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MODELLING OF STEAM INJECTION INTO TAR SANDS

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ABSTRACT

Significant reserves of heavy oil and bitumen exist in the world, but are particularly difficult and expensive to exploit. Difficulties are due to the very high viscosity of the oil. Enhanced oil recovery methods are needed, and in particular thermal recovery methods are used. An increase in temperature leads to an exponential decrease in the viscosity of the oil, and facilitates the flow of oil through a porous medium. To optimise recovery methods which involve the injection of steam, models for the various interacting processes involved are required.

We present a numerical model for simulating three-phase immiscible flow (oil, liquid water, steam) through a porous medium which accounts for thermal effects and phase changes for the water components. Various numerical challenges are faced due to the different nature of the various governing equations, which are elliptic, parabolic and hyperbolic; the presence of advection dominated transport equations; the development of shocks in the saturation equations; and vast differences in the magnitude of parameters in the model. A collection of methodologies are presented for developing robust and stable finite element models, and techniques are presented for generating the necessary computer code automatically. The automated generation of computer code is particularly important when considering the complexity and variety of the equations involved. As an example, the steam assisted gravity drainage process is simulated. Steam is injected into a reservoir. The steam rises due to buoyancy and transports heat. The oil viscosity reduces due to the increase in temperature, and oil flow towards a recovery well is driven by gravity. For this problem, special attention is paid to the model for the change of phase for the water components.