Improved Oil Recovery in Fluvial Dominated Deltaic Reservoirs of Kansas - Near-Term

**Quarterly Report
April 1 - June 30, 1997**

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Work Performed Under Contract No.: DE-FC22-93BC14957

For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

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

Cooperative Agreement Number DE-FC22-93BC14957--20

The University of Kansas Center for Research, Inc.

July 15, 1997

Budget Period #1 Duration from 06/18/93 - 03/31/95

Budget Period #2 Duration from 04/01/95 - 12/31/98

DOE Award \$ 2,007,446

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Reporting Period 04/01/97 - 06/30/97
(16th Quarterly Report)

"U.S./DOE PATENT CLEARANCE IS NOT REQUIRED
PRIOR TO PUBLICATION OF THIS DOCUMENT"

Objectives

The objective of this project is to address waterflood problems of the type found in Morrow sandstone reservoirs in southwestern Kansas and in 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. Tasks 1-3 have been completed and water injection began in October 1995.

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 is 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

No major work.

Summary of planned work for next quarter

None planned at this time, but adaptations will be made 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

No major work.

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

An infill well, the Pauls 9-5 and a replacement well, the Haag Estate #6 were drilled during the quarter. The Haag Estate #6 did not encounter any Morrow sand and was subsequently plugged and abandoned. The Pauls 9-5 was completed with 27 ft of Morrow perforations. The perforations were broken down with diesel and the well was placed on production 06/05/97. The Pauls 9-5 was producing over 100 BOPD and 6 BWPD during the latter part of June.

Ongoing pump changes, installation of tubing anchors, stroke length changes, and speeding up pumping units were performed during the quarter on numerous wells. These changes are usually made as a result of the well testing program, which quickly identifies wells with production problems, rising fluid levels, abnormal production trends, and low pump efficiencies. The changes that were made are a continued effort to maximize oil production and keep all the wells near a pumped off condition. All but one producing well (Meyer 10-5) are producing near a pumped off condition, although this can change weekly.

Long term static fluid levels were taken (to estimate bottomhole pressure) on the Meyer 10-5 and the Nelson 2-2. Also the bottomhole pressure of the Pauls 9-5 was measured on a drill stem test. These pressures were as follows:

Meyer 10-5	06/09/97	6 day shut-in BHP	1072 psi
Nelson 2-2	06/09/97	5 day shut-in BHP	35 psi
Pauls 9-5	05/23/97	DST	307 psi

The Pauls 9-3 is currently shut-in for a long-term bottomhole pressure build-up.

Continued monitoring production, injection, and water supply volumes and pressures. Ongoing testing of producing wells with test trailers and fluid level guns continues. Oil production increased approximately 450 BOPD and 500 BWPD during the quarter due to waterflood response. This brings the total increase to approximately 1700 BOPD and 1800 BWPD. A total of 23 of the 34 producing wells have shown a response due to the water injection. Increasing water/oil ratios to varying degrees have been observed at 11 of the producing wells that have seen a response. Ongoing allocation of injection volumes in injection wells continues based on response in producers and injectors, but overall field injection rates have remained constant at 5700 BWPD. Daily production and injection rates for the field are displayed on the attached plot.

Summary of planned work for next quarter

Run one or two injection well falloff tests and obtain a few more static shut-in fluid levels on producers. Continue to monitor for response at producing wells with well tests and fluid levels. Update the reservoir computer model and simulate when applicable. Monitor water treatment program. Upgrade pumping equipment as necessary.

Task II.5 - Technology Transfer

Summary of work in last quarter

Continued to publicize information on the Stewart Field's increasing oil production. A presentation on the Stewart Field was presented as part of an industry workshop sponsored by the North Mid-Continent Region of the Petroleum Technology Transfer Council. The workshop titled "Computer Applications for the Petroleum Industry" was held on June 23, 1997 in Lawrence, Kansas.

Operators throughout the region continue to visit the field to view the state-of-the-art waterflood installation and computerized monitoring system.

Summary of planned work for next quarter

Continue to publicize information on the Stewart Field's increasing oil production. Presentations are scheduled for August 25th at the annual meeting of the Kansas Independent Oil and Gas Association in Wichita, Kansas and September 11th at the Kiwanis meeting in Lawrence, Kansas.

Summary of Technical Progress

Savonburg Field Project

Task II.1 - Water Plant Development

Summary of work in last quarter

The Ecosol meter was replaced in order to produce more consistent produced water measurements. The new meter is presently in the testing stage.

Additional bench testing of flotation-aid chemicals was continued. In June a test program was conducted to better quantify air-flotation unit operations. A report was prepared.

Cleaning and calibration of the chemical pumps continues to be a major item.

Summary of planned work for next quarter

The water plant will be continually monitored and optimized as problems arise.

Task II.2 - Profile Modification Treatments

Summary of work in last quarter

No profile modification treatments were conducted during this quarter.

Summary of work planned for next quarter

Gel polymer treatments are planned for the near future. Before designing the treatments fluid balance calculations will be performed to confirm the necessity of the treatments.

Task II.3 - Pattern Changes and Wellbore Cleanup

Summary of work in last quarter

Mechanical Integrity Tests were performed on wells RW-3, RW-6, KW-10, RW-14, H-12 and H-29. Wells RW-5 and RW-15 were successfully tested after replacing the top joint of casing.

Well HW-23 was worked-over and converted to an injection well in June. A fishing job was performed and the well was equipped with tubing and packer.

Well H-10 was cleaned-out to bottom and returned to production.

A pressure fall-off test in May on well R-20 was invalidated when the well ceased taking water.

The following wells were serviced during the second quarter; H-16, H-17 and H-22 (twice) in April, and H-3 (twice), H-10 (twice) and K-43 in June. The service was required to replace joints of 1" pumping string that developed leaks, and to service pumps.

Summary of planned work for next quarter

Wells will be tested, cleaned and worked on as needed.

Task II.4 - Reservoir Development (Polymer Flooding)

Summary of work in last quarter

Waiting on a decision to implement polymer flooding.

Summary of work for next quarter

Waiting on a decision to implement polymer flooding.

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	28.0 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
July 1996	25.4 B/D
August 1996	26.5 B/D
September 1996	26.1 B/D
October 1996	27.1 B/D
November 1996	26.4 B/D
December 1996	27.8 B/D
January 1997	26.9 B/D
February 1997	26.9 B/D
March 1997	27.5 B/D
April 1997	26.3 B/D
May 1997	25.5 B/D
June 1997	24.6 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 plant tour was conducted for Mike Madden of BDM/Oklahoma in June.

Summary of planned work for next quarter

The field will be visited by other operators from the area.

STEWART WATERFLOOD DAILY TOTALS