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Recovery Enhancement with Application of FAWAG for a Malaysian Field

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Abstract: At present, petroleum engineering has become economics based field hence all efforts are being made to make sure that we squeeze out the last drop of oil from the reservoir. Field A, one of Malaysian oil field is a strong candidate for Enhanced Oil Recovery (EOR) which was producing for more than 15 years. Here, in this research, we are focusing one of the currently demanded techniques for better oil recovery. There are various water alternating gas “WAG” techniques which have proven to be the best answer in improving the recovery. Foam can also be added in water alternating gas technique to improve the sweeping mechanism and cut off the gas production which is termed as Foam Assisted Water-Alternating Gas (FAWAG). In this study, a detailed application of FAWAG has been done on crude oil sample from Field A. Results shows that FAWAG tends to address all recovery related problems efficiently where as foam has been seen to address the problems by assisting other enhanced oil recovery techniques and proved that foam assistance has given better recovery.

Key words: EOR, foam, oil recovery, sodium dodecyl sulphate and WAG, surfactant

INTRODUCTION

Water and gas might be injected alternatively as Water Alternating Gas (WAG) or sometimes depending on the conditions, addition of foam can address all issues as Foam Assisted Water Alternating Gas (FAWAG) injection (Aarra, 2002). This process uses foam for improving the sweep efficiency during gas injection while reducing Gas Oil Ratio (GOR) and maximizing production rate in the producer well. Foam can be used as EOR technique to solve the problems such as overriding caused by thief zone or gravity override. Here, one of the Malaysian oil field is focused using FAWAG to increase oil recovery.

Foam Assisted Water Alternating Gas (FAWAG) process: This process has given tremendous improvement in recovery by improving sweep efficiency (Coskuner, 1992) during gas injection and gas shut-off even less GOR was seen in most of the process. Foam has increased mobility control of gas flow and has come up with new method for improvement of well flow.

Foam is well known as a selective blocking agent and has shown promise for the diversion of steam under conditions of poor reservoir conformance. The hydrocarbon as in many other tertiary recovery schemes is less viscous and less dense than the fluids in the reservoir. Therefore, it is likely that a significant portion of the reservoir is bypassed due to gravity segregation and viscous fingering. One way to minimize such problems is the injection of foam (Coskuner, 1992). Usually the foam injection has given better results and in most of applications oil rate increased by 1.5-5 times while the water cut seems to be decreased by 20%, (for example from 80 to 60%) (Alex and Ashok, 1998).

FAWAG is usually introduced in reservoirs with WAG already in use. In WAG water displaces the lower part of the oil bearing sands and gas fills the upper part though WAG is considered an oil-recovery enhancement technique but usually injected gas tends to rise to top of the reservoir relatively quickly and its presence can be detected from the oil production from the upper zone. Hence FAWAG can be intended to create a foam barrier that impedes the upward passage of the gas, forcing it spread laterally and in the process contact previously un-swept parts. Hence to achieve that barrier, water and surfactant are injected simultaneously over several days followed by gas injection. Foam is created in the area near wellbore vicinity at first making it difficult to inject gas but the injectivity gradually increases as gas finds paths unimpeded by the foam (Anonymous, 2010).

Foam performance depends on many factors from its structural study (i.e., molecular weight, mole % of surfactant, hydrophobe carbon no, chemical structure etc) (Borchardt, 1987) but usually chemical structure parameters are not enough to evaluate its performance hence a correlation is required. Foams quality the forth texture and size of bubbles plays decisive role in its performance. (Rossen, 1988).

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Fig. 1: RPS830-1000 machine

Fig. 2: Oil recovery at RPS outlet

Experimental setup and application: Core flooding runs for FAWAG were carried out on RPS 830-10,000 machine (Fig. 1). A surfactant, brine solution and CO_2 was used where as surfactant used is Sodium Dodecyl Sulphate (SDS). We are working on a light crude oil 37º API with less wax and asphaltene contents while brine to be injected was 30,000 ppm. Both the cores are taken from sandstone reservoirs with almost similar rock properties.

THE EXPERIMENT

FAWAG application: The experiment was conducted at conditions which could closely relate to field applications at injecting pressure of 1000 psia. Mixture of surfactant and brine solution was prepared as 2 wt % surfactant in 3000 ppm of brine solution. Following steps were followed:

- All three injectants brine, crude and CO_2 are injected into different accumulators.
- After achieving S_{wir} and S_{oir}, we apply FAWAG technique with pumping the surfactant brine solution in accumulator and following steps were carried out for FAWAG application.

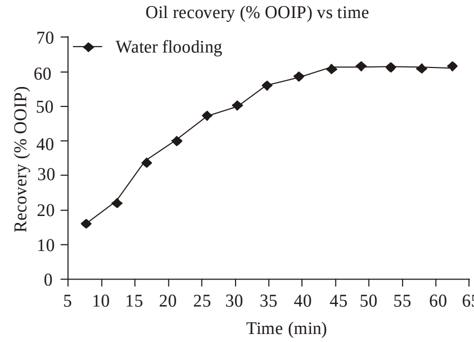

Fig. 3: Oil recovery after water flooding

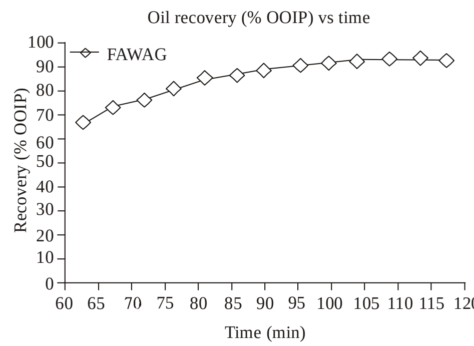

Fig. 4: Oil recovery after FAWAG application

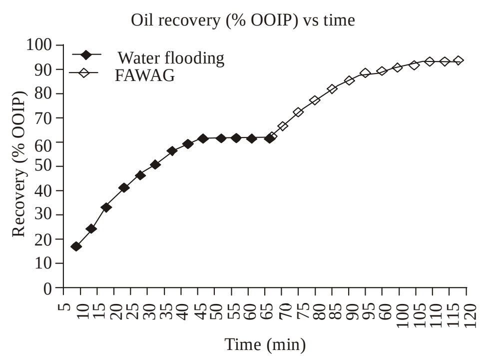

Fig. 5: Oil recovery comparison

- ◦ 4 PV of surfactant/ brine is injected followed by 4 PV of CO_2 and again followed by 4 PV of surfactant/ brine followed by 4 PV of CO_2.
- ◦ The crude oil is seen to be recovered, as shown in Fig. 2, at the outlet which is recovered in test tube.
- ◦ After the phases are allowed to be settled, recovery details are noted.

RESULTS AND DISCUSSION

The experiment was seen giving expected results and impact of FAWAG on recovery was seen tremendously higher.

The ultimate recovery with water flooding increased to 61% (Fig. 3) and was seen tremendously increasing to 92% after FAWAG application (Fig. 4).

FAWAG addresses the problems in more detail and tends to improve the recovery. Hence as shown in Fig. 5, it can be seen that recovery pattern was tending to slow down with time after water flooding but as soon as FAWAG slugs are injected, it tends to improve the recovery rapidly by addressing the reservoir related issues. Hence, it can be predicted that for better oil recovery, FAWAG can be applied after any WAG technique to manage the reservoir economically.

CONCLUSION

FAWAG with better understanding and proper application tend to provide better recoveries. It tends to address the problems like gas mobility control, gravity segregation and viscous fingering in detail.

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