Aufgabe 1)

a)

Energiebilanz Kühlmantel:

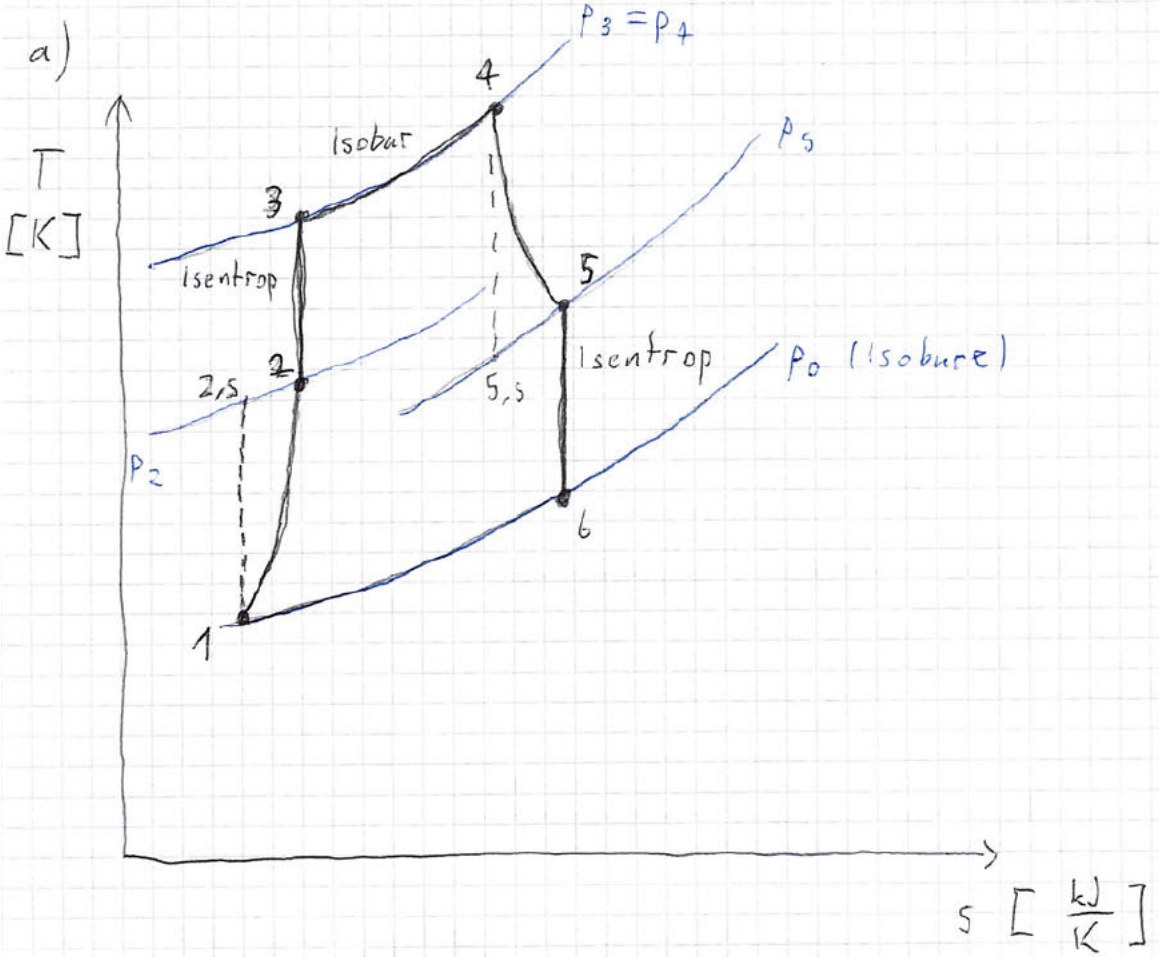
isobar

$$\frac{dE}{dt} = \sum_i \dot{m}_i (h_i + \cancel{ke_i} + \cancel{pe_i}) + \sum_j \dot{Q}_j - \sum_n \cancel{\dot{W}_n}$$

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

Aufgabe 2)

a)




b)

Energiebilanz ganze Turbine:

st. Fp.

adiabat

$$\frac{dE}{dt} = \sum_i \dot{m}_i (h_i + ke_i + pe_i) + \sum_j \dot{Q}_j - \sum_n \dot{W}_n$$

$$0 = \dot{m}_{ges} \left( h_0 - h_6 + \frac{w_0^2 - w_6^2}{2} \right)$$

5 → 6 Isentrop:

$$\Rightarrow \quad \frac{T_6}{T_5} = \left( \frac{p_6}{p_5} \right)^{\frac{n-1}{n}} \qquad \underline{T_6 = \left( \frac{p_6}{p_5} \right)^{\frac{n-1}{n}} T_5 = 328,07\ K}$$

$$w_6^2 = 2(h_0 - h_6) + w_0^2 \qquad w_0 = w_{Luft}$$

$$w_6 = \sqrt{2(h_0 - h_6) + w_0^2} \qquad T_0 = 243{,}15\ K$$

$$w_6 = \sqrt{2 \int_{T_6}^{T_0} c_{p,Luft}\, dT + w_0^2} = \sqrt{2\, c_{p,Luft} (T_0 - T_6) + w_0^2}$$

$$=$$

c) Mit gegebenen Werten weiter gerechnet:

$$p_0 = p_6$$

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

$$= c_{p,Luft} (T_6 - T_0) - T_0 \left( c_p \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right)^{0} \right) + \frac{w_6^2 - w_0^2}{2}$$

$$= 125{,}47 \frac{kJ}{kg}$$

d) st. Fp.

$$\frac{dE_x}{dt} = \sum_i \dot{E}_{x,str,i} - \dot{E}_{x,verl}$$ (restliche Therme der Bilanz sind 0)

$$\dot{E}_{x,verl} = \Delta \dot{E}_{x,str}$$

$$e_{x,verl} = \Delta e_{x,str} = 125{,}47 \frac{kJ}{kg}$$

# Aufgabe 3

a)

$$R = \frac{\bar{R}}{M_g} = 166{,}28 \frac{J}{kg\,K}$$

~~$p_g = m_{EW} g \cdot \frac{d^2}{4} + m_K g \cdot \frac{d^2}{4} + p_{amb}$~~ $\quad d = 0{,}1\,m$

$$p_g = \frac{m_{EV}\, g}{\left(\frac{d}{2}\right)^2} + \frac{m_K\, g}{\left(\frac{d}{2}\right)^2} + p_{amb} = 2{,}259\ bar$$

$pV = mRT \qquad T_g = 773{,}15\,K \qquad V_g = 3{,}14 \cdot 10^{-3}\,m^3$

$$m_g = \frac{p_g V_g}{R\,T_g} = 5{,}52\,g$$

b)

Der Druck $p_{g,2}$ entspricht dem Druck $p_{g,1}$ da sich die Masse, die drauf drückt nicht verändert.

c) Mit gegebenen Werten weiter gerechnet:

~~$pU_{12} = \sum_j Q_j$~~ $\qquad m_g = 3{,}6\,g \qquad T_{2,g} = 0{,}003\,°C = 273{,}153\,K$

$$\Delta U_{12} = \sum_j Q - \sum_n W_{V,n}$$

$$|Q_{12}| = m_g (u_2 - u_1) = m_g c_V (T_2 - T_1) = 1139{,}4\,J$$

d)

~~$\frac{dE}{dt} = \dot{Q}$~~

$\Delta U_{12} = Q_{12}$

$m_{EW} (u_2 - u_1) = Q_{12}$

~~$u_1 = u_f$~~

TAB-1 (Prüfung):

$u_{1,f} = -0,045 \frac{kJ}{kg}$ $u$

TAB-1 (Prüfung):

$u_{1,flüssig} = -0,045 \frac{kJ}{kg}$ $u_{1,fest} = -333,458 \frac{kJ}{kg}$

$u_1 = u_{1,flüssig} + 0,6 (u_{1,Fest} - u_{1 Flüssig}) = -200,1 \frac{kJ}{kg}$

$u_2 = \frac{Q_{12}}{m_{EW}} + u_1 = -188,7 \frac{kJ}{kg}$

$p_2 = \frac{m_{Kg}}{(\frac{d}{2})^2} = 2,256 \text{ bar}$

TAB: $u_{Fest}(2 bar) = -333,498 \frac{kJ}{kg}$ $u_{Fest}(10 bar) = -333,812 \frac{kJ}{kg}$

$u_{Fest}(2,256 bar) = u_{Fest}(2 bar) + \frac{2,256 bar - 2 bar}{10 bar - 2 bar} (u_{Fest}(10 bar) - u_{Fest}(2 bar))$

$= -333,51 \frac{kJ}{kg}$

TAB: $u_{Flüssig}(2 bar) = -0,079 \frac{kJ}{kg}$ $u_{Flüssig}(10 bar) = -0,332 \frac{kJ}{kg}$

$u_{Flüssig}(2,256 bar) = u_{Flüssig}(2 bar) + \frac{2,256 bar - 2 bar}{10 bar - 2 bar} (u_{Flüssig}(10 bar) - u_{Flüssig}(2 bar))$

Aufgabe 3

d)

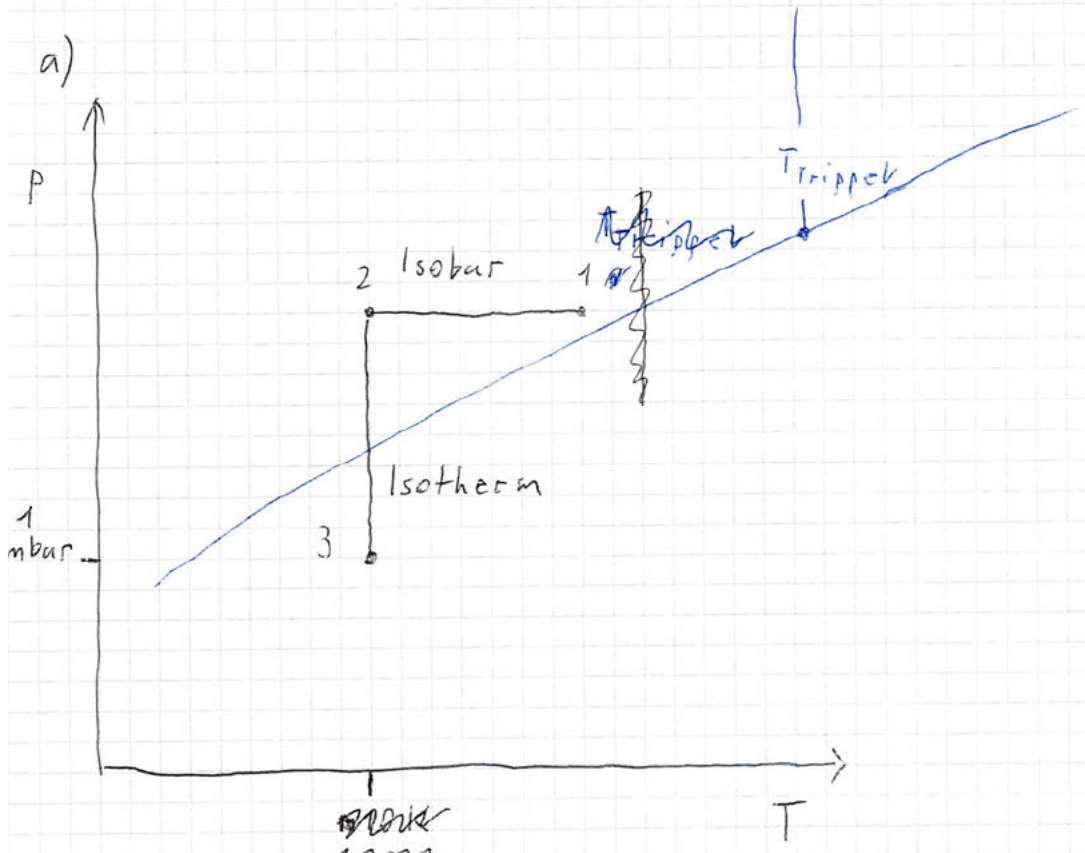
$$u_{Flüssig}(2{,}256\,bar) = -0{,}0871\,\frac{kJ}{kg}$$

$$x = \frac{u_2 - u_{Flüssig}}{u_{Fest} - u_{Flüssig}} = 0{,}566$$

# Aufgabe 4

[redacted]

a)




263,15 K = $T_1$

b)

$T_2 = T_1 - 6K = 257,15K = -16°C$

TAB - 10:

$h_2 = h_g(T_2) = 237,74$

$s_2 = s_g(T_2) = 0,9298 \frac{kJ}{kgK} = s_3$

$h_3(8bar, s_3) = h(8bar, 0,9066 \frac{kJ}{kgK}) + \frac{s_3 - 0,9066}{0,9374 - 0,9066} (h(8bar, 0,9374 \frac{kJ}{kgK} -$

$h(8bar, 0,9066 \frac{kJ}{kgK}) = 271,31 \frac{kJ}{kg}$

TAB - A 12: $h(8bar, 0,9066 \frac{kJ}{kgK}) = 264,15 \frac{kJ}{kg}$

$h(8bar, 0,9374 \frac{kJ}{kgK}) = 273,66 \frac{kJ}{kg}$

Energiebilanz Kompressor:

st. fp.

$$\frac{dE}{dt} = \sum_i \dot{m}_i (h_i + ke_i + pe_i) + \sum_j \dot{Q}_j - \sum_n \dot{W}_n$$

adiabat

$$0 = \dot{m}(h_2 - h_3) - \dot{W}_{23} \qquad \dot{W}_{23} = -\dot{W}_K$$

$$\dot{m} = \frac{-W_K}{h_2 - h_3} = 2{,}8 \frac{kg}{h}$$

c)

TAB-A11:

$$h_4 = h_f(8\,bar) = 93{,}42 \frac{kJ}{kg}$$

$$h_4 = h_1 = 93{,}42 \frac{kJ}{kg}$$

TAB-A11

$$T_4 = 31{,}33\,°C = T_1$$

$$h_{1,f}(T_1) = h_f(30°C) + \frac{31{,}33 - 30}{32 - 30}\left(h_f(32°C) - h_f(30°C)\right) =$$

$$h_{1,g}(T_1) = h_g(30°C) + \frac{31{,}33 - 30}{32 - 30}\left(h_g(32°C) - h_g(30°C)\right) =$$

TAB-A10:

$$h_f(30°C) = 91{,}49$$

$$h_f(32°C) = 94{,}39$$