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Aufgabe 1:

a) Energiebilanz:

$$0 = \dot{m}_{ein}\left(h_{ein} - h_{aus}\right) \mp \dot{Q}_{aus} + \dot{Q}_R$$

$$0 = \dot{m}_{ein}\left(h_f(70°C) - h_f(100°C)\right) - \dot{Q}_{aus} + \dot{Q}_R$$

$$\Rightarrow \quad \dot{m}_{ein} = 0.3\,\frac{kg}{s}$$

$$h_f(70°C) = 292.98\,\frac{kJ}{kg}$$

$$h_f(100°C) = 419.04\,\frac{kJ}{kg}$$

$$\dot{Q}_{aus} = \dot{m}_{ein}\left(h_f(70°C) - h_f(100°C)\right) + 100\,kW$$

$$\dot{Q}_{aus} = \underline{\underline{62.182\,kW}}$$

b) $$\overline{T}_{KF} = \frac{\int_e^a T\,ds}{s_a - s_e}$$

ideale Flüssigkeit: $s_a - s_e = \int_{T_{K,ein}}^{T_{K,aus}} \frac{c^{if}(T)}{T}\,dT$

$p_{KF,aus} = p_{KF,ein} \Rightarrow$ isobar + adiabat = reversibel = isentrop

$$\overline{T}_{KF} = \frac{T_{KF,aus} + T_{KF,ein}}{2} = \underline{\underline{293.15\,K}}$$

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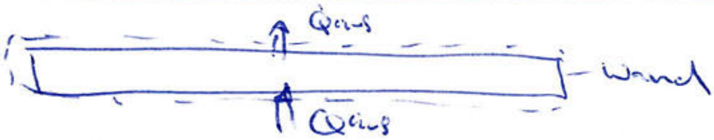
c) $\overline{T}_{KF} = 295\,K$ / $\dot{Q}_{aus} = 65\,kW$



$$0 = \frac{\dot{Q}_{aus}}{T_{Reaktor}} - \frac{\dot{Q}_{aus}}{\overline{T}_{KF}} + \dot{S}_{erz}$$

$T_{Reaktor} = 373.15\,K$

$$\dot{S}_{erz} = \frac{\dot{Q}_{aus}}{\overline{T}_{KF}} - \frac{\dot{Q}_{aus}}{T_{Reaktor}} = \underline{46.146\,kJ}$$

d) $\Delta E = \Delta m_{ein} h_{ein} + \cancel{Q_e} - \cancel{Q_{aus}} - \cancel{W_{\nearrow}}$

$m_2 u_2 - m_1 u_1 = \Delta m_{ein} h_{ein}$ mit $m_2 = m_1 + \Delta m_{ein}$

$(m_1 + \Delta m_{ein}) u_2 - m_1 u_1 = \Delta m_{ein} h_{ein}$

$m_1 u_2 + \Delta m u_2 - m_1 u_1 = \Delta m_{ein} h_{ein}$

$\Delta m_{ein}(h_{ein} - u_2) = m_1 u_2 - m_1 u_1 = m_1(u_2 - u_1)$

$$\Delta m_{ein} = \frac{m_1 (u_2 - u_1)}{(h_{ein} - u_2)}$$

Tabelle:

$u_2 = u_2(70°C) = 292.95 \frac{kJ}{kg}$

$u_1 = u_1(100°C) = 418.94 \frac{kJ}{kg}$

$h_{ein} = h_f(70°C) = 83.96 \frac{kJ}{kg}$

$m_1 = 5755\,kg$

$$\Delta m_{ein} = \frac{5755\,kg\,(u_2 - u_1)}{(h_{ein} - u_2)} = \underline{\underline{3469.4\,kg}}$$

$$\underline{\underline{\Delta m_{12} = 3469.4\,kg}}$$

e) $\Delta S = m_2 s_2 - m_1 s_1$

$m_1 = 5755\,kg$

$m_2 = \Delta m_{12} + m_1 = 9224.4\,kg$

$s_2(70°C) = 0{,}9549 \frac{kJ}{kg}$

$s_1(100°C) = 1.3069 \frac{kJ}{kg}$

Tabelle

~~$\Delta S = \Delta m_{12} s_{12} + \ldots$~~

$\Delta S = 16329.6\,kJ = \underline{\underline{16.33\,MJ}}$

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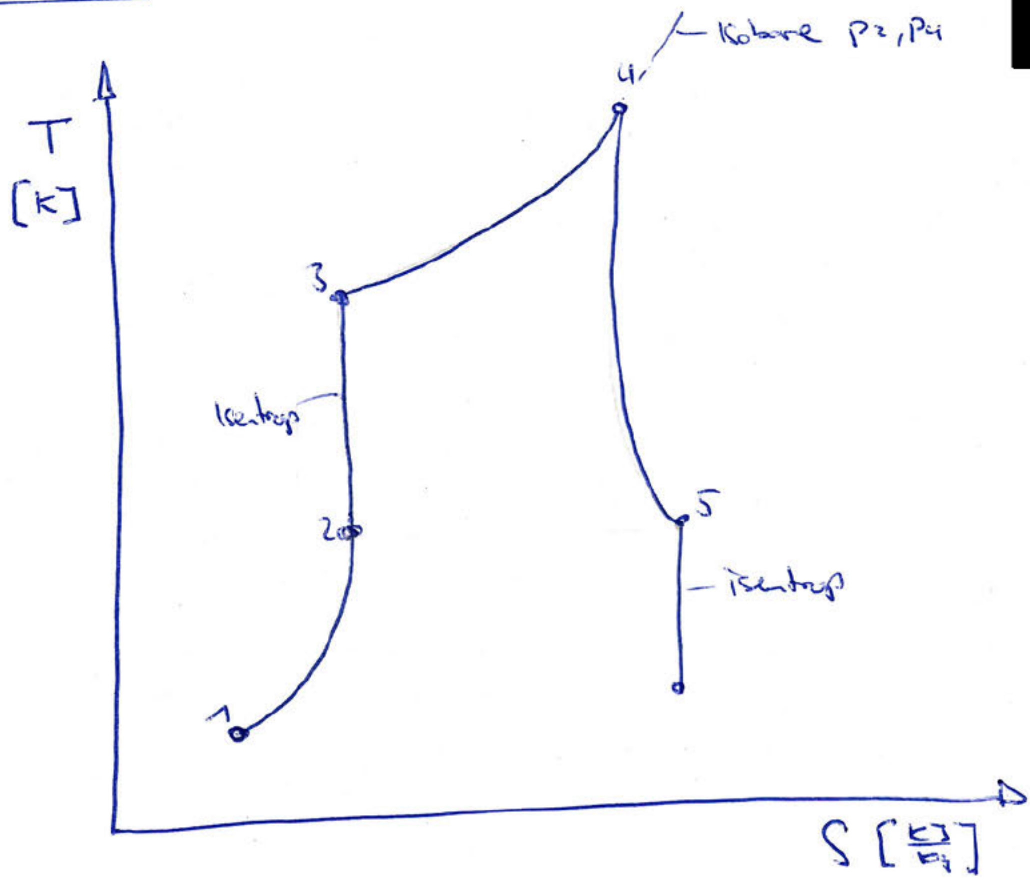
Aufgabe 2:

a)



b) w_6 / T_6:

$$s_5 = s_6$$

$$0 = \Delta s = \int_{T_5}^{T_6} \frac{c_p^{ig}(T)}{T}\, dT - R \ln\left(\frac{p_0}{p_5}\right)$$

$$0 = c_p^{ig}\left(\ln\left(\frac{T_6}{T_5}\right) - R \ln\left(\frac{p_0}{p_5}\right)\right)$$

auch: $\frac{T_6}{T_5} = \left(\frac{p_0}{p_5}\right)^{\frac{n-1}{n}} \Rightarrow T_6 = T_5 \left(\frac{p_0}{p_5}\right)^{\frac{n-1}{n}} = \cancel{328.08}$ $\underline{\underline{328.07\,K}}$

$$0 = \dot m\left((h_5 - h_6) + \frac{w_5^2 - w_6^2}{2}\right) \overset{0 \text{ adiabat}}{\cancel{+ \sum \dot Q}} - \sum \dot W_{t,in}$$

$$0 = h_5 - h_6 + \frac{w_5^2 - w_6^2}{2} - \dot w$$

$\cancel{2(h_6 - h_5 + \dot w)}$ $\quad w_6 = \sqrt{2\left(h_5 - h_6 - \dot w + \frac{w_5^2}{2}\right)}$

$$\dot{w} = \frac{R(T_6 - T_5)}{1-n} =$$

$$c_v = \frac{c_p}{k}$$

$$R = c_p - \frac{c_p}{k} = 0{,}2879 \frac{kJ}{kg\,K}$$

$$\dot{w}_t = \underline{259.56\ kJ}$$

$$w_5 = 220 \frac{m}{s}$$

ideal Gas

$$w_6 = \sqrt{2\left((h_5 - h_6) - \dot{w}_t\right) + \frac{w_5^2}{2}}$$

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

$$w_6 = \sqrt{2\left(c_p(T_6 - T_5) - \frac{R(T_6 - T_5)}{1-n}\right) + \frac{w_5^2}{2}}$$

$$\underline{\underline{w_6 = 551.5 \frac{m}{s}}}$$

c) $w_6 = 510 \frac{m}{s}$ / $T_6 = 340 K$

$$0 = \dot{m}\left(h_{ein} - h_{aus} - T_0 (s_{ein} - s_{aus}) + \frac{w_5^2 - w_6^2}{2}\right) + \dot{W}_{t,n} - \dot{E}_{x,verl}$$

$$\Delta e_{x,str} = h_6 - h_0 - T_0 (s_6 - s_0) + \frac{w_5^2 - w_6^2}{2}$$

$$\Delta e_{x,str} = c_p\left(T_6 - T_0 - T_0 \ln\left(\frac{T_6}{T_0}\right)\right) + \frac{w_5^2 - w_6^2}{2}$$

$$h_6 - h_0 = c_p (T_6 - T_0)$$

$$s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right)$$

d) $\dot{E}_{x,verl} = T_0 \dot{S}_{erz}$

$$\dot{S}_{erz} = \dot{m}(s_{aus} - s_{ein})$$

$$e_{x,verl} = T_0 (s_{aus} - s_{ein}) =$$

Aufgabe 3:

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a) p_{g1} / m_g

$$m_g = \frac{p_{g1} \cdot V_{g1}}{R_g T_{g1}}$$

$$p_{g,1} = p_{amb} + \frac{m_K \cdot g}{\left(\frac{D}{2}\right)^2 \cdot \pi} + \frac{m_{EW} \cdot g}{\left(\frac{D}{2}\right)^2 \cdot \pi}$$

$$p_{g,1} = \underline{\underline{1,401 \text{ bar}}}$$

$$m_g = \underline{\underline{3.422 g}}$$

$$R_g = \frac{\bar{R}}{M_g} = 0,16628 \frac{kJ}{kKg}$$

b)

c) Energiebilanz am Gas

$$\Delta E = Q_{12} - W_v$$

$$V_2 = \frac{m_g R_g T_{g,2}}{p_2}$$

$$m(u_2 - u_1) + W_v = Q_{12}$$

$$m c_v (T_{g,2} - T_{g,1}) + \frac{R(T_{g2} - T_{g1})}{1-n} = Q_{12}$$

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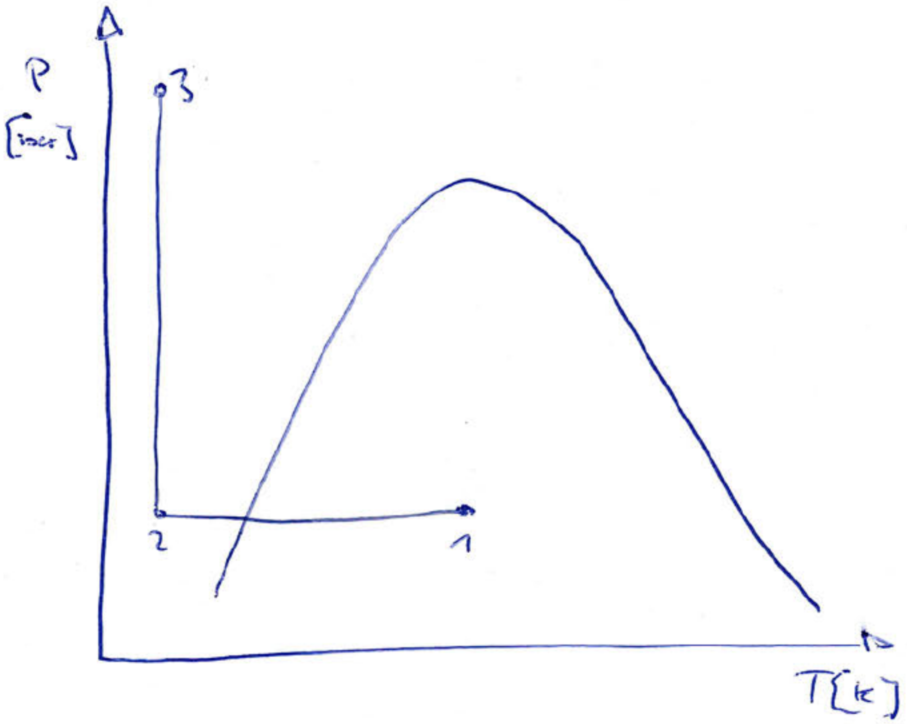
Aufgabe 4

a)



b) $0 = \dot{m}_R (h_2 - h_3) - \dot{W}_K$

$\dot{m}_{R134a} = \frac{\dot{W}_K}{(h_2 - h_3)}$

h_3 = interpolation mit $s_2 = s_3$

c) $h_3 = x h_{3g} + (1-x) h_{3f}$

$h_4 = 93{,}42 \frac{kJ}{kg}$ Tabelle

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

$\dot{Q}_K = \dot{m}_{R134a} (h_2 - h_1)$

e)