M1 2013./2014.

11.

$c_v = 718 \text{ J/kgK}$

$R = 287 \text{ J/kgK}$

turbina - otvoreni sustav

$p_1 = 5 \text{ bar} = 5 \cdot 10^5 \text{ Pa}$

$\vartheta_1 = 200°C \Rightarrow T_1 = 473,15 \text{ K}$

$p_2 = 1 \text{ bar} = 10^5 \text{ Pa}$

$q_{12} = 0$

$\vartheta_2 = 100°C \Rightarrow T_2 = 373,15 \text{ K}$

$c_1 = 30 \text{ m/s}$

$c_2 = 200 \text{ m/s}$

$\Delta z = 5 \text{ m} = z_1 - z_2$

$P = ?$

$\Delta h = h_2 - h_1$

$-\Delta h = h_1 - h_2$

$\dot{m} = 10 \text{ kg/s}$

$$q_{12} + h_1 + \frac{c_1^2}{2} + g z_1 = w_{t12} + h_2 + \frac{c_2^2}{2} + g z_2$$

$$\frac{c_1^2}{2} + g(z_1 - z_2) + (h_1 - h_2) = \frac{P}{\dot{m}} + \frac{c_2^2}{2} \quad / \cdot \dot{m}$$

$$\dot{m}\left(\frac{c_1^2 - c_2^2}{2} + g\Delta z + \Delta h\right) = P$$

$$P = \dot{m}\left(\frac{c_1^2 - c_2^2}{2} + g\Delta z + c_p \Delta T\right) \quad / c_p = c_v + R$$

$$P = 10\left[\frac{20^2 - 200^2}{2} + 9,81 \cdot 5 + (718 + 287) \cdot (473,15 - 373,15)\right]$$

$$P = 807,49 \text{ kW}$$

(12.)

$eks_{ZS} = w_{max} = ?$

$c_v = 718\ J/kg\,K$

$R = 287\ J/kg\,K$

$p = 30\ bara = 30 \cdot 10^5\ Pa$

$\vartheta = 350°C \Rightarrow T = 623,15\ K$

$p_{ok} = 1\,bar = 10^5\ Pa$

$T_{ok} = 17°C + 273,15 = 290,15\ K$

$w_{max} = u - u_{ok} - T_{ok}(s - s_{ok}) + p_{ok}(v - v_{ok})$

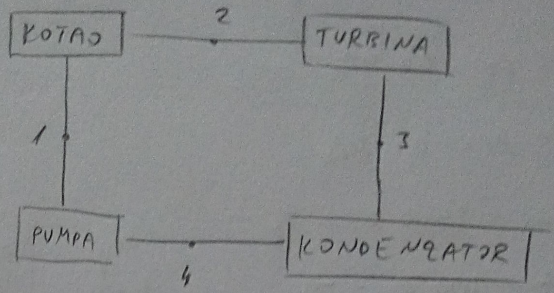
$u - u_{ok} = c_v (T - T_{ok}) = 239034\ J/kg$

$T_{ok}(s - s_{ok}) = T_{ok}\left[c_p \ln\left(\frac{T}{T_{ok}}\right) - R \ln\left(\frac{p}{p_{ok}}\right)\right] = -60331,61\ J/kg$

$p_{ok}(v - v_{ok}) = p_{ok} \cdot \left(\frac{R \cdot T}{p} - \frac{R \cdot T_{ok}}{p_{ok}}\right) = -77311,58\ J/kg$

$w_{max} = 222,054\ kJ/kg$

(13.) realni RK P



$P_t = 1000\ MW$

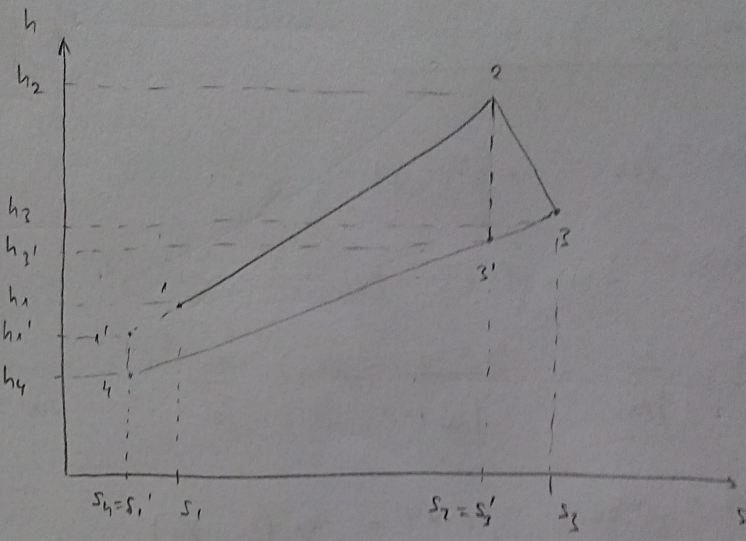
$p_2 = 8,5\ MPa = p_1$; $h_2 = 3756\ kJ/kg$

$t_2 = 650\ °C \Rightarrow T_2 = 923,15\ K$; $s_2 = 7,121\ kJ/kgK$

$p_3 = 10\ kPa = p_4$; $h' = 191,8\ kJ/kg$; $h'' = 2585\ kJ/kg$; $v' = 0,001\ m^3/kg$

$\eta_t = 0,9$ p_3 ; $s_3' = 7,121\ kJ/kg$; $h_3' = 2256\ kJ/kg$

$\eta_p = 0,85$



(a) $\eta = ?$

(b) $x = ?$

(c) $\dot{m} = ?$

$h_3 = h''$ $h = h_3'$

$h_4 = h'$

$$x = \frac{h - h'}{h'' - h'} = \frac{2256 - 191,8}{2585 - 191,8} = 0,8625$$

$$\dot{m} = \frac{P_t}{w_t} \quad ; \quad \eta = \frac{w}{q_{dov}} = \frac{w_{real,t} + w_{real,p}}{q_{dov}} \quad ; \quad q_{dov} = h_2 - h_1$$

$$\eta_t = \frac{w_{real,t}}{w_{id,t}} = \frac{h_2 - h_3}{h_2 - h_3'} \Rightarrow w_{real,t} = h_2 - h_3 = 3756 - 2585 = 1171\ kJ/kg$$

$$\eta_p = \frac{w_{id,p}}{w_{real,p}} = \frac{h_1' - h_4}{h_1 - h_4}$$

$w_{id,p} = v(p_1' - p_4)$ / $p_1' = p_1$

$= 0,001\ (8,5 \cdot 10^6 - 10\,10^3) = 8,49\ kJ/kg$

$w_{real,p} = h_1 - h_4 = \frac{w_{id,p}}{\eta_p} = 9,988\ kJ/kg$

$h_1 = \frac{8490}{0,85} + 191,8 \cdot 10^3 = 201,788\ kJ/kg$

$$\eta = \frac{1171 + 9,988}{3756 - 201,788} = 0,33$$

$$\dot{m} = \frac{P_t}{w_{real,t}} = \frac{1000 \cdot 10^6}{1171 \cdot 10^3} = 853,97\ kg/s$$

(14.) idealni Braytonov kružni proces

$p_2 = p_3 = 1{,}2$ MPa

$p_4 = p_1 = 0{,}1$ MPa

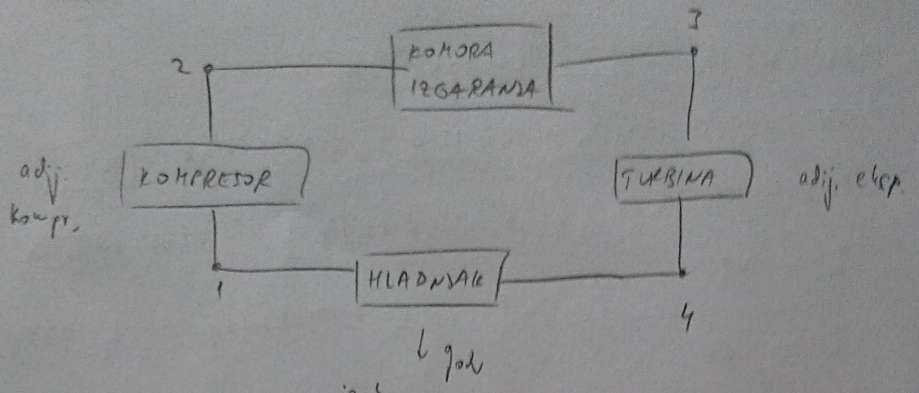
$T_{max} = 1400$ K $= T_3$

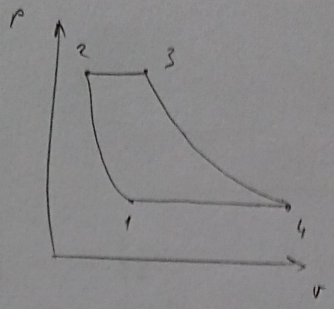
$T_{min} = 300$ K $= T_1$

$R = 287$ J/kgK

$\varkappa = 1{,}4$

$q_{dov}, q_{odv}, \eta = ?$





$q_{dov} = q_{23} = c_p (T_3 - T_2)$

$q_{odv} = q_{41} = c_p (T_1 - T_4)$

$\eta = \frac{w}{q_{dov}} = \frac{w_t + w_k}{q_{dov}} = 1 - \frac{T_1}{T_2}$

$w_t = w_{34} = -c_p \Delta T = -c_p (T_4 - T_3)$

$w_k = w_{12} = -c_p \Delta T = -c_p (T_2 - T_1)$

2-3 $p_2 = p_3$; T_3

$p_2 v_2 = R T_2$

$p_3 v_3 = R T_3$

$\left.\begin{matrix} \\ \\ \end{matrix}\right\} \frac{RT_2}{v_2} = \frac{RT_3}{v_3}$

$v_3 = \frac{RT_3}{p_3} = 0{,}3348$ m³/kg

-1 $p_1 = p_4$; T_1

$p_1 v_1 = R T_1$

$p_2 v_2 = R T_2$

$\left.\begin{matrix} \\ \\ \end{matrix}\right\} \frac{RT_1}{v_1} = \frac{RT_2}{v_2}$

$v_1 = \frac{RT_1}{p_1} = 0{,}861$ m³/kg

$q_{dov} = \frac{\varkappa R}{\varkappa - 1} (T_3 - T_2) = 793{,}37$ kJ/kg

$q_{odv} = -390{,}067$ kJ/kg

$\eta = 0{,}508$

1-2 T_1, v_1, p_1, p_2

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

$T_2 = T_1 \left(\frac{p_2}{p_1}\right)^{\frac{\varkappa - 1}{\varkappa}} = 610{,}18$ K

3-4 T_3, p_3, p_4

$\frac{T_3}{T_4} = \left(\frac{p_3}{p_4}\right)^{\frac{\varkappa - 1}{\varkappa}}$

$T_4 = T_3 \left(\frac{p_4}{p_3}\right)^{\frac{\varkappa - 1}{\varkappa}} = 689{,}12$ K

15.

$\vartheta_H = -5\,^\circ C \Rightarrow T_H = 268{,}15\ K$

$\vartheta_{ok} = 22\,^\circ C \Rightarrow T_{ok} = 295{,}13\ K$

$\dot{Q} = 8000\ kJ/h$

$\dot{W} = 3200\ kJ/h$

$\left|\frac{q_{odv}}{w}\right| = ?$ (Geotretni kružni proces)

$\left|\frac{q_{dov}}{w}\right|_C = ?$ (Carnotov geotretni kružni proces)

$$\left|\frac{q_{odv}}{w}\right| = \left|\frac{\dot{Q}}{\dot{W}}\right| = \left|\frac{8000}{3200}\right| = 2{,}5$$

$$\left|\frac{q_{dov}}{w}\right|_C = \frac{q_{dov}}{|q_{dov}| - q_{odv}} = \frac{T_{dov}}{T_{dov} - T_{odv}} = \frac{T_{ok}}{T_{ok} - T_H} = 10{,}93$$

16. PWR

$n = 2$ petlje

$\dot{m}_1 = 6\ t/s$

$\dot{m}_{vl} = 12\ t/s$

$P_{pump} = 5\ MW$

$h_1 = 1510\ kJ/kg$

$h_2 = 1340\ kJ/kg$

$P_{kond} = 1350\ MW$

$\Phi = 3 \cdot 10^{13}\ n/cm^2 s = 3 \cdot 10^{17}\ \frac{n}{m^2 s}$

(a) $P_{jez} = ?$

(b) $P_{turb.} = ?$

(c) $m = ?$

$e = 0{,}03 \quad (NO_2)$

$\nabla_f = 580 \cdot 10^{-28}\ m^2$

$Q_{fis.} = 200\ MeV$

(d) $t - t_0 = 2$ dana

$t_0 = 18\ mj = 18 \cdot 30 = 540$ dana

$P_{jez.} = ?$

(a) $P_{jez.} = P_T - 2 P_{pump}$

$P_{turb} = \dot{m}_{vl} \cdot (h_1 - h_2) = 2{,}04\ GW$

$P_{jez} = 2{,}03\ GW$

(b) $P_{turb} = 2{,}04\ GW$

(c) $P_{jez} = 200 \cdot 1{,}6 \cdot 10^{-13} \cdot N \cdot \nabla_f \cdot \Phi$

$$N = \frac{2{,}03 \cdot 10^9}{200 \cdot 1{,}6 \cdot 10^{-13} \cdot 580 \cdot 10^{-28} \cdot 3 \cdot 10^{17}}$$

$N = 3{,}6458 \cdot 10^{27}$

$N = e \cdot m \cdot \frac{238}{270} \cdot \frac{N_A}{235}$

$$m = \frac{3{,}6458 \cdot 10^{27} \cdot 270 \cdot 235}{0{,}03 \cdot 238 \cdot 6{,}022 \cdot 10^{26}}$$

$m = 53{,}8\ t$

(d) $t = 542$ dana

$P_{jez} = 0{,}0061 \cdot P_0 \left[(t - t_0)^{-0{,}2} - t^{-0{,}2} \right]$

$= 0{,}0061 \cdot 2{,}03 \cdot 10^9 \left[2^{-0{,}2} - 542^{-0{,}2} \right]$

$= 7{,}26\ MW$