[redacted]

(1) a) $\dot{Q}_{aus}$

E-Bilanz stat. Fliessprozess

$$0 = \dot{m}(h_e - h_a) + \sum \dot{Q} - \cancel{\dot{W}}^{0} = \dot{m}(h_e - h_a) + \dot{Q}_R - \dot{Q}_{aus}$$

Variabeln

$A := \dot{Q}_{aus}$

$$\dot{Q}_{aus} = \dot{m}(h_e - h_a) + \dot{Q}_R$$

$h_e = h_f(70°) \cancel{+ x_D (h_g(70°) - h_f(70°))} = \cancel{304.649}$ 292.98 (A-2)

$h_a = h_f(100°) \cancel{+ x_D (h_{fg}(100°))} = \cancel{409.311}$ 419.04 (A-2)

~~$\dot{Q}_{aus} = 68.6044$ kW =: A~~

$\dot{Q}_{aus} = 62.182$ kW =: A

b) $\overline{T}_{KF}$

Entropiebilanz Stat. keine druckänderung, adiabat => isentrop

$$0 = \dot{m}(s_e - s_a) + \frac{\dot{Q}}{\overline{T}} + \cancel{\dot{S}_{erz}}^{0}$$

$$\overline{T} = \frac{\dot{Q}}{\dot{m}(s_e - s_a)}$$

c) $\dot{S}_{erz}$ $\overline{T}_{KF} = 295$ K

$$0 = \dot{m}(s_e - s_a) + \frac{\dot{Q}}{\overline{T}} + \dot{S}_{erz}$$

$$\dot{S}_{erz} = \dot{m}(s_a - s_e) - \frac{\dot{Q}}{\overline{T}} = \dot{m}\, c \ln\left(\frac{T_a}{T_e}\right) - \frac{\dot{Q}}{\overline{T}}$$

Entropiebilanz um Wand

$$0 = \cancel{\dot{m} s_i}^{0} + \sum \frac{\dot{Q}}{\overline{T}} + \dot{S}_{erz}$$

$$\dot{S}_{erz} = -\sum \frac{\dot{Q}}{\overline{T}} = -\frac{\dot{Q}_{aus}}{T_{Reaktor}} + \frac{\dot{Q}_{as}}{\overline{T}_{KF}} = 0.0441 \frac{kJ}{kg\,K}$$

d) Δm_{12}

E-Bil.

$$\Delta E = m_2 u_2 - m_1 u_1 + \cancel{\ldots}^{0} = \Delta m_{12} (h_{ein} + \cancel{\ldots}^{0}) + \dot{Q} - \cancel{\dot{W}}$$

$$(m_1 + \Delta m_{12}) u_2 - m_1 u_1 = \Delta m_{12} h_{ein} - Q_{aus12} \Rightarrow m_1(u_2 - u_1) + \Delta m_{12} u_2 = \Delta m_{12} h_{ein} - Q_{aus12}$$

$h_{ein} = h_f(20°C) = \cancel{84.541}$ 83.96 (A-2)

$u_1 = u_f(100°) + x_D (u_g(100°) - u_f(100°)) = \cancel{409.311}$ 429.3778 (A-2)

$u_2 = u_f(70°C) = \cancel{2469.}$ 292.95 (A-2)

$$\Delta m_{12} = \frac{1}{u_2 - h_{ein}} \left(-m_1(u_2 - u_1) - Q_{aus12}\right) = 3589.4 \text{ kg}$$

[redacted]

① e) $\Delta S = m_2 s_2 - m_1 s_1 = m_1(s_2 - s_1) + \Delta m\, s_2$

$s_1 = s_f(100°) + x_D\,(s_g(100°) - s_f(100°))$ (A-2)

$s_2 = s_f(70°)$

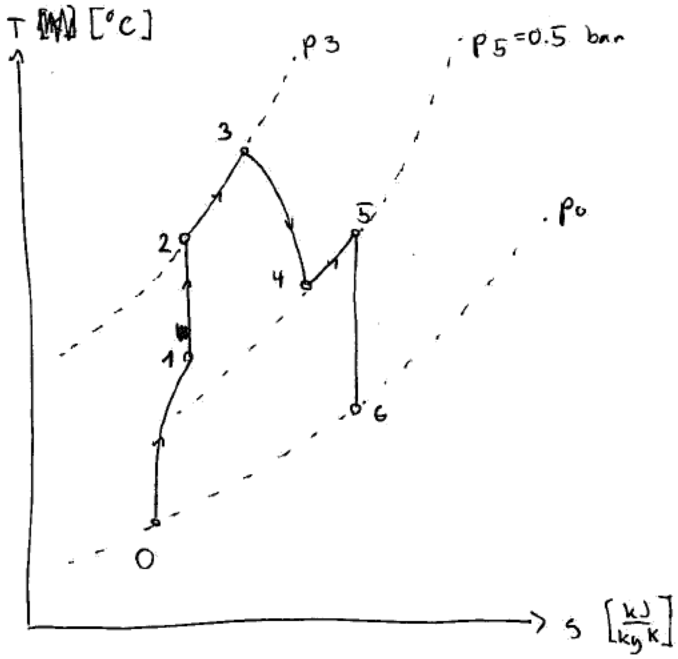
$s_1 = 1.33714 =: B$

$s_2 = 0.9549$

$\underline{\underline{\Delta S = -4299.4 \, \frac{kJ}{K}}}$

[redacted]

② a)



b) Flugzeugtriebwerk stationär und adiabat

~~E-Bil um gesamtes System~~

$$\cancel{0 = \dot m \left(h_e - h_a + \frac{w_e^2 - w_a^2}{2} + \cancel{\ } \right) + \cancel{\dot Q} - \dot W}$$

5 → 6 isentrop

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

$$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = \underline{\underline{328.1\ K}} =: A$$

E-Bilanz um Schubdüse

$$0 = \dot m \left(h_e - h_a + \frac{w_e^2 - w_a^2}{2} + \cancel{\ }\right) - \dot W \qquad | \div m$$

$$\cancel{\frac{w_0^2}{2} = h_a - h_e + \frac{w_a^2}{2}}$$

$$\frac{w_6^2}{2} = h_5 - h_6 + \frac{w_5^2}{2} - w_{rev\,56} \qquad | \cdot 2$$

$$w_6 = \sqrt{2\left(h_5 - h_6\right) + w_5^2 - 2 w_{rev\,56}} \qquad \Big| \ h_5 - h_6 = c_p\left(T_5 - T_6\right), \ w_{rev\,56} = \frac{R\left(T_6 - T_5\right)}{1-n}$$

$$w_6 = \sqrt{2 c_p \left(T_5 - T_6\right) + w_5^2 - 2 \cdot \frac{R\left(T_6 - T_5\right)}{1-n}} \qquad \Big| \ R = \frac{\bar R}{M_{Luft}} = 28699 =: B \quad (A1)^*$$

$$\underline{\underline{w_6 = 329.11\ \frac{m}{s}}} =: C$$

[redacted]

② c) rechnen mit $w_6 = 510 \frac{m}{s}$ $T_6 = 340\,K$

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

$$\Delta e_{x,str} = -\left(c_p (T_6 - T_0) - T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\cancel{\frac{p_6}{p_0}}\right)\right) + \frac{w_0^2 - w_0^2}{2}\right)$$

$$= \cancel{-1003.46}\ \cancel{9.4628} + 94.628 \frac{kW}{kg}$$

d) rechnen mit $100 \frac{kJ}{kg}$

Exergiebilanz um alles

$$e_{x,verl} = \Delta e_{x,str} + \ldots \cancel{\dot{Q}}^{0,\ adiabat} - \dot{W}_t$$

$$\dot{W}_t = w_{schubdüse}$$

$$w_{rev} = \frac{R\,(T_6 - T_5)}{1-n} = 65.935 \frac{kW}{kg}$$

$\cancel{e_{x\,verl}}$

[redacted]

(3) a) p_{g1}

~~IG-Gleichung~~

~~$p_{g1} = \frac{mRT}{V} = \frac{m\bar{R}T}{MV}$~~

$A := p_1\ [Pa]$

$B := m_g\ [kg]$

Kräftegleichgewicht

$F_G + F_{p_0} = F_{p_1}$

$m_K \cdot g + p_{amb} \cdot \left(\frac{D}{2}\right)^2 \pi = \left(\frac{D}{2}\right)^2 \pi\, p_1$

$p_1 = \frac{m_K\, g}{\left(\frac{D}{2}\right)^2 \pi} + p_{amb} = \underline{\underline{1.40\ bar}} =: A$

m_g

IG-Gleichung

$m_g = \frac{p_1 V}{R T_1}$

$R = \frac{\bar{R}}{M} = 166.28 = \frac{4157}{25}$

$m_g = \underline{\underline{3.419\ g}} =: B$

b) $p_{g2} = p_{g1} = 1.40$ bar, da der Prozess isobar ist, weil sich das Gewicht von EW oder der aussendruck nicht geändert hat.

$\Delta E = 0 \quad m_{EW}(u_2 - u_1) = m_g(u_2 - u_1)$

$m_{EW}\left(c\left(T_2 - T_{1EW}\right)\right) = m_g\, c_v\left(T_2 - T_{1g}\right)$

$m_g c_v T_{1g} - m_{EW} c T_{1EW} = T_2(m_g c_v - m_{EW} c)$

$T_2 = \frac{m_g c_v T_{1g} - m_{EW} c T_{1EW}}{m_g c_v - m_{EW} c} =$

c) Rechnen mit $T_{g2} = 0.003°C$

E-Bilanz Gas

$\Delta E = Q - \cancel{W}^{0}$

$Q = m_g(u_2 - u_1) = m_g c_v (T_2 - T_1) = -\cancel{1.082\ kJ}$

$|Q| = 1.082\ kJ$

d) rechnen mit $|Q_{12}| = 1500\ J$

$\Delta E = m_{EW}(u_2 - u_1) = Q_{12} + \cancel{W}^{0}$

$u_2 = u_1 + \frac{Q_{12}}{m_{EW}}$

$u_1 = u_{fe}(0°C) + (1 - x_{E1})\left(u_{fl}(0°C) - u_{fe}(0°C)\right) = -200.0928$

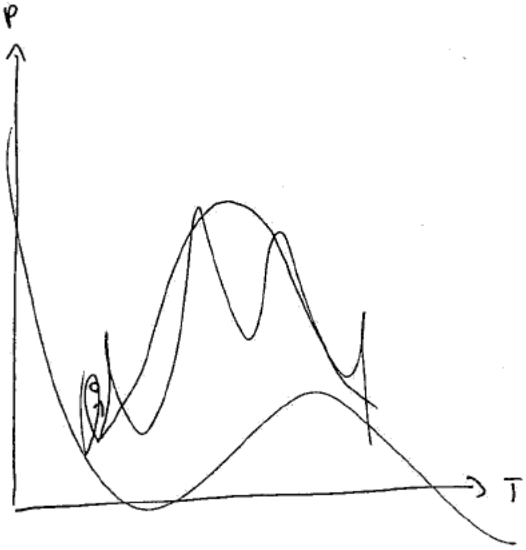
$u_2 = \cancel{238.67}\ -185.0928 =: D$

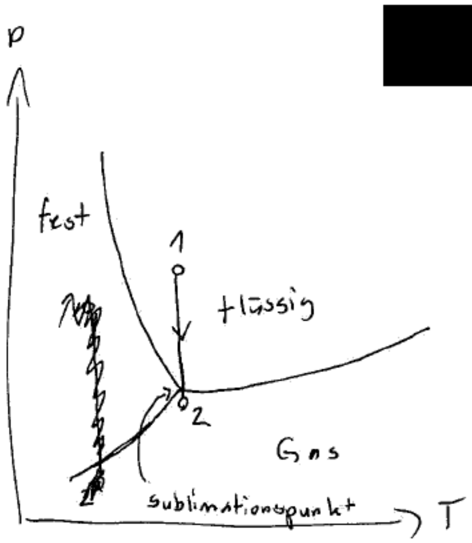
Interpol bei $0.003°C$

$x_{E2} = 1 - \left[\frac{-185.0928 - u_{Fe}}{u_{Fl} - u_{Fe}}\right] = \underline{\underline{0.555}}$

[redacted]

4 a)





b) E-Bil um Verdichter

$0 = \dot{m}\,(u_2 - u_3) + \cancel{\dot{Q}} - \dot{W}_K$

$W_K = \dot{m}\,(u_2 - u_3)$

$u_2 = \cancel{u_g(0°C)} = u_g(4°C) = 229.27$ (A-10)

$T_i = 0°C + 10°C = 10°C$

$\underline{u_3}$

$s_2 = s_3$ (isentrop

$s_2 = s_g(4°C) = 0.9169$

Interpol bei 8 bar Tab. A-12

$x_3 = \dfrac{s_2 - s_f(\cancel{8\,bar}\ sat)}{s_g(\cancel{8\,bar}\ 40°C) - s_f(\cancel{8\,bar}\ sat)} = 0.334$ (A-12)

$u_3 = u_f(sat) + x\,(u_g(40°C) - u(sat)) =$

$\dot{m} = \dfrac{W_K}{u_2 - u_3} =$

d)

$\epsilon_K = \dfrac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \dfrac{|\dot{Q}_{zu}|}{|\dot{Q}_{ab}| - |\dot{Q}_{zu}|}$