LJETNI ROK 2012.

11.

$G_n = 1200 W/m^2$

$H_{h,ged} = 1500 kWh/m^2$

$A = 10\,000 m^2$

$\eta_s = 0.5$

$\eta_R = 0.3$

$\eta_{FC} = 0.11$

$\eta_{direkt} = 0.8$

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a) SOLARNI TOKANJ

$$P_{instalirano} = P_{direkt,max} \cdot \eta_s \cdot \eta_R$$
$$= P_n \cdot \eta_{direkt} \cdot \eta_s \cdot \eta_R$$
$$= A \cdot G_n \cdot \eta_{direkt} \cdot \eta_s \cdot \eta_R$$
$$= 1.44 MW$$

b) ST $\eta_{usmerjen} = 1.2$

$$W_{el} = A \cdot \eta_s \eta_R \cdot \eta_{direkt} \cdot \eta_{usmerjen} \cdot H_{h,ged}$$
$$= 2160 MWh$$

c) $m = \frac{W_{el}}{8760 \cdot P_{el}} = 0.171$

FN ČELIJE

$$\eta_{FN} = \frac{P_{el}}{G_n A}$$

$P_{el} = 1.32 MW$

FN

$$H_{sept} = H_{h,ged} \cdot \eta_{usmerjen}$$

$$W_{el} = H_{sept} \cdot A \cdot \eta_{FN}$$
$$= 1980 MWh$$

$$m = \frac{W_{el}}{t \cdot P_{el}} = 0.171$$

(12.) Rankine

$P_{tur} = 400MW$

$p_3 = p_2 = 8,5MPa$

$t_3 = 550°C \rightarrow T_3 = 923.15K$

$p_4 = p_1 = 10kPa$

$\eta_{tur} = 0.9, \quad \eta_{pump} = 0.85$

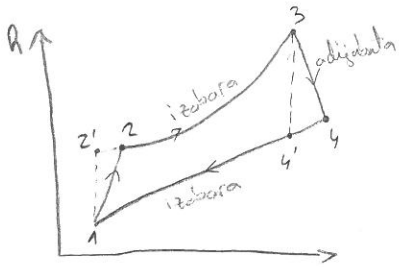
$h_3 = 3756 kJ/kg$

$s_4' = s_3 = 7,1291 kJ/kgK$

$h_4' = 2256 kJ/kg$

$h_1 = h' = 192 kJ/kg$

$v = 0,001 m^3/kg$



2', 4' - idealni proces

$$\eta_{pump} = \frac{v \cdot (p_2 - p_1)}{h_2 - h_1}$$

$h_2 = 201.958 kJ/kg$

$$\eta_{tur} = \frac{h_3 - h_4}{h_3 - h_4'}$$

$h_4 = 2406 kJ/kg$

a) $$\eta_t = \frac{h_3 - h_4 - (h_2 - h_1)}{h_3 - h_2} = 0.377$$

b) $\dot{m} = ?$ radni medij

$$P_{tur} = \dot{m} \cdot w_{34} = \dot{m}(h_3 - h_4) \rightarrow \dot{m} = 296.296 kg/s$$

(13.) derivacijska HE

$Q_{inst} = 340 m^3/s$

vjerojatnosna krivulja $Q(t) = 500 - 40t$, t - mjeseci

$H_{zahvat} = 250m$

$H_{postrojenje} = 40m$

$H_{vode} = 30m$

$\eta = 0.9$

$$H_{neto} = H_{vode} + (H_{zahvat} - H_{postrojenje})$$

$H_{neto} = 240m$

a) $P_{max}, P_{min} = ?$

$P_{max} = P_i = g \cdot \rho \cdot \eta \cdot H_{neto} \cdot Q_{inst} = 720.446 MW$

$P_{min} = g \cdot \rho \cdot \eta \cdot H_{neto} \cdot Q_{12mj.}$, $\quad Q(12mj.) = 500 - 40 \cdot 12 = 20 m^3/s$

$P_{min} = 42.379 MW$

b) vjerojatna godišnja proizvodnja $W = ?$

$Q_{inst} = 340 = 500 - 40t_i \Rightarrow t_i = 4$ mjeseca

$$W = 9.81 \cdot \rho \left[Q_{inst} \cdot \eta \cdot \int_0^{t_i} H_n(t) dt + \int_{t_i}^{12} Q(t) H_n \cdot \eta \, dt \right] \; [Wmj]$$

$$= 9.81 \cdot \eta \cdot H_{neto} \left(Q_{inst} \cdot t_i + \int_{t_i}^{12} (500 - 40t) dt \right) = 5933085 kWmj = 4331.15 GWh$$

c) $m_{HE} = ?$

$$m_{HE} = \frac{W}{P_{max} \cdot 8760h} = 0.6863$$

(14.) idealni plin : $c_v = 717\ J/kgK$, $R = 287\ J/kgK$ → $c_p = c_v + R = 1004\ J/kgK$

↳ zatvoreni spremnik

① $\begin{cases} p_1 = 500kPa \\ T_1 = 500K \end{cases}$

② $\begin{cases} p_2 = 300kPa \\ T_2 = 400K \end{cases}$

okolica $\begin{cases} p_{ok} = 100kPa \\ T_{ok} = 300K \end{cases}$

$W_{max} = ?$

$pv = RT$

① → okolica

$W_{max1} = u_1 - u_{ok} - T_{ok}(s_1 - s_{ok}) + p_{ok}(v_1 - v_{ok})$

okolica → ②

$W_{max2} = u_{ok} - u_2 - T_{ok}(s_{ok} - s_2) + p_{ok}(v_{ok} - v_2)$

$W_{max} = W_{max1} + W_{max2}$

$W_{max} = u_1 - u_2 - T_{ok}(s_1 - s_2) + p_{ok}(v_1 - v_2)$

$W_{max} = c_v(T_1 - T_2) - T_{ok}\left(c_p \ln\frac{T_1}{T_2} - R\ln\frac{p_1}{p_2}\right) + p_{ok}\left(\frac{RT_1}{p_1} - \frac{RT_2}{p_2}\right)$

$= 21700 - 23228.75 - 9566.67$

$W_{max} = 38904.6\ J/kg$

(15.) PWR

- dvije petlje : $x = 2$

$N_g = 121$, $l = 3{,}65m$, 16×16, $n_k = 21$

$\Delta T = 37\ K$

$\rho = 750 kg/m^3$

$c_p = 5{,}7\ kJ/kgK$

$\dot{V} = 6{,}2\ m^3/s$

$\Delta p = 750kPa$

$h_3 = h_{pegma} = 990kJ/kg$

$h_4 = h_{rara} = 2760kJ/kg$

$\eta_{term} = 0.33$

a) $\dot{m}_j = ?$

$\dot{V} = \frac{\dot{m}_{1P}}{\rho}$ ($\dot{m}_{1P}$ – maseni protok jedne pumpe)

$\dot{m}_{1P} = 4650\ kg/s$

$\dot{m}_j = x \cdot \dot{m}_{1P} = 9300\ kg/s$

b) $Q' = ?$

$P_{jezgre} = \dot{m}_j \cdot c_p \Delta T = 1961.37\ MW$

$P_{jezgre} = N_g \cdot (16 \cdot 16 - 21) \cdot l \cdot Q'$

$Q' = 18897.9\ \frac{W}{m}$

c) $\dot{m}_{pare} = ?$

$P_{dov} = P_{jezgre} + x \cdot P_{pumpe}$, $P_{pumpe} = \Delta p \cdot \dot{V} = 4650\ kW$

$P_{dov} = 1970.67\ MW$

$\frac{P_{dov}}{x} = \dot{m}_{P1}(h_{rare} - h_{pegma})$

$\dot{m}_{P1} = 556.69\ kg/s$ – maseni protok po paro generatoru

$\dot{m}_p = x \cdot \dot{m}_{P1} = 1113.4\ kg/s$

15. d) $P_{odv} = ?$

$$\eta_{term} = 1 - \frac{P_{odv}}{P_{dov}}$$

$P_{odv} = 1320.35\ MW$

e) $m_U = ?$

$e = 0.03$

$\phi = 3 \cdot 10^{17}\ n/m^2 s$

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

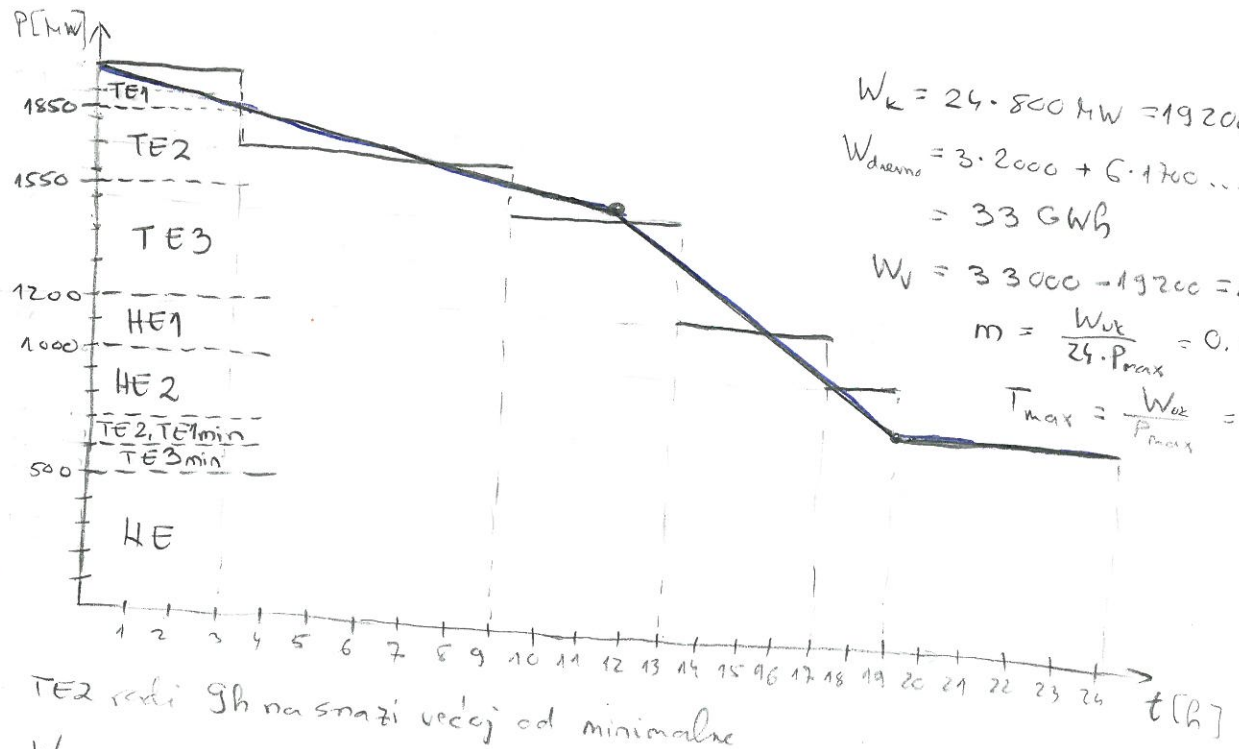
$P_{jedja} = 200 \cdot 1.6 \cdot 10^{-13} \cdot N_{U-235} \cdot \sigma_f \cdot \phi$

$N_{U-235} = 3.522257 \cdot 10^{27}$

$N_{U-235} = e\, m_U \frac{N_A}{235}$, $N_A = 6,022 \cdot 10^{26}\ mol^{-1}$ (za kilograme)

$m_U = 45.82\ t$

19.



$W_k = 24 \cdot 800\ MW = 19200\ MWh$

$W_{drevno} = 3 \cdot 2000 + 6 \cdot 1700 \ldots$
$= 33\ GWh$

$W_V = 33000 - 19200 = 13800\ MWh$

$m = \frac{W_{VE}}{24 \cdot P_{max}} = 0.6875$

$T_{max} = \frac{W_{VE}}{P_{max}} = 16.5\ h$

TE2 radi 9h na snazi vecoj od minimalne

$W_{TE1} = 24 \cdot 50 + 3 \cdot 150 = 1650\ MWh$

$2\alpha = \frac{2 W_V}{T_V P_V}$, $T_V = 19h$, $P_V = P_{max} - P_{min} = 1200\ MW$

$\alpha = \beta = 0.605$, točka pripadna (1526, 11.495)

16. elektrarna na ugljen: $P_{el1} = 250\,MW$, $m_1 = 0.7$, $\eta_1 = 0.37$, $H_1 = 26\,MJ/kg$, $w(C) = 0.8$

$C + O_2 \rightarrow CO_2$

$m_1(CO_2) = ?$

elektrarna na plin: $P_{el2} = 250\,MW$, $m_2 = 0.7$, $\eta_2 = 0.42$, $H_2 = 33\,MJ/m^3$, $w(CH_4) = 1$

$CH_4 + 2O_2 \rightarrow CO_2 + H_2O$

$m_2(CO_2) = ?$

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a) na ugljen:

$W_{el1} = m_1 \cdot P_{el1} \cdot t_{tjed}$

$W_{el1} = 1,533 \cdot 10^{12}\,Wh$

$W_{top} = \frac{W_{el1}}{\eta_1} = 4.143 \cdot 10^{12}\,Wh = 1,49148 \cdot 10^{10}\,MJ$

$W_{top} = m_{gorivo} \cdot H_1 \rightarrow m_{gorivo} = 573646153\,kg$

$m(CO_2) = n(C) \cdot (M(C) + 2M(O))$, $n(C) = \frac{m(C)}{M(C)}$

$= m(C)\left(1 + 2 \cdot \frac{M(O)}{M(C)}\right)$, $M(O) = 16\,g/mol$, $M(C) = 12\,g/mol$

$= m_{gorivo} \cdot w(C)\left(1 + 2 \cdot \frac{16}{12}\right)$

$m_1(CO_2) = 1682695385\,kg$

b) na plin

$W_{el2} = m_2 \cdot P_{el2} \cdot t_{tjed}$

$= 1,533 \cdot 10^{12}\,Wh$

$W_{top} = \frac{W_{el2}}{\eta_2} = 3.65 \cdot 10^{12}\,Wh = 1.314 \cdot 10^{10}\,MJ$

$W_{top} = V_{gorivo} \cdot H_2 \rightarrow V_{gorivo} = 398181818\,m^3$

$V_{gorivo} = V(CO_2) = V(CH_4)$

-> formula: $V(CO_2) = \frac{m(CO_2) \cdot V_\mu}{M(CO_2)}$, $M(CO_2) = M(C) + 2M(O) = 44\,g/mol$

$V_\mu = 22,4\,m^3/kmol = 0.0224\,m^3/mol$

$m_2(CO_2) = 7.82142857 \cdot 10^8\,kg$

16. nastavak

$m_2 - m_1 = 900552528$

$\frac{m_2 - m_1}{m_1} = 0,535 = 53.5\%$

17. $t_{odv} = 23°C$

$t_{dov} = 32°C$

$Q_{dov} = 15kWh$

$P = 2kW$

↓

$w = 2kWh$

faktor prečrpavbe $\eta = \frac{T_{odv}}{T_{dov} - T_{odv}} = \frac{296.15}{9} = 32.9 = \frac{Q_{dov}}{W_{min}}$

$W_{min} = \frac{Q_{dov}}{32.9} = 455.9\ Wh = 0.4559\ kWh$

$W_{min} < W \rightarrow$ w je dostatan za rad uređaja

$\eta = \frac{Q_{dov}}{w} = \frac{15kWh}{2kWh} = 7.5$

18. $d = 40m \rightarrow r = 20m$, $A = r^2 \pi$, $\rho = 1,225\ kg/m^3$, $\eta_{mech-el} = 0,95$

$v_{n1} = 8m/s \rightarrow v_{min1} = 4m/s$, $v_{max1} = 16m/s$

$v_{n2} = 11m/s \rightarrow v_{min2} = 5,5m/s$, $v_{max2} = 22m/s$

$W_{ged1} = \eta_{mech-el} \cdot c_{pe} \cdot 0.5 \cdot \rho r^2 \pi \left(0.35 \cdot 5^3 + (0.23 + 0.07 + 0.05) \cdot 8^3\right) \cdot t_{ged}$

$P = c_{pe} \frac{\rho \cdot A \cdot v^3}{2}$, $P_{5m/s} = c_{pe} \frac{\rho r^2 \pi \cdot 5^3}{2}$

$c_{pe} = 0,593$

$W_{ged1} = 861.09\ MWh$

$W_{ged2} = \eta_{mech-el} \cdot c_{pe} \cdot 0.5 \cdot \rho r^2 \pi \left(\overbrace{0.23 \cdot 8^3}^{\text{poč.-nazivna}} + \overbrace{(0.07 + 0.05 + 0.03) \cdot 11^3}^{\text{nazivna-končna}}\right) \cdot t_{ged}$

$W_{ged2} = 1205.64 \cdot 10^6\ MWh$

↳ drugi agregat više proizvodi

$m_{opt} = \frac{W_{ged2}}{t_{ged} \cdot P_{max\,el}}$, $P_{max\,el} = \frac{\rho \cdot r^2 \pi \cdot 11^3}{2} \cdot \eta_{mech-el} \cdot c_{pe} = 577.128\ kW$

$m_{opt} = 0.238$