding process. In this study the performance of Tertiary Carbonated Water Injection (TCWI) for EOR in light, medium and heavy crude oil has been examined under consistent operating conditions through sequences of core flooding experiments using Berea sandstone cores. The core flooding results are compared with other findings such as CO_2 solubility in oil and brine, oil swelling factor, oil viscosity reduction and CO_2/oil density in order to provide comprehensive analyses and investigate different oil recovery mechanisms and their extents for various oil types during TCWI. The results of this study prove that TCWI has good potential in oil recovery enhancement. The highest incremental in oil recovery was observed during heavy oil TCWI. Heavy oil recovery increased by 25.6 % when WF was switched to TCWI. It was found that there are two mechanisms that play role in increasing the oil recovery by TCWI. The first one is oil swelling or volume expansion which was found to be more noticeable in light and medium oil samples. The second mechanism is mobility improvement due to oil viscosity reduction which was more effective in heavy crude oil recovery.