# Aufgabe 1

a) ~~Aus TAB A-19 $c_p = 4.179 \frac{kJ}{kg\,K}$~~

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

~~$\dot{Q}_{aus}$~~

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

$h_{ein} = 292.95 \frac{kJ}{kg}$ TAB A-2

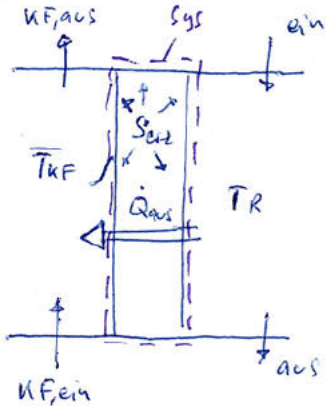
$h_{aus} = 419.04 \frac{kJ}{kg}$ TAB A-2

$\Rightarrow \dot{Q}_{aus} = 100\,kW + 0.3 \frac{kg}{s}(292.95 - 419.04)\frac{kJ}{kg} = \underline{62.173\,kW}$

b) $\overline{T}_{KF} = \frac{\int_e^a T\,ds}{s_a - s_e} = \frac{\int_e^a dh - v\,dp}{s_a - s_e} = \frac{h_a - h_e}{s_a - s_e} \overset{ig}{=} \frac{T_a - T_e}{\ln(\frac{T_a}{T_e})}$

$= \frac{10\,K}{\ln(\frac{298.15}{288.15})} = 293.12\,K$

c)




entropiebilanz:

$\dot{S}_{erz} = \dot{Q}_{aus}\left(\frac{1}{\overline{T}_{KF}} - \frac{1}{T_R}\right) =$

$= 62.173\,\frac{kW}{K}\left(\frac{1}{293.12} - \frac{1}{373.15}\right)$

$= 45.49\,\frac{W}{K}$

d) $u_1 = \hat{u}_f + x_D(\hat{u}_g - \hat{u}_f)$

$= 429.38\,\frac{kJ}{kg}$

$\hat{u}_f = 419.04\,\frac{kJ}{kg}$ TAB A-2

$\hat{u}_g = 2506.5\,\frac{kJ}{kg}$ TAB A-1

~~$u_2 = u_f^2$~~ Energiebilanz:

$(m_1 + \Delta m_{12})u_2 - m_1 u_1 = \Delta m_{12} h - \dot{Q}_{aus}$

$(\hat{m}_f + \Delta m_{12})u_f^2 + \hat{m}_g u_g^2 - m_1 u_1 = \Delta m_{12} h - Q_{aus}$

$\Rightarrow \Delta m_{12} = \frac{\hat{m}_f u_f^2 + \hat{m}_g u_g^2 - m_1 u_1 + Q_{aus}}{h - u_f^2}$

Aufgabe 1.d)

$u_{f^2} = 292.95 \frac{kJ}{kg}$ TAB A-2 $\quad h = 87.96 \frac{kJ}{kg}$

$u_{g^2} = 2469.6 \frac{kJ}{kg}$ TAB A-2

$m_f^{\uparrow} = m_{ges}(1 - x_D) = 5726.225\ kg \quad m_g^{\uparrow} = m_{ges} x_D = 28.775\ kg$

$\Rightarrow \Delta m_{12} = 3289.73\ kg$

e) Entropiebilanz (hier: $\Delta m_{12} = 3600\ kg$)

$$\Delta S_{12} = \Delta m_{12} s(70°C) \overset{*}{=} -\frac{\dot{Q}_{aus}}{T} = m_2 s_2 - m_1 s_1$$

$*$

$m_{2,f} = m_f^{\uparrow} + \Delta m_{12} = 9326.225 \quad m_{2,g} = m_g^{\uparrow} = 28.775$

$\Rightarrow \Delta S_{12} = m_{2,f} s_{2,f} + m_{2,g} s_{2,g} - m_1 s_1$

$= 1433.53 \frac{kJ}{K}$

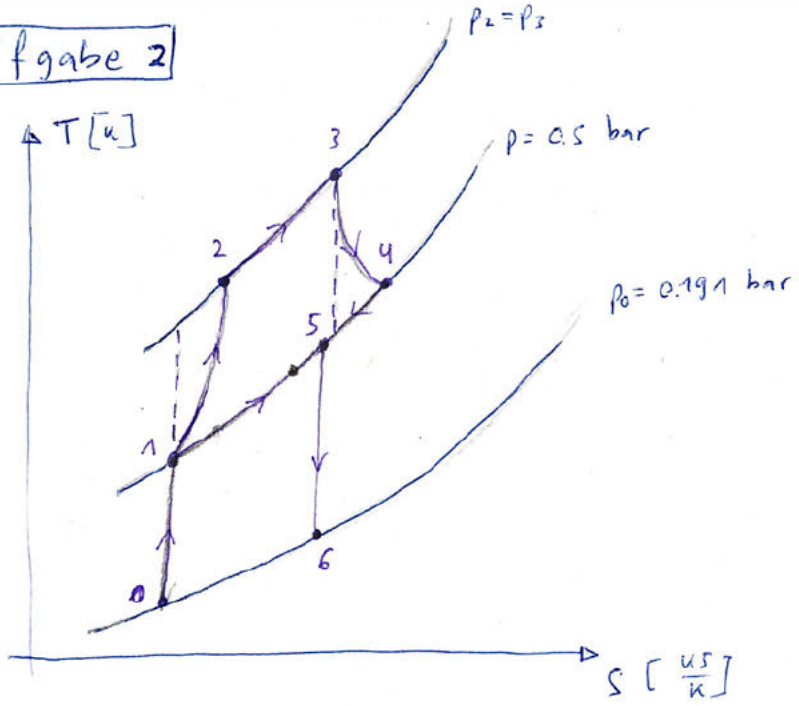
$s_1 = 1.33714 \frac{kJ}{kg\,K}$ TAB A-2 (interpoliert $x_D$)

$s_{2,f} = 0.9549 \frac{kJ}{kg\,K}$ TAB A-2

$s_{2,g} = 7.7553 \frac{kJ}{kg\,K}$ TAB A-2

## Aufgabe 2

a)

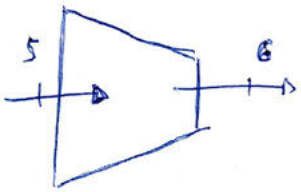



$T_0 = 273.15 - 30 = 243.15\ K$

b)

$$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{\kappa-1}{\kappa}} = 431.9\ K \left(\frac{0.191}{0.5}\right)^{\frac{0.4}{1.4}} = 327.39\ K$$

Energiebilanz:




$$0 = \dot{m}\left(h_5 - h_6 + \frac{1}{2}\left(w_5^2 - w_6^2\right)\right)$$

$$\Rightarrow w_6 = \sqrt{w_5^2 - 2\left(h_6 - h_5\right)} = \sqrt{w_5^2 - 2c_p\left(T_6 - T_5\right)}$$

$$= 508.6\ \frac{m}{s}$$

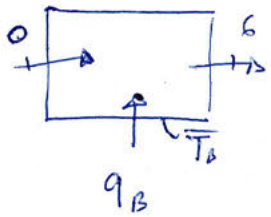
c)

$$\Delta e_{x,str} = e_{x,str,6} - e_{x,str,0} = h_6 - h_0 - T_0\left(s_6 - s_0\right) + \frac{1}{2}\left(w_6^2 - w_0^2\right)$$

$$= c_p\left(T_6 - T_0\right) - T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right) - R\ln\left(\frac{p_6}{p_0}\right)^{0}\right) + \frac{1}{2}\left(w_6^2 - w_0^2\right)$$

$$= 124.32\ \frac{kJ}{kg}$$

d)




Exergiebilanz:

$$0 = -\Delta e_{x,str} + \left(1 - \frac{T_0}{T_B}\right) q_B - e_{x,vel}$$

$$\Rightarrow e_{x,vel} = \left(1 - \frac{T_0}{T_B}\right) q_B - \Delta e_{x,st}$$

$$= 84826\ \frac{kJ}{kg}$$

## Aufgabe 3

a) $R_g = \frac{8.314}{50} \frac{kJ}{kg\,K} = 0.16628 \frac{kJ}{kg\,K}$

$$p_{g,1} = p_{amb} + \frac{m_K + m_{EW}}{A} g = p_{amb} + \frac{m_K + m_{EW}}{D^2 \pi} 4g = 1.4 \text{ bar}$$

$$m_{g,1} = \left(\frac{R_g T_1}{p_{g,1} V_1}\right)^{-1} = \left(\frac{0.16628 \cdot 773.15}{140\ kPa \cdot 3.14 \cdot 10^{-3} m} \frac{kJ}{kg}\right)^{-1} = 3.419 \cdot 10^{-3}\ kg = 3.419\ g$$

b) $\Delta U = 0$ $\quad c_w = 4.211 \frac{kJ}{kg\,K}$ TAB A-19

$$m_{g,1} c_v (T_1 - T_{eq}) + m_{EW} c_w (T_{EW,1} - T_{eq})$$

$$\Rightarrow T_{eq} = \frac{m_{g,1} c_v T_1 + m_{EW} c_w T_{EW,1}}{m_{g,1} c_v + m_{EW} c_w} = 275.71\ K = 2.56\ °C$~~$\frac{p_g T_{eq} m}{V_2}$~~

$p_{g,2} = p_{g,1}$ · wenn wir isentrope am aciven wollen haben ist $\Delta U = 0$ also bleibt der druck gleich

c) $V_2 = \frac{R_g T_{eq} m}{p_{g,2}} = 1.1092 \cdot 10^{-3}\ m^3 = 1.1092\ L$

$\Delta V = -2.031\ L$

$W_{12} = p_1 \Delta V = -284.3\ J$

d) $Q_{12} = \Delta U + W_{12} = m_{g,1} c_v (T_1 - T_{eq}) - 284.3\ J =$

$= 797.8\ J$

d) $u_2 = u_1 + \frac{|Q_{12}|}{m_{EW}} = u_f(0) + x_E (u_g - u_E) + \frac{Q_{12}}{m_{EW}} =$

$= -333.458 + 0.6\,(-0.045 + 333.458) + \frac{1.5}{0.1} = -118.410\ kJ$

$$x_{Eis,2} = \frac{-118.410 + 0.033}{-333.442 + 0.033} = 0.355$$

## Aufgabe 4

b) $h_3 = 170.73 \frac{kJ}{kg}$ $s_4 = 0.3459 \frac{kJ}{kgK} = s_1$ TAB A-11

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

$T_1 = T_2 = -16\,°C \Rightarrow h_2 = 237.74 \frac{kJ}{kg}$ TAB A-10

$\dot{m} = 4.178 \cdot 10^{-4} \frac{kg}{s}$

c) $x_1 = \frac{0.3459 - 0.1192}{0.9298 - 0.1192} = 0.28$ ← (Werte aus TAB A-10)

d) $h_1 = h_f + x_1(h_g - h_f) = 87.6632 \frac{kJ}{kg}$ (Werte aus TAB A-10)

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

$h_2 = h_g = 237.74 \frac{kJ}{kg}$ TAB A-10

$\Rightarrow \dot{Q}_K = 62.7\ W$

$\varepsilon_K = \frac{\dot{Q}_K}{\dot{W}_K} = 2.24$