Note Title 4/24/2017

Fetkovich Wellhead Backpressure Equation

$$\underbrace{\overbrace{p_c^2 - p_t^2}^{R+T}}_{\text{@Surface Datum}} = A_{WH}\, q_g + B_{WH}\, q_g^2$$

$$A_{WH} = A_R' \cdot \frac{1}{e^s} = A_R''$$

$$B_{WH} = B_R' \cdot \frac{1}{e^s} + B_T = B_R'' + B_T$$

$$A_R' = \frac{T_R (\mu Z)^*}{(\ )\, kh} \left[\ln \frac{r_e}{r_w} - \frac{3}{4} + s^* \right]$$

$$B_R' = \frac{T_R (\mu Z)^*}{(\ )\, kh}\, D$$

D ← Rate-dependent skin ($\sim \beta$)

$$B_T = \frac{1}{C_T^2}$$

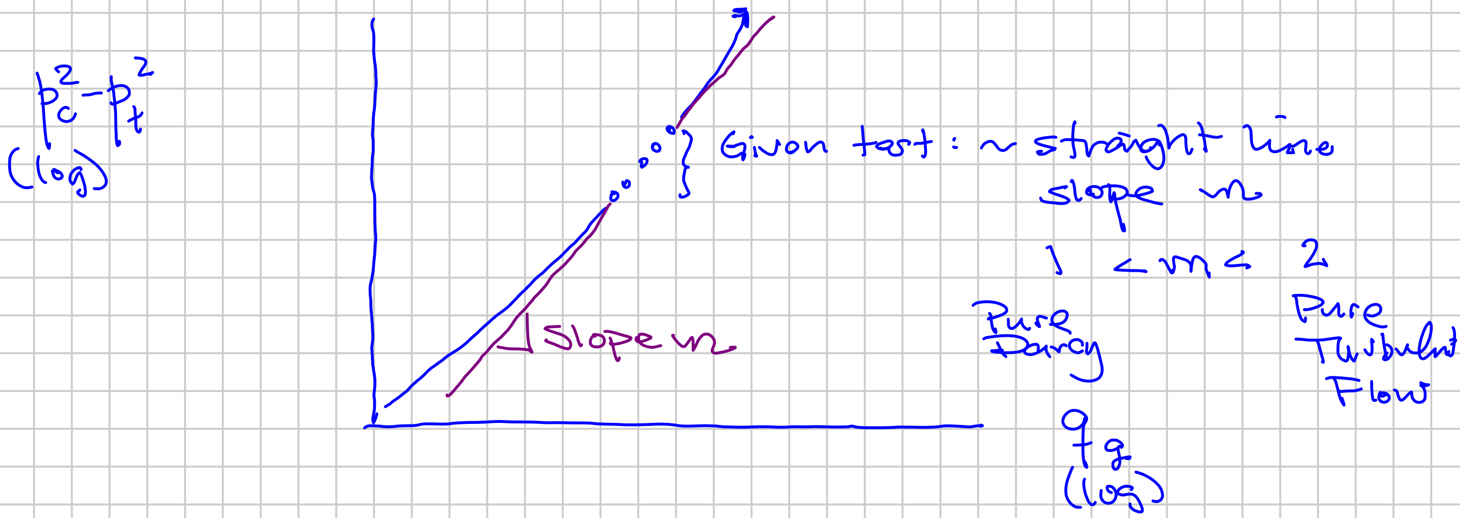
Tubing:

$$q_g \simeq C_T \left(p_w^2 - p_t^2\right)^{0.5}$$

S : Static Gas Column Correction

$$= 2\, \frac{M_g\, g\, TVD}{R\, \bar{T}\, \bar{Z}_g}$$

$$C_T \propto d_T^{2.6}$$

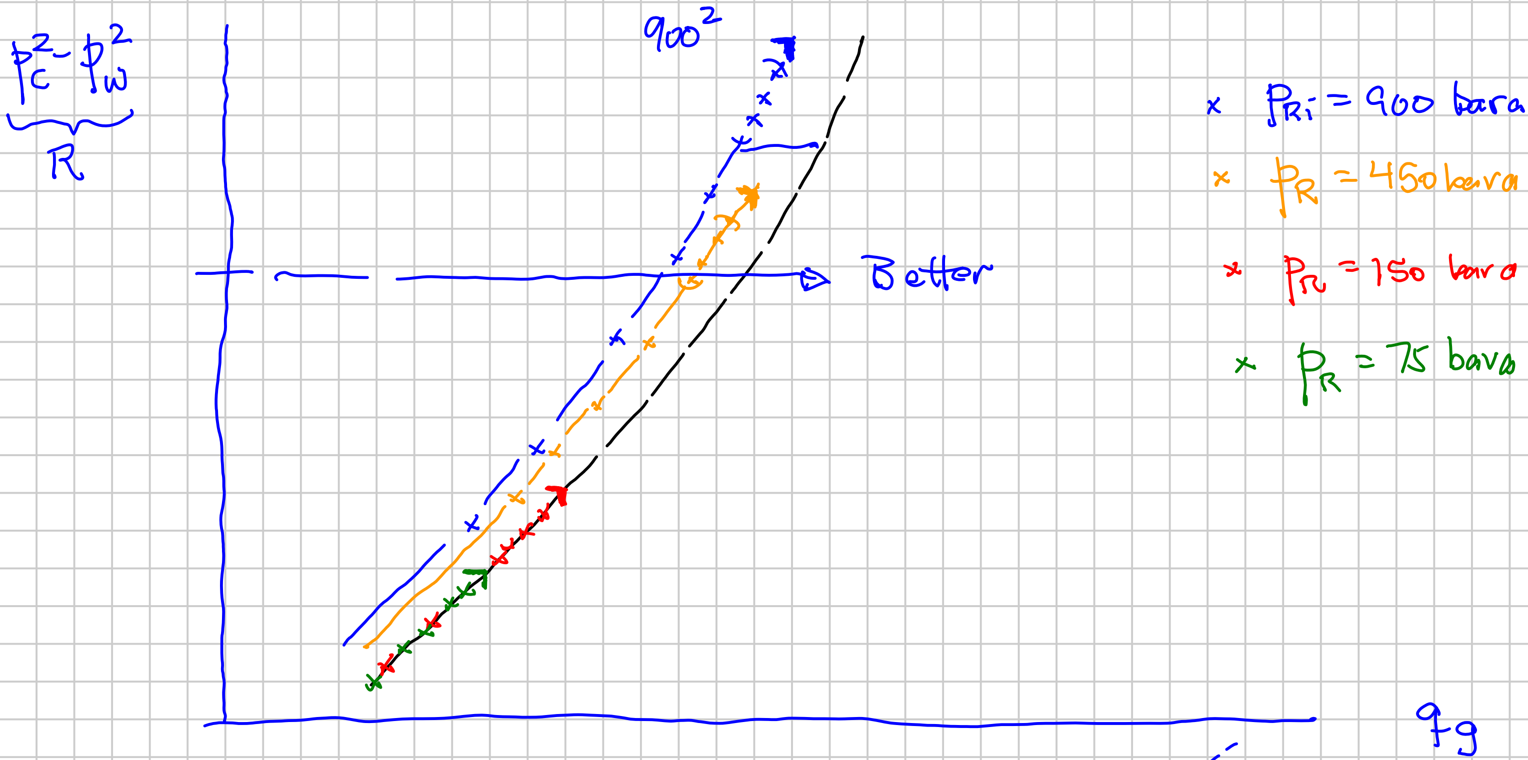


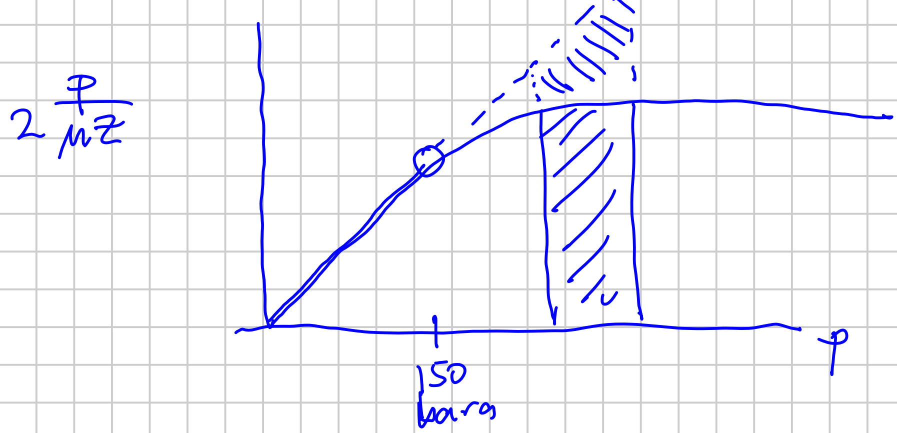
$$q_g \approx C_{WH} (p_c^2 - p_t^2)^n$$

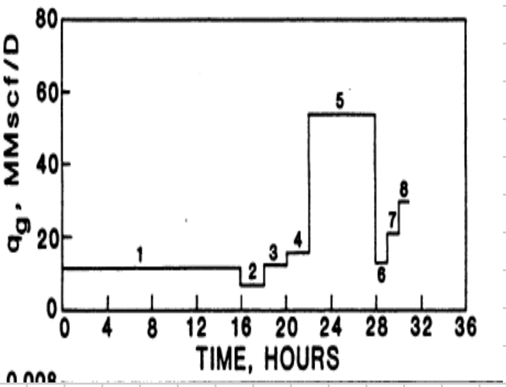
$$n = \frac{1}{\text{slope}}$$

$$0.5 < n < 1$$

Purely Turbulent — Purely Laminar (Darcy)







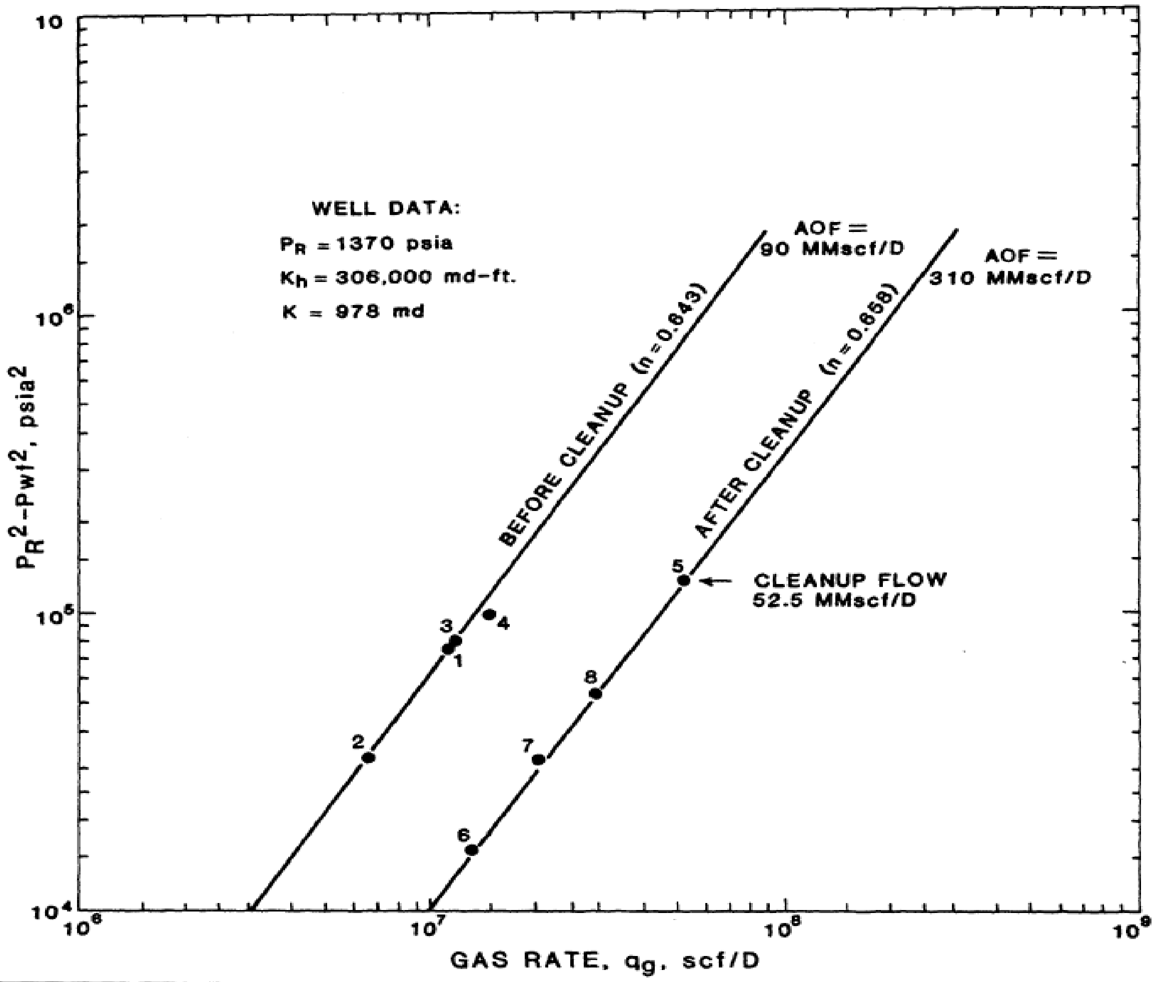


Figure E3.13b Logarithmic backpressure plot of the multirate test data for the Java No. 2 gas well. Reprinted by permission of the authors from Fetkovich 1975, fig. 8.

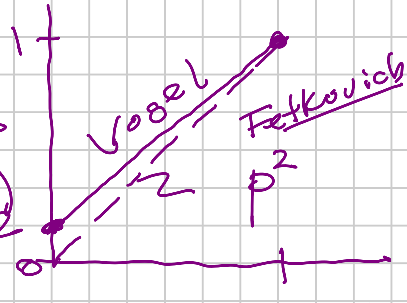
1946: Muskat

$$q_o = q_{omax,\,p_{wf}=0}\left[1-\left(\frac{p_{wf}}{p_R}\right)0.2-\left(\frac{p_{wf}}{p_R}\right)^2 0.8\right]$$

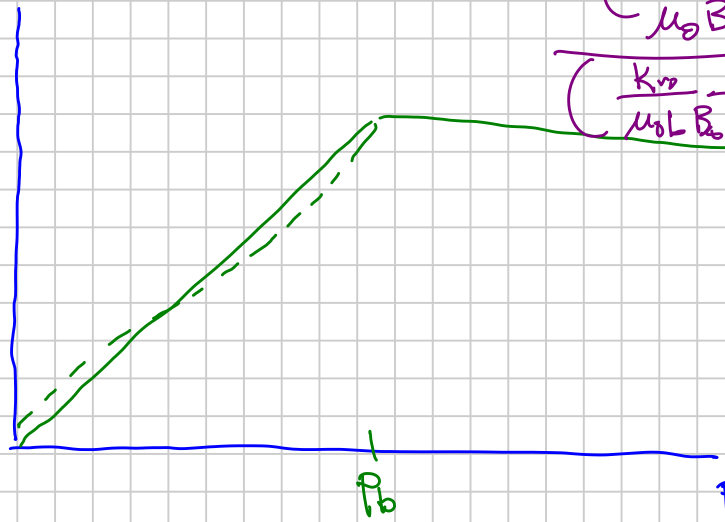
$q_o(p_R, p_{wf})$ Vogel (1960s)

$p_{wf} < p_b \Rightarrow$ 2-phase gas-oil flow

$$\frac{\left(\frac{k_{ro}}{\mu_o B_o}\right)}{\left(\frac{k_{ro}}{\mu_{ob} B_{ob}}\right)}$$



$$\frac{k_{ro}}{\mu_o B_o} \sim \frac{1}{\mu_g B_g} = \frac{p}{\mu Z}$$



$$q_o = \frac{kh}{\ln\frac{r_e}{r_w}-\frac{3}{4}+s}\int_{p_{wf}}^{p_R}\frac{k_{ro}(S_o(p))}{\mu_o B_o}\,dp$$

$PVT_g(\gamma_g, T_R, p)$

Homework Problem 5:

PVT: e-notes Gas-PVT .xls

Depth	3000 m ✓	
✓ T_R	120 °C	
p_{Ri}	300 bara	
✓ γ_g	0.7	
$\bar{k}$	500 md	
$\bar{h}$	100 m	
D	$2.5 \cdot 10^{-6}$ $(Sm^3/d)^{-1}$	
s^*	+3	$\ln \frac{r_e}{r_w} - \frac{3}{4}$: 7–10
G (IGIP)	$0.1 \cdot 10^{12}$ Sm^3	
$N_{w,max}$	5 (–10)	
$\bar{S}_w$	0.3	
$\bar{\phi}$	0.21	
T_f	80 °C	
$p_{t,min}$	30 bara	= p_t end plateau
r_w	0.1 m	

$$r_e \cong \left(\frac{A_w}{\pi}\right)^{0.5}$$

(A_w: well drainage area)

$$A_w = \frac{HCPV_g}{\bar{h}\,\bar{\phi}\,(1-\bar{S}_w)\,N_w}$$

($HCPV_g$ = IGIP × B_{gi})

$\{A_R' \quad B_R' \quad S \quad e^S\}$ Just Calc.

$\{B_T \quad C_T\}$ design*

$A_{WH} \quad B_{WH} \quad d_T$

You design d_T recommendation

$$\frac{\Delta p_T}{\Delta p_R + \Delta p_T} \sim 50\%$$

@ $q_g = 10^6 \frac{Sm^3}{d}$

when we reach end plateau:

$p_R \cong 150$ bara

Drill constraint

$d_{T,max} = 7''$ OD

6'' ID

Q: N_w

5% IGIP/yr

$p_R = 150$ bara

at end plateau

① Choose Units: Fetkovich units

① Calc. A_R' B_R'

② Calc. S', $e^{S'}$

③ Calc. A_R'' B_R''

④ Calc. $C_T = [\,]\, d_T^{2.612}$ $\Rightarrow$ $B_T(d_T) = \dfrac{1}{C_T^2}$

⑤ Calc A_{WH} B_{WH}

⑥ Set $q_g = 10^6\ Sm^3/d$ $p_R = 150$ bara

$\downarrow$

p_o

Solve for B_T to give $\Delta p_T / (\Delta p_T + \Delta p_R) = 50\%$

7" OD or what you find

$\Rightarrow$ 6" ID

$\Downarrow$

B_T (w/ final d_T choice)

⑦ Final B_{WH} A_{WH}

⑧ N_W to deliver $q_{gF} = \dfrac{0.05\ G}{\text{year}}$ ✓

$= q_{gw} \times N_W$

@ $p_R = 150$ bara

$p_t = p_{t,min} = 30$ bara