M1 2013

1 kompresor

$p_2 = 0.5\ MPa$

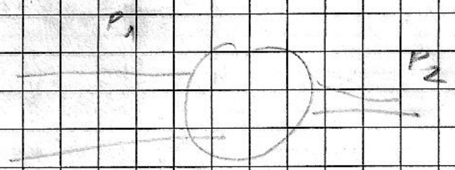
$t_2 = 473.15\ K$

$q_{0k} = -50\ kJ/kg$

$R = 287\ J/kgK$ $c_v = 718\ J/kgK$

$p_1 = 0.2\ MPa$ $t_1 = 323.15\ K$ $c_1 = 200\ m/s$ $c_2 = 100\ m/s$

w_{t12}



$$q_{12} + h_1 + \frac{1}{2}c_1^2 = w_{t12} + h_2 + \frac{1}{2}c_2^2$$

ako se gubi energija od 50 kJ/kg

$$w_{t12} = h_1 - h_2 + q_{12} + \frac{1}{2}(c_1^2 - c_2^2)$$

$$= c_v(T_1 - T_2) + q_{12} + \frac{1}{2}(c_1^2 - c_2^2)$$

$$= 718(323.15 - 473.15) - 50 \cdot 10^3 + \frac{1}{2}(200^2 - 100^2) =$$

$$w_{t12} = -142.7\ kJ/kg$$

1 kg idealnog plina $c_v = 718\ J/kgK$ $R = 287\ J/kgK$ tlaka $p = 100\ kPa$ i temperature 300°C polagano se komprimira na temperaturu 100°C

Topl. en. prilikom hlađenja s okolicom temp 20°C, $K_{gub} = ?$

2. Izobarna kompresija $p_1 = p_2$

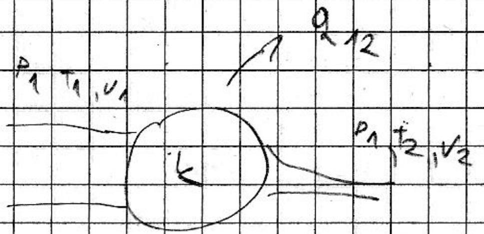
$m = 1\ kg$

$c_v = 718\ kJ/kgK \qquad R = 287\ J/kgK$

$p_1 = p_2 = 100\ kPa$

$T_1 = 573.15\ K \qquad T_2 = 373.15\ K$

$T_{ok} = 293.15\ K$



$c_p = 718 + 287 = 1005\ J/kgK$

$w_{gub} = ?$

$w_{gub} = m \cdot [\Delta s_{uk} \cdot T_{ok}]$

$\Delta s_{uk} = \Delta s_{pl} + \Delta s_{ok}$

$\Delta s_{pl} = c_p \ln \frac{T_2}{T_1} + R \ln \cancel{\frac{p_2}{p_1}}$ 0

izobarno

$\Delta s_{pl} = 1005 \ln \left(\frac{373.15}{573.15} \right) = -431.31\ J/kgK$

$\Delta s_{pl} = 431.31\ J/kgK$

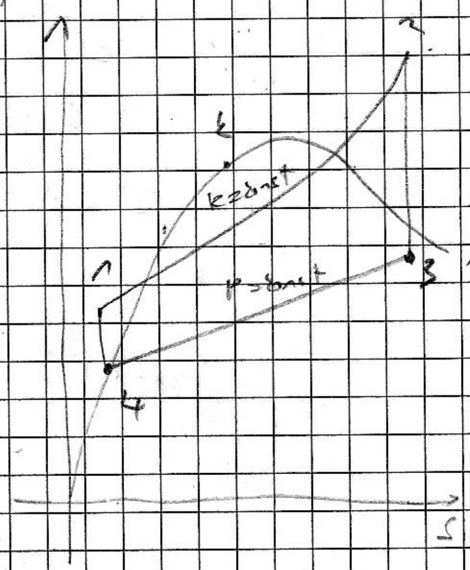
izobarni proces:

$q_{12} = c_p (T_2 - T_1) = 1005 (-200) = -201\ kJ/kg$ (znak tgub topline)

$\Delta s_{ok} = \frac{+201 \cdot 10^3}{293} = +686.01\ J/kgK$

$w_{gub} = 1 \cdot [293.15 \cdot (686.01 - 431.31)]$
$= 74.67\ kJ$

3. Idealni Rankine



$P_t = 450$ MW

$p_1 = p_2 = 7$ MPa

$T_2 = 773.15$ K

$p_3 = p_4 = 10$ kPa

Cv bi trebao sit 4180 J/kgK

10 kPa: $v' = 0.001$ m³/kg

$h' = 191.8$ kJ/kg $\quad h'' = 2584$ kJ/kg

$s' = 0.449$ kJ/kgK $\quad s'' = 8.151$ kJ/kgK

7 MPa: $h = 3410$ kJ/kg $\quad s = 7$ kJ/kgK

$x = ?$ $\quad \eta_t = ?$ $\quad \Delta T_v = ?$ $\quad (c_v = 4180$ J/kgK $\quad m_v = 20000$ kg/s$)$

$$h_3 = h' + x(h'' - h') \Rightarrow x = \frac{h_3 - h'}{h'' - h'} = \frac{s_3 - s'}{s'' - s'}$$

$$x = \frac{7 - 0.449}{8.151 - 0.449} = 0.851$$

$$h_3 = 191.8 + 0.851 \cdot (2584 - 191.8) = 2227.56 \text{ kJ/kg}$$

$$\eta_t = \frac{w_{korisno}}{q_{uloženo}} = \frac{h_2 - h_3 + h_4 - h_1}{h_2 - h_1} = \frac{3410 - 2227.56 + 191.8 - 198.79}{2584 - 198.79}$$

$$w_p = v \cdot (p_4 - p_1) = 0.001 \cdot (10 \cdot 10^3 - 7 \cdot 10^6) = -6.99 \text{ kJ/kg}$$

$$w_p = h_4 - h_1 \qquad h_1 = h_4 - w_p = 191.8 + 6.99 = 198.79 \text{ kJ/kg}$$

$$h_4 = h'$$

$q_{12} - h_1 = w_{12} + h_2$

$q_{12} = h_2 - h_1$ $\quad q_{kond}(h_4 - h_3)$

$$\eta_t = 0.492$$

$$m_{pare} = \frac{P_t}{w_t} = \frac{450 \cdot 10^6}{3410 \cdot 10^3 - 2227.56 \cdot 10^3} = 380.57 \text{ kg/s}$$

$$m_{pare}(h_3 - h_4) = m_{vode}\, c_v \cdot \Delta T$$

$$\Delta T = \frac{m_{pare} \cdot (h_3 - h_4)}{m_{vode}\, c_v} = \frac{380.57 \cdot (2227.56 - 191.8) \cdot 10^3}{22 \cdot 10^3 \cdot 4190}$$

$$= 8.42 \text{ K}$$

4 desnokretni Brayton - realni

$\varkappa = 1.4 \quad R = 287 \ J/kg\,K$

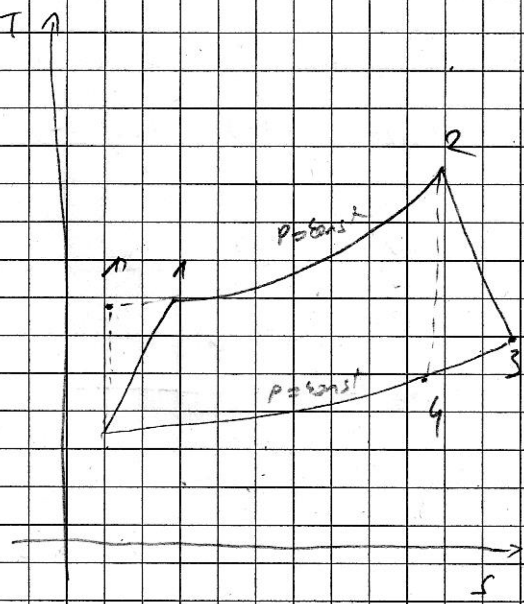
$p_3 = p_4 = 0.1 \ MPa$ — 2 realne adijabate

$T_4 = 350 \ K$ — 2 izobare

$p_1 = p_2 = 1 \ MPa$

$T_2 = 1400 \ K$

$\eta_{kompr} = 0.85 \quad \eta_{turb} = 0.9$



$w_t = ? \quad w_{komp} = ? \quad \eta_t = ?$

$$\frac{T_2}{T_3} = \left(\frac{p_2}{p_3}\right)^{\frac{0.4}{1.4}} \qquad T_3' = \frac{T_2}{\left(\frac{p_2}{p_3}\right)^{\frac{0.4}{1.4}}} = \frac{1400}{(10)^{\frac{0.4}{1.4}}} = 725.12$$

$$\eta_{turb} = \frac{w_{real}}{w_{ideal}} = \frac{\cancel{c_p}(T_2 - T_3)}{\cancel{c_p}(T_2 - T_3')} \qquad \eta_{turb}(T_2 - T_3') = T_2 - T_3$$

$$T_3 = T_2 - \eta_{turb}(T_2 - T_3')$$

$$= 1400 - 0.9 \cdot (1400 - 725.12)$$

$$= 792.64 \ K$$

$$c_p = c_v + R \qquad c_v = \frac{c_p}{\varkappa}$$

$$c_p\left(1 - \frac{1}{\varkappa}\right) = R$$

$$c_p = \frac{R}{1 - \frac{1}{\varkappa}} = \frac{287}{1 - \frac{1}{1.4}} = 1004.5$$

$$\eta_t = \frac{w_{turb} + w_{komp}}{c_p(T_2 - T_1)} = \frac{(610.09 - 327.2) \cdot 10^3}{1004.5 \cdot (1400 - 733.22)}$$

$$= 0.422$$

$$w_t = c_p(T_2 - T_3) = 1004.5(1400 - 792.64) = \underline{\underline{610.09 \ kJ/kg}}$$

$$\frac{T_4}{T_1} = \left(\frac{p_4}{p_1}\right)^{\frac{0.4}{1.4}} \qquad T_1' = \frac{T_4}{\left(\frac{p_4}{p_1}\right)^{\frac{0.4}{1.4}}} = \frac{350}{\left(\frac{1}{10}\right)^{\frac{0.4}{1.4}}} = 675.74 \ K$$

$$\eta_k = \frac{T_4 - T_1'}{T_4 - T_1}$$ (idealni rad manji od realnog)

$$T_4 - T_1 = \frac{T_4 - T_1'}{\eta_k}$$

$$T_1 = T_4 - \frac{T_4 - T_1'}{\eta_k} = 350 - \frac{350 - 675.74}{0.85} = 733.22 \ K$$

$$w_k = c_p(T_4 - T_1) = 1004.5 \cdot (350 - 675.74) = \underline{\underline{-327.2 \ kJ/kg}}$$

3. Toplinska pumpa

Odvodi toplinu → CARNOTEOV PROCES

2 izoterme – 2 adijabate

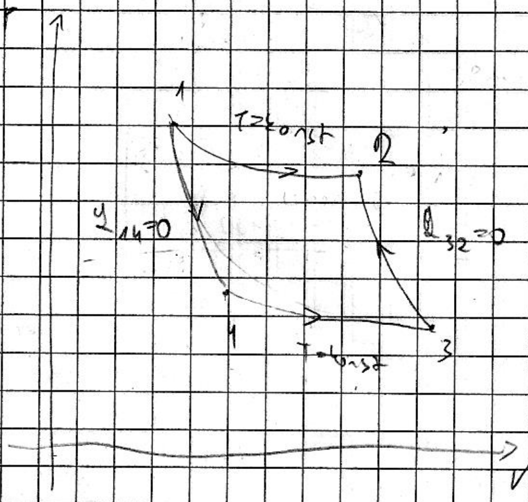
$\dot m_v = 0.5$ kg/s $\dot m_f = 0.1$ kg/s

$q_{odv} = Q_{kond} = -170$ kJ/kg

q_{dov} $Q_f = 120$ kJ/kg

$\left| \frac{q_{dov}}{w} \right| = 3$

P_{kompr} ? $T_{h_v} = ?$ ako je $c_v = 4.18$ kJ/kg



$\Phi_{isparivača} = Q_f \cdot \dot m_f = 12$ kW

$P_{cev} =$

$W_{kompr} =$

6. $n=3$ $m_U = 70\,t$ $e=0.03$ $\phi = 3\cdot 10^{17}\ n/m^2 s$ $\sigma_f = 580\cdot 10^{-28}\ m^2$

$T_{UL} = 295°C = 568.15\,K$ $T_{IZL} = 328°C = 601.15\,K$ $c_v = 5.7\ kJ/kg\,K$ $\rho = 720\ kg/m^3$

sec: $h_{vode} = 381\ kJ/kg$ $h_{para} = 2764\ kJ/kg$ $m_{pg} = 423\ kg/s$

a) P_j b) m_j $P_p = ?$ $\Delta p = ?$

?

$P_j = N_{U235} \cdot \cancel{n_k} \cdot e\, \sigma_f \cdot \phi$

$= 5.381\cdot 10^{27} \cdot 3.2\cdot 10^{-11} \cdot 580\cdot 10^{-28} \cdot 3\cdot 10^{17}$

$P_j = 2996.39\ MW$

$N_{U235} = e \cdot m_U \cdot \frac{6.022\cdot 10^{26}}{235} = 70\cdot 10^3 \cdot 0.03 \cdot \frac{6.022\cdot 10^{26}}{235}$

$= 5.381 \cdot 10^{27}$

$P_T = P_j + P_p$

$P_T = m_{UL} \cdot h(_{UL} - h_{IZL})$

$\frac{P_T}{3} = m_{pg} \cdot (h_p - h_v)$ $P_T =$

?

$P_T = 3024.03\ MW$ Je li to previše?

$P_p = \frac{3024.03 - 2996.14}{3} = 9.23\ MW$

$P_p = m_p \cdot V \cdot \Delta p$

$\Delta p = \frac{P_p}{m_p \cdot V} = \frac{9.23\cdot 10^6}{5305.84 \cdot \frac{1}{700}} = 1.217\ MPa$

$m_p = \frac{m_j}{3}$

$P_j = m_j \cdot c_p \cdot \Delta T \Rightarrow m_j = \frac{2996.34\cdot 10^6}{5700 \cdot 33} = 15929.51\ kg/s$

$m_j = 5309.84\ kg/s$