CYCLIC CO₂ INJECTION FOR LIGHT OIL RECOVERY:
PERFORMANCE OF A COST SHARED FIELD TEST IN
LOUISIANA

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OBJECTIVES

The ultimate objective of this research is to provide a base of knowledge on the CO₂ huff 'n' puff process for the enhanced recovery of Louisiana crude oil. Project goals include laboratory corefloods to investigate several parameters important to the process, and numerical simulation to interpret coreflood results. Additional activities include construction and analysis of a field test data base to facilitate target reservoir screening, and to identify sensitive operational parameters. The information from laboratory corefloods and data base evaluations will be used in the design and implementation of a Department of Energy sponsored field test. The results of all laboratory and field evaluations will be made available to the industry through workshops, periodic reports, and meetings.

SUMMARY OF TECHNICAL PROGRESS

Subtask 1: Laboratory Corefloods

Coreflood experiments were initiated during this reporting period to examine the influence of CO₂ injection rate on process performance. Experiments designed to determine the benefits of using a drive gas have been completed.

Previous laboratory coreflood and field test results have indicated that process performance improved when CO₂ penetrates further into the reservoir. Deeper penetration of CO₂ may be achieved by increasing the CO₂ slug size; however, the cost of additional CO₂ may be prohibitive. Since nitrogen is a less expensive gas, it was thought that a nitrogen drive might provide a cost-effective means of enhancing the reservoir penetration of CO₂.

Three sets of first and second cycle corefloods have been performed to test this hypothesis. Corefloods were conducted using Timbalier Bay oil and the horizontal Berea core (6 ft long; 2 in diameter). Experimental procedures and oil properties have been described previously.¹ Injections of 16 cc CO₂ or 16 cc nitrogen alone were compared with injections of 16 cc CO₂ followed by 16 cc nitrogen. Gases were injected at 1640 psig and 78 °F, the pressure of the core was slowly reduced at constant temperature to 500 psig, and the core was shut-in for a soak period before production of oil commenced. Although equal volumes of CO₂ and N₂ were injected, the masses injected were quite different since the gas densities were not the same, and subsequently the gas volumes at soak conditions were different. Comparisons of CO₂ and N₂ masses injected, volumes injected, and reservoir pore volumes are presented in Table 1.

Since previous studies have shown that incremental oil recovery was linearly related to the amount of CO₂ injected, the benefits of a drive gas could be evaluated by comparing the recovery achieved by injection of CO₂ followed by nitrogen (N_{PCO₂+N₂})

with the sum of the recoveries of the separate processes ($Np_{N_2} + Np_{CO_2}$).² Coreflood results presented in Table 2 indicate that a nitrogen drive dramatically enhanced oil recovery. In the first cycle, the flood conducted with the drive gas produced 45% more oil than the combined recoveries of the first cycle floods where CO_2 or nitrogen was injected alone. The second cycle results were even more favorable with the drive gas flood recovering 108% more oil than the combined recoveries of the CO_2 and N_2 floods. The magnitude of the benefits derived from nitrogen drive gas was unexpected and further experiments are planned to substantiate this conclusion.

Subtask 2: Field Tests

The past reporting period was directed towards obtaining the necessary permission from various regulatory agencies in the State of Louisiana for implementation of the planned CO_2 huff 'n' puff field test. Applications for a hearing before the Louisiana Office of Conservation and an Underground Injection Control (UIC) Permit have been filed. A hearing date of March 19, 1991 has been set by the Commissioner of Conservation. Approval of the UIC Permit awaits the outcome of the hearing before the Office of Conservation. It is anticipated that the field test will commence shortly after the hearing date.

Since the project is considered to be a pilot, a formal letter was submitted to the Department of Environmental Quality (DEQ) Air Quality Division requesting DEQ to waive the need for an emissions permit. The waiver is currently awaiting DEQ approval. Although the measurement of emissions will presumably not be required, monitoring of CO_2 and hydrocarbon emissions is planned to document emission levels and rates. A Microsensor Technology, Inc. Model P200D Double Module Gas Analyzer has been purchased to facilitate monitoring of gaseous emissions. Analytical procedures utilizing this instrument are currently being developed.

The following bids for Professional Engineering Services and supplies have been prepared to facilitate implementation of the field test when the necessary permits have been obtained.

1. Workover rig and labor to remove currently existing production tubing from test well.
2. Rental of equipment and labor for pressure testing and installation of tubing and tubing anchor in test well.
3. CO_2 , CO_2 storage tanks, and pumping equipment, including labor and handling equipment.

REFERENCES

1. T.G. Monger and J.M. Coma: "A Laboratory and Field Evaluation of the CO_2 Huff 'n' Puff Process for Light Oil Recovery", SPE

Res. Engr. (November 1988) 1168.

2. Coma, J.M.: "The CO₂ Huff 'n' Puff Process For Light Oil Recovery - An Initial Laboratory and Field Evaluation", M.S. Thesis, Louisiana State University, Baton Rouge, LA (1986).

TABLE 1
GAS VOLUMES AT INJECTION AND SOAK CONDITIONS

Gas	CO ₂	N ₂
Volume Injected (cc)	16	16
Density (g/cc) 1640 psig, 78 °F	0.834	0.126
Mass Injected (g)	13.35	2.02
Density (g/cc) 500 psig, 78 °F	0.079	0.04
Volume (cc) 500 psig, 78 °F	168.7	50.4
Gas Fractional Pore Volume 500 psig, 78 °F	0.225	0.067

TABLE 2
RESULTS OF DRIVE FLUID INVESTIGATION

Run #	Fluid Injected	Cycle	Oil Recovered (cc)	Total Gas Utilization ^a (Mscf/STB)
81	CO ₂	1	21	1.92
82	CO ₂	2	8	5.05
107	CO ₂ + N ₂	1	50	0.99
108	CO ₂ + N ₂	2	25	1.98
111	N ₂	1	13	0.71
112	N ₂	2	4	2.31

a. Total Gas Utilization = CO₂ Utilization + N₂ Utilization

Gas Utilization = Mscf gas injected/incremental bbl oil produced

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