Øvelsesopgaver i Ventilationsteknik

1: a) $X = \frac{m_{damp}}{m_{luft}}$

b) $h = 2500X + (2x+1)t \; [kJ/kg\,tør\,luft]$

c) $\varphi = \frac{p_{damp}}{p_{mættet\,damp}}$

d) $20°C \Rightarrow t_{dug} = 23\,mbar$

e) $t_e = 20°C,\ \varphi = 0.8 \Rightarrow h = 50\,kJ/kg$

f) $X = 11.7\,g/kg$ og $p_d = 18\,mbar$

g) dugpunkt = den laveste temperatur, som luften kan afkøles til, uden at udskille vand

h) kølegrænse: Den laveste temperatur, som et vådt legeme kan afkøles til, med luft af en given tilstand.

i) $t_e = 20°C,\ \varphi = 0{,}6 \Rightarrow t_{dug} = \underline{11{,}5°C}$, $t_{køl} = \underline{15.5°C}$

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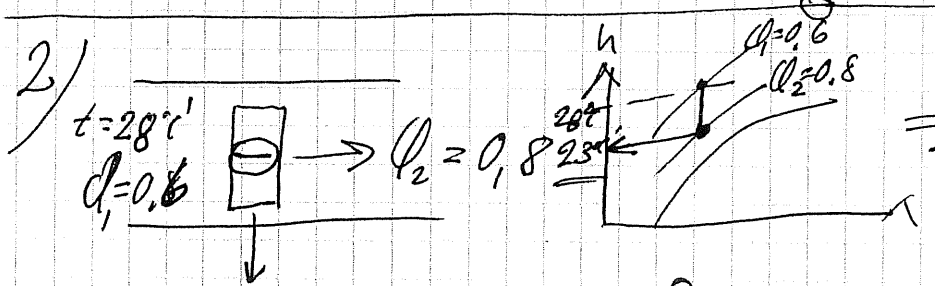
2)



$\Rightarrow t_{l_2} = \underline{23°C}$

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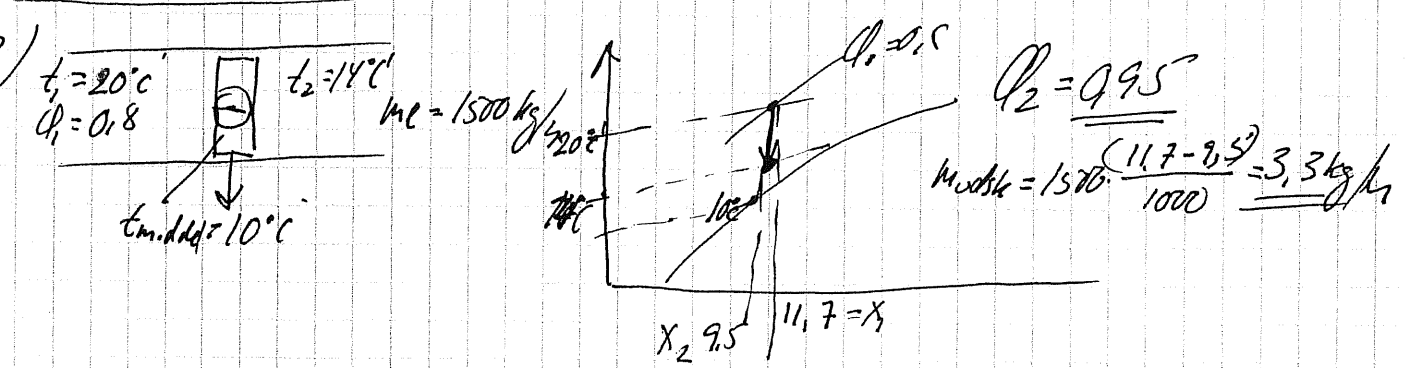
3)



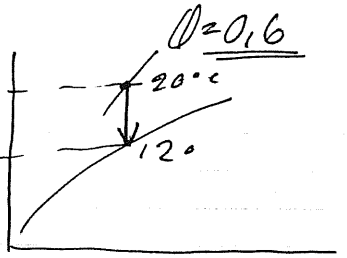
$m_{vand} = 1500 \cdot \frac{(11{,}7 - 9{,}5)}{1000} = \underline{3{,}3\,kg/h}$

Luftkølerens indblæsningsgrad $= \frac{50-38}{50-29.5} = \underline{0{,}585}$

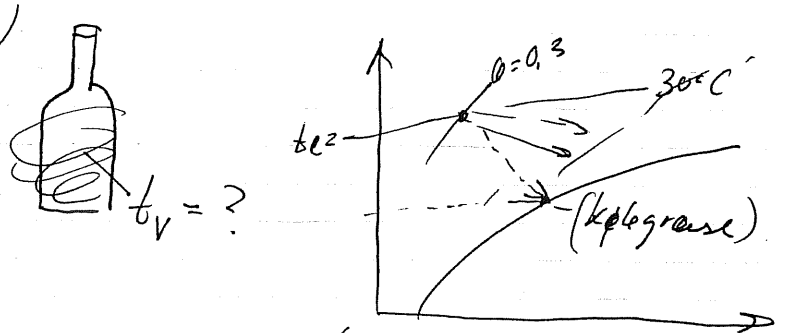
- - - temperaturvirkningsgrad $= \eta_t = \frac{20-14}{20-10} = \underline{0{,}6}$

Små opgaver i ventilation 27/1-04

4/ $t_{dug} = 12°C$ $t_e = 20°C$



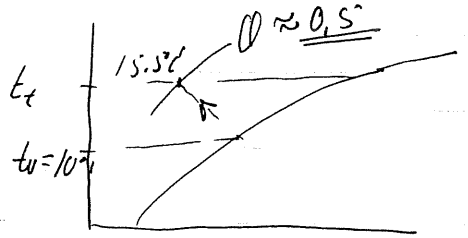
5/



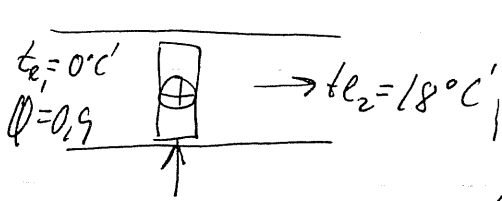
a/ $t_{min} = t_{kølegrænse} = \underline{17,5°C}$

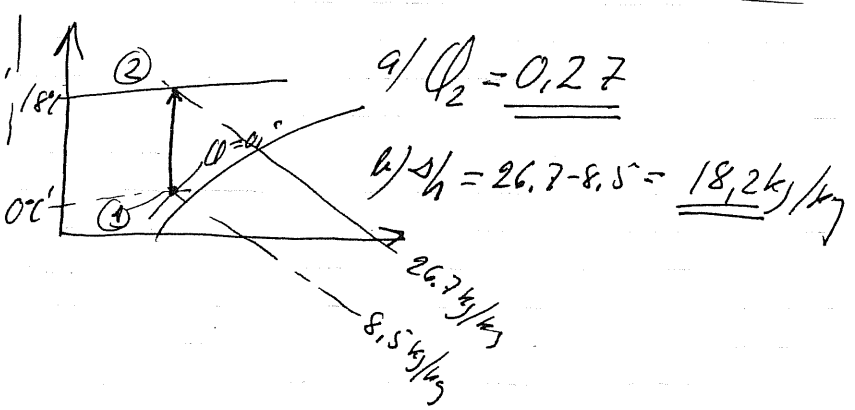
b/ Ølleds temperatur vil stige

6/



7/





a/ $Ø_2 = \underline{0,27}$

b/ $\Delta h = 26,7 - 8,5 = \underline{18,2 kJ/kg}$

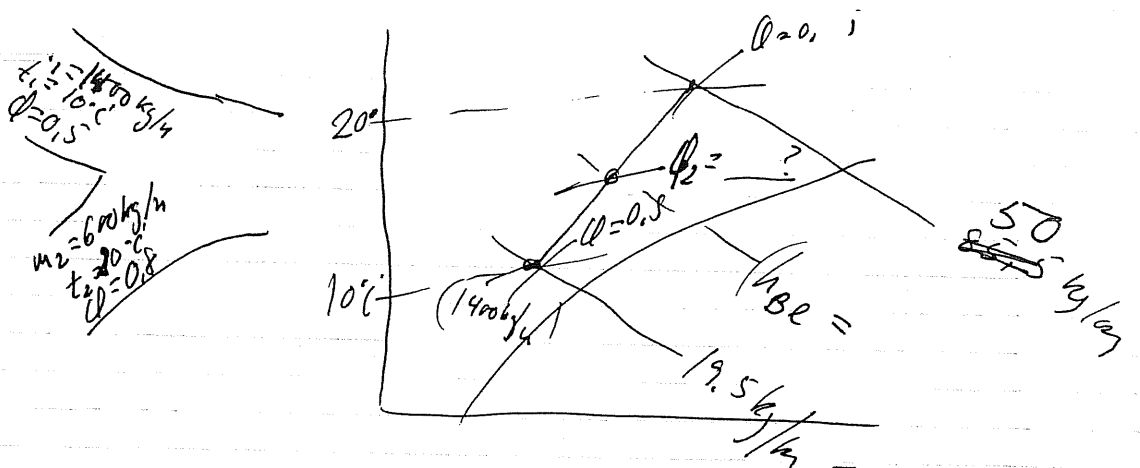
$V_{rum} = 4 \times 8 \times 3 = 96 m^3$

$\dot{V}_{ved} = 4 \times 96 = \underline{384 m^3/h}$

$\dot{m}_{ved} = 384 \times 1,293 = \underline{500 kg/h}$

$P_{kølf} = \frac{\dot{m}_{ved} \cdot \Delta h}{3600} = \frac{500 \cdot 18,2}{3600} = \underline{2,5 kW}$

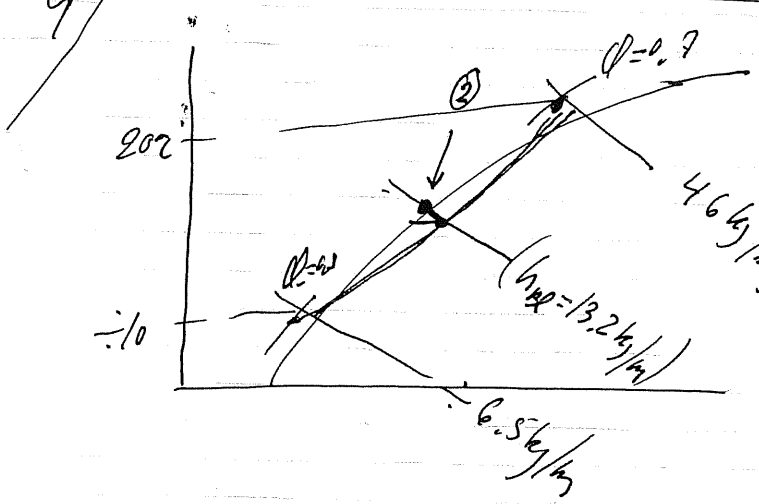
(NB: der ses bort fra luftens fugtighed)



$$h_{bl} = \frac{1400 \cdot 19{,}5 + 600 \cdot 50}{(1400+600)} = 28{,}7 \text{ kJ/kg}$$

$\varphi_2 = 0{,}65$

9)



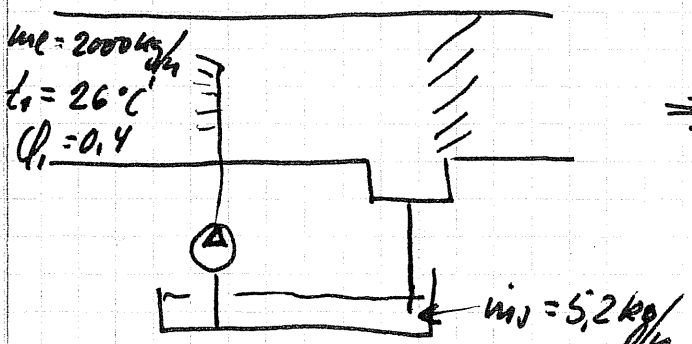
$$h_{bl} = \frac{500 \cdot 6{,}5 + 300 \cdot 46}{800} = 13{,}2 \text{ kJ/kg}$$

(ligger i tågområdet)

$\Rightarrow \varphi = 1$

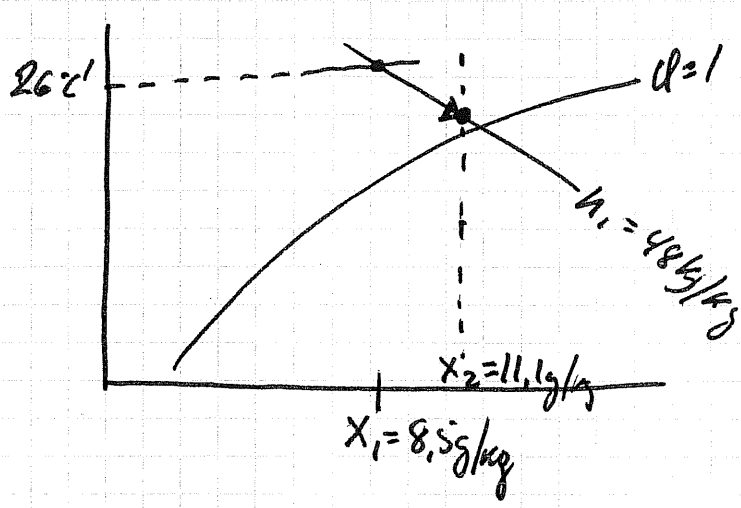
$\Delta X = 4{,}7 - 4{,}3 = 0{,}4 \text{ g/kg}$

10



$$\Rightarrow \Delta X = \frac{m_v}{m_l} = \frac{5,2 \cdot 10^3}{2000} = \underline{2,6 g/kg}$$

$$X_2 = X_1 + \Delta X = 8,5 + 2,6 = \underline{11,1 g/kg}$$

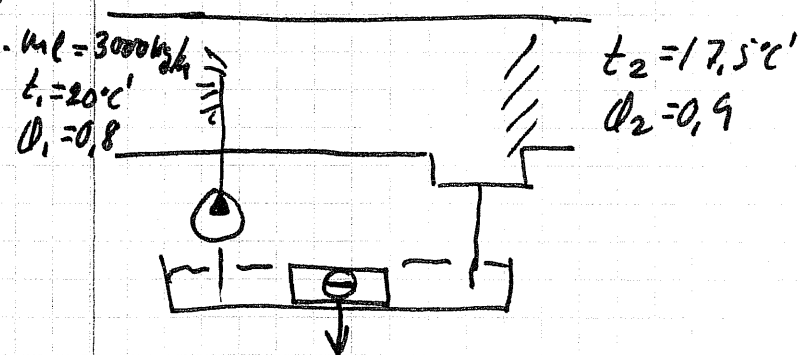


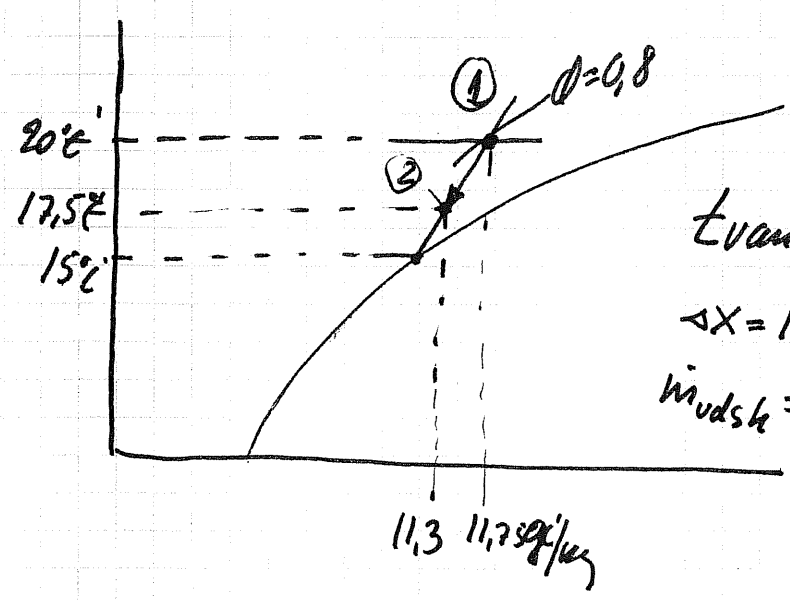
$\Rightarrow \varphi_2 = \underline{0,77}$ (aflæst)

$t_2 = \underline{19,5°C'}$ (- " -)

$$\eta_x = \frac{11,1 - 8,5}{12,25 - 8,5} \approx \underline{0,7}$$

11



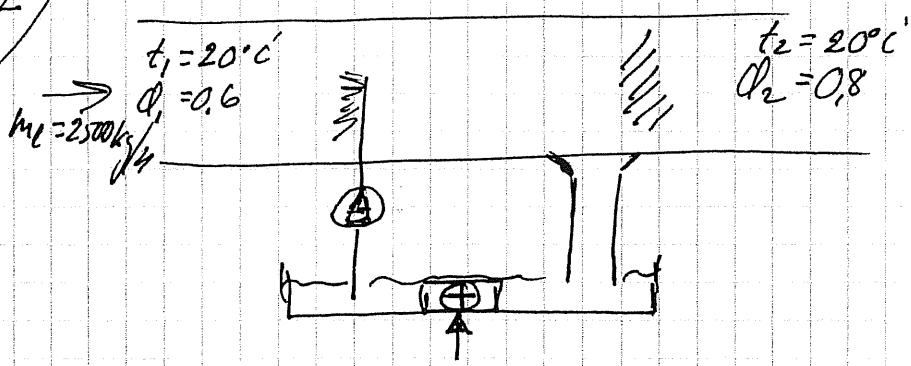


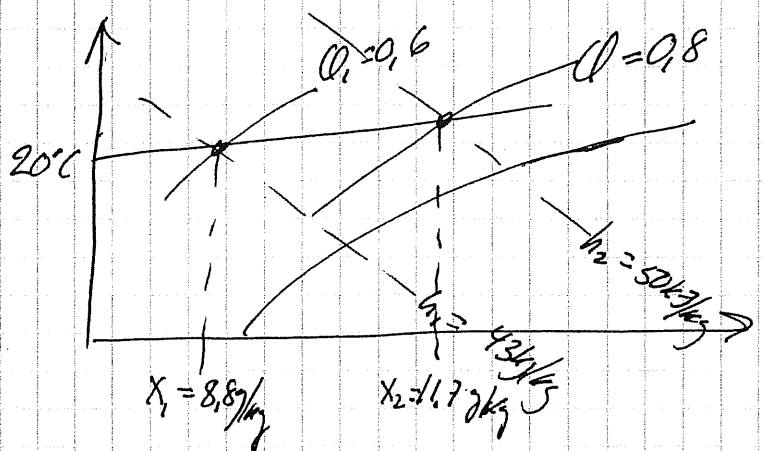
$t_{vand} = \underline{15°C'}$

$\Delta X = 11,75 - 11,3 = 0,45 g/kg$

$$m_{vdsk} = \frac{m_l \cdot \Delta x}{10^3} = \frac{3000 \cdot 0,45}{10^3} = \underline{1,35 kg/h}$$

12)





a) opnås ved at holde vandet på en middeltemperatur på ~~20°C~~ 20°C! Altså effekttilførsel.

b) Tilført effekt. $P_{tilf} = \frac{m_l}{3600}(h_2 - h_1) = \frac{2500}{3600}(50-43) = \underline{4,9kW}$

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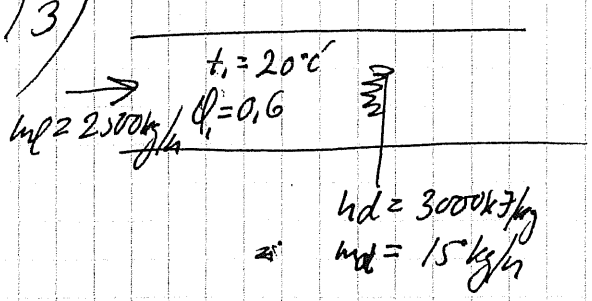
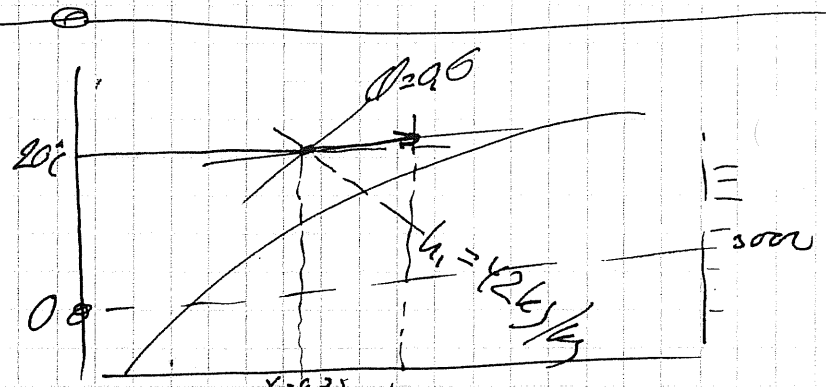
13)





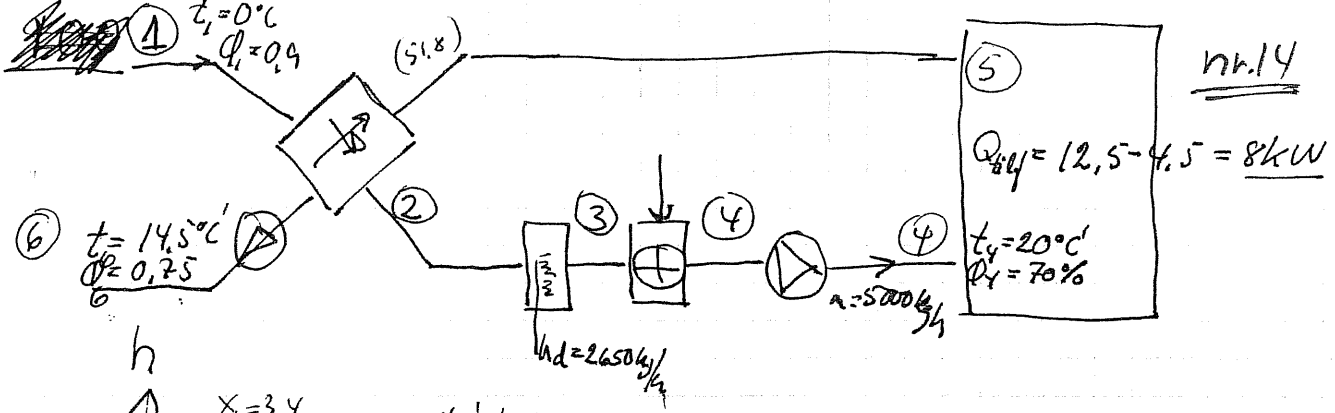
$\Delta X = \frac{15 \cdot 10^3}{4000} = 3,75 g/kg \Rightarrow X_2 = X_1 + \Delta X = 8,7 + 3,75 = \underline{11,45 g/kg}$

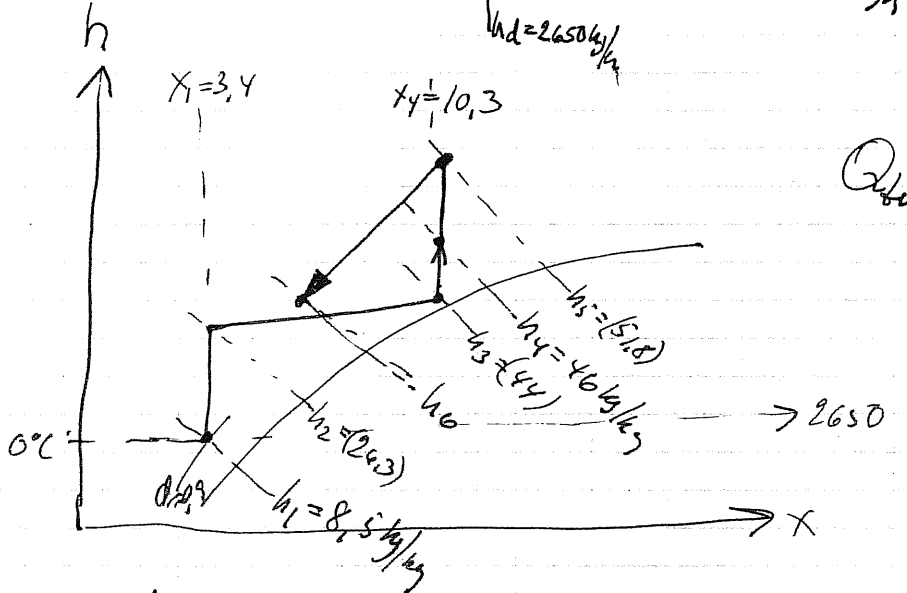
$\Delta h = \Delta X \cdot h_d = \frac{3,75}{10^3} \cdot 3000 = 11,25 kJ/kg$

$\Rightarrow h_2 = h_1 + \Delta h = 42 + 11,25 = \underline{53,25 kJ/kg}$

(tilstandene kan også beskrives ved parallelforskydning)

nr. 14





$Q_{tilf/rum} = 12,5 - 4,5 = 8kW$

$\Delta h_{rum} = \frac{8 \cdot 3600}{5000} = 5,8 kJ/kg \Rightarrow h_5 = h_4 + \Delta h = 46 + 5,8 = 51,8 kJ/kg$

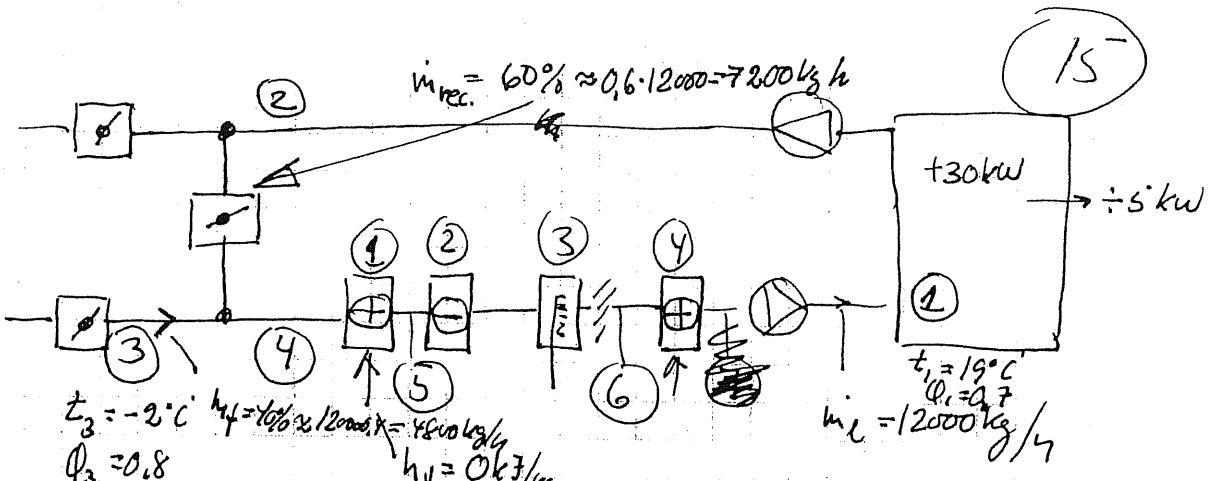
Afsat enthalpi i V.V = $\Delta h_{VV} = h_6 - h_6 = 51,8 - 34 = 17,8 kJ/kg$

Afsat enthalpi = Opløgt $\Rightarrow h_2 = h_1 + \Delta h_{VV} = 8,5 + 17,8 = 26,3 kJ/kg$

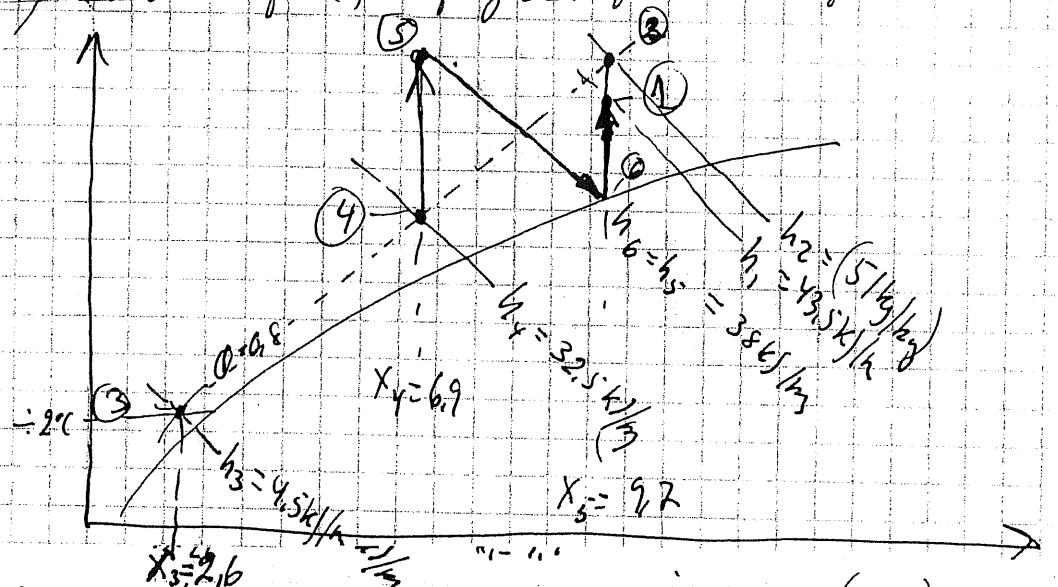
damptrindspkt. $\Rightarrow h_3 = 44 kJ/kg$

b) Effekt i efterkøleflade: $Q_{EV} = \frac{5000}{3600} \cdot (46 - 44) = 2,8 kW$ ($h_4 - h_3$)

a) Damp til befugtning $\dot{m}_V = \frac{5000}{1000} \cdot (10,3 - 3,4) = 34,5 kg/h$



a) Forvarmeflade, befugter + efter varmeflade



Afgangsentalpiforøgelse: $\Delta h_{forøg} = \frac{\dot{Q}_{forøg} \cdot 3600}{\dot{m}_l} = \frac{(30-5)\cdot 3600}{12000} = 7{,}5\,kJ/kg$

$\Rightarrow h_2 = h_1 + \Delta h_{forøg} = 43{,}5 + 7{,}5 = 51\,kJ/kg$

Beregn pkt. 4 (blandes)

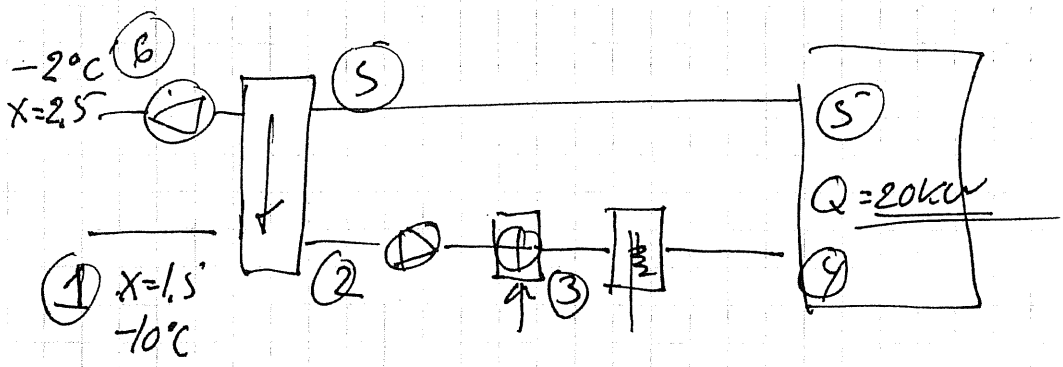
$\dot{m}_l \cdot h_4 = \dot{m}_{rec} \cdot h_2 + \dot{m}_{friskluft} \cdot h_3 = 12000 \cdot h_4 = 7200 \cdot 51 + 4800 \cdot 4{,}5 \Rightarrow h_4 = 32{,}5\,kJ/kg$

(eller $12000 \cdot X_4 = 7200 \cdot 9{,}7 + 4800 \cdot 2{,}6 \Rightarrow X_4 = 6{,}9\,g/kg$)

$$Q_{forvarmeflade} = \frac{\dot{m}_l}{3600} \cdot (h_6 - h_4) = \frac{12000}{3600} \cdot (38 - 32{,}5) = \underline{18{,}3\,kW}$$

$$Q_{efter\,v.flade} = \frac{\dot{m}_l}{3600} \cdot (h_1 - h_5) = \frac{12000}{3600}(43{,}5 - 38) = \underline{18{,}3\,kW}$$

$$\dot{m}_{befugter} = \frac{\dot{m}_l}{1000}(X_5 - X_4) = \frac{12000}{1000}(9{,}7 - 6{,}9) = \underline{33{,}6\,kg/h}$$



(Se selv.st. hx-diagram)

$\Delta X_{1\to 2} = X_2 - X_1 = 5 - 1{,}5 = \underline{3{,}5\ g/kg}$ — samme overføres $\Delta X_{5\to 6}$ $\Rightarrow X_5 = X_6 + \Delta X = 2{,}5 + 3{,}5 = 6\ g/kg$

(temp (5') er oppgitt til 22°C)

$\Rightarrow$ (5') er bestemt

- Oppvarmning fra (2) → (3) med konstant 'X' $\Rightarrow h_3$ avlesers til $\underline{35\ kJ/kg}$

- Befuktning med konstant entalpi $\Rightarrow h_4 = h_3$ og punktet er fastlagt ($h_{H_2O} = 0$)

fra (4) → (5') er dør opp. i rom: ($\Delta h_{rom} = h_5 - h_4 = 37{,}5 - 35 = 2{,}5\ kJ/kg$)

$$\dot{m} = \frac{\dot{Q}_{rom}}{\Delta h_{rom}} = \frac{20}{2{,}5} = 8\ kg/s \Rightarrow \underline{28800\ kg/h}$$

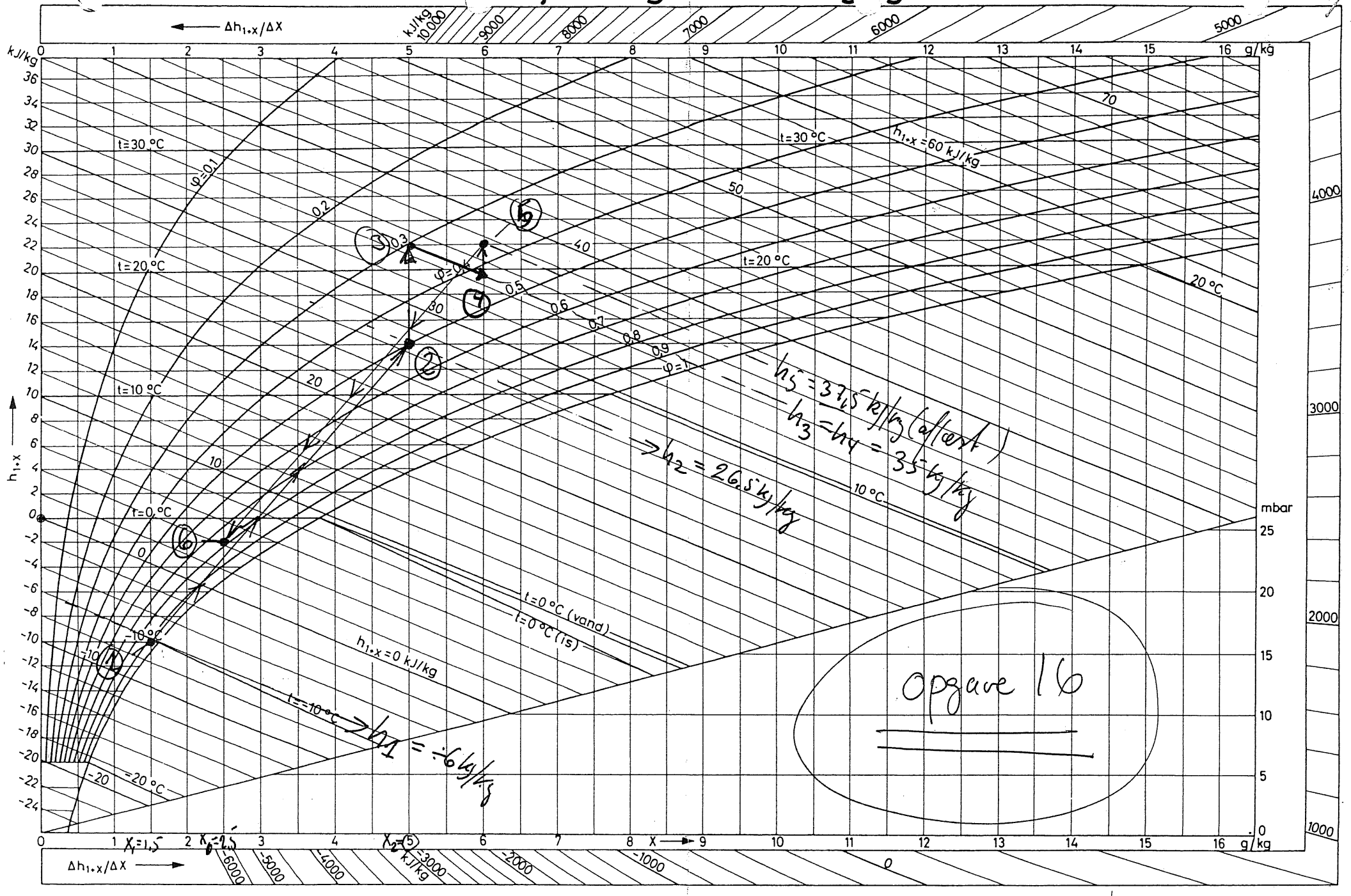
a) $Q_{fuktelyft}$: $\dot{m} \cdot (h_2 - h_1) = 8 \cdot (26{,}5 - (-6)) = \underline{260\ kW}$

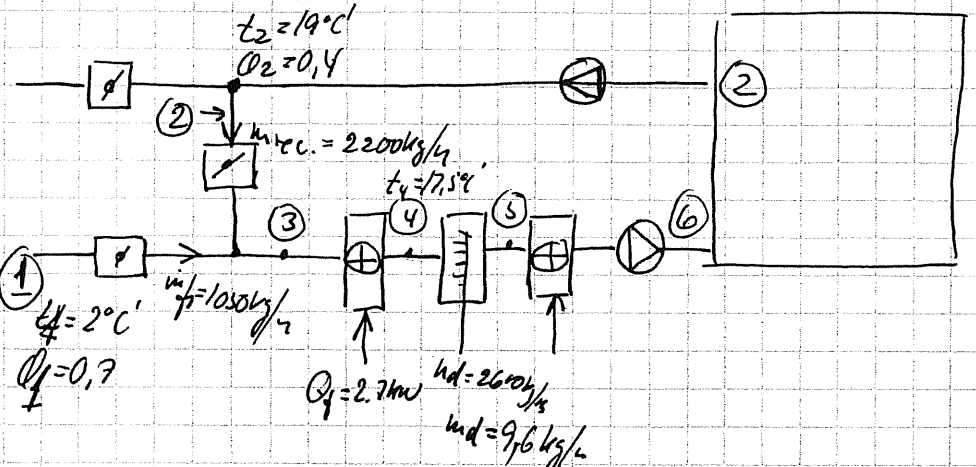
b) Vannmengde, fuktelyften oppleger: $\dfrac{\dot{m} \cdot (X_2 - X_1)}{10^3} = \dfrac{8 \cdot 3600\,(5 - 1{,}5)}{10^3} = \underline{100{,}8\ kg/h}$

c) Vannmengde i befukter: $\dot{m}_{bef} = \dfrac{\dot{m}(X_4 - X_3)}{10^3} = \dfrac{8 \cdot 3600 \cdot (6 - 5)}{10^3} = \underline{28{,}8\ kg/h}$

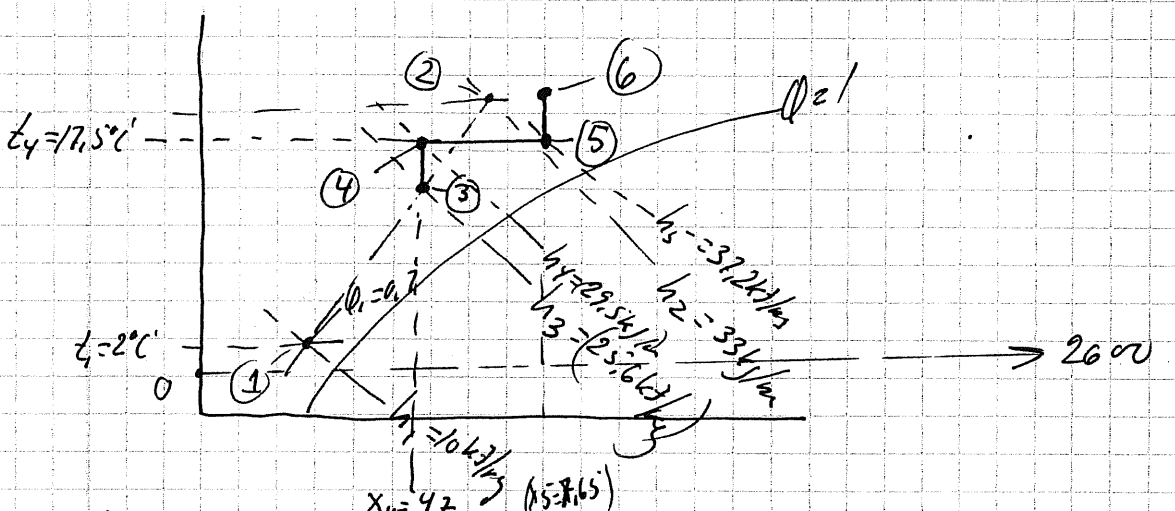
d) Varme effekt i V.V: $Q_V = \dot{m} \cdot (h_3 - h_2) = 8\,(35 - 26{,}5) = \underline{56\ kW}$

Mollier h,x-diagram for fugtig luft





Blandingspunkt pt: $h_3 = \frac{\dot{m}_{rec} h_2 + \dot{m}_{luft} \cdot h_1}{(\dot{m}_{rec} + \dot{m}_{luft})} = \frac{2200 \cdot 33 + 1050 \cdot 10}{(1050 + 2200)} = 25,6 kJ/kg$



($t_4 = 17,5°C$ og $x_3 = x_4$) $\Rightarrow$ h_4 aflæses til 29,5 kJ/kg

a) $Q_{fan} = (\dot{m}_{rec + luft}) \frac{h_4 - h_3}{3600} = (1050 + 2200) \frac{(29,5 - 25,6)}{3600} = 3,5 kW$

b) $\Delta x_{befugtet} = \frac{\dot{m}_d \cdot 10^3}{(\dot{m}_{rec + luft})} = \frac{9,6 \cdot 10^3 \cdot 10^3}{(1050 + 2200)} = 2,95 g/kg$

$x_5 = x_4 + \Delta x_{befug} = 4,7 + 2,95 = 7,65 g/kg$

($\Delta h = \Delta x \cdot h_d \Rightarrow h_5 = 29,5 + \frac{2,95}{10^3} \cdot 2600 = 37,2 kJ/kg$)

ell. ved parallelforskydning

$\Delta h_{efter\ varmeflade} = \frac{Q_{ev} \cdot 3600}{(\dot{m}_{rec + luft})} = \frac{2,7 \cdot 3600}{(1050 + 2200)} = 3 kJ/kg \Rightarrow h_6 = h_5 + \Delta h_{ev} = 37,2 + 3 = 40,2$

$\Rightarrow t_6 = 21°C$
$\varphi_6 = 0,5$
} aflæst

Moll[illegible]r h,x-diagram for fug[illegible]g luft