[redacted]

① a) Energiebilanz um Reaktor

$$\frac{dE}{dt} = \dot{m}_{ein}(h_{ein} - h_{aus}) + \dot{Q}_{aus} - \sum_i \dot{W}_i + \dot{Q}_R$$

(stationär: $\frac{dE}{dt} = 0$; $\sum_i \dot{W}_i = 0$)

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

$$\rightarrow h_{ein} = h(T = 70°C, x = 1, evap) = 2626,8 \frac{kJ}{kg}$$

$$\rightarrow h_{aus} = h(T = 100°, evap) = 2676,1 \frac{kJ}{kg}$$ (TAB- A2)

$$\rightarrow \dot{Q}_{aus} = 0,3 \frac{kg}{s}(2257,0 - 2333,8) + 100kW = \underline{76,96\,kW}$$

b)

$$\bar{T} = \frac{\int_e^a T\,ds}{s_a - s_e}$$

$$\rightarrow s_a - s_e = s(298,15K) - s(288,15K) = \int_{288,15}^{298,15}$$

c) Entropiebilanz um Reaktor / stationärer Fliessprozess mit einem Massenstrom

$$0 = \dot{m}_{ein}[s_{ein} - s_{aus}] + \frac{\dot{Q}_R}{T} - \frac{\dot{Q}_{aus}}{T} + \dot{S}_{erz}$$

$$\rightarrow \dot{S}_{erz} = \dot{m}_{ein}[s_{aus} - s_{ein}] - \frac{\dot{Q}_R}{T} + \frac{\dot{Q}_{aus}}{T}$$

$$\rightarrow \dot{S}_{erz} = 0,3 \frac{kg}{s}(7,3549 - 7,7553) - \frac{100 \frac{kJ}{s}}{295K} + \frac{76,96 \frac{kJ}{s}}{295K}$$

~~$s_{Dampf} = s(70°C) = 7,7553 \frac{kJ}{kg \cdot K}$~~

$s_{ein} = s(70°C) = 7,7553 \frac{kJ}{kg \cdot K}$

$s_{aus} = s(100°C) = 7,3549 \frac{kJ}{kg \cdot K}$ TAB A2

$$\rightarrow \dot{S}_{erz} = -0,2015 \frac{kJ}{kg\,K}$$

d) $\frac{dE}{dt} = \Delta m_{12}(h_{ein}) + Q_{aus,12}$

$u_2 - u_1 = \Delta m_{12}(h_{ein}) - Q_{aus,12}$

$-c\,(m_{ges1} + \Delta m)(u_2) - m_{ges1}(u_1) = \Delta m_{12} h_{ein} - Q_{aus12}$

$\rightarrow \Delta m_{12} = \frac{m_{ges1} u_1 - m_{ges1} u_2 - Q}{u_2 - h_{ein}}$

$h_{ein} = h(20°C, x=1) = 2538{,}1 \frac{kJ}{kg}$ TAB-A2

$u_1 = u(100°C, x=1) = 2676{,}1 \frac{kJ}{kg}$

$u_2 = u(70°C, x=1) = 2626{,}8 \frac{kJ}{kg}$

$\rightarrow \Delta m_{12} = \frac{5755\,kg \cdot 2676{,}1 - 5755 \cdot 2626{,}8 - 100\,kJ}{2626{,}8 - 2538{,}1}$

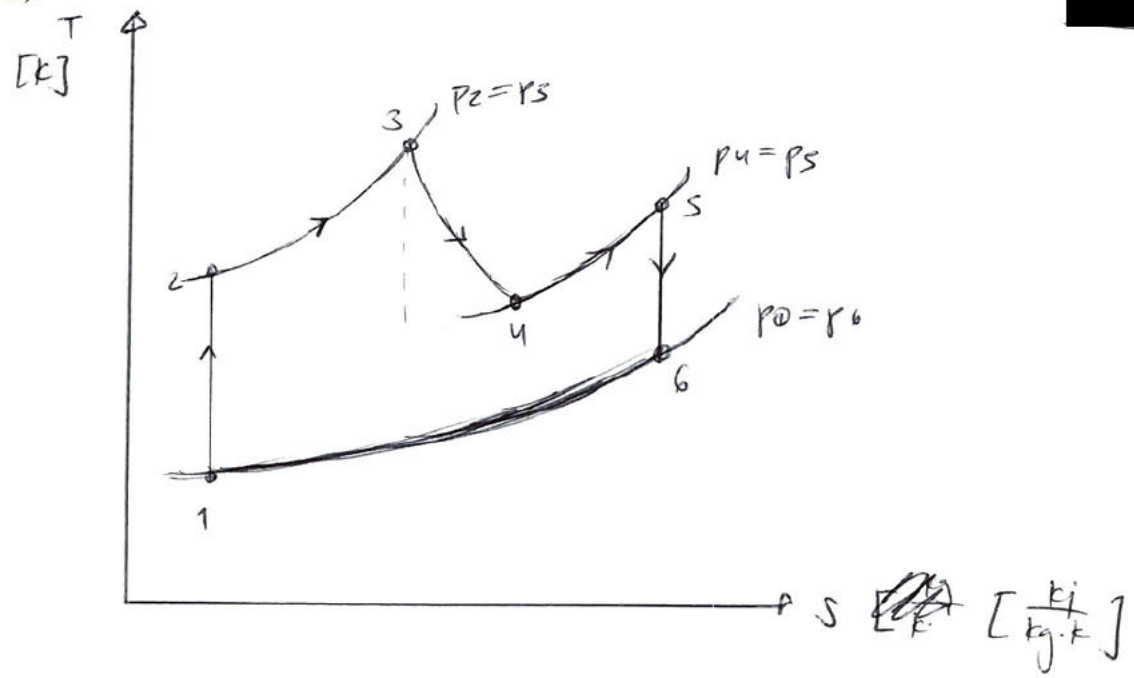
e) $\Delta S = m_{ges1} + \Delta m s_2 - m_{ges1} s_1$

$\rightarrow$ Stark $s_1 = 1{,}3069 + 0{,}005(7{,}3549 - 1{,}3069) = 1{,}33714 \frac{kJ}{kg \cdot K}$

$s_2 = s(70°C, x=1) = 7{,}7553$ TAB-A2

$\rightarrow \Delta S = 5755 + 3600(7{,}7553) - 5755(1{,}33714) = 66'230{,}38 \frac{kJ}{kg\,K}$

(2) a)



b) Energiebilanz um Flugzeugtriebwerk (Systemgrenze um ganzes Triebwerk)

$$\frac{dE}{dt} = \dot{m}_{gas}\left[h_0 - h_6 + \frac{w_{luft}^2}{2} - \frac{w_6^2}{2}\right] + \sum_i \dot{Q}_i - \sum \dot{W}_i$$

$$\rightarrow \quad w_6^2 = 2h_0 - 2h_6 + w_{luft}^2$$

$$\rightarrow \quad h_0 - h_6 = \int_{T_6}^{T_0} c_p \, dT$$

T_6 bestimmen:

$$\rightarrow \quad T_6 = T_5 \left(\frac{p_0}{p_5}\right)^{\frac{1,4-1}{1,4}}$$

$$\rightarrow \quad T_6 = 431,5\,K \cdot \left(\frac{0,191}{0,5}\right)^{\frac{1,4-1}{1,4}} = 328,04747\,K$$

$$\rightarrow h_0 - h_6 = c_p\,(243,15\,K - 328,04747\,K) = -85,434\ \frac{kJ}{kg}$$

$$\rightarrow w_6 = \sqrt{2\,(-85,434) + 200\ \frac{m}{s}} =$$

c) ~~$Ex_{str,6} = \dot{m}_{gas}[h_6 - h_0 - T_0(s_6 - s_0) + p_0(v_6 - v_0)]$~~

$$\Delta ex_{,str} = \dot{m}_{gas}\left[h_6 - h_0 - T_0(s_6 - s_0) + \frac{w_6^2 - w_0^2}{2}\right]$$

$$\rightarrow \Delta ex_{,str} = h_6 - h_0 - T_0(s_6 - s_0) + \frac{w_6^2 + w_0^2}{2}$$

$$h_6 - h_0 = c_p(T_6 - T_0) = 97{,}43 \frac{kJ}{kg}$$

$$s_6 - s_0 = c_p \cdot \ln\left(\frac{T_6}{T_0}\right) = 0{,}3373 \frac{kJ}{kgK}$$

$$\rightarrow \Delta ex_{,str} = 97{,}43 \frac{kJ}{kg} - 245{,}15K\left(0{,}3373 \frac{kJ}{kgK}\right) + \frac{510^2 - 200^2}{2}$$

$$= 110'065 \frac{kJ}{kg}$$

d)

$$ex_{,verl} = T_0 \cdot \dot{S}_{erz}$$

Entropiebilanz

$$\dot{S}_{erz} = \dot{m} \cdot \Delta ex_{,str} = 0{,}3 \frac{kg}{s} \cdot 100 \frac{kJ}{kg} = 30 \frac{kJ}{s}$$

$$ex_{,verl} = 245{,}15K \cdot 30 \frac{kJ}{s} = 7294{,}5 \frac{kJ \cdot K}{s}$$

③ a) $T_{g,1} = 500\,°C$, $V_{g,1} = 3{,}14\,L = 3{,}14 \cdot 10^{-3}\,m^3$

$c_v = 0{,}633 \frac{kJ}{kg \cdot K}$, $M_g = 50 \frac{kg}{kmol}$ $= 0{,}00314\,m^3$

$\rightarrow R = \frac{\bar{R}}{M_g} = \frac{8{,}314 \frac{J}{kmol \cdot K}}{50 \frac{kg}{kmol}} = 166{,}28 \frac{J}{kg \cdot K}$

$\rightarrow pV = RT \quad \rightarrow p \frac{V}{m} = RT \rightarrow p = \frac{RTm}{V}$

$\rightarrow$ ~~$pV = mRT \rightarrow \frac{RTm}{V} \rightarrow \frac{V}{m} = RT$~~

Druckbilanz:

④ ~~p_g~~ $p_g = \frac{m_{ew} \cdot g}{\pi \cdot 5cm^2} + \frac{32kg \cdot g}{\pi \cdot 5cm^2} + 1\,bar$

$\rightarrow p_{g,1} = 1\,bar + 0{,}12\,bar + 39{,}97\,bar = \underline{41{,}09\,bar}$

$m_{g,1} = \frac{R \cdot T_1}{p_1 \cdot V_1} = \frac{166{,}28 \frac{J}{kg \cdot K} \cdot 773{,}15\,K}{1{,}5\,10^5\,Pa \cdot 0{,}00314\,m^3} = 272$

b) aus $p_2 = p_1 \rightarrow$ Dichte und Masse von EW haben sich nicht verändert

c) Energiebilanz um EW und Gas

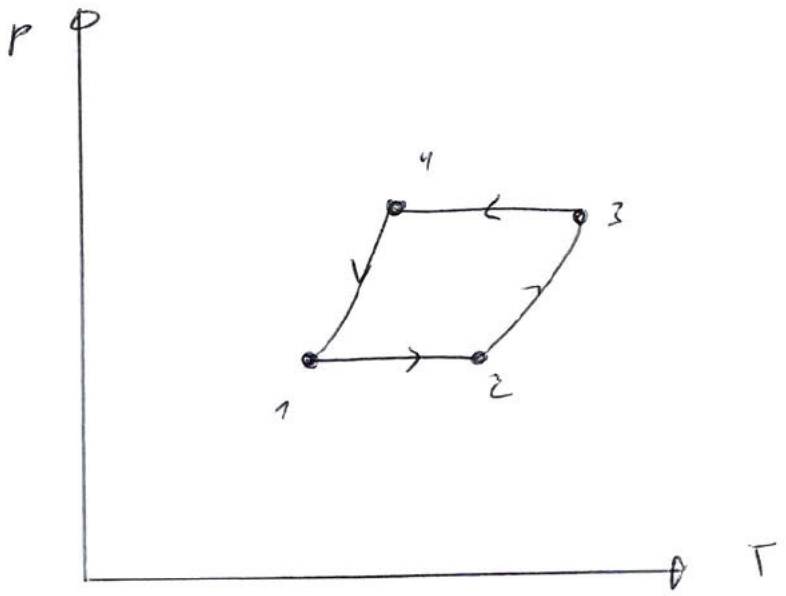
$U_2 - U_1 = Q_{12}$

$\rightarrow m_g u_2 - m_g u_1 = Q_{12} \rightarrow Q_{12} = 30{,}0036\,kg\,(u(0{,}003\,°C)\,1{,}5\,bar) -$

$u(500\,°C, 1{,}5\,bar)$

4)

a)



b) Energiebilanz Kompressor

$0 = \dot{m}(h_2 - h_3) - \dot{W}_K$ Annahme: $T = 10°C$

$\rightarrow \dot{m} = \frac{\dot{W}_K}{h_2 - h_3}$

$h_2 = h(10°C, x=0)$ TAB. A10

lineare Interpolation $\frac{233,63 - 231,46}{0,2545 - 0,2354}$ (

c) Drossel ist isentrop $\rightarrow s_4 = s_7$

$x = \frac{s_7 - s_f}{s_g - s_f}$

d) $\varepsilon_K = \frac{\dot{Q}_{zu}}{\dot{Q}_{ab} - Q_{zu}}$

e) Die Temperatur würde abnehmen, da der Druck sinkt