Electromagnetic field computations for saturated porous media

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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 electromagnetic (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 multi-physical environment of COMSOL makes attractive to model physical 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 (cf. [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 an example mention the EM heating method for in-situ upgrading which can be found elsewhere [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 simulator, 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 multiphysical 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 new version (COMSOL) model (both elements choice and solver features) are demonstrated.

References

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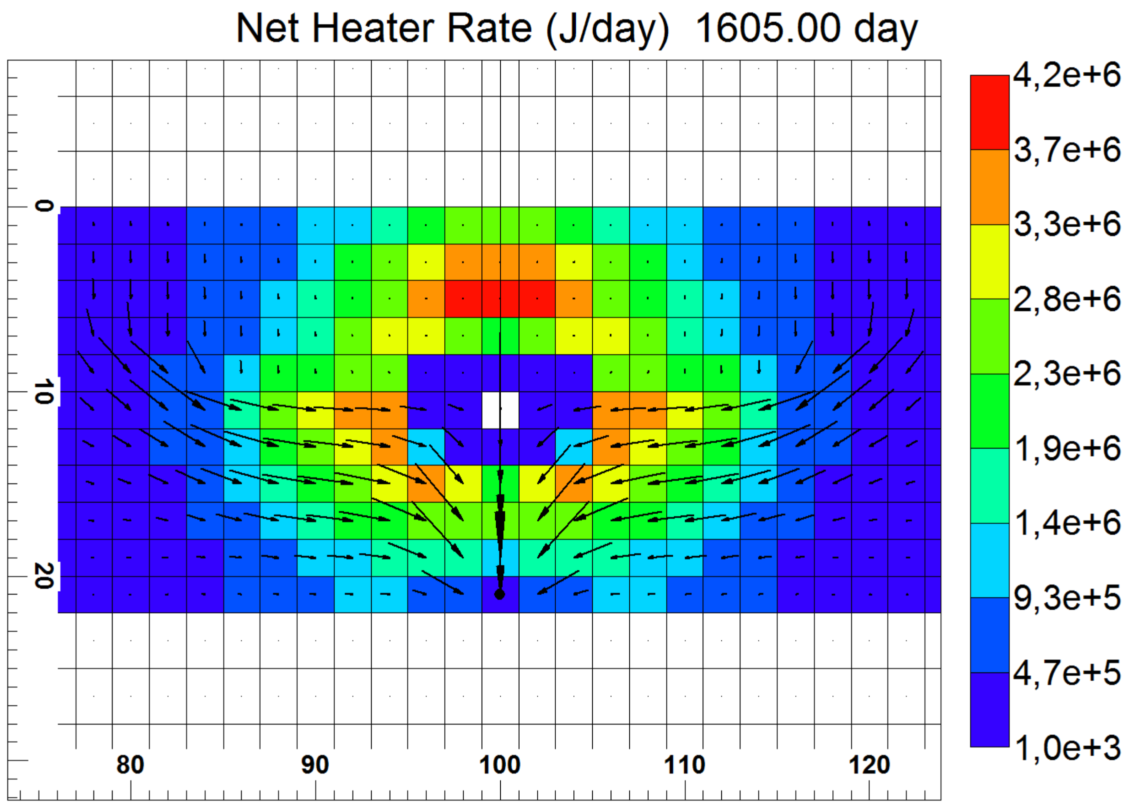

Computed and integrated by COMSOL EM power field (in *J/day*) around an applicator and heated bitumen velocity field (black arrows) per grid block of reservoir simulator; distances in both directions are in *m*.