

**Material Balance Calculations (Zero-Dimensional Analysis)**

The following parameters apply to an oil reservoir:

Porosity, compressibilities

$$\phi = 0.25, c_w = 2.0 \times 10^{-5} \text{ bar}^{-1}, c_g = 3.0 \times 10^{-3} \text{ bar}^{-1}, c_r = 5.0 \times 10^{-5} \text{ bar}^{-1}, C_o = 15.0 \times 10^{-5} \text{ bar}^{-1}$$

Initial conditions

$$P = 330 \text{ bar}, T = 110^\circ \text{C}, S_{w1} = 20\%$$

Black Oil PVT data

Pressure (bar)	$B_o$ (rb/stb)	$R_{so}$ (scf/stb)
350	1.25	500
250	1.35	500
200	1.40	500
100	1.25	200

Gas PVT data

Compute the required gas properties from the real gas equation, using standard conditions of  $T = 20^\circ \text{C}$  and  $P = 1.0133 \text{ bar}$ , where  $Z = 1.0$ , and final conditions of  $T = 110^\circ \text{C}$  and  $P = 100 \text{ bar}$ , where  $Z = 0.9$

Production data

Reservoir pressure (bar)	Cumulative oil production (st. $m^3$ )	Cumulative gas production (st. $m^3$ )	Cumulative water production (st. $m^3$ )
330	0	0	0
250	240.000	21.384.000	0
100	1.023.000	105.678.000	0

Questions

- 1) Derive the necessary material balance equations, or start with the general form of the equation and simplify it for this specific case.
- 2) Use the equations to calculate initial oil in place,  $N$ , using production data at 250 bar
- 3) Use the equations to calculate initial oil in place,  $N$ , using production data at 100 bar

In both cases 2) and 3), do the calculations with and without rock and water compressibility, in order to see the effect of these.

**4) Solution Gas Drive: Undersaturated oil reservoir**

Consider a reservoir with updip injection of the solution gas to enhance the primary recovery.

- 1- Determine recovery factor during the pressure drop to bubble point pressure?
- 2- The reservoir will be produced down till the pressure of 100 bar (below the bubble point).
  - Determine an expression for the recovery factor as a function of the  $R_p$ . (Assumption: No initial gascap; Negligible water influx; Negligible pore volume reduction and connate water expansion)
  - Plot the recovery factor Vs.  $R_p$  ( $R_p$  changes from 500 till 5000 scf/stb). Get a conclusion and explain the results.
  - Compare the recovery factor in under-saturated and saturated conditions and get a conclusion. (What is the real reason of the difference?)
  - Drive an expression for the free gas saturation at the pressure of 100 bar.