Tishk International University
Engineering Faculty
Petroleum and Mining Engineering Department

Petroleum Reservoir Engineering II

Calculation of STOIIP (Volumetric Method, MBE)

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Instructor: Nabaz Ali Abdulrahman

Content:

- STOIIP
- Estimation of OIIP:

✓ Volumetric Method (Calculation)

✓ Material Balance Equation (Mbal)

STOIIP

- The volume of oil in a reservoir prior to production.
- STOIIP is a method of estimating how much oil in a reservoir can be economically brought to the surface.

Estimation of STOIIP:

- Volumetric Method:

> Consider a reservoir with an areal extent of A acres and an average thickness of h feet. The total bulk volume of the reservoir can be determined from the following expressions:

$$Bulk\ Volume = 43{,}560Ah, ft^3 \ --- (1)$$

Or

$$Bulk\ Volume = 7{,}758Ah, bbl \ --- (2)$$

Where A= areal extent, acres

h= average thickness

Estimation of STOIIP:

- Volumetric Method:

➢ Expressing the reservoir pore volume in cubic feet gives:

$$PV = 43{,}560 Ah\phi, ft^3 \text{ ---}(3)$$

➢ Expressing the reservoir pore volume in barrels gives:

$$PV = 7{,}758 Ah\phi, bbl \text{ ---}(4)$$

Estimation of STOIIP:

- Volumetric Method:

➢ The initial oil in place:

$$Initial\ oil\ in\ place = \frac{PV(1 - S_{wc})}{B_o} --- (5)$$

Estimation of STOIIP:

- Volumetric Method:

Example:

S_{wc}= 0.25

B_o= 1.3

PV= 430 MMbbl

Estimation of STOIIP:

- Volumetric Method:

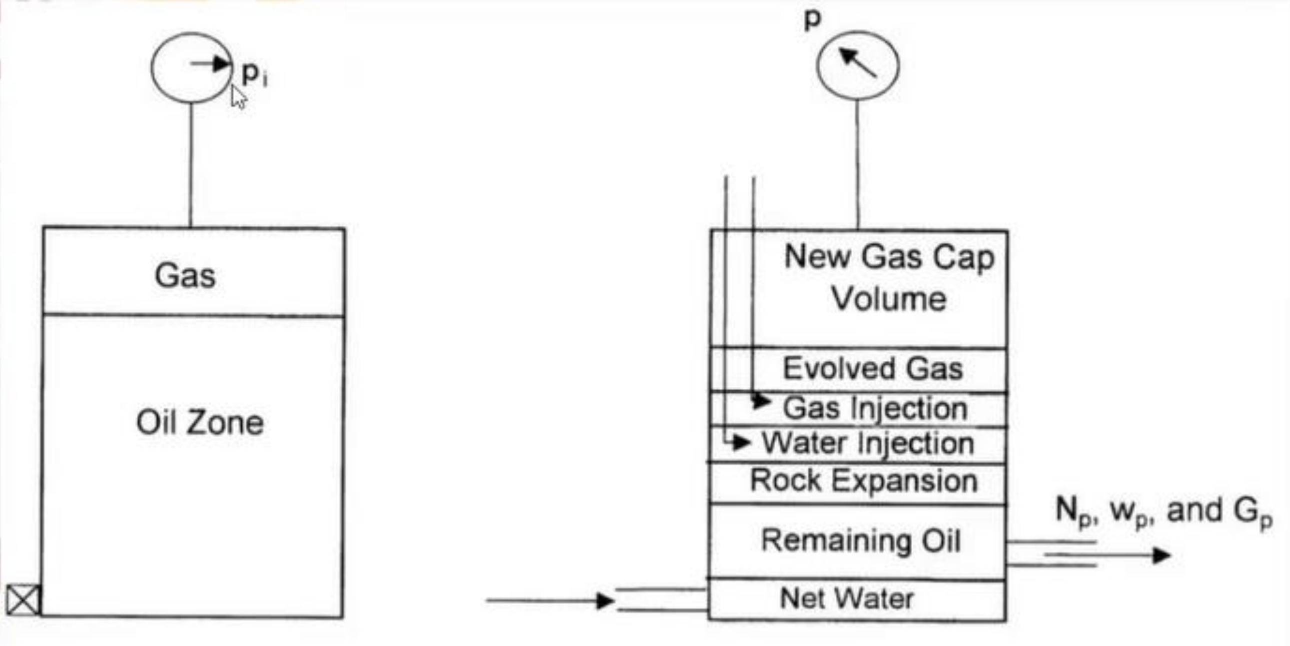
➢ The initial oil in place:

$$Initial\ oil\ in\ place = \frac{430(1-0.25)}{1.3}$$

$$Initial\ oil\ in\ place = 248.076\ \mathrm{MMSTB}$$

The Material Balance Equation Derivation

- Treating the reservoir pore as an idealized container as illustrated below, volumetric balance expressions can be derived to account for all volumetric changes which occur during the natural productive life of the reservoir.



Tank-model concept.

The Material Balance Equation Derivation

- The MBE can be written in a generalized form as follows:

Pore volume occupied by the oil initially in place at p_i + Pore volume occupied by the gas in the gas cap at p_i=

Pore volume occupied by the remaining oil at p + Pore volume occupied by the gas in the gas cap at p + Pore volume occupied by the evolved solution gas at p + Pore volume occupied by the net water influx at p + Change in pore volume due to connate-water expansion and pore volume reduction due to rock expansion + Pore volume occupied by the injected gas at p + Pore volume occupied by the injected water at p _ _ _ _ (2)

The Material Balance Equation Derivation

- Combining equations (3) through (12) with equation (2) and rearranging gives:

$$N = \frac{N_pB_o + (G_p - N_pR_s)B_g - (W_e - W_pB_w) - G_{inj}B_{ginj} - W_{inj}B_w}{(B_o - B_{oi}) + (R_{si} - R_s)B_g + mB_{oi}\left[\frac{B_g}{B_{gi}} - 1\right] + B_{oi}(1+m)\left[\frac{S_{wi}c_w + c_f}{1 - S_{wi}}\right]\Delta p} --- (13)$$

Where N= initial oil-in-place, STB

G_p= cumulative gas produced, scf

N_p= cumulative oil produced, STB

R_{si}= gas solubility at initial pressure, scf/STB

m= ratio of gas-cap gas volume to oil volume, bbl/bbl

B_{gi}= gas formation volume factor at p_i, bbl/scf

B_{ginj}= gas formation volume factor of the injected gas, bbl/scf

The Material Balance Equation Derivation

- The cumulative gas produced G_p can be expressed in terms of the cumulative gas-oil ratio R_p and cumulative oil produced N_p by:

$$G_p = R_p N_p \quad ---(14)$$

- Combining equation (14) with equation (13) gives:

$$N = \frac{N_p\left[B_o + \left(R_p - R_s\right)B_g\right] - \left(W_e - W_p B_w\right) - G_{inj}B_{ginj} - W_{inj}B_w}{\left(B_o - B_{oi}\right) + \left(R_{si} - R_s\right)B_g + mB_{oi}\left[\frac{B_g}{B_{gi}} - 1\right] + B_{oi}(1+m)\left[\frac{S_{wi}c_w + c_f}{1 - S_{wi}}\right]\Delta p} \quad ---(15)$$

- The above relationship is referred to as the **material balance equation** (MBE).

Estimation of STOIIP:

- **Material Balance Equation:**

Example: Reservoir Thickness: 100 feet

Verify that the volume which is found by volumetric method is logic based on production history?

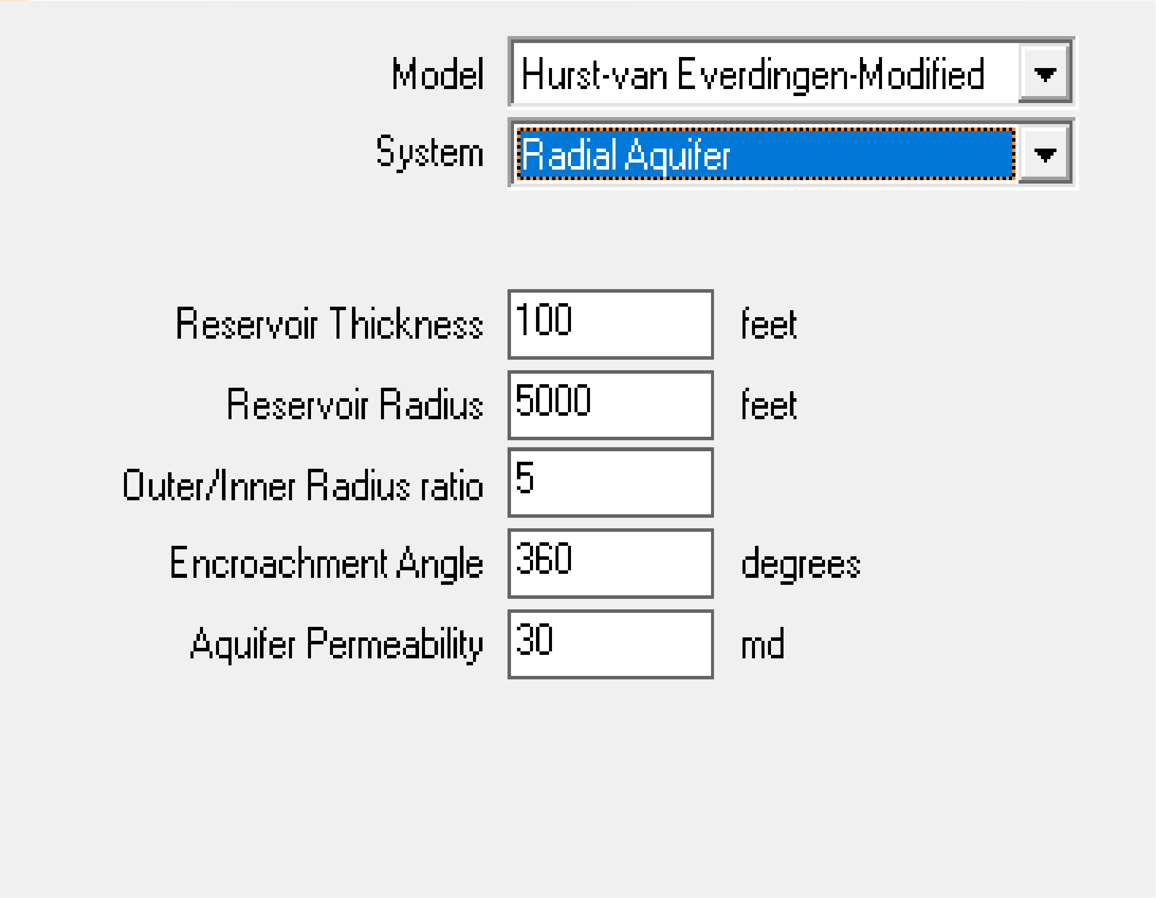
Tank Type	Oil	
Name	Tank01	
Temperature	250	deg F
Initial Pressure	5212	psig
Porosity	0.23	fraction
Connate Water Saturation	0.15	fraction
Water Compressibility	Use Corr	1/psi
Initial Gas Cap	0	
Original Oil In Place	248.76	MMSTB
Start of Production	02/01/2000	date m/d/y

Estimation of STOIIP:

- **Material Balance Equation:**

Example: Reservoir Thickness: 100 feet

Verify that the volume which is found by volumetric method is logic based on production history?



Estimation of STOIIP:

- **Material Balance Equation:**

Example: Reservoir Thickness: 100 feet

Verify that the volume which is found by volumetric method is logic based on production history?

	Residual Saturation	End Point	Exponent
	fraction	fraction	
Krw	0.15	0.5	2
Kro	0.15	1	2
Krg	0.05	0.5	2