Finite Element Modelling Of Three-phase Non-isothermal Flow In Heavy Oil Reservoirs- Case Study SAGD

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Abstract

Thermal enhanced oil recovery methods form the majority of the enhanced oil recovery projects worldwide. Among the thermal methods, steam injection is the most effective and most applied process in petroleum industry. The main mechanism of the steam injection method is the reduction of heavy oil viscosity with increasing reservoir temperature. The mathematical description of the steam injection process involves multiphase fluid flow and heat transfer in porous media. Its numerical solution enables engineers to analyse incremental oil recovery and field performance.

For commercial reservoir simulators, the finite-difference method is the dominant numerical technique to solve the governing equations. However, in recent decades, finite-element method (FEM) has been adapted favourably in many other industries because of its accurate solution and solid fundamental theory.

The application of FEM in reservoir engineering has been introduced in the early 1970s but has not gained much popularity due to high computational expense.
With faster solvers in COMSOL Multiphysics®, we try to reformulate the problem of non-isothermal three-phase flow during steam assisted gravity drainage (SAGD). The problem has been solved previously by COMSOL Multiphysics® along with MATLAB® code [1]. In this short communication we formulate the governing equations using total flux concept which end up in one pressure equation, two saturation equations, and an energy equation. This set of PDE's can be solved easily in COMSOL Multiphysics® using equation based module.

The results show that using an alternative formulation of the multiphase flow equations, which is convenient for the FEM discretization in COMSOL Multiphysics®, the physical behaviour of the steam injection process can be modelled in a clear and user-accessible form.

References
- I. I. Bogdanov, K. El Ganaoui and A. M. Kamp, COMSOL Multiphysics® 2D Simulation of Heavy Oil Recovery by Steam Assisted Gravity Drainage, Proceedings of the Users COMSOL® Conference, Grenoble (2007)

Figures used in the abstract

Figure 1 : Oil saturation (So) distribution after 75 days of the kick off of SAGD process