Tertiary Oil Recovery Project
Advisory Board Meeting

Arbuckle Polymer Jobs

University of Kansas
Kansas Union
November 15, 2002

Rich Pancake
Presentation Outline

- Status of Arbuckle Polymer Treatments
- TORP’s Efforts in Evaluating Polymer Treatments
- Future TORP/PTTC Activities Related to Polymer Treatments
Status of Arbuckle Polymer Treatments

- +/- 100 MARCIT technology polymer jobs pumped in the Arbuckle since 2000
  - +/- 60 by TIORCO
  - +/- 40 by Gel-Tec

- Treatment locations
  - +/- 60 % of jobs pumped in Bemis-Shutts Field
  - Remainder pumped in Marcotte, Star Northwest, Northampton, Jelinek, Ogallah, Trapp, Geneseo-Edwards, and other fields
Polymer Treatments in Ellis County

Bemis-Shutts

Star Northwest

Courtesy of the Kansas Geological Survey
Polymer Treatments in Rooks County

Courtesy of the Kansas Geological Survey
Polymer Treatments in Bemis-Shutts

29 Polymer Jobs Shown

Courtesy of the Kansas Geological Survey
Well selection criteria

- Well drilled up structure
- Well originally had high, water-free IP
- Well at its economic limit because of high WOR
- Well has very high fluid level
- Well has high calculated flow potential
Status of Arbuckle Polymer Treatments

- Treatment design criteria
  - **Vender 1**
    - For high fluid level wells, pump 2x well’s daily production, up to 4000 bbls.
    - For low fluid level wells, pump 1x well’s daily production.
    - Surface treating pressure not to exceed 200 psig.
  - **Vender 2**
    - Gel volume pumped to be near well’s calculated maximum inflow, up to 4000 bbls.
    - Surface treating pressure to be between 200 and 400 psig.
Typical treatment design

- Pull pump & tbg. Sand pump well. RIH w/ tbg & packer. Set pkr +/- 100 ft above interval.

- Acidize well w/ between 250 & 1500 gals 15% HCl.
  - Recent trend appears to be towards the larger, 1500 gal acid jobs.

- Pump polymer down tbg.
  - Small job - 1000 to 1600 bbls.
  - Large job - 3000 to 4100 bbls.
  - Larger jobs are typically in Bemis.
  - Recent trend may be to pump even larger jobs.
Typical treatment design (cont’d)

- Pump polymer down tbg (cont’d).
  - Gel loadings increase in 3 to 4 stages – 3500, 4000, 5000, and 6500 ppm.
  - Recent trend appears to be to increase gel loading at end of job to 7500 or 8500 ppm.

- Flush tbg w/ oil or water.
  - Typically 100 bbl water flush.
  - Typically 50 to 80 bbl oil flush.
  - Philosophy of oil or water flush varies among operators.

- Shut-in well 7 to 14 days. Return well to production.
Status of Arbuckle Polymer Treatments

Polymer treatment examples
Example of Good Response

Murfin’s Hadley BC #10 Polymer Job
August 14-18, 2001
(3806 bbls gel, 100% of job treated on a vacuum, 0 psig max treating press)

Before Treatment
SPM - 12.5
SL - 120 in
Pump - 3.25 in
FL - ?

After Treatment
SPM - 6.0
SL - 120 in
Pump - 1.5 in
FL - as indicated

SPM - increase 2/19/02 to 7.5
Pump - increase 5/2/02 to 2 inch
Example of Good Response

Murfin's Peavey A-6 Polymer Job
August 10-13, 2001
(3806 bbls gel, 64% of job treated on a vacuum, 446 psig max treating press)

**Before Treatment**
- SPM - 12
- SL - 100 in
- Pump - 3.25 in
- FL - ?

**After Treatment**
- SPM - 7.5
- SL - 100 in
- Pump - 1.5 in
- FL - as indicated

**Notes:**
- SPM increase 2/19/02 to 9.5
- Pump increase 5/3/02 to 2 inch

**Graph:**
- X-axis: Dates from 12/16/2000 to 6/16/2002
- Y-axis: 10,000, 1,000, 100, 10
- Different lines represent different production types:
  - Green: Oil Production (BOPD)
  - Blue: Water Production (BWPD)
  - Red: WOR
  - Black: Fluid above zone (ft)
Example of Good Response

Murfin's Jorgensen #4 Polymer Job
August 6-9, 2001
(3805 bbls gel, 58% of job treated on a vacuum, 102 psig max treating press)
Example of Good Response

Murfin's Johnson B #3A Polymer Job
August 2-3, 2001
(1621 bbls gel, 97% of job treated on a vacuum, 51 psig max treating press)

Before Treatment
SPM - 12.5
SL - 120 in
Pump - 2.0 in
FL - 834' above zone in March 1997

After Treatment
SPM - 6.0
SL - 120 in
Pump - 1.5 in
FL - as indicated

These fluid levels questionable

Example of Good Response
Example of Poorer Response

Vess's Colahan A #41 Polymer Job
August 18-21, 2001
(2988 bbls gel, 8.2% of job treated on a vacuum, 923 psig max treating press)

Before Treatment
- SPM: 13.5
- SL: 86 in
- Pump: 2.25 in
- FL: as indicated

After Treatment
- SPM: 6.5
- SL: 62 in
- Pump: 1.5 in
- FL: as indicated

Pump - increase 12/1/01 to 2 inch

Oil Production (BOPD)  Water Production (BWPD)  WOR  Fluid above zone (ft)
Example of Poorer Response

Vess’s Colahan A #2 Polymer Job
August 26-30, 2001
(4093 bbls gel, 29% of job treated on a vacuum, 591 psig max treating press)
**Example of Poorest Response**

*Murfin's Glathart #1 Polymer Job*

*December 8-9, 2001*

*(1007 bbls gel, 0% of job treated on a vacuum, 200 psig max treating press)*

**Before Treatment**
- SPM: 16.9
- SL: 54 in
- Pump: 2.25 in
- FL: ??

**After Treatment**
- SPM: 12.35
- SL: 54 in
- Pump: 2.0 in
- FL: pumped off

SPM decrease 1/10/02 to 9.2

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**Graph 1:**
- Oil Production (BOPD)
- Water Production (BWPD)
- WOR
- Fluid above zone (ft)
### Status of Arbuckle Polymer Treatments

#### Job costs
- **Gel cost**
  - $30 M to $35 M for larger jobs (4,000 bbl)
  - $15 M to $20 M for smaller jobs (1,500 bbl)

- **Rig & acid costs**
  - $5 M to $10 M depending on rig time & volume acid

- **Total costs**
  - $45 M for large jobs
  - $20 M for very small jobs
Status of Arbuckle Polymer Treatments

- **Pay-out (based only on incremental oil recovery)**
  - **3.8 months for average performing jobs (4 wells)**
    - **Assumptions**
      - +/- 3200 bbl/well net incremental oil recovery over 6 months (+/- 18 bbl/day/well incremental for 6 months)
      - $22/bbl oil price
      - $45 M job cost

- **Three poorest performing jobs did not pay-out**
  - **Assumptions**
    - +/- 1120 bbl/well net incremental oil recovery over 6 months (+/- 6 bbl/day/well incremental for 6 months)
    - $22/bbl oil price
    - $45 M job cost
TIORCO’s Polymer Injection Equipment
Gel-Tec Polymer Job on an Elysium Well
Pumping into well
Tri-plex pump and crosslinker storage
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TORP’s Efforts

- Objective – help operators maximize gel polymer treatments.

- Develop comprehensive database by which to compare all Arbuckle gel polymer treatments.

  - Hope to spot trends that lead to improved treatments.
  - Have contacted several operators requesting information on gel polymer treatments.
  - Getting some positive feedback and information.
TORP’s Efforts

- Conduct and analyze pre and post-treatment build-up tests using TORP’s computerized Echometer.
  - Measure formation kh and skin.
  - Determine if reservoir flow is linear (through fracture) or radial (through matrix).
  - For pre-treatment build-ups, attempt to predict how much polymer a well will take.
  - Have performed pre-treatment build-ups on 7 Arbuckle wells.
    5 in Bemis-Shutts  2 in Geneseo-Edwards
Build-up Test on Vess Oil’s McCord A #4
View from Vess Oil’s Colahan A #8
TORP’s Efforts

- Analyze bottom-hole pressure (BHP) surveys that are to be run on 4 wells.
  - Bottom-hole pressure to be measured (via pressure bomb on slickline) before, during, and after gel treatment.
  - Hope to gain insights into the gel/rock interface, which should help in sizing treatments and setting maximum treating pressures.
  - Hope to determine a friction coefficient for pumping gel down tubing.
  - 3 BHP surveys have already been run in Bemis-Shutts.
Trilobite Testing’s Slickline Trailer at Vess Oil’s Hall B #4
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Future TORP/PTTC Activities

- Conduct post-treatment build-ups on same 7 wells.
  - Hope to document how reservoir changes after treatment.

- Sponsor operator forum for those operators who have pumped jobs.
  - Possibly in late January 2003.

- Put gel polymer database online.