Quarterly Technical Progress Report - West Hackberry Tertiary Project

**Quarterly Report
January 1 - March 31, 1998**

**By:
Travis Gillham; Bruce Cerveney; Tor Kragas**

Work Performed Under Contract No.: DE-FC22-93BC14963

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

By
Amoco Energy Group North America
150 West Warrenville Road
Naperville, Illinois 60566

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**QUARTERLY TECHNICAL PROGRESS REPORT
1/1/98-3/31/98**

WEST HACKBERRY TERTIARY PROJECT

Cooperative Agreement No. DE-FC22-93BC14963--19

Amoco Production Company

Date of Report: 4/15/98

Award Date: 9/3/93

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

Government Award: \$6,017,500 (Budget Period 1)

Program Manager: Travis Gillham

Principal Investigators: Travis Gillham, Demetrios Yannimaras (research)

Technical Project Officer: Jerry Casteel

Reporting Period: 1/1/98-3/31/98 (18th Quarter of Budget Period 1)

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

On the North Flank of West Hackberry Field, air injection has increased oil production in two low pressure reservoirs and air injection was extended to a third low pressure reservoir in December of 1997. On the West Flank, air injection has increased reservoir pressure by 500 psi and a recent sidetrack is expected to generate the project's first West Flank oil production. During the first quarter of 1998, the project moved forward with the following activities: 1)solving the problem of iron oxide plugging in air injectors, 2)on the North Flank, a sidetrack and renewed injection, 3)interrupted injection in the Bol 3, 4)continued injection in the North Flank Cam D reservoir, 5)on the West Flank, a sidetrack and new production, and 6)ongoing technology transfer.

1)Solving the Problem of Iron Oxide Plugging in Air Injectors

During the last half of 1997, air injection was interrupted due to plugging in the downhole completions of the air injectors. A plot of cumulative air injected versus time is included as Figure 1. The plugging material was magnetite, an iron oxide (Fe_3O_4). The source of the magnetite was corrosion in the uncoated steel injection lines and injection well tubing.

To prevent future plugging in air injectors, the following steps were taken:

- 1)The bare steel tubing was replaced with coated tubing in each of the two active air injectors.
- 2)The injection lines were treated with hydrochloric acid to remove iron oxide followed by a slug of compressor synthetic lubricant to inhibit corrosion.
- 3)Pumps were installed on the air injection flowlines to periodically inject a small volume of compressor synthetic lubricant for the purpose of inhibiting corrosion.
- 4)High pressure air filters were installed at the wellhead of each of the two active air injectors.

These practices have been in place since December of 1997 and neither air injector is exhibiting any evidence of plugging. The results are particularly attributable to the diligence of field personnel who have implemented this effort to keep the injection wellbores clean.

2)On the North Flank, a Sidetrack and Renewed Injection

The low pressure Cam C reservoir on the North Flank of West Hackberry has generated the greatest production response to air injection seen to date. Unfortunately, the air injector for the reservoir, the SL 42 No. 155, had been shut-in due to plugging since July 22, 1997. Attempts to re-establish injection by cleaning out the SL 42 No. 155, first with coil tubing and second with a workover rig, proved unsuccessful. In order to return the SL 42 No. 155 to injection, the well was sidetracked out of seven inch casing and

completed in the Cam C with a five inch liner. The sidetrack of the SL 42 No. 155 was a success and the well began injection in March (of 1998).

Recent tests have shown production increases in three of the four producing wells since the SL 42 No. 155 returned to injection. Unfortunately, this is not readily discernible from the composite production plot since three of the four producing wells were off production due to mechanical problems (parted rods or holes in the tubing) during much of March. See the composite Cam C production plot shown on Figure 2. With the mechanical problems in the producing and injection wells resolved, the North Flank Cam C reservoir is expected to exhibit strong production performance during the second quarter of 1998.

To increase the number of producing wells that are benefiting from Cam C air injection, the SL 42 No. 98 will be sidetracked and completed in the oil rim during the second quarter of 1998.

3) Interrupted Injection in the Bol 3

The GLAC No. 245 serves as the air injector for the low pressure North Flank Bol 3 reservoir. The GLAC No. 245 became totally plugged in December. Thus far, attempts to clean out the injector with coiled tubing and a workover rig have been unsuccessful. As noted on Figure 3, the lack of air injection has already resulted in oil production falling by over 30 barrels of oil per day (BOPD). To re-establish injection in the Bol 3, an evaluation is under way to determine whether it is more cost effective to repair the GLAC No. 245 or to convert another well, the GLAC No. 42 to air injection.

4) Continued Injection in the North Flank Cam D Reservoir

With the production increases noted in the North Flank Cam C and Bol 3 reservoirs, the project was expanded to a third low pressure North Flank reservoir, the Cam D sand in December of 1997. The Cam D is a similar albeit much larger version of the other North Flank air injection reservoirs with a thin oil rim, low reservoir pressure, steep bed dip and a large low pressure gas cap. The air injector for the Cam D is the CPSB No. 58 and the only producing well is the CPSB No. 57. Due to the size of the Cam D reservoir, more injection volume will be required before production response is seen. A production plot for the CPSB No. 57 is included as Figure 4. A workover is planned during the second quarter of 1998 to return a second Cam D well to production, the CPSB No. 26.

5) On the West Flank, a Sidetrack and New Production

The air injector for the high pressure Cam C reservoir on the west flank, the GLD No. 51, became totally plugged with magnetite in October of 1997. Attempts to clean out the well with coiled tubing and acid were unsuccessful. The GLD No. 51 was sidetracked and

completed as a producing well in the lowest portion of the Cam C, the Cam C-3. A pulsed neutron log in the sidetrack indicated that while the Cam C-3 was oil productive, the Cam C-1,2 (top and middle portions of the Cam C) was still wet. Initial tests at the beginning of April indicate that the well is producing oil, water and nitrogen from the Cam C-3. The GLD No. 51 is currently temporarily shut-in while awaiting a permit to flare the produced gas.

The GLD No. 45, a shut-in well located slightly downstructure, will be converted to air injection in the near future. Air injection in the GLD No. 45 is expected to push the oil rim in the Cam C-1,2 down to the GLD No. 51.

6)Ongoing Technology Transfer

The following technology transfer events occurred during the first quarter of 1998:

- 1)On January 23, 1998, a talk entitled “Air Injection: Low Cost IOR for Gulf Coast Reservoirs” was given at a technology transfer conference in New Orleans sponsored by LSU’s Basin Research Institute.
- 2)On February 10, 1998, a West Hackberry talk was presented to the monthly meeting of the Mississippi Geological Society in Jackson, Mississippi.

The SPE/DOE Eleventh Symposium on Improved Oil Recovery will be held in Tulsa, Oklahoma on April 19-22, 1998. A paper entitled “Low Cost IOR: An Update on the West Hackberry Air Injection Project” will be presented at that time.

Figures:

- 1) Cumulative Air Injected versus Time
- 2) Composite Production Plot for the North Flank Cam C
- 3) Composite Production Plot for the North Flank Bol 3
- 4) Production Plot for the North Flank Cam D

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