Streamline Simulation: Solving a Large Number of 1D Problems Versus a Large 3D Problem

R. Archer
Department of Engineering Science University of Auckland
New Zealand

This lecture reviews the development and application of the streamline simulation approach for modeling fluid flow in petroleum reservoirs. In a standard reservoir simulator mass balance equations are constructed and solved which involve pressure and saturation unknowns. In an IMPES (Implicit Pressure Explicit Saturation) formulation a pressure equation is decoupled and solved by using explicit saturation information. This results in a stability restriction via the CFL condition, which can be very limiting in some cases. In a fully implicit formulation all unknowns are treated implicitly resulting in three unknowns per gridblock for a three-phase flow case. This approach requires a large matrix problem to be solved at each timestep, though the timesteps can be larger since the method is unconditionally stable.

The streamline simulation method decouples the pressure and saturation equations. The pressure equation, which is elliptic, is solved on a different time scale to the hyperbolic saturation equation. The solution of the pressure equation is used to define streamlines that are by nature one-dimensional. This decomposition of a large three-dimensional problem into a large number of one-dimensional problems provides the basis for the significant savings in CPU time that is observed with streamline methods.

The streamline method can successfully incorporate gravity and compositional effects. It has also recently been extended to dual-porosity media. Several groups have also found it to be a powerful tool in history matching reservoir models. This talk will review these innovations.