EVALUATION OF THE N-SOLV PROCESS – EXPERIMENTAL OPERATION AND RESULTS

REPORT PREPARED FOR
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EXECUTIVE SUMMARY

This report describes an experimental study of the N-Solv process. Three experiments were performed, in a physical model representing an unscaled segment of a bitumen bearing Athabasca formation. All experiments used propane as the solvent, with the third experiment modelling levels of methane contamination expected in the field. The experiments represented the oil-solvent interface at conditions from non-thermal Vapex to a fully condensing N-Solv extraction process. The experiments were done using reservoir permeability sand and at reservoir temperature and pressure, and at conditions appropriate to using condensing propane as a solvent.

A uniquely developed Adiabatic Test System (ATS) apparatus using over 1000 individually controlled heating tiles was used to dynamically match the internal sand pack temperature profiles and thereby maintain the sand pack at near-adiabatic conditions.

The first experiment reproduced conditions varying from Vapex at 11°C, to condensing solvent conditions at 40°C. Intermediate conditions of condensing solvent at temperatures of 20°C, 32°C and 35°C were also tested. Experiment #1 was run with the ATS set to maintain a constant temperature gradient from the sand pack face to the back of the pack, rather than adiabatic mode. Experiment #1 is a validation of Vapex oil production rates, and oil rates at varying temperatures with condensing propane.

Experiment #2 reproduced a single condition, namely condensing propane at 40°C. Initially, the ATS was run in constant temperature mode, to maintain a gradient from the sand face to the back of the pack. Adiabatic mode was used when temperatures stabilized. The propane supply was switched late in the experiment, and some reduction in oil rate was observed, due to the presence of residual helium in the propane supply. The use of an adiabatic temperature gradient control in this experiment meant that this test was primarily a confirmation of oil production rates, with better control of propane injection requirements than experiment #1.

Experiment #3 reproduced several operating conditions, namely pure propane at 40°C condensing condition, propane with 0.5 mole% methane and 40°C condensing, propane with 1.0 mole% methane and 40°C condensing, and finally a switch to pure propane to purge methane and helium contamination from the sand pack, followed by operation with pure propane at 40°C.

The helium contamination of the propane and consequent effect on oil rates underscored the importance of propane purity for this process. For this experiment, the ATS was first tested extensively to verify that it was capable of maintaining a truly adiabatic state, then run in the adiabatic mode. The piping to the cell was also modified to minimize heat losses through propane condensation in the lines connected to the pack. Experiment #3 therefore has the best heat balance data, and is a better validation of propane rate data as well as oil rate data.

The experiments produced data on oil extraction rates, heat transfer, bitumen yield, effect of temperature and pressure, oil upgrading and effect of solvent purity. The experiments showed an increase in production rates by a factor of 50 from Vapex operating conditions of 11ºC to N-Solv operating conditions of 40ºC. High recoveries (In range of 66 to –72 wt.% in the swept zone) were obtained, substantial upgrading of the produced oil due to asphaltene deposition (API increase of 5) was observed, and significant metals, sulphur and nitrogen removal (70%, 20% and 50%, respectively) was noted. Propane purity was important, as it was observed that contamination of the propane by non-condensable gasses led to a significant reduction of oil rates.

The experiments predicted front advance rates of from 0.88cm/day (Experiment #3, 1% CH_4) to 3.05 cm/day (Experiment #1), considering 66% to 72% of the oil in place was produced from the swept zone. The oil left behind was predominantly asphaltenes, and was solid at room temperature up to 40°C.

It must be kept in mind that heat losses in the field are not necessarily scaleable from those produced in the lab. It is recommended that field extrapolations be done with state-of-the-art numerical simulation, in order to better represent these heat losses. This would require several advances in current numerical simulation practice, including better treatment of diffusion, dispersion, asphaltene dropout, and viscosity of the resulting liquid phase(s).

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