Exploitation and Optimization of Reservoir Performance in

Hunton Formation, Oklahoma

QUARTERLY TECHNICAL PROGRESS REPORT

Submitted by

Dr. Mohan Kelkar
Department of Petroleum Engineering
The University of Tulsa
600 S. College Avenue
Tulsa, Oklahoma 74104-3189

Contract Date: March 7, 2000

Completion Date: March 6, 2005

Reporting Period: January 1 – March 31, 2005

Date Issued: April 2005

DOE Contract No. DE-FC26-00NT15125

Prepared for

U.S. Department of Energy
Assistant Secretary for Fossil Energy

Contracting Officer's Representative:

Mr. Paul West
U.S. Department of Energy
National Petroleum Technology Office/DOE
Post Office Box 3628
Tulsa, Oklahoma 74103

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 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.

Abstract

West Carney field – one of the newest fields discovered in Oklahoma – exhibits many unique production characteristics. These characteristics include:

1) decreasing water-oil ratio;
2) decreasing gas-oil ratio followed by an increase;
3) poor prediction capability of the reserves based on the log data; and
4) low geological connectivity but high hydrodynamic connectivity.

The purpose of this investigation is to understand the principal mechanisms affecting the production, and propose methods by which we can extend the phenomenon to other fields with similar characteristics.

In our experimental investigation section, we present the data on methane injection using huff-n-puff process. It appears that additional oil can be recovered using methane as a solvent. Additional experiments will be needed to confirm our analysis.

Our engineering analysis has laid out detailed indicators to make the de-watering successful. Using those indicators, we are currently investigating potential in fill well locations in West Carney field.

Our technology transfer activities continued this quarter with two presentations and one workshop.

Table of Contents

Executive Summary

The analysis of production data from the West Carney field is continued in this quarter. Based on the analysis of the production data, the following observations can be reached:

- By injecting methane in a depleted core, additional oil can be recovered using huff-n-puff process.
- Potential exists for in fill well locations in West Carney Field using the criterion established in the previous reports. .
- Technology transfer activities are conducted aggressively to present the work carried out in this project.

Experimental

Kishore Mohanty, University of Houston

Objective

The objectives of the third phase of this project are to test the feasibility of using Hunton reservoir as a gas storage reservoir and improve near-wellbore wettability. The feasibility of the gas storage was tested in the laboratory scale by conducting huff-puff test with gas. Treatment of the near-well bore region by a surfactant solution can decrease near-wellbore water blocking and increase gas productivity; we are continuing this study. Laboratory scale huff-n-puff tests are described in this report.

Experimental Procedure

A Berea core, 7 in (17.78 cm) long and 2 in (5.05 cm) OD, is placed vertically in the core holder with a spacing ring on its top. The characteristics of the core are listed in Table 1.

Core			
D (cm)	5.05	A (cm^2)	20.03
L (cm)	17.78	V (cm^3)	356.13
K (md)	132.1	V_p (cm^3)	65.20
		ϕ	18.31

Table 1: Characteristics of the core

The circular spacing area is 12 cm^2 and height is 0.3 cm. This spacing is filled with CH_4 to allow methane diffusion into the core through the surface area where the core is exposed to methane. The injection sequence was as follows:

1. Oil injection: The core is injected with more than 2 pore volumes of Mary Marie oil at the atmospheric pressure. Care is taken to eliminate methane residue from previous runs.
2. CH_4 injection: The CH_4 is first injected into the spacing area to blow out the oil in the spacing area while the pressure regulator is set at atmospheric pressure. After blowing out all the oil from the spacing area, the valve connecting the 150 ml CH_4

storage tank and the spacing area is closed. Then CH_4 is introduced into the storage tank until it is filled with CH_4 at 1600 psi. The pressure regulator is also set at 1600 psi. The valve connecting the storage tank and the spacing area is then open to allow CH_4 to get into the spacing area and diffuse into the core. A differential pressure gage is used to monitor the diffusion rate of CH_4 into the core until near equilibrium is reached. The core is then left for a day to make sure no more diffusion takes place.

3. Depressurizing the core: After no more CH_4 diffusion, the valve connecting the storage tank and the spacing area is shut. The dome liquid pressure of the regulator is controlled by an Isco pump. By either slowly or rapidly reducing the pressure of the regulator, gas and oil are produced. The oil production is monitored with respect to time along with the pressure of the regulator.

Results and Discussion

Two huff-n-puff experiments are described below. In the first experiment, in the first cycle of depressurization the regulator pressure was reduced from 1600 psi to 20 psi slowly; some oil got produced. Then methane was injected again to bring the pressure up to 1600 psi. The second cycle of depressurization was conducted again to 20 psi. This cycle was further continued down to 20 psi. In the second experiment, in the first cycle of depressurization the regulator pressure was reduced from 1600 psi to 500 psi slowly; some oil got produced. Then methane was injected again to bring the pressure up to 1600 psi. The second cycle of depressurization was conducted again to 500 psi. This cycle was further continued down to 20 psi. The effect of depressurization pressure on oil production can be shown from the comparison of the two experiments. The effect of cycle number on oil production can be shown in each experiment.

The oil production in the first huff-n-puff experiment as a function of back pressure regulator pressure is shown in Figure 1. Very little oil is produced between 1600 psi and 900 psi. Below 900 psi, oil production increases. About 13% PV is produced out of the core (not including the dead space on the top of the core) when the pressure reaches 20 psi. The core is then repressurized with methane to 1600 psi for the second cycle of depressurization. As the pressure falls, more oil comes out; the cumulative oil production (%PV) is plotted. Again very little is produced above 900 psi. As the pressure falls further more oil is produced. An additional 7.5% PV oil (a total of 20.5% PV) is produced when the pressure reaches 20 psi. As expected, the oil production in the second cycle (7.5% PV) is lower than that (13% PV) in the first cycle.

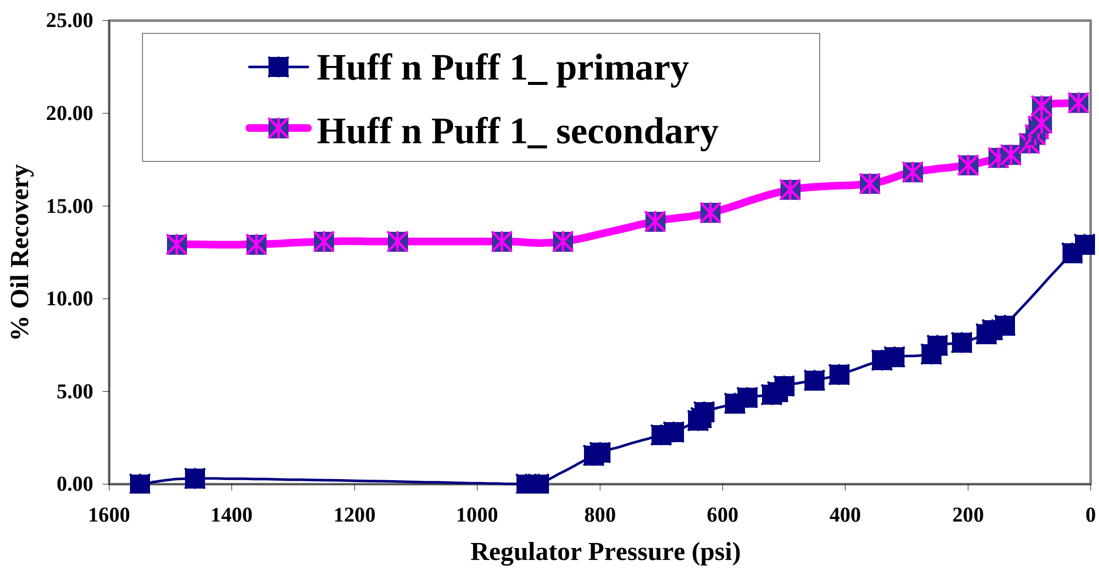

Figure 1: Cumulative oil production vs. pressure

The oil production in the second huff-n-puff experiment as a function of back pressure regulator pressure is shown in Figure 2. Very little oil is produced between 1600 psi and 800 psi. Below 800 psi, oil is produced. About 4% PV is produced out of the core (not including the dead space on the top of the core) when the pressure reaches 500 psi. The core is then repressurized with methane to 1600 psi for the second cycle of depressurization. As the pressure falls, more oil comes out; the cumulative oil production (%PV) is plotted. Again very little is produced above 900 psi. As the pressure falls further, more oil is produced. An additional 1.4% PV oil (a total of 5.4% PV) is produced in the second cycle when the pressure reaches 500 psi. As expected, the oil production in the second cycle (1.4% PV) is lower than that (4% PV) in the first cycle. The back pressure is reduced further down to 20 psi. The oil recovery increases and another 10% PV oil is produced giving a total of 15.4% PV. Comparison with the first experiment shows that as the depressurization pressure increases, oil production decreases.

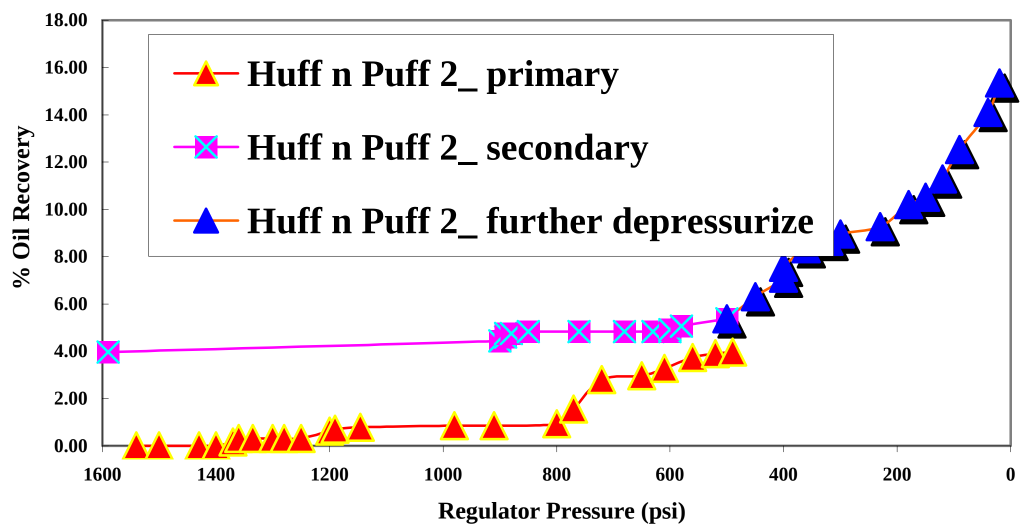

Figure 2: Cumulative oil production vs. pressure

Conclusions

Methane huff-n-puff experiments were conducted for the Mary Marie oil in a ~17 cm core. Substantial amount of oil (~20% PV) can be recovered by two cycles of huff-n-puff. The oil recovery increases as the depressurization pressure decreases. Oil produced decreases with depressurization cycle.

Future Work

The impact of surfactant treatment on near wellbore gas permeability will be studied with Hunton cores.

Results and Discussion

Geological Analysis

Jim Derby, Derby and Associates

The cores have been fully described. We are in the process of generating spatial distribution of facies using interpolation software so that we can study the geological heterogeneity in greater detail.

Engineering Analysis

Log and Production Data Evaluation

Manas Gupta, Rahul Joshi and Mohan Kelkar, The University of Tulsa

In the last quarterly report, we presented a detailed analysis of why the de-watering works in Hunton formation. We also provided the type of characteristics we need to make it successful. We are currently examining the West Carney field using the developed criterion to find out if additional in fill well potential exists in the field. We will be able to present those results in the next quarterly report.

Technology Transfer

We made two presentations during the last quarter.

1. "Hunton Formation: how does it Work," SPE Mid-Continent Section Meeting, March 3, 2005. This was part of the weekly luncheon program and was attended by more than 120 people. Lot of interest was expressed by the attendees after the presentation.
2. "De-watering of Hunton Reservoir – What Makes it Work?" SPE 94347, paper presented at SPE Production Symposium, OK City, OK (April 17-19, 2005). This paper was also attended by more than 60 people in the audience and was well received.

In addition to these two presentations, we also presented a workshop on March 3rd in Tulsa about the project. This workshop was attended by thirty people. We provided the participants with a copy of the presentations as well as all the publications from the project. We intend to hold another workshop in OK City in the next quarter.

Conclusions

Based on the material presented in this report, the following conclusions can be drawn:

- A huff-n-puff experiment, using methane as injectant, provided promising results in terms of additional oil recovery.
- A detailed analysis about what makes the de-watering work in Hunton formation is presented in previous reports. Using the criteria established, we are searching for in fill well locations in Hunton formation.
- Two presentations were made as part of technology transfer activity. In addition, a workshop in Tulsa was taught about the project. All the presentations as well as the workshop was well received.