Appropriate Flow Parameters for Use in Coarse-Scale Flow Simulations

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Reservoir models are very uncertain – in terms of both structure and petrophysical properties. Recently, engineers have become more aware of the need to quantify the effects of these uncertainties, and so are generating large numbers (100s or 1000s) of coarse-scale models, rather than a few finer-scale models. Although coarse-scale models are useful for history-matching, these models may not produce accurate predictions of production, because the flow physics is wrong.

In two-phase systems (e.g. water flood of an oil reservoir), we need to consider relative permeability in addition to absolute permeability. The effect of fine-scale structure depends on the balance of forces – viscous, capillary and gravity. In general these will act to spread the front, so ignoring the fine-scale will tend to produce a later, sharper breakthrough and higher recovery. On the other hand, there is more numerical dispersion in coarse-scale models, which will counter this by spreading out the front. We should therefore use suitable relative permeabilities, which represent the flow physics at the relevant scale.

One solution is to generate sets of "type" curves to use in coarse-scale simulations. These are relative permeability curves which may be calculated using fine-scale flow simulation of representative sections of a reservoir. For each rock type, a particular model for sub-grid heterogeneities is assumed (e.g. layers, models of bedding, random fields). These models are upscaled to obtain relative permeabilities, and sensitivity studies are carried out to obtain a distribution of values. These "upscaled" parameters may then be used in the coarse-scale model. Although this may not be as accurate as true two-phase upscaling, it is a feasible approach, and enables engineers to simulate with the coarse-scale models required for flow simulation, while still taking fine-scale effects into account.

Related papers:

Barker, J. W. and Thibeau, S., 1997. "A Critical Review of the Use of Pseudorelative Permeabilities for Upscaling", SPE RE, 12, 138-143.

Stephen, K. D., Clark, J. D. and Pickup, G. E., 2002. "Modelling and Flow Simulation of a North Sea Turbidite Reservoir: Sensitivities and Upscaling Studies", presented at the EUROPEC Conference, Aberdeen, UK, 23 – 25 October, 2002.