[redacted]

1

1a) Energiebilanz.

IF mit konst c_p.

$\cancel{h_{kon}}$

$$\frac{dE}{dt} = \sum \dot m_i [h_i + ke_i + pe_i] + \sum \dot Q_j - \sum \dot W_n$$

$$0 = \dot m [h_e - h_a + 0 + 0] + \dot Q_{aus} + \dot Q_K$$

$$= \dot m [h_{KF ein} - h_{KF aus}] + \dot Q_{aus} + \dot Q_K$$

$$= \dot m [c_p (T_{ein} - T_{aus})] + \dot Q_{aus} + 100\,kW$$

$$\dot Q_{aus} = \dot m c_p (T_{aus} - T_{ein}) = 0.3(298.15 - 288.15) = \cancel{30\,kW} + 100\,W = -70\,kW.$$

1b)

$$\overline{T}_{KF} = \frac{\int_e^a T\,ds}{s_a - s_e}.$$

∵ adiabat & isobar ∴ $\cancel{\int_e^a T\,ds =}$

$\cancel{q_{rev} = \Delta S \cdot T}$

$$ds = \left(\frac{\delta Q}{T}\right)_{rev}$$

∴ $q_{rev} = \Delta S \cdot T = h_a - h_e$

$$\therefore \overline{T}_{KF} = \frac{h_a - h_e}{s_a - s_e}$$

$$= \cancel{\frac{c_p(T_a - T_e)}{c_p (}} \quad \frac{\int_{T_1}^{T_2} c^{if}\,dT + v^{if}(p_2 - p_1)}{\int_{T_1}^{T_2} \frac{c^{if}}{T}\,dT} = \frac{c^{if}(T_2 - T_1) + 0}{c^{if} \cdot \ln\left(\frac{T_2}{T_1}\right)}$$

$$= \frac{T_2 - T_1}{\ln\left(\frac{T_2}{T_1}\right)}$$

$$= \frac{298.15\,K - 288.15\,K}{\ln\left(\frac{298.15}{288.15}\right)} = 293.1257\,K.$$

1c) $\cancel{S_{erz}}$

$$0 = \dot m [s_e - s_a] + \sum \frac{\dot Q_j}{\overline{T}_j} + \dot S_{erz}$$

$$\dot S_{erz} = \dot m [s_a - s_e] + \frac{\dot Q_{aus}}{\overline{T}_{KF}}$$

$$= 0.3\,\frac{kg}{s}\left[c_p \ln\left(\frac{T_a}{T_e}\right)\right] + \frac{\dot Q_{aus}}{\overline{T}_{KF}}$$

1d) $\cancel{0 = \dot m [h_e - h_a + \left(\frac{w_e^2 - w_a^2}{2}\right) + g(z_e - z_a)] + \sum \dot Q_j - \sum \dot W_{en}}$

Zustand 1:
$T_1 = 100°C$.
$T_{ein\,12} = 20°C$.

Zustand 2:
$T_2 = 70°C$.

halboffnes System

$\cancel{m_2 u_2 \ldots}$

$$\Delta E = m_2 u_2 - m_1 u_1 = \sum \Delta m_i [h_i + \frac{w_i^2}{2} + g z_i] + \sum Q - \sum W.$$

$$(m_1 + \Delta m_{12}) u_2 - m_1 u_1 = \Delta m_{12} [h_e] - 35\,MJ$$

$u_{2f}(@\,20°C) = 83.95\,\frac{m^3}{kg}$ (TAB A2)

$u_{1f}(@\,100°C) = 418.94\,m^3/kg$ (TAB A2)

$h_{ef}(@\,20°C) = 83.96\,kJ/kg$.

$$(5755\,kg + \Delta m_{12})\,83.95 - 5755 \cdot 418.94 + 35000\,kJ = \Delta m_{12} \cdot 83.96$$

$$-1812867 + (83.95 - 83.96)\,\Delta m_{12} = 0$$

$$\Delta m_{12} =$$

1e). $\Delta S = m_2 s_2 - m_1 s_1 = \sum \Delta m_i s_i + \sum \frac{Q_j}{T_j} + S_{erz}$.

$\cancel{m_2}(m_1 + m_{\Delta 12})\, s_2 - m_1 s_1 = \Delta m_{12}\, s_{12} + \frac{Q_{12}}{T} + S_{erz}$.

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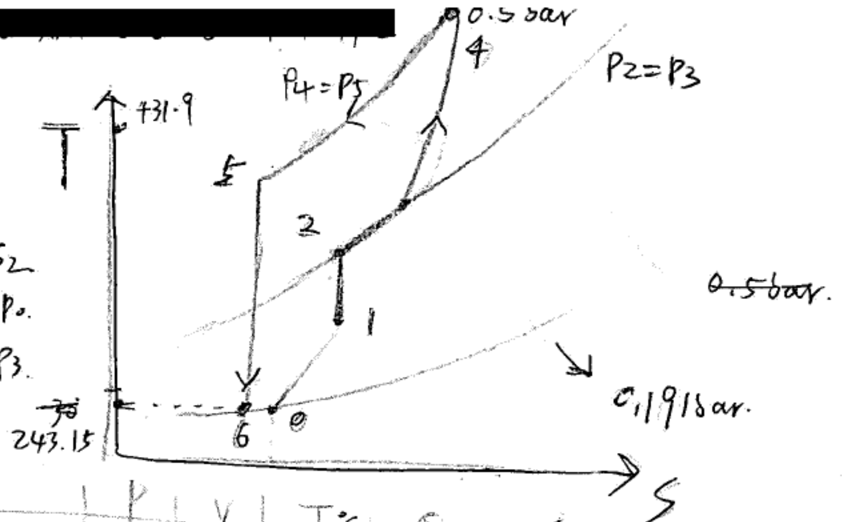
2a).

$s_1 = s_2$

$p_6 = p_0$

$p_2 = p_3$



	p	v	T °C	Q	s
0	0.191		−30		
1				$Q_{12}=0$	~~P=P~~ $s_1=s_2$ ~~Q_{12}~~$=0$. ~~p=~~
2	$p_2=p_3$				
3					
4	0.5 $p_4=p_5$				
5	0.5				
6					

$w_{Luft} = 200\,m/s$

$\eta_{vs}' < 1$.

b). $0 = \dot m\left[h_e - h_a + \frac{w_e^2 - w_a^2}{2} + g(z_e - z_a)\right] + \sum \dot Q - \sum \dot W$

~~for~~ für 5–6, isentropic.

$0 = \dot m\left[h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}\right] + 0 - 0$

$= \dot m_{ges}\left[h_5 - h_6 + \frac{220^2 - w_6^2}{2}\right]$

sucht $h_5 - h_6$.

∵ Luft ist IG mit $c_p^{ig} = 1.006 \frac{kJ}{kg\,K}$, 5–6 isentrope, $n = k = 1.4$,

$h(T_5) - h(T_6) = c_p^{ig}(T_5 - T_6)$

$= 1.006 \frac{kJ}{kg\,K} \cdot (431.9K - T_6)$

~~Such~~ sucht ~~T_6~~. w_6.

Für gesamte system 0–6,

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

$= \dot m\left[h_0 - h_6 + \frac{w_0^2 - w_6^2}{2}\right]$

~~$h_0 - h_6$~~ $h_0(-30°C) - h_6(T_6) = c_p^{ig}(T_0 - T_6) = 1.006 \frac{kJ}{kg} \cdot (243.15 - T_6)$

$\begin{cases} 0 = 1.006 \cdot (243.15 - T_6) + \frac{200^2 - w_6^2}{2} \\ 0 = 1.006\,(431.9K - T_6) + \frac{220^2 - w_6^2}{2} \end{cases}$ (1).

T_6.

[redacted]

$\cancel{h_5}$ $\cancel{h_5}$ h_6 $h_6 - h_5 = \frac{220^2 - W_6^2}{2}$

$h_6 - h_0 = \frac{200^2 - W_6^2}{2}$

$\therefore$ $-h_5 + h_0 = \frac{220^2 - W_6^2}{2} - \frac{200^2 - W_6^2}{2}$

$\because$ 5-6 isentropic.

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

$\frac{431.9K}{T_6} = \left(\frac{0.5}{p_6}\right)^{\frac{k-1}{k}}$

$= \left(\frac{0.5}{0.191}\right)^{\frac{0.4}{1.4}}$

$= 1.3164684$

$\therefore$ $T_6 = 328.0747$

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

$= \left(\frac{0.191}{0.5}\right)^{\frac{0.4}{1.4}}$

$= 0.759608$

$T_6 = 0.759608 \cdot 431.9K$

$= 328.0747\ K.$

Von (1): $0 = 1.006(431.9K - 328.0747K) + \frac{220^2 - W_6^2}{2}$

$= 104.4482 + 24200 - \frac{W_6^2}{2}$

$\frac{W_6^2}{2} = 24304$

$W_6 = \sqrt{48608} = 220.472\,m/s$

2C) $\Delta e_{xstr} = e_{x6} - e_{x0}$

$= h - h_0 - T_0(s - s_0) + ke + pe$

$= h_6 - h_0 - T_0(s_6 - s_0) + \frac{W_6^2 - W_0^2}{2}$

$\because p_6 = p_0$ isobar, adiabat $\therefore$ 6-1 isentropen.

$\therefore$ $s_6 - s_0 = c_{p,ig} \ln\left(\frac{T_6}{T_0}\right) - R\ln\left(\frac{p_6}{p_0}\right)$

$= 1.006 \cdot \ln\left(\frac{340}{243.15}\right) - R\ln(1) = 0.337278\ kJ/K\cdot kg$

$h_6 - h_0 = c_{p,ig}(T_6 - T_0) = 1.006 \times (340 - 243.15) = 97.4311\ kJ/kg$

$\Delta e_{xstr} = 97.4311\ kJ/kg - (243.15K)(0.337278)\ kJ/kg + \frac{510^2 - 200^2}{2} \cdot \frac{1}{1000}$

$= \cancel{110065\ kJ/kg}$ $15.42 + 110.05$

$= 125.47\ kJ/kg$

2d). $\cancel{0=}\ \dot m \frac{dE_x}{dt} = \sum \dot E_{x,str} + \sum \dot E_{xQ} - \sum[\dot W_n - p_0 \frac{dV}{dt}] - \dot E_{x,verl}$

$0 = \dot m[h_e - h_a - T_0(s_e - s_a) + \Delta ke + \Delta pe] + \sum(1-\frac{T_0}{T})\dot Q_j - \sum \dot W_{tn} - \dot E_{x,verl}$

~~Exverl~~ $ex_{verl} = h_0 - h_6 - T_0(\cancel{h_0}\ s_0 - s_6) + \cancel{\ } \Delta ke \cancel{+0} \frac{\sum \dot Q_{ex}}{\dot m} - \frac{\sum \dot W_{ex}}{\dot m}$

find $\frac{\sum(1-\frac{T_0}{T_j})\dot Q_j}{\dot m}$

$= \sum(1-\frac{T_0}{T_j})\cdot q_j$

$= (1 - \frac{243.15K}{1289K}) \cdot 1195 \frac{kJ}{kg}$

$= 969.581\ kJ/kg$

~~lez~~ 0-1. $\eta_{vs} < 1$

$\eta_{vs} = \frac{w_{t,rev}}{w_{t01}} = \frac{h_0 - h_{1s}}{h_0 - h_1}$

- energie~~b~~bilanz 0-1.

$0 = \dot m(h_0 - h_1) + \sum \dot Q - \sum \dot W$

$\frac{\dot W}{\dot m} = w_{t01} = h_0 - h_1 = c_{p,luft}^{ig}(T_0 - T_1) = 1.006\cdot(243.15K - T_1)$

find T_1.

in 1-4, $0 = \dot m_m(h_4 - h_1)$

$h_4 = h_1$

$\because$ IG mit konst. c_p, $\therefore T_4 = T_1$,

find T_4, ~~$p_4 = p_1$~~ $\because$ 3-4 isentrope, $s_3 = s_4$, $T_4 = T_3$ due to $pg \propto T$.

$= 1289K$.

$\therefore T_1 = 1289K$

$w_{t01} = 1.006(243.15 - 1289) = -1272.439\ kW/kg$.

$\rightarrow$. $ex_{verl} = h_0 - h_6 - T_0(s_0 - s_6) + 969.581 + 1272.439$

$= c_p(T_0 - T_6) - T_0(\cancel{ln} \cdot c_p(\frac{T_0}{T_6}) + 2242.02$.

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4

3 a) ~~PV=~~

b) ~~P~~ $PV = mRT$.

$P_{2g}V_{g2} = mRT_{g2}$

c) $0 = \dot{m}\left[h_e - h_a + \frac{w_e^2 - w_a^2}{2} + g(z_e - z_a)\right] + \sum \dot{Q} - \sum \dot{W}$

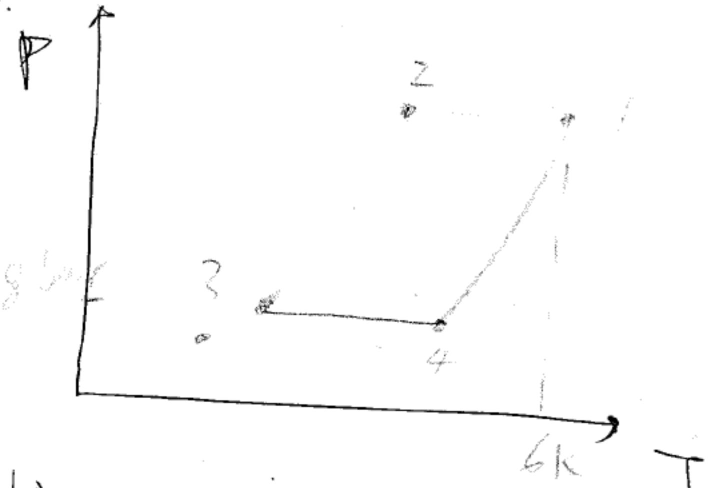
$=$

d) $x_{ED} = \frac{m_{ED}}{m_{EW}} = 0.6$.

[redacted]

5

4 a).



b).
$$0 = \dot m[h_e - h_a] + ke + g(z_e - z_a)] + \sum \dot Q_j - \sum \dot W_{in}$$
$$= \dot m_{R134a}[h_1 - h_4] + (-\dot Q_{ab}) + \dot Q_k + 28W.$$

$$0 = \dot m[h_1 - h_2] + \dot Q_k$$
$$\dot Q_k = \dot m_{R134a}[h_2 - h_1].$$

2-3: $0 = \dot m_{R134a}[h_2 - h_3] + \dot Q_k + 28\,W$
$$= \dot m[\int_{T_1}^{T_2} c^{if}(T)\,dT + v^{if}(p_2 - p_1)) + \cancel{\dot Q_k} + 28W$$

h_3 h_2 gesättigt dampf.
$h_2 =$

c). $\phi = \phi_f + x(\phi_g - \phi_f)$
$s = s_f + x(s_g - s_f)$
$s_1 = s_4,$
$\because$ Zustand 4 gerade kondensiert,
$\therefore$ TAB A7.

d). $$\varepsilon_k = \frac{|\dot Q_{zu}|}{|\dot W_t|} = \frac{|\dot Q_{ab}|}{|\dot Q_{ab}| - |\dot Q_{zu}|}$$