Lecture # 27
Chapter 13
Surface Separation
Separator Calculations

- Oil and gas are recombined to determine initial reservoir composition & properties (provided oil is above $p_b$)
- Separator calculations are done to determine best operating $p$ and $T$ such that stock tank API is maximum... (dejavu)
Separator Stages

2

Well stream

Separator

Pressure control

Separator gas

Stock tank gas

Stock tank

Level control

3

Well stream

Primary separator

Pressure control

1st-stage gas

Stock-tank gas

Stock tank

Level control

Secondary separator

Pressure control

2nd-stage gas

Level control
Separator Designs

Fig. 2-2 Oil and gas gravitational separator
3-Phase Separators

- Water is also separated, but will not be considered in our calculations

*Fig. 2–5 Vertical three-phase separator*
Bottom Hole Sampling

- Preserved Samples
- Reservoirs Conditions
- Selective Sampling Zones
- Sampling early in the life of the reservoir with minimum disturbance
- Lower overall cost
Nomenclature Used

Recall

\[ f_{v1} + f_{l1} = 1 \]
\[ f_{v2} + f_{l2} = 1 \]
Separator Calculations

Six step procedure for 2 stage separators

1. Given separator p and T, k-values, and feed composition $z_i$ run a flash and evaluate:

$$x_{i1}, y_{i1}, f_{v1}, \text{or } \left( \overline{n}_{g1} \right)$$

2. Using $x_{i1}$ as the feed from separator to stock tank evaluate

$$x_{i2}, y_{i2}, f_{v2}, \text{or } \left( \overline{n}_{g2} \right)$$
Separator Calculations

- Procedure for 2 stage separators (cont.)
  
  3. Using recently evaluated stock tank liquid compositions evaluate (Chapter 11 methods)

\[ x_{i2} \Rightarrow M_{wo} \Rightarrow \rho_{po} \]

4. Evaluate gas-oil ratio from steps 1, 2, 3 as follows:

\[
\frac{\bar{n}_{g1}}{n_{L1}^L} \frac{\text{lb mole SP gas}}{\text{lb mole SP feed}} \left( \frac{\text{lb mole SP oil}}{\text{lb mole SP feed}} \right) \left( \frac{\text{lb mole STO oil}}{\text{lb mole SP oil}} \right) \rightarrow \frac{\bar{n}_{g1}}{n_{L1}^L n_{L2}^L}
\]
Separator Calculations

Procedure for 2 stage separators (cont.)

4. Evaluate gas-oil ratio from steps 1, 2, 3 as follows:

\[
R_{SP} = \left( \frac{n_{g1}}{n_{L1}n_{L2}} \frac{\text{lb mole SP gas}}{\text{lb mole STO oil}} \right) \times 
\left( \frac{\text{380.7 scf SP gas}}{\text{lb mole SP gas}} \right) \times 
\left( \frac{\rho_{sto} \frac{\text{lb}}{\text{ft}^3} \frac{\text{lbmole}}{\text{STO oil}}}{M_{STO} \frac{\text{lb}}{\text{STB}}} \right) \times 
\frac{5.615}{\text{ft}^3} \]

\[
R_{SP} = \frac{2138 n_{g1} \rho_{sto}}{n_{L1}n_{L2}M_{STO}} 
R_{SP} \left[ \frac{\text{SCF SP gas}}{\text{STB}} \right]
\]
Separator Calculations

- Procedure for 2 stage separators (cont.)

4. Evaluate gas-oil ratio from steps 1, 2, 3 as follows:

\[ R_{SP} = \frac{2138 \overline{n}_{g1} \rho_{sto}}{\overline{n}_{L1} \overline{n}_{L2} M_{STO}} \]

Similarly for the stock tank

\[ R = R_{SP} + R_{ST} \]

\[ R_{ST} = \frac{2138 \overline{n}_{g2} \rho_{sto}}{\overline{n}_{L2} M_{STO}} \]
Separator Calculations

- Procedure for 2 stage separators (cont.)

5. Evaluate the oil density at reservoir conditions using the reservoir compositions, you get a pseudo liquid density and next (adjust for p and T, provided \( p \leq p_b \))

\[
Z_i \Rightarrow \rho_{po} \Rightarrow \rho_{oR}
\]

6. Evaluate the oil formation volume factor using quantities evaluated in stages 1, 2, 3, and 5.
Procedure for 2 stage separators (cont.)

6. Evaluate the oil formation volume factor using quantities evaluated in stages 1, 2, 3, and 5.

$$B_{ob} = \frac{\text{res bbl}/\text{lb mole res oil}}{\text{STB}/\text{lb mole res oil}}$$

$$\frac{\text{res bbl}}{\text{lb mole res oil}} = M_{OR} \frac{\text{lb res oil}}{\text{lb mole res oil}}$$

$$\rho_{OR} \frac{\text{lb res oil}}{\text{cu ft res oil}} \times 5.615 \frac{\text{cu ft res oil}}{\text{res bbl}}$$

$$\text{STO} = \frac{M_{STO} \frac{\text{lb STO}}{\text{lb mole STO}}}{\rho_{STO} \frac{\text{lb STO}}{\text{cu ft STO}}} \times \frac{n_{L1} \frac{\text{lb mole SP oil}}{\text{lb mole res oil}}}{5.615 \frac{\text{cu ft STO}}{\text{STB}}} \times \frac{n_{L2} \frac{\text{lb mole STO}}{\text{lb mole SP oil}}}{\text{STO}/\text{lb mole res oil}}$$
Separator Calculations

- Procedure for 2 stage separators (cont.)

6. Evaluate the oil formation volume factor using quantities evaluated in stages 1, 2, 3, and 5.

\[ B_{ob} = \frac{\text{res bbl/lb mole res oil}}{\text{STB/lb mole res oil}} \]

\[ B_{ob} = \frac{M_{oR} \rho_{STO}}{M_{STO} \rho_{oR} \bar{n}_{L1} \bar{n}_{L2}} \]
Calculations

Let’s see from our excel file

- Separator-calculations.xls
- Download from webct site