Aufgabe 1

gegeben:

$\dot{m} = 0,3 \frac{kg}{s}$

$m_{1ges} = 5755\,kg$

$x_D = 0,005$

$\dot{Q}_R = 100\,kW$

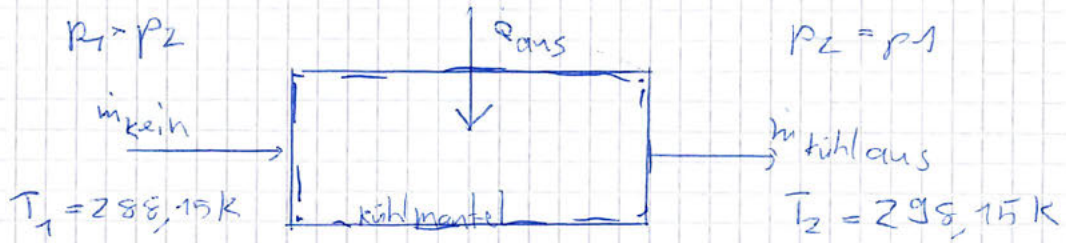
$T_{ein} = 70°C = 343,15\,K$

$T_{aus} = 100°C = 373,15\,K$

$T_{Reak} = 100°C = 373,15\,K$

$T_{Kein} = 288,15\,K$

$T_{Kaus} = 298,15\,K$



perkolate Flüssigkeit

Energiebilanz um Kühlmantel

$$0 = \dot{m}[h_1 - h_2] + \dot{Q} - \cancel{\dot{W}}^{0}$$

st. $\dot{Q}_{ab} = \dot{m}[h_2 - h_1]$

$$= \dot{m} \int_{T_1}^{T_2} c_{if}\, dT \quad \text{if } (p_2 \cancel{=} p_1)$$

$$= \dot{m}\, c_{if} (T_2 - T_1)$$

Energiebilanz um Reaktor

$$0 = \dot{m}[h_e - h_a] + \dot{Q}_R + \dot{Q}_{Ab} - \cancel{\dot{W}}^{0}$$

$$\dot{Q}_{ab} = \dot{m}[h_a - h_e] - \dot{Q}_R$$

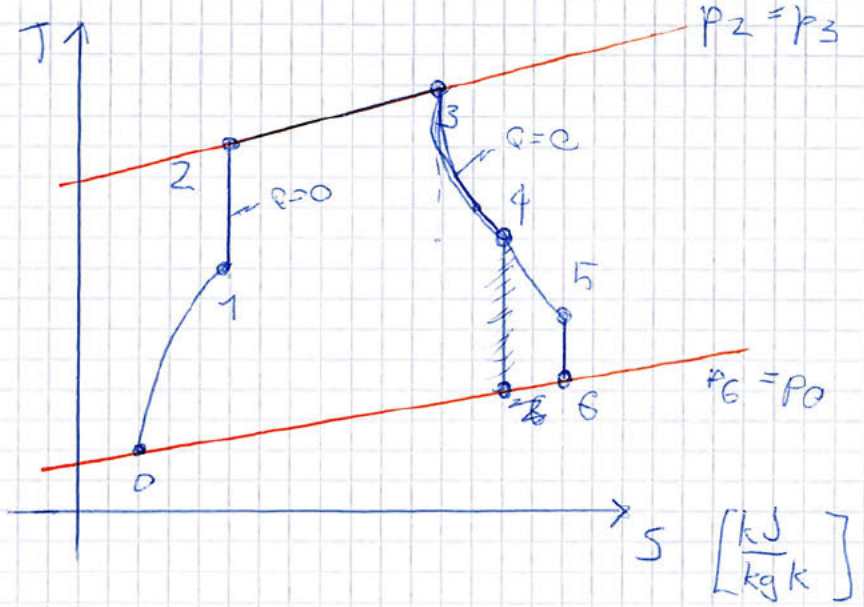
Aufgabe 2.

$w_L = 200 \frac{m}{s}$ $\quad p_0 = 0{,}191\,bar$ $\quad T_0 = -30°C$

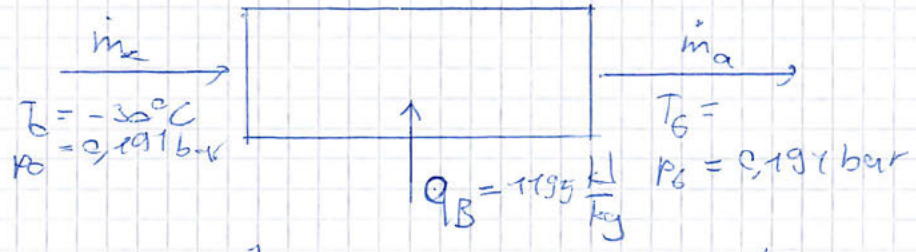
$q_B = 1195 \frac{kJ}{kg}$ $\quad T_{13} = 1289\,K$

Luft als perfektes Gas

a)



b) Energiebilanz um Triebwerk



$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \Rightarrow T_6 = T_5 \cdot \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \qquad n = 1{,}4$$

$T_6 = \cancel{565{,}6\,K} = 325{,}07\,K$

$0 = \dot{m}(h_e - h_a) + Q - \cancel{W}^{\,0}$

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

$0 = 2(h_e - h_a) + (w_e - w_a)^2 + Q$

$2(h_a - h_e) - Q = (w_e - w_a)^2$

$$\sqrt{2(h_a - h_e) - q} = w_e - w_a$$

$$w_a = w_e - \sqrt{2(h_a - h_e) - q}$$

$$w_e - \sqrt{2 c_p (T_e - T_0) + q}$$

$$200 \frac{m}{s} - \sqrt{2 \cdot 1{,}006 \frac{kJ}{kgK} (568{,}6 - 243{,}15) K - 1195 \frac{kJ}{kg}}$$
$$328{,}07$$

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

$$0 = h_e - h_a + \frac{w_e^2 - w_a^2}{2} + q_B$$

$$\sqrt{2(h_a - h_e - q_B)} = w_e^2 - w_a^2$$

$$w_a = w_e$$

$$w_a^2 = w_e^2 - 2(h_a - h_e - q_B)$$

$$w_e^2 - 2(c_p (T_6 - T_0) + q_B)$$

$$w_a^2 =$$

$$w_a^2 = 2(h_e - h_a + q_B) + w_e^2$$

$$= 2(c_p (T_0 - T_6) + q_B) + w_e^2$$

$$w_a = \sqrt{w_a^2} =$$

Aufgabe 2.

b)

$$0 = [h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}] + \cancel{q}^{0} - \cancel{w}^{0}$$

$$\Leftrightarrow w_6^2 = 2(h_5 - h_6) + w_5^2$$

$$2 c_p^{ig}(T_5 - T_6) + w_5^2$$

$$w_6 = \sqrt{2 \cdot 1{,}006\,(931{,}9\,K - 328{,}07\,K) + 220^2 \frac{m^2}{s}}$$

Aufgabe 3

$T_{G1} = 500°C$ $\quad m_{EW} = 0,1\,kg$

$V_{G1} = 3,14\,L$ $\quad T_{EW} = 0°C$

$c_v = 0,633 \frac{kJ}{kgK}$ $\quad x_{Eis1} = 0,6$

$M_g = 50 \frac{kg}{kmol}$

a) $p_{G1} = \frac{F}{A}$ $\quad A = \left(\frac{D}{2}\right)^2 \pi$

$F = m_{EW} \cdot g + m_k \cdot g$

$$p_{G1} = \frac{(m_{EW} + m_k) \cdot g}{\left(\frac{D}{2}\right)^2 \pi} + p_0 = 1,4\ bar$$

$p_{G1} \cdot V_{G1} = m R T_{G1}$

$$m = \frac{p_{G1} \cdot V_{G1}}{\frac{R}{M_g} \cdot T_{G1}} = 3,42\,g$$

b) $p_{G2} = p_{G1} = 1,4\,bar$, Druck von aussen auf das Gas hat sich nicht geändert.

$x_{eis2} > 0 \rightarrow$ nicht alles Eis ist geschmolzen $\rightarrow T_{EW1} = T_{EW2}$

$T_{EW2} = 0°C = T_{g2}$, kein Wärmestrom, Temperaturen sind gleich

c) $dU = Q - W$ $\quad \frac{W}{m} = \int_1^2 p\,dV$

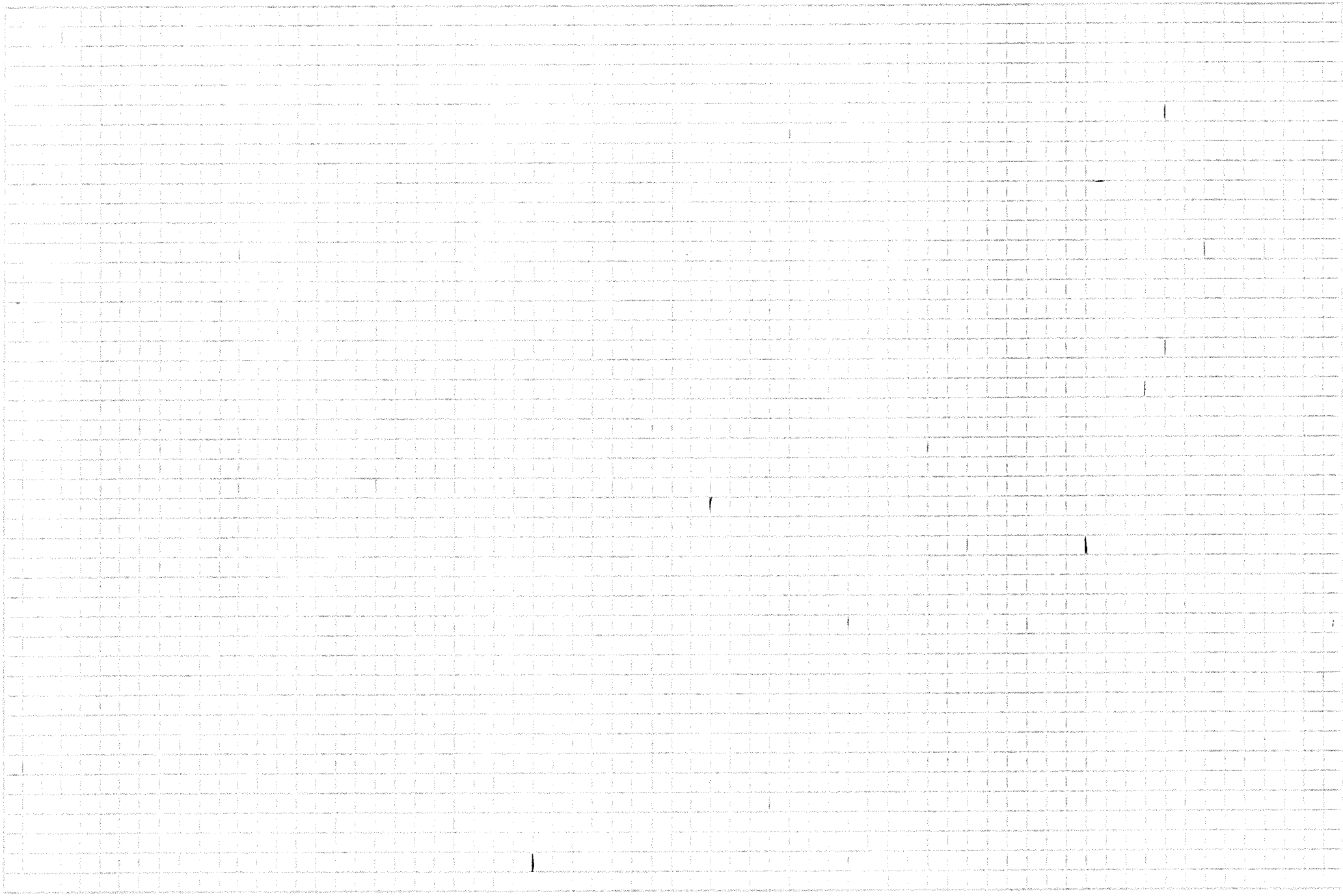
$u_2 - u_1 = c_v (T_2 - T_1)$ $\quad \frac{W}{m} = p(V_2 - V_1) = 0,972\,kJ$

$du = 316,5 \frac{kJ}{kg}$ $\quad V_2 = \frac{m R T_2}{p_{2b}} = 1,11\,L$

$Q = dU + W$

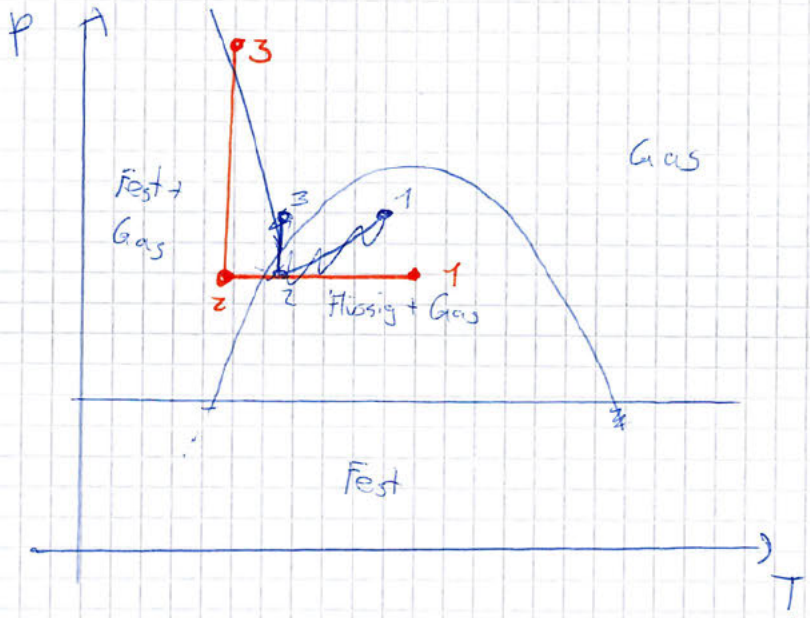
$Q = m\,du + W = 2052\,J$

$m\,du = 1,08\,kJ$



Aufgabe 4

a)



b)

$s_2 = s_3$ $\quad p_3 = 8\,bar$

$x_2 = 1$ $\quad x_4 = 0$ $\quad p_4 = 8\,bar$

Energiebilanz um Kühler

$$0 = \dot{m}[h_1 - h_2] + \dot{Q} - \cancel{\dot{W}}^{0}$$

TA-19

$h_4 = h_4(8\,bar, x=0) = 93{,}42$

TA-17

$s_2 = s_3 = s_3(8\,bar) = s_2(x=1) = 9{,}0656 \frac{kJ}{kgK}$ ↯ Adiabate Drossel:

$$0 = \dot{m}[h_4 - h_1]$$

$$h_4 = h_1$$

Energiebilanz um Kompressor

$$0 = \dot{m}(h_2 - h_3) + \cancel{\dot{Q}}^{0} - \dot{W} \qquad \dot{W} = \dot{m}\int p$$