[redacted]

Aufgabe 1.

a) $\dot{Q}_{aus}$:

Energiebilanz um reaktor Flussigkeit

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

$$0.3\left(292.98 - 428.23\right) + \dot{Q}_{aus} + 100 = 0$$

$$h_{aus} = 0.005 \cdot 2257 + (1-0.005) \cdot 419.04 = 428.23 \frac{kJ}{kg}$$

$$\dot{Q}_{aus} = 59.425$$

---

b) $$\bar{T}_{KF} = \frac{\int_{ein}^{aus} T\,ds}{\underbrace{s_{aus} - s_{ein}}_{\text{stoff model}}} = \frac{U_{aus} - U_{ein}}{c^{lf} \ln\left(\frac{T_{aus}}{T_{ein}}\right)}$$

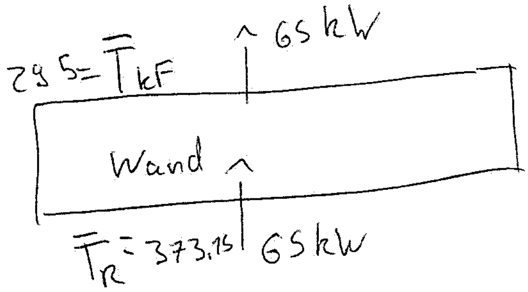
$\int dU + \underbrace{p\,dV}_{0}$

$$\Delta s = c^{lf} \cdot \ln\left(\frac{T_{aus}}{T_{ein}}\right)$$

$$\Delta u = c_{if}\left(T_{aus} - T_{ein}\right)$$

$$\bar{T} = \frac{T_{aus} - T_{ein}}{\ln\left(\frac{T_{aus}}{T_{ein}}\right)} = 293.12\,K$$

1c)




$$0 + \frac{65\,kW}{373.15\,K} - \frac{65\,kW}{295\,K} + \dot{S}_{erz} = 0$$

Entropie bilanz um Wand:

$$\dot{S}_{erz} = 0.04615 \frac{kW}{K} = 46.15 \frac{W}{K}$$

d) $\dot{m}_R = 0$

Da if:
$h \approx h_F$
$U = U_F$

$T_{R1} = 100\,°C$

$T_{R2} = 70\,°C$

$T_{ein} = 20\,°C$

$Q_{aus} = 35\,MJ$

Energie bilanz Halboffenes system:

$$\Delta U = \Delta m_{ein} \cdot (h_{ein}) + Q_j$$

$$\cancel{m_2 u_2}\ m_2 U_2 - m_1 U_1 = \Delta m_{ein} \cdot (h_{ein}) - Q_{aus}$$

$m_2 = m_1 + \Delta m_{ein}$

$m_1 = 5755\,kg$

$U_1 = 2506.5 \cdot 0.005 + (1 - 0.005) \cdot 418.94 = 429.38$

$U_2 = U(70\,°C) = 292.95$

$h_{ein} = h(20\,°C) = 83.96$

$(5755+\Delta m)\cdot 292.95 - 5755\cdot 429.38 = \Delta m \cdot 83.96 - 35\cdot 10^3$

$\cancel{-278}$

$-750154 = -208.99\,\Delta m$

$\Delta m = 3589\,kg$

$\Delta s_{12} = S_1 - S_2 = m_1 s_1 - m_2 s_2$

$m_1 = 5755\,kg$

$m_2 = 9355\,kg$

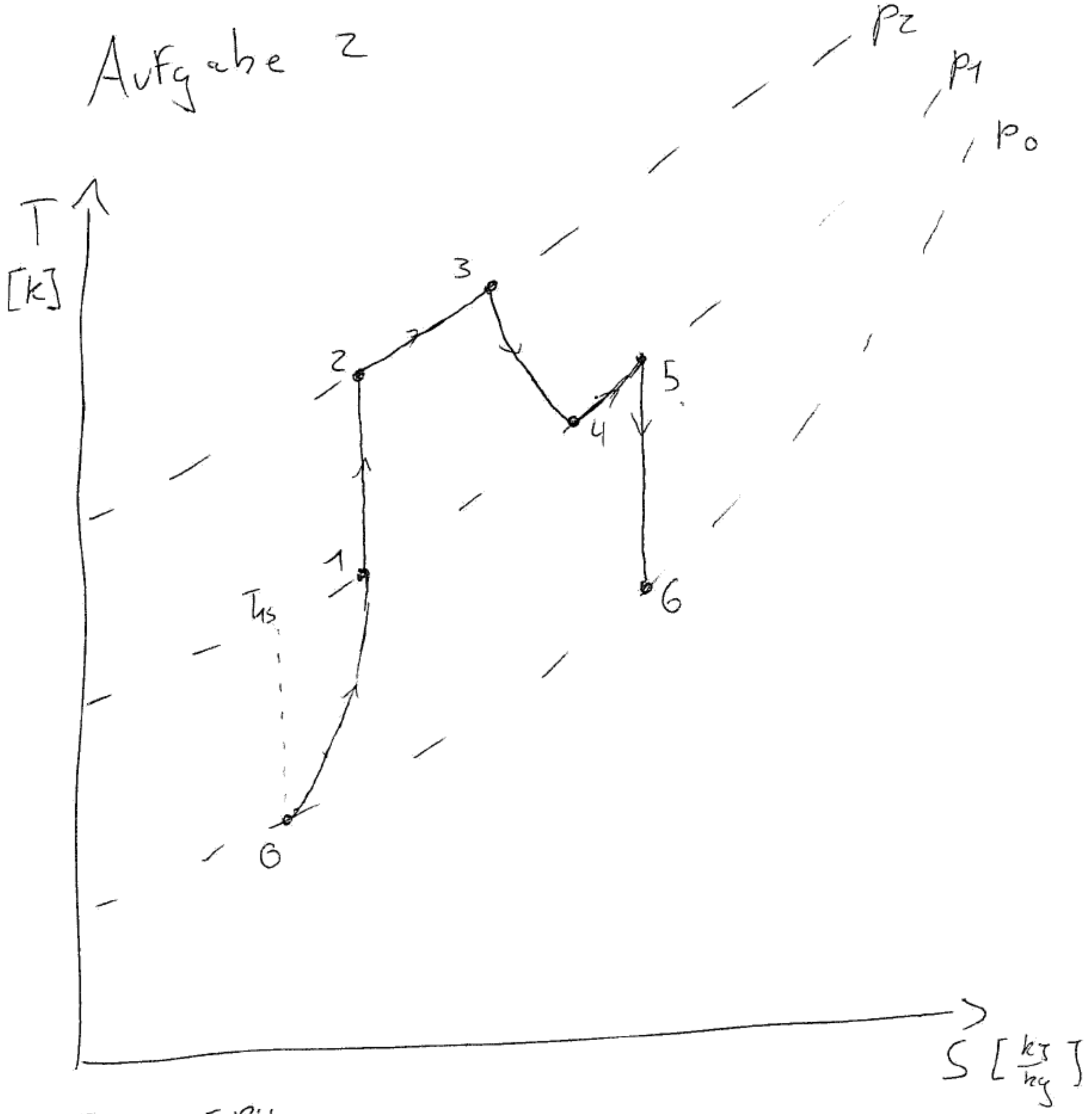
$s_1 = 0.005 \cdot 7.3549 + \cancel{0.995 \cdot 1.3}$ $0.995 \cdot 1.3069 = 1.33714$

$s_2 = 6.9549$

$\Delta S_{12} = -1237.85\,kJ$

[redacted]

# Aufgabe 2




$p_5 = p_1 = p_4$

0-1: $\eta < 1$

1-2 isentrop

2-3 Isobar

3-4 Adiab non-rev

4-5 isobar

5-6 Isentrop

2b

$w_6$ $T_6$ ?

$s_5 = s_6$ $\quad p_6 = 0.191$ bar

$p_5 = 0.5$bar

$n = 1.4$ $\quad T_5 = 431.9$k

Stoffmodel: $\cancel{\text{Iz}}$ $\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}}$

$$T_6 = 431.9 \cdot \left(\frac{0.191}{0.5}\right)^{\frac{0.4}{1.4}} = 328.1K$$

Für $w_6$:

Turbine imganzen leistet kein $\dot{W}$ oder $\dot{Q}$

Ene- bilanz

$$\dot{m}_{ein}\left(h_{ein} + ke_{ein}\right) - \dot{m}_{aus}\left(h_{aus} + ke_{aus}\right) = 0$$

$$\underbrace{h_{ein} - h_{aus}}_{\text{stoff mod.}} + ke_{ein} - ke_{aus} = 0$$

$$ke_{aus} = c_p\left(T_0 - T_6\right)[kJ] + \frac{200^2}{2}[J] = \frac{V_{aus}^2}{2}[J]$$

$$= +85.46kJ + 20kJ = \frac{V_{aus}^2}{2}$$

$$V_{aus} = 459.3 m/s$$

[redacted]

2c) ~~ingges~~

$$\Delta e_{x,str} = e_{xstr6} - e_{xstr0}$$

$$= \left(h_6 - h_0 - T_0 (s_6 - s_0) + ke_6 - ke_0\right)$$

ause stoff model:

$$h_6 - h_0 = c_p \left(T_6 - T_0\right) = 97.43 \frac{kJ}{kg}$$

$$s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right) - R \cdot \ln\left(\frac{p_0}{p_0}\right) = 0.3372786$$

$$ke_6 = \frac{V_6^2}{2} = 130.05 \frac{kJ}{kg}$$

$$ke_0 = \frac{V_5^2}{2} = 20$$

$$\Delta e_{x\,str} = 125.471 \frac{kJ}{kg}$$

---

d) exverl: Flugzeugtriebwerk adiabat

Exergie bilanz:

$$0 = \dot{m}\, e_{x0} - \dot{m} e_{x6} + 0 - 0 - E_{xverl}$$

$$+ \dot{m}\, \Delta e_{xstr} - E_{xverl} = 0$$

$$\frac{E_{xverl}}{\dot{m}} = 100 \frac{kJ}{kg}$$

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3

a) $p_{g1}$ $m_g$ $A = (5 \cdot 10^{-2})^2 \cdot \pi = 7.854 m^3 \cdot 10^{-3}$

$1bar + \frac{32kg}{A} + \frac{0.1}{A} = 1.041 bar$

$pV = mRT$ $R = \frac{8.314}{50}$

$m = \frac{10^5 \cdot 1.041 \cdot 3.14 \cdot 10^{-3}}{\frac{8.314}{50} \cdot 773.15} = 2.5426 \cancel{kg}\, g$

---

b) $p_g = 1.5 bar$ $m_g = 3.6 g$

$p_{g2} = p_{g1} = 1.5 bar$ da $m_{EW}$ gleich bleibt

$T_{EIS2} = 0$ da $x_{eis} > 0$

$T_{g2} = 0°C$ da $T_{EIS2} = T_{g2}$ ist und

---

c) $Q_{12}$ ?

$c_v = \cancel{c_p - R} = 0.633 \frac{kJ}{kg}$

da $\Delta p = 0$

$\Delta U = Q$

$m \cdot c_v \cdot \Delta T = Q_{12}$

$\Delta T = -500°C$

$Q_{12} = 1140 J$

d) $x_{eis}$ 2

$p_{g1} = 1.5\,bar$ $T_{EW2} = 0.003\,°C$

$m_g = 3.6\,g$ $x_{EW1} = 0.6$

$m_{EW} = 0.1\,kg$ $T_1 = 0\,°C$

$Q_{12} = 1500\,J$

$Q_{12} = m_{EW} \cdot \Delta u$

$u_1 = 0.6 \cdot (\cancel{-333.442}) + 0.4\,(\cancel{-0.033}) = 200.\cancel{0784}\ 0928$

$-333.4\cancel{42}58$

$u_1 = 0.6 \cdot (-333.442) + (1-x) \cdot (-0.033)$

$U_2 = x(-333.442) + \ldots$

$1500 \cdot 10^{-3} = 0.1\,(200.0928 + 333.442x - 0.033 + 0.033x)$

~~182~~

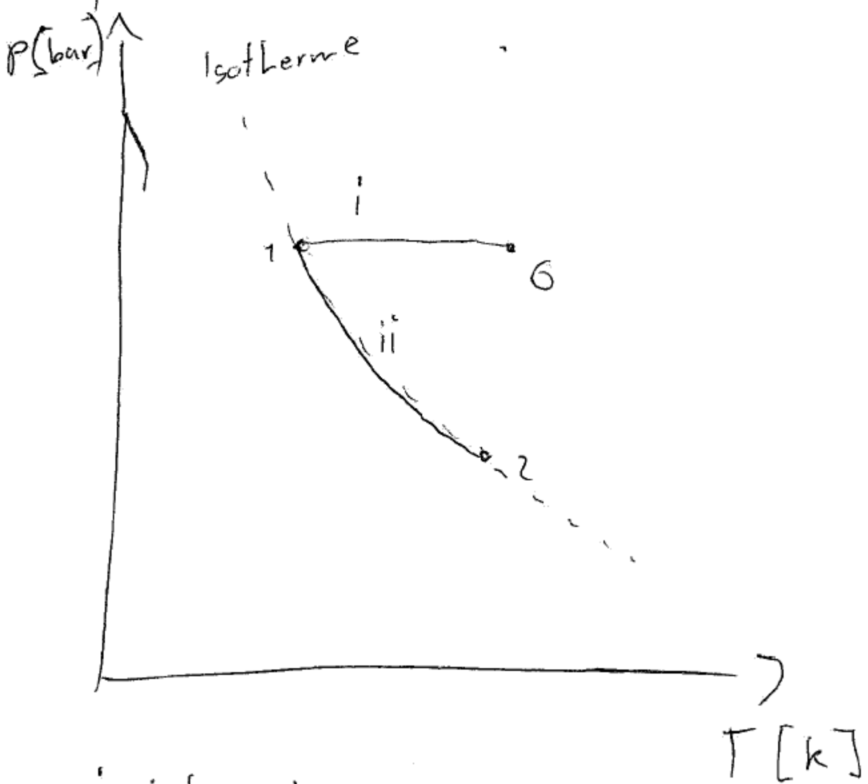
$-185.06 = -333.475x$

$x = 0.554944 \rightarrow \underbrace{0.555}_{3SF}$

[redacted]

Aufgabe 4:

a)




i ist isobar $\Delta T < 0$

ii ist isotherm

b)

$\dot{m}_{R134a)}$

Energbilanz um Verdichter → isentrop

use $s_3$ to interpolate $h_3$ in A 9

$\dot{m}_R (h_1 - h_3) - 28W = 0$

$p_2 = p_1$

$p_4 = p_3$

$h_4 = h_1$ $\quad s_2 = s_3$

~~$x_3 = 0$~~

$h_1 = 63.53 \frac{kJ}{kg}$ aus c) (vorher gemacht) ~~tabs~~

$s_2$ = interpolieren mit $p_2$

$p_2 = 2.2698$ bar

~~$s_2 = 0.9636 + (0.9586 - 0$~~

$$s_2 = (2.2698 - 2.25) \cdot \frac{(0.9556 - 0.9636)}{0.25} + 0.9636$$

$s_2 = 0.9632 = s_3$

c) Energ. v drossel $\quad t_2 = -22°C \quad \dot{m} = \frac{4kg}{h}$

$p_4 = p_3 = 8 bar$

$h_4 = h_1$

$p_1 = p_2$

$p_2 = 2.2698$ bar $= p_1$

$T_4 = 15.45°C$

aus Tab: $h_4 = 63.53 \frac{kJ}{kg}$

$h_1 = 63.53 \frac{kJ}{kg}$

[redacted]

d)

aus def.

$$\varepsilon = \frac{\dot{Q}_k}{\dot{W}_k}$$

$$\varepsilon = \frac{0.99745 \cdot 10^3}{28} = \underline{\underline{7.052}}$$

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

$$\frac{4}{3600}(63.53 - 241.24) = -\dot{Q}_k$$

aus c)

$$\dot{Q}_k = 0.19745 \text{ kW}$$

e.) ~~Wie man in Abb 5 sieht, Falls Tü weiter Senken wird~~

Temperatur würde Fallen da $p < p_{trippel}$

c) $63.53 = 19.92\,(1-x) + \cancel{221.32}\,x$

$241.24$

$43.61 = \cancel{201.4x_1}\ 221.32\,x_1$

$x_1 = \cancel{0.2165}\ 0.197$