MATH MATTERS

Apply It.

The math behind… Oil Production

Technical terms used:

Multi-phase flow, upscaling, optimization, history matching, numerical discretization.

Uses and applications:

Decide on the number and location of wells before actual drilling. Predict the amount of recovered oil with respect to different well conditions. Optimize future oil recovery.

How it works:

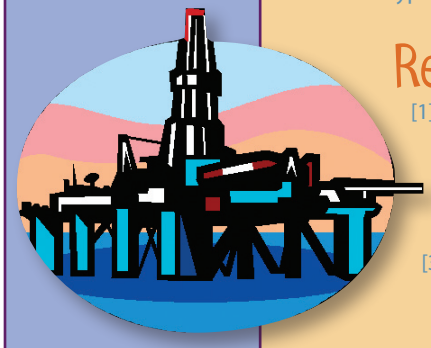
To predict the recovery rate of an oil reservoir, high-resolution computer simulations are carried out on an abstract model of the reservoir. A reservoir model consists of a static geological model and dynamic flow model. The geological model is a spatial distribution of various rock properties, such as permeability, porosity, or fracture density. It is constructed from analysis of the geological history of an area, as well as from the data obtained from seismic imaging experiments and, at a later stage, various borehole logging measurements.

The flow model is a set of coupled non-linear partial differential equations that describe multi-phase flow (oil, water, and gas phases) through the porous rock structure. These equations are transformed into a discrete algebraic form that can be solved on a computer using a variety of methods such as finite element, finite volume, and streamline methods. One important property of the discretized equations is that they must be mass conserving. In other words, any loss in mass of reservoir fluid predicted by the numerical model has to be due to physical conditions rather than caused by the discretization method employed.

Merging these two components together allows one to calculate the subsurface flow behavior. Before performing actual prediction, two operations have to be conducted. First, the geological model has to be upscaled, that is, the amount of spatial data points has to be decreased in order to reduce the time and computer memory size necessary for calculations. Second, the simplified model has to be tuned by matching simulation outputs with the amount of oil actually produced from the field. This process is known as history matching. Finally, the future recovery forecasts can be made. Such an approach allows oil companies to decide whether and where it is economically viable to drill a new well.

Interesting fact:

A single onshore well can cost anywhere between $1 millionand $15 million to drill, depending on the depth and rock formation type. Offshore wells cost up to $50 million. The price of erroneously drilling an oil well is cost prohibitive.



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[3] Z. Chen, G. Huan, and Y. Ma. Computational Methods for Multiphase Flows in Porous Media (SIAM, 2006).

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