PET 500 Fall 2021

SKETCH solution

Part 2, PVT of fluids

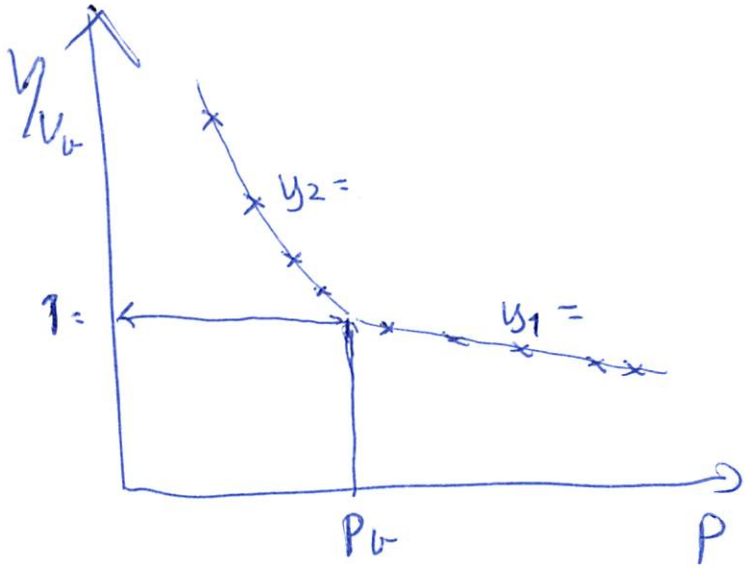
Q1

CME:

- Reservoir fluid transfered to PVT cell and equilibriated at T_{res} and P_{res}
- Stepwise pressure reduction above and below saturation pressure (P_s)
- Volume measured at each pressure step
- Saturation point (P_s) and saturation Volume (V_s) determined.
- V/V_s calculated at each pressure step
- Compressibility factor $\left(c = -\frac{1}{V}\left(\frac{dV}{dP}\right)\right)$ calc. in one phase area.
- Y-factor $\left(Y = \frac{(P_v - P)}{P\left(\frac{V}{V_v} - 1\right)}\right)$ which should be a straight line in the 2 phase area.

a2

Bubble point determination:



- graphical solution
  or trough curve fitting ~~what~~

$y_2 = y_1$

a3:

V_b at P_b

- graphical as above
- Curve fitting as above
- From tabled values: ~~as~~.

$$V_b = \frac{160,528}{1,0033}$$

$$= 160,000$$

4)

Compressibility factor

$$c = -\left(\frac{1}{V}\right)\frac{dV}{dP}$$

at P_{ve} $\quad c = -\left(\frac{1}{160}\right)\frac{(160 - 158{,}624)}{(263 - 310)} = 1{,}88 \cdot 10^{-4}$ 1/bar

at P_i

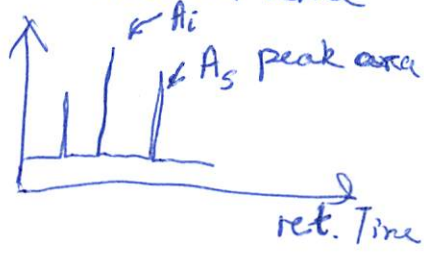
$c = 1{,}24 \cdot 10^{-4}$ 1/bar

P, bar	Compr. 1/bar
460	$1{,}24 \cdot 10^{-4}$
410	1,36
360	1,51
310	1,69
263	$1{,}88 \cdot 10^{-4}$

b)

GC analyses:

- coated/Packed column
- carrier gas (N_2)
- Partitioning comp to their BP - retension time
- Flame ionization detector FID



HC components

$A \propto m$

- internal standard, iso-octane, m_s, added to m_{STO} (1% typically)
- response factor $R_s = \frac{m_s}{A_s}$

$$m_i = R_s \cdot A_i$$

$$m_{STO} = \sum_{C_1}^{C_8} m_i + m_{Clot}$$

- Inorganic gasses

TCD - thermal conductivity detector

IC of Calibration gas with known comp i:

- N_2 m_1 A_1
- CO_2 m_2 A_2 $R_i = \frac{m_i}{A_i}$
- H_2S m_3 A_3

IC ~~reactor~~ analyses of sample also containg inorganic gasses

$$(m_i)_{sample} = (A_{sample})_i \cdot R_i$$

C1.

$P_i = 460$ bar

$(B_o)_b$ = FVF at 263 bar = $1,340 \ (m^3)_b/Sm^3$

$(B_o)_i = 0,9699 \ (m^3)_i/(m^3)_b \cdot 1,340 \ (m^3)_b/Sm^3$

$= 1,299 \ m^3/Sm^3$

C2

$$IOIP = \frac{HCPV}{(B_o)_i} = \frac{10^6 \cdot 0,2(1-0,15)}{1,299} = \frac{170 \cdot 10^3}{1,299}$$

$= 130,88 \cdot 10^3 \ Sm^3$

C3

$(GOR)_t = (75 + 33 + 22) = 130 \ Sm^3/Sm^3$

$IGIP = (GOR)_t \cdot IOIP$

$= 130 + 130,88 \cdot 10^3$

$= 17,015 \cdot 10^6 Sm^3$

d1

$(B_o)_b = 1,340\ m^3/Sm^3$

$(B_o)_i = 1,299\ m^3/Sm^3$

$P_i \rightarrow P_b$

$V_{STO} = \frac{HCPV}{(B_o)_i} - \frac{HCPV}{(B_o)_b} =$

$= 4,018 \cdot 10^3\ Sm^3$

$V_g = (GCR)_t \cdot V_{STO}$

$= 522,357\ Sm^3$

d2 Recovery factor:

$R\% = \frac{100 \cdot V_{STO}}{OIP} = 3,0\%$

e)

e1)

Average molecule weight produced gas (M_g)

$$(\gamma_g)_{avg} = \frac{0,682 \cdot 75 + 0,710 \cdot 33 + 1,048 \cdot 22}{(GOR)_t}$$

$$= 0,751$$

$$M_g = (\gamma_g)_{avg} \cdot M_{air}$$

$$= 0,751 \cdot 28,96$$

$$= 21,75$$

e2)

$$\rho_{STO} = \gamma_{STO} = 0,865$$

$$^{\circ}API = \frac{141,5}{0,865} - 131,5 = 32,08$$

From add. 2

$^{\circ}API = 32,08$
$(\gamma_g)_{avg} = 0,715$
$\Rightarrow (\rho_g^L)^* = 24,5 \ lb/ft^3 = \frac{24,5 \ lb/ft^3}{62,43}$

$= 0,392 \ g/cm^3$
$= 392,44 \ kg/m^3$

Basis in 1 Sm^3 STO:

$$V_{STO} = 1\ Sm^3$$

$$m_{STO} = 865\ kg$$

$$m_g = \frac{(GOR)_{tot}}{V_m} \cdot M_g =$$

$$= 119,58\ kg$$

$$V_g^L = \frac{m_g}{(\rho_g^L)_{app}} = \frac{119,58}{392,44} = 0,3047\ m^3$$

$$(\rho_o)_{app} = \frac{m}{V} = \frac{m_{STO} + m_g}{V_{STO} + V_g^L}$$

(m_{STO} = 865, m_g = 119,58, V_{STO} = 1, V_g^L = 0,3047)

$$= 754,63\ kg/m^3$$

$$= 0,75546\ g/cm^3$$

$$= 47,118\ lb/ft^3$$

add. 3°:

$P_{sc} \rightarrow P_b$ 263 bara = 3866 psia

$\Delta g_p = 1,15 \text{ lb/ft}^3$

$(g_o)_p^{app} = 48,26 \text{ lb/ft}^3$

add 4°:

$T_{sc} \rightarrow T_b$ 90°C = 194 °F

$(\Delta g)_T = 3,35 \text{ lb/ft}^3$

$(g_o)_b = 44,91 \text{ lb/ft}^3$

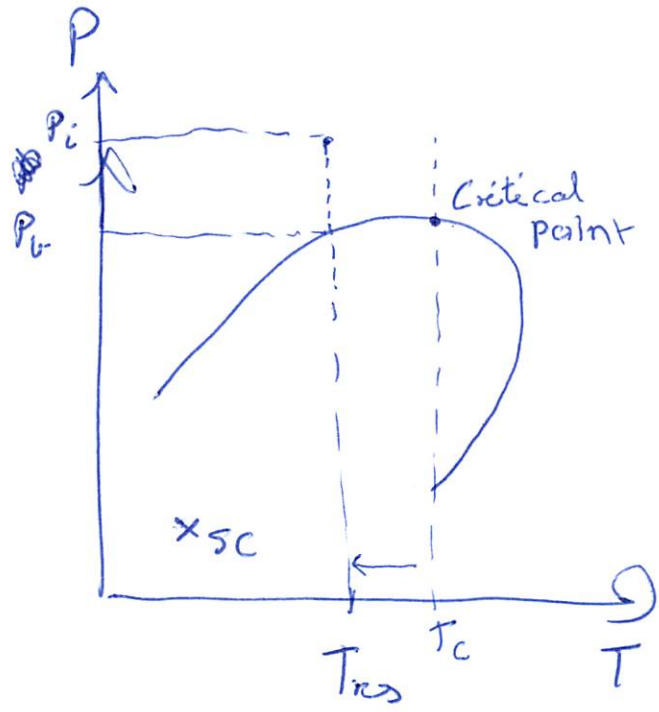
$= 0,719 \text{ g/cm}^3$

measured $(g_o)_b = 0,728 \text{ g/cm}^3$ liveoil

somewhat higher than the calculated, but not a significant deviation (1,18%)

d)

d1)



$P_i = 460$

$P_b = 263$

$T_{res} = 90°C$

T_{res} significant to the left of T_c

Black oil

d2)