Semi-annual Technical Progress Report

IMPROVING CO₂ EFFICIENCY FOR RECOVERING OIL IN HETEROGENEOUS
RESERVOIRS

DOE CONTRACT NO. DE-FG26-01BC15364

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ABSTRACT/ EXECUTIVE SUMMARY

A three-year contract, DOE Contract No. DE-FG26-01BC15364 “Improving CO₂ Efficiency for Recovering Oil in Heterogeneous Reservoirs,” was started on September 28, 2001. This project examines three major areas in which CO₂ flooding can be improved: fluid and matrix interactions, conformance control/sweep efficiency, and reservoir simulation for improved oil recovery.

This report discusses the activity during the six-month period covering January 1, 2002 through June 30, 2002 that covers the second and third fiscal quarters of the project’s first year. Paper SPE 75178, “Cost Reduction and Injectivity Improvements for CO₂ Foams for Mobility Control,” has been presented and included in the proceedings of the SPE/DOE Thirteenth Symposium on Improved Oil Recovery, Tulsa, OK, April 13-17, 2002.

During these two quarters of the project we have been working in several areas: reservoir fluid/rock interactions and their relationships to changing injectivity, producer survey on injectivity, and surfactant adsorption on quarried and reservoir core.

INTRODUCTION

Of the available advanced oil recovery methods, CO₂ injection has the greatest potential for improved oil recovery (IOR) from light oil reservoirs in the United States. Presently eleven states have CO₂ injection projects, with 75% found in west Texas and southeast New Mexico. Almost universally, CO₂ injection has been a technical success when applied, and has proven profitable in the majority of reported projects. New CO₂ projects commence yearly but many reservoirs are not considered for CO₂ flooding because of low fracture pressure, poor injectivity, and/or extreme heterogeneity. The proposed work centers on crucial research to optimize CO₂ injection to maximize domestic hydrocarbon reserves. This project will expand the range of reservoirs amenable to CO₂ flooding.

During the course of our investigations, we will determine parameters and methodologies that will result in more efficient CO₂ flooding in heterogeneous reservoirs. Major areas of interests are: identifying reservoirs amenable to CO₂ flooding, characterizing CO₂ foaming agents, CO₂ flooding predictions, and parameters that affect CO₂ sweep efficiency, production rate, reservoir retention, and injectivity change affecting CO₂ and water injection rates.

Benefits will include: increasing the range of reservoirs amenable to CO₂ flooding, improving efficiency and lowering cost of CO₂ foam systems, improving CO₂ flooding predictions, improving sweep efficiency, controlling production timing, and optimizing retention and injectivity changes.

SUMMARY OF TECHNICAL PROGRESS

This report discusses the activity covering January 1, 2002 through June 30, 2002 that coincides with the second and third fiscal quarter of the projects first year.

Current Work: There are several areas of concentration at this time:

1. Understanding problems related to injectivity changes in WAG processes. This includes both dialogues with field and supervising engineers and laboratory testing. In the laboratory, we have been examining dissolution and precipitation of solids in reservoir core.
2. Testing and evaluating mixed surfactant systems and lower value components to be used as sacrificial agents to satisfy adsorption requirements in the reservoir.

Scheduled Milestones: Scheduled the second half of 2002.

1. Completion of literature survey and site visits with project personnel to summarize what is perceived as injectivity problems related to the WAG process. This will include what is being experienced, suspected causes, remedies attempted, and success or failures in remedying the problem.
2. Laboratory core flood tests that determine solids dissolution and precipitation. This is a follow-up on earlier findings that indicated precipitation of minerals dissolved upstream.
3. Laboratory tests to evaluate adsorption trends for the lignosulfonate/CD1045 system in reservoir core. We are particularly looking at San Andres dolomite from the Permian Basin.

Accomplishments: Highlights of the first six months of 2002:

1. Presentation at the SPE/DOE Thirteenth Symposium on IOR on the economic evaluation of the lignosulfonate/CD1045 system. This is SPE 75178, "Cost Reduction and Injectivity Improvements for CO₂ Foams for Mobility Control."

Paper Abstract:

This paper identifies chemical cost reduction derived from the synergistic effects of co-surfactant systems using a good foaming agent and a less expensive, poor foaming agent. The required good foaming agent is reduced by at least 75%. Also, the effect on injectivity is reduced by as much as 50% using the co-surfactant system, compared to a previously used surfactant system. Mobility control of injected CO₂ for improved oil recovery can be achieved with significant reduction in the chemical cost of SAG, improved injectivity of SAG, and improved economics of CO₂ injection project when compared to reported systems.

2. Thesis, "Concatenation of Reactive Transport Model to Simulate CO₂ Sequestration in Geologic Media," Tristan P. Wellman. This thesis work covers initial work and outlines future work in the area of a coupled flow and transport model of a multi-component geochemistry module to aid in our prediction and understanding of reservoir fluid/rock interactions. The purpose of this study was to better understand injectivity changes due to these interactions and to improve our later understanding of surfactant adsorption on reservoir rock.
3. Visits to petroleum operators in Midland and Houston (BP, ChevronTexaco, Anadarko, Kinder Morgan, Transpetco, Phillips, Pure Resources, Quay Valley, Amerada Hess) with CO₂ injection project for improved oil recovery. In general, injectivity in many of these Permian

Basin projects is a concern. It is not understood and many of the projects are injection limited. It is not unusual to have the brine injectivity decrease after the injection of CO₂, sometimes as much as 50% or more during brine half cycle. This is excluding the relative permeability effects of the two-phase when switching from one fluid to the other. In some lower permeability reservoirs the decrease in injectivity even limits the injection rate of CO₂. It is suspected that injectivity might be decreasing in all CO₂ floods, but in higher permeability situations it is not perceived as a problem because the desired amount of fluid is still being injected into the reservoir. In some of these situations, it could become a problem if the decrease of injectivity continues to the point where injection becomes the limiting factor.

Technology Transfer

SPE 75178, "Cost Reduction and Injectivity Improvements for CO₂ Foams for Mobility Control," was presented and included in the proceedings of the SPE/DOE Thirteenth Symposium on Improved Oil Recovery to be held in Tulsa, OK, April 13-17, 2002.

A number of visits to petroleum production companies were made during this time period.

Public Relations

Program Chair for SPE/DOE Thirteenth Symposium on Improved Oil Recovery held 13-17 April 2002 in Tulsa, OK.