Oil & Natural Gas Technology

DOE Award No.: DE-FG26-08NT05679

Quarterly Report
No. 14

January - March 2012

Bridging the Gap between Chemical Flooding and Independent Oil Producers

Submitted by:
University of Kansas Center for Research, Inc.
2385 Irving Hill Rd
Lawrence, KS 66045-7563

Stan McCool, Tony Walton, Paul Willhite, Mark Ballard
Miguel Rondon, Kaixu Song, Zhijun Liu

Prepared for:
United States Department of Energy
National Energy Technology Laboratory

May 8, 2012

Office of Fossil Energy

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EXECUTIVE SUMMARY

Basic economic analyses of field applications of chemical flooding were prepared using the results of the laboratory studies, the geological studies prepared for each lease and the field data obtained from the operators. Consultations with the operators of these leases resulted in the development/preparation of a research proposal that was submitted to Research Partnership to Secure Energy for America. The proposal is a "Field Demonstration of Chemical Flooding of the Trembley Oilfield, Reno County, Kansas." The University of Kansas is partnering with Berexco, Inc., SNF Holding Co. and Huntsman Petrochemical Inc. to extend the work of this project to field testing

INTRODUCTION

This research project aims to demonstrate the potential of "next generation" chemical flooding processes and will provide the design work that is necessary for Independent Oil Producers to make an informed assessment for implementation of a pilot or demonstration project. Laboratory testing is a major focus of the design process and this testing will be conducted to design proper chemical formulations for specific oils/reservoirs. Field response to chemical flooding will be determined through reservoir simulations. Economics of pilot/demonstration and field applications will be evaluated. Laboratory, simulation and economic results will be dispersed through technical papers and presentations to independent oil operators. Designs of chemical floods provide the basis for demonstration projects and a starting point for independent oil operators to implement the new chemical flooding technology. An outcome of this project would be a field project to demonstrate the benefits of new chemical flooding technologies to Independent Oil Producers. We anticipate that the field project would be supported with Department of Energy funds.

A summary of an economic analysis of proposed field-pilot projects is presented.

PROGRESS, RESULTS AND DISCUSSION

Five leases were selected as the best opportunities for testing chemical flooding in the field. The selection was based on results of the laboratory studies, the geological studies, availability of field data and the perceived willingness of the oil operators to consider a field test. The five leases were: Trembley, Reno Co.; Beaver Creek, Rawlins Co.; Pleasant Prairie, Haskell Co.; Vinland Lease, Douglas Co.; and Celia South, Rawlins Co.

Economic analysis of field pilot test was prepared for use in discussions with the oil operators. Results of the economic analysis for pilot projects on the five leases are presented in **Table 1**. A pilot pattern was determined for each lease and the volumetric reservoir properties were estimated for the patterns. Compositions of chemical systems tested in core floods were used to estimate chemical costs. Unit cost estimates for surfactant, alcohol, alkali and polymer were 3.00, 1.00. 0.63 and 1.75 dollars/active pound of chemical, respectively. Oil price was 80 dollars/barrel and a 12.5% royalty was used.

Oil recoveries determined from the core tests were used as the microscopic efficiency for the pilots. Sweep efficiencies were set at 80%. The sweep efficiency factor was used for both the volume of chemicals used and the oil recovered.

This analysis provides a general magnitude of the total chemical costs and the unit chemical cost for barrel of recovered oil (bottom rows of Table 1). These chemical costs were used for discussions with the oil operators to determine their interest in participating in a field test. Two comments are noted about the economic analysis: (1) Costs for injection equipment and operating expenses were not estimated; (2) The chemical systems were not fully optimized and it is anticipated that additional laboratory work to optimize the systems would reduce chemical loadings and costs.

Discussions with operators resulted in the development of a field trial of chemical flooding at the Trembley Lease in Reno County, Kansas. A proposal was written and submitted to the Research Partnership to Secure Energy for America (RPSEA). The Kansas University Center for Research has offered the proposal in partnership with Berexco, Inc., the lease operator, SNF Holding Company, polymer manufacturer/supplier, and Huntsman Petrochemical Inc., a surfactant manufacturer/supplier.

Work was also conducted on simulation of chemical flooding for the Trembley lease. This work includes the development of a reservoir model, history matching of primary production and waterflooding processes and simulation of chemical flooding. Simulation work will be presented in the final report.

Table 1 – Economics of chemical flooding for pilot projects for five selected leases.

	LEASE				
	Trembley	Beaver Creek	Pleasant Prairie (OXY)	Vinland	Celia South
Pattern Pore Volume (bbl)	160,000	208,000	1,865,950	64,000	418,921
Remaining Oil Saturation	0.50	0.48	0.49	0.50	0.42
Chemical System:					
Surfactant %	1.00	0.50	0.50	1.00	0.50
Alcohol %	2.00	1.75	1.75	0.00	1.75
Alkali %	1.0	1.0	1.0	0.0	1.0
Chemical Slug size (PV)	0.30	0.60	0.60	0.30	0.60
Polymer ppm	2,250	1,800	2,500	1,500	3,500
Pore –level efficiency (Laboratory recovery)	0.88	0.97	0.98	0.50	0.77
Volumetric Sweep	.80	0.80	0.80	0.80	0.80
Avg saturation at the end of Tertiary recovery	0.06	0.11	0.11	0.30	0.16
Tertiary Oil recovered (bbl)	70,519	76,940	724,074	12,823	107,383
Surfactant Required (lb)	168,244	174,974	1,569,674	53,838	352,404
Alcohol Required (lb)	320,706	583,686	5,236,186	0	1,175,566
Alkali (lb)	427,340	888,868	7,973,944	0	1,790,214
Polymer Required (lb)	37,855	62,991	784,837	8,076	246,683
Surfactant cost	504,732	524,922	4,709,022	161,515	881,011
Alcohol cost	320,706	583,686	5,236,186	0	1,175,566
Alkali cost	269,224	559,987	5,023,584	0	17,902
Polymer cost	66,246	110,234	1,373,465	14,133	246,683
Total Chemical Costs	1,160,908	1,778,828	16,342,256	175,647	2,321,162
Est Oil Revenue	4,936,309	5,385,811	50,685,191	897,633	7,516,812
Chemical cost / bbl oil recovered	16.46	23.12	22.57	13.70	21.62

MILESTONE STATUS

The end date for the project was 3/31/2012.

Task	Project milestone Description	Planned		Actual		Comments, explanation of deviations from plan
		Start Date	End Date	Start Date	End date	
1	Project Management Plan updated	**10/1/08**	**11/30/08**	**10/08**	**12/08**	**The Project Management Plan was updated and approved.**
2	Development of database of KS reservoirs – Critical 1	**10/1/08**	**3/31/09**	**11/08**	**3/09**	**Databases were prepared and are available online. The databases were not effective in the process to select leases for Task 3.**
2	Reservoirs/leases selected for study – Critical 2	**10/1/08**	**6/30/09**	**1/09**	**6/09**	**Ten leases were selected for study in Task 3.**
3.1	Acid numbers of oils determined	**3/31/09**	**9/30/09**	**5/09**	**8/09**	**Acid numbers of the crude oils have been measured.**
3.1	Phase behavior studies completed – Critical 3	**3/31/09**	**9/30/10**	**1/09**	**12/10**	**Phase behavior studies are being conducted for crude oils from the selected leases**
3.1	Efficient chemical formulations designed for a minimum of two crude oils based on phase behavior studies.- Critical 4	**3/31/09**	**9/30/10**	**1/09**	**9/10**	**Efficient chemical systems for seven crude oils have been identified.**
3.1	Flow tests completed in lab rocks	**6/30/09**	**9/30/10**	**11/09**	**2/11**	**Flow tests in Berea cores have shown oil tertiary recoveries greater than 88% for oils form seven leases.**
3.2	Flow tests completed in reservoir rocks	**6/30/10**	**11/30/11**	**2/11**	**12/11**	**Flow tests in limestone rocks have been completed. No reservoir cores could be obtained for the leases.**
3.2	Efficient chemical formulations designed for a minimum of two applications based on flow experiments.- Critical 5	**6/30/10**	**11/11**	**11/09**	**3/12**	**The completion date was pushed back to 3/12.**
4	Simulations completed – Critical 6	**12/31/10**	**3/31/12**	**2/11**	**3/12**	**The completion data was pushed back to 3/12.**
4	Economics completed	**3/31/11**	**3/31/12**	**6/11**	**3/12**	**The completion data was been pushed back to 3/12.**

National Energy Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

One West Third Street, Suite 1400
Tulsa, OK 74103-3519

1450 Queen Avenue SW
Albany, OR 97321-2198

2175 University Ave. South
Suite 201
Fairbanks, AK 99709

Visit the NETL website at:
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