Immiscible Water Alternating Gas (IWAG) Pilot in Mauddud Reservoir, Bahrain Field

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ABSTRACT

Mauddud reservoir is one of the most productive reservoirs of the Bahrain field responsible for 54% of the total oil production. Mauddud zone is a carbonate reservoir with oil-wet characteristics. The field was put on production in 1932.Crestal gas injection was initiated in 1938 following a pressure decline. Production continued for the next 70 years with continued crestal gas injection which led to development of a secondary gas cap. Increased GOR from the gas injection has led to decreased field performance and has strained surface handling capacities. An IWAG process is considered for mobility control and improve oil recovery. A sector model of Mauddud reservoir was run using relative permeability and hysteresis model parameters obtained from the history matching of the composite core-floods. A water and gas flood base case was run and compared to the IWAG sequence. The IWAG process showed incremental recovery compared to the base case water injection. In the up-dip pattern(lower water saturation), IWAG recovers 3% more than base case gas injection while gas injection recovers 5% more than the IWAG sequence in the down-dip pattern (higher water saturation). The objective of introducing the IWAG process in Mauddud was to reduce gas production by controlling the mobility during the three-phase flow. Incremental oil, compared with gas and water injection was also to be evaluated. In 2014, three IWAG pilots were introduced after an extensive study on optimum locations. Two inverted 5-spot patterns and one line drive pattern were selected, each pattern around 40 acre spacing, targeting Mauddud B interval. The original WAG ratio was designed to be 1:3 (Water:Gas) and WAG period was originally designed to be from 3-6 months based on simulation work. WAG ratio and duration optimization were subject to performance. After one year of cyclic injection, both inverted 5-spot patterns showed lack of response to the WAG cycles. In one of the two latter patterns, the water cycles badly affected the oil production. In the line drive pattern the WAG cycles initially showed favorable response. After one year of injection water and gas overcame the oil production leading to higher oil decline and the termination of the pilot. Since November 2015, there were no injection cycles in any of the patterns. This study will cover the pilot Selection criteria, WAG approach strategy, the key mechanisms affect the flow behavior, patterns performance & final results.