Note Title 10/1/2018

Field Units Oil Rate Eq. (Single Phase Oil: PSS)

$$q_o = \frac{kh\,(P_R - P_{wf})}{141.2\,\mu_o B_o \left[\ln\frac{r_e}{r_w} - \frac{3}{4} + s\right]}$$

$P_b < P_w < P_R$

$s = 0$ MBS notes

q_o	[STB/D]
k	[md]
h	[ft]
p	[psia]
μ_o	[cp]
B_o	[RB/STB]
r	[ft]

$$\ln\frac{r_e}{r_w} - \frac{3}{4} \simeq \ln\frac{0.472 r_e}{r_w}$$

$$= \ln\frac{r_e}{r_w} + \underbrace{\ln 0.472}_{-3/4}$$

$1 - \left(\frac{P_{wf}}{P_R}\right)^2$ Fetkovich Eq.

$$q_o = \frac{\bar{k}_o h \bar{p}\left[1 - 0.2(p_{wf}/\bar{p}) - 0.8(p_{wf}/\bar{p})^2\right]}{254.2\,\bar{\mu}_o \bar{B}_o (\ln 0.47\, r_e/r_w)} \qquad (19)$$

(141.2×2)

$254.2 = 141.2 \times \frac{9}{5}$

Field Units ✓

$\bar{p} = P_R$

$k_o = k \cdot k_{ro}$

Vogel:

$P_R \le P_b$

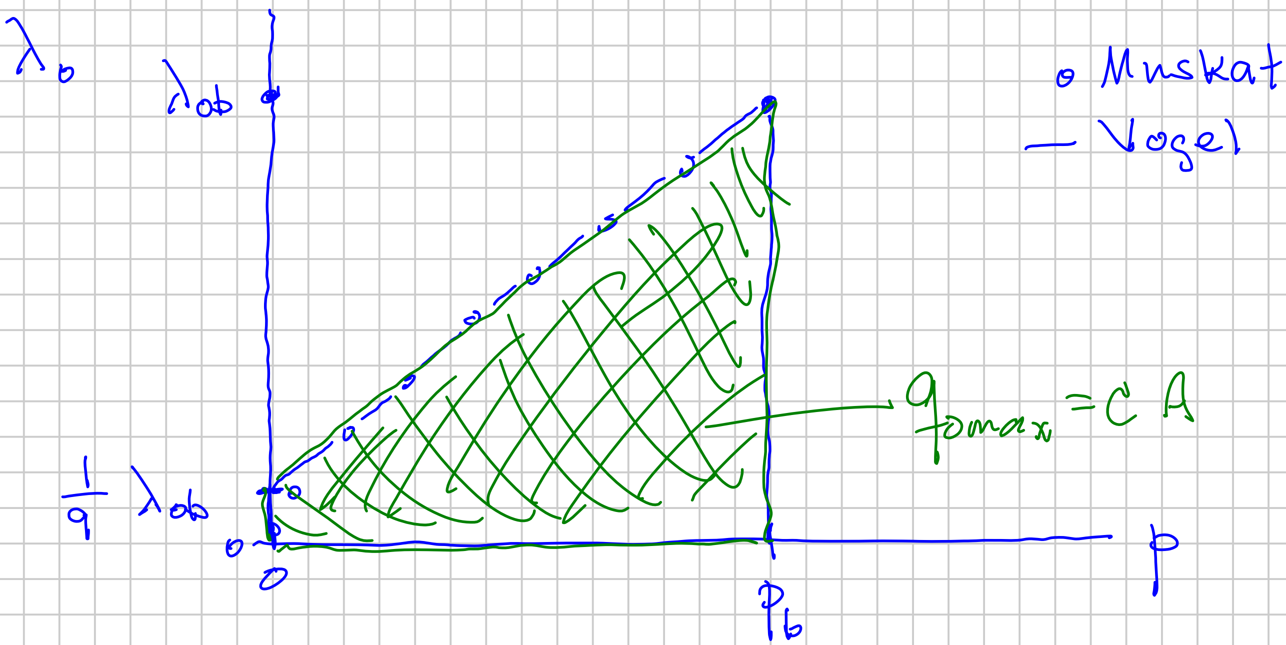
$\bar{k}_o$, $\bar{\mu}_o$, $\bar{B}_o$ @ $\bar{p} = p_R$

"Vogel" SGD saturated oil rate eq.

$$\frac{q_o}{\boxed{q_{omax}}} \cong 1 - 0.2\frac{p_{wf}}{p_R} - 0.8\left(\frac{p_{wf}}{p_R}\right)^2$$

$$= 1 - V\frac{p_{wf}}{p_R} - (1-V)\left(\frac{p_{wf}}{p_R}\right)^2$$

Fetkovich (197x) : $V = 0$



$k_{ro}(p)$!

Evinger – Muskat (1942) :

$$q_o = \underbrace{\frac{kh}{141.2\left[\ln\frac{r_e}{r_w} - \frac{3}{4} + s\right]}}_{C} \cdot \int_{p_{wf}}^{p_R} \underbrace{\frac{k_{ro}}{\mu_o B_o}}_{\lambda_o}\, dp$$

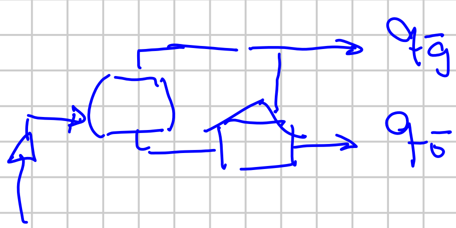
Foundation of Two-Phase Gas-Oil Flow

⇒ "Evinger-Muskat" methods (1942)
· SGD (Saturated Oil R)

⇒ Fevang - Whitson
Gas Condensate R

E-M:

$p_R \leq p_b$

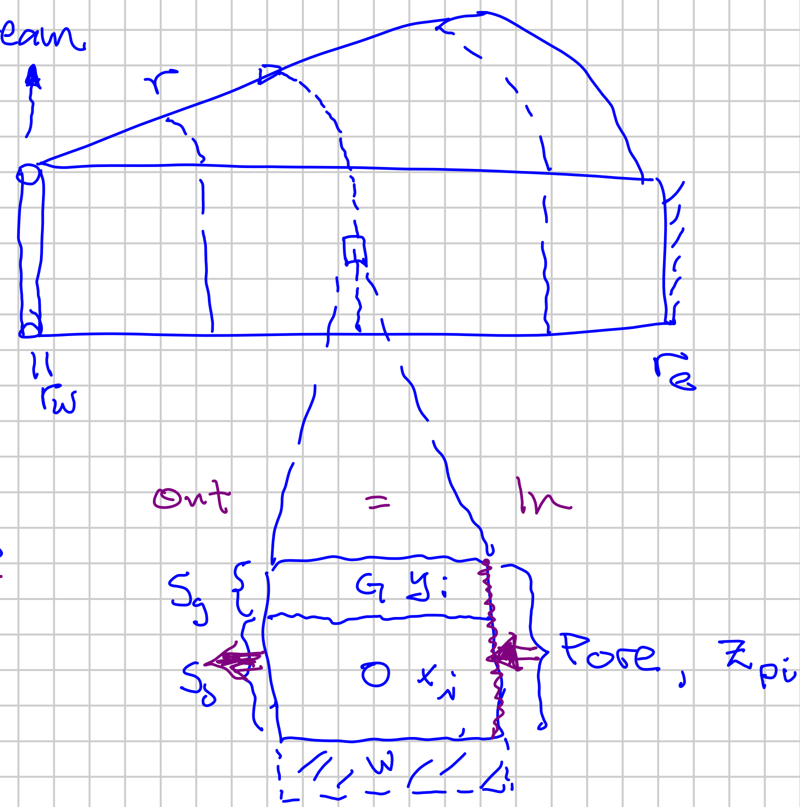


$R_p = \dfrac{q_{\bar{g}}}{q_{\bar{o}}}$

Wellstream
z_{wi}

Steady State Flow Region

SGD:
$r_w \to r_e$
@



E-M
Assumption for SGD

$r_w < r < r_e$

$z_{wi} = z_{fi} = \text{constant}$

$R_p = R_{pf}$

$$\frac{S_o \frac{\rho_o}{M_o} x_i + S_g \frac{\rho_g}{M_g} y_i}{S_o \frac{\rho_o}{M_o} + S_g \frac{\rho_g}{M_g}} = z_{pi} \neq z_{fi} = \frac{\left(\frac{k_{ro}}{\mu_o}\frac{\rho_o}{M_o}\right) x_i + \left(\frac{k_{rg}}{\mu_g}\frac{\rho_g}{M_g}\right) y_i}{\left(\frac{k_{ro}}{\mu_o}\frac{\rho_o}{M_o}\right) + \left(\frac{k_{rg}}{\mu_g}\frac{\rho_g}{M_g}\right)}$$

Pore Composition Flowing Composition

When SS Flow Region is Valid

$$R_p \;@\; r=r_w \;=\; R_s + \frac{k_{rg}}{k_{ro}}\,\frac{\mu_o B_o}{\mu_g B_g} \;=\; R_{pf}$$

$r > r_w \rightarrow r_e$

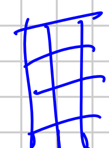
any and all

$p_{wf} < p \leq \bar{p}_R$

SGD M.B.

At given time, with R_p known $(p_{wf}, \bar{p}_R)$

$$\frac{k_{rg}}{k_{ro}}(p) = \underbrace{\left(R_p - R_s(p)\right)\left(\frac{\mu_g B_g}{\mu_o B_o}\right)(p)}_{f(p)}$$



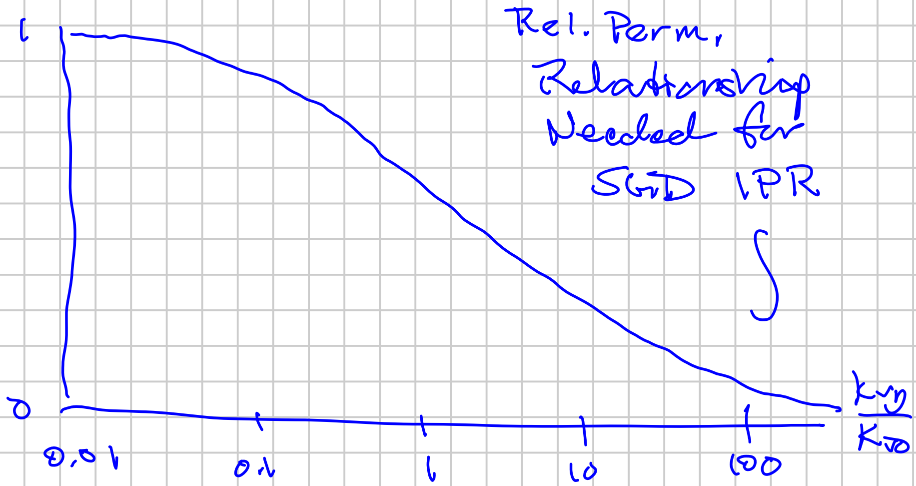
$p_{wf} < p < \bar{p}_R$

$$\int \frac{k_{ro}(p)}{\mu_o(p) B_o(p)}$$

Rel. Perm. (G-O) : S_{wc}

~~S_o~~ ~~S_g~~ k_{rg} k_{ro} → k_{rg}/k_{ro} → $k_{ro}\left(k_{rg}/k_{ro}\,(p)\right)$

Measure "SCAL"



Rel. Perm. Relationship Needed for SGD IPR

Before 1994

Gas Condensates:

$$q_g = \frac{0.703\ Kh}{T_R\left[\ln\frac{r_e}{r_w} - \frac{3}{4} + s\right]} \cdot \underbrace{\int_{p_{wf}}^{p_R}\left(\frac{k_{rg}}{\mu_g B_{gd}} + \frac{k_{ro}}{\mu_o B_o} R_s\right) dp}_{<1994\ ?}$$

SS Assumption:

$r_w < r < r^*$ $\quad r^*$ $\quad r_d$ $\quad r_e$

Region 1 SS $\quad$ (2) $\quad$ Single Phase Gas (3)

Z_{wi} ⟵ Z_{fin} ⟶ p^*_2 $= p_d(Z_{wi})$ $\quad p = p_d$

$$\underbrace{\int_{p_{wf}}^{p^* = p_{dw}} \frac{k_{rg}(p)}{\mu_g B_g} + \frac{k_{ro}(p)}{\mu_o B_o} R_s}_{EM} + \underbrace{\int_{p^*}^{p_d} \frac{k_{rg}}{\mu_g B_g}}_{} + \underbrace{\int_{p_d}^{p_R} \frac{1}{\mu_g B_g}}_{}$$