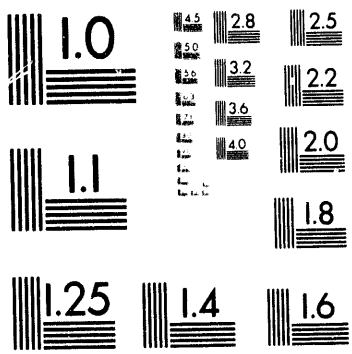
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1 of 1

ASSIST IN THE RECOVERY OF BYPASSED OIL FROM RESERVOIRS IN THE GULF OF MEXICO

Contract Number: DE-AC22-92BC14831

Louisiana State University
Department of Petroleum Engineering
Baton Rouge, LA 70803-6417

Contract Date: February 18, 1992
Anticipated Completion Date: March 18, 1994

Principal Investigator: Philip A. Schenewerk

Project Manager: Gene Pauling
Metairie Project Office

Quarterly Status Report (Final): Covering July 1, 1993 - September 30, 1993

Report Date: November 30, 1993

DISCLAIMER

US/DOE Patent Clearance is <u>not</u> required prior to publication of this document.

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Executive Summary

During this reporting period, data collection from the Minerals Management Service (MMS) was completed and continued from several operators.

Data analysis continued on Reservoir 3 in Field 2. Evaluation included well log analysis, pressure and production data analysis, evaluation of PVT data and development of preliminary model grid schemes.

Material balance and computer simulations studies of the B-65-G Sand reservoir, in South Marsh 73 Field, also continued. Work continues on refining the match for use in predictive runs. Four wells produced from the reservoir; three injected some quantity of gas and one well injected no gas. A fifth downdip well, served as a primary gas injector.

The reservoir model was developed by integrating geologic and engineering data. The reservoir is a long, north-south trending, steeply dipping sandstone, which pinches out just before encountering a piercement salt dome.

The reservoir produced 3,909.8 MSTB of oil, 3,760.2 MMCF (2,745 MMCF was re-injected) of gas and 545 MBbls of water over a period of 27 years.

Originally, it was believed that the reservoir was subject to a fairly strong water drive. However, upon performing material balance studies it was found to have a very weak and limited water drive. This was later confirmed by the simulation work.

A 2D adaptive finite element model capable of simulating oil/water flow in a porous media was constructed. These results have been submitted for publication and accepted for presentation in March, 1994. In addition, a manuscript describing the construction of a new finite element for use in 3D adaptive methods has been submitted for review.

INTRODUCTION

Much of the remaining oil offshore is trapped in formations that are extremely complex due to intrusions of salt domes. Conventional seismic processing techniques cannot clearly image either these traps or the full extent of oil-bearing segments near the salt domes; therefore, substantial volumes of oil may have remained uncontacted by previous drilling.

Recently, however, significant innovations have been made in seismic processing and mathematical migration of seismic signal. In addition, significant advances have been made in deviated and horizontal drilling technologies and applications. These technology advances make it possible to reprocess existing seismic data to identify non-contacted portions of the reservoirs, which can then be contacted using advanced drilling technologies to kick out new wells from existing wells. Effective application of these technologies, along with improved recovery methods, offers opportunities to significantly increase Gulf of Mexico production, delay platform abandonments, and preserve access to a substantial remaining oil target for enhanced recovery and other advanced recovery processes.

Project Description

The objective of this research is to assist the recovery of non contacted oil from known reservoirs on the Outer Continental Shelf in the Gulf of Mexico. Mature offshore reservoirs, declining oil reserves, declining production, and other natural forces are accelerating the abandonment of offshore oil resources and production platforms. As these offshore wells are plugged and the platforms are abandoned, an enormous volume of remaining oil will be permanently abandoned. Significant quantities of this oil could be recovered using advanced technologies now available if the resource can be identified.

This project will proceed under three broad phases:

Analysis -- TORIS level data will be collected on the major fields located in the piercement salt dome province of the Gulf of Mexico Outer Continental Shelf. Representative reservoirs will be studied in detail in order to evaluate undeveloped and attic oil reserve potential. These detailed investigations will be used to calibrate the TORIS level predictive models. The recovery potential of advanced secondary and enhanced oil recovery processes and the exploitation of undeveloped and attic oil zones for salt dome reservoirs in the Gulf of Mexico will be assessed.

Supporting Research -- Supporting research will focus on the modification of public domain reservoir simulation models to accurately simulate the conditions encountered in the piercement salt dome province of the Gulf of Mexico. Laboratory research will focus on the development of fluid relationships that will be used in the simulation of miscible and immiscible processes in the project area.

Technology Transfer -- A significant effort is planned to transfer the results of this project to potential users of the technology. Technology transfer activities will also provide feedback channels that will help keep the analysis and supporting research focused on the most important problems associated with this project.

Project Status and Planned Activities

Data Collection

ICF completed its data collection from MMS. This data is now being input into the TORIS model. Data is being collected from several operators on an "as need basis".

Data Analysis

LSU continued the analysis of data obtained from Taylor Energy on the South Marsh Island (SMI) Block 73 Field in the Gulf of Mexico.

Reservoir 3, Field 2

Data analysis continued on Reservoir 3 in Field 2. Evaluation included well log analysis, pressure and production data analysis, evaluation of PVT data and development of preliminary model grid schemes. Well logs and log analysis were used to define the optimum layering for use in the simulator. Subsequently, net sand isopach maps were prepared for each of these layers. 3-D geophysical data was used to define the structural interpretation for use in the geologic model. Proprietary material balance programs were used to evaluate the production and pressure history of the reservoir. Through an iterative process, the optimum PVT properties were defined for use in the simulator. The material balance programs defined the aquifer size and strength and established the original oil in place vale that was in agreement with the material balance work.

B-65-G Sand Reservoir

Material balance and computer simulations studies of the B-65-G Sand reservoir, in South Marsh 73 Field, also continued. Work continues on refining the match for use in predictive runs. The B-65-G Sand reservoir was chosen to be modelled for calibration studies because of its numerous gas injection cycles from different locales, longevity of its production and access to data.

Four wells produced from the reservoir; three injected some quantity of gas and one well injected no gas. A fifth downdip well, served as a primary gas

injector.

The reservoir model was developed by integrating geologic and engineering data. The reservoir is a long, north-south trending, steeply dipping sandstone, which pinches out just before encountering a piercement salt dome. Structure and trapping are all results of the piercement salt dome. The sandstone produces in several reservoirs within the field, including two which are adjacent to the B-65-G reservoir. It is believed that these two adjacent reservoirs are isolated from the B-65-G reservoir by faulting, because of differences observed in the bottomhole pressure histories of producing wells.

The reservoir consists of approximately 7,000 acre-feet with an average net thickness of 27 feet. Porosity averages 28.5% and the original oil saturation was estimated at 75%. Material balance calculations and simulation work indicates that the reservoir was originally near its bubble point (saturated, but no gas cap) and contained about 8 MMSTB of oil. It's original reservoir pressure was 3457 psi at -7351 feet subsea. Simulation work assumed that this original reservoir pressure was the bubble point. These and other reservoir characteristics have been summarized in Table 1.

The reservoir produced 3,909.8 MSTB of oil, 3,760.2 MMCF (2,745 MMCF was re-injected) of gas and 545 MBbls of water over a period of 27 years. Illustrated in Table 2 is the cumulative production and cumulative gas injection for the reservoir and each well.

The model consists of 12 rows and 12 columns, oriented northeast-southwest over the reservoir. Grid block lengths averaged 425 feet and grid block widths averaged 224 feet. Grid block dimensions around well bores were about 150 feet by 150 feet.

The sand was subdivided into three flow-unit layers. These flow-unit layers were defined by alternating layers of low and high permeability (alternating sand-shale sequences) as observed on electric logs. Average values for porosity and permeability were assigned to each layer initially. Vertical permeability was taken to be 1/10 of the horizontal permeability. While attempting to obtain a history match, detailed modifications were made to these

values. On average, the layers were 22 feet in gross thickness and 10 feet in net thickness.

Table 1

South Marsh Island Block 73 Field

B-65-G Reservoir Characteristics

Original Reservoir Pressure	3457 psi
Datum	7351 feet subsea
Average Porosity	28.5%
Original Water Saturation	25%
Average Thickness	27 feet
Areal Extent	250 acres
Average Horizontal Permeability	620 md
Average Horizontal/Vertical Permeability Ratio	0.1
Initial Gas-Oil Ratio	867 SCF/STB

Table 2

South Marsh Island Block 73 Field

B-65-G Reservoir Production Summary

Well	Oil-MSTB	Gas-MMCF	Water-MBbls	Gas Inj.-MMCF
B-1	990.7	943.0	82.7	654.0
B-7	544.2	740.0	0.8	0.0
B-10-D	537.9	332.2	132.0	11.2
B-12	1,836.9	1,745.0	330.0	1,348.0
B-15	0.0	0.0	0.0	732.0
Total	3,909.8	3,760.2	545.2	2,745.2

PVT values were based on values at initial conditions. The initial relative permeability curves used at the beginning of the simulation were based on values calculated using empirical methods described by Glaso[2]. These relative permeability curves were later modified slightly in order to obtain a history match.

Originally, it was believed that the reservoir was subject to a fairly strong water drive. However, upon performing material balance studies it was found to have a very weak and limited water drive. This was later confirmed by the simulation work.

Critical Process Parameter Laboratory Experiments

The apparatus for experiments for the study of attic oil recovery techniques was tested.

BOAST II Modification

A 2D adaptive finite element model capable of simulating oil/water flow in a porous media was constructed and it has produced coning traces similar to those in Lance Hebert's thesis[1]. Unfortunately, the model requires a great deal of mesh refinement, resulting in prohibitive memory requirements. To resolve this problem, methods that will use less memory are being prioritized and the process of parallelizing the model in order to facilitate the use of more than one computer's resources is being worked on.

The results of the Hebert simulation have been submitted for publication and accepted for presentation in March, 1994. In addition, a manuscript describing the construction of a new finite element for use in 3D adaptive methods has been submitted for review. This element will fit in well with the current 2D strategy of mesh refinement. Implementation of the 3D model will be delayed until problems in the 2D model are resolved.

MASTER Modification

The Master modification continues with no problems or delays.

Summary of Progress

ICF Resources Incorporated (ICF), a subcontractor for the project, completed its data collection with Minerals Management Service (MMS). LSU continued collecting data from operators on an "as needed" basis.

LSU continued the analysis of data obtained from Taylor Energy in South Marsh 73 Field. LSU and BDM personnel continued analyzing Reservoir 3 within a blind coded Field 2.

LSU continued modifying BOAST II for the integration of radial grid systems and testing experimental apparatus designed for studying the recovery of attic oil.

Report Distribution List

Document Control Center
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Pittsburgh, PA 15236-0940

References

[1]Hebert, Edward L: "An Experimental Study of Effects of Water Coning on a Horizontal Well in a Bottom Water Drive Reservoir." Master's Thesis, Department of Petroleum Engineering - Louisiana State University (May, 1990).

[2]Glaso, Oistein: "Generalized Pressure-Volume-Temperature Correlations," Journal of Petroleum Technology. (May, 1980) 785 - 795.

Publications

There were no publications during this reporting period.

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