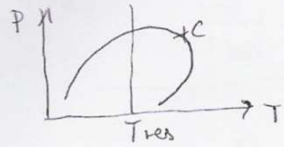
PVT MPE-510 Høst 2010.

Oppg. 1.

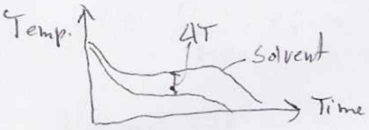
a (1) - $P_{wf} > P_{sat}$.

- Both oils and gas-condensates.

(2)  Crude oil.

(3) - Freezing point depression

- Water-saturated benzene as solvent.



- Solvent contaminated by oil. about 1 wt%.

$$\Delta T = K_f \cdot \frac{\frac{m_{STO}}{M_{STO}}}{\frac{m_{benz}}{1000}}$$

m_{STO}: Mass of oil

m_{benz}: —"— benzene

ΔT : Freezing point depress.

K_f : molale freezing point konst for benz

$$\Rightarrow M_{STO} = \frac{m_{STO} \cdot 1000}{m_{benz} \cdot \Delta T} \cdot K_f$$

(4) - FID-detector, respons prop. to mass. ($A \propto m$)

- iso-octane as internal standard ≈ 1 wt%; $m_{STO} \approx m_i$

- $R = \frac{A}{A_i}$ (respons factor samme for alle components)

$$\left(\frac{A}{m}\right)_s = \left(\frac{A}{m}\right)_i \Rightarrow m_i = \frac{A_i}{A_s} \cdot m_s$$

$$(wt\%)_i = \frac{100\% \cdot m_i}{m_{STO}} \qquad i = 1 - C_9$$

$$(wt\%)_{C_{10+}} = \frac{100\% \cdot (m_{STO} - \sum_{i=1}^{C_9} w_i)}{m_{STO}}$$

(5) Based on 100 g STO : mass balanse:

$$\frac{100}{M_{STO}} = \sum_{i=C_1}^{C_9} \frac{W_i\%}{M_i} + \frac{W_{C10+}}{M_{C10+}}$$

$$M_{C10+} = \frac{W_{C10+}}{\frac{100}{M_{STO}} - \sum_{i=1}^{C_9} \frac{W_i}{M_i}}$$ where $M_{STO} = 187$

0,535

(6) Based on 1 Sm^3 STO :

$$z_i' = n_{STO} \cdot x_i + n_g \cdot y_i$$

$$z_i' = \frac{\rho_{STO}}{M_{STO}} \cdot x_i + \frac{GOR}{V_m} \cdot y_i = \frac{839.4}{187} \cdot x_i + \frac{382}{23.6447} \cdot y_i$$

Normalizes:

$$z_i' = 4.4888 \cdot x_i + 16.1558 \cdot y_i$$

$$z_i = \frac{z_i'}{\sum_{i=C_1}^{C_{10+}} z_i'}$$

(7) Based on 1 mol STO : Additive volume method.

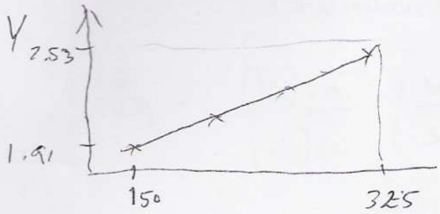
$$\frac{M_{STO}}{\rho_{STO}} = \sum_{i=C_1}^{C_9} \frac{M_i \cdot x_i}{\rho_i} + \frac{M_{C10+} \cdot x_{C10+}}{\rho_{C10+}}$$

$$\rho_{C10+} = \frac{M_{C10+} \cdot x_{C10+}}{\frac{M_{STO}}{\rho_{STO}} - \sum_{i=1}^{C_9} \frac{M_i \cdot x_i}{\rho_i}} = \frac{M_{C10+} \cdot x_{C10+}}{\frac{187}{839.4} - \sum_{i=C_1}^{C_9} \frac{M_i \cdot x_i}{\rho_i}} \ kg/m^3$$

0,223

b. (1) Y-funksjonen is dimentionless

$$Y = \frac{P_b - P}{P\left(\frac{V_t}{V_b} - 1\right)} \quad \text{for } P < P_b.$$



Linearity ⇒ P_b is determined correctly.

(2) $V_b = 10^6 \, m^3$

$HCPV = 10^6 m^3 \cdot \Phi (1 - S_{wr}) = 10^6 \cdot 0.25 (1 - 0.22) = \underline{1.95 \times 10^5 \, m^3}$

From single flash data: $(B_o)_b = 2.29 \; m^3/Sm^3$

$(B_o)_i$ at $P_i = 450$ bara: $(B_o)_i = (B_o)_b \frac{m_b^3}{Sm^3} \cdot 0.9439 \frac{m_b^3}{m_b^3}$

$(B_o)_i = 2.29 \cdot 0.9439 = 2.161 \; \frac{m^3}{Sm^3}$

$$IOIP = \frac{HCPV(m^3)}{(B_o)_i \; \frac{m^3}{Sm^3}} = \frac{195 \times 10^5}{2.161} = \underline{90.24 \times 10^3 \; Sm^3}$$

$IGIP = GOR \cdot IOIP = 382 \cdot 90.24 \times 10^3$

$= \underline{34.471 \times 10^6 \; Sm^3}$

(3) $P_i \rightarrow P_b$

$$V_{STO} = \frac{HCPV_r}{(B_o)_i} - \frac{HCPV}{(B_o)_b} = HCPV \left(\frac{1}{(B_o)_i} - \frac{1}{(B_o)_b} \right)$$

$$= 1.95 \times 10^{5} \left(\frac{1}{2.161} - \frac{1}{2.29} \right) = 5.08 \times 10^{3} \; Sm^3$$

$V_g = GOR \cdot V_{STO}$
$= 382 \cdot 5.08 \times 10^3$
$= \underline{19.40 \times 10^5 \; Sm^3}$

% recovery: $\frac{100 \cdot 5.08 \times 10^3}{90.24 \times 10^3} = \underline{5.63\%}$

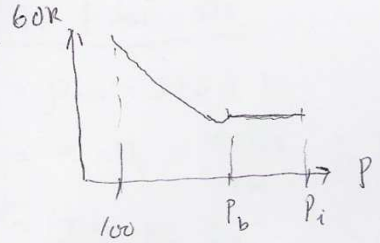
IC.

(1) $B_{od} = \frac{(V_o)_{res.}}{(V_o)_{residuell}} \left(\frac{m^3}{Sm^3}\right)$ PS! $((V_o)_{residuell} \neq V_{STO}.)$

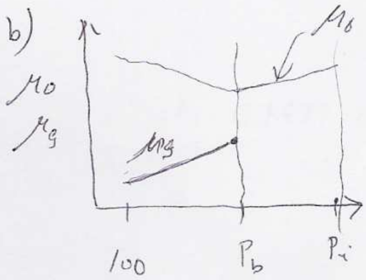
$R_{sd} = \frac{(V_g)_{dissolved\ at\ SC}}{(V_o)_{residuell}} \left(\frac{Sm^3}{Sm^3}\right)$ (opplest gass pr. volumenhet residuell olje.)

$B_g = \frac{(V_g)_{res.}}{(V_g)_{sc}} \left(\frac{m^3}{Sm^3}\right)$

(2) a.



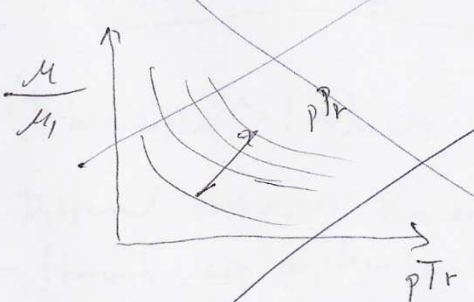
b)



Gas is boiled out of oil when $P_{res} < P_b$

- GOR increases due to prod. of gassface.
- μ_o minimum at P_b
- μ_g decreases due to decrease in P.

(3) Use of "corresponding state" theorem Carr-method.



$\frac{\mu}{\mu_1}$ = visc. ratio

μ_1 : Viscosity at 1atm and actual T. from graf.

$pT_r = \frac{T}{\sum y_i \cdot T_{ci}}$, $pP_r = \frac{P}{\sum y_i \cdot P_{ci}}$

> PS: Not viscosity but Z-factor
>
> $Z = f(pP_r, pT_r)$
>
> $pT_r = \frac{T}{\sum y_i T_{ci}}$
>
> $pP_r = \frac{P}{\sum y_i \cdot P_{ci}}$
>
> (Corresponding state theorem)

Based on 1 mole feed.

d. (1) $$(GOR)_t = \frac{V_{g(sc)}}{V_{STO}} = \frac{n_g \cdot V_m}{\frac{n_{STO} \cdot M_{STO}}{\rho_{STO}}} = \frac{n_g \cdot V_m \cdot \rho_{STO}}{n_{STO} \cdot M_{STO}}$$

$$(GOR)_t = \frac{(1 - L_1 \cdot L_2 \cdot L_3) \cdot V_m \cdot \rho_{STO}}{\underbrace{(L_1 \cdot L_2 \cdot L_3)}_{0.2415} \cdot M_{STO}} = \frac{(1-0.2415) \cdot 23.6447 \cdot 828.7}{0.2415 \cdot 173.8}$$

$$(GOR)_t = 354.1 \ Sm^3/Sm^3$$

(2) Basis in 1 Sm^3 STO

$$m_{STO} = \rho_{STO} = 828.7 \ kg$$

$$m_g = n_g \cdot M_g = \frac{(GOR)_t}{V_m} \cdot \gamma_g \cdot M_{air} = \frac{354.1}{23.6447} \cdot 0.7977 \cdot 28.96$$

$$m_g = 345.96 \ kg$$

$$(m)_{tot} = m_{STO} + m_g = 1174.6 \ kg.$$

$(\rho_o)_b = 537.5 \ kg/m^3$ from CME.

$$(V_o)_{res} = \frac{m_{tot.}}{(\rho_o)_b} = \frac{1174.6}{537.5} = 2.18 \ m^3$$

$$\Rightarrow (B_o)_b = 2.18 \ \frac{m^3}{Sm^3}$$

(3) $(B_o)_{b \ singleflash} > (B_o)_{b \ sep.}$

Different processes. V_{STO} becomes larger when produced through sep. system. (contain more light components.)