(11) TE1

$h_4 = 195 \frac{kJ}{kg}$

$h_2 = 3300 \frac{kJ}{kg}$

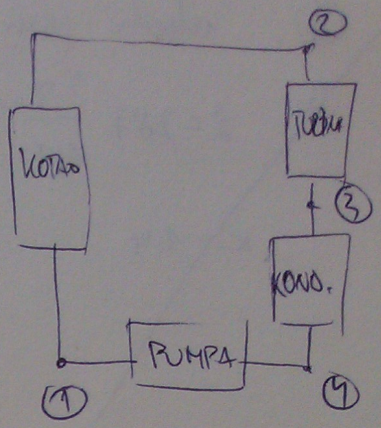
$h_3 = 2400 \frac{kJ}{kg}$

TE2

$h_4 = 195 \frac{kJ}{kg}$

$h_2 = 3300 \frac{kJ}{kg}$

$h_3 = 2400 \frac{kJ}{kg}$



a) TERMIČKI STUPANJ TE1 : $\eta_T = ?$

$q_{DOV} = ?$

$q_{ODV} = ?$

Dovođenje topline → KOTAO ① - ②

odvođenje topline → KONDENZATOR ③ - ④

$h_1 = ?$

$h_4 = h_1$ (zanemarenje rad pumpe)

$q_{DOV} = h_2 - h_1 = 3105 \frac{kJ}{kg}$

$q_{ODV} = h_4 - h_3 = -2205 \frac{kJ}{kg}$

$\eta_T = 1 - \frac{|q_{ODV}|}{q_{DOV}} = 1 - \frac{2205}{3105} = 0,29$

b)

$\eta_{T2} = 1,25 \cdot \eta_T = 0,3625$

$\eta_{2T} = \frac{q_{ODV}}{q_{DOV1} + q_{DOV2}}$

$q_{DOV2} = \frac{q_{ODV}}{\eta_{2T}} - q_{DOV1}$

$q_{DOV2} = \frac{2205}{0,3625} - 3105 = 2977,75 \frac{kJ}{kg}$

(12) $R = 287 \frac{J}{kg\,K}$

a) $q_{12} = ?$ $q_{23} = ?$ $q_{31} = ?$

$k = 1{,}4$

$p_1 = 10\ MPa$

$T_1 = 500\ K$

$T_2 = T_1 = 500\ K$

$p_2 = 5\ MPa$

$V_2 - V_3$

$p_3 = 4\ MPa$

1 → 2 (Izoterma)

$w_{12} = q_{12} = RT \cdot \ln \frac{p_1}{p_2}$

$= 287 \cdot 500 \cdot \ln \frac{10}{5} = 99\,466{,}62 \frac{J}{kg}$ //

dovođenje topline

2 → 3 izohorna

$w_{23} = 0$

$q_{23} = c_v (T_3 - T_2)$

$q_{23} = 717{,}5 \cdot (400 - 500)$

$q_{23} = -71750 \frac{J}{kg}$ //

odvođenje topline

$\frac{p_2}{T_2} = \frac{p_3}{T_3}$

$T_3 = \frac{T_3}{T_2} \cdot T_2 = 400\ K$

$c_p - c_v = R$

$k c_v - c_v = R$

$c_v = \frac{R}{k-1} = \frac{287}{1{,}4 - 1} = 717{,}5 \frac{J}{kg\,K}$

3 → 1 adijabata

$q_{31} = 0$

b) termički stupanj djelovanja kružnog procesa

$\eta_T = \frac{q_{DOV} + q_{ODV}}{q_{DOV}} = \frac{99\,466{,}62 + (-71750)}{99\,466{,}62} = 0{,}279$ //

(13) přibranská HE

$H_{zach} = 500$ m n.v.

$Q_i = 400 \frac{m^3}{s}$

$H_{gv} = 50$m

$d_T = 6$m

$H_T = 485$ m n.v.

$H_{dv} = 477$ m n.v.

$\eta = ?$

$d_D = 9$m

$A = \frac{d^2 \pi}{4}$

a) bez difuzoru $\quad H_{gv} = H_{zach} + H_{gv} = 550$ m n.v.

$A = \frac{d_T^2 \pi}{4} = \frac{6^2 \pi}{4} = 9\pi = 28{,}26\ m^2$

$Q_i = A \cdot c_T \Rightarrow c_T = \frac{Q_i}{A} = \frac{400}{28{,}26} = 14{,}15 \frac{m}{s}$

$H_u = H_{gv} - H_T - \frac{c_T^2}{2g} = 550 - 485 - \frac{14{,}15^2}{2g}$

$H_u = 54{,}8$ m

$P_u = 9{,}81\, \rho\, Q\, H_u\, \eta \quad (\eta = 1)$

$P_1 = 9{,}81 \cdot 1000 \cdot 400 \cdot 54{,}8 = 215{,}0352$ MW

b) se difuzorem

$A = \frac{d d^2 \pi}{4} = \frac{9^2 \pi}{4} = 63{,}585\ m^2$

$Q_i = A \cdot c_T \Rightarrow c_T = \frac{400}{63{,}585} = 6{,}3 \frac{m}{s}$

$H_u = H_{gv} - H_{dv} - \frac{c_T^2}{2g} = 550 - 477 - \frac{6{,}3^2}{2g}$

$= 70{,}98$ m

$P_2 = 9{,}81 \cdot 1000 \cdot 400 \cdot 70{,}98 = 278{,}52552$ MW

$\frac{P_2}{P_1} \approx 30\%$

(14) PWR

4 rashladne petlje

$P_j = 4100$ MW

$l_{ge} = 3,75$

18×18

36 vodilica

$q' = 18,61 \frac{kW}{m}$

$\Delta T_j = 33K$

$c_v = 5,54 \frac{kJ}{kgK}$

$\rho = 700 \frac{kg}{m^3}$

$\Delta p = 686$ kPa

⋮

a) broj gorivih elemenata u jezgri

$P_j = N_{ge}(18 \cdot 18 - 36) \cdot l_{ge} \cdot q'$

$$N_{ge} = \frac{4100 \cdot 10^6}{288 \cdot 3,75 \cdot 18,61 \cdot 10^3} = 203,95 = \underline{204}$$

b) snagu primarne rashladne pumpe

$$\dot{m}_{reaktor} = \frac{P_j}{c_v \cdot \Delta T_j} = 22426,43 \frac{kg}{s}$$

$$\dot{m}_{petlje} = \frac{\dot{m}_{reaktor}}{4} = 5606,61 \frac{kg}{s}$$

$$\rho = \frac{\dot{m}_{petlje}}{\dot{V}_{petlje}} \Rightarrow \dot{V}_{petlje} = 8 \frac{m^3}{s}$$

$$P_{PUMPA} = \Delta p \cdot \dot{V}_{petlje} = 686 \cdot 10^3 \cdot 8 = 5,488 \text{ MW}$$

~~$P_T = P_j + 4 \cdot P_{PUMPA} = 4100 + 4 \cdot 5,488 = 4121,952$ MW~~

↳ nema potrebe :)

c) masu UO_2

$m = 0,92$

$e = 0,04$

$E = 200$ MeV

~~$W_{el} = \eta \cdot W_{ee} \Rightarrow W_{ee} = \frac{W_{el}}{\eta}$~~

~~$18 \cdot 30 \cdot 24 \cdot P_j$~~

$$m = \frac{W_{el}}{18mj \cdot 30dan \cdot 24h \cdot 3600s \cdot P_j} \Rightarrow W_{ee} = 1,76 \cdot 10^{17} \text{ Ws}$$

$$N_{235} = \frac{W_{el}}{E} = \frac{1,76 \cdot 10^{17}}{200 \cdot 1,6 \cdot 10^{-13}} = 0,0055 \cdot 10^{30} = 5,5 \cdot 10^{27}$$

$$N_{235} = e \cdot m_{UO_2} \cdot \frac{238}{270} \cdot \frac{N_A}{235}$$

$$\underline{m_{UO_2} = 60\,871,866 \text{ t}}$$

(15) $R = 287 \frac{J}{kgK}$

$k = 1{,}4$

$p_1 = 7\,bar$

$\vartheta_1 = 600°C$

$p_2 = 1\,bar$

$\vartheta_2 = 300°C$

$p_{ok} = 1\,bar$

$\vartheta_{ok} = 15°C$

$\Delta Q = 8 \frac{kJ}{kg}$

$c_p = 1004{,}5 \frac{J}{kgK}$

a) realni tehnički rad turbine

b) max. tehnički rad turbine

c) $\Delta S = ?$

TURBINA ⇒ OTVOREN SUSTAV

$w_{max} = ?$

$$w_{max} = h_1 - h_2 - T_{ok}(s_1 - s_2)$$ (??)

$$w_t = h_1 - h_{ok} - T_{ok}(s_1 - s_{ok})$$ (?)

formula w_{max}(o.s.)

$$w_{max} = c_p(T_1 - T_2) - T_{ok}\left(c_p \ln \frac{T_1}{T_2} - R \ln \frac{p_1}{p_2}\right)$$

$$w_{max} = 301350 - 288{,}15(422{,}85 - 558{,}48)$$

$$w_{max} = 340430{,}7 \frac{J}{kg}$$ → max. t.r.

→ realni teh. rad

iz 1. g.s. termodinamike

$$q_{12} + h_1 = w_{t12} + h_2$$

$$w_{t12} = h_1 - h_2 + q_{12} = c_p(T_1 - T_2) + q_{12} = 1004{,}5(600 - 300) + (-8000)$$

$$w_{t12} = 293\,350 \frac{J}{kg}$$

promjena entropije id. plin.

$$\Delta S = c_p \ln \frac{T_2}{T_1} - R \ln \frac{p_2}{p_1} = 1004{,}5 \cdot \ln \frac{573{,}15}{873{,}15} - 287 \cdot \ln \frac{7}{1} =$$

$$= -422{,}85 - 558{,}476 = -981{,}33 \frac{J}{K}$$

(16) Biomasa & FV

$A_B = 0{,}9 \cdot A$

$\eta_T = 0{,}29$

$H = 12 \ \frac{MJ}{kg}$

$M = 15 \ \frac{t}{Ha}$

Weigod = ?

$A = 20 \ km^2 = 20 \cdot 10\,000 \ m^2$

$A_a = \frac{A}{2}$

$G_v = 1 \ \frac{kW}{m^2}$

$H_{nigod} = 1500 \ \frac{kWh}{m^2}$

$\eta_{FV} = 0{,}12$

$\frac{H_{part}}{H_n} = 1{,}15 = \eta_{DIR}$

$W_{eigod} = M \cdot H \cdot \frac{A_{uk}}{\eta_{te}}$

$= 15\,000 \cdot 12 \cdot 0{,}5 \cdot \frac{20}{200\,000}$

$= \left[\frac{kg}{kg} \cdot \frac{MJ}{kg} \cdot km^2 \right]$

$= 3240 \ GWh$

$W_{eigod} = H_{nigod} \cdot A_a \cdot \eta_{FV} \cdot \eta_{DIR}$

$= 1500 \cdot 10^5 \cdot 0{,}12 \cdot 1{,}15 \cdot 10^3$

$= 20{,}7 \ GWh$

(17)

0	5	8	11	15	20	25	m/s
16	38	23	7	5	3	8	godišnje %

$d = 40\,m$

VA1

$v_{max_1} = 10\ \frac{m}{s}$

$[5, 20]\ \frac{m}{s}$

VA2

$v_{max_2} = 12\ \frac{m}{s}$

$[6, 24\ \frac{m}{s}]$

$\eta_{MEH-EL} = 0{,}95$

a) koji proizvodi više el. en. godišnje?

$W_1 = 8760(0{,}38 \cdot P_5 + 0{,}23 \cdot P_8 + 0{,}15 \cdot P_{10})$

$W_2 = 8760(0{,}23 \cdot P_8 + 0{,}07 \cdot P_{11} + 0{,}08 \cdot P_{12})$

$P_5 = \eta \cdot c_p \cdot 0{,}5 \cdot \rho \cdot A \cdot v^3$

$P_5 = 0{,}95 \cdot 0{,}5 \cdot 1225 \cdot \frac{40^2\pi}{4} \cdot 5^3$ → 730835

$= 91{,}35\ MW$

$P_8 = 0{,}95 \cdot 0{,}5 \cdot 1225 \cdot \frac{40^2\pi}{4} \cdot 8^3$

$= 374{,}19\ MW$

$P_{11} = 972{,}27\ MW$

$P_{15} = 2466{,}57\ MW$

$P_{20} = 5846{,}68\ MW$

ne treba ovo sve računati!!

$P_{10} = 730{,}835\ MW$

$P_{12} = 1262{,}88\ MW$

$W_1 = 2018{,}32\ GWh$

$W_2 = 2235{,}14\ GWh$

VA2 proizvodi više

$m_1 = ?\quad m_2 = ?$

$m_1 = \frac{2018{,}32\ GWh}{8760 \cdot P_{10}} = 0{,}32$

$m_2 = 0{,}20$

$P_{max} = P_{10} = 730{,}835\ MW$

$c_{pe_1} = \frac{P_{10}}{0{,}5 \cdot \rho \cdot A \cdot v^3} = 0{,}95$ → uzeti drugu brzinu za $c_p = 0$

$c_{pe_2} = \frac{P_{12}}{0{,}5 \cdot \rho \cdot A \cdot v^3} = 0{,}949 \approx 0{,}95$

(18) $P_{max} = 2000$ MW

$P_{min} = 800$ MW

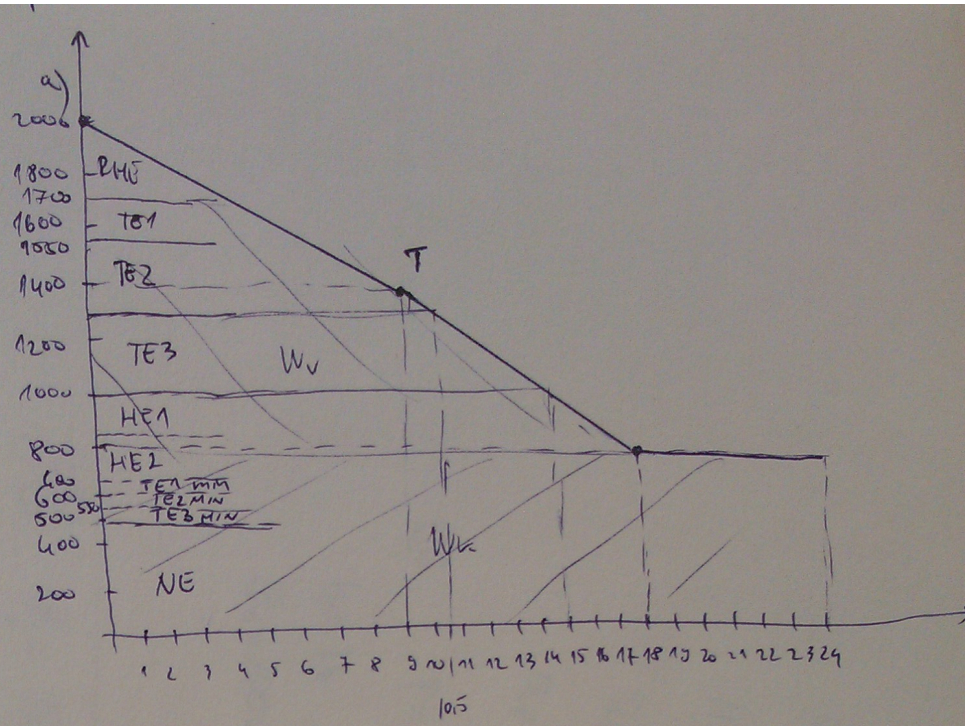
$T_{min} = 6$ h

$m = 0{,}625$

$\alpha = \beta$

$\eta_p = 0{,}5625$

$T_v = 24 - 6 = 18$ h



(x, y)

$$\eta: \quad 2\alpha = 2 \cdot \frac{W_v}{T_v \cdot P_v}$$

$$\beta = \alpha = \frac{W_v}{T_v \cdot P_v}$$

$$\alpha = \beta = \frac{10\,800 \text{ MWh}}{18 \cdot 1200}$$

$\alpha = \beta = 0{,}5$

$T\,(0{,}5 \cdot 18,\ 800 + 0{,}5 \cdot 1200)$

$T\,(9\text{ h},\ 1400 \text{ MW})$

$P_v = P_{max} - P_{min} = 1200$ MW

$$m = \frac{W}{24 \cdot P_{max}} \Rightarrow W_{uk} = 30\,000 \text{ MWh}$$

$W_{min} = 24 \cdot P_{min} = 19\,200$ MWh

$W_v = W_{uk} - W_{min} = 10\,800$ MWh

b) $T_{max} = ?$

$$T_{max} = \frac{W_{uk}}{P_{max}} = 15 \text{ h}$$

c) $W_v = ?$ $\quad W_v = \frac{9 \cdot 600}{2} + 9 \cdot 600 + 9 \cdot \frac{600}{2}$

$= 10800$ MWh

d) $TE_3 = ?$

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

$$y - 1400 = \frac{-600}{9}(x - 9)$$

$$y = -66{,}67x + 2000$$

$y = 1300 \Rightarrow x = 10{,}5$ h

$y = 1000 \Rightarrow 15$ h $= x$

$W_{TE_3} = 10{,}5 \cdot 300 + \frac{4{,}5 \cdot 300}{2} + 24 \cdot 50 = 5025$ MWh

e) ...