[redacted]

A1) Reaktor

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

Bilanzgleichung ~~halboffenes~~ stationärer FP

$$0 = \dot{m}[h_e - h_a] + \dot{Q}_R - \dot{Q}_{aus}$$

$$\Rightarrow \dot{Q}_{aus} = \dot{m}[h(T = 70°C$$

Siedende Flüssigkeit: Tsat superheated water vapor

~~F~~ p_e = interpoliert aus 0,35 bar und 0,06 bar (A-4)

$$= 0{,}06 + \frac{0{,}35 - 0{,}06}{72{,}69 - 36{,}16}(70 - 36{,}16)$$

$$= 0{,}328 \text{ bar}$$

p_a = interpoliert aus 1 bar, 1,5 bar

$$= 1 + \frac{1{,}5 - 1}{111{,}37 - 99{,}63}(100 - 99{,}63)$$

$$= 1{,}015 \text{ bar}$$

h_a = ~~interpoliert~~ aus A-2

A-2: $\rightarrow h_e = h_f(70°) + 0{,}005(h_g - h_f)$

$$= 292{,}98 + 0{,}005(2626{,}8 - 292{,}98) = \underline{304{,}65}$$

~~Δh ~~ ~~$\frac{he - ha}{se - sa}$~~

$$h_a = 419{,}04 + 0{,}005(2257 - 419{,}04)$$

$$= \underline{428{,}23}$$

$$\rightarrow \dot{Q}_{aus} = 0{,}3\frac{kg}{s}[304{,}65 - 428{,}23) + \dot{Q}_R$$

$$= -37{,}074 \text{ kW} + 100 \text{ kW} = \underline{\underline{62{,}94 \text{ kW}}}$$

b) $T_{KT} = \frac{h_e - h_a}{s_e - s_a} =$

$$\dot{m}\,[s_e - s_a] + \frac{\dot{Q}_{aus}}{T} = 0$$

$$T = \frac{\dot{Q}_{aus}}{\dot{m}\,[s_e - s_a]}$$

c) $\dot{S}_{erz}$:

$$0 = \dot{m}\,[s_e - s_a] + \frac{\dot{Q}}{T} + \dot{S}_{erz}$$

$$\Rightarrow \dot{S}_{erz} = \dot{m}\,[s_a - s_e] - \underbrace{\frac{\dot{Q}}{T}}_{= \frac{-65\,kW}{295\,K}}$$

$$= 0{,}3\,(1{,}33714 - 0{,}9889)$$

A-2:

$$s_a = 1{,}3069 + 0{,}005\,(7{,}3549 - 1{,}3069) \Big\}\ s\ @\ 100^\circ$$

$$= 1{,}33714$$

$$s_e = s\,@\,70^\circ = 0{,}9549 + 0{,}005\,(7{,}7553 - 0{,}9549)$$

$$= 0{,}9889$$

$$\dot{S}_{erz} = 0{,}3\,[1{,}33714 - 0{,}9889] - \frac{65\,kW}{295\,K} = \underline{\underline{-220{,}23\,\frac{kJ}{kg\,K}}}$$

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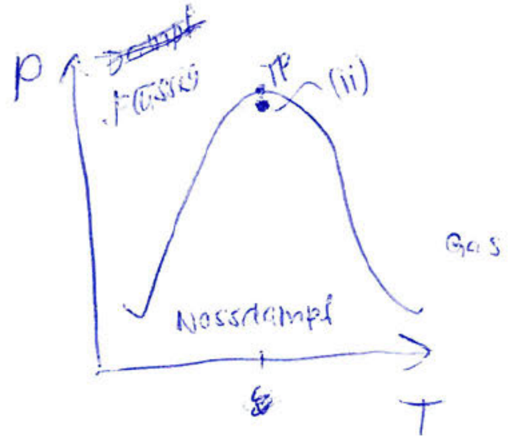
A4)



c) x_1 direkt nach Drossel:

$$x_1 = \frac{s - s_f}{s_g - s_f}$$

d) $$\varepsilon = \frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \frac{|\dot{Q}_{zu}|}{|\dot{Q}_{ab}| - |\dot{Q}_{zu}|}$$

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A1) d)

$$\Delta E \cancel{= m_2 u_2 - m_1 u_1} = \cancel{\Delta m \cdot h_2 + \dot{Q}_{aus}}$$

$$\cancel{h_2 =}$$

$$m_2 u_2 - m_1 u_1 = \dot{Q}_{aus}$$

$$(m_2 - m_1)(u_2 + u_1) = \dot{Q}_{aus}$$

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

$$\Rightarrow \Delta m_{12} = \frac{\dot{Q}_{aus}}{(u_2 + u_1)} = \frac{35\ MJ}{(399,37)} =$$

$u_2 = u$ saturated water @ 70°C

$$= 292,95 + 0,005(2469,6 - 292,95)$$

$$= 303,83$$

$u_1 = u$ saturated water @ 20°C

$$= 83,95 + 0,005(2402,9 - 83,95)$$

$$= 95,5$$

e) $\Delta S_{12} = \Delta m_{12} (s_2 - s_1)$

$$= 3600kg\,(0,9889 - 1,33714) = -1,253 \frac{kJ}{kg\,K}$$

$s_2 = s$ @ 70°C $= 0,9889$

$s_1 = s$ @ 100°C $= 1,33714$

c) $T_{g,2} = 0{,}003°C$ (aus Tipp)

$= 273{,}153\,K$

X

$\rightarrow p_{2,g} \cdot v_{2,g} = R_g \cdot T_{2,g}$

$v_{2,g} = \frac{V_{2,g}}{m_g}$

$\rightarrow T_{2,g} = 0{,}003°C = 273{,}153\,K$

$\rightarrow \dot{Q} = c_v \cdot m_g \cdot (T_{2,g} - T_{1,g})$

$= 0{,}633 \frac{kJ}{kgK} \cdot 0{,}00392\,kg\,(273{,}153 - 773)$

$= \underline{\underline{-1{,}08\,kJ}} \Rightarrow |Q| = \underline{\underline{1{,}08\,kJ}}$

d) $x_{Eis,2}$ berechnen:

Energiebilanz:

$m_{EW}(u_2 - u_1) = \dot{Q}_{12}$

$m_{EW} = 0{,}1\,kg$

Thermodyn. GGW: $u_2\,_{EW} = u_{2g} \rightarrow (u_2 - u_1)_{EW} = (u_{2g} - u_{1g})$

~~$u_{2g} = u_1$~~ $(u_{2g} - u_{1g}) = \int_{T_1}^{T_2} c_v(T)\,dT = c_v(T_2 - T_1)$

$= Q_{12}$

$u_2 - u_1 = \frac{\dot{Q}}{m_{EW}}$

$u_2 = \frac{\dot{Q}}{m_{EW}} + u_1$

u_1

[redacted]

A3) EIJ

a) $p_{g,1}$, m_g im Zylinder:

$c_v = 0{,}633 \frac{kJ}{kg\,k}$

$p_{g,1} = p_{amb} + \left(\frac{m_k \cdot g}{A_{zyl.}}\right) + \left(\frac{m_{EW} \cdot g}{A_{zyl}}\right)$

$= 10^5\,Pa + \left(\frac{32 \cdot 9{,}81}{0{,}00785\,m^2}\right) + \left(\frac{0{,}1 \cdot 9{,}81}{0{,}00785}\right) = 10^5\,Pa + 39\,989{,}8\,Pa + 125\,Pa$

$= \underline{\underline{1{,}4\,bar}}$

$A_{zyl} = \left(\frac{D}{2}\right)^2 \cdot \pi$

$= (0{,}05\,m)^2 \cdot \pi$

$=$

m_g: $p_{1,g} \cdot V_{g,1} = m_g \cdot R_g \cdot T_{g,1}$

$R_g = \frac{8{,}314}{50 \cdot 10^{-3}} = 166{,}28$

$\Rightarrow m_g = \frac{p_{1,g} \cdot V_{1,g}}{R_g \cdot T_{g,1}} = \frac{1{,}4\,bar \cdot 3{,}14 \cdot 10^{-3}\,m^3}{166{,}28 \cdot 773\,k} = 0{,}00342\,kg$

$= \underline{\underline{3{,}42\,g}}$

$3{,}14\,L = 3{,}14\,dm^3$

$= 3{,}14 \cdot 10^{-3}\,m^3$

$500\,°C = 773\,k$

b) Thermodyn. GGW: $T_{g,2} = T_{EW,2}$

~~$x_{EW,2} = \frac{m_{EIS}}{m_{EW}} = 0{,}6$~~

~~$T_{2,g} = T_{1,g}$~~ $\quad \Delta U = \dot{Q} = c_v \cdot m_g \cdot (T_{2,g} - T_{1,g})$

$T_{2,g} = \frac{T_{1,g}}{c_v\, m_g} = \frac{773\,k}{\quad}$

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$0 \to 1$ isentrop, $T\uparrow$

A2) Exergie am Triebwerk

$1 \to 2$ $\dot{m}_K$ = isentrop, $T\uparrow$

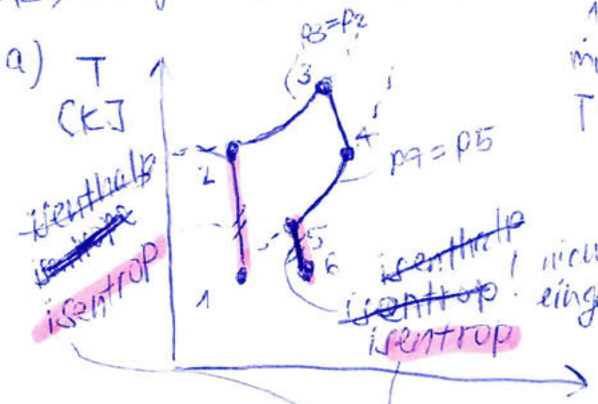
$2 \to 3$ $\dot{m}_K$ = isobare $T\uparrow$

$3 \to 4$ $\dot{m}_K$ = irreversible Turbine

$4 \to 5$ $\dot{m}_K + \dot{m}_M$ = isobar

$5 \to 6$ $s\uparrow$, isotherm

a)



$1 \to 4$
$\dot{m}_M$
$T\uparrow$

nicht so schön eingezeichnet sorry.

$s\left[\frac{kJ}{kgK}\right]$

$T_6 > T_1$,

$s_6 > s_1$

Sorry, Deutsch-Salat im Kopf :-/ ich meine isentrop.

b) w_6, T_6 bestimmen:

Luft = ideales gas $\quad p_6 \cdot v_6 = R \cdot T_6$

$$R_{Luft} = \frac{8{,}314}{M_{Luft}} = \frac{8{,}314 \text{ kJ/kmol K}}{28{,}97 \cdot 10^{-3} \text{ kg/mol}} = 287 \frac{kJ}{kgK}$$

~~Es~~ ~~4→5~~ $5 \to 6$ ist isentrop

$\Rightarrow$ ~~...~~ $s_6 = s_5$

$s_5 = s @ p = 0{,}5 \cdot 10^5 \text{ Pa}, 431{,}9 \text{ K} = \text{Tab-A-22}$

=

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A2) c) ~~E_x~~ $\dot{E}_{x,str} = \dot{m}\, e_{x,str} = \dot{m}\left[h - h_0 - T_0(s - s_0) + \cancel{ke}^{0} + \cancel{pe}^{0}\right]$

$= \dot{m}\left[h - h_0 - T_0(s - s_0)\right]$