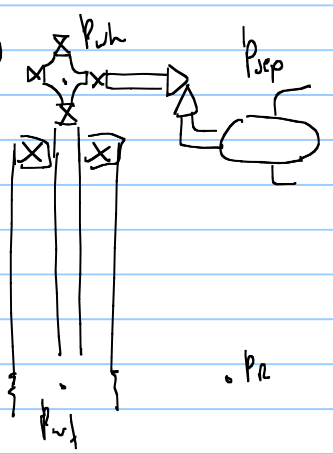
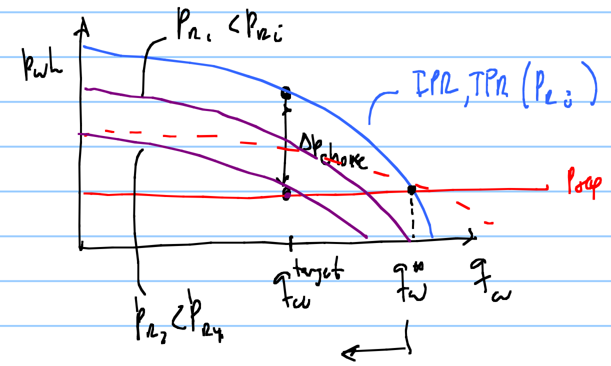
Notes of class 20210420

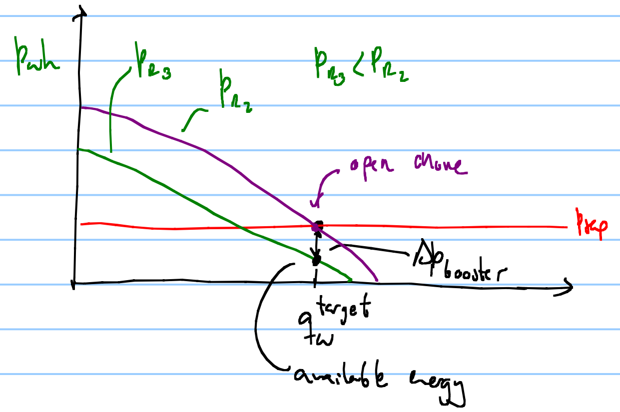
Class 20210420: Boosting



wellhead equilibrium



remember: another option, instead of using a booster is to modify the available and required pressure curves (e.g. fracking, stimulation, tubing ϕ change, gas-lift, Psep lowering)



when $P_R \downarrow \longrightarrow \Delta p_{booster} \uparrow$

- Boosters
  - in well (Artificial lift)
    - ESP (electric submersible pump) ← offshore (screwed at end of tubing)
    - Jet pump
    - rod pumps
    - other

    mostly onshore (not very common in NCS)

    reasons
    - "short" life time (6m - 2 years) ↑ intervention costs
    - if dry x-mas tree well the offshore structure should have a drilling package
    - if wet x-mas tree $ ↑

find "something" (equipment) to provide @ $q^{target}_{fw} \rightarrow \Delta p_{booster}$

is this combination feasible?
- technically?/physically
- $
- equipment available on market
- others

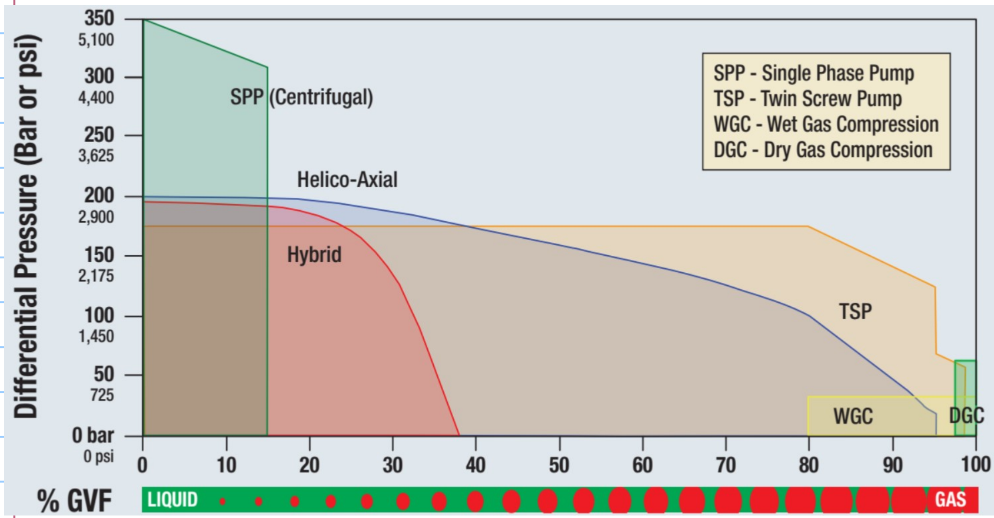
  - outside of well (typically subsea)
    - centrifugal pump GVF ≤ 0.1
    - helico-axial pumps. (GVF, gas volume fraction) @ inlet $\frac{q_g}{q_g+q_L}$

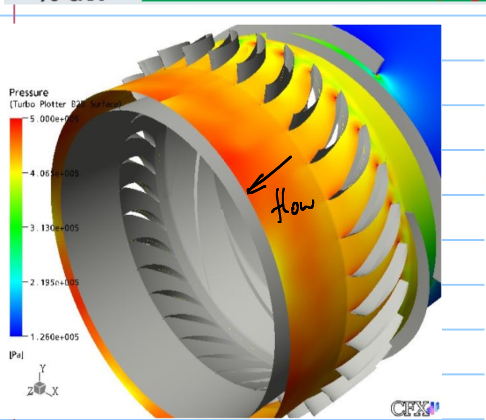
0.1 ≤ GVF < 0.9

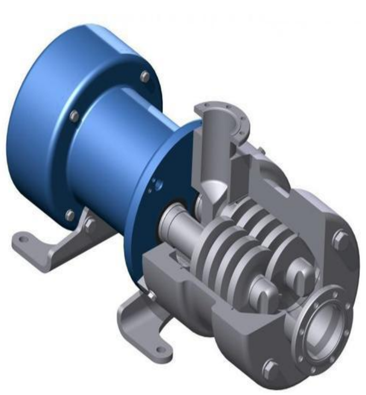
- twin screw pump
- Wet gas compressor (Gullfaks ↑)

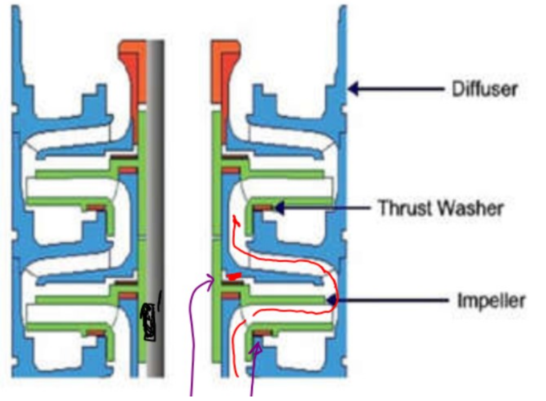
0.9 ≤ GVF

- Dry gas compressor GVF > 0.97 (Åsgard ↑)





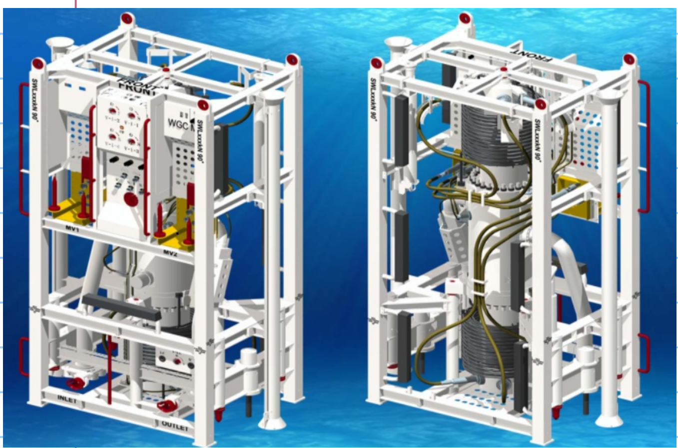




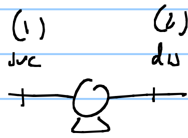
Helico-axial

twin-screw pump

ESP



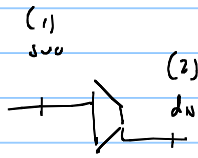
WGC



Determining technical feasibility of booster

if single phase pump (liquid only) $P_{suc} > P_b(T_{suc}) \cdot F_{safety}$

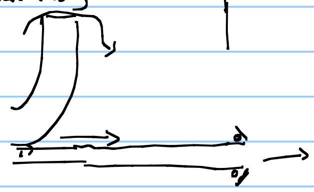
otherwise → multiphase pump ↑ \$
↳ upstream separation



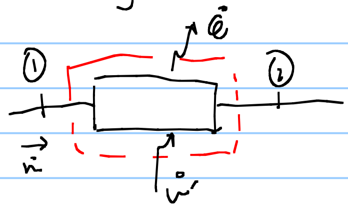
if single phase compressor $P_{suc} > P_d(T_{suc}) \cdot F_{safety}$

- for all machines

$p_{suc} \geq p_{min}$ { for mechanical purposes, rotor balancing, seals }



first law of thermodynamics for open systems:



$$\cancel{\dot{e}} - \dot{w} = E_1 - E_2$$

$$\dot{w} = E_2 - E_1 = \dot{m}\,(e_2 - e_1)$$

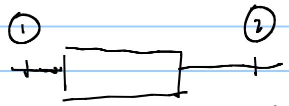
neglecting kynetic potential

$$P = \dot{w} = \dot{m}\,(h_2 - h_1)$$

Δh ?

$h \rightarrow f(p, T)$

$h, p \rightarrow T$

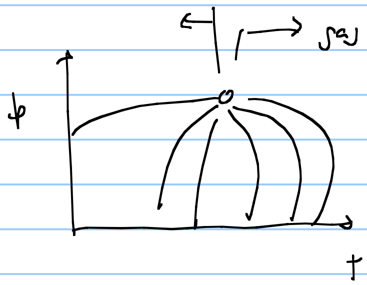


p = 50 bara, T = 50°C → h_1

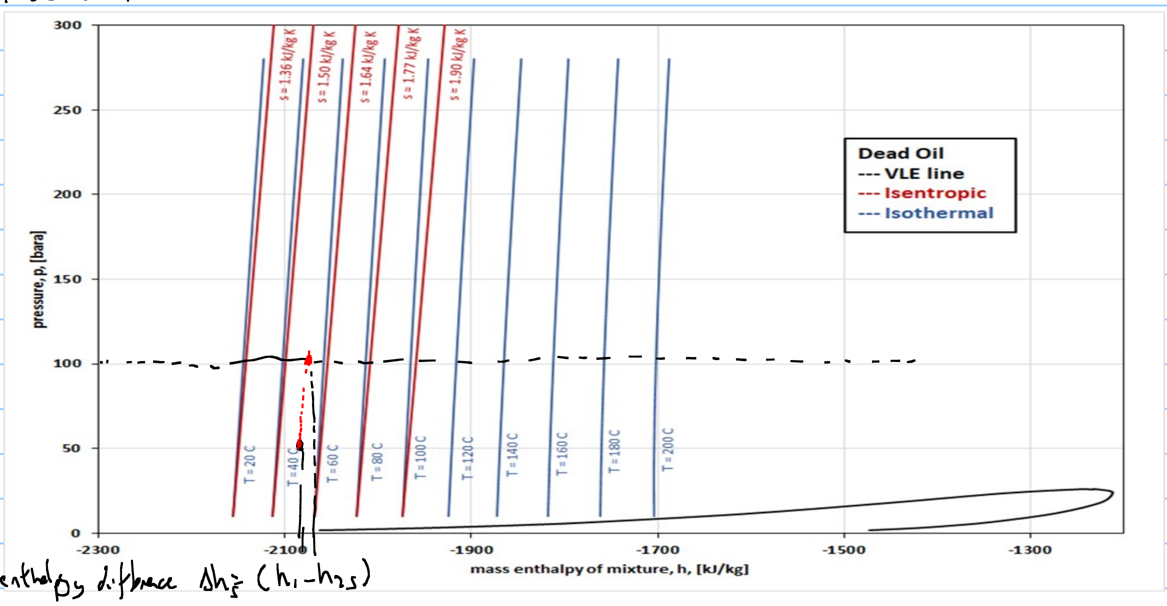
100 bara, T = ?

pressure-enthalpy diagram

water - Molliere diagram



Case: dead oil



ideal enthalpy difference $\Delta h_s = (h_1 - h_{2s})$

$$\Delta h_{real} = (h_2 - h_1) = \frac{(h_{2s} - h_1)}{\eta_{adiabatic}}$$

adiabatic efficiency (0 - 1)

in boosters (0.3 - 0.8)

$\Delta h_{real} > \Delta h_{ideal}$

$$\dot{w} = \dot{m} \cdot \frac{\Delta h_s}{\eta_{adiabatic}}$$

$\eta = 0.6$ (assumed)

example

$q_{\bar{o}} = 50000$ stb/d $\rho_{\bar{o}} = 800$ kg/m^3

$\dot{m} = q_{\bar{o}} \cdot \rho_{\bar{o}}$ kg/s

$$= \underbrace{\frac{50000}{6.29} \cdot \frac{1}{(24 \cdot 3600)}}_{7.} \cdot 800 = 7.4 \text{ kg/s}$$

Δh_s = instead of reading from chart, i use an approximation

for liquids $\Delta h_s \simeq \frac{\Delta p}{\rho} = \frac{(100-50) \cdot 10^5}{800} = 6250$ J/kg

ρ = const = 800

from chart

(1) -2087.298387096774, 50.47013977128336
(2) -2080.040322580645, 100.78780177890721

$\Delta h_s \simeq 7.2$ kJ/kg

$(-2080 - (-2087)) = 7.2$ kJ/kg

$h_{(p,T)} = (h_{p,T} - h_{ref})$

$h_{ref} > h_{p,T}$

$h_{ref} < h_{p,T}$

$$\dot{w} = \dot{m} \cdot \frac{(\Delta h_s)}{\eta_{adiab}} = \frac{7.4 \cdot 6250}{0.6 \cdot 1000} = 77 \quad [kW]$$

ideal Power = 46.3 kW

nadiab	required power [kW]
0.3	154.2
0.4	115.6
0.5	92.5
0.6	77.1
0.7	66.1
0.8	57.8