Lecture 10 summary

Major Elements of a Reservoir Simulation Study- initialization

5. Major Elements of a Reservoir Simulation Study

The essential elements of a simulation study include:

5.1- Data Preparation.

5.2- Model Initialization.

5.3- History matching.

5.4- Base case prediction & Predictions scenarios.

5.1. Data Preparation

Some of the data that is required for a model can be found in existing reports. The modeling team should find as many reports as it can from as many disciplines as possible. Table 11 lists the types of data that are needed in a model study.

Table 11 Data Required for a Simulation Study

Property	Sources
Permeability	Core analyses, Correlations, Pressure transient testing
Porosity, Rock compressibility	Core analyses, Well logs
Relative permeability and capillary pressure	Laboratory core, flow tests
Saturations	Core analyses, Well logs, Single well tracer tests
Fluid property (PVT) data	Laboratory analyses of reservoir fluid samples

Faults, boundaries, fluid contacts	Seismic, Pressure transient testing
Aquifers	Seismic, Material balance calculations, Regional studies
Fracture spacing, connectivity	Core analyses, Well logs, Seismic, Pressure transient tests, Wellbore performance
Rate and pressure data, completion and workover data	Field performance history

A review of available data may identify gaps or errors in the data. The modeling team should take care to avoid underestimating the amount of work that may be needed to prepare an input data set. It can take as long to collect and prepare the data as it does to do the study.

Simulator Type Selection

We focus on black oil simulator or a compositional simulator.

A compositional simulator represents the fluid as a mixture of hydrocarbon components.

Black oil simulators may be viewed as compositional simulators with two components. They can have gas dissolved in the oil phase, as well as oil dissolved in the gas phase. Black oil simulators need both saturated and undersaturated fluid property data.

The selection of a reservoir simulator depends on such factors as:

From a reservoir perspective: reservoir architecture, fluid type, and drive mechanisms that are anticipated.

Non reservoir requirements include: simulator availability and cost.

5.2. Model Initialization

The flow model is considered initialized when it has all the data it needs to calculate fluids in place.

The reservoir must be characterized in a format that can be used by a simulator.

Reservoir characterization includes the selection of a grid and the distribution of reservoir properties in the grid.

Initialization Data

Initialization data records are read once at the beginning of the simulation. Tabular data entered by the user should cover the entire range of values expected to occur during a simulation

1. Model Dimensions and Geometry

2. Rock Properties and distributions

4. Reservoir Geophysical Parameters

5. Fluid PVT Tables

6. Pressures and Saturation Initialization

7. Analytic Aquifer Models

Grid Definition

Flow model grids may be defined in several different ways. Reservoir grids can often be constructed in one-, two-, or three-dimensions, and in Cartesian or cylindrical coordinates. Horizontal 1-D models are used to model linear systems that do not include gravity effects.

Figure 30 shows an example of a 2-D grid. Grids in 2-D may be used to model areal fluid movement. Figure 30 is useful if the boundary of the reservoir is not well known or an aquifer needs to be attached to the flanks of the reservoir to match reservoir behavior.

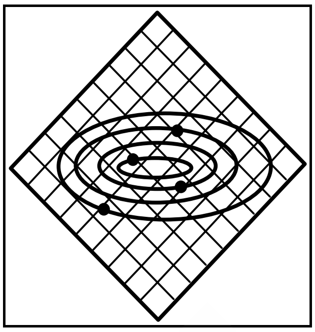

Figure 30. Grid Orientation

The use of 2-D grids for full field modeling has continued to be popular even as computer power has increased and made large 3-D models practical.

Figure 31 shows a simple 3-D grid that is often called a “layer cake” grid.

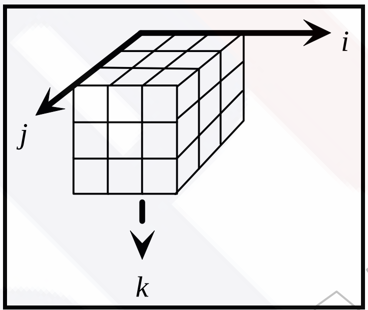

Figure 31. Example of a 3-D "layer cake" grid

Non-Cartesian Grids

Near-well bore coning models may be either 2-D or 3-D grids, but are defined in cylindrical rather than Cartesian coordinates. Figure 32 shows an example of a radial grid.

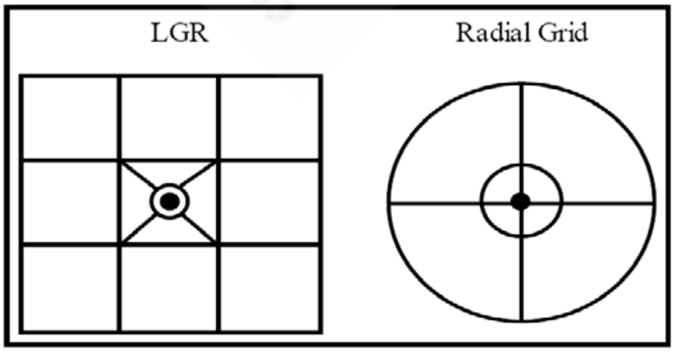

Figure 32. LGR and Radial Grids

Local grid refinement (LGR) is used to provide additional grid definition in a few selected regions of a larger grid.

Corner Point Geometry

Grid blocks may be defined in terms of corner point geometry or grid block centered geometry (Figure 33). Grid block centered geometry is the most straight forward technique, but corner point geometry has gained popularity because it yields more visually realistic representations of reservoir architecture.

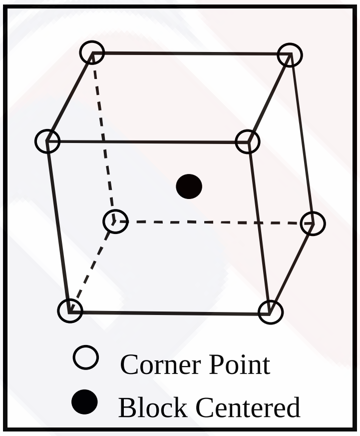

Figure 33. Grid block Representation

Initialization Model

An equilibrium initialization algorithm and a gravity segregation algorithm are available as options in simulator.

Equilibrium Initialization

Suppose a grid block has a gas-oil contact (GOC) and a water-oil contact (WOC) as shown in Figure 34. The pressure at GOC is PGOC. Similarly, PWOC is the pressure at WOC.

The initial oil phase pressure assigned to the grid block in Figure 17-8 is determined by PWOC, PGOC and the depth of the node (midpoint) relative to the respective contact elevations.

The oil density RO_{WOC} and water density RW_{WOC} at WOC are calculated using the pressure PWOC.

The water-oil capillary pressure PCOW is calculated for the grid block at the midpoint elevation EL using the densities at WOC.

The initial water saturation SWI for the grid block is calculated at the midpoint elevation using PCOW

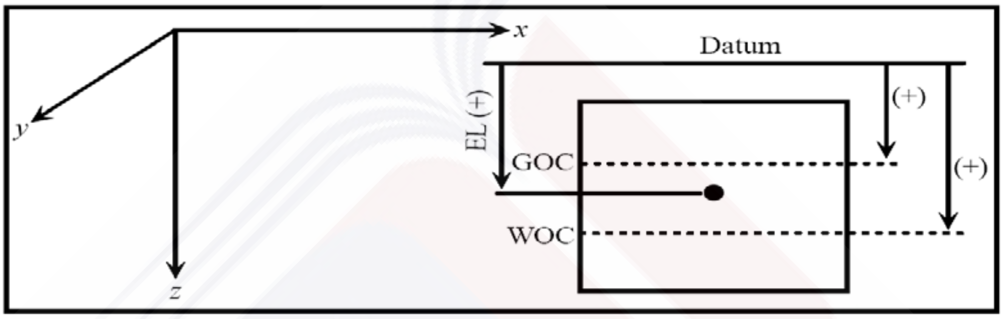

Figure 34. Depths for Initialization Algorithm

A similar calculation is performed to determine initial oil phase pressure at the GOC using gas and oil densities.

Oil saturation is obtained from the constraint $S_o + S_w + S_g = 1$.

The initial oil phase pressure P is calculated using the saturations determined above and capillary pressure to define the appropriate pressure gradient.

The oil-water transition zone thickness is given by

$$H_{owTZ} = \frac{\mathrm{PCWO}(\mathrm{SW} = S_{wr}) - \mathrm{PCWO}(\mathrm{SW} = 1)}{|\gamma_w - \gamma_o|}$$, ---------- (21)

Where, γ_o and γ_w are the oil and water pressure gradients in psia/ft. A similar calculation is performed to determine the gas-oil transition zone thickness.