WEST HACKBERRY TERTIARY PROJECT

Quarterly Technical Progress Report
July 1, 1998-September 30, 1998

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Amoco Exploration and Production Co.
Houston, Texas

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November 1999

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QUARTERLY TECHNICAL PROGRESS REPORT
7/1/98-9/30/98

WEST HACKBERRY TERTIARY PROJECT

Cooperative Agreement No. DE-FC22-93BC14963 -20

Amoco Production Company

Date of Report: 10/14/98

Award Date: 9/3/93

Anticipated Completion Date: 3/31/99 (Budget Period 1)

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Technical Project Officer: Dan Ferguson

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Abstract

The West Hackberry Tertiary Project is a field test of the concept that air injection can generate tertiary oil recovery through the Double Displacement Process. The Double Displacement Process is the gas displacement of a water invaded oil column for the purpose of recovering tertiary oil through gravity drainage. The novel aspect of this project is the use of air as the injection fluid. In Gulf Coast oil reservoirs with pronounced bed dip, reservoir performance has shown that gravity drainage recoveries average 80% to 90% of the original oil in place while water drive recoveries average 50% to 60% of the original oil in place. The target for tertiary oil recovery with the Double Displacement Process is the incremental oil between the 50% to 60% water drive recoveries and the 80% to 90% gravity drainage recoveries. The use of air injection in this process combines the benefits of air's low cost and universal accessibility with the potential for improved oil recovery resulting from spontaneous in situ combustion. If successful, this project will demonstrate that utilizing air injection in the Double Displacement Process will result in an economically viable tertiary process in many Gulf Coast oil reservoirs where other tertiary processes are presently uneconomic. The West Hackberry Tertiary Project receives matching funds from the United States Department of Energy (DOE) as part of the DOE's Class 1 Program for the development of advance recovery technologies in fluvial dominated deltaic reservoirs. In addition, the Petroleum Engineering Department at Louisiana State University (LSU) provides independent study and technology transfer.

Objectives

The goal of the West Hackberry Tertiary Project is to demonstrate the technical and economic feasibility of combining air injection with the Double Displacement Process for tertiary oil recovery. The concept is being field tested in low pressure (300 to 600 pounds per square inch (psi)) reservoirs on the North Flank of the field and high pressure reservoirs (2500 to 3300 psi) on the West Flank of the field.

The low pressure reservoirs on the North Flank of the field are characterized by steep bed dips, large low pressure gas caps, slow water encroachment and thin oil rims. A thin oil rim on a steeply dipping structure occupies a small area. As water encroaches, a producing well will water out while upstructure wells will still reside in the gas cap. Finding an economic method to produce the oil rim represents a considerable challenge. Air injection in this situation can increase oil recovery by: 1)repressurizing the reservoir, 2)pushing the oil rim to downstructure producing wells and 3)effective use of the Double Displacement Process.

The high pressure reservoirs on the West Flank are under active water drive and all producing wells have watered out. Air injection in the high pressure reservoirs is expected to generate tertiary oil recovery through the Double Displacement Process.

Summary of Technical Progress

Through September of 1998, air injection in the three low pressure reservoirs on the North Flank had increased oil production by 148,000 barrels over the expected decline. Air injection is currently underway in only two of the four project reservoirs due to iron oxide plugging in the air injectors. As shown on the production plot on Figure 1, the combined September production rate for the three low pressure reservoirs was 468 barrels of oil per day (BOPD) or 220 BOPD greater than the expected decline. In the high pressure West Flank reservoir, air injection has not yet pushed the oil rim down to the most upstructure well. The following is an update of the third quarter activities for each of the project reservoirs.

Cam C (North Flank - Low Pressure)

One injector and four producers are currently active in the North Flank Cam C reservoir. The air injector is the SL 42 No. 155. Even though historical performance suggests that air injection rates of about one million standard cubic feet per day (MMSCFD) are optimum for this reservoir, recent injection rates have averaged only 0.4 to 0.5 MMSCFD. Air injection has been hampered by continuing plugging of the wellhead air filters with iron oxide. After cleaning, the air filters become plugged again in as little as 15 minutes. To counter this problem, strainers are on order which will catch much of the iron oxide before it reaches the filters. The strainers should be installed by the end of November.

In September, the SL 42 No. 221, was converted to serve as a second air injector. The final hookup of surface facilities is underway and the well should be on line by the end of October. The addition of the SL 42 No. 221 will increase injection rates and also provide the Cam C with a backup injector.

During the second quarter, the SL 42 No. 98 was sidetracked out of the gas cap into the oil rim with a goal of increasing the number of producing wells from four to five. The SL 42 No. 98 was completed in September and tested low fluid feed-in. A workover rig will move onto the well during the fourth quarter and the source of the feed-in problem will be determined at that time.

Producing rates in the Cam C fell in September as two producers, the SL 42 Nos. 185 and 212 were off production for much of the month due to downhole mechanical problems. A plot of injection and producing rates for the North Flank Cam C reservoir is included as Figure 2. Examples of downhole mechanical problems on pumping wells at Hackberry include holes in the tubing, pump failures and parted rods.

Bol 3 (North Flank)

In December of 1997, the injector for the North Flank Bol 3 reservoir, the GLAC No. 245, became plugged with iron oxide and could not be cleaned out. While air injection had increased production in this reservoir, the lack of injection over the past nine months has allowed production to decline. A recent workover on the Gulf Land D (GLD) No. 46 corrected a downhole mechanical problem and improved the producing rate. A plot of injection and producing rates for the North Flank Bol 3 reservoir can be found on Figure 3. Permits have been obtained to convert an alternate well, the GLAC No. 42, to air injection. The conversion is expected to take place during the fourth quarter of 1998.

Cam D (North Flank)

In December of 1997, the North Flank Cam D became the largest low pressure reservoir to undergo air injection at West Hackberry. The Cam D has two producing wells, the CPSB No. 57 and the SL 42 No. 173. Air injection has generated increased production in both wells. In 1998, oil production from the two wells gradually increased from 109 BOPD in June to 141 BOPD in September. A composite production plot is shown on Figure 4.

At this time, the Cam D has one injector and two producers. Workovers are planned to add two more producing wells. The CPSB Nos. 26 and 55 had watered out in the Cam D in prior years. Air injection is expected to continue to push the oil rim downstructure and thereby cause the CPSB Nos. 26 and 55 to produce oil once again. In November, a workover is planned for the CPSB No. 26. The work on the CPSB No. 55 is expected to follow.

The air injector for the Cam D is the CPSB No. 58. During November, a strainer will be installed near the wellhead of the CPSB No. 58 to increase injection rates.

Cam C (West Flank)

Throughout most of the project, the GLD No. 51 served as an air injector in the Cam C sand on the West Flank. In October of 1997, the GLD No. 51 became plugged with iron oxide after injection of almost 1.6 billion standard cubic feet (BCF). Efforts to clean out the GLD No. 51 were not successful. To help assess the location of the oil rim, the GLD No. 51 was sidetracked and logged. The location of the sidetrack hole is immediately adjacent to the original hole. The Cam C-1,2 was found wet and the Cam C-3 appeared to contain a small amount of oil pay. The sidetrack was completed in the Cam C-3 and initially tested nitrogen and oil with a high water cut. After several months of testing, the Cam C-3 watered out.

The GLD No. 51 ST is the highest well on structure in the Cam C sand and encounters the sand wet below the oil rim. A structure map for the West Flank Cam C is shown on Figure 4. When the oil rim reaches the GLD No. 51 ST, using the GLD No. 51 ST as a producing well would generate the earliest possible oil production. If the GLD No. 51 ST serves as a producer, then an alternate wellbore would need to serve as an injector. During late September of 1998, the GLD No. 45 was converted into an air injector. Air injected into the GLD No. 45 is expected to migrate upstructure, accumulate in the gas cap and push the oil rim down to the GLD No. 51 ST. Air injection is expected to begin in the GLD No. 45 in December after air injection flowlines have been run to the well.

The GLD No. 51 ST was completed in the Cam C-3 in a manner that would allow for pulsed neutron logs to be run over the Cam C-1 through tubing. After the GLD No. 45 begins air injection, a pulsed neutron log will be run each quarter to monitor the arrival of the oil rim in the Cam C-1. When the oil rim reaches the GLD No. 51 ST, the GLD No. 51 ST will be recompleted to the Cam C-1 and placed on production.

Figures:

- 1) Composite Production Plot for All Three Low Pressure North Flank Reservoirs
- 2) Production Plot for the North Flank Cam C (4 producing wells)
- 3) Production Plot for the North Flank Bol 3 (2 producing wells)
- 4) Production Plot for the North Flank Cam D (2 producing wells)
- 5) Structure Map for the West Flank Cam C

SI Metric Conversion Factors

bbl x 1.589 873	E-01 = cubic meters
cubic feet x 2.831 685	E-02 = cubic meters
psi x 6.894 757	E+00 = kPa

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