Electromagnetic Field Computations for Saturated Porous Media

SEBASTIEN CAMBON[1], IGOR BOGDANOV[1]

[1]CHLOE, Bâtiment UFR Sciences et Techniques, Pau Cedex, France

Abstract

Non-conventional hydrocarbon resources become more and more challenging object for energy producing companies throughout the world. Being already known and long-explored method, the electromagnetically (EM) assisted recovery constitutes a promising idea of technology for deposits of such a kind. COMSOL has been used recently for modeling the thermal multiphase flow through porous media in the different frameworks [1], in-situ resistive heating field in a bitumen reservoir [2], etc. Although this experience demonstrated that some problems related to petroleum applications can be resolved successfully using fully-integrated models, the modeling of the real non-conventional fluids and their properties evolution requires considerable efforts and specific knowledge application. Nevertheless the multiphysics environment of COMSOL makes attractive to model phenomena of particular interest in parallel to petroleum related computations. The main advantage of this approach is to implement quasi-independent numerical models to different physical phenomena described each by its own equations and taking place in corresponding time and space regions [3]. In practice the total number of such models constituting a complex problem is limited by the computational power and the type of coupling between them may be a user-defined option. The main purpose of our current work is to develop an efficient COMSOL-based model for radio-frequency EM field distribution inside heterogeneous saturated porous media. Such a model can be a promising tool, for instance, in petroleum applications. As a successful example we can mention is the EM heating method for in-situ upgrading which can be found in [4]. Relatively simple geometrical configurations have been used to validate our models using comparison to available and developed analytical solutions. In particular for two different versions of the simulation, the accuracy and convergence rate of numerical EM field solutions for different grids and element orders have been checked. Then the models have been applied in more complex multidomain multiphysics framework of field-scale recovery problem. The examples of EM field computations are presented with detailed analysis of numerical solution accuracy and computational performance of the model. The advantages of the new model (where both elements choice and solver features have been explored) are demonstrated.

Reference

1. I.I. Bogdanov, K. El Ganaoui, A.M. Kamp (2007) COMSOL 2D Simulation of Heavy Oil Recovery by Steam Assisted Gravity Drainage, Proceedings of the European COMSOL Conference 2007, Grenoble, France.
2. I.I. Bogdanov, K. El Ganaoui, A.M. Kamp (2008) Study of Electric Heating Application for Heavy Oil Recovery, Proceedings of the European COMSOL Conference 2008, Hannover, Germany.
3. J.A. Torres, I.I. Bogdanov, V. Dabir, and A.M. Kamp (2010) Analysis of Coupled and Fully Integrated Models for Low-Frequency Electrical Heating Assisted Heavy Oil Recovery, Proceedings of the 12th European Conference on Mathematics in Oil Recovery (ECMOR XII), Oxford, United Kingdom.
4. Richard Snow (2011) In-situ thermal upgrading of bitumen and shale oil by radio frequency (RF) Electrical Heating, 31th Oil Shale Symposium, Colorado School of Mines, Golden, Colorado.

Figures used in the abstract

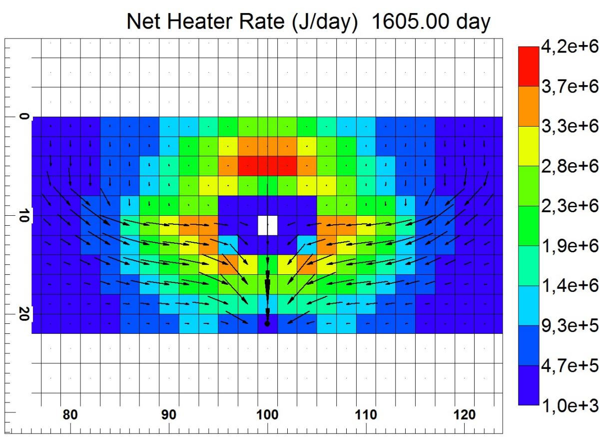

Figure 1: Computed and integrated EM power field (in J/day) around an applicator and heated bitumen velocity field (black arrows) per grid block of reservoir simulator. Distances in both directions are in m.