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Low Salinity Water Flooding –Proof of Field Pressure Improvement Using Numerical Simulation

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Abstract: ***Over the past decades, water has been injected into the reservoir to drive oil towards producing wells and/or to maintain the Field Pressure (FPR). These conventional water flooding projects have involved the use of seawater or produced water, which is high salinity. However, many new developments have shown that reducing the salinity of the injected water increases the oil recovery. There have been many hypotheses in literature on the actual mechanism that take place during Low Salinity Water flooding (LSW). In this paper, flood tests under high and low water salinities were simulated in Eclipse 100 simulator. It was observed that flood test under LSW yielded an increased Field Oil Production Rate (FOPR)and Field Oil Efficiency(FOE) as a result of increased Field Pressure (FPR). We also observed low water cut with LSW.***

Keywords: Field Oil Production Rate (FOPR), Field Oil Efficiency (FOE), Field Pressure (FPR), Field Water Cut (FWCT), Low Salinity Water flooding (LSW)

1. Introduction

Water flooding is a secondary recovery technique used to drive oil tothe producing wells. Beside drivingoil towards the wellbore, another objective of water flooding is to replace the reservoir fluid volume withdrawn with the injected fluid in order to repressurize the reservoir and increase production rate(Terry, 2001). Over the years, the sources of water for water flooding have often been produced water or seawater. The salinity of the injected water had not been taken into consideration untilin the 1990s when (Yildiz and Morrow, 1996)and others showed that modification in brine concentration and removal of divalent cations such as Ca^{2+} and Mg^{2+} from the injected water resulted in improved recovery compared to conventional water floods. Since then, LSW has been of great interest in the petroleum industry. A number of authors including (Skrettingland et al., 2011), (McGuire et al., 2005), (Tang and Morrow, 1996), (Lager et al., 2008), (Webb et al., 2003), (Austad et al., 2010)and (Al-Shalabi et al., 2014)have performed various field and laboratory experiments that showed improved oil recovery using clayey sandstone and carbonate reservoirs.(Lager et al., 2008),(Sharma and Filoco, 2000)and (Tang and Morrow, 1999)went further to add that for LSW to be effective some conditions have to be met. These include the presence of connate water, presence of divalent cations in the fresh water and presence of clay. However,(Fjelde et al., 2012)and many authors have argued that even though proposed screening criteria have been fulfilled in some cases, improved recovery was not observed.

There have been many proposed theories regarding the mechanism of LSW. (Austad et al., 2010)believe that this has been so because the process involves many parameters, which are linked to the rock, reservoir fluids and the injected fluids. While (Austad et al., 2010) and (McGuire et al., 2005) suggested that improved recovery was due to pH increase, (Ligthelm et al., 2009)and (Tang and Morrow, 1999) proposed wettability alterations due to a double layer expansion that promoted easier dispersion of clay-bounded oil.(Lager et al., 2008)also explained that improved recovery was due to multi-component ion exchange.

Knowing that improvement in the FPR improves recovery, we study the impact of low and high salinity floods on the FPR. We go on to study the water production trend under these different salinity flood tests.

1.1 Field Oil Efficiency (FOE)

The objective of EOR is to increase theFOE; the amount of hydrocarbon initially in place that can be recovered. This parameter is a product of displacement efficiency, Ed, and sweeps efficiency, Es. The Sweep efficiency is a measure of how well the displacing fluid has come in contact with the oil-bearing parts of the reservoir. It is affected by factors including reservoir heterogeneities and anisotropy, mobility and the arrangement of injection and production wells. The displacement efficiency is a measure of how well the displacing fluid mobilizes the residual oil once the fluid has come in contact with the oil. It is also affected by various factors including wettability, interfacial tension, relative permeability and capillary pressure(Terry, 2001). Increasing the sweep and displacement efficiencies thus improve the FOE.

2. Methodology

Two main scenarios were simulated in the Eclipse 100 simulator. Case 1 (reference case);High Salinity Waterflooding (HSW), and Case 2; Low Salinity Waterflooding (LSW)

2.1 Modelling of Low Salinity

The option for LSW can be activated in the ECLIPSE 100 simulator by keyword LOWSALT in the RUNSPEC section. The model is based on the change in relative permeability model proposed by (Jerauld et al., 2006).The methodology for modeling LSW followed that in Schlumberger Eclipse Manual.

2.2 Model Properties

The data for the reservoir model was obtained from Snark oil field. The synthetic model had dimensions 24 meters, 25meters and 12 meters in the I, J, Kdirections respectively.There were five (5) producer wells, placed in the grid numbers: 13, 7, 16, 17,6 and two (2) infill injector wells in grid numbers 11, 3. It is a heterogeneous model with porosity range of 0.06 to 0.19 and permeability range between 29 – 335mD. The oil density was42.24 lb/ft3, water and gas densities were 62.42 lb/ft3 and 0.0971lb/ft3 respectively. The reference pressure was between 2000 – 3400 psia and the initial oil and water viscosity were 0.11cp and 0.4cprespectively at reservoir conditions.

3. Results and Discussion

3.1 Case 1: High Salinity water Flooding

Figure 1, shows the result obtained after simulating with water of salinity40000ppmon day 3400 after theprimary recovery stage when FOPR had declined from 15000 stb/day to 2800 stb/day and the FPR had decreased from 3300psia to 400psia. The FPR was observed to have increased from 400 psia to 700 psia with a corresponding increase in the FOPR from 2800 stb/day to 10600 stb/day. The FOE increased from 0.042 to 0.057.

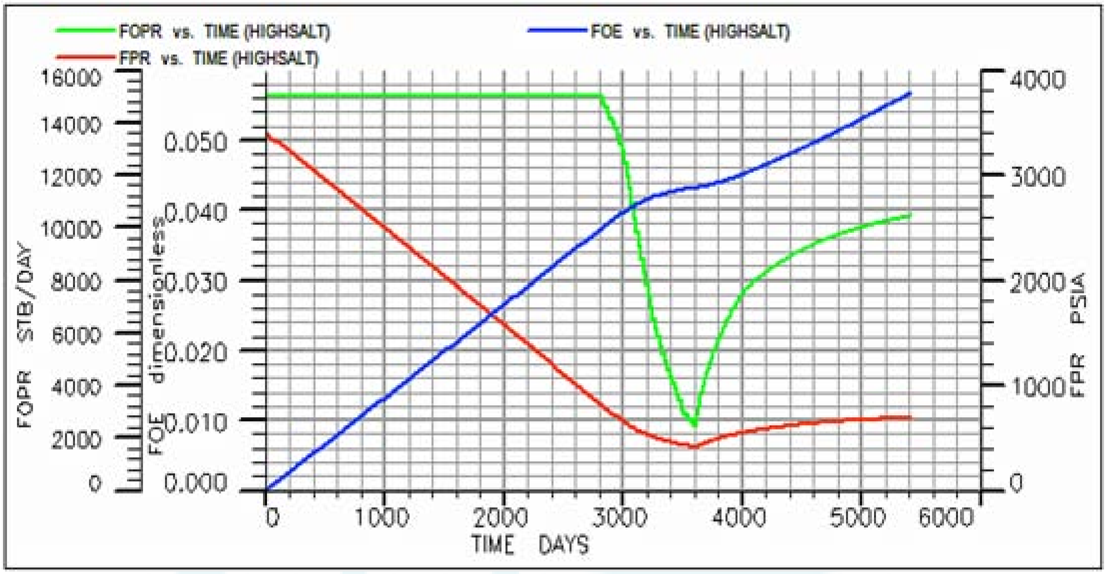

Figure 1: Plot of FOPR, FPR AND FOE -40000ppm

3.2 CASE 1b; 30000ppm Salinity

The salinity of the injected water was reduced to 30000ppm to study the trend for high saline water but lower than the previously simulated 40000ppm. We noticed that there was a little improvement in the FPR, FOPR and FOE as compared to results achieved under 40000ppm. This corroborated the fact that lowering the salinity improves recovery. In Figure 2, (with label SECENDORYREC), the FPR after simulating on day 3400 after the primary drive, increased from 400 psia to 720 psia resulting increase in FOPR increase from 2800 stb/day to 11200 stb/day and FOE from 0.042 to 0.058.

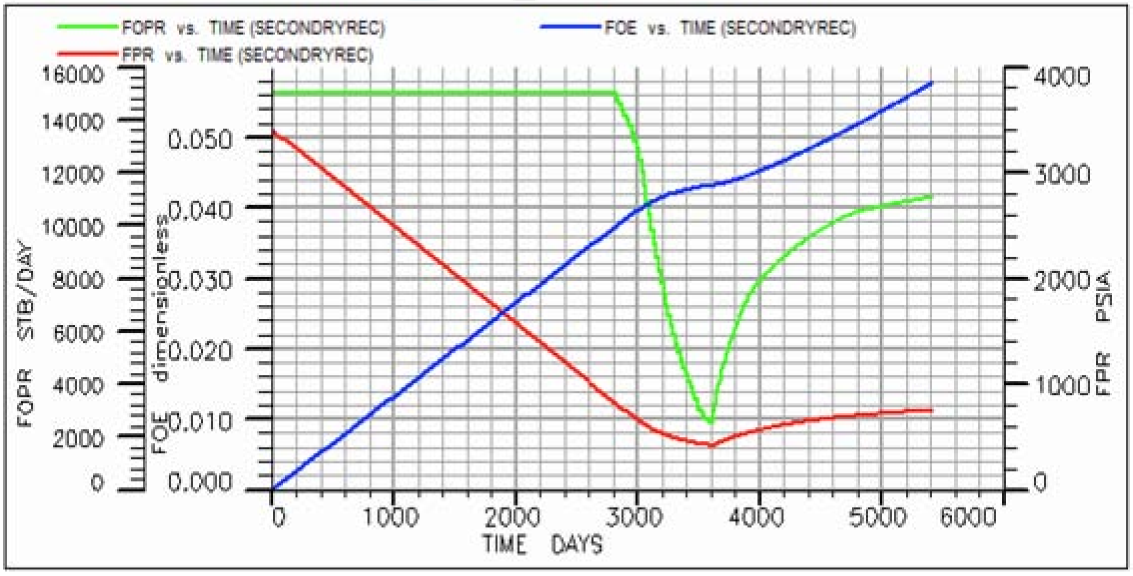

Figure 2: FOPR, FPR AND FOE

3.3 Case 2; Low Salinity Waterflooding

Low Saline Water (1000ppm) injection was implemented in the simulator after the end of primary recovery. From Figure 3, it was observed that there was a great increase in the FPR from 400 to 1700 psia. This led to a great increase in FOPR from2400 stb/day to 11800 stb/day and FOEfrom 0.042 to 0.061.

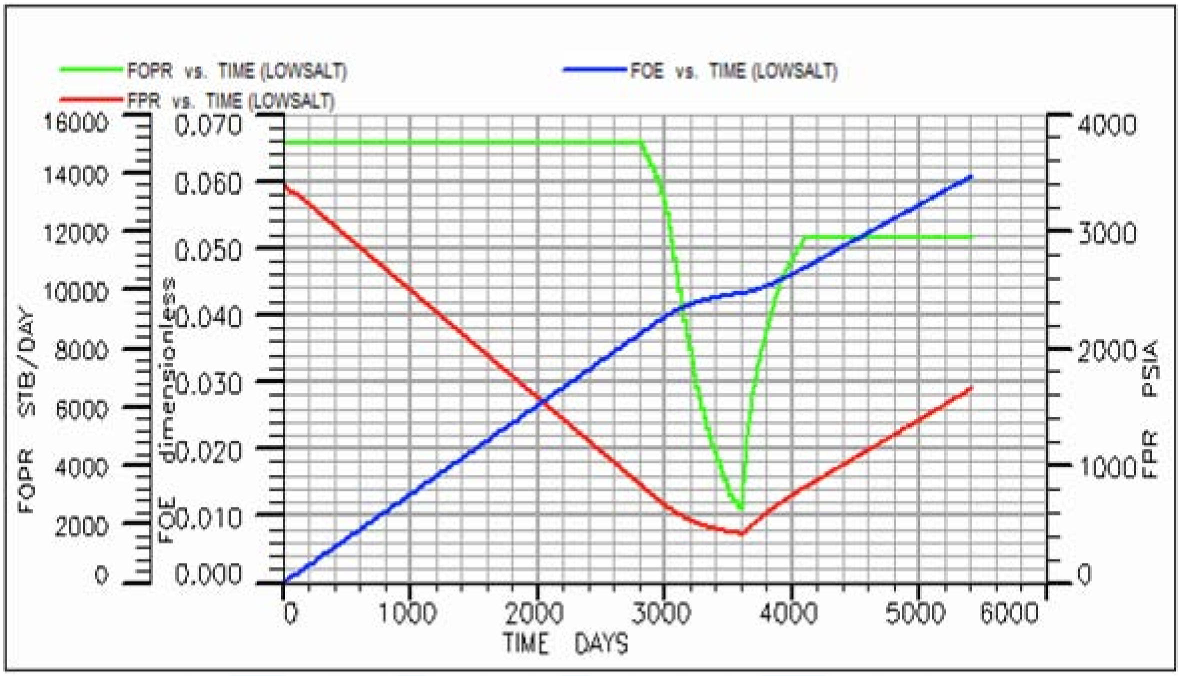

Figure 3: PLOT OF FOPR, FPR AND FOR LSW

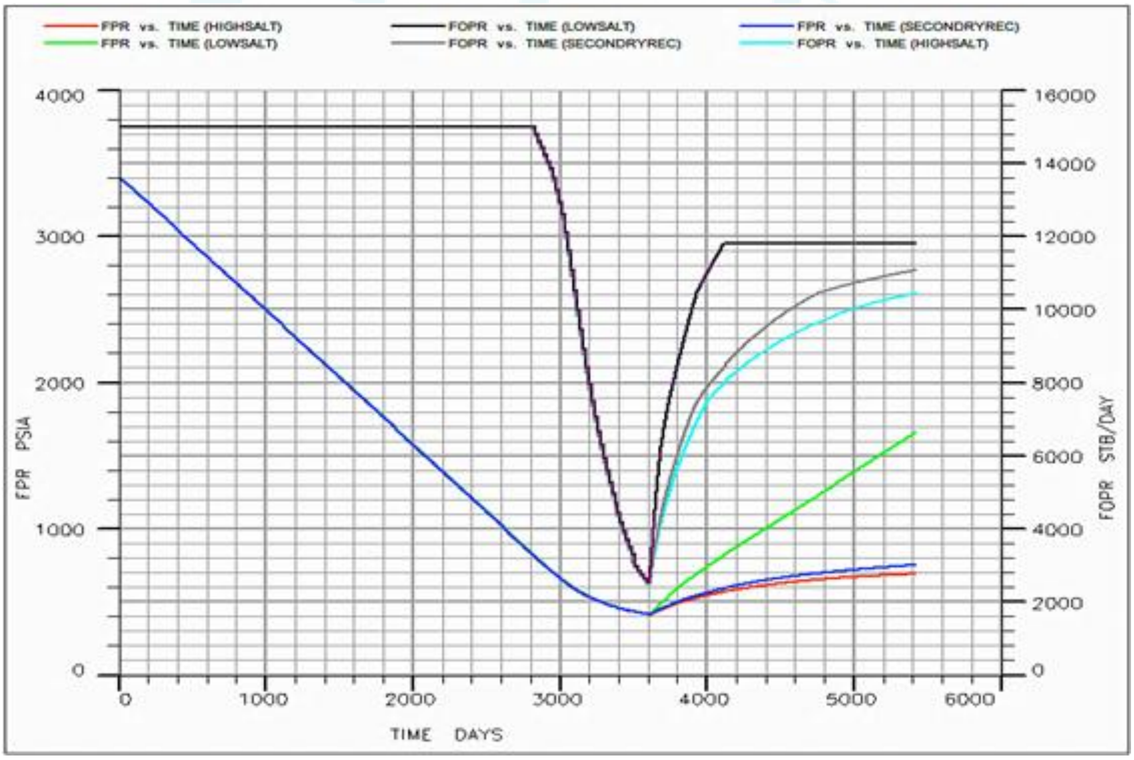

Figure 4: Plot of FOPR and FPR for Cases 1 and 2

Figure 4 shows a summary of variations in the FPR and FOPR for the various scenarios simulated.

3.4 Field Water Cut (FWCT)

Figure 5 shows the trend for FWCT for the scenarios simulated. It is seen that LSW had the lowest water cut of 0.00028 compared to high saline water; 40000ppm and 30000ppm of 0.00039 and 0.00050 respectively at the end of 5,400 days.

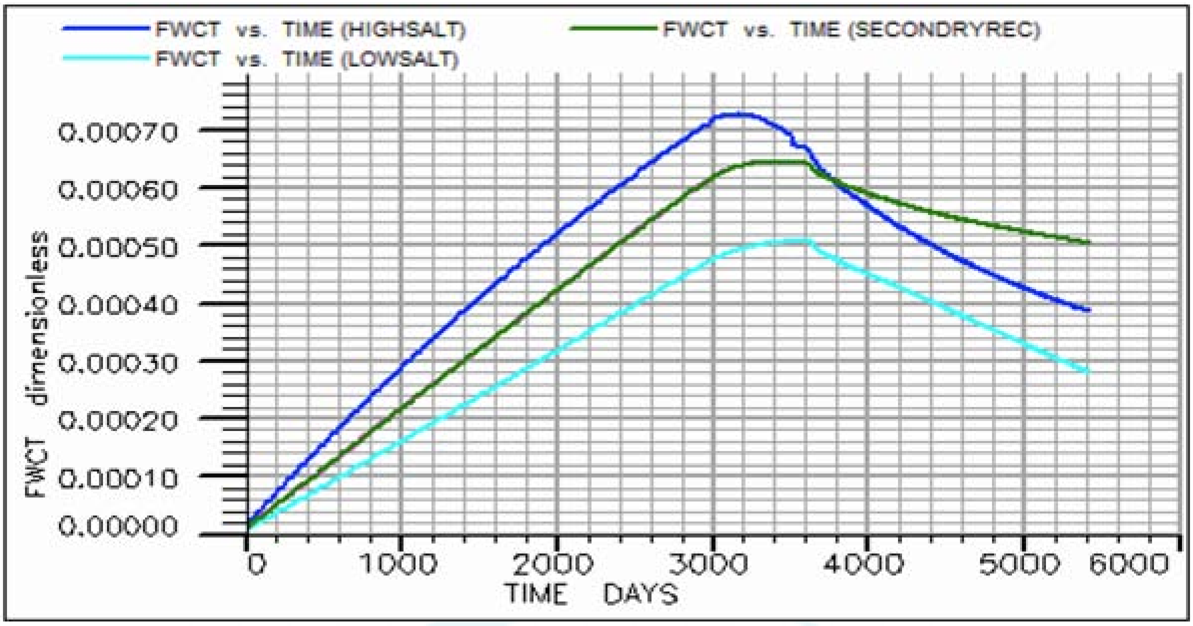

Figure 5: PLOT of FWCT for SIMULATED CASES

4. Conclusion

LSW has been implemented in a numerical simulator after primary recovery to supplement for pressure reduction as a result of voidage, created through withdrawal of reservoir fluids and to drive oil towards producing well.

It was observed that lowering the salinity of the injected water increasedthe Field Pressure, which resulted in an increase in the Field Oil Production Rate and Field Oil Efficiency.
It tells that there is a greater volumetric replacement of produced fluids by the injected fluid when the salinity of the injected fluid is reduced. This is possible when the injected water is able to enter both smaller and larger pores to displace oil and fill the void spaces. This phenomenon is favored in a water-wet system. In an oil-wet system, the injected water mainly pushes oil trapped in the bigger pores leaving significant quantity of oil in the smaller pores. Hence there is a smaller FOE associated with an oil- wet system. We therefore agree that the major mechanism occurring during LSW is that of wettability alteration from an oil –wet / mixed – wet state to a water – wet state as proposed by some authors. Beside improved oil recovery by LSW, numerical simulation has shown that it gives the lowest FWCT.

References

[1] AL-SHALABI, E. W., SEPEHRNOORI, K., POPE, G. & MOHANTY, K. A Fundamental Model for Predicting Oil Recovery Due to Low Salinity Water Injection in Carbonate Rocks. SPE Energy Resources Conference, 2014. Society of Petroleum Engineers.
[2] AUSTAD, T., REZAEIDOUST, A. & PUNTERVOLD, T. Chemical mechanism of low salinity water flooding in sandstone reservoirs. SPE improved oil recovery symposium, 2010. Society of Petroleum Engineers.
[3] CISSOKHO, M., BERTIN, H., BOUSSOUR, S., CORDIER, P. & HAMON, G. 2010. Low salinity oil recovery on clayey sandstone: Experimental study. *Petrophysics,* 51.
[4] DENNEY, D. 2009. Low-salinity waterflooding improves oil recovery-Historical field evidence. *Journal of Petroleum Technology,* 61**,** 47-49.
[5] FJELDE, I., ASEN, S. M. & OMEKEH, A. V. Low salinity water flooding experiments and interpretation by simulations. SPE Improved Oil Recovery Symposium, 2012. Society of Petroleum Engineers.
[6] JERAULD, G., WEBB, K., LIN, C. & SECCOMBE, J. 2006. Modeling low-salinity waterflooding, paper SPE 102239 presented at the SPE Annual Technical Conference and Exhibition, 24-27 September. *San Antonio, Texas, USA*.
[7] LAGER, A., WEBB, K., BLACK, C., SINGLETON, M. & SORBIE, K. 2008. Low Salinity Oil Recovery-An Experimental Investigation1. *Petrophysics,* 49.
[8] LIGTHELM, D. J., GRONSVELD, J., HOFMAN, J., BRUSSEE, N., MARCELIS, F. & VAN DER LINDE, H. Novel Waterflooding Strategy By Manipulation Of Injection Brine Composition. EUROPEC/EAGE Conference and Exhibition, 2009. Society of Petroleum Engineers.
[9] MCGUIRE, P., CHATHAM, J., PASKVAN, F., SOMMER, D. & CARINI, F. Low salinity oil recovery: An exciting new EOR opportunity for Alaska's North Slope. SPE Western Regional Meeting, 2005. Society of Petroleum Engineers.
[10] SHARMA, M. & FILOCO, P. 2000. Effect of brine salinity and crude-oil properties on oil recovery and residual saturations. *SPE Journal,* 5**,** 293-300.
[11] SKRETTINGLAND, K., HOLT, T., TWEHEYO, M. T. & SKJEVRAK, I. 2011. Snorre Low-Salinity-Water Injection--Coreflooding Experiments and Single-Well Field Pilot. *SPE Reservoir Evaluation & Engineering,* 14**,** 182-192.
[12] TANG, G. & MORROW, N. 1996. Effect of temperature, salinity and oil composition on wetting behavior and oil recovery by waterflooding. Society of

Petroleum Engineers (SPE), Inc., Richardson, TX (United States).
[13] TANG, G.-Q. & MORROW, N. R. 1999. Influence of brine composition and fines migration on crude oil/brine/rock interactions and oil recovery. *Journal of Petroleum Science and Engineering,* 24**,** 99-111.
[14] TERRY, R. E. 2001. Enhanced oil recovery. *Encyclopedia of physical science and technology,* 18**,** 503-518.
[15] WEBB, K., BLACK, C. & AL-AJEEL, H. Low salinity oil recovery-log-inject-log. Middle East Oil Show, 2003. Society of Petroleum Engineers.
[16] YILDIZ, H. O. & MORROW, N. R. 1996. Effect of brine composition on recovery of Moutray crude oil by waterflooding. *Journal of Petroleum science and Engineering,* 14**,** 159-168.