3-D Physical and Numerical Modelling of Thermal Solvent Vapour Extraction (TSVX)

The advancement of thermal heavy oil and bitumen recovery processes has been boosted in recent years at SRC, thanks to the significant expansion of capabilities and capacity in physical modelling, bitumen-capable pressure-volume-temperature measurements and core displacement experiments.

SRC's TSVX lab, featuring a 3-D scaled physical model that operates at temperatures up to ~310°C, enables us to evaluate and develop the full spectrum of steam-solvent processes, from pure solvent injection to pure thermal, as well as numerous hybrids. SRC researchers complement realistic laboratory results with rigorous approaches to numerical simulation to improve performance predictions for this large range of processes.

TSVX Model Facts and Features

- Includes overburden pressure vessel (OBPV) system and 3-D physical model system
- At 10 to ~250°C, OBPV rated up to 10.5 MPa (1500 psi) working pressure; 3-D system to 10 MPa and 10 to ~310°C
- Certified OBPV system measures 3.0 m long × 1.06 m ID
- Can evaluate various wellbore geometries and be rotated 90° for a vertical section up to 3 m, the actual pay zone of many thin reservoirs in Western Canada

SRC SASKATCHEWAN RESEARCH COUNCIL

Muhammad Imran
Manager
EOR Field Development

129 - 6 Research Drive
Regina, SK Canada S4S 7J7
306-564-3543 | muhammad.imran@src.sk.ca

EOR Processes Available at SRC's TSVX Lab

- Solvent vapour extraction post-steam-assisted gravity drainage (SAGD)
- Solvent-assisted gravity drainage
- Expanding-solvent SAGD
- Solvent-aided process
- Steam alternating solvent
- Thermal methods with wedge wells
- Thermal with T-wells
- Thermal with no-flow boundaries
- Thermal with isothermal boundaries
- Warm solvent vapour extraction
- Warm vapex

Numerical Simulation of TSVX

To scale up TSVX processes and predict both laboratory and field performance, SRC history-matches 3-D physical model run results. We offer advanced techniques and algorithms custom developed to tune numerical models to:

- Properly handle the non-equilibrium solvent solubility that occurs during the solvent injection phase of TSVX processes
- Correct for effects of changing gridblock sizes, while maintaining an acceptable history match

These techniques require two or more 3-D physical model runs conducted with similar solvent–oil systems and run conditions, but with different well placement geometries. Through history matching and/or adjustment of various run parameters, the simulator is tuned to accurately predict the oil, gas and water (condensate) production rates and recoveries, and injection/production pressures from the geometrically different experiments. The tuned simulator can then be used to estimate field-scale performance for various well types and patterns.

Semi-Analytical Flow Model of TSVX Processes

SRC has developed a semi-analytical flow model of SVX processes that can be used to provide reasonable estimates of field performance. Semi-analytical flow models for TSVX processes are now being developed from this SVX flow model and from Butler's model for SAGD.

Additional Analytical Tests and Property Determinations

SRC offers further expertise needed to analyze and model 3-D physical model experiments:

- Equation of state determinations to generate steam-solvent vapour quality diagrams
- Phase behaviour (PVT) analysis and fluid characterization of oil viscosity, density and vapour-liquid equilibrium (VLE) as a function of solvent concentration, pressure and temperature
- Pseudorelative permeability determinations
- Asphaltene precipitation modelling and capillary pressure determination

Bitumen-Capable PVT System

A special bitumen-capable PVT system, commissioned at SRC's Regina laboratories, is used to determine oil density, viscosity and VLE relationships as a function of solvent concentration, pressure and temperature. Analysis is conducted at various pressure and temperature conditions, from 200 to 23,000 kPaa and 5 to 250°C (density measurements to only ~200°C).

Production vessels and flow control valve

Instrumented wet test meter

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