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Challenges in Modelling Thermal-Conduction based Hydrocarbon Recovery Methods

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Thermal oil recovery methods have been proposed and progressed for many years as a convenient way to mainly unlock the potential from heavy oil/bitumen accumulations. These methods cover a wide range of techniques like steam/hot fluids injection, in-situ heaters, in-situ combustion, toe to heel air injection etc. A few of them are successful commercially while others are still under development.

Over the past two decades, Shell has executed research programs focused on the development and maturation of in-situ thermal-conduction based methods to recover high quality hydrocarbons from unconventional reservoirs. In this technology solution, heat is injected into the reservoir through a series of heater wells operated at high temperatures. The initial reservoir temperature increases to elevated values around 300C where thermal cracking of in-situ hydrocarbons and/or enhanced maturation of organic matter takes place, resulting in complex temperature-dependent compositional flow and transport phenomena. At those conditions, most of the fluids in the reservoir are in the vapor phase allowing their recovery through dedicated producer wells. Significant changes are observed in the near wellbore area as the formation responds to the large temperature increase that can negatively impact the production system if not designed properly. Evaluation of the use of the technology relies on the modeling of such process, which is very challenging and computational expensive since it involves the description of these effects occurring in a complex subsurface environment.

This presentation covers: a) an overview of the phenomenology associated with thermal conduction based in-situ methods, b) a discussion on the requirements for the description of the complex associated Physics and Chemistry, c) types of simulation models and numerical tools needed to improve the representation of the observed phenomena, d) alternatives developed to reduce computational requirements of the simulations, e) strategies for hydrocarbon recovery optimization, and f) key focus areas for technology maturation in a commercial development.

The methods and workflows developed were tested in a variety of resources worldwide where Shell gathered extensive laboratory and field data through pilots, providing critical input for model calibration. Examples include in-situ conversion for Colorado and Jordan oil shale reservoirs, evaluation of potential use in liquid rich shale in China, in-situ upgrading for sandstones and carbonates in Canadian heavy oil and bitumen, and could be of interest to other type of unconventional resources.

References

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