Using a Compositional Thermal Reservoir Simulator (STARS) to Examine Mechanisms and Scaling of Enhanced Oil Recovery Processes

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Understanding scaling of enhanced oil/bitumen recovery processes is essential in moving laboratory scale experimental results to field scale. Scaling theory for thermal processes, was developed by Pujol and Boberg [1], but for many processes such as Steam-Assisted Gravity Drainage (SAGD), solvent enhanced oil recovery and in-situ combustion [2], scaling from lab scale to field scale is not well understood. This talk summarizes research done at MacEwan University that uses a commercial thermal compositional reservoir simulator to study the mechanistic behavior and scaling of SAGD, solvent and combustion processes in Athabasca bitumen. This work stems from Shook et al. [2] who used reservoir simulation to confirm scaling groups for waterflooding. A similar strategy to Shook et al. was used in this work whereby the scaling of the enhanced oil recovery processes was examined using reservoir simulation at three different reservoir scales: lab scale, semi-field scale and field scale. Parameters were chosen to investigate the capability of the reservoir simulator for capturing scalability with a focus examining the results considering scaling groups that define the mechanisms for each of the processes. Compositional reservoir simulation is extremely flexible as it permits the numerical modeling of many physical mechanisms for enhanced oil recovery in a porous media. A wide variety of mechanisms such as chemical kinetics, diffusion, dispersion, gravity and/or drive forces, viscous forces, and capillary effects can be readily examined and analyzed. In addition, multiple components can be used in a 3D examination of complex reservoir properties such as permeability and porosity.

Temperature, oil saturation and water saturation profiles and process recovery variables were examined at the three different scales. Results confirmed scalability of the processes when the simulation results were non-dimensionalized. Other parameters included effects of capillary pressure, and other injection parameters on scalability. Scaling approaches are summarized for each process as well as a discussion about the suitability of reservoir simulation as a tool in examining the mechanisms that drive each process and whether or not reservoir simulation supports the scaling groups for the processes.

1 L. Pujol and T.C. Boberg, Scaling Accuracy of Laboratory Steam Flooding Models, SPE Paper 4191, SPE California Regional Meeting, 8-10 November, Bakersfield, California, (1972).

2 M.R. Islam and S.M. Farouq Ali, New scaling criteria for in-situ combustion experiments, Journal of Petroleum Science and Engineering, Volume 6, Issue 4, p. 367-379, (1992), ISSN 0920-4105, https://doi.org/10.1016/0920-4105(92)90063-7.

3 M. [2] Shook, D. Li and L.W. Lake, Scaling Immiscible Flow Through Permeable Media by Inspectional Analysis, In Situ, 16(4), p. 311-349, (1992).