IMPROVED OIL RECOVERY
IN FLUVIAL DOMINATED DELTAIC RESERVOIRS OF KANSAS - NEAR-TERM

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Objectives

The objective of this project is to address waterflood problems of the type found in Morrow sandstone reservoirs in southwestern Kansas and Cherokee Group reservoirs in southeastern Kansas. Two demonstration sites operated by different independent oil operators are involved in this project. The Stewart Field is located in Finney County, Kansas and is operated by North American Resources Company. The Nelson Lease is located in Allen County, Kansas, in the N.E. Savonburg Field and is operated by James E. Russell Petroleum, Inc.

General topics to be addressed are 1) reservoir management and performance evaluation, 2) waterflood optimization, and 3) the demonstration of recovery processes involving off-the-shelf technologies which can be used to enhance waterflood recovery, increase reserves, and reduce the abandonment rate of these reservoir types.

In the Stewart Project, the reservoir management portion of the project conducted during Budget Period 1 involved performance evaluation. This included 1) reservoir characterization and the development of a reservoir database, 2) volumetric analysis to evaluate production performance, 3) reservoir modeling, 4) laboratory work, 5) identification of operational problems, 6) identification of unrecovered mobile oil and estimation of recovery factors, and 7) identification of the most efficient and economical recovery process.

To accomplish these objectives the initial budget period was subdivided into three major tasks. The tasks were 1) geological and engineering analysis, 2) laboratory testing, and 3) unitization. Due to the presence of different operators within the field, it was necessary to unitize the field in order to demonstrate a field-wide improved recovery process. This work was completed and the project moved into Budget Period 2.

Budget Period 2 objectives consisted of the design, construction, and operation of a field-wide waterflood utilizing state-of-the-art, off-the-shelf technologies in an attempt to optimize secondary oil recovery. To accomplish these objectives the second budget period was subdivided into five major tasks. The tasks were 1) design and construction of a waterflood plant, 2) design and construction of a water injection system, 3) design and construction of tank battery consolidation and gathering system, 4) initiation of waterflood operations and reservoir management, and 5) technology transfer.

In the Savonburg Project, the reservoir management portion involves performance evaluation. This work included 1) reservoir characterization and the development of a reservoir database, 2) identification of operational problems, 3) identification of near wellbore problems such as plugging caused from poor water quality, 4) identification of unrecovered mobile oil and estimation of recovery factors, and 5) preliminary identification of the most efficient and economical recovery process i.e., polymer augmented waterflooding or infill drilling (vertical or horizontal wells).

To accomplish this work the initial budget period was subdivided into four major tasks. The tasks included 1) geological and engineering analysis, 2) waterplant optimization, 3) wellbore cleanup and pattern changes, and 4) field operations. This work was completed and the project has moved into Budget Period 2.

The Budget Period 2 objectives consisted of continual optimization of this mature waterflood in an attempt to optimize secondary and tertiary oil recovery. To accomplish these objectives the second budget period was subdivided into six major tasks. The tasks were 1) waterplant development, 2) profile modification treatments, 3) pattern changes, new wells and wellbore cleanups, 4) reservoir development (polymer flooding), 5) field operations, and 6) technology transfer.

Summary of Technical Progress

Stewart Field Project

Task II.1 - Design/Construct Waterflood Plant

Summary of work in last quarter

Only small adaptations were made during the quarter.

Summary of planned work for next quarter

None planned at this time, but will made adaptations as necessary.

Task II.2 - Design/Construct Injection System

Summary of work in last quarter

No major work.

Summary of planned work for next quarter

No additional construction work planned at this time.

Task II.3 - Design/Construct Battery Consolidation and Gathering System

Summary of work in last quarter

Finish well test grind out work area/sink.

Summary of planned work for next quarter

Make adaptations as needed for an efficient cost effective operation.

Task II.4 - Waterflood Operations and Reservoir Management

Summary of work in last quarter

Continued monitoring production, injection, and water supply volumes and pressures. Maintained total injection rate of 5600 BWPD. Ongoing testing of producing wells with test trailers and fluid level guns. Increased pumping unit speed in 3 responding producing wells that showed a slightly higher fluid level. Oil production increased approximately 240 BOPD during the quarter due to waterflood response. This brings the total increase to approximately 285 BOPD. Ongoing allocation of injection volumes in injection wells depending on response in producers and injectors. Daily production and injection rates for the field are displayed on the attached plot. Ran injection profiles in three injection wells and a falloff test on one injection well. Squeezed casing leak on Mackey #1 and returned well to production. Performed well servicing as necessary (pump changes, minor well work). Approximately a third of the producing

wells have been electrified in the ongoing field electrification program. Set up daily production/injection data transfer from field office to Denver via modem.

Summary of planned work for next quarter

Attempt to repair Haag Estate #1 and #2 and return these wells to production. These wells have been temporarily abandoned for over two years and casing problems are suspected due to high fluid levels. Run addition injection well falloff tests. Continue to monitor for response at the producing wells with well tests and fluid levels. Update the reservoir model and simulate when applicable. Monitor water treatment program. Finish electrification of the producing wells.

Task II.5 - Technology Transfer

Summary of work in last quarter

A paper titled, "Evaluating Waterflood Potential in a Morrow Sandstone Reservoir" was presented at the SPE/DOE Tenth Symposium on Improved Oil Recovery in April 1996 at Tulsa, Oklahoma and was published in the conference proceedings.

A tour of the waterflood facilities was held in conjunction with the mid-year meeting of the Kansas Independent Oil and Gas Association in Garden City, Kansas in May 1996.

Summary of planned work for next quarter

The field will be visited by operators throughout the area.

Savonburg Field Project

Task II.1 - Water Plant Development

Summary of work in last quarter

Development work on the flotation process consisted primarily of testing various combinations of chemicals. The chemicals being tested as flotation aids consist of polymers, surfactants, and wetting agents. Various adjustments were made to the slop weir and wiper brushes. Plant downtime of 28 hours was necessitated by replacement of the injection pump. All field injection lines and manifolds were cleaned by chemical flushing and all field filters were changed.

Major electrical control work was done during the quarter to further integrate the air flotation unit with the waterplant control functions. A new transfer pump was installed with a larger (1.5 Hp) motor. Most of the other plant work was cleaning and maintenance. Two of the air turbines from the flotation unit were cleaned.

Equipment to measure the water quality at various locations in the plant has been obtained. Coupons have been placed on various locations throughout the system to monitor corrosion and scale.

Summary of planned work for next quarter

The water plant will be continually monitored and optimized as problems arise. It is believed the greatest opportunity lies in the area of metering, monitoring, and controlling the water streams leading into and out of the flotation unit. It has been difficult to maintain constant flotation efficiency at the unit. This is caused by a variation in the percentage of produced and make-up water that is being treated over time. When this mix changes, the constituents of the combined water stream also change, necessitating a variation in the chemical treatment. This problem could be solved by automatically monitoring the water mix and adjusting the chemical feed accordingly. This development would certainly make the technology useable by most operators and applicable over a wide range of conditions.

Task II.2 - Profile Modification Treatments

Summary of work in last quarter

No treatments were conducted.

Summary of work planned for next quarter

Plans are to conduct two gel polymer treatments in the next quarter. Treatments will be conducted on H-14 and H-5. H-14 is channeled to H-15 and H-5 has a poor injection profile with the water entering the formation above the target zone.

Task II.3 - Pattern Changes and Wellbore Cleanup

Summary of work in last quarter

In the month of April, additional completion work was conducted on injection well #RW-20. Acid chemical mixture was spotted by coiled tubing and pumped in to initiate injection. The well is now taking water satisfactorily. Acid/chemical stimulation jobs were performed by coiled tubing on the following injection wells: RW-1, RW-2, RW-6, RW-8, RW-9, RW-12, KW-7, KW-8, KW-11, HW-18. Tubing and packers were pulled and differential temperature surveys were conducted on converted wells #H-5, and H-14. Both wells indicate some degree of water channeling problem. Tubing and packers were reinstalled and injection resumed. Well # H-25 was pulled for a hole in the 1 inch pump string. Pumping equipment was removed from well #K-32 and K-41, and the wells were shut down as uneconomical. Both are edge wells in the northern portion of the field.

In the month of May, three major workovers were performed. Well H-29 and HW-31 were washed, cleaned, and acid-jetted with emphasis on the B-3 zone. Well # H-12 was washed, cleaned, and acid-jetted. Plastic-lined tubing and packer were run to isolate injection to the B-3 zone. Coiled tubing acid/chemical treatments were performed on well # HW-1, KW-9, and RW-13. Well H-26 and K-45 were pulled and pumps repaired.

In the month of June, differential temperature surveys were conducted on wells #HW-23 and HW-31. Results from HW-31 were generally satisfactory, but #HW-23 showed a major anomaly at a depth of approximately 480 ft. The log indicates a problem with the casing which will require a workover.

Summary of planned work for next quarter

Wells will be continuously cleaned and worked on as needed.

Task II.4 - Reservoir Development (Polymer Flooding)

Summary of work in last quarter

Waiting for a decision to implement polymer flood.

Summary of work for next quarter

It is anticipated that polymer injection could begin during this quarter.

Task II.5 - Field Operations

Summary of work in last quarter

Normal field operations have included: 1) monitoring wells on a daily basis, 2) repairing waterplant, piping, and wells as required, 3) collecting daily rate and pressure data, and 4) solving any other daily field operational problem that might occur.

<u>Month</u>	<u>Oil Production</u>
October 1993	26.4 B/D
November 1993	30.7 B/D
December 1993	32.0 B/D
January 1994	30.8 B/D
February 1994	30.9 B/D
March 1994	30.3 B/D
April 1994	29.1 B/D
May 1994	28.5 B/D
June 1994	30.3 B/D
July 1994	28.9 B/D
August 1994	24.6 B/D
October 1994	23.0 B/D
November 1994	25.7 B/D
December 1994	27.8 B/D
January 1995	27.0 B/D
February 1995	25.3 B/D
March 1995	22.4 B/D
April 1995	22.4 B/D
May 1995	25.0 B/D
June 1995	23.9 B/D
July 1995	26.8 B/D
August 1995	25.2 B/D
September 1995	24.8 B/D
October 1995	24.4 B/D

November 1995	24.4 B/D
December 1995	26.3 B/D
January 1996	29.0 B/D
February 1996	29.2 B/D
March 1996	27.2 B/D
April 1996	26.7 B/D
May 1996	26.6 B/D
June 1996	24.9 B/D

Summary of planned work for next quarter

Field operations will be continued.

Task II.6 - Technology Transfer

Summary of work in last quarter

A paper titled "Development of an Improved Waterflood Optimization Program from the Northeast Savonburg Waterflood" was presented at the SPE/DOE Tenth Symposium on Improved Oil Recovery April 21-24, 1996 in Tulsa, Oklahoma.

Summary of planned work for next quarter

The field will be visited by operators throughout the area.

STEWART WATERFLOOD DAILY TOTALS