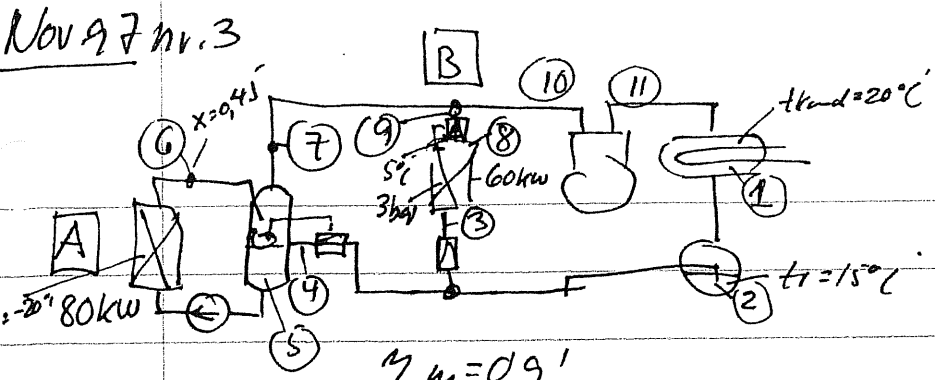
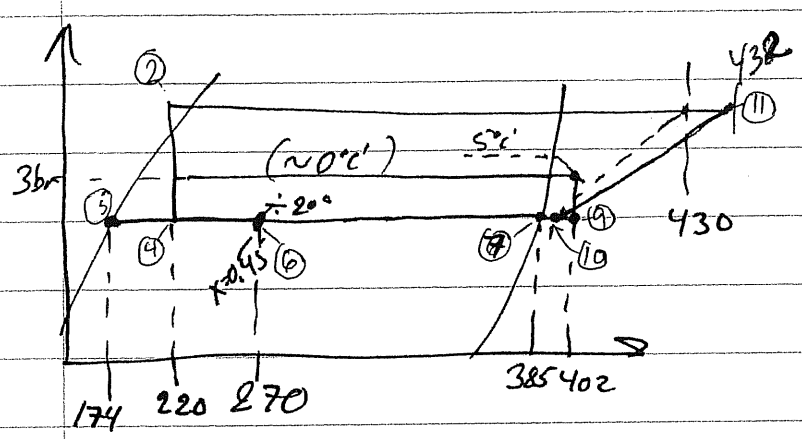
Nov 97 nr. 3



$\eta_m = 0{,}9$

$\eta_i = 0{,}83$



a) Massestrømmen A: $\dot{m}_A = \frac{Q_A}{h_6 - h_5} = \frac{80}{270-174} = \underline{0{,}833\ kg/s} \approx 3000\ kg/h$

b) Massestrømmen B = $\dot{m}_{rB} = \frac{Q_B}{h_8 - h_3} = \frac{60}{(402-220)} = \underline{0{,}33\ kg/s}$

c) Væskestrømmen gjennom væskeavskilleren:

$$\dot{m}_V = \frac{Q_A}{h_7 - h_4} = \frac{80}{385-220} = \underline{0{,}485\ kg/sec}$$

Blandingsentalpi (h_{10})

$$h_{10} = \frac{\dot{m}_{rB} \cdot h_8 + \dot{m}_V \cdot h_7}{(\dot{m}_{rB} + \dot{m}_V)} = \frac{0{,}33 \cdot 402 + 0{,}485 \cdot 385}{\underbrace{(0{,}33 + 0{,}485)}_{0{,}815}} = \underline{392\ kJ/kg}$$

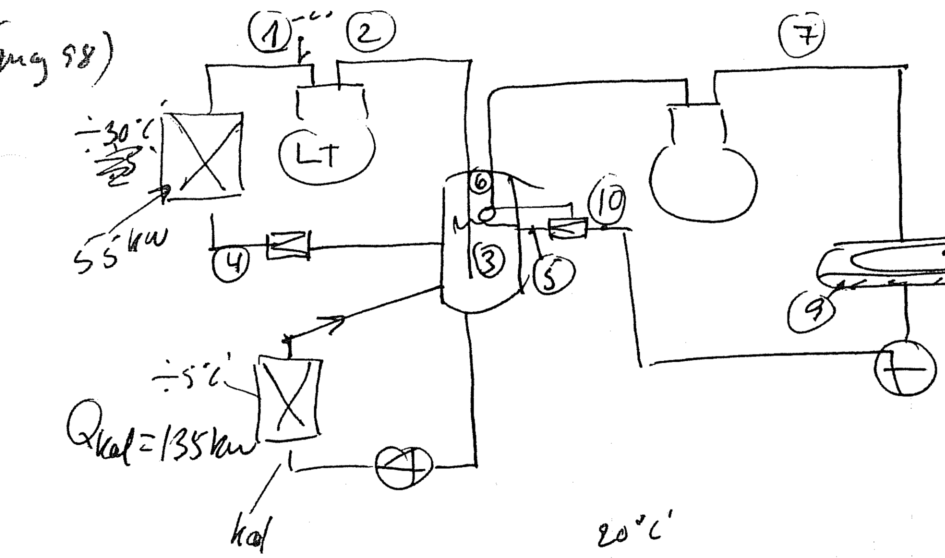
$(\Rightarrow h_{11\,is} = 426\ kJ/kg)$

$$\Rightarrow h_{11} = 392 + \frac{426 - 392}{0{,}83} = \underline{432\ kJ/kg}$$

$$P_{el} = (\dot{m}_{rB} + \dot{m}_{rV}) \cdot \frac{h_{11} - h_{10}}{\eta_m} = (0{,}33 + 0{,}485) \cdot \frac{438 - 392}{0{,}91} = \underline{35\ kW}$$

Nr 11

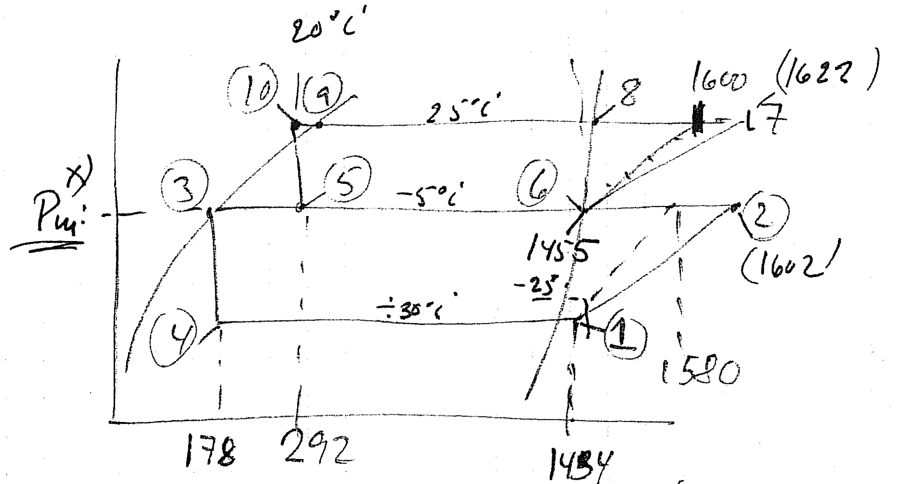
Leif's



$\eta_m = 0,92$

$\eta_i = 0,87$

$\eta_{el} = 0,93$



$$h_2 = 1434 + \frac{1580-1434}{0,87} = \underline{1602 \text{ kJ/kg}}$$

$$h_7 = 1455 + \frac{1600-1455}{0,87} = \underline{1622 \text{ kJ/kg}}$$

x) Bem: P_m er det trykk, der svarer til ÷5°C ≈ 3,5486 b_a

a) $$m_{rLT} = \frac{55}{1434-178} = \underline{\underline{0,044 \text{ kg/sec}}}$$

$$P_{i\,LT kompr.} = 0,044(1602-1434) = \underline{7,4 \text{ kW}}$$

$$Q_{tilf\,LT} = Q_{opt\,HT}$$

b) $$Q_A + Q_B + P_i = \dot{m}_{r_{HT}}(h_6 - h_5) \Rightarrow m_{rHT} = \frac{55+135+7,4}{1455-292} = \underline{\underline{0,17 \text{ kg/s}}}$$

c) $$Q_{kond} = \dot{m}_{rHT} \times (h_7 - h_{10}) = 0,17(1622-292) = \underline{\underline{225,7 \text{ kW}}}$$

d) $$P_{i\,HT} = 0,17(1622-1455) = 28,4 \text{ kW}$$

$$\Sigma P_{tilf} = \frac{7,4+28,4}{0,92 \times 0,93} = \underline{41,8 \text{ kW}}$$

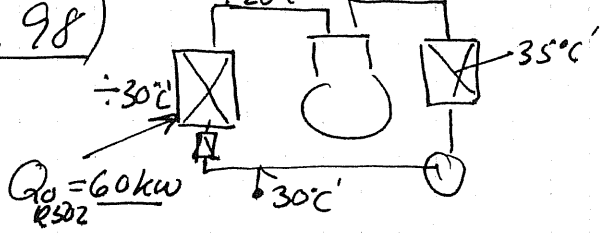
$$COP = \frac{\Sigma Q_o}{\Sigma P} = \frac{55+135}{41,8} = \underline{4,55}$$

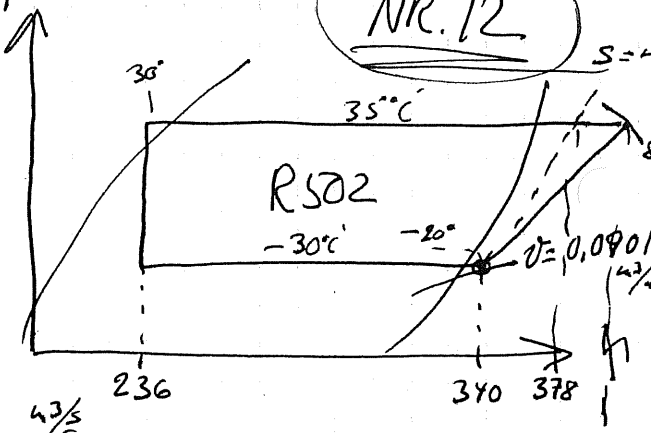
ell.

$$\Sigma P_i = Q_{kond} - Q_{kal} - Q_{frys} = 225,7 - 135 - 55 = 35,7 \text{ kW}$$

$$\Rightarrow \Sigma P_{el} = \frac{35,7}{0,92 \times 0,93} = 41,8 \text{ kW}$$

(Nov. 98)





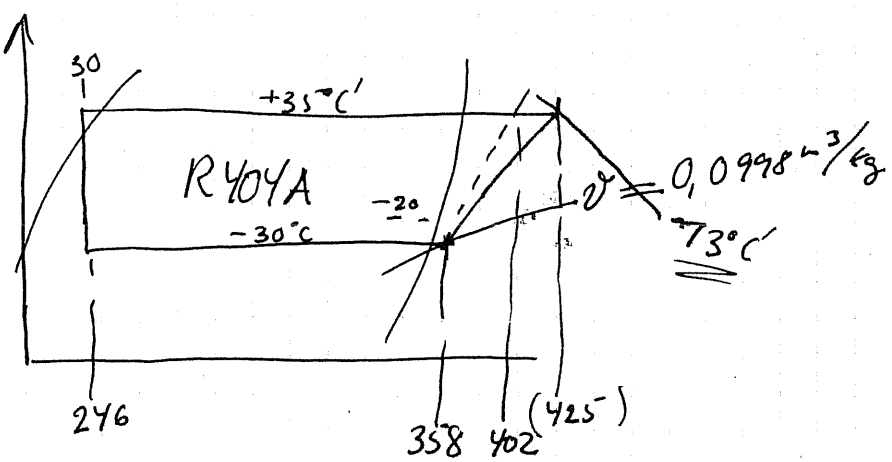
R502

$$\dot{m}_{r\,502} = \frac{60}{340-236} = 0{,}577\ kg/s$$

$$V_{inds} = \dot{m}_r \cdot v = 0{,}577 \times 0{,}0901 = 0{,}052\ m^3/s\ (= 187{,}2\ m^3/h)$$

$$\eta_{IIS} = \frac{378-340}{398-340} = 0{,}66$$

R404A



$$h_{kompalg} = 358 + \frac{402-358}{0{,}66} \approx 425\ kJ/kg \Rightarrow \text{tryktrørstemp: } 73°C$$

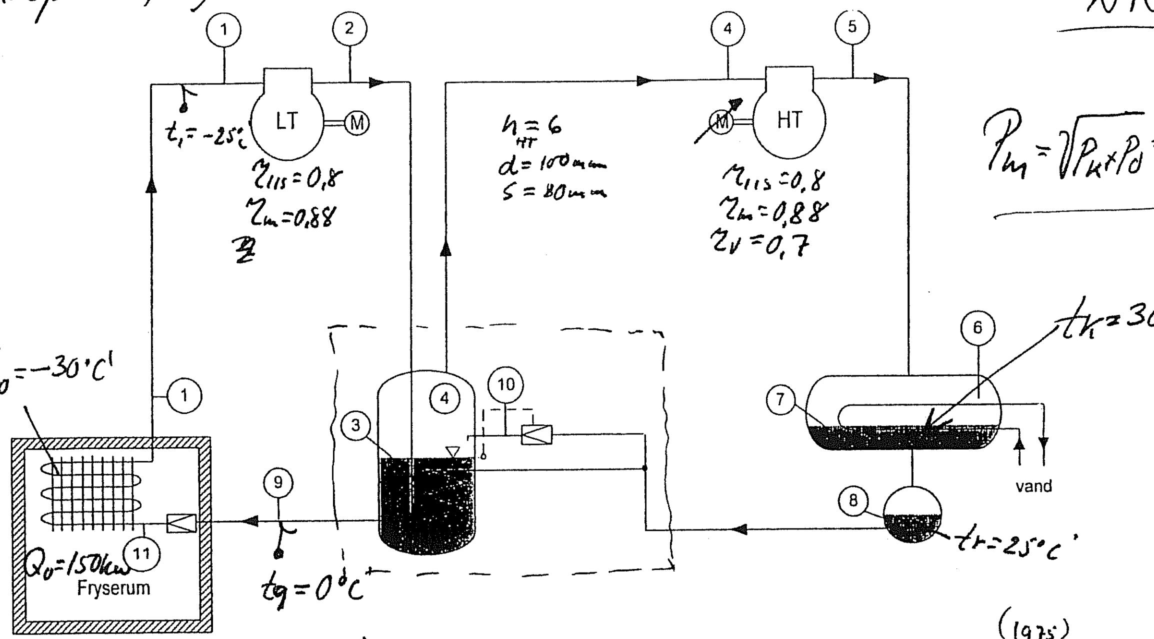
$$\dot{m}_{r\,404A} = \frac{V_{inds}}{v} = \frac{0{,}052}{0{,}0998} = 0{,}521\ kg/sec$$

$$Q_{0\,R404A} = \dot{m}_{r\,404A} \cdot \Delta h = 0{,}521 \cdot (358-246) = 58{,}4\ kW$$

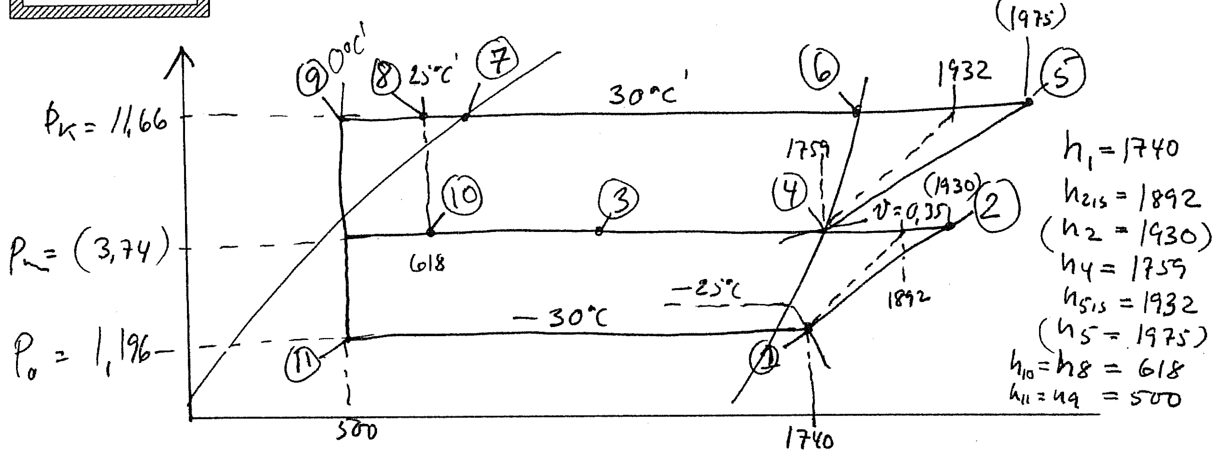
~~2. Afsprøvning...~~

3 NR. 13

$P_m = \sqrt{P_K \times P_0} = \sqrt{11{,}66 \times 1{,}196} = \underline{3{,}74\ \text{bar}}$



3.1



$h_1 = 1740$
$h_{2is} = 1892$
$(h_2 = 1930)$
$h_4 = 1759$
$h_{5is} = 1932$
$(h_5 = 1975)$
$h_{10} = h_8 = 618$
$h_{11} = h_9 = 500$

$$h_2 = 1740 + \frac{1892-1740}{0{,}8} = \underline{1930\ kJ/kg}$$

$$\dot{m}_{r\,LT} = \frac{150}{1740-500} = \underline{0{,}121\ kg/sec}\ (\approx 436\ kg/h)$$

$$\dot{m}_{r\,LT} \cdot (h_2 - h_9) = \dot{m}_{r\,HT}\,(h_4 - h_8)$$

$$0{,}121\,(1930-500) = \dot{m}_{r\,HT}\,(1759-618) \Rightarrow \dot{m}_{r\,HT} = \underline{0{,}152\ kg/sec} \approx 547{,}2\ kg/h$$

3.2.1 $\dot{m}_{SV} = \dot{m}_{r\,HT} - \dot{m}_{r\,LT} = 0{,}152 - 0{,}121 = \underline{\underline{0{,}031}}\ kg/sec\ (\approx \underline{110{,}3}\ kg/sec)$

$(v_{HT,ind} = 0{,}35\ m^3/kg)$

$$\dot{V}_{inds,HT} = \dot{m}_{r\,HT} \cdot v_{HT,ind} = 0{,}152 \cdot 0{,}35 = \underline{0{,}0532}\ m^3/sec$$

$$\dot{V}_{HT\,teo} = \frac{V_{inds,HT}}{\eta_v} = \frac{0{,}0532}{0{,}7} = \underline{0{,}076\ m^3/sec}$$

3.2.2 $$n_{HT} = \frac{V_{HT\,teo} \cdot 4 \cdot 60}{c \cdot \pi \cdot d^2 \cdot s} = \frac{0{,}076 \times 4 \times 60}{6 \times \pi \times 0{,}1^2 \cdot 0{,}08} = \underline{\underline{1210\ \text{o/min}}}$$

3.2.3 $$h_5 = 1759 + \frac{\overset{216{,}25}{\overbrace{1932-1759}}}{0{,}8} = \underline{1975}$$

$P_{i\,HT} = 0{,}152 \cdot (1975-1759) = 32{,}8\ kW \Rightarrow P_{HT\,akl} = \dfrac{32{,}8}{0{,}88} = \underline{37{,}3\ kW}$

$P_{i\,LT} = 0{,}121\,(1930-1740) = \underline{23{,}0}\ kW \Rightarrow P_{LT\,akl} = \dfrac{23}{0{,}88} = \underline{26{,}13\ kW}$

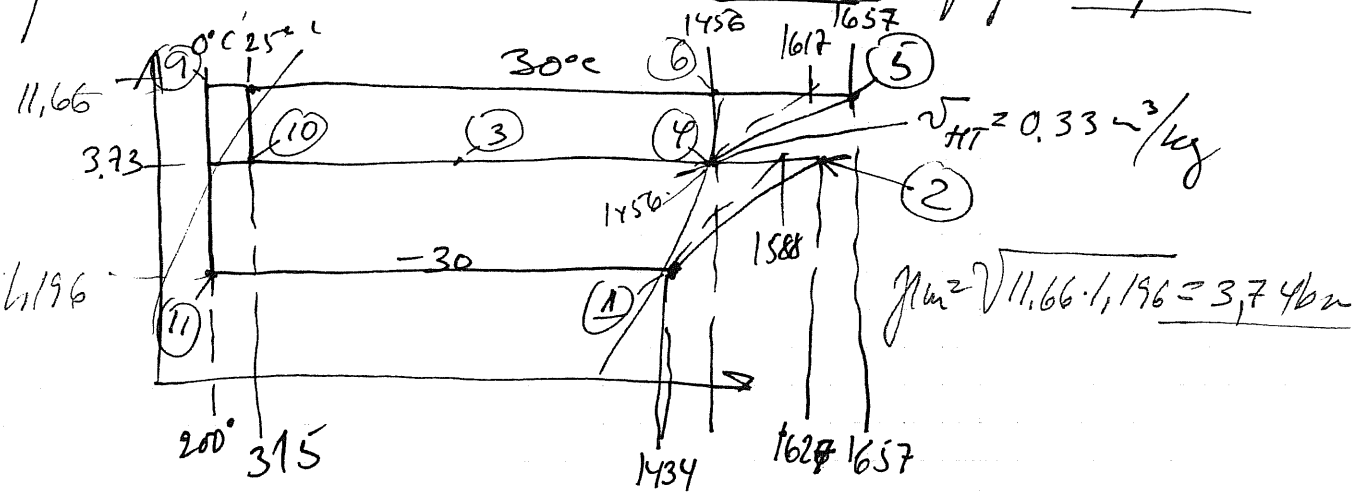
$\Sigma P_i = 55{,}8\ kW$ $\qquad \Sigma_{akl}\ 63{,}4\ kW$

3.3 **Fordele:**
- større Δh_{ford} ⇒ mindre cirkuleret $\dot{m}$ i LTsyst.
- større Δp over ekspansionsventilen
- kun en lille sv. ventil er nødvendig

Ulemper:
1.
2.

(maj 99)

Nr. 13 i flg. Coolpack



$$h_2 = 1434 + \frac{1588-1434}{0,8} = 1434 + 192,5 \cong 1627\ kJ/kg$$

$$h_5 = 1456 + \frac{1617-1456}{0,8} = 1456 + 201 = 1657\ kJ/kg$$

$$\dot{m}_{rLT} = \frac{150}{1434-200} = 0,122\ kg/s$$

$$\dot{m}_{rHT} = 0,122\ \frac{1627-200}{1456-315} = 0,152\ kg/s$$

$$\dot{m}_{SV} = \dot{m}_{rHT} - \dot{m}_{rLT} = 0,152 - 0,122 = 0,030\ kg/sec = 108\ kg/h$$

$$\dot{V}_{ins\,HT} = \dot{m}_{rHT} \cdot \nu_{HT} = 0,152 \times 0,33 = 0,05\ m^3/s\ (\cong 180\ m^3/h)$$

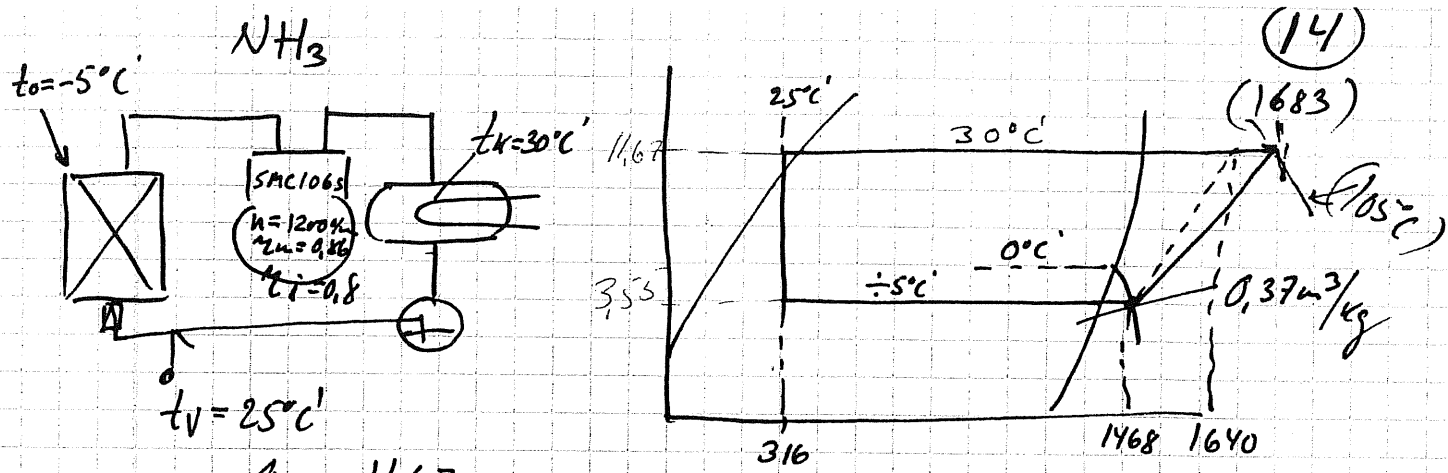
$$\dot{V}_{HT\,Teo} = \frac{\dot{V}_{ind\,HT}}{\eta_V} = \frac{0,05}{0,7} = 0,072\ m^3/s$$

$$n_H = \frac{\dot{V}_{teoHT} \cdot 4 \cdot 6}{c \cdot \pi \cdot d^2 \cdot s} = \frac{0,072 \cdot 4 \cdot 60}{6 \cdot \pi \cdot 0,1^2 \cdot 0,08} = 1140\ o/m$$

$$P_{dyn\,HT} = 0,152 \cdot \frac{(1657-1456)}{0,88} = 34,7\ kW$$

$$P_{dyn\,LT} = 0,122 \left(\frac{1657-1434}{0,88}\right) = 30,9\ "$$

$$\Sigma P_{dyn} = 65,6\ kW$$



$$\frac{p_K}{p_0} = \frac{11,67}{3,55} \approx 3,3 \Rightarrow \eta_V = 0,72 \quad \text{(diagram)}$$

$$\dot{V}_{teo} = c \cdot \frac{\pi}{4} \cdot d^2 \cdot s \cdot \frac{n}{60} = 6 \cdot \frac{\pi}{4} \cdot 0,1^2 \cdot 0,08 \cdot \frac{1200}{60} = 0,0754\ m^3/s \quad (\sim 271\ m^3/h)$$

eller ift. affaring: $339 \times \frac{1200}{1500} = 271,2\ m^3/h \approx 0,0753\ m^3/s$

$$\dot{V}_{inds} = \dot{V}_{teo} \cdot \eta_V = 0,0754 \cdot 0,72 = 0,0543\ m^3/s \quad (\sim 195\ m^3/h)$$

$$\dot{m}_r = \frac{\dot{V}_{inds}}{v_g} = \frac{0,0543}{0,37} = 0,147\ kg/s \quad (\sim 5,28\ kg/h)$$

$$\Delta h_{fordamper} = 1468 - 316 = 1152\ kJ/kg$$

a) $$\dot{Q}_{ford} = \dot{m}_r \cdot \Delta h_{ford.} = 0,147 \cdot 1152 = \underline{\underline{169,3\ kW}}$$

$$\Delta h_{iskompr.} = 1640 - 1468 = 172\ kJ/kg$$

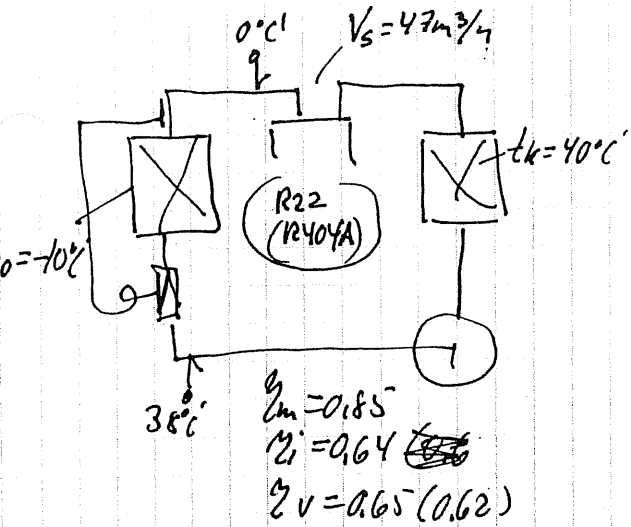
$$\Delta h_{kompr.} = \frac{\Delta h_{iskompr}}{\eta_i} = \frac{172}{0,8} = 215\ kJ/kg$$

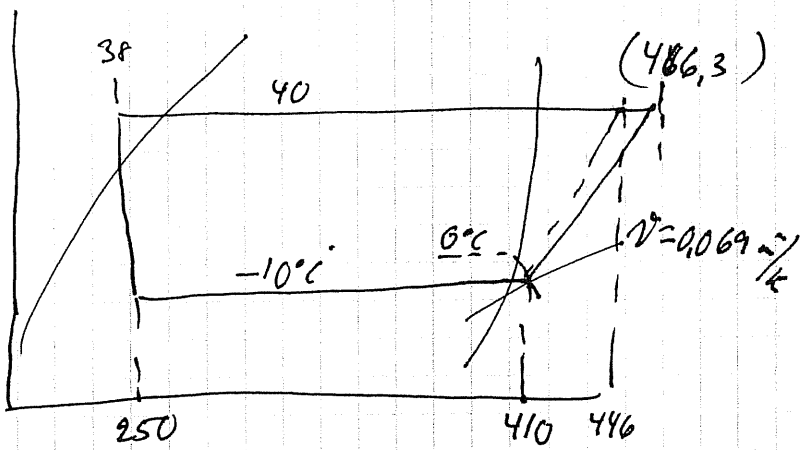
$$h_{afg.} = 1468 + 215 = 1683\ kJ/kg$$

b) $$P_{ikompr.} = \dot{m}_r \cdot \Delta h_{kompr} = 0,147 \cdot 215 = 31,6\ kW$$

$$P_{tilf.\ kompr} = \frac{P_{ikompr}}{\eta_m} = \frac{31,6}{0,86} = \underline{\underline{36,8\ kW}}$$

c) trykrørstemperatur = $t_{afg} = \underline{\underline{105°C}}$ (aflæst)





$$V_{inds.} = V_s \cdot \eta_v = 47 \cdot 0,65 = 30,55 m^3/h \approx \underline{0,00849 m^3/s}$$

$$\dot{m}_{r22} = \frac{V_{inds}}{v} = \frac{0,00849}{0,069} = \underline{0,123 kg/s}$$

a) $Q_{0_1} = \dot{m}_{r22} \cdot \Delta h_{isparenja} = 0,123 (410 - 250) = \underline{19,7 kW}$

$h_{a/s\,r22} = 410 + \frac{446 - 410}{0,64} = 466,25$

b) $P_{tel_1} = \dot{m}_{r22} \cdot \frac{\Delta h_{kompresija}}{\eta_m} = 0,123 \frac{(466 - 410)}{0,85} = \underline{8,1 kW}$

c) $COP_1 = \frac{Q_0}{P_{tel_1}} = \frac{19,7}{8,1} = \underline{2,43}$

d) – – –
e) – – –
F) – – –

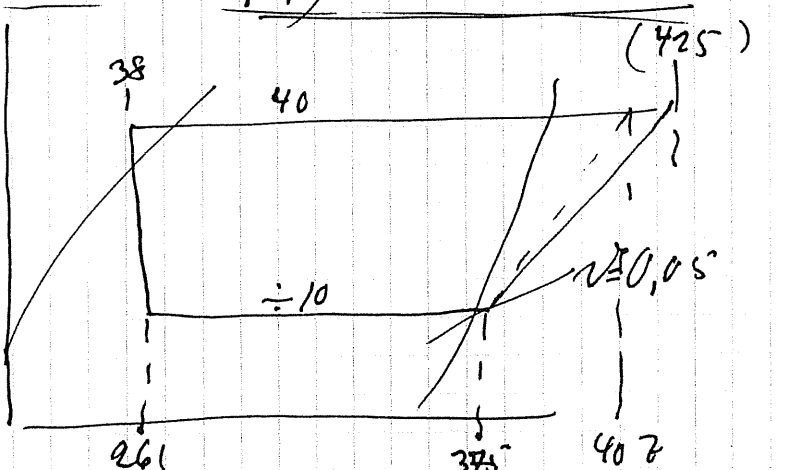
R404a ($\eta_{V_2} = 0,62$)

$V_{inds_2} = 47 \cdot 0,62 = 29,14 m^3/h \approx \underline{0,00809 m^3/s}$

$\dot{m}_{r_{404a}} = \frac{0,00809}{0,05} = \underline{0,162 kg/s}$ (+30%)

g) $Q_{0_2} = 0,162 (375 - 261) = \underline{18,45 kW}$

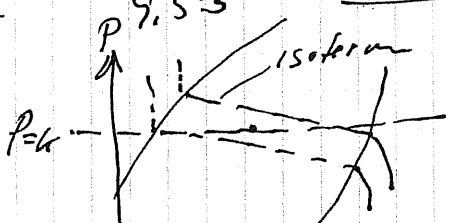
$h_{a/s\,R404a} = 375 + \frac{407 - 375}{0,64} = \underline{425 kJ/kg}$



h) $P_{tel_2} = 0,162 \left(\frac{425 - 375}{0,85}\right) = \underline{9,53 kW}$

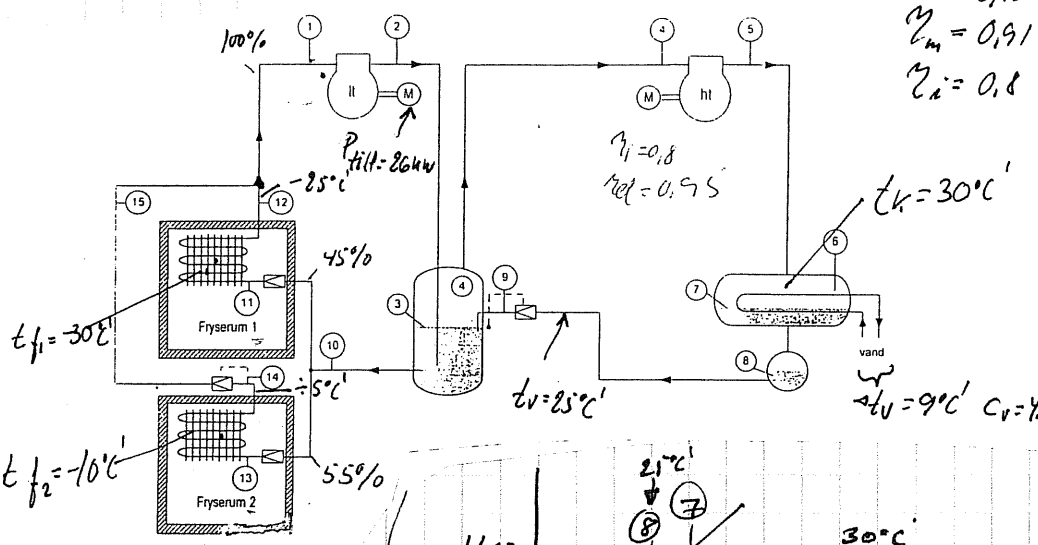
i) $COP_2 = \frac{18,45}{9,53} = \underline{1,936}$

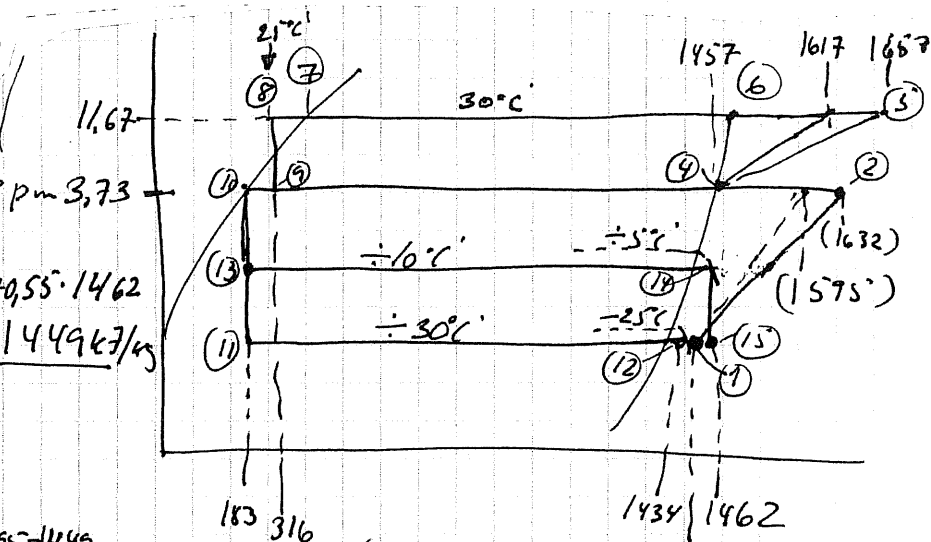
J)



16

$\eta_{el} = 0{,}95$
$\eta_m = 0{,}91$
$\eta_i = 0{,}8$





$p_m = \sqrt{11{,}67 \times 1{,}195} = \underline{3{,}73\ bar} \rightarrow p_m\ 3{,}73$

$h_1 = h_{12} \cdot 0{,}45 + h_{15} \cdot 0{,}55 = 0{,}45 \cdot 1434 + 0{,}55 \cdot 1462 = \underline{1449\ kJ/kg}$

$\Rightarrow$ (h_{2s} aflæses til 1595 kJ/kg)

2: Entalpi efter LT kompr. $= 1449 + \frac{1595 - 1449}{0{,}8} = \underline{1632\ kJ/kg}$ ($\Delta h_{LT} = 183\ kJ/kg$) (1449)

5: Entalpi efter HT-kompr. $= 1457 + \frac{1617 - 1457}{0{,}8} = \underline{1657\ kJ/kg}$ ($\Delta h_{HT} = 200\ kJ/kg$)

$P_{i\,LT} = P_{tilf} \cdot \eta_{el} \cdot \eta_m = 26 \cdot 0{,}95 \cdot 0{,}91 = 22{,}5\ kW$

$\Sigma \dot{m}_{r\,LT} = \frac{P_{i\,LT}}{\Delta h_{LT}} = \frac{22{,}5}{183\ (1632 - 1449)} = \underline{0{,}123\ kg/s}$

$\dot{m}_{r\,rum1} = 0{,}123 \times 0{,}45 = \underline{0{,}0553\ kg/s}$

$\dot{m}_{r\,rum2} = 0{,}123 \times 0{,}55 = \underline{0{,}0677\ kg/s}$

a) $\dot{Q}_{0\,rum1} = \dot{m}_{r\,rum1} \times \Delta h_1 = 0{,}0553 \times (1434 - 183) = \underline{69{,}2\ kW}$

b) $\dot{Q}_{0\,rum2} = \dot{m}_{r\,rum2} \times \Delta h_2 = 0{,}0677 \times (1462 - 183) = \underline{86{,}6\ kW}$

c) $\dot{m}_{r\,HT} = 0{,}123 \times \frac{h_2 - h_{10}}{h_4 - h_9} = \frac{1632 - 183}{1457 - 316} = \underline{0{,}156\ kg/s}$

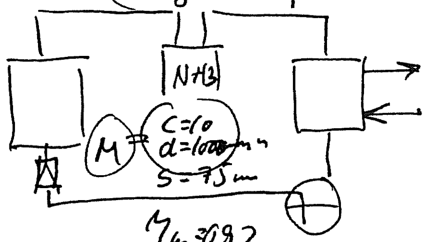
$P_{tilf\,HT\,kompr.} = \frac{0{,}156\,(h_5 - h_4)}{0{,}95 \times 0{,}91} = \frac{0{,}156 \times 200}{0{,}95 \times 0{,}91} = \underline{36\ kW}$

d) $P_{kond} = 0{,}156 \times (h_5 - h_8) = \underline{209{,}2\ kW}$

$\dot{m}_{vand} = \frac{209{,}2}{4{,}2 \cdot 9} = \underline{5{,}5\ kg/s}$ ($\dot{V} = 5{,}5\ l/s$)

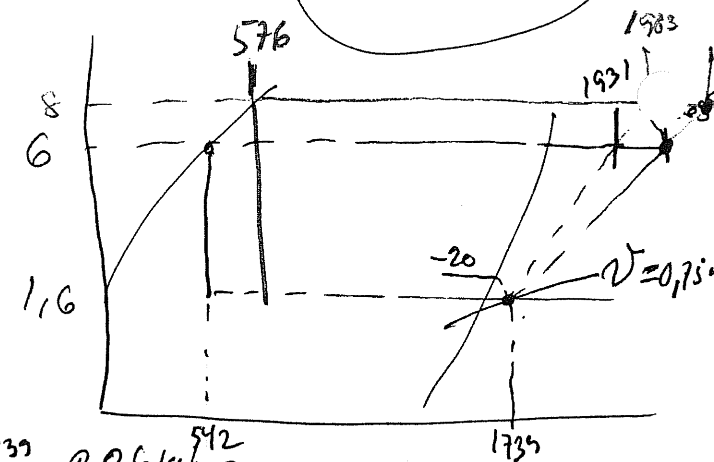
August 2001, 2. Årsprøve/OMPRØVE ? nr. 17

4) (6 cyl. idrift)



$\eta_m = 0{,}92$
$\eta_i = 0{,}85$
$n = 1450$ o/min
$\eta_{el} = 0{,}95$

$\eta_{v1} = 0{,}7$



$\Delta h_{kompr.} = \frac{1931-1739}{0{,}85} = 226$ kJ/kg

4.1 endalpi efter kompr. $h' = 1739 + 226 = \underline{1965}$

$V_{teo} = 6 \cdot \frac{\pi}{4} \cdot 0{,}1^2 \cdot 0{,}075 \cdot \frac{1450}{60} = 0{,}0854$ m³/sec

$V_r = V_{teo} \times \eta_v = 0{,}0854 \cdot 0{,}7 = \underline{0{,}05979}$ m³/sec

$\dot m_r = \frac{V_r}{v} = \frac{0{,}05979}{0{,}75} = \underline{0{,}0797}$ kg/sec

4.1.1. $Q_0 = \dot m_r \cdot \Delta h_{ford} = 0{,}0797 (1739-542) = \underline{\underline{95{,}4}}$ kW

4.1.2 $P_{el_{tilf}} = \frac{\dot m_r \cdot \Delta h_{kom}}{\eta_m \cdot \eta_{el}} = \frac{0{,}0797 \cdot (1965-1739)}{0{,}92 \cdot 0{,}95} = \underline{\underline{20{,}6}}$ kW

4.2
- luft i kond
- belægninger på vandsid
- mindre køle
- højere vand temp

} – stigende trykforskel – større effektfor

4.3 $\dot m_{r_2} = \frac{95{,}4}{1739-576} = \frac{95{,}4}{1163} = \underline{0{,}0821}$ kg/sec $(\eta_{v_2} = 0{,}59)$

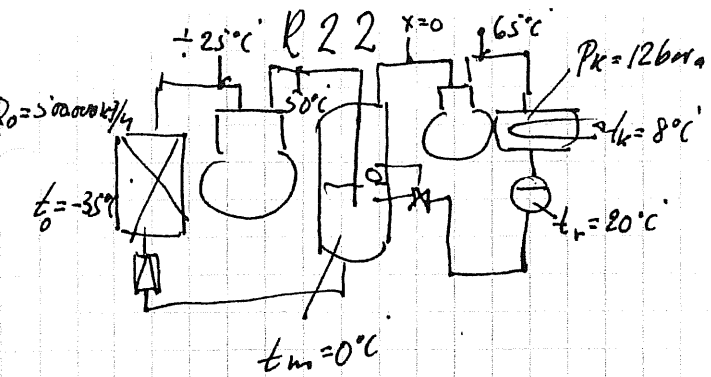
$\Rightarrow V_{r_2} = \dot m_{r_2} \cdot v = 0{,}0821 \cdot 0{,}75 = \underline{0{,}0615}$ m³/sec

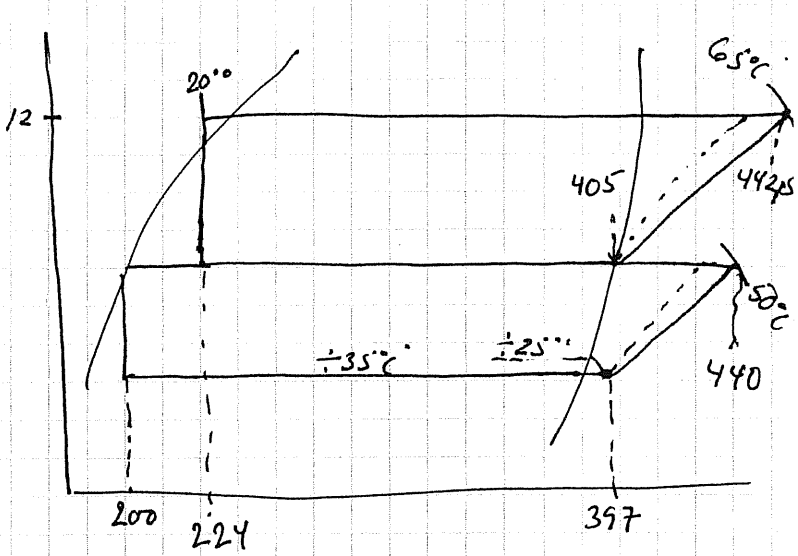
$V_{teo} = \frac{V_{r_2}}{\eta_{v_2}} = \frac{0{,}0615}{0{,}59} = \underline{0{,}10427}$ m³/sec

4.3.1 $c \cdot \frac{\pi}{4} \cdot 0{,}1^2 \cdot 0{,}075 \cdot \frac{1450}{60} = 0{,}10427 \Rightarrow c = 0{,}10427 \cdot \frac{60 \cdot 4}{\pi \cdot 1450 \cdot 0{,}075 \cdot 0{,}1^2} = 7{,}3 \approx \underline{8}$ cyl

4.3.2 $\Delta h_{komp.2} = \frac{1983-1739}{0{,}85} = \underline{287{,}1}$ kJ/kg

$P_{el\,tilf.2} = \frac{\dot m_r^2 \cdot \Delta h_{km}}{\eta_m \cdot \eta_{el}} = \frac{0{,}0821 \cdot 287{,}1}{0{,}92 \cdot 0{,}95} = 26{,}9 \approx \underline{27}$ kW





$= 500.000\ kJ/h = \frac{500.000}{3600} = \underline{138,9\ kW}$

a) $\dot{m}_{LT} = \frac{Q_0}{\Delta h_{fpd}} = \frac{138,9}{(397-200)} = \underline{\underline{0,705\ kg/s}} \approx (2540\ kg/h)$

LT-side afgiver i mellemkøler:

b) $Q_{LT} = 0,705\,(440-200) = \underline{\underline{169,2\ kW}}$ $(\approx 609120\ kJ/h)$

c) $\dot{m}_{HT} = 0,705 \cdot \frac{440-200}{405-224} = \underline{\underline{0,935\ kg/s}}$ $(3365\ kg/h)$

d) $Q_{kond.} = 0,935\,(442,5-224) = \underline{204,3\ kW}$

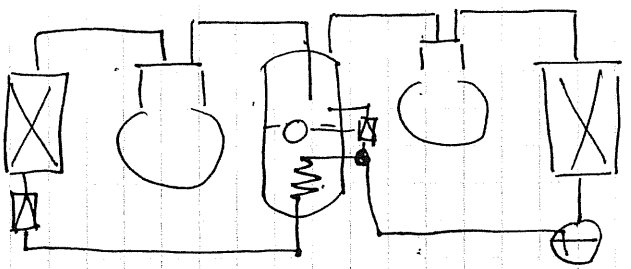
$\dot{m}_{køle.} = \frac{Q_{kond}}{c \cdot \Delta t} = \frac{204,3}{4,19 \cdot 8} = \underline{\underline{6,1\ kg/s}}$ $(21940\ kg/h)$

e) $Q_{kond} = Q_0 + \Sigma Q_{kompr.}$

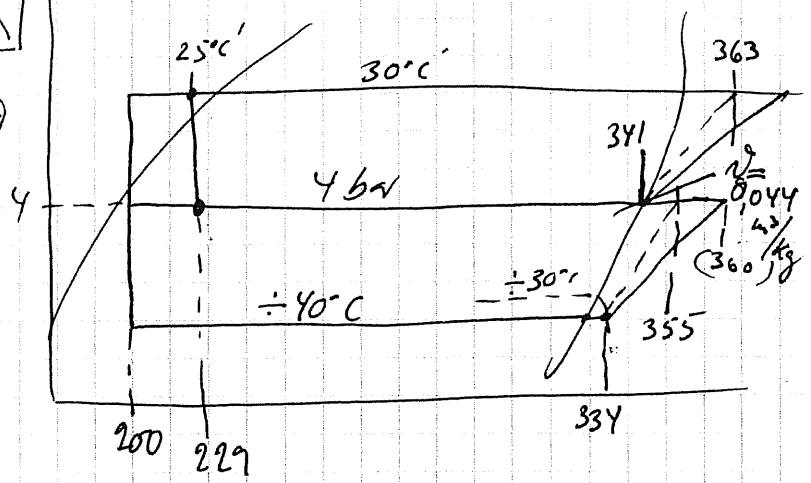
$204,3 = 138,9 + \Sigma Q_{kompr.} \Rightarrow \Sigma Q_{kompr.} = \underline{65,4\ kW}$

): $204,3 = 138,9 + 65,4$

f)
- mindre risiko for flashgas i væskeledningen
- mindre cirkuleret kølemiddelmængde i systemet.



RSD 2



$\eta_{i,s} = 0,82$
$\eta_m = 0,88$ } HT+LT
$\eta_v = 0,74$

$n_{HT} = 1450$ °/min

$h_{LT\ kompr.\ a/g} = 334 + \frac{(355-334)}{0,82} = 360\ kJ/kg$

$V_{teo_{HT}} = 8 \cdot \frac{\pi}{4} \cdot 0,08^2 \cdot 0,06 \cdot \frac{1450}{60} = \underline{0,0583\ m^3/sec.}$

$Ve_{HT} = V_{teo.HT} \times \eta_v = 0,0583 \times 0,74 = 0,04315\ m^3/sec$

$(v_g = 0,044\ m^3/kg) \Rightarrow$

$\dot{m}_{HT} = \frac{Ve_{HT}}{v_g} = \frac{0,04315}{0,044} = \underline{0,98\ kg/s}$

$\dot{m}_{LT} = 0,98\ \frac{341-229}{360-200} = \underline{0,686\ kg/sec}$

a) $\dot{m}_{rsv.v} = \dot{m}_{HT} - \dot{m}_{LT} = 0,98 - 0,686 = \underline{0,294\ kg/s}\ (1058,4\ kg/h)$

b) $\dot{Q}_0 = \dot{m}_{LT} \cdot \Delta h = 0,686\ (334-200) = \underline{92\ kW}$

c) $\Delta h_{LT} = \frac{355-334}{0,82} = \underline{25,6\ kJ/kg}$

$\Delta h_{HT} = \frac{363-341}{0,82} = \underline{26,8\ kJ/kg}$

$P_{i\,LT} = \dot{m}_{LT} \cdot \Delta h_{LT} = 0,686 \cdot 25,6 = 17,6\ kW$

$P_{i\,HT} = \dot{m}_{HT} \cdot \Delta h_{HT} = 0,98 \times 26,8 = \underline{26,3\ kW}$

$\Sigma P_i = 43,9\ kW$

$P_{tot} = \frac{\Sigma P_i}{\eta_m} = \frac{43,9}{0,88} = \underline{49,8\ kW}$