22-930-689

Aufgabe 1

a) $\dot{m}_{ein} = 0{,}3\ kg/s$ $T_{ein} = 70°$ $T_{aus} = 100°$ $x_D = 0{,}005$

$\dot{Q}_R = 100\ kW$

1HS um Reaktor ohne Hülle $\dot{m}_{ein} = \dot{m}_{aus} = \dot{m}$

TAB A-2

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

$0 = \dot{m}(c_f (T_{ein} - T_{aus})) + \dot{Q}_{aus} + \dot{Q}_R$

$-\dot{Q}_R - \dot{m}(c_f(T_{ein} - T_{aus})) = \dot{Q}_{aus}$

$h_{ein} = 292{,}98 = h_f$ @ TAB A-2 @ 70°C

$h_{aus} = 419{,}04 = h_f$ @ TAB A-2 @ 100°

$\dot{Q}_{aus} = 0{,}3(h_{aus} - h_{ein}) - \dot{Q}_R$

$= 0{,}3(419{,}04 - 292{,}98) - 100\ kW$

$= -62{,}182\ kW$ ((von Tank aus gesehen)

von mantel aus $+62{,}182\ kW$)

b) $\bar{T}_{kF}$ entropiebilanz

$0 = \dot{m}(s_{ein} - s_{aus}) - \frac{\dot{Q}_{aus}}{\bar{T}} + \dot{s}_{erz}$

$\bar{T} = \frac{\int_a^e T\,ds}{s_a - s_e} = \frac{q_{rev}}{s_{aus} - s_{ein}}$

$\int T\,ds = q_{rev}$

$q_{rev} = \frac{\dot{Q}_{aus}}{\dot{m}} = \frac{62{,}182}{0{,}3} = 207{,}273$

$= \frac{207{,}273}{1{,}3069 - 0{,}9549}$

$= 588{,}3735\ K$ TAB A-2

c) $\dot{s}_{erz} = \dot{m}(s_{aus} - s_{ein}) - \frac{\dot{Q}_{aus}}{\bar{T}}$

$= 0{,}3(1{,}3069 - 0{,}9549) - \frac{62{,}182}{588{,}8375}$

$= 0{,}211$

d) T_2

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

$$\Delta E = \Delta m (h_{ein}) + \dot{Q} - W$$

$$\Delta U = \Delta m (h_{ein}) + \dot{Q}_{aus}$$

$$m(u_2 - u_1) = \Delta m_{12} (h_{ein}) + \dot{Q}$$

$$\Delta m = \left(-\dot{Q} + m(u_2 - u_1)\right) \cdot \frac{1}{h_{ein}}$$

$$= -35 \cdot 10^3 \text{ kJ} + 5755 \text{ kg} (\quad$$

$T_{Reaktor} = 20°C$

$T_{ein} = 20°C$

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

$h_{ein} = 83,96 \text{ kJ/kg}$

↳ T+B A-2 @ 20°

e) $\Delta S = m(s_2 - s_1) = \frac{\dot{Q}}{T} + \dot{S}_{erz}$

$= \Delta m ($

$\bar{T} = 100°C = T_{Reaktor}$

T+B A-2

$u_2 = 418,94 + 0,005 (2506,5 - 418,94)$

$= 431,395 \text{ kJ/kg}$

$u_1 = 83,95 \text{ kJ/kg}$

$\Delta m_{12} = -35 \cdot 10^3 + 5755 (431,395 - 83,95) \cdot \frac{1}{83,96}$

$= -11184,54 \text{ kg}$

e) $= \Delta S = m(s_2 - s_1)$

$= 5755 (1,33714 - 0,2966)$

$= 769,5 \text{ MW/kgK}$

T+B A-2

$s_2 = 1,3069 + 0,005 (1,3549 - 1,3069)$

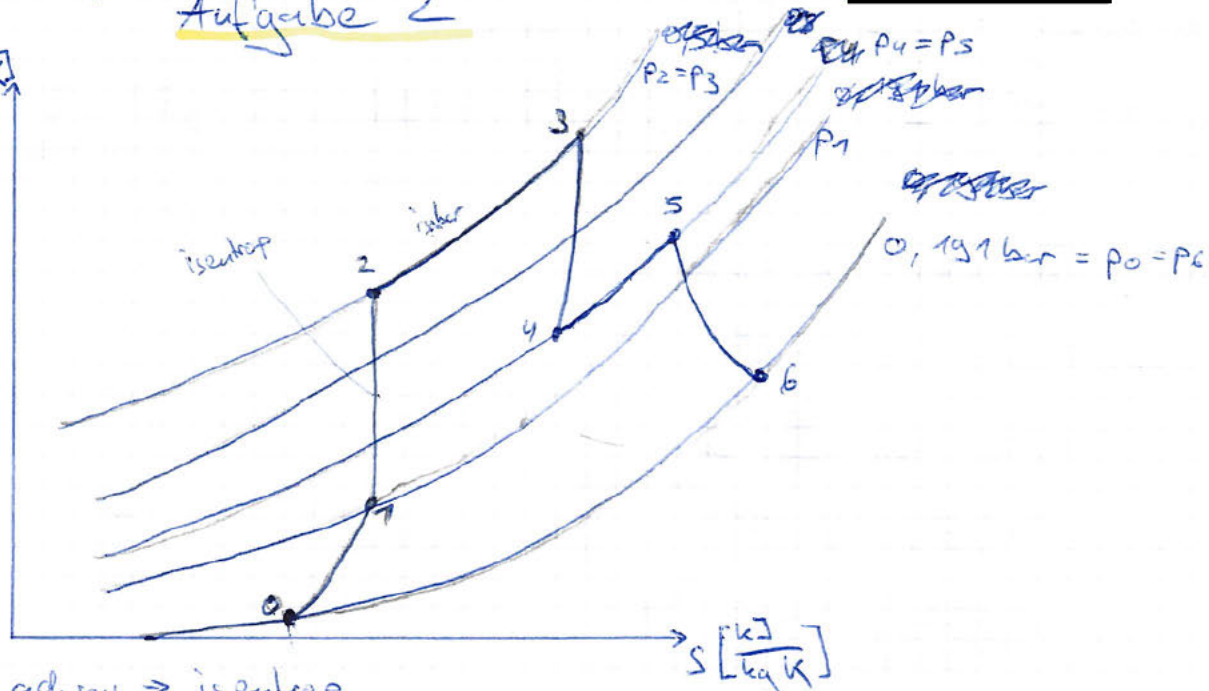
$= 1,33714 \text{ kJ/kgK}$

$s_1 = 0,2966 \text{ kJ/kgK}$

22-930-689 [redacted]

Aufgabe 2

a)



1-2 ad. rev → isentrop

2-3 isobar

b) St. fp. mit massenstrom $pV = mRT$

$$0 = \dot{m}_{ges}\left[(h_5 - h_6) + \frac{\omega_5^2 - \omega_6^2}{2}\right] + \dot{Q} - \dot{W}_t$$

1. HS um Bk.

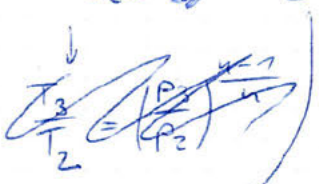
$$0 = \dot{m}_k (h_2 - h_3) + \dot{Q} - W$$

$$0 = \dot{m}_k (c_p (T_2 - T_3)) + \frac{\dot{Q}_B}{\dot{m}_k}$$

$$0 = \dot{m}_{ges}\left(c_p (T_1 - T_6) + \frac{\omega_4^2 - \omega_6^2}{2}\right)$$

$\dot{m}_{ges} = \dot{m}_k + \dot{m}_M$

$s_2 = s_1$



$$\frac{T_3}{T_2} = \left(\frac{p_3}{p_2}\right)^{\frac{\kappa-1}{\kappa}}$$

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\kappa-1}{\kappa}}$$

$p_2 = p_3$

$$T_6 = \frac{pV}{RT} \quad \Big| \quad \kappa = \frac{c_p}{c_v} \qquad c_v = \frac{c_p}{\kappa}$$

$$R = c_p - c_v = c_p - \frac{c_p}{\kappa} = 1{,}006 \frac{kJ}{kg\,K} - \frac{1{,}006 \frac{kJ}{kg\,K}}{1{,}4} = \underline{0{,}287 \frac{kJ}{kg\,K}}$$

c)

$$\Delta e_{x,ke} = h_6 - h_0 - T_0 (s_6 - s_0) + \Delta ke$$

$$= c_p (T_6 - T_0) - T_0 \left(c_p \cdot \ln\left(\frac{T_6}{T_0}\right) - R \cdot \ln\left(\frac{p_{a6}}{p_0}\right)\right) + \Delta ke$$

$p_6 = p_0$

$$= 1{,}006 \cdot (340 - 243{,}15) - 243{,}15 \cdot \left(1{,}006 \cdot \ln\left(\frac{340}{243{,}15}\right) + 110{,}50 \cdot 10^{-3}\right)$$

$$= \underline{125{,}471 \frac{kJ}{kg}}$$

$$\Delta ke = \frac{\omega_6^2 - \omega_0^2}{2} = \frac{510^2 - 200^2}{2} = 110{,}50\ N$$

d) $0 = \Delta e_{x\,sk} + e_{xQ} - w_{tn} - e_{x\,verl}$

$e_{xQ} = \left(1 - \frac{T_0}{T}\right) \cdot Q = \left(1 - \frac{243,15\,K}{1289\,K}\right) \cdot 1195 = 969,58\ kJ/kg$

$e_{x\,verl} = T_0 \cdot s_{er2}$

$s_{er2} = (s_2 - s_1) - \frac{Q}{T}$

$= (s_6 - s_0) - \frac{Q}{T}$ $\quad p_6 = p_0$

$= \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right)^0 - \frac{Q}{T}$

$= \ln\left(\frac{340K}{243,15K}\right) - \frac{(-1195)\,kJ/kg}{1289\,K}$

$= 1,262\ kJ/kgK$

$e_{x\,verl} = 243,15 \cdot 1,262 = \underline{306,855\ kJ/kg}$

22-930-689 Aufgabe 3

[redacted]

a)

$$p_{g1} = p_0 + \frac{m_k g}{A} + \frac{m_{ew} g}{A}$$

$$A = \pi r^2 = \pi \cdot (0{,}05\,m)^2 = 0{,}00785\,m^2$$

$$= 1 \cdot 10^5\,Pa + \frac{32 \cdot 9{,}81}{0{,}00785} + \frac{0{,}1 \cdot 9{,}81}{0{,}00785}$$

$$= 140114{,}7\,Pa \triangleq \underline{1{,}401\,bar}$$

m_g: $pV = mRT$

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

$$m_g = \frac{p_g V_g}{RT}$$

$$= \frac{1{,}401 \cdot 10^5\,Pa \cdot 3{,}14 \cdot 10^{-3}\,m^3}{166{,}28\,J \cdot (273{,}15\,K)}$$

$$= 0{,}00342\,kg \triangleq \underline{3{,}42\,g}$$

b) $p_{2g} = p_{1g}$ da sich die Masse des Eises, weder noch die des Gewichts geändert hat.

T_{2g}

$x_{1\,eis} = 0{,}6$

$$V_2 = \frac{m_g R T_2}{p} = \frac{0{,}00342 \cdot 166{,}28 \cdot 273{,}15}{1{,}401 \cdot 10^5}$$

$$= 0{,}0011\,m^3$$

c) $\frac{dE}{dt} = \sum \dot{Q} - \dot{W}_{vn}$

$W_{vn} = \oint \int_1^2 p\,dV$

$\Delta U = Q_{12} - W_{vn}$

$= p(V_2 - V_1)$

$u(u_2 - u_1) = Q_{12} - W_{vn}$

$= 1{,}401 \cdot 10^5 \cdot (0{,}0011 - 3{,}14 \cdot 10^{-3})$

$= -285{,}8\,J$

$m(u_{g2} - u_{g1}) + [redacted] = Q_{12} - W_{vn}$

$m_g(c_v(T_2 - T_1)) + [redacted] = Q_{12} - W_{vn}$

$0{,}00342 \cdot 0{,}633(273{,}153 - 273{,}15) = Q_{12} - W_{vn}$

$\underline{Q_{12} = -284{,}7\,J}$

$V_2 =$

d)

$$\varphi = \varphi_f + x_2 (\varphi_g - \varphi_f)$$

$$u_2 = u_{2f} + x_2 (u_{2g} - u_{2f})$$

u_2 $\quad$ $\boxed{u_g = u_{fest.}}$

$\sigma = u_{EW}$ $\quad$ $T_{EW_2} = 0{,}0°$ $\quad$ $T_{EW_2} = ?$

~~$T_{EW_2} = 0.0°C$~~

$$x_2 = \frac{u_2 - u_{2f}}{u_{2g} - u_{2f}}$$

$$x_2 = \frac{-3047{,}093 - (-0{,}045)}{-333{,}458 - (-0{,}045)}$$

$$= 0{,}919$$

$$m_{EW}(u_2 - u_1) = Q_{12}$$

$$u_1 = u_{1f} + x_1 (u_{1g} - u_{1f}) \quad \text{aus (c)}$$

$$= -0{,}045 + 0{,}6 \left(-333{,}458 - (-0{,}045)\right)$$

$$= -200{,}093$$

$$u_2 = \frac{Q_{12}}{m_{EW}} + u_1 = \frac{-284{,}7}{0{,}1} + (-200{,}093)$$

$$= -3047{,}093 \ kJ/kg$$

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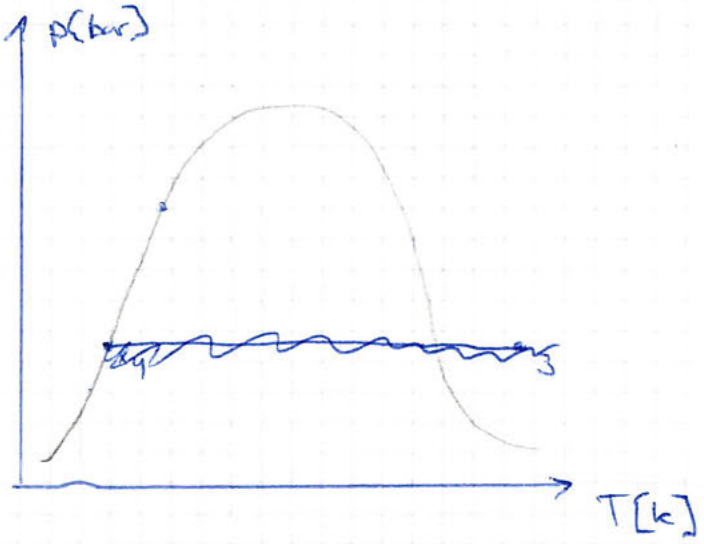
Aufgabe 4

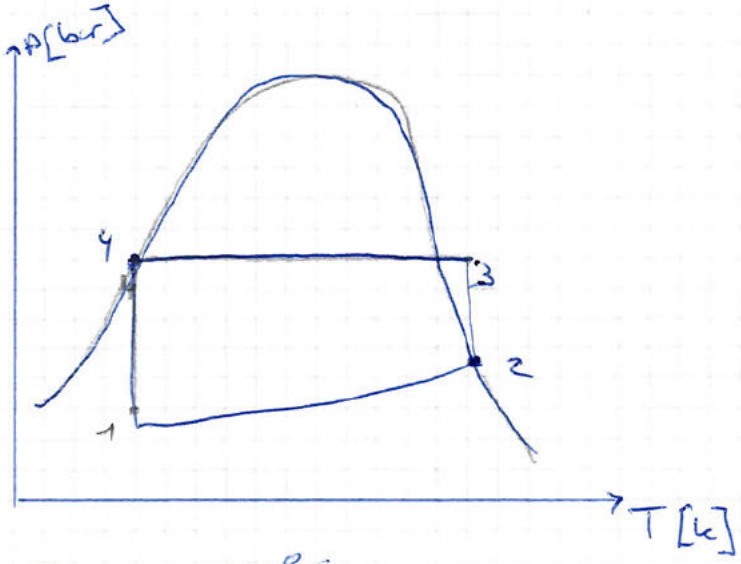
a)



b) ad. rev 2-3 ⇒ isentrop $s_2 = s_3$

3-4 isobar

a)



b) $T_i = -10°C$

c) $x_1 = \frac{h_1 - h_{1l}}{h_{1g} - h_{1f}}$

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

e) würde schneller abkühlen