

CONFORMANCE IMPROVEMENT IN THE WEST TEXAS GRAYBURG FORMATION

Improved Sweep Efficiency and Incremental Oil Recovery



SITUATION

This West Texas field was discovered in 1953 and due to the low original pressure was put on waterflood in 1956 becoming one of the first waterfloods in a West Texas carbonate reservoir. The field produces from the naturally fractured Permian age Grayburg carbonate, with a starting depth of 4,700 feet and a maximum pay of 150 feet. The average porosity is 12% and the permeability ranges from less than 1 md to over 1 Darcy resulting in a Dykstra Parsons factor of 0.82. This reservoir heterogeneity resulted in lower than expected waterflood recovery factors in some areas of the field.

CUSTOMER CHALLENGE

The customer identified a significant number of waterflood patterns that suffered from severe communication between injectors and their offset producers. High water production and poor sweep efficiency resulted in greater operating costs and lower oil production.

SOLUTION

Based on the geological information and water flood communication analysis using injection / production data, TIORCO Enhanced Oil Recovery (EOR) experts recommended a crosslinked polymer gel solution to correct the rapid water channeling through fractures and high permeability streaks. Laboratory analysis was performed and it was determined the MARCIT polymer gel system would be optimal based on reservoir temperature and the injection water total dissolved solids (TDS). The gel is made up of a medium molecular weight partially hydrolyzed polyacrylamide and a crosslinker which are mixed on the surface using specialty equipment and then injected downhole. The reaction rate is sufficiently delayed to allow for placement of the gel in the reservoir.

From 2001 to 2006, 24 injectors were treated in four phases using an average gel volume of 16,550 bbl per well of gel polymer with concentrations from 1,500 to 10,000 ppm. Each injection well had an individual gel volume design based off the estimated thief zone volume between the injector and offset producers. The pumped gel volume and concentrations were changed on-the-fly based on the injection pressure response, which is a good indicator of how effective the gel is filling up the offending reservoir features.

RESULTS

The polymer gel was placed in the high permeability features and fractures responsible for high water production and low sweep efficiency, without damaging the low permeability rock matrix. Figure 1 shows a typical job log where the injection pressure is continuously increasing throughout the treatment. Note this pressure increase is promoted by increasing the polymer and crosslinker concentration (gel strength) throughout the treatment.

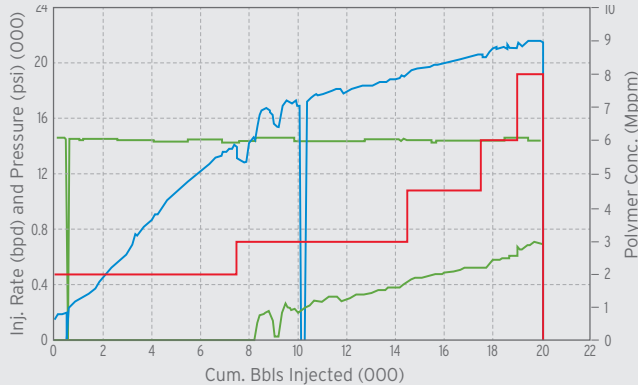


Figure 1: Job log from this Permian Grayburg conformance treatment

Figure 2 shows the monthly oil rate trend for all 38 offset producers in Phases I through IV. Note the increase in oil production 3 months after the first treatment followed by continual oil rate increases and a significant change in the oil production decline throughout the four phases.

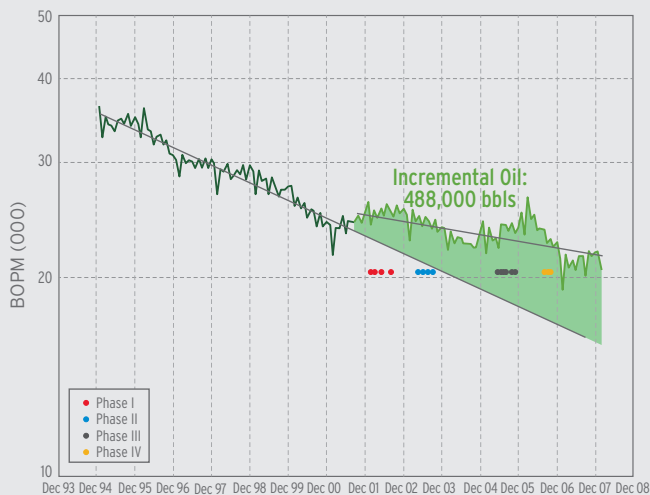


Figure 2: Incremental oil production from Phases I-IV of conformance treatments

Figure 3 shows the WOR vs Cumulative Oil plot for the area which clearly shows a change in the WOR trend indicative of sweep improvement. Based off this analysis, the estimated incremental oil was 488,000 bbl. This resulted in an incremental cost per barrel of \$4.68, an average payout per phase of 12 months, and internal rate of return for the customer of 31%.

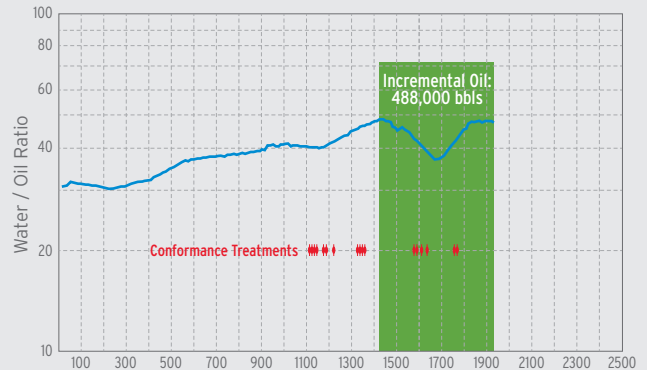


Figure 3: WOR vs Cum Oil Produced of Phases I-IV

Phases I-IV Summary	
Phase I-IV Cost	\$2,284,283
Total IOR (bbls)	488,000
Oil Cost (\$/bbl)	\$4.68

Table 1: Phases I-IV Summary

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GOALZERO

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