ENCANA

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Dear Sir:

Please find below a summary report from EnCana on the completed Project "Low Pressure Steam Assisted Gravity Drainage (SAGD) Artificial Lift Bench Scale Testing Program" which was funded thru the IETP, Project 01-006.

**Low Pressure Steam Assisted Gravity Drainage (SAGD) Artificial Lift Bench Scale Testing Program**

**Introduction:**

There is major concern regarding the situation where exploitable gas reserves overlay oil sand deposits that are recoverable by a SAGD process. The fear is that the development of either resource autonomously, may have a detrimental effect on the exploitation of the other.

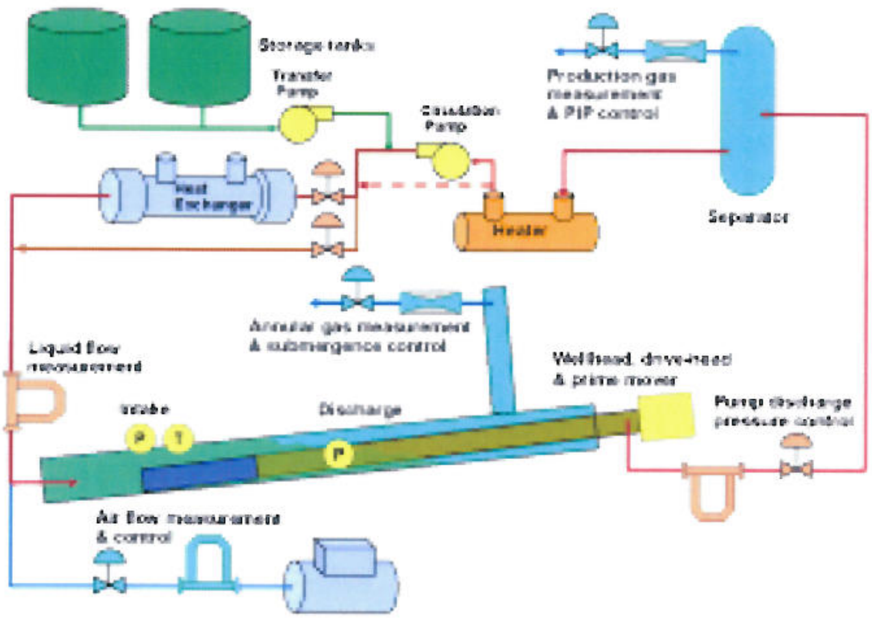
In large regions of the Athabasca oil sands, where SAGD recovery techniques are currently being used or considered, the presence of a depleted or naturally low pressured formation directly above the reservoir makes it necessary to operate the producing wells at relatively low pressures. It is still uncertain if current artificial lift systems can operate efficiently and reliably at these low pressures, especially at low degrees of sub-cool, i.e. close to steam saturation conditions. Therefore, it is the objective of this project to test a number of down hole pumping systems, at low pump intake pressures and low pump intake degrees of sub-cool, in a laboratory environment, in order to prioritize and select candidates for further field trials.

**Testing Program:**

The experimental program consisted of the design and construction of a test loop with the following capabilities:

- Control fluid temperature between 60 and 200°C (+/- 2°C);
- Allow for testing with oil, water or an oil/water mixture at various water cuts (%);
- Control pump intake pressure (PIP), between 200 – 2,070 kPag (+/- 7kPag);
- Handle liquid rates up to 800 m3/d; and
- Achieve up to 20% Gas Void Fraction (GVF) at the pump intake.

The test loop consists of a 24.4 m long section of 244 mm casing, at ~87 degrees of inclination (i.e. close to horizontal). An annulus separator was designed to allow for additional pump submergence. The separator consists of a 4 m long section of 152 mm pipe that is connected to the main casing section of the flow loop (downstream of the pump intake location). The liquid and air flow rates are measured using a Coriolis mass flow meter. Pressure and temperature measurements are made using pressure and temperature transmitters with 420 mA output signals. A heater allows for the fluid temperature to be controlled during testing in cases where the heat losses in the loop exceed the energy added by the pumping system. A heat exchanger allows for the fluid temperature to be reduced in cases where the energy provided by the pumping system exceeds the heat losses in the loop. Air injection into the loop is provided by a radial air cooled booster. The air supply into the loop is regulated by a PID controller that operates an automatic control valve, based on the feedback from the corresponding Coriolis mass flow meter. The Data Acquisition System (DAS) and control system were built using the LabViewTM platform. The DAS allows for real time data capture of all loop parameters. The main components of the flow loop are shown below:




The design and construction of the flow loop was completed by the end of May 2004, and loop commissioning was completed by the end of June 2004. The table below shows the typical test matrix the systems were tested under.

| | OIL | | OIL/WATER | |
|---|---|---|---|---|
| T (°C) | NO AIR | WITH AIR | NO AIR | WITH AIR |
| Min (*) | • Pump curve and PIP reduction for 3 RPM's | • N/A | • Pump curve at reference RPM<br>• PIP reduction | • Pump curve at reference RPM<br>• PIP reduction |
| 150 | • Pump curve for 3 RPM's | • N/A | • Pump curve at reference RPM<br>• PIP reduction | • Pump curve at reference RPM<br>• PIP reduction |
| 180 | • Pump curve for 3 RPM's | • ALR Sensitivity for 3 RPM's | • Pump curve at reference RPM<br>• PIP reduction | • Pump curve at reference RPM<br>• PIP reduction<br>• ALR Sensitivity |
| 200 | • Pump curve and PIP reduction for 3 RPM's | • N/A | • 1 RPM (Reference)<br>• PIP reduction | • 1 RPM (Reference)<br>• PIP reduction |

(*) To be determined experimentally. Criteria: Efficiency at minimum delta-P = 80%

Four pumping systems were tested:

- Twin Screw Pump: this pumping system was first tested on June 17, 2004. The pumping system was tested to a maximum capacity of 355 $m^3/d$ at 375 RPM and to a maximum discharge pressure of approximately 2.4 MPa at 250 RPM;
- Elastomer Stator Progressive Cavity Pump (EPCP) System: this DT226 elastomer stator PCP System was supplied for testing on September 29, 2004. The pumping system had a published pump capacity of 226 m3/d/100 RPM and a maximum discharge pressure of approximately 9.0 MPa;
- Electric Submersible Pump (ESP) System: this ESP system was supplied for testing on December 1, 2004. The system was comprised of a 41 stage TE 5500 pump, with a nominal operating rate of 875 m3/d, and a TR5-92 motor with a 111.8 kW rating;
- Metal Stator Progressive Cavity Pump (METPCP) System: this 550MET675 metal stator PCP system was provided for testing on May 9, 2005. The pumping system had a published pump capacity of 110 m3/d/100 RPM and a maximum discharge pressure of approximately 6.6MPa.

**Conclusions and Recommendations:**

The full results are documented in the C-FER Technologies Interim Testing Report, entitled "Laboratory Testing of Artificial Lift Systems for Low Pressure SAGD Applications", dated January 2006.

The primary goal of the testing program was to identify the operational limits of each pumping system under controlled laboratory conditions, in terms of the lowest intake pressure the systems can operate without significant deterioration of performance, under simulated SAGD operational conditions.

The table below shows the lower limit of the intake pressure for the systems tested under clear oil test conditions.

| Artificial Lift System | Lowest PIP Achieved without significant impact (kPa) |
|---|---|
| Twin Screw Pump | ~23 kPa, resulting in a ~10% reduction in flow rate |
| EPCP | As low as 7 kPa with very little reduction in Vol. Eff. |
| METPCP | As low as 7 kPa with very little reduction in Vol. Eff. |
| ESP System | ~ 140 kPa @ "delta-P ratio" of ~0.5 |

The testing results showed that artificial lift systems tested that can operate at low intake pressures without losing significant performance. As expected, positive displacement systems (Twin Screw, PC Pumps (Elastomer and Metal)) provided the best operation at low intake pressures, as low as 7 kPa, while there was some impact on the performance of the dynamic system (ESP's) at the lower intake pressures. It was also observed that ESP's could still operate at intake pressure as low as 140 kPa, however under this condition operational stability lessened.

This is a significant result in addressing the issue of what the lower operating limit achievable for SAGD operations is. Based on the results, EnCana feels that these artificial lift systems can allow SAGD operation at pressures as low as 350 kPa, assuming a drawdown of 200 kPa between the chamber and the pump intake.

A secondary goal was to identify the pumping systems that have a good chance of performing adequately in the field, and that therefore deserve to be subject to further field trials.

Of the 4 systems tested, only two of the systems operated to the level needed to complete the full test matrix outlined earlier: the Metal Stator PCP and the WoodGroup ESP. After completion of the testing program, however, the Metal Stator PCP did show signs of rotor wear, and the ESP pump experienced a seal failure part way through the test and had to be repaired.

Vendors continue to make improvements and further developments to their pumping systems. Kudu (METPCP) with their partner PC Pompes from France, have developed coatings for their rotor and stator to increase erosion and corrosion resistance. Woodgroup ESP has a new downhole seal design to handle the high temperature conditions. In addition, the performance of the ESP can be extended to other ESP vendors, namely Schlumberger and Centrilift, who have developed versions suitable for SAGD conditions which perform the similar to the WoodGroup system.

The testing results indicate to EnCana that field testing of the METPCP and ESP's would be warranted to further qualify their use in SAGD. To that extent, EnCana, along with other operators, are using ESP's and METPCP in SAGD operations. However, the field tests to date have not been used for low pressure application, which still remains to be fully field tested.

Please note that this report is governed by the Confidentiality agreement signed for the project.

Sincerely,

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