SOLUTION GAS DRIVE MAT. BAL.

Note Title 9/26/2018

Ch. 7 Borthne MBO Mat. Bal.

$V_b = 1$ bbl

$V_p = V_b \phi = \phi$

$V_{HC} = V_p (1 - S_w) = V_{oR} + V_{gR}$

(Modified) Black-Oil PVT Formulation: $\rho_{\bar{g}g} = \rho_{\bar{g}o} = \text{const.}$; $\rho_{\bar{o}o} = \rho_{\bar{o}g} = \text{const.}$! ECL100 :

Conserve Surface Product Volumes $(\bar{g}, \bar{o})$

G.B.: Mass conservation $\Rightarrow$ $\underbrace{\rho_{\bar{o}o} \neq \rho_{\bar{o}g} \quad \rho_{\bar{g}g} \neq \rho_{\bar{g}o}}_{f(p)}$

Vol. BO: $\dfrac{\gamma_{\bar{o}o}}{\gamma_{\bar{o}g}} = 1 \qquad \dfrac{\gamma_{\bar{g}g}}{\gamma_{\bar{g}o}} = 1$

"$\bar{o}$"

$$\phi \left[\underbrace{\frac{S_o}{B_o}}_{V_{\bar{o}o}} + \underbrace{\underbrace{\frac{\overset{(1-S_w-S_o)}{S_g}}{B_{gd}}}_{V_{\bar{g}g}} \cdot \underbrace{r_s}_{\frac{V_{\bar{o}g}}{V_{\bar{g}g}}}}_{V_{\bar{o}g}} \right] = V_{\bar{o}} \quad @\ t, p_R$$

$$= (N - N_p)$$

"$\bar{g}$"

$$\phi \left[\underbrace{\frac{S_o}{B_o} R_s}_{V_{\bar{g}o}} + \underbrace{\frac{\overset{(1-S_w-S_o)}{S_g}}{B_{gd}}}_{V_{\bar{g}g}} \right] = V_{\bar{g}} \quad @\ t, p_R$$

$$= (G - G_p)$$

p_{Ri} S_{oi}, S_{gi} $\Rightarrow$ $V_{\bar{o}} = N = \underbrace{N_o}_{6 \cdot 10^9 \text{ STB}} + \underbrace{N_g}_{0}$

p_{Ri} S_{oi}, S_{gi}

$$V_g = G = G_o + G_g$$

$7 \cdot 10^{12}$ scf

$$S_g = (1-S_w) - S_o$$

$[\, r_s \equiv R_v \,]$

SPE Walsh/Elloo

$$\frac{\phi \left[\frac{S_o}{B_o} + \frac{(1-S_w)-S_o}{B_{gd}} \cdot r_s \right]}{\phi \frac{(1-S_w)}{B_{oi}}} = \frac{N - N_p}{N}$$

For $S_{oi} = 1-S_w$ ($S_{gi} = 0$) : "Initial Res. Oil"

$$\frac{1}{(1-S_w)} \frac{B_{oi}}{B_o} S_o + \frac{r_s}{B_{gd}} B_{oi} - \frac{S_o}{(1-S_w)} \frac{r_s}{B_{gd}} B_{oi} = 1 - \frac{N_p}{N}$$

$$S_o = (1-S_w) \left[\frac{\left(1 - \frac{N_p}{N}\right) - \frac{r_s}{B_{gd}} B_{oi}}{\frac{B_{oi}}{B_o} - \frac{r_s}{B_{gd}} B_{oi}} \right] \quad \frac{B_o B_{gd}}{B_o B_{gd}}$$

$$\underline{r_s = 0}$$

$$S_o = (1-S_w) \Big(\underbrace{1 - \frac{N_p}{N}}_{RF_o} \Big) \frac{B_o}{B_{oi}}$$

Monday

Walsh: Eq. 2

$$S_o = (1 - S_w)\left[\frac{\left(1 - \frac{N_p}{N}\right) B_o B_{gd} - r_s B_o B_{oi}}{B_{oi}\left(B_{gd} - r_s B_o\right)}\right]$$

Need to deal with the surface gas also:

Using the approximate reservoir rate equations for $\bar{g}$ and $\bar{o}$:

$$q_{gR} = C \cdot \int_{p_{wf}}^{p_R} \frac{k_{rg}}{\mu_g}\, dp$$

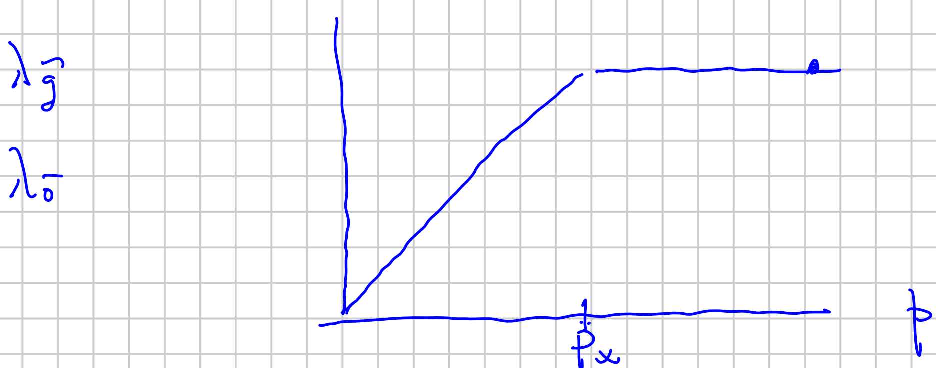
$$q_{\bar{g}g} = q_{gR} / B_{gd}$$

$$q_{\bar{g}g} = C \cdot \int_{p_{wf}}^{p_R} \underbrace{\frac{k_{rg}}{\mu_g B_{gd}}}_{\lambda_{\bar{g}}}\, dp \simeq \left(\overline{\frac{k_{rg}}{\mu_g B_{gd}}}\right)_{p_R} \cdot (p_R - p_{wf})$$

Surface Oil Product

$$q_{\bar{o}o} = C \cdot \int_{p_{wf}}^{p_R} \underbrace{\frac{k_{ro}}{\mu_o B_o}}_{\lambda_{\bar{o}}}\, dp \simeq \left(\overline{\frac{k_{ro}}{\mu_o B_o}}\right)_{p_R} (p_R - p_{wf})$$

All SGD M.B. eqs. (Tarner, Standing, Walsh, Borthe)



Conventional BOPVT $\quad p_{wf} > p_x \Rightarrow$ OK Approx.

$$R_p = R_s + \frac{k_{rg}}{k_{ro}} \frac{\mu_o B_o}{\mu_g B_g}$$

Modified BO : $r_s > 0$

$$R_p \equiv \frac{q_{\bar{g}}}{q_{\bar{o}}} = \frac{q_{\bar{g}g} + q_{\bar{g}o}}{q_{\bar{o}o} + q_{\bar{o}g}}$$

$$R_s \equiv \frac{q_{\bar{g}o}}{q_{\bar{o}o}} \qquad r_s \equiv \frac{q_{\bar{o}g}}{q_{\bar{g}g}}$$

$$R_p = \frac{q_{\bar{g}g} + R_s\, q_{\bar{o}o}}{q_{\bar{o}o} + q_{\bar{g}g}\, r_s}$$

$$q_{\bar{g}g} \simeq C \left(\frac{k_{rg}}{\mu_g B_{gd}}\right)_{p_R} (p_R - p_{wf})$$

$$q_{\bar{o}o} \simeq C \left(\frac{k_{ro}}{\mu_o B_o}\right)_{p_R} (p_R - p_{wf})$$

$$R_p = \frac{\left[\frac{k_{rg}}{k_{ro}} \frac{\mu_o B_o}{\mu_g B_{gd}} + R_s\right]}{\left[1 + \frac{k_{rg}}{k_{ro}} \frac{\mu_o B_o}{\mu_g B_{gd}} \cdot r_s\right]} = \frac{[E_g]}{[E_o]}$$

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< Derive $\frac{k_{rg}}{k_{ro}} = f\left(R_p \mid PVT(p)\right)$ >