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PRELIMINARY RUNS WITH COLD LAKE HEAVY OIL: REPORT ON PILOT PLANT OPERATIONAL PROBLEMS

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March 1976

This report relates essentially to the samples as received.

ENERGY RESEARCH PROGRAM
Energy Research Laboratories
Report ERP/ERL 76-18 (TR)

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by

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ABSTRACT

An experimental run (85-1-1) at 3500 psi is compared with all previous runs with Cold Lake heavy oil (in-situ bitumen). Recommendations are that no new runs on Cold Lake heavy oil be attempted unless the feed is substantially modified by physical or chemical treatment, since all runs to date, with virgin material or dewatered material, have been shut down in less than 12 hours due to coke formation. It is also recommended that a program be initiated to investigate the differences between Cold Lake heavy oil and Athabasca bitumen.

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INTRODUCTION

Cold Lake heavy oil is a material which has been recovered from deep tar sands deposits using an in-situ technique in which high pressure steam serves to fracture the formation[1, 2], heat the oil and provide a driving force for production. A comparison with hot-water-process recovered Athabasca bitumen is given in Reference 3. The two feedstocks are very similar with large differences in only the ash, the carbon disulphide insolubles and the acid number. These differences are enough, as will be seen in this report, to make a large difference in pilot plant operation for the two feedstocks.

In this report, a detailed description of run 85-1-1 is given, including preparations, start-up, operation, and clean-up. A discussion and comparison of this run to previous runs is given, with recommendations for future work.

(1) F.W. Camp, The Tar Sands of Alberta, 2nd Ed. Cameron Engineers, Denver, Colorado (1974).

(2) D.A. Redford, In-situ Recovery from the Alberta Oil Sands, Paper 7B, 25th Canadian Chem. Eng. Conference, Montreal (1975).

(3) E.C. McColgan, P.S. Soutar, J.M. Denis and B.I. Parsons, The Hydrocracking of Residual Oils and Tars, Part 4: Catalyst De-Activation with Bitumens from Athabasca, Cold Lake, and Lloydminster, Report R261, Fuels Research Centre, EMR (1973).

PART 1 - DESCRIPTION OF RUN 85-1-1

Run No. 85-1-1, February 17, 1976, Operating Conditions

Feed: Cold Lake Bitumen SF-110

Feed Rate: 9000 g/h LHSV = 2.0 h^{-1}

Pressure: 3500 psi

Reactor: $1\frac{1}{2}$ in diameter x 13 in long inside dimensions

Temperatures:

Reactor 460°C (not reached)

HCP top 350°C

bottom 370°C

Gas Flow: 1.5 ft^3/h at 3500 psi, 25°C

Purity: 85% H_2 (not reached)

Purpose

To determine whether in-situ recovered bitumen from Cold Lake could be thermally hydrocracked at conditions similar to those used with Great Canadian Oil Sands (GCOS) bitumen.

Preparations for run

The entire system was cleaned and checked for operation. The large and small feed tanks were filled with Cold Lake bitumen, SF-110. Conditions of runs with GCOS bitumen were duplicated as closely as possible.

Start-up

The feed was started when reactor temperatures reached 350°C. The run was commencing normally until 438°C was reached, at which time a plug in the reactor outlet line was observed (D/P cells 1, 5, 6). This caused fluctuations in the gas flowrate resulting in periodic dumping of some of the reactor contents into the hot catch pot (HCP).

The cyclic behaviour of plugging, with up to 400 psi pressure drop between reactor and hot receiver, and unplugging with violent swings in gas flowrate (1-3 ft^3/min, sometimes offscale, sometimes nearly zero) was observed for one hour, during which time the reactor temperature was increased by five degrees. Further increases in temperature up to 455°C over the next five hours failed to improve the situation. At approximately 16:30 the HCP drain plugged and could not be cleared by purging. The reactor was not dumped because

the emergency line was plugged and could not be purged. The gases would not recycle after being taken off by-pass. The preheater lines could not be purged with oil.

Minor Problems and Notes

The speed control on the west recycle gas pump was inoperative during the run. This was discovered when the reactor outlet lines began to plug up and the spare pump was used.

The recycle gas purity only reached 95% during the run, so that the oil scrubber was not used. The water scrubber had a small leak throughout the run.

Disassembly & Clean-up

Reactor:

The bottom 3 feet of the reactor were solid with a hard black coke-like substance. The remainder of the reactor was filled with liquid and the walls were heavily coated with coke up to 3 ft from the top of the reactor. The top 3 ft were relatively clean.

Hot Catch Pot:

The hot catch pot was relatively clean except for a deposit in the bottom cap.

Cross-over Line & Downtube:

These lines had a deposit in them but were not plugged.

HCP Drain:

The first down section of the HCP drain was plugged.

Emergency Line:

The emergency line from the reactor to the first valve was plugged. This included the large 4-way block and short line to the reactor. This caused the preheaters to act as if they were plugged when purging was attempted at the end of the run.

Preheaters:

The preheaters were clear.

Water Scrubber:

The water scrubber had no O-ring which was the cause of it leaking.

PART 2 DISCUSSION AND RECOMMENDATIONS

There were no meaningful samples taken during the run. Due to operating difficulties, the gas usage data and analyses were also meaningless.

The reactor pressure in this run was 3500 psi, compared to the Series 80 runs which were at 2000 psi. In this run, and in the Series 80 runs, operating difficulties were experienced at a reactor temperature of about 440°C. Previous runs are summarized below:

80-1-1 July 16, 1975, 2000 psi, 430°C, LHSV = 2.0, recycle gas 1.5 ft^3/h
Ran at 430°C for 4 hours, conditions were steady, startup was good.
Pitch conversion - 48%, other analyses available.
This run was continued as 80-2-1.

80-2-1 July 16, 1975, 2000 psi, 440°C, LHSV = 2.0, recycle gas 1.5 ft^3/h
As soon as 440°C was reached, a 400 psi pressure drop developed and recycle gas and pressure drops varied throughout the 3½ hour run. Gas flow varied from 1-2 ft^3/h over 10-minute cycles, and pressure drop cycled up to 700 psi. After 3½ hours, a 2700 psi pressure drop terminated the run. There was coke in the reactor and HCP.

80-1-2 August 19, 1975, same conditions as 80-2-1, but with feed stored for a period of several days at 200°F to remove water. This run was shut down 35 minutes after 440°C was reached and 2½ hours after feed was introduced to the reactor. This was due to a large pressure drop. There was foam-like coke in the HCP and coke on the reactor walls. Another run was attempted in which steady state was reached with Athabasca bitumen as feed, at the conditions of run 80-2-1 but at 450°C, and then feed was switched over to dewatered Cold Lake heavy oil. This run was also unsuccessful. Although the run time was 10-12 hours before shutdown there were violent swings in the pressure and unsteady state conditions.

It is obvious from this inspection of previous work that runs using virgin Cold Lake material or runs using dewatered material have not been satisfactory from an operations point of view for even a few hours.

It is recommended that no further pilot plant runs be made on material received "as is" unless some physical or chemical pre-treatment, based on a detailed comparison between Cold Lake heavy oil and Athabasca bitumen, is made. This could be, for example, topping, acid or base addition or chemical extraction.

It is recommended that we initiate a program to investigate the chemical differences between GCOS bitumen and Cold Lake heavy oil with the objective of finding methods of pre-treatment in order that this heavy oil can be thermally hydrotreated. A comparison of these two feedstocks is appended. Such a study would help in experiments using Athabasca bitumen and heavy crude oils, since the Cold Lake material has a very strong tendency to coke compared to the Athabasca bitumen. A run with Athabasca bitumen under the conditions of run 85-1-1 would show only a few grams of coke after a twenty-one day operation.

APPENDIX

	Cold Lake S.F. 75	G.C.O.S. S.F. 109
Sp Gr (60/60°F)	1.000	1.012
Ash (% wt)	0.05	0.56
Sulphur (% wt)	4.35	4.77
CCR (% wt)	12.8	13.8
Pentane insol (% wt)	0.02	0.56
Benzene insol (% wt)	15.5	15.6
Carbon disulphide insolubles (% wt)	0.03	0.88
Vanadium (ppm)	190	196
Nickel (ppm)	65	68
Total acid no. (mg KOH/gm)	0.93	2.7
Total base no. (mg KOH/gm)	1.44	1.76
Carbon (% wt)	83.09	82.59
Hydrogen (% wt)	11.00	10.82
Nitrogen (% wt)	0.65	0.40
Oxygen (% wt)	(0.86)*	0.86
Chlorine (% wt)		0.0055
C/H ratio	7.55	7.63

* By difference