Lecture 9: Reservoir Simulation Workflow

Fourth Grade - Spring Semester 2020-2021

Instructor: Ms. Sheida Mostafa Sheikheh
Content:

- Overview of Modeling Procedure
- Reservoir Simulation Workflow
- Reservoir Simulation System
- Eclipse Workflow
Major Steps of Numerical Solution
Overview of Modeling Procedure:

- Property 3D, FloGrid, CPS3, Petrel: Describe reservoir
  - reservoir structure (seismic, logs)
  - gross and net thickness (logs)
  - well locations and perforated intervals

- VFPI, FloGrid, PVTi, Schedule, SCAL
  - Design reservoir grid
  - porosity, permeability (logs, cores)
  - fluid analyses (lab data)
  - pressure and contacts (logs, well tests, etc.)

- ECLIPSE 100/300/500
  - Select simulator model
  - black oil or compositional fractured, condensate, etc.
  - horizontal wells, EOR, thermal, etc.

- ECLIPSE SimOpt
  - Solve for pressures and saturations
  - historical production data

- FloViz Peep
  - Predict and optimize future production
  - investigate different scenarios
  - visualize results
  - economic calculations
Reservoir Simulation Workflow:

- Building a geo-model
- Assemble other necessary data (PVT, SCAL, ...)
- Initialization: calculation of P, S, Hydrocarbon in place
- History Matching: reduce the uncertainty in the geo-model
- Forecast: compute production profiles and reserves
  - For different development scenarios (production mechanisms, well architecture, ....)
  - Taking into account the surface facility constraints
Reservoir Simulation Workflow:

- What do we have at the start of this process?

  - **Static model:**

    ✓ Structure- tops, thickness, layering, faults, boundaries, shales, sands, rock type, depositional environment, grain size distribution fractures (all locations), property of aquifer.

    ✓ Rock properties at all points in the reservoir, permeabilities in all directions, porosities, capillary pressure, relative permeabilities.
Reservoir Simulation Workflow:

- What do we have at the start of this process?
  - Static model:
    - Initial reservoir conditions: water, oil and gas saturations, pressures at all points in the reservoirs, contacts.
Reservoir Simulation Workflow:

What do we have at the start of this process?

➢ Well Data:

✓ Well locations, trajectory, completions, workover schedule

✓ Production rates of oil, water, and gas as a function of time

✓ Pressure history of the wells- bottom hole flowing pressure and/or build-up pressures (well tests) at specific times

✓ Injection history- rates, fluids, pressures, etc.
Reservoir Simulation Workflow:

- What do we have at the start of this process?
  - Fluid data: PVT experiments with the reservoir fluids, viscosities, densities.
  - Material balance of the reservoir history
  - Reservoir Compartments
  - Reservoir mechanisms
  - Surface facilities and conditions
Reservoir Simulation Workflow:

- Static model
- Well Data
- Fluid data
- Material balance of the reservoir history
- Reservoir Compartments
- Reservoir mechanisms
- Surface facilities and conditions
Reservoir Simulation System:

- Suite of Software Applications for:
  - Pre-Processing
    - Data Loading and Importing
    - Gridding
  - Processing
    - Numerical Calculations
  - Post-Processing
    - Visualization of calculated results
Reservoir Simulation System:

1) Importing Geological Data
2) Parameterized Grid, Neighborhood Connections
3) Rock-, PVT-, and Well data
4) Simulated Results for Visualization
Reservoir Simulation System:

- Pre-Processor:
  - Automatic Grid generation
  - Cartesian, Radial and Corner Point grids
  - Local Grid Refinement, Aquifer Modeling
  - Flexible Well Modeling (arbitrary directed wells)
  - Fault Modeling (vertical, sloping)
Reservoir Simulation System:

- Pre-Processor:
  - Data Importing from various sources and formats
  - Graphical User interfaces and Visualization
  - Data preparation modules (Rock, PVT and Well data)
  - Validation of Geological Model
Reservoir Simulation System:

- Processor:
  - Black-Oil Models (single phase to three phase models)
  - Extended Black Oil (Salt, Polymer, API)
  - Compositional Model (n components, EOS model)
  - Thermal Model
- Solution Techniques: IMPES, Fully implicit, adaptive implicit method
Reservoir Simulation System:

- Processor:
  - Dual Porosity Dual Permeability Models
  - Rock compaction and hysteresis models
  - Analytical and numerical aquifer treatment
  - Flexible and multilevel well management controls
Reservoir Simulation System:

- Post-Processor:
  - Visualization of calculated results on grid: distribution plots for any object
  - Visualization of results vs. time
  - Well plots, well group plots, reservoir plots: Animation of results
  - Supporting all major graphic formats
  - Exporting maps
Content:

- Overview of Modeling Procedure
- Reservoir Simulation Workflow
- Reservoir Simulation System
- Eclipse Workflow
Eclipse Workflow:

- **FloGrid**: From the Static Model - Create a numerical grid of the reservoir (flow field) that includes at all points:
  - Rock permeability, porosity, relative permeability, capillary pressure, pressure saturations
  - Location, volumes, adjacent rocks or features

- The input data are a set of mesh maps and fault traces, generated in an external mapping package, and well deviation surveys.

- The output is a simulation grid and cell properties.
Eclipse Workflow:

1. Load maps, fault, traces, wells
2. Build the Structural Framework
3. Build the corner point grid
4. Populate grid with properties to create the property model.
5. The rest of the workflow follows as before.
Eclipse Workflow:

maps, fault, traces, wells

Structural Framework

Simulation grid model
Eclipse Workflow:

➢ PVTi:

✓ PVT Analysis and Fluid Characterization

✓ Using Equation of State and PVT Program characterize oil and/or gas and match laboratory phase behavior experiments

✓ Export PVT files for Blackoil, Compositional, or Thermal simulations
Eclipse Workflow:

- SCAL:
  - Analysis of Rock Types
  - Relative Permeabilities
  - Capillary Pressure
  - Imbibition and Drainage
  - Assignment of curves to grid blocks
Eclipse Workflow:

- **Schedule:**
  - Well Data Preparation
  - Location of wells in the grid
  - Averaging and Assignment of production rates to wells
  - Workover wells
  - Assign all well, control, economic limits and time stepping keywords to ECLIPSE data set
Eclipse Workflow:

- VFPI:
  - Create Table relating BHP to THP as a function of:
    - Well design – depth, ID, roughness, depth, temperatures,
    - GOR, Water Cut
    - Oil rates
    - Pumps, gas lift, compressors
  - Simulator need BHP – if you want to control well from the surface must have lift curves
Eclipse Workflow:

- FloViz:
  - Provides 3D visualization capabilities for display and analysis of reservoir simulation results.
  - FloViz can display both structured and unstructured grids.
FloViz:
Eclipse Workflow:

- Office:
  - Provides an environment for simulation pre- and post- processing.
  - It can be used for creation and modification of models, submission and control of runs, analysis of results and report generation.
Office:

![Graph showing FDE vs. TIME (FELB)](image)
Eclipse Workflow:

- SimOpt:
  - To achieve a history match between an ECLIPSE 100/300 simulation model and the corresponding observed reservoir data
  - By applying mathematical techniques, it provides additional information on which the reservoir engineer can exercise judgement to improve the history match.