Grid Design

Match to objective of study
Criteria for selecting gridblock size

1. Able to identify saturations and pressures at specific locations and times

≥ 3 blocks between locations
Criteria for selecting gridblock size

2. Adequately represent the geometry/geology and physical properties of the reservoir

Ertekin, et al.
Criteria for selecting gridblock size

Structure Map and Overlying grid
Criteria for selecting gridblock size

Malhotra

Dakota Structure Map

Sandstone Layers in the Model
- Twowells
- Paguate
- Cubero
- 2 Shale Layers in Model

Elevations (ft)

Malhotra
Criteria for selecting gridblock size

3. Sufficient to describe the dynamics
   a. Able to describe pressures as $f(t)$
   b. Able to follow front locations and movement
   c. Able to correctly represent well behavior
Criteria for selecting gridblock size

4. Correctly model the reservoir fluid mechanics; for example: coning, displacement

5. Compatible with the mathematics of the simulator
Numerical Dispersion

- Artifact of numerical analysis techniques
- Can cause severe distortions in simulations, especially in rapid saturation changes

If upstream mobility, then water will flow From Blocks 2 to 3. Next time step, water Flows from 3 to 4.
Numerical Dispersion

- Effect is to decrease displacement efficiency at breakthrough
- Most serious for favorable mobility ratios
- Tends to smear the front
Gridsize Guidelines

• No general rule for proper cell size
• Perform sensitivity analysis
• Rule of thumb
  – 3 to 5 blocks between producers
  – 5 to 10 between producers/injectors
Limiting Numerical Dispersion

1. Increase number of gridblocks
2. Improved upstream, mobility weighting
3. Apply pseudofunctions

relative permeability curves in areal models are modified to restrict the movement of the displacing phase until saturation reaches the finely gridded simulation value.

4. Finite Element Modelling (FEM)
Grid Orientation Effect

- Performance influenced by the orientation of the grid relative to the well locations.
- Multi-dimensional, multiphase problem
- Important when $M_{\text{displacing phase}} \gg M_{\text{displaced phase}}$

- Flow path from Well B longer, Thus front will arrive later
- but sweep efficiency greater…
  Higher oil recovery
Grid Orientation

Effect

Parallel model

Diagonal model
Grid Orientation Effect

Case I: Unit mobility, diagonal grid

- Gridblock size ($\Delta x$) varied from 0.05 to 0.20.
- Results insensitive to number of gridblocks.
Grid Orientation Effect

Case II: Unit mobility, parallel grid

- Oil recovery increases as grid block size decreases,
- but is less than diagonal model for all grid spacings

$\Delta x$

$P V_{\text{rec}}$

$P V_{\text{inj}}$
Grid Orientation Effect

Case III: Unfavorable mobility ratio (10:1)

$PV_{inj}$

Increasing

$Δx$

$PV_{rec}$

Diagonal

9 point formulation

Parallel

New Mexico Tech

SCIENCE, ENGINEERING, RESEARCH UNIVERSITY
Grid Orientation Effect

• For simulations with favorable to slightly favorable mobility ratio…grid orientation effect can be reduced by *refining the grid*.

• Diagonal orientation less likely to introduce distortion.

• Grid orientation effect more pronounced for unfavorable mobility ratios (10:1)
Grid Orientation Effect

Orient grid parallel to principal directions of permeability…….. if known.

Strike curvature map
Approaches to Reduce Grid Orientation Effect

1. Nine point formulation
2. Initialize with high displacing phase saturation near injection wells
3. Two-point upstream weighting
4. Curvilinear coordinates
5. Triangular grid systems
6. F.E.M.
Selection of Timestep

• Selection function of study; e.g. single well pressure test vs. full field reservoir simulation

• Consequences of large time step
  – Incorrect mobilities
  – Numerical dispersion
  – Physics of system not represented

• Initialization

• Automatic timestep
  – Controlling parameters are pressure and saturation change