Note Title

operational map of esp

Δp

f_1
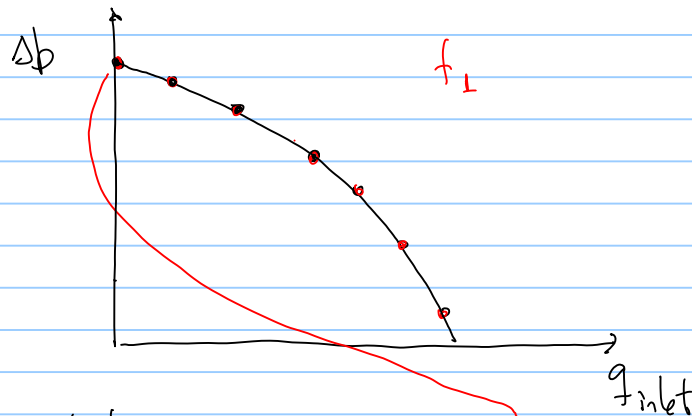
-Bench test   → 1 stage , f_{ref} $\begin{cases} 50 Hz \\ 60 Hz \end{cases}$, water
-Definition of head

q_{inlet}

head

$\delta h = h = \dfrac{\Delta p}{\rho_{fluid} \cdot g}$

δh → it's not affected by ρ_{fluid}

q
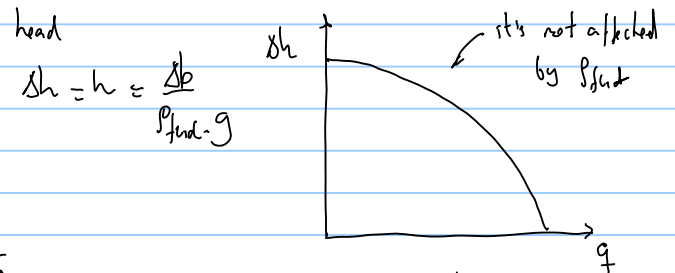
$\Delta p = \delta h \cdot \rho_{fluid} \cdot g$

affected by viscosity

$\mu \simeq \mu_w = 1 cP$

Δp	q
Δp_1	q_1
δp_2	q_2
Δp_3	q_3
⋮	

$\delta h = a \cdot q^2 + b q + c$

Single stage vs multi-stage $(50 - 100)$

δh_{pvp}

2 stages

1 stage

q

3

2

p_2

1

p_1

$\dot{m} = constant$

$\Delta p_{esp} = \overset{N_{stage}}{\underset{i=1}{\sum}} \delta p_i = N_{stages} \cdot \Delta p_{stage} \cdot F_{procane}$
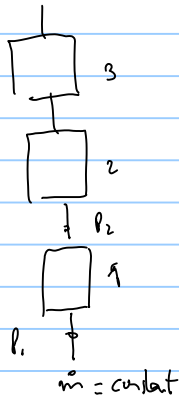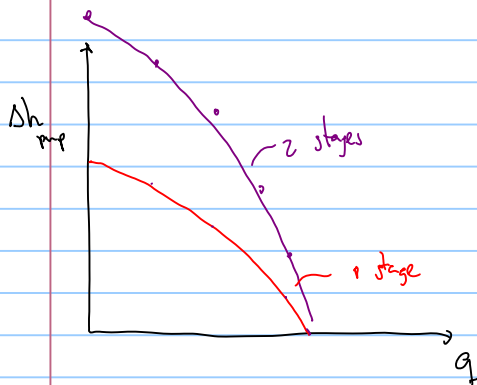
$F_{procane} < 1$

$q_{\bar{o}}$

$q_{oi} = q_{\bar{o}} \cdot B_{o_i}(P_i, T_r)$

Variation of frequency - why?

Depletion

$$f_4 > t_3 > t_2 > f_1$$

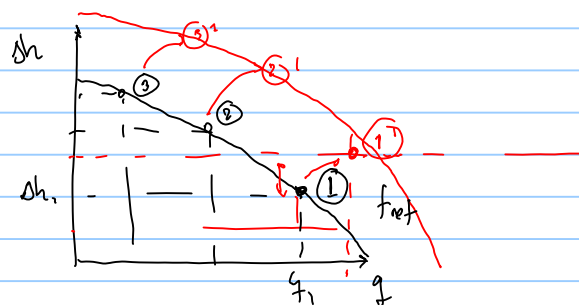$$q_b = q_o - b_o \Theta (P_{we}, t_{sur})$$
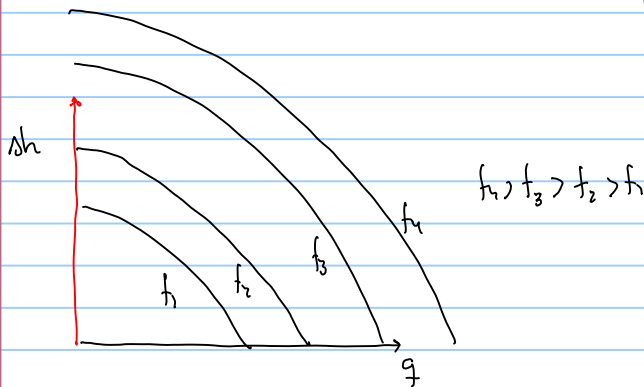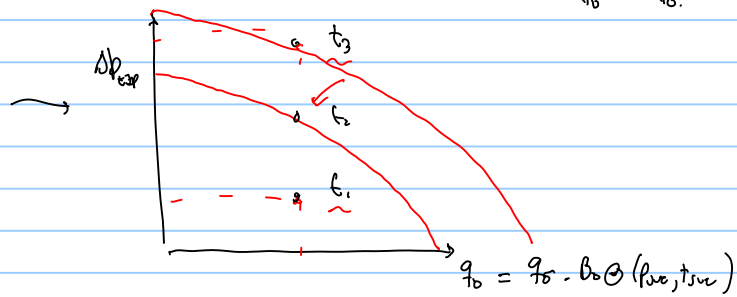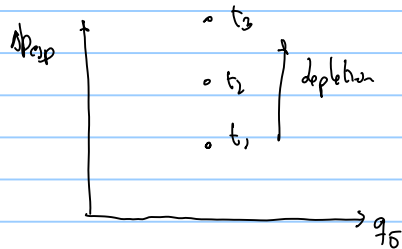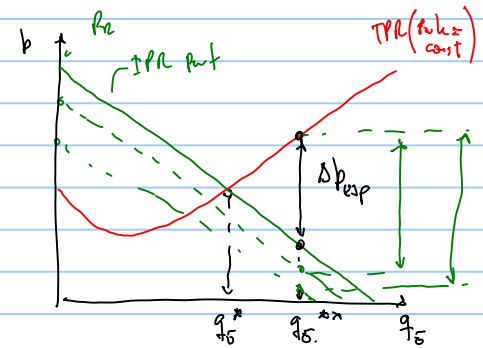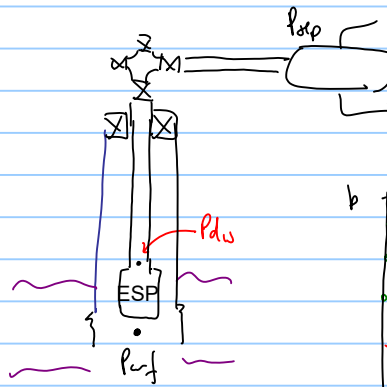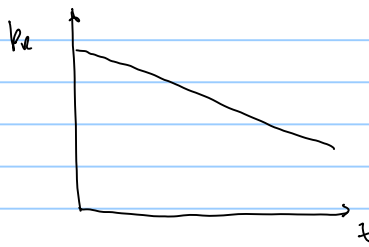
Analytical estimation:

Affinity laws
Similarity laws

$$Q_B = Q_A \cdot \frac{n_B}{n_A}$$

$$H_B = H_A \cdot \left(\frac{n_B}{n_A}\right)^2$$

$$P_B = P_A \cdot \left(\frac{n_B}{n_A}\right)^3$$

$$\frac{\Delta h_1}{\Delta h_{1^*}} = \left(\frac{f_{ref}}{f}\right)^2 \implies \Delta h_{1^*} = \Delta h_1 \cdot \left(\frac{f_\cdot}{f_{ref}}\right)^2$$

$$\frac{q_1}{q_{1^*}} = \left(\frac{f_{ref}}{f}\right) \implies q_1^* = q_1 \left(\frac{f}{f_{ref}}\right)$$

f_{ref}	
Δh	q
D	D
D	D
D	D

$$a q^2 + b q + c$$

f	
Δh	q
D	D
D	D
D	D

$$\downarrow$$

$$\Delta h_{ref} = a \, q_{ref}^2 + b \, q_{ref} + c$$

$$\frac{q_{ref}}{q} = \frac{f_{ref}}{f}$$

$$\Delta h_{ref} = a \cdot \left(\frac{f_{ref}}{f}\right)^2 q^2 + b \cdot \frac{f_{ref}}{f} q + c$$

$$\Delta h = \Delta h_{ref} \left(\frac{f}{f_{ref}}\right)^2 = a\,q^2 + b\left(\frac{f}{f_{ref}}\right)q + \left(\frac{f}{f_{ref}}\right)^2 c$$