PVT LAB TESTS (Ch. 6)

Note Title 3/13/2018

Quiz (Based on 5 video lectures)

(1) What three lab tests are conducted at T_R (reservoir T)?

(2) What is "common" between DLE (differential liberation) test and multi-stage separator test (SEP)?

(3) What PVT lab test measures oil viscosity $\mu_o(p)$?
——— " ——— reports gas viscosity $\mu_g(p)$?

(4) What PVT lab test measures oil FVF B_o?

(5) Given ρ_{ob} and CCE $V_{rt} = V_t / V_{ob}$, how does one calculate ρ_{oi} at p_{Ri}?

(6) What is the main purpose of the CVD (constant volume depletion) test for a gas condensate reservoir fluid?

(7) How does one use $B_{od}(p)$ and $R_{sd}(p)$ from DLE test in engineering calcs?

(8) How is bubblepoint pressure measured? (two methods) How is dewpoint pressure measured?

① What three lab tests are conducted at T_R (reservoir T)?

"Depletion PVT performance properties" $p_{Ri} \rightarrow p_{R,abandonment}$

* CCE	* DLE$_{PVT}$	* CVD
U+S	U	S
(θ's & G.C.)	($\leq p_b$, Oils)	($\leq p_s$, G.C. & Oils)

$p_{Ri} \geq p_s$ } U
$p_R = p_s$ } S
$p_R < p_s$ }

why 3 tests, not just one?

S_o, Z_g, C — B_{od}, B_g or Z_g
p_s — "SF" $\rho_o \rho_g \mu_o \mu_g$
$V_t (p < p_s)$ — R_{sd}

② What is "common" between DLE (differential liberation) test and multi-stage separator test (SEP)?

DLE @ T_R gas removed
SEP @ $T_{sp,k}$ — " — } remove ALL gas @ each stage

③ What PVT lab test measures oil viscosity $\mu_o(p)$?
——— " ——— reports gas viscosity $\mu_g(p)$?

* DLE$_{\mu_o}$: U & S μ_o
DLE$_{\mu_o}$: $p > p_b$ & $p < p_b$

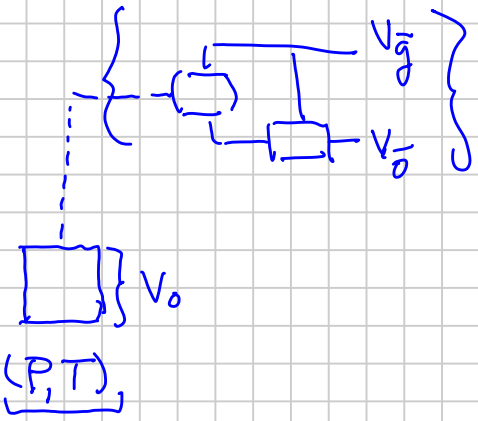
μ_g calculated only @ $p < p_b$

Lee-Gonzalez, Ch. 3 μ_g (T, M_g or γ_g, ρ_g)

CCE: Gas Condensate @ $p \geq p_d$
CVD: — " — ($p \leq p_d$) $M_g(p)$

④ What PVT lab test measures oil FVF B_o?
MSST (SEP)

x (Bod from DLE)



P = multi-stage separator test "SEP"

$$B_o = \frac{V_o(P,T)}{V_o}$$

Usually P_b @ T_R : $V_o = V_{ob}$ $\quad B_o = B_{ob}$

DLE & CCE

⑤ Given ρ_{ob} and CCE $V_{rt} = V_t / V_{ob}$, how does one calculate ρ_{oi} at P_{Ri}?

$$\frac{m_{oi}}{V_{ob}} = \frac{m_{ob}}{V_{ob}} = \rho_{ob} = \boxed{500}\ kg/m^3 \quad @\ P_b = 450\ bara,\ 120°C$$

$P_{Ri} = 700$ bara $V_{rt} = \frac{V_t}{V_{ob}} = \boxed{0.9} = \frac{V_{oi}}{V_{ob}}$

$P_{Ri} > P_b$

$$\rho_{oi} = \frac{m_{oi}}{V_{oi}} = \frac{m_{oi}}{V_{ob}} \cdot \frac{V_{ob}}{V_{oi}}$$

$$500 \cdot \frac{1}{0.9}$$

P_R (depth) vs MDT | RCI data

⑥ What is the main purpose of the CVD (constant volume depletion) test for a gas condensate reservoir fluid?

Removed Gas Comp. $y_i (p \le p_d) \Rightarrow$ Solution OGR $r_s(p)$ $\frac{STB}{MMscf}$ $\frac{Sm^3}{10^6 Sm^3}$

$$r_p(p_R) \overset{\checkmark}{\simeq} r_s^{CVD}(p = p_R)$$

because of steady-state flow region $r_w \to r^*$ $p^*(r^*) \sim p_R$ close

Fevang-Whitson

⑦ How does one use $B_{od}(p)$ and $R_{sd}(p)$ from DLE test in engineering calcs?

$B_{od}(p) \to B_o(p)$ $\quad R_{sd}(p) \to R_s(p)$

Use B_{ob} & R_{sb} from MSST (SEP)

$B_{od,b}$ $\quad R_{sd,b}$

$$B_o(p) \simeq B_{od}(p) \cdot \frac{B_{ob}}{B_{od,b}}$$

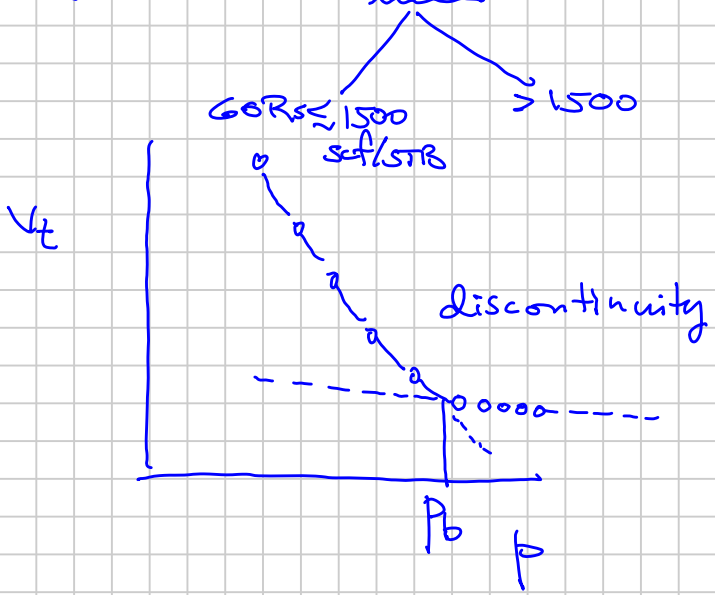
SF from $p_b \to$ STC $= \left(\frac{1}{B_o}\right)$

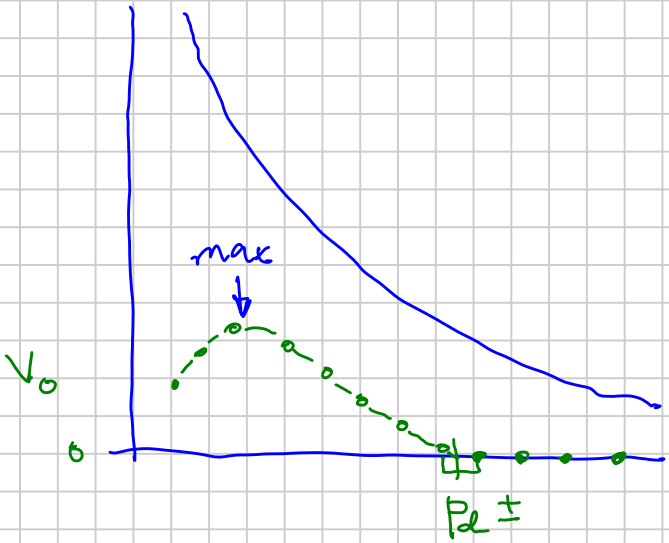
$$B_{ob} = 2 \frac{RB @ p_b}{STB}$$

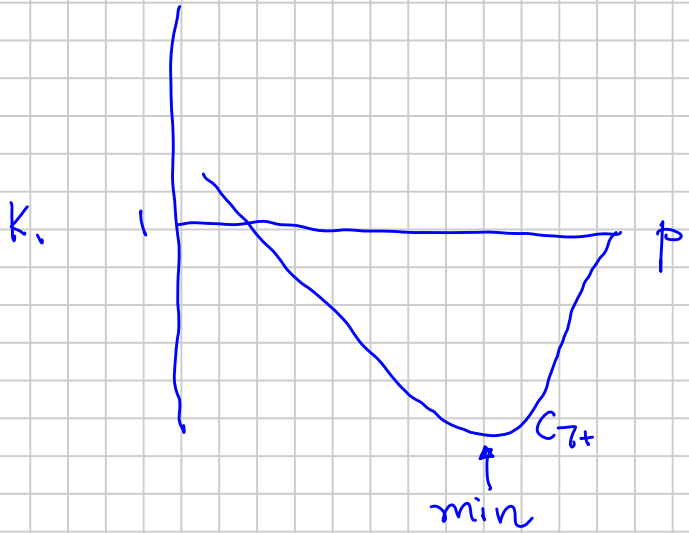
$$B_{od,b} = 2. \times \frac{RB @ p_b}{\text{residual DLE bbl @ STC}}$$

(8) How is bubblepoint pressure measured? (two methods) How is dewpoint pressure measured?

(a) DLE / CCE







"Flip the Classroom"

Started ~2008
Salman
Khan Academy TED

Ch. 7 Black-Oil PVT Properties (Ch. 3 correlation)

90% petroleum engineering calculations, software use BO PVT model.

① Ch. 3 Correlations

② Ch. 6 Lab PVT reports, e.g. DLE B_{od} R_{sd} ↓ B_o R_s

③ Equation of State Model (EOS)
Flash Calculations

Review: Specific $T \equiv$ || Specific P || Specific "$\{z_i\}$"

Oil Phase Table
PVTO (ECL100)

p	R_s	B_o	μ_o

(a) Saturated Table

(b) Undersaturate Table

Gas Phase Table
PVTG (ECL100)

p	r_s	B_g	μ_g

(a) Saturated Table

(b) Undersaturate Table

Surface Oil Density $\rho_{\bar{o}}$
Surface Gas Density $\rho_{\bar{g}}$

$\bar{g}$, $\bar{o}$ } Two-Component Compositional Model

"Composition" (vols)

Oil Phase consists of $V_{\bar{g}}$ $V_{\bar{o}}$ "x_i" $R_s = V_{\bar{g}o}/V_{\bar{o}o}$

Gas Phase consist of $V_{\bar{g}}$ $V_{\bar{o}}$ "y_i" $r_s = V_{\bar{o}g}/V_{\bar{g}g}$

$$R_p = \frac{V_{\bar{g}}}{V_{\bar{o}}} = \frac{V_{\bar{g}g} + V_{\bar{g}o}}{V_{\bar{o}g} + V_{\bar{o}o}}$$

Conservation of surface products "$\bar{g}$" "$\bar{o}$" VOLUMES

"Composition" of Oil Phase : R_s ("x_i") p_b ?

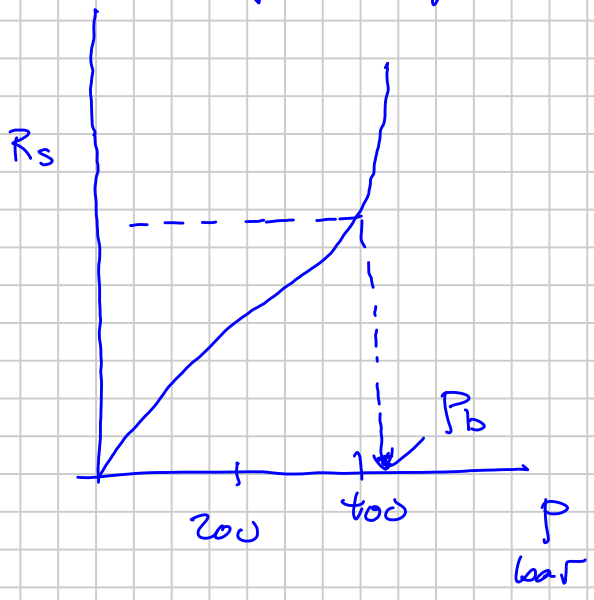
—— " —— Gas Phase : r_s ("y_i") p_d ?

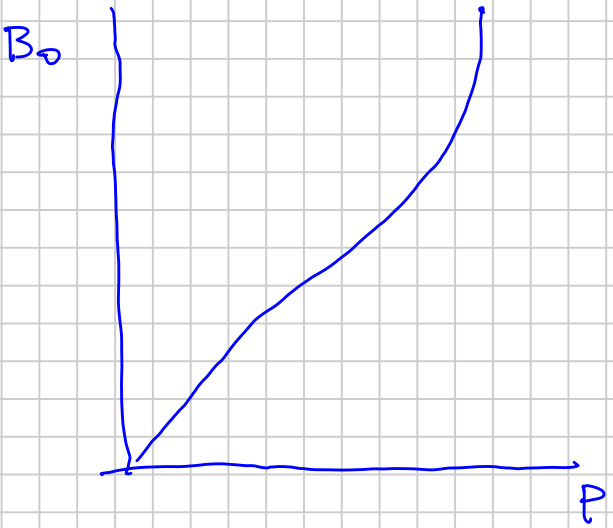
Saturated BO PVT Table

for Oil Phase

p_b "x_i"

p	R_s	B_{ob}	μ_{ob}
1	0		
5	3		
(10)	8	1.88	1.62
25	21		
50	42		
100	80		
200	156		
300	220		





$R_s(p) \sim B_o(p)$

Same "shape"