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Aufgabe 1

a) $\dot{Q}_{aus}$ über wand

Energie Billanz um Kessel

$$0 = \dot{m}\left[h_e - h_a\right] + \sum \dot{Q}_j - \cancel{\sum \dot{W}_n}^{0}$$

$$h_e = h_f + x\cdot(h_g - h_f) \Rightarrow h_f + x\cdot h_{gf}$$

$$h_g = h_g[100°C] \quad h_f = h_f[100°C]$$

Einfliessendes wasser $x = 0$
ausfliessend $x = 0.005$
aus Tabelle A2
$h_a = 292.98 \frac{kJ}{kg}$

$$= 419.04 + 0.005 \cdot \overset{2257.0}{\cancel{2230.2}} = 430.325$$

$$\Rightarrow -Q = 0.3 \frac{kg}{s} \cdot \cancel{3}(430.325 - 292.98) = \underline{\underline{-41.204\ kW = Q_{aus}}}$$

b) $$\overline{T}_{kf} = \frac{\int_e^a T\,ds}{s_a - s_e} = \frac{T\cdot(s_a - s_e)}{s_a - s_e}$$

TaB A2
$s_a = 0.\cancel{94}9549\ kJ/kg\cdot K$ $s_e = 7.7553\ kJ/kg\cdot K$

~~c)~~

c) $\dot{S}_{erz} \Rightarrow 0 = \dot{m}[s_e - s_a] + \sum \frac{\dot{Q}_j}{\overline{T}_j} + \dot{S}_{erz}$ $\quad$ $\overline{T}$ aus aufgabenstellung

$$\dot{S}_{erz} = \dot{m}[s_e - s_a] + \frac{\dot{Q}_R}{\overline{T}} - \frac{\dot{Q}_{aus}}{\overline{T}} = m[s_e - s_a] + \frac{Q_R - Q_{aus}}{\overline{T}}$$

$$\dot{S}_{erz} = \cancel{0.9549}\ 0.3 \cdot \cancel{e_z}[7.7553 - 0.99549] + \frac{100\,kW - 41.204\,kW}{298.15\,K}$$

$$S_{erz} = \underline{\underline{2.225\ kJ/kg\cdot K}}$$

d) halboffenes system! $\Delta E = m_2 u_2 - m_1 u_1 = \Delta m\, h_i + \sum Q_j - \cancel{\sum W_n}^{0}$

$$E = U + \cancel{K_e + P_e}^{0} \rightarrow \Delta E = \Delta U$$

$$\Delta U = \Delta m h_i + \sum Q_j = \Delta m \Delta h + \sum Q_j$$

$$\Delta m = \frac{\Delta U + Q_{R,12}}{\Delta h} = 1 = \Delta u + \frac{Q_{R,12}}{\Delta h \Delta m}$$

$$\Delta U = \Delta m \cdot \Delta u \quad \cancel{Q_{R,12}}$$

Δu: $u_f[20°C] = 83.95 \frac{kJ}{kg}$
$u[70°C] = 292.95 \frac{kJ}{kg}$

Δh: $h[20°C] = 83.96$ } kJ/kg
$h[70°C] = 292.98$

$$\Rightarrow 1 - \Delta u = \frac{Q_{R12}}{\Delta h \Delta m} \Rightarrow (1 - \Delta u)\Delta m = \frac{Q_{R12}}{\Delta h}$$

$$\Delta m = Q_{R12} / (\Delta h(1 - \Delta u))$$

$$\Delta m = \frac{-Q_{RR}}{\Delta h(1-\Delta u)} = \frac{35\cdot 10^6}{209.35(1-209)\frac{kJ}{kg}} = \underline{\underline{803.76\ kg}}$$

Δ

Δm aus aufgabenstellung!

ⓔ $\Delta S_{12} = m_2 s_2 - m_1 s_1$ ~~$(m_2 - m_1)(s_2 - s_1) - m_2 s_2 - m_2 s_1 + m_1$~~

$\Rightarrow \Delta m$ ~~$\Delta m = (m_2 - \Delta m)\ \Delta s \Rightarrow m_2(s_2 - s_1) - m_1(s_2 - s_1) =$~~

$s_2 = 0.9549$

$s_1 = s_f + 0.005\cdot(s_g - s_f) = 1.3069 + 0.005\cdot(7.3549 - 1.3069)$
$= 1.33714$

$\Rightarrow m_1 = 5755\,kg \quad m_2 = 5755 + 3600 = 9355\,kg$

$\Delta S_{12} =$ ~~5755~~ $9355\cdot 0.9549 - 5755\cdot 1.33714 =$

$= 8933.0895 - 7695.24407 = \underline{\underline{1237.85\ kJ/kg\cdot K}}$

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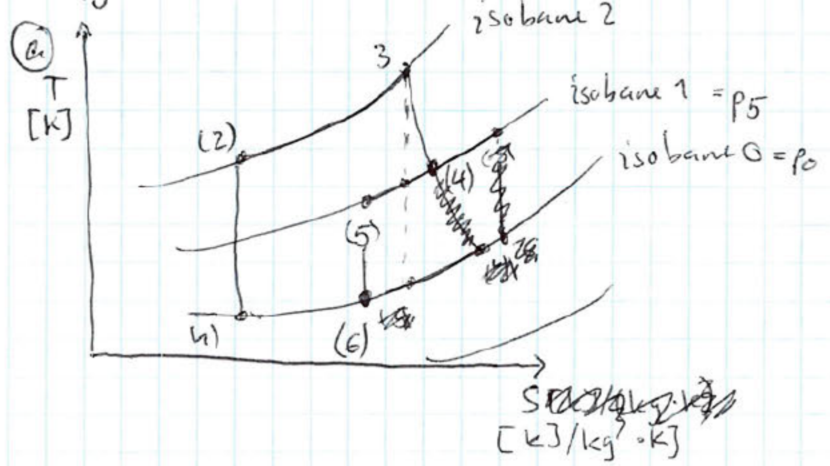
Aufgabe 2

Aufgabe 2

a)



b) w_6, T_6 Da ideales Gas mit Polytropem Tverhältnis

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \qquad n = k = 1.4 \qquad p_6 = p_0 = 0.191\ \text{Bar}. \qquad T_5 = 431.9\,K,\ p_5 = 0.5\ \text{Bar}$$

$$T_6 = 431.9\,K \cdot \left(\frac{0.191}{0.5}\right)^{\frac{0.4}{1.4}} = \underline{\underline{328.075\ K}}$$

$$\left.\begin{array}{l} \rho A w = \dot m \\ \rho \dot v = \dot m \end{array}\right\} \rightarrow \dot m_6 = \dot m_5 \qquad \left(\frac{v_1}{v_2}\right)^{n-1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} \Rightarrow V_6 = V_5 \cdot \left(\frac{p_6}{p_5}\right)^{\frac{1}{n}}$$

$$v_5 = \frac{R T_5}{p_5} \qquad R = \frac{\bar R}{M} \rightarrow \cancel{\frac{8.314}{1.006}} = c_p^{ig} - c_v^{ig} \qquad K = \frac{c_p^{ig}}{c_v^{ig}} \rightarrow c_v^{ig} = \frac{c_p^{ig}}{K}$$

$$R = 1.006 - 0.718 = 0.287\ \frac{kJ}{kg\,K} \qquad = 0.718\ \frac{kJ}{kg\,K}$$

c) $\Delta e_{x,str} = e_{x,str,6} - e_{x,str,0}$

0 vernachlässigbar

$$\dot m\, e_{x,str} = \dot m\left[h - h_0 - T_0(s - s_0) + ke + \cancel{pe}\right] \Rightarrow e_{x,str} = h_6 - h_0 - T_0(s_6 - s_0) + \frac{w^2}{2}$$

$$h_6 - h_0 = \int_{T_0}^{T_6} c_p^{ig}\, dT = c_p^{ig}(T_6 - T_0) = 1.006 \cdot (328.075\,K - 243.15\,K) = \underline{85.43\ \frac{kJ}{kg}}$$

Δh

$$s_6 - s_0 = \int_{T_0}^{T_6} \frac{c_p^{ig}}{T}\, dT - R \ln\left(\frac{p_6}{p_0}\right) = c_p^{ig} \ln\left(\frac{T_6}{T_0}\right) - R \cdot \ln\left(\frac{p_6}{p_0}\right) =$$

$$= 1.006 \ln\left(\frac{328.075\,K}{243.15\,K}\right) - 0.287 \cdot \cancel{\ln(1)} = 1.006 \ln\left(\frac{328.075\,K}{243.15\,K}\right) - 0$$

$$= \underline{0.301\ \frac{kJ}{kg\,K}}$$

$$\Rightarrow T_0 \cdot \Delta s = 243.15 \cdot 0.301 = \underline{73.27\ \frac{kJ}{kg}}$$

$\Delta s\, T_0$

w_6 von aufgaben stellung, da nicht gefunden vorher!

$$\Delta ke = \Delta\frac{w^2}{2} = \Delta e_{x,str} = 85.43\frac{kJ}{kg} - 73.27\frac{kJ}{kg} + \cancel{\frac{510\frac{m}{s}^2}{2}} = \cancel{12.16} + \cancel{130050\frac{m^2}{s^2 kg^2}}$$

$$\frac{\Delta w^2}{2} = \cancel{12.16\frac{kJ}{kg} + 130.05\frac{kJ}{kg}}$$

$$\cancel{= 142.21\frac{kJ}{kg}}$$

$$\Delta w = w_6 - w_7 = 510 - 200 = 310\frac{m}{s}$$

~~(d) $e_{x,verl}$~~ $\Rightarrow \frac{\Delta w^2}{2} = 48050\cancel{\frac{kJ}{kg}}\frac{m^2}{s^2} \Rightarrow ke = \cancel{4850}\ 48050\frac{m^2}{s^2 kg} \Rightarrow \frac{kJ}{kg} \Rightarrow 48.050\frac{kJ}{kg^2} = ke$

$$e_{xstr} = 85.43 - 73.27 + 48.050 = 60.21\frac{kJ}{kg^2}$$

(d) $e_{x,verl}$ Stationärer Fliessprozess $\Rightarrow$ Exergie Bilanz um Triebwerk

$$0 = \dot m\,\Delta e_{x,str} + \underbrace{\sum\left(1-\frac{T_0}{T_j}\right)\dot Q_j}_{\dot E_{x,Q,j}} - \cancel{\sum \dot W_{t,n}}^{0} - \dot E_{x,verl}$$

$$\dot E_{x,Q} = \left(1-\frac{T_0}{T}\right)\dot Q$$

$$= \left(1-\frac{243.15\,K}{1289\,K}\right)\cdot 1195 = 969.582\frac{kJ}{kg}\cdot\dot m \Rightarrow e_{x,Q} = 969.582\frac{kJ}{kg}$$

$$\Rightarrow \dot e_{x,verl} = \cancel{\dot m}\,\Delta e_{xstr} + e_{xQ}$$

$$\dot e_{x,verl} = -\Delta e_{x,str} + e_{xQ} = 969.582\frac{kJ}{kg} - 60.21\frac{kJ}{kg} = 909.37\frac{kJ}{kg}$$

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Aufgabe 3

a) $p_{g,1}$ m_g

$p_{g,1} = p_{amb} + p_{gewicht} = p_{amb} + p_{g2} \Rightarrow$

$D = 0.1 m$

$p_{gewicht} = \frac{m_k \cdot g}{A} + \frac{m_{EW} \cdot g}{A}$

$= \frac{32 kg \cdot 9.81 \frac{m}{s^2} + 0.1 kg \cdot 9.81 \frac{m}{s^2}}{\pi \cdot D}$

$= 1002.36\ Pa$

$p_{g1} = 1 Bar + 0.1002 Bar = \underline{\underline{1.1002 Bar}} = \underline{\underline{1.1 Bar}}$

für Masse: $pV = m \cdot R \cdot T \Rightarrow m = \frac{pV}{RT}$

$V_{g1} = 3.14 \cdot 10^{-3} m^3$

$T_{g1} = 773.15 K$

$m = \frac{11002.36 Pa \cdot 3.14 \cdot 10^{-3} m^3}{773.15 K \cdot 0.166} = \cancel{269.2}$ $\underline{\underline{\cancel{0.2692 kg}}}$

$= \underline{\underline{2.692 g}}$

$R = \frac{\bar{R}}{M} = \frac{8.314}{50} = 0.166 \frac{kJ}{kgK}$

b) $x_{E,2} > 0$ $T_{g,2}$, $p_{g,2}$ $T_{g,2}$ ist gleich wie ~~T~~ $T_{1,g}$, da sich das EW noch im "Nass-fest" gebiet ~~war~~ ist.

~~c)~~

c) Q_{12} zwischen $1 \rightarrow 2$ Energie Billanz: $\frac{dE}{dt} = \sum \dot{Q}_j - \cancel{\sum \dot{W}_{v,n}}$ (geschlossenes system)

$\frac{d}{dt}(U + K_e + \cancel{E} P_e) = \Delta Q$ (T_2 aus aufgaben stellung)

$\Delta U_{12} = \Delta Q_{12} \Rightarrow \Delta u_{1,2} = \int_{T_1}^{T_2} c_v^{ig}\, dT = c_v^{ig}(T_2 - T_1) \Rightarrow \cancel{c_v^{ig}} q$

$\Delta u_{1,2} = 0.633 \cdot (-0.003) = \cancel{0.0019}\ 0.0019 \frac{kJ}{kg}$

$\Delta q_{12} = 0.0019 \frac{kJ}{kg} \rightarrow m \cdot \Delta q_{12} =$ ~~100g~~ ~~...~~ $= 1900J$ ~~1900J~~ $\underline{1900 J}$

$\Rightarrow$ ~~1900 J über tragen~~ 1900J übertragen zwischen gas und EW

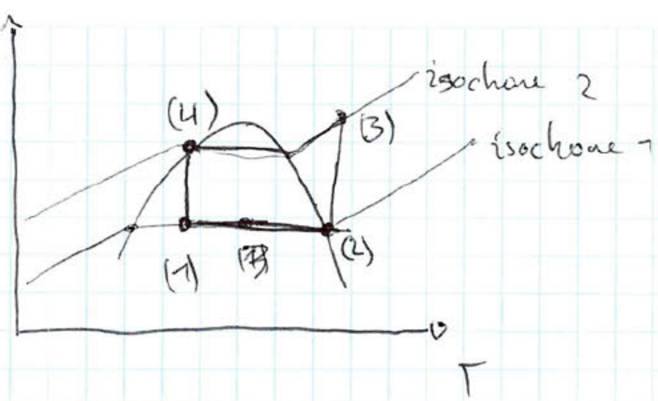
~~$\Rightarrow$ aus sicht Gas -1901~~

j $x_{EIS,2}$

[redacted]

Aufgabe 4

(a)



(b) $\dot{m}_{r134}$ Energie Billanz um ~~Drossel~~ Kompressor /Verdichter

$0 = \dot{m}\,(h_e - h_a) - \dot{W}_K \rightarrow \dot{m} = \frac{\dot{W}_K}{h_e - h_a}$

243.78 = h nach drossel

(c) x_1 nach drossel $x = \frac{\phi - \phi_f}{\phi_g - \phi_f}$ mit $\phi = v, u, h, s$

$\Rightarrow h = 243.78$ da drossel isenthalp per definition

(d) $\varepsilon_K = \frac{|\dot{Q}_{ab}|}{|\dot{W}_t|} = \frac{6}{28} = \underline{\underline{0.214}}$

(e) Das Wasser würde in die kritische phase übergehen!