Aufgabe 1 Reaktor

a) stationärer fliessprozess

weil wärme aus System

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

$\dot{m}_{ein} = \dot{m}_{aus}$

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

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

$\hookrightarrow p_{KF}^e = p_{KF}^a \Rightarrow$ isobar

$\Rightarrow 0 = \dot{m}_{KF}(s_{KF\,ein} - s_{KF\,aus}) + \frac{\dot{Q}_{aus}}{\overline{T}}$

$\Rightarrow \frac{\dot{Q}_{aus}}{s_{KF\,EIN} - s_{KF\,aus}} = \overline{T}$

$\hookrightarrow \overline{T} = \frac{T_{aus} - T_{EIN}}{\ln\left(\frac{T_{aus}}{T_{EIN}}\right)} = 357.34\,K$

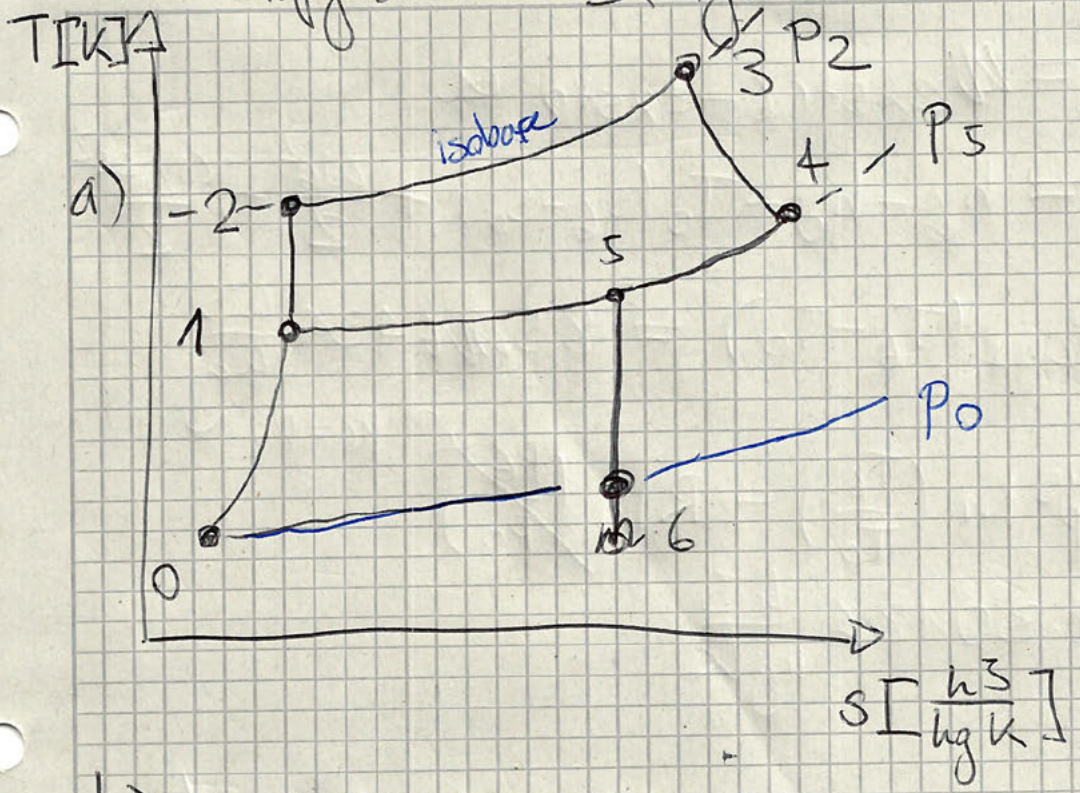
c) $\dot{S}_{erz} = \frac{\dot{Q}_{aus}}{T_{Reaktor}} + \frac{\dot{Q}_{aus}}{\overline{T}} =$

$= -\frac{\dot{Q}_{aus}}{T_{Reaktor}} + \frac{\dot{Q}_{aus}}{\overline{T}} = 46.146\,\frac{kJ}{K}$

d)

e) $\Delta S_{12} = m (s_2 - s_1)$

Aufgabe 2 Exergie am Triebwerk [redacted]



b) Schubdüse adiab, reversibel

$\Rightarrow s_5 = s_6$ isentrope

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

$$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{\kappa-1}{\kappa}} = \underline{328.075\,K}$$

$\Rightarrow$ 1HS von an der Subdüse

$$0 = \dot{m}_2 \left(h_5 - h_6 + \frac{w_5^2}{2} - \frac{w_6^2}{2}\right)$$

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

$$h_5 - h_6 = c_{p,Luft}^{ig} (T_5 - T_6) = 103.888 \frac{kJ}{kg}$$

$$w_6 = \sqrt{2\left(h_5 - h_6 + \frac{w_5^2}{2}\right)} = \underline{506.14\,\frac{m}{s}}$$

c) $\Delta ex_{str} = ex_{str6} - ex_{sto}$

$= h_6 - h_0 - T_0(s_6 - s_0) + \frac{w_6^2}{2} - \frac{w_{Luft}^2}{2}$

$h_6 - h_0 = c_{p_{Luft}}^{ig}(T_6 - T_0) = 85.\overline{84434}\ \frac{kJ}{kg}$

$s_6 - s_0 = c_p^{ig} \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right)^{0}$ $\quad p_6 = p_0$

$= 0.30136\ \frac{kJ}{kgK}$

$\Delta ex_{str} = ex_{str6} - ex_{str0} =$ [illegible]

$= 120.247\ \frac{kJ}{kg}$

d)

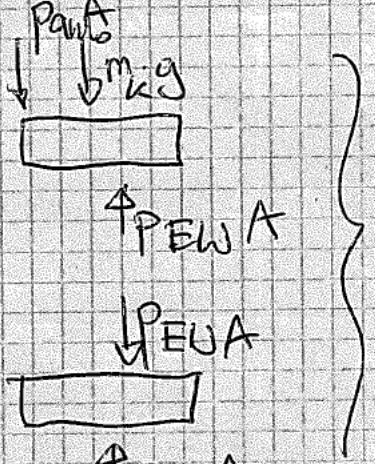
$0 = \dot{m}_L \left(ex_{str0} - ex_{str6}\right) + \left(1 - \frac{T_0}{T}\right) Q_B - W_t - \dot{E}x_{verl}$

$ex_{verl} = ex_{str0} - ex_{str6} + \left(1 - \frac{T_0}{T_B}\right) q_B - w_t^{0}$

$= 849.335\ \frac{kJ}{kg}$

Aufgabe 3 Schweben von Eis durch perfektes Gas

a) $T_{g,1} = 500°C$ $V_{g,1} = 3.14\,L$



$A = \frac{\pi}{4} D^2 = 0.00785\,m^2$

$P_{G1} = P_{EW1}$

$\Rightarrow P_{A1} = P_{amb} + \frac{m_k \cdot g}{A}$

$= 1.40\,bar$

$P_{1G} V_{1G} = m_G R_G T_{1G}$

$R_G = \frac{R}{M_G} = 0.1628 \frac{kJ}{kgK}$

$m_G = \frac{P_{1G} \cdot V_{1G}}{R_G \cdot T_{1G}} = 3.419\,gramm$

b) der Deckel bleibt konst $\Rightarrow P_{1G} = P_{2G} = 1.4\,bar$

↳ reibungsfrei

m_G bleibt auch const

$T_{2,G}$ muss $= T_H = 0°C$ ↝ Eis noch nicht geschmolzen

↳ Thermo Gleichgewicht

/HS in bride

$$m_W(u_{2W}-u_{1W})+m_G(u_{2G}-u_{1G}) \overset{!}{=} 0$$

$$m_W = 0.4\, m_{EW}$$

$$V_{2G} = \frac{m_G \cdot R \cdot T_{2G}}{p_{2G}} = 0.0011106\ m^3$$

c) $$W_{12\,gas} = \int p_G\, dV = \int_1^2 p_0 + \frac{m_g}{A}\, dV$$

$$= p_0 (V_2 - V_1) + \frac{m_g}{A}(V_2 - V_1) =$$

$$Q_{12} = m_G \underbrace{(u_{2G} - u_{1G})}_{c_v (T_2 - T_1) = -233.586 \frac{kJ}{kg}} - W_{12}$$

$$c_v = \frac{8}{M} R - c_p = 0.4672 \frac{kJ}{kgK} = -233.168$$

Aufgabe 3

[redacted]

d)

$$m_{EW} = m_{W,2} + m_{E,2}$$

$$\Rightarrow T_{1,EW} = T_{2,EW}$$

$$\text{mit } m_{E,2} = m_{EW} - m_{W,2}$$

$$\Rightarrow m_{W,2} u_{2,W} + m_{E,2} u_{2,E} - m_{W,1} u_{1,W} - m_{E,1} u_{1,E} = Q_{12}$$

$$m_{W,1} = 0.4\, m_{EW} = 0.04\,kg$$

$$m_{E,1} = 0.6\, m_{EW} = 0.06\,kg$$

$$u_{1,W} = -0.045 \frac{kJ}{kg} = u_{2,W}$$

$$u_{1,E} = -333.458 \frac{kJ}{kg} = u_{2,E}$$

$$\Rightarrow m_{W,2} u_{2,W} + (m_{EW,1} - m_{W,2}) u_{2,E} = m_{W,1} u_{1,W} + m_{E,1} u_{1,E} + Q_{12}$$

$$m_{W,2}(u_{2,W} - u_{2,E}) = m_{W,1} u_{1,W} + m_{E,1} u_{1,E} + Q_{12} - m_{EW} u_{2,E}$$

$$m_{W,2} = 0.044499\,kg$$

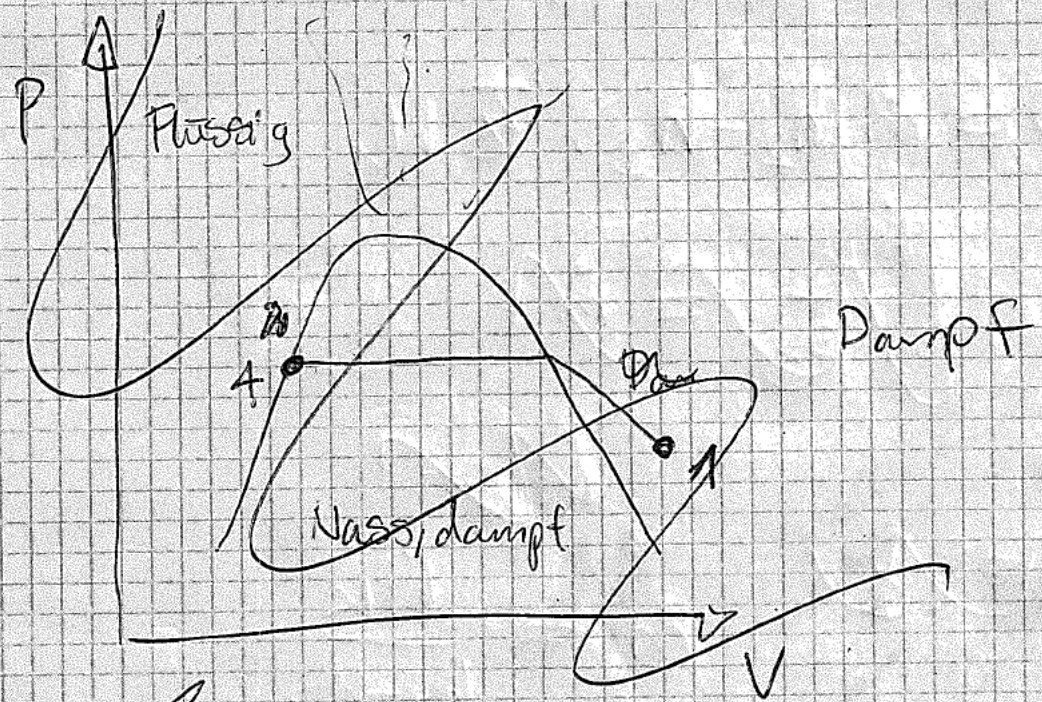
$$\Rightarrow m_{E,2} = 0.056\,kg$$

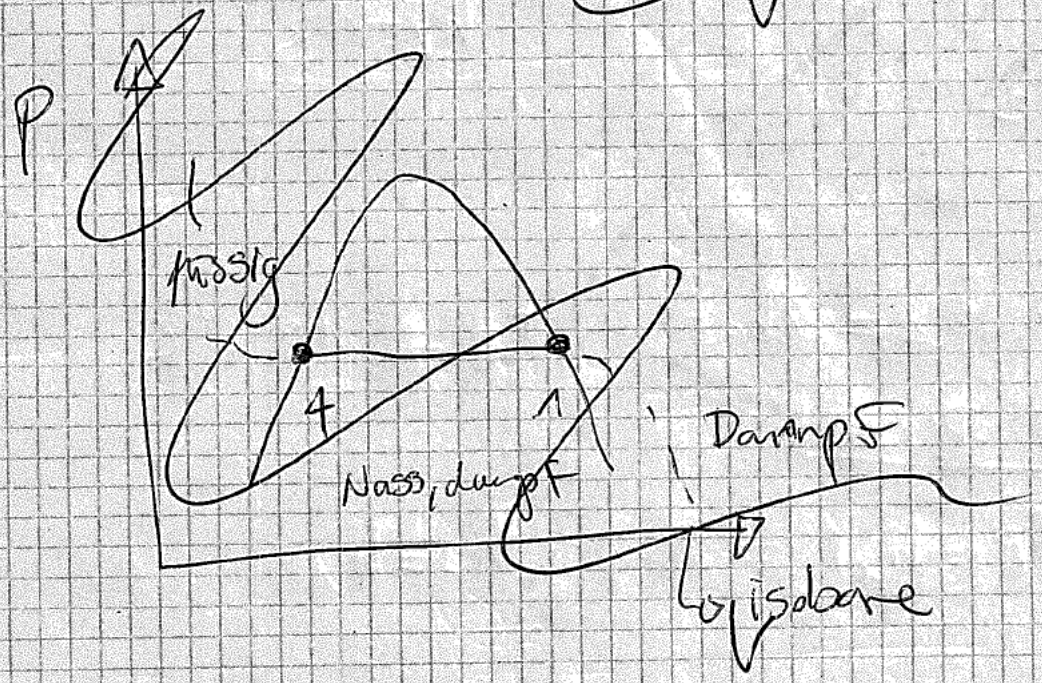
$$x_{E,2} = \underline{0.555}$$

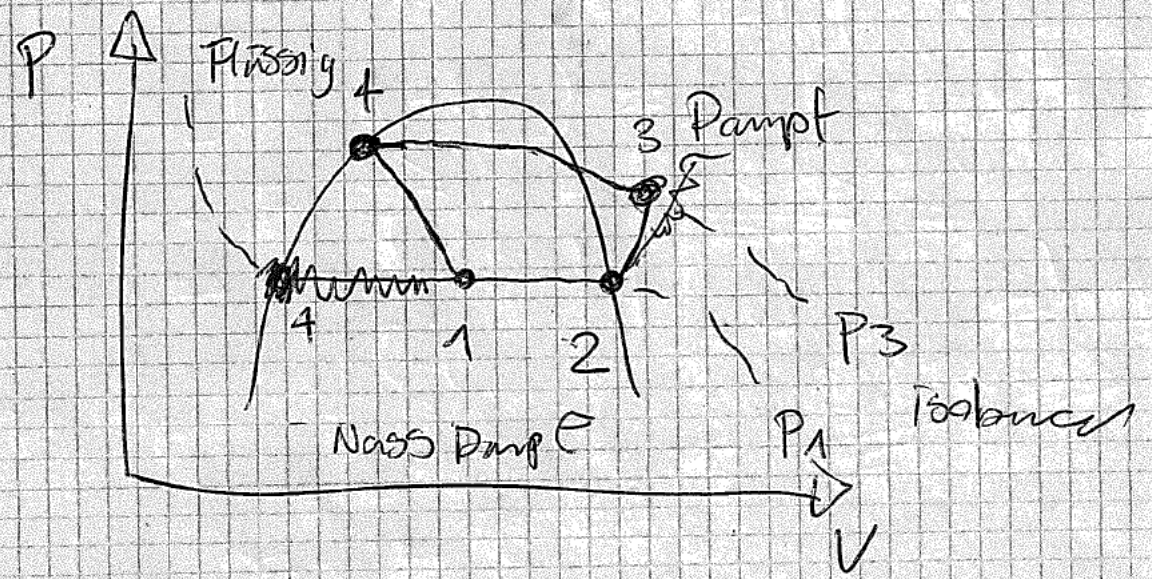
Aufgabe 4

[redacted]

a)







b) 1HS Verdichter

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

$$\frac{\dot{W}_K}{s_2 - s_3} = \dot{m}$$

$$\dot{m} = \frac{\dot{W}_K}{h_2 - h_3}$$

$s_2 = s_3$

$p_1 = p_2$

$x_4 = 0 \quad p_4 = 8\,bar \quad T_4 = 31.33°C$

1HS Drossel

$$\dot{m}(h_4 - h_1) = 0 \qquad h_4 = h_1$$

[redacted]

Aufgabe 4

rest bei b)

c) $h_4 = h_1 = 93.42 \frac{kJ}{kg}$

$p_2 = p_1 = 1.2192\,bar$

$$\Rightarrow x_1 = \frac{h_1 - h_f(p_1)}{h_g(p_1) - h_f(p_1)} = 0.3375$$

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

$\dot{Q}_K = \dot{m}_{R134} (h_2 - h_1) = 156.28\,W$

$h_1 = h_f(p_1) - x_1 (h_g - h_f) = 93.42 \frac{kJ}{kg}$

$$\frac{4\,kg}{h} = \frac{4\,kg}{1\,h \cdot \frac{60}{1} \cdot \frac{60}{1}} = \frac{1}{900} \frac{kg}{s}$$

$h_4 = 93.43 \frac{kJ}{kg}$

$\dot{Q}_{ab} = \dot{m}_{RW3} (h_4 - h_3)$

$s_2 = s_3 = 0.9351 \frac{kJ}{kg}$

$h_3 = \frac{273.66 \frac{kJ}{kg} - 264.15 \frac{kJ}{kg}}{0.9374 - 0.9066} (0.9351 - 0.9066) + 264.15 \frac{kJ}{kg}$

$= 272.95 \frac{kJ}{kg}$

$\dot{Q}_{ab} = -199.47\ kW$

$\varepsilon_K = 3.6184$