Aufgabe 1 A1, Seite 1 [redacted]

a) 1. HS um Reaktor ohne Kühlmantel

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

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

$$h_{ein} = h(70°C,\ x=0) \overset{\text{Tab A-2}}{=} 292{,}98\ \frac{kJ}{kg}$$

$$h_{aus} = h(100°C,\ x=0) \overset{\text{Tab A-2}}{=} 419{,}04\ \frac{kJ}{kg}$$

$$\Rightarrow \dot{Q}_{aus} = \underline{62{,}182\ kW}$$

b) $$\bar{T} = \frac{\dot{Q}_{aus}}{s_{KF,aus}-s_{KF,ein}}$$

$$= \frac{\dot{Q}_{aus}}{\dot{m}_{KF} c^{if}_{KF} \ln\left(\frac{T_{KF,aus}}{T_{KF,ein}}\right)}$$

1. HS am Kühlmantel

$$\cancel{\dot{Q}_{aus} = c^{if}_{KF}(T_{KFaus}-T_{KF,ein})}$$

$$\cancel{\Rightarrow c^{if}_{KF} = \frac{\dot{Q}_{aus}}{T_{KFaus}-T_{KFein}} = 6{,}5\ \frac{kJ}{kg\,K}}$$

$$\dot{Q}_{aus} = \cancel{c_{KF}}(h_{KF,ein}-h_{KF,aus})\cdot \dot{m}_{KF}$$

$$= -c^{if}_{KF}(T_{ein}-T_{aus})\dot{m}_{KF} \Rightarrow -\frac{\dot{Q}_{aus}}{\dot{m}_{KF}} = c^{if}_{KF}(T_{ein}-T_{aus})$$

$$\Rightarrow \overline{T} = \frac{(T_{ein} - T_{aus})}{\ln\left(T_{aus}/T_{ein}\right)}$$

$$\approx \underline{\underline{293{,}12\ K}}$$

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

aus Entropiebilanz um Reaktorwand

d) $$m_2 u_2 - m_1 u_1 = \Delta m\, h(x=0, 20°C) - Q_{aus,12}$$

$$\Leftrightarrow m_1 (u_2 - u_1) + \Delta m\, u(x=0, 20°C) = \Delta m\, h(x=0, 20°C) - Q_{aus,12}$$

$$\Rightarrow \Delta m = \frac{m_1 (u_2(x=0, 70°C) - u_1(x=x_0, 100°C)) + Q_{aus,12}}{h(x=0, 20°C) - u(x=0, 20°C)}$$

e) $$\Delta S_{12} = m_2 s_2 - m_1 s_1$$

$= \cancel{2M}$

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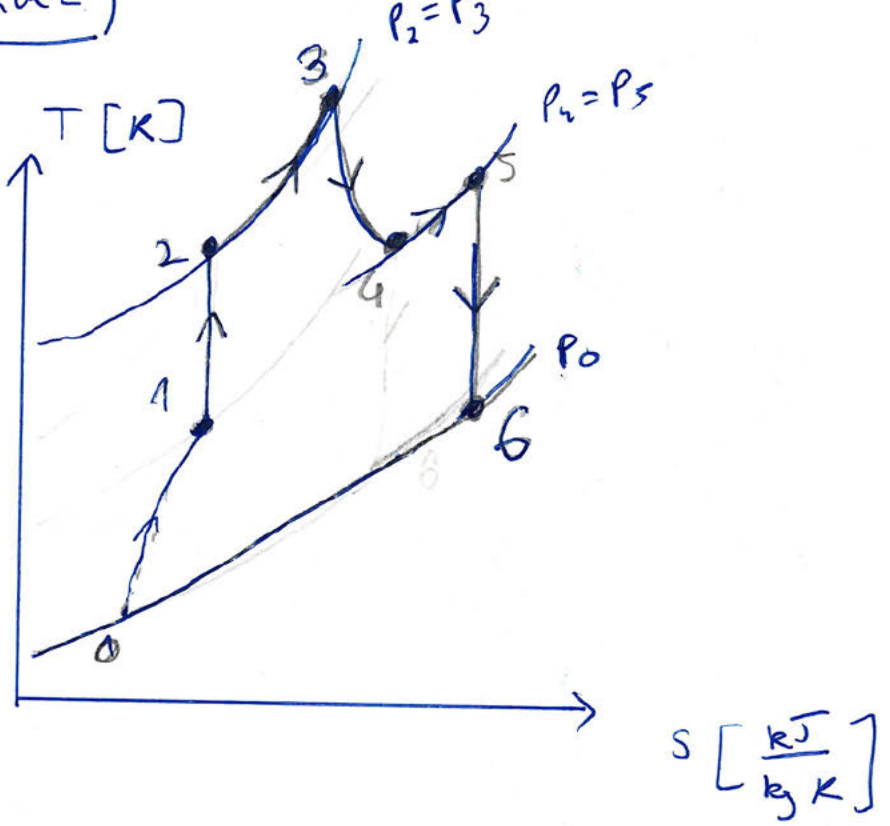
Aufgabe 2)

a)



b) 1. HS Am Gesamtsystem :

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

$$\Rightarrow \sqrt{2\cdot\left(h_0 - h_6 + \frac{w_{Luft}^2}{2}\right)} = w_6$$

$$h_0 - h_6 = c_{p,Luft}^{ig}\left(T_0 - T_6\right)$$

1. HS an der Schubdüse :

$$\cancel{h_5 = h_6 \xrightarrow{ig}} T_5 = T_6$$

$$0 = h_5 - h_6 + w_5 - w_6$$

$$= c_{p,Luft}^{ig} (T_5 - T_6) + w_5 - w_6$$

reversible, adiabate Schubdüse

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

$$\Rightarrow T_6 = \left(\frac{p_0}{p_5}\right)^{1-1/\kappa} \cdot T_5 = 328{,}07\,K$$

$$\Rightarrow h_0 - h_6 = \underline{-85{,}43\,\frac{kJ}{kg}}$$

$$\Rightarrow w_6 = 510\,m/s$$

c) $$\Delta e_{x,str} = \left(h_6 - h_0 - T_0(s_6 - s_0) + \Delta ke\right)$$

$$= \left(c_p(T_6 - T_0) - T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right) - \underbrace{R\ln\left(\frac{p_0}{p_6}\right)}_{\to 0}\right) + \underbrace{\Delta ke}_{\frac{w_6^2}{2} - \frac{w_0^2}{2}}\right)$$

$$\simeq \underline{125{,}47\,\frac{kJ}{kg}}$$

[redacted]

Aufgabe 2

d) Entropiebilanz um Brennkammer um $\dot{m}_{gas}$ auszurechnen

$$0 = \dot{m}_K (s_2 - s_3) + \frac{\dot{Q}_B}{\overline{T}_B} + \dot{S}_{erz}$$

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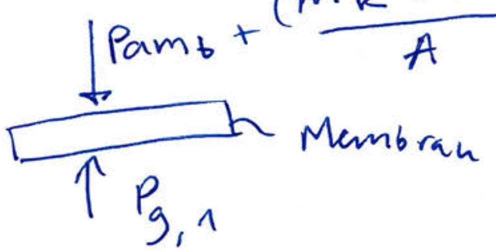
Aufgabe 3

a) Kräfte GGW:



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

$$p_{g,1} = p_{amb} + \frac{(m_K + m_{EW})g}{A}$$

$$= \underline{1{,}4 \text{ bar}}$$

$$p_{g,1} V_{g,1} = m_g R T_1 \quad , \quad R = \frac{\bar{R}}{M_g} = 0{,}16628 \frac{kJ}{kg\,K}$$

$$\Rightarrow m_g = \frac{p_{1,g} V_{g,1}}{R T_{g,1}}$$

$$= \underline{2{,}687 \cdot 10^{-3} \text{ kg}}$$

b) 1. HS am Gesamtsystem

$$\Delta U = -W$$

c) 1. HS am Gas

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

$$m_g c_v (T_{2,g} - T_{1,g}) \overset{!}{=} Q_{12} - W_{12}$$

$$W_{12} = \int_1^2 p \, dV$$

$$= \underline{R(T_{2,g} - T_{1,g})}$$

$$= \underline{-83{,}14 \text{ kJ}}$$

$$\Rightarrow \quad Q_{12} = m_g c_v (T_{2,g} - T_{1,g}) - 83{,}14 \text{ kJ}$$

$$= \underline{\underline{-82 \text{ kJ}}}$$

d) 1. HS am EW

$$\Delta U_{12} = Q_{12} - \underbrace{W_{12}}_{\to 0 \text{ da } V = \text{const}}$$

$$(u_2 - u_1) m_{EW} = Q_{12} = 1{,}5 \text{ kJ}$$

$$\Rightarrow \quad u_2 = \frac{1{,}5 \text{ kJ}}{m_{EW}} + u_1 \qquad , \; u_1 = u_f\Big(p = \overbrace{1 \text{bar} + \frac{m_K g}{A}}^{= 1{,}4 \text{bar}}\Big) + x_{eis,1} (u_f - u_{Fl})$$

$$\simeq -118{,}45 \; \frac{\text{kJ}}{\text{kg}} \qquad\qquad \simeq -133{,}45 \; \frac{\text{kJ}}{\text{kg}}$$

Aufgabe 3) Erweiterung A3, Seite 3

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d)

$u_2 = -118{,}45 \frac{kJ}{kg}$, $p_2 = p_1 = 1{,}4$ bar

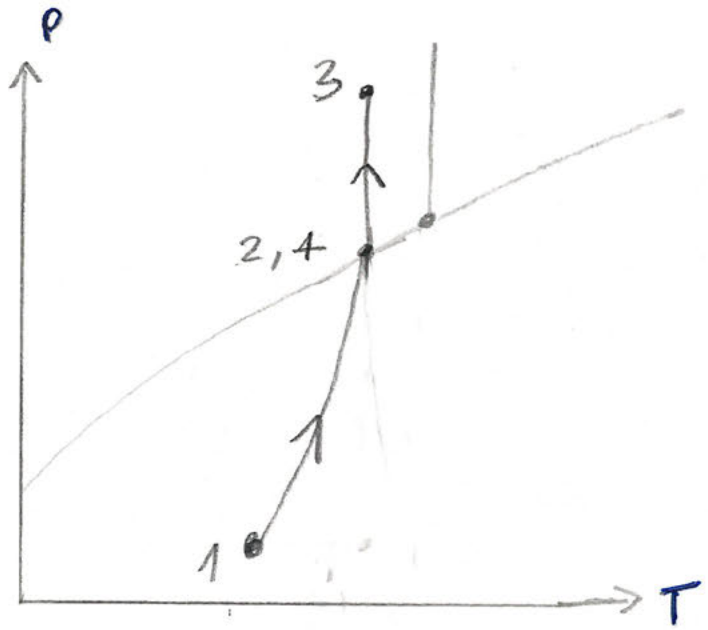
$$\Rightarrow x_2 = \frac{u_2 - u_{Fest}}{u_{Flüssig} - u_{Fest}}$$

$$= \underline{\underline{0{,}645}} = x_{Eis,2}$$

[redacted]

Aufgabe 4

a)



b) 1. HS am Verdichter

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

$$h_2 = h(x=1, T = T_i - 6) \overset{\text{Tab A-10}}{=} 237{,}74 \frac{kJ}{kg}$$

$T_i = -10°C$

$s_2 \overset{\text{Tab-A-10}}{=} 0{,}9298$

$$h_3 = h(\underset{\text{adiabat, rev.}}{s = s_2}, 8\,bar) =$$

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

c) Adiabate Drossel: $h_4 = h_1$ aus 1. HS.

$x_4 = 0$, $p_4 = 8\,bar$ (isobar 3 → 4)

$$\Rightarrow h_4 \overset{\text{Tab A-11}}{=} 93{,}42 \frac{kJ}{kg} = h_1$$

$p_1 = p_2$ ~~11,8 bar~~ (isobare

$$x_2 = 1,\ T_2 = -22°C \Rightarrow p_2 \overset{\text{Tab A-10}}{=} 1{,}2192\,bar = p_1$$

$$x_1 = \frac{h_1 - h_f}{h_g - h_f}$$, ~~$h_1 = h(p = 1{,}2192\,bar, h$~~

$$= \underline{\underline{0{,}337}}$$

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

$$\dot{Q}_{zu} = \dot{Q}_K = \dot{m}_{134a} \cdot (h_2 - h_1)$$ 1. HS

$$= \underline{0{,}156\ kW}$$

$h_2 = h(-22°C, x = 1)$
$\overset{\text{Tab. A-10}}{\simeq} 234{,}08 \frac{kJ}{kg}$

$$\rightarrow \underline{\varepsilon_K = 5{,}58 \cdot 10^{-3}}$$

e) Temperatur würde wachsen.