Lecture 2 summary

Basic reservoir simulation concepts - Static information.

2.1. Original Oil Initially In Place (OOIIP)

Methods of calculation

Volumetric Method:

Fluid volumes originally in place in the reservoir can be estimated as:

$$STOIIP = V * \phi * (1 - S_{wc}) / B_{oi}\,, \quad \text{(stock tank volume)}, \quad \text{------ (1)}$$

Where,

V - the net bulk volume of the reservoir rock.

ϕ - the porosity.

S_{wc}- the connate water saturation. It is normally 10−25% (PV).

B_{oi} - the initial oil formation volume factor, (rb/stb).

The simulator calculates reservoir volume by subdividing the reservoir volume into an array, or grid, of smaller volume elements (Figure 2). Many names are used to denote the individual volume elements: for example, grid block, cell, or node.

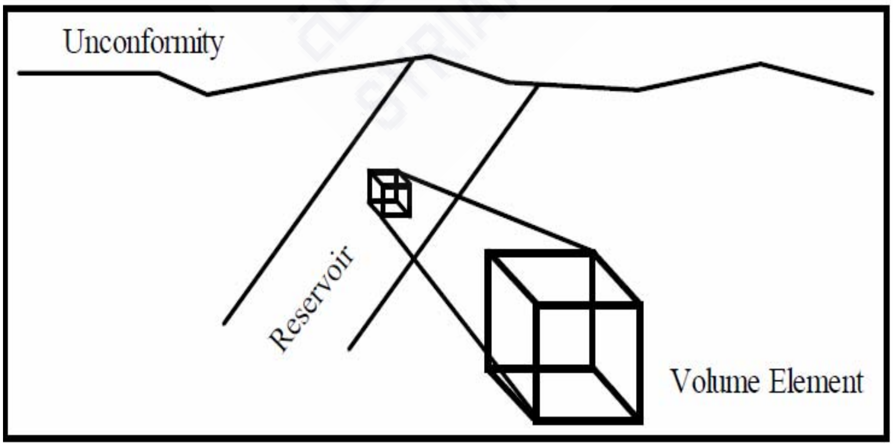

Figure 2. Subdivide reservoir into volume elements

Material Balance Method:

Material balance calculates fluid volumes, based on law of conservation of mass, for comparison with volumetric estimates. It also indicates the relative contribution of different drive mechanisms at work in the reservoir and predicts future reservoir performance and cumulative recovery efficiency.

General material balance equation can be expressed in a form:

$$N\left[D_o + D_{go} + D_w + D_{gw} + D_r\right] = N_p B_o - N_p R_{so} B_g + \left[G_{ps} B_g + G_{pc} B_{gc} - G_i B_g'\right] - \left(W_e + W_i - W_p\right) B_w$$

, ---------- (2)

Table 1. Physical Significance of Material Balance Terms

Term	Physical Significance
ND_o	Change in volume of initial oil and associated gas
ND_{go}	Change in volume of free gas
$N(D_w + D_{gw})$	Change in volume of initial connate water
ND_r	Change in formation pore volume
N_pB_o	Cumulative oil production
$N_pR_{so}B_g$	Cumulative gas produced in solution with oil
$G_{ps}B_g$	Cumulative solution gas produced as evolved gas
$G_{pc}B_{gc}$	Cumulative gas cap gas production
G_iB_g'	Cumulative gas injection
W_eB_w	Cumulative water influx
W_iB_w	Cumulative water injection
W_pB_w	Cumulative water production

The derivation of the material balance equation is based on several assumptions: the system is in pressure equilibrium; the system is isothermal; available fluid property data are representative of reservoir fluids; production data is reliable; and gravity segregation of phases can be neglected.

Equation (2) can be used to validate the reservoir modeling features of a reservoir flow simulator.

Decline Curve Method:

Arps [1945] studied the relationship between flow rate and time for producing wells.

Assuming constant flowing pressure, he found Three decline curves: *exponential, hyperbolic and harmonic decline* curves.

Cumulative production for decline curve analysis is the integral of the rate from the initial rate q_i at time t = 0 to the rate q at time t.

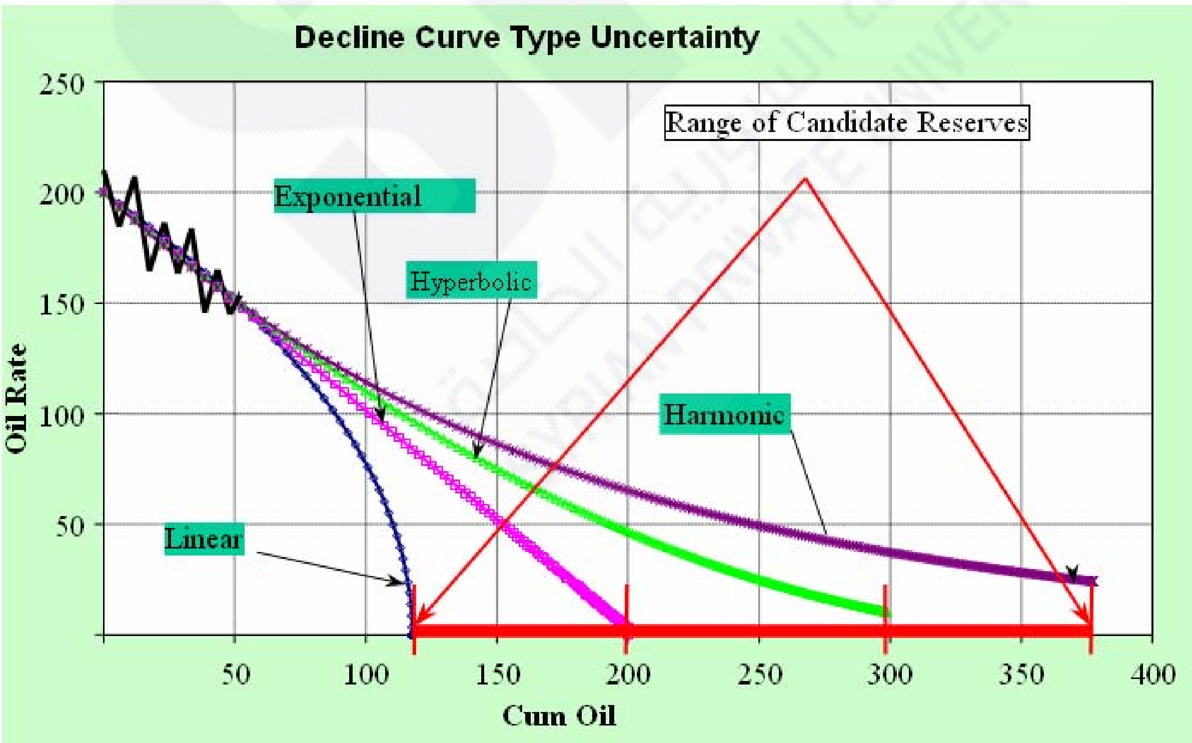

Figure 3. Decline curves on semi-log plot

2.2. Pressure Transient Test results:

Pressure transient testing can provide information that can be used in modeling to estimate the distance to reservoir boundaries, structural discontinuities, and communication between wells Table 2.

Table 2. Reservoir Properties from Pressure Transient Tests

Type of Test	Properties	Development Stage
Drill stem tests	▪ Reservoir behavior ▪ Permeability / Skin ▪ Fracture length ▪ Reservoir pressure ▪ Reservoir limit / Boundaries	Exploration and appraisal wells
Repeat formation tests	▪ Pressure profile	Exploration and appraisal wells
Drawdown tests	▪ Reservoir behavior ▪ Permeability / Skin ▪ Fracture length ▪ Reservoir limit / Boundaries	Primary, secondary and enhanced recovery
Buildup tests	▪ Reservoir behavior ▪ Permeability / Skin ▪ Fracture length ▪ Reservoir pressure ▪ Reservoir limit / Boundaries	Primary, secondary, and enhanced recovery

Falloff tests	▪ Mobility in various banks ▪ Skin ▪ Reservoir pressure ▪ Fracture length ▪ Location of front ▪ Boundaries	Secondary and enhanced recovery
Interference and pulse tests	▪ Communication between wells ▪ Reservoir type behavior ▪ Porosity ▪ Interwell permeability ▪ Vertical permeability	Primary, secondary, and enhanced recovery
Layered reservoir tests	▪ Properties of individual layers ▪ Horizontal permeability ▪ Vertical permeability ▪ Skin ▪ Average layer pressure ▪ Outer boundaries	Throughout reservoir life