TM-6011 - Modul 3: Model Aliran Fluida Dalam Reservoir

Advanced Reservoir Simulation

Reservoir simulation
Fluid Flow Equation (Darcy)

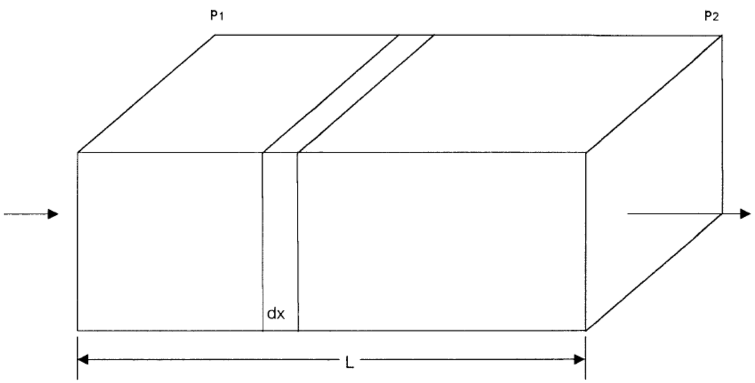
Fluid Flow Equations

- Describe flow eq. in porous media.
- The form of floweq. Depends on:
  - Fluid type
  - Flow regime/ flow type
  - etc
- Commonly in the cobination of:
  - conservation of mass
  - Flow Eq.in porous media(Darcy)
  - EOS

Assumptions: Darcy Law

- Laminar (viscous flow)
- Steady-state
  - Pressure in every point of reservoir is independent to time.
- Incompressible
- Homogeneous formation

Linear Flow of Incompressible Fluids (Horizontal flow)



$$\frac{q}{A}\int_0^L dx = -\frac{k}{\mu}\int_{p_1}^{p_2} dp$$

$$q = \frac{kA\left(p_1 - p_2\right)}{\mu L}$$

$$q = \frac{0.001127\ kA\left(p_1 - p_2\right)}{\mu L}$$

q = flow rate, bbl/day
k = absolute permeability, md
p = pressure, psia
μ = viscosity, cp
L = distance, ft
A = cross-sectional area, ft^2

Contoh

- L = 1000 ft
- h = 20 ft
- w = 300 ft
- k = 100 md
- Porosity = 15%
- μ = 2 cp
- Δp = 20 psi

Linear Flow of Incompressible Fluids (non-Horizontal flow)

- $$q = \frac{0.001127\, kA\, (\Phi_1 - \Phi_2)}{\mu L}$$

- $(\Phi_1 - \Phi_2) > 0$, flow is flow 1 to 2

- $$\Phi_i = p_i + \left(\frac{\rho}{144}\right)\Delta z_i$$

Linear Flow of Slightly Compressible Fluids

- V = Vref [1 + c (pref – p)]
- q = qref [1 + c (pref – p)]
- $$\frac{q}{A} = \frac{q_{ref}\,[1 + c\,(p_{ref} - p)]}{A} = -\,0.001127\,\frac{k}{\mu}\,\frac{dp}{dx}$$
- $$\frac{q_{ref}}{A}\int_{o}^{L} dx = -\,0.001127\,\frac{k}{\mu}\int_{p_1}^{p_2}\left[\frac{dp}{1 + c\,(p_{ref} - p)}\right]$$
- $$q_{ref} = \left[\frac{0.001127\;kA}{\mu\;c\;L}\right]\ln\left[\frac{1 + c\,(p_{ref} - p_2)}{1 + c\,(p_{ref} - p_1)}\right]$$

Linear Flow of Compressible Fluids (Gases)

- $$n = \frac{pV}{zRT}$$
- $$\frac{pV}{zT} = \frac{p_{sc}\ V_{sc}}{T_{sc}}$$
- $$\frac{5.615pq}{zT} = \frac{p_{sc}\ Q_{sc}}{T_{sc}}$$

$$\left(\frac{p_{sc}}{T_{sc}}\right)\left(\frac{zT}{p}\right)\left(\frac{Q_{sc}}{5.615}\right) = q$$

where q = gas flow rate at pressure p in bbl/day
Q_{sc} = gas flow rate at standard conditions, scf/day
z = gas compressibility factor
T_{sc}, p_{sc} = standard temperature and pressure in °R and psia, respectively

Linear Flow of Compressible Fluids (Gases)

- $$\frac{q}{A} = \left(\frac{p_{sc}}{T_{sc}}\right)\left(\frac{zT}{p}\right)\left(\frac{Q_{sc}}{5.615}\right)\left(\frac{1}{A}\right) = -0.001127\frac{k}{\mu}\frac{dp}{dx}$$

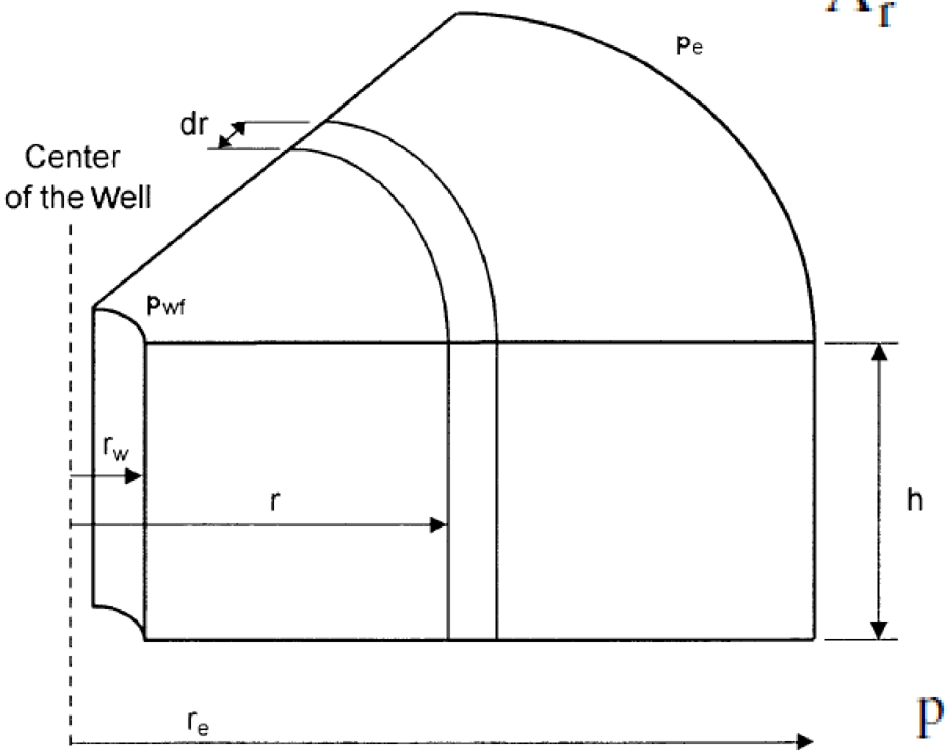
$$\left[\frac{q_{sc}\ p_{sc}\ T}{0.006328\ k\ T_{sc}\ A}\right]\int_0^L dx = -\int_{p_1}^{p_2}\frac{p}{z\mu_g}dp$$

$$Q_{sc} = \frac{0.003164\ T_{sc}\ A\,k\,(p_1^2 - p_2^2)}{p_{sc}\,T\,L\,\overline{z\mu_g}}$$

$$Q_{sc} = \frac{0.111924\,A\,k\,(p_1^2 - p_2^2)}{T\,L\,\overline{z\mu_g}}$$

Radial Flow of Incompressible Fluids

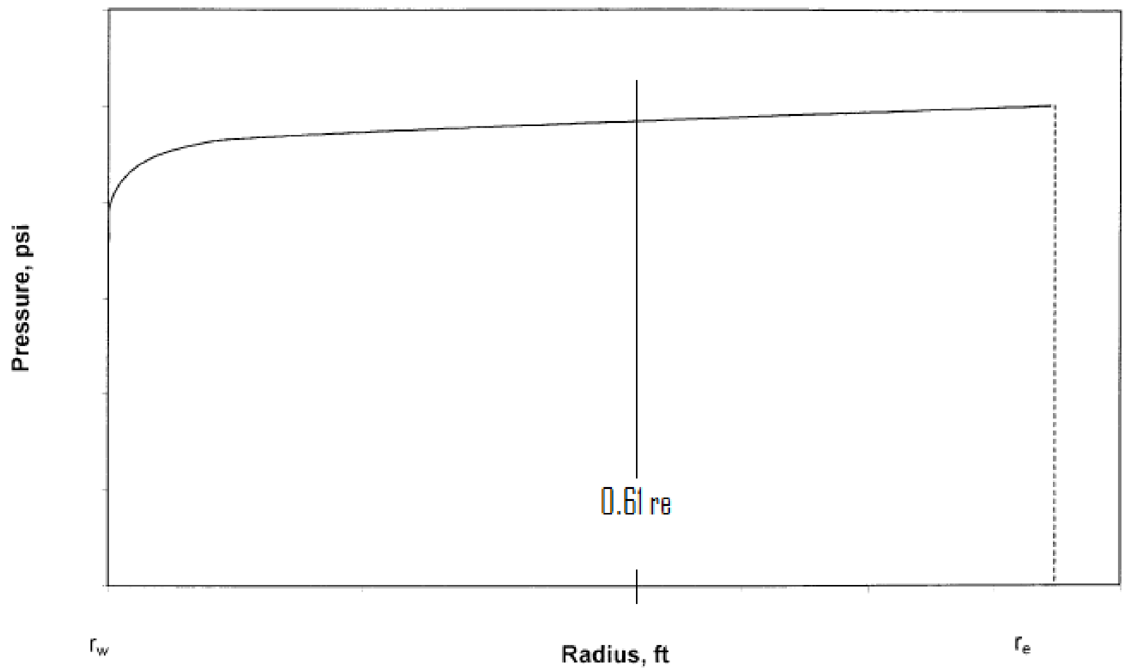
$$v = \frac{q}{A_r} = \frac{q}{2\pi rh} = 0.001127\,\frac{k}{\mu}\,\frac{dp}{dr}$$



$$Q_o = \frac{0.00708\,k\,h\,(p_e - p_w)}{\mu_o\,B_o\,\ln\,(r_e/r_w)}$$

$$p = p_{wf} + \left[\frac{Q_o\,B_o\,\mu_o}{0.00708\,kh}\right]\ln\left(\frac{r}{r_w}\right)$$

Average Reservoir Pressure



$$Q_o = \frac{0.00708\, k\, h\, (p_r - p_{wf})}{\mu_o\, B_o \left[\ln\left(\frac{r_e}{r_w} \right) - 0.5 \right]}$$

Radial Flow of Slightly Compressible Fluids

- Basic Equation:

$$\frac{q}{A_r} = \frac{q_{ref}\,[1 + c\,(p_{ref} - p)]}{2\pi r h} = 0.001127\,\frac{k}{\mu}\,\frac{dp}{dr}$$

- Homework (No:1): Derive the complete form of the equation for Radial Flow of Slightly compressible fluids.

Radial Flow of Compressible Gases

- $$q_{gr} = \frac{0.001127\,(2\pi rh)\,k}{\mu_g}\,\frac{dp}{dr}$$
- $$\left(\frac{T\,Q_g}{k\,h}\right)\frac{dr}{r} = 0.703\left(\frac{2p}{\mu_g\,z}\right)dp$$
- $$Q_g = \frac{0.703\,kh\,(\psi_e - \psi_w)}{T\left(\ln\frac{r_e}{r_w}\right)} \qquad m(p) = \psi = \int_0^p \left(\frac{2p}{\mu_g\,z}\right)dp$$

Horizontal Multiple-Phase Flow

$$q_o = 0.001127\left(\frac{2\pi rh}{\mu_o}\right)k_o\frac{dp}{dr}$$

$$q_w = 0.001127\left(\frac{2\pi rh}{\mu_w}\right)k_w\frac{dp}{dr}$$

$$q_g = 0.001127\left(\frac{2\pi rh}{\mu_g}\right)k_g\frac{dp}{dr}$$

UNSTEADY-STATE FLOW

- Homework (No:3):
  1. Apa definisi Unsteady State Flow
  2. Apa macam-macam jenis aliran yang termasuk dalam katagori unsteady state flow.
  3. Kondisi seperti apakah dalam praktek termasuk kondisi steady state, transient, dan pseudo-steady state?