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Sensitivity and Economic Analysis of Solvent Assisted SAGD Considering Geomechanics

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Solvent Assisted SAGD (SA-SAGD) has the potential to lower steam oil ratio and increase oil production rate compared to SAGD alone and is usually operated close to reservoir pressure. Three Key design parameters are solvent type, injected solvent concentration and solvent retention in situ. However, the impact of oil sands Geomechanics, i.e. in situ dilation due to pressurization and thermal stresses, on the design parameters and on the economy of the process in general, has received less attention.

Mechanistic simulation studies from Abbasi and Chalaturnyk (2016) together with semi-analytical modeling efforts from Abbasi and Chalaturnyk (2017), on a shallow Athabasca type oil sands reservoir (UTF Phase A), revealed that operating SA-SAGD at a pressure that is high enough to promote zones of shear failure inside and beyond the chamber edge is economically advantageous. This paper applies these findings to a wide range of homogenous oil sands reservoirs in terms of formation depth, oil viscosity and formation thickness. Solvents from light to heavy hydrocarbons are injected as soon as the steam chamber reaches the top of the reservoir. A simple NCG injection is considered for the ramp down phase. The sensitivity of the three key design parameters to the degree of in-situ dilation, which is mainly controlled by pressure, is assessed and the impact on the overall economy of the process is quantified for different oil price scenarios. This work considers the uncertainty around rock mechanical properties and is verified both semi-analytically and through coupled reservoir geomechanical simulations.

Results show that managing the operating pressure can yield an increase in NPV of 5% to 25% only due to Geomechanics. The actual figure depends on the type of solvent, reservoir and also the confidence in volume change-effective permeability coupling. The criteria for maximum NPV impact are shown in the attached table (Qualitative). The improvement in NPV is observed to be mainly due to: 1. Increased oil drainage rate as a result of improved effective permeability. 2. Further increase in oil drainage rate due to enhanced convective heating and solvent mixing ahead of the chamber edge; the enhanced mixing also means less solvent volume is required at the injection point 3. Improved displacement efficiency and solvent recovery as shear dilation reduces the residual oil saturation in oil sands.

The optimum operating pressure for such thermal processes is a complex task as additional phenomena such as aquathermolysis, water in oil emulsion, reservoir integrity and artificial lift needs are also in play and either encourage or discourage high pressure scenarios. The conclusions of this research should aid asset managers in selecting the correct operating pressure for SA-SAGD, or even SAGD alone for that matter.

Improvement potential	Operating Pressure	Reservoir Depth	Reservoir Thickness	Oil Viscosity	Solvent Type	volume change-eff. permeability coupling
Minimum	Reservoir Pressure	Deep	Thin	Lloydminster type	Light	High
Average	In between	Medium	Medium	Cold Lake type	Medium	Average

Table: Criteria for NPV improvement due to geomechanics