[redacted]

0, stationär

1) a) 1. HS: $\frac{dE}{dt} = \sum \dot{m}_i [h_i + k_{e,i} + p_{e,i}] + \sum \dot{Q}_j - \sum \dot{W}_n$ (0)

$\rightarrow 0 = \dot{m}_{ein} [h_{ein} - h_{aus}] + \dot{Q}_R - \dot{Q}_{aus}$

$\rightarrow \dot{Q}_{aus} = \dot{m}_{ein} [h_{ein} - h_{aus}] + \dot{Q}_R$

h_{ein}: aus TAB A-2: $h_{ein} = 292.98$ kJ/kg

h_{aus}: aus TAB A-2: $h_{aus} = 419.04$ kJ/kg

$\rightarrow \dot{Q}_{aus} = 0.3\,kg/s \cdot [292.98 - 419.04]\,kJ/kg + 100\,kW$

$= 62.182\,kW$

b) $\overline{T}_k = \frac{\int_e^a T\,ds}{s_a - s_e} = \frac{h_a - h_e}{s_a - s_e}$

0, da $p_{aus} = p_{ein}$

ideale Flüssigkeit $\rightarrow$ $h_a - h_e = c_f (T_A - T_E) + v_f (p_2 - p_1)$

$s_a - s_e = c_f \cdot \ln\left(\frac{T_A}{T_E}\right)$

$\rightarrow \overline{T}_k = \frac{c_f (T_A - T_E)}{c_f \ln\left(\frac{T_A}{T_E}\right)} = \frac{T_A - T_E}{\ln\left(\frac{T_A}{T_E}\right)} = 293.12\,K$

c) Entropiebilanz: $\frac{dS}{dt} = \sum \frac{\dot{Q}_j}{T_j} + \dot{S}_{erz}$ (0)

$\rightarrow \dot{S}_{erz} = \frac{\dot{Q}_{aus}}{\overline{T}_k} = \frac{62.182\,kW}{293.12\,K} = 0.212\,kJ/K$

d) 1. HS: ~~$\Delta E = \Delta m_{12} u_{ein} + \delta L$~~

$\Delta E = \sum \Delta m_i [h_i + k_i + p_{e,i}] + \sum Q_j - \sum W_n$ (0)

$m_{ges,2} u_2 - m_{ges,1} u_1 = \Delta m_{12} h_{ein} + Q_{R12}$

u_1: aus TAB-A2 $u_1 = u_f(100°C) + x_D (u_g(100°C) - u_f(100°C))$

$= 429.38\,kJ/kg$

u_2: aus TAB-A2: $u_f = 292.95\,kJ/kg = h_2$

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1) d) weiter: h_{ein}: aus TAB-A2: $h_{ein} = 83.896\ kJ/kg$

$\rightarrow m_{ges,1}(u_2 - u_1) + \Delta m_{12} u_2 = \Delta m_{12} h_{ein} + Q_R$

$\rightarrow \Delta m_{12} = \dfrac{m_{ges,1}(u_2 - u_1) - Q_R}{h_{ein} - u_2} = 3923.45\ kg$

e) $\Delta S_{12} = (m_{ges,1} + \Delta m_{12}) s_2 - m_{ges,1} s_1$

$\rightarrow s_1 = 1.337\ \frac{kJ}{kg\,K}$

$s_2 = 0.9549\ \frac{kJ}{kg\,K}$

$\rightarrow \Delta S_{12} = 1547.5\ \frac{kJ}{K}$

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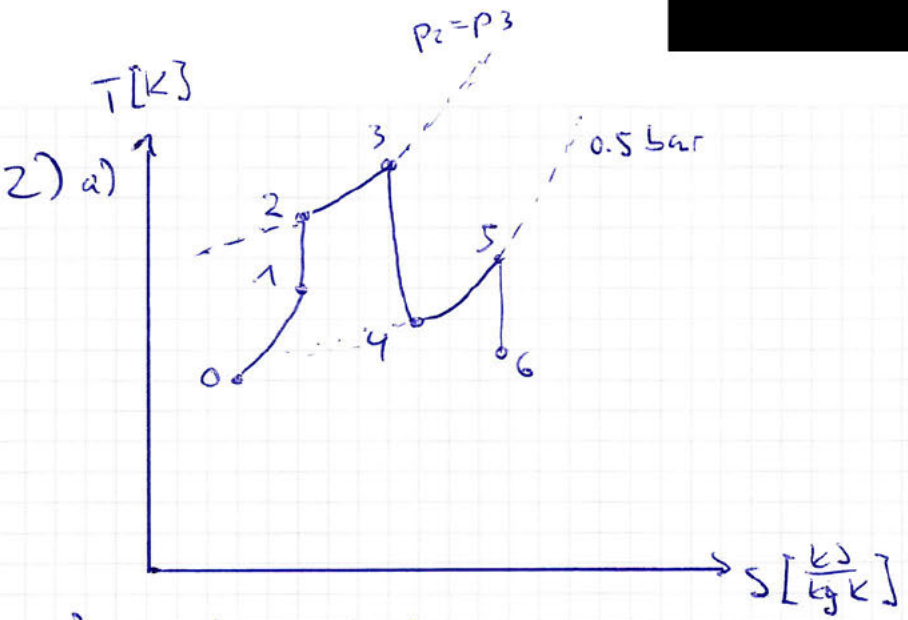


b) → isentrope schaufeldüse

$$\Rightarrow \frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}}$$

$$\hookrightarrow T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 431.9\,K \left(\frac{0.191}{0.5}\right)^{\frac{0.4}{1.4}}$$

$$= 328.07\,K = T_6$$

1. HS: $\frac{dE}{dt} = \dot{m}\left[h_5 + \frac{w_5^2}{2} - h_6 - \frac{v_6^2}{2}\right] + \sum \dot{Q}_i - \sum \dot{W}_n$

$$w_6 = \left(\left(h_5 + \frac{w_5^2}{2} - h_6\right) \cdot 2\right)^{1/2}$$

$$h_5 - h_6 = c_p (T_5 - T_6)$$

$$\rightarrow w_6 = \sqrt{2} \cdot \left(c_p (T_5 - T_6) + \frac{w_5^2}{2}\right)^{1/2} = 257.31\,m/s$$

c) $w_6 = 510\,m/s$, $T_6 = 340\,K$

aus Formelsammlung

$$e_{x,sf} = h_6 - h_0 - T_0 (s_6 - s_0) + \frac{w_6^2 - w_0^2}{2}$$

$$h_6 - h_0 = c_p (T_6 - T_0) \qquad s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right) - R \cdot \ln\left(\frac{p_6}{p_0}\right)^{=0,\ da\ p_6 = p_0}$$

$$\rightarrow = c_p (T_6 - T_0) - T_0 c_p \ln\left(\frac{T_6}{T_0}\right) + \frac{v_6^2 - v_0^2}{2}$$

$$= 125.47\,kJ/kg$$

2) d) ~~1. HS: $0 = \dot{m}_{Ges}\left(h_0 - h_G + \frac{w_0^2 - w_G^2}{2}\right) - \dots$~~

Exergiebilanz: $0 = -\sigma_{ex,str} + \left(1 - \frac{T_U}{T_B}\right)\dot{Q}_B - E_{x,vel}$

$\Rightarrow E_{x,vel} = \left(1 - \frac{T_U}{T_B}\right)\underbrace{\dot{Q}_B}_{\dot{m}_{Dys}} - \sigma_{ex,str}$

$= \left(1 - \frac{T_U}{T_B}\right) q_B - \sigma_{ex,str} = 844.11\ kJ/kg$

3) a) $A = \left(\frac{D}{2}\right)^2 \pi = 0.00785\,m^2$

$p_K = \frac{m \cdot g}{A} = 39990\,Pa = 39.99\,kPa$

$p_{EW} \approx 0.6108\,kPa \rightarrow$ TAB A-6

$p_G + p_{EW} = p_K + p_{amb}$

$\rightarrow p_G = p_K + p_{amb} - p_{EW} = \underline{1.394\,bar}$

b) $pV = nRT \rightarrow m = \frac{pV}{RT}$

$\rightarrow V = 0.00314\,m^3 \quad R = \frac{\bar{R}}{M} = \frac{8.314\,kJ/kmol}{50\,kg/kmol} = 0.16628\,\frac{kJ}{kg}$

$\rightarrow m_G = 3.405\,g$

c) $T_{s/2} = 0.003°C$

1. HS: $\Delta U = Q_{12}$

$\rightarrow m(u_2 - u_1) = Q_{12} \quad u_2 - u_1 = c_v(T_2 - T_1)$

$\rightarrow Q_{12} = m_G c_v (T_2 - T_1) = -1.08\,kJ$

d) 1. HS: $\Delta U_{12} = -Q_{12} = 1.08\,kJ$

$m_{EW}(u_2 - u_1) = 1.08\,kJ$

$u_1 = -0.045 + 0.6(-333.458 + 0.045)$

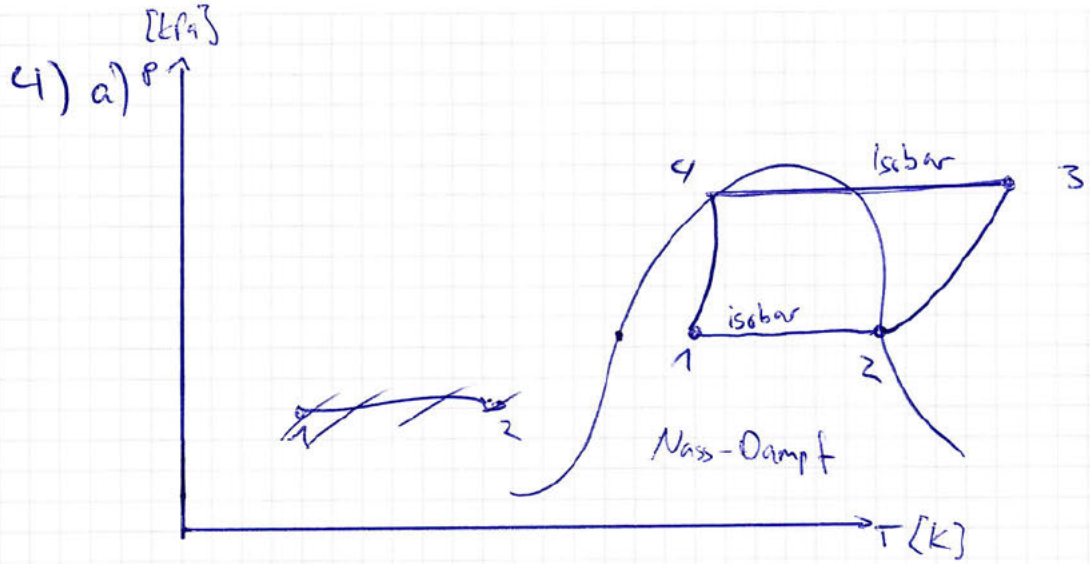
$= -200.093\,kJ/kg$

$u_2 = 1.08\,kJ + m_{EW} \cdot (-200.093)\,kJ/kg = -18.99\,kJ/kg$

$\rightarrow x_2 = \frac{u_2 - u_f}{u_g - u_f}\,(\text{at } 0.003°C) = 0.05686$

$\downarrow T_2$

4) a)



b) $T_i = -10\,°C$ $T_{Verdampfer} = -16\,°C$

$p_4 = 8\,bar$ $x_4 = 0$

~~$s_4 = 0.3452\ kJ/kgK = s_1$~~

$h_4 = 93.42\ kJ/kg = h_1$, weil ~~Drossel isenthalp~~

c) ~~$\dot{m}_{Kälte} = \dots\ kg/s$~~ $T_2 = -22\,°C$

b) $h_3 = 264.15\ kJ/kg$ -> TAB A-11

$h_2 = 237.74\ kJ/kg$ -> TAB A-10

1. HS: $0 = \dot{m}[h_2 - h_3] + \dot{W}_K$

$\rightarrow \dot{m} = \frac{\dot{W}_K}{[h_3 - h_2]} = 0.000106\ kg/s$

1. HS Verdichter: $0 = \dot{m}[h_2 - h_3] - \dot{W}_K$

1. HS Verdampfer: $0 = \dot{m}[h_1 - h_2] + \dot{Q}_K$

1. HS Kondensator: $0 = \dot{m}[h_3 - h_4] + \dot{Q}_{ab}$

4.c) $\dot{m} = \frac{4kg}{h}$ $T_2 = -22°C$

$p_2 = p_1 = 1.2112$ bar → TAB A-10

1. HS Drossel: $0 = \dot{m}[h_4 - h_1]$

→ $h_1 = h_4 = 93.42\ kJ/kg$ → TAB A-11

→ x_1: $h_1 = 93.42\ kJ/kg$

$h_1 = h_f + x_1 (h_g - h_f)$ → bei $T = -22°C$

$x_1 = \frac{h_1 - h_f}{h_g - h_f} = 0.3375$

d) $\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \frac{|\dot{Q}_K|}{|\dot{W}_K|}$

1. HS Verdampfer: $0 = \dot{m}[h_1 - h_2] + \dot{Q}_K$

→ $\dot{Q}_K = \dot{m}[h_2 - h_1]$

$h_2 = 234.08\ kJ/kg$ → TAB - A10

→ $\frac{4kg}{h} \cdot \frac{h}{60min} \cdot \frac{min}{60s} \cdot [234.08 - 93.42]\ kJ/kg = 156.3\ W$

↳ $\varepsilon_K = \frac{156.3\ W}{28\ W} = 5.582$

e) Temperatur bleibt gleich, da das Wasser zuerst zürcke in den festen Zustand geht, bevor es weiter gekocht wird.