Wyoming Case Studies Related to MARCIT Gel Treatments
Introduction

- Excerpts from SPE 132978 “Quantitative Evaluation of Aquifer Diversion to Surrounding Wells after Multiple Large Polymer Gel Treatments”
- Results of a polymer gel water shutoff treatment in the Willow Draw field
- Evaluation of sweep improvement using polymer gel in a highly fractured mature water flood
MARCIT Technology

- Made up of polyacrylamide and a crosslinker
- Reaction is delayed to allow deeper placement
- Blocks flow into channels, fractures and thief zones
- Resistant to H₂S, CO₂ & high TDS
- Reservoir temps to 100°C
Case Study 1

SPE 132978
Quantitative Evaluation of Aquifer Diversion to Surrounding Wells after Multiple Large Polymer Gel Water Shutoff Treatments

Ben Turner / TIORCO Jude Nwaozo and Brad Funston / Marathon Oil Company
Reservoir Description

- Comingled production from the Tensleep sandstone and Phosphoria carbonate
- Both formations are highly fractured
- Both formations are connected to prolific aquifers which supply reservoir energy, but eventually a high rate of water
Situation

- Many wells in the field produce at or near their economic limit due to excessive water rate
- Wellbores limit pump size and wells carry a high fluid level
- Well spacing is roughly 5 acres
Strategy

• Select wells with the highest water-cut and inject polymer gel that will reduce the productivity of the water-bearing fractures

• This reduces productivity of the well and thus the fluid level, allowing the well to be pumped off

• Results in lower water rates and higher oil rates

• This strategy has been applied in hundreds of wells in the region, and thousands in the world
• Treatment sizes ranged 8,000 to 11,500 bbl (Average of 9,800)

• Bull-headed treatments above producing formation(s)
Production Response in Seven Treated Wells
Water Oil Ratio in Seven Treated Wells
22 Offset Wells

Spring Creek Field

11
1 22
12
13
Production Response in 22 Offset Wells
Seven Treated Wells and 22 Offset Wells
Production Response in Seven Treated Wells and 22 Offset Producers

![Graph showing production response over time. The graph displays oil rate and water rate in bbl/day, with dates ranging from 12/02 to 10/10. The graph shows a trend of increasing oil rate and decreasing water rate over time.]
Water Oil Ratio in Seven Treated Wells and 22 Offset Wells

1.5 Million BBLS IOR
Economics

- Project cost about 1.5 Million US$
  - Includes both services by gel provider and workover costs associated with pulling tubing, setting packers, and changing pumps
  - Cost split 50/50 between gel application and workover
- No substantial incremental oil has been produced as a result of this treatment, so cash flow has not improved
- However, reserves were developed at a cost of approximately 1 US$ per bbl of oil
Conclusions

• Treating producing wells with large volumes of MARCIT gel can result in significant water rate reduction, but can also negatively impact oil rate.

• When evaluating the efficacy of gel treatments in producing wells, it is important to also look at the offset producing wells, especially in highly fractured reservoirs where multiple large treatments have occurred in fields with tight well spacing.
Conclusions (cont’d)

• In this case, although rapid payback is not realized, incremental oil is created by reduction in WOR extending the life of the field

• Reserves can be developed in mature water drive reservoirs by pumping large volumes of crosslinked polymer gel to reduce WOR
Case Study 2

Water Shut-off Treatment with Polymer Gel in the Willow Draw Field
Field Location

Willow Draw

Bighorn Basin, Wyoming
Reservoir Description

- Majority of production at Willow Draw is from the Dinwoody and Phosphoria carbonates
  - Tensleep shows mostly water in this field
- Both formations are highly fractured
- Both formations are connected to prolific aquifers which supply reservoir energy, but eventually a high rate of water
Treatment Design

- WD 30-2 chosen as first well due to production at water-cut of > 99%
- Preliminary design technique is based off wells maximum drawdown potential
- WD 30-2 had a PI = 50 bpd / psi and max flow potential of ~33,500 bpd
- Based on experience treating high productivity wells a treatment size of 8,000 bbl was chosen
- WD 30-2 only completed in the Dinwoody formation
Production Response

Willow Draw 30-2

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<th>Month</th>
<th>BOPD</th>
<th>BWPD</th>
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<td>Oct-10</td>
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MARCIT Treatment
Water to Oil Ratio

Willow Draw 30-2

MARCIT Treatment

Month

Dec-09 Feb-10 Mar-10 May-10 Jul-10 Aug-10 Oct-10

WOR

Water to Oil Ratio
Conclusions

• To date, incremental oil is ~ +50 bopd and water reduction is ~ -2,400 bwpd

• Total treatment cost including service provider costs and well costs to operator was ~$215,000
  - Gel treatment to well cost split 45/55

• Payout is estimated to be 3.1 months (oil price $50/bbl)

• Increased water facilities capacity may allow for additional production wells to be brought on-line
Case Study 3

Evaluation of sweep improvement using polymer gel in a highly fractured mature water flood
Field / Reservoir Description

- Field is located in Big Horn Basin
- Reservoir is a highly fractured carbonate with strong natural water drive
- Combination of natural water drive and ~13-15 years of water flooding has led to a mature and highly water saturated flood
- Majority of wells produce at water-cuts > 99%
Treatment Pattern Map

PW 1
PW 3
PW 4
PW 5
PW 6
Treated Injector
PW 7
PW 2

~5 acre spacing
Thief zone analysis shows limited waterflood response and subsequent water breakthrough.

Injection of polymer gel is designed to significantly reduce the thief zone permeability, diverting water to more oil saturated rock.

Based on the calculated thief zone volume of 45,000 bbl, a gel treatment volume of 15,000 bbl was designed.
Response of 7 Offset Production Wells

- Oil
- MARCIT Treatment
- Water
WOR of 7 Offset Production Wells
Conclusions

• To date, average incremental oil = +8 bopd and average water reduction = -150 bpd

• Total cost was $145,000 which yields a payout of ~12 months (oil price of $50/bbl)

• Injection well polymer gel treatments can produce sustained incremental oil benefits in mature, highly water saturated floods
Thanks

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- Scott Dobson, Legacy Energy, LLC
- TIORCO, LLC
Q & A: Discussion