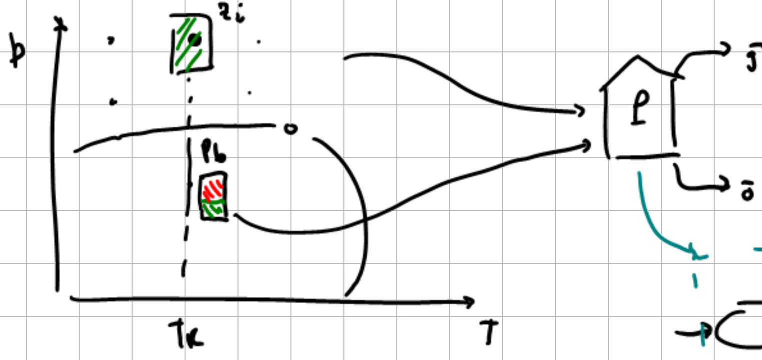
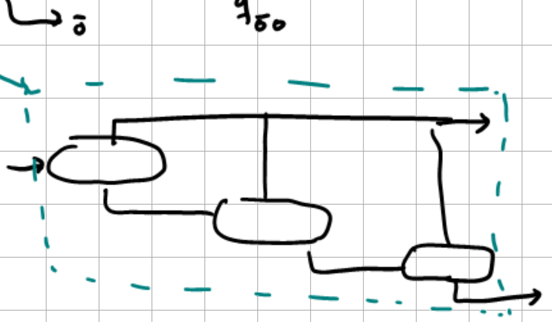
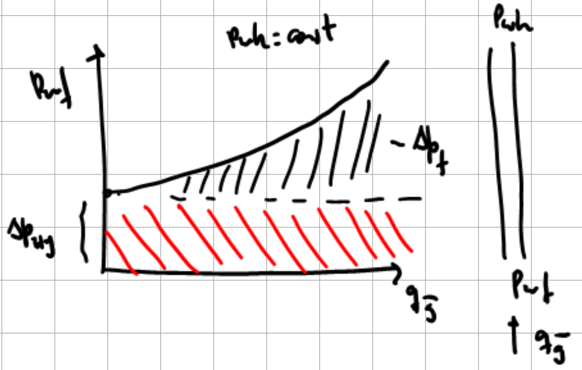
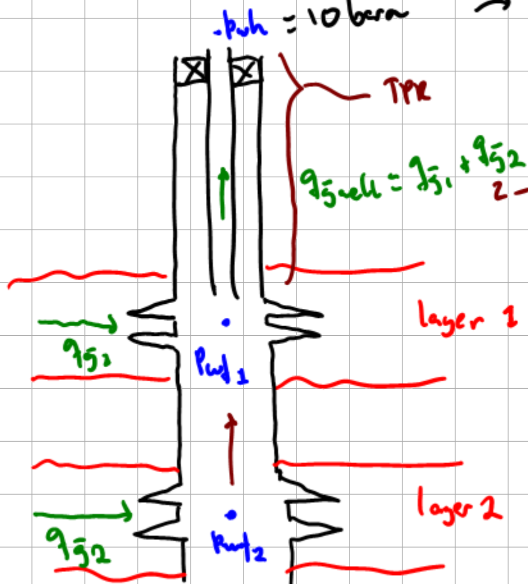


$R_s = \frac{q_{go}}{q_{oo}}$





$p_{wh} = 10$ bara $\rightarrow p_{wf_1}, p_{wf_2}, q_{g1}, q_{g2}$



$$q_{sc} = C_T \cdot \left[\left(\frac{p_{wf}^2}{e^S} - p_t^2 \cdot \right) \right]^{0.5}$$

— CPR casing performance relationship

$$q_g = C_c \left[\frac{p_{wf_2}^2}{e^{S_c}} - p_{wf_1}^2 \right]^{0.5}$$

$C_c > C_T$?

$q_c > q_T$

$$C_T = \left(\frac{\pi}{4}\right) \cdot \left(\frac{R}{M_{air}}\right)^{0.5} \cdot \left(\frac{T_{sc}}{p_{sc}}\right) \cdot \left(\frac{D^5}{f_M \cdot L \cdot \gamma_g \cdot Z_{av} \cdot T_{av}}\right)^{0.5} \cdot \left(\frac{S \cdot e^S}{e^S - 1}\right)^{0.5}$$

$D \uparrow \rightarrow C \uparrow$

$$S = 2 \cdot \frac{M_g \cdot g}{Z_{av} \cdot R \cdot T_{av}} \cdot L \cdot \cos(\alpha) = 2 \cdot \frac{28.97 \cdot \gamma_g \cdot g}{Z_{av} \cdot R \cdot T_{av}} \cdot L \cdot \cos(\alpha)$$

$S_T > S_c$

$L_T > L_c$

		eq	new unknowns
TPR	$q_{well} = C_T \left(\frac{P_{wf_1}^2}{e^S} - P_{wh}^2 \right)^{0.5}$	(1)	2
IPR 1	$q_{g_1} = C_{R_1} \left(P_{R_1}^2 - P_{wf_1}^2 \right)^{n_1}$	1	1
CPR	$q_{g_2} = C_c \left(\frac{P_{wf_2}^2}{e^{S_c}} - P_{wf_1}^2 \right)^{0.5}$	1	2
IPR$_2$	$q_{g_2} = C_{R_2} \left(P_{R_2}^2 - P_{wf_2}^2 \right)^{n_2}$	1	0
mass conservation	$q_{well} = q_{g_1} + q_{g_2}$	1	0
		5	5 ✓

$P_{wf_1} = 150$ bara

300.000 →

230000

pwh [bara]	pwf1 [bara]	qwell [Sm3/d]	q1 [Sm3/d]	q2 [Sm3/d]
10	150.0	2.34E+05	3.23E+05	-8.94E+04

Oil and gas wells, Prof. Milan Stanko (NTNU)

	pR [bara]	C [Sm3/bar2n]	n
Layer 1	200	2010	0.52
Layer 2	250	1150	0.54

Inflow performance relationship (IPR)

$$q_g = c(p_R^2 - p_{wf}^2)^n$$

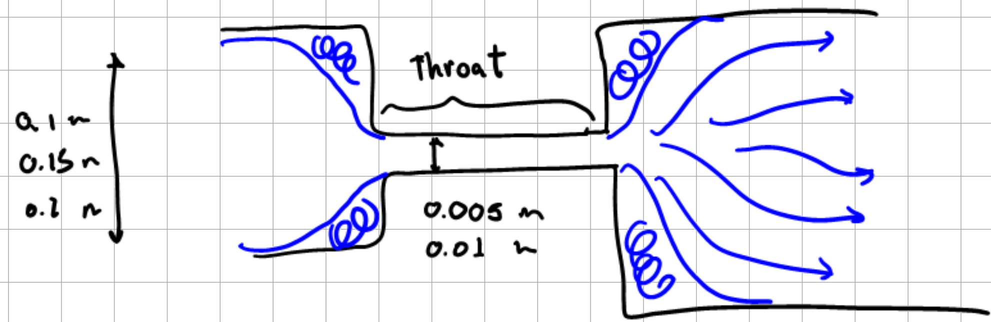
	Cf [Sm3/d/bar]	s
Tubing	2.09E+03	0.58
Casing between 1-2	4.00E+03	0.02

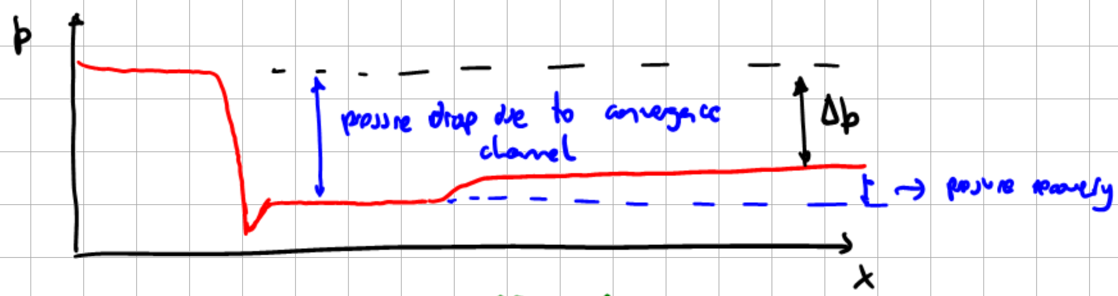
Tubing performance relationship (TPR)

$$p_{wh} = p_2 = \left(\frac{p_1^2}{e^s} - \frac{q_g^2}{C_T^2}\right)^{0.5}$$

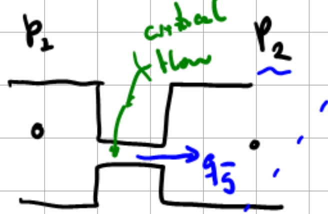
pwh [bara]	pwf1 [bara]	qwell [Sm3/d]	q1 [Sm3/d]	q2 [Sm3/d]	pwf2 (from TPR) [bara]	pwf2 (from IPR) [bara]	error [bar]
10	197.5	3.08E+05	7.21E+04	2.36E+05	208.1	208.1	0.0

Production choke





Dry gas

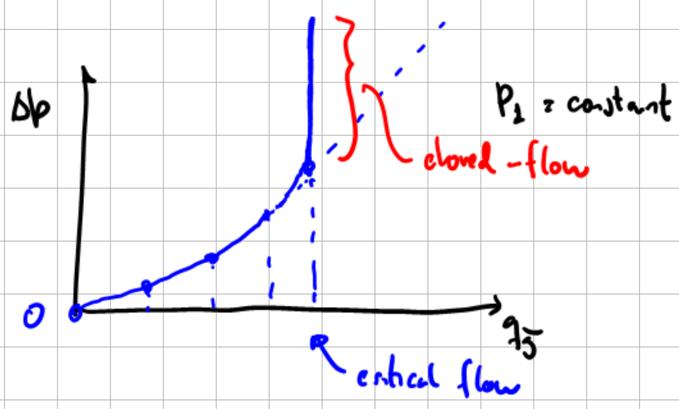


$\to v_g = v_{sound}$ (fluid, p, T)

↳ 300 m/s (air)

Mach number $M = 1$

$M = \frac{v_g}{v_{sound}}$



p_1 = constant

$\frac{p_2^{out}}{p_1^{in}} = 0.5$

(0.4 - 0.6)

- flow performance $f\left(p_{in}, p_{out}, q_{\bar{s}}, \varphi_{throat}\right)$

- temperature performance

B. Choke Equations

Undersaturated Oil Flow

Based on a frictionless flow contraction from an upstream point 1 to a downstream point 2.

The single-phase Bernoulli equation for steady state frictionless flow along a streamline, neglecting elevation changes, is:

$$\frac{dp}{\rho} + V \cdot dV = 0 \qquad \text{Eq. B-1}$$

Where:

p	Pressure
ρ	Density
V	Velocity

$p_{throat} \approx p_2 \quad \Delta p_{recovery} \approx 0$

Undersaturated oil

$$q_{\bar{o}} = \frac{A_2 \cdot C_d}{B_{o,@2}} \cdot \sqrt{\frac{2 \cdot (p_2 - p_1)}{\rho \cdot (1 - \beta^4)}}$$

dry gas

$$q_{\bar{g}} = \frac{p_1 \cdot T_{sc} \cdot A_2 \cdot C_d}{p_{sc}} \cdot \sqrt{2 \cdot \frac{R}{Z_1 \cdot T_1 \cdot M_w} \cdot \frac{k}{k-1} \cdot \left(y^{\frac{2}{k}} - y^{\frac{k+1}{k}}\right)}$$

$$\frac{p_2}{p_1} \rightarrow y_c = \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

adiabatic exponent of gas

$$k = \frac{C_p}{C_v}$$

$k = 1.3$

$\frac{p_2}{p_1} > y_c \qquad \frac{p_2}{p_1} < y_c$

$$q_{\bar{g}} = \frac{p_1 \cdot T_{sc} \cdot A_2 \cdot C_d}{p_{sc}} \cdot \sqrt{2 \cdot \frac{R}{Z_1 \cdot T_1 \cdot M_w} \cdot \frac{k}{k-1} \cdot \left(y_c^{\frac{2}{k}} - y_c^{\frac{k+1}{k}}\right)}$$