ENERGIJSKE TEHNOLOGIJE

1. TEHNIČKA TERMODINAMIKA

- PLIN U CILINDRU → ZATVORENI SUSTAV

⇝ KORISNI RAD :

- rad plina umanjen za rad potiskivanja okolice

$$\boxed{W_{KORISNI} = W_{12} - p_{ok}(V_2 - V_1)}$$

⇝ ULOŽEN RAD (−)

- KOMPRESOR → OTVORENI SUSTAV (zrak neometano prolazi granice)
- UNUTRAŠNJOST BENZINSKOG MOTORA (KOMORA IZGARANJA) → OTVORENI SUSTAV

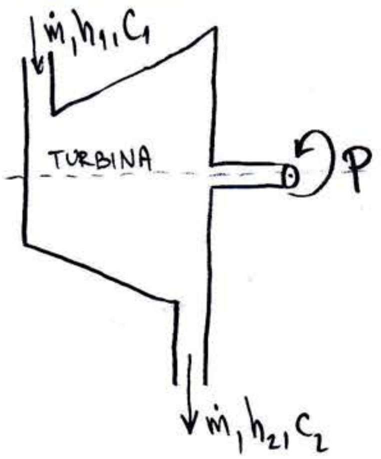
$\Delta h = h_2 - h_1 = q_{12} - w_{t12} \quad / \cdot \dot{m}$ $\qquad P = w_{t12} \cdot \dot{m}$ $\qquad \Delta \dot{H} = \Delta h \cdot \dot{m}$

$\Rightarrow \Delta \dot{H} = \dot{Q}_{12} - P$ → SNAGE ! $\qquad \dot{Q}_{12} = q_{12} \cdot \dot{m}$

⇝ izmjenjena toplinska snaga jednaka je SUMI TOPLINSKE SNAGE koja se ODVODI RASHLADNOM VODOM i TOPLINSKE SNAGE KOJA PRELAZI U OKOLICU

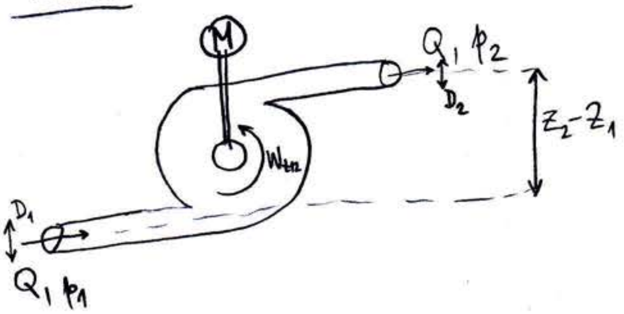
$$\dot{Q}_{12} = \dot{Q}_V + \dot{Q}_{OK}$$

PARNA TURBINA:



OTVOREN SUSTAV

PUMPA:



OTVOREN SUSTAV

$$\boxed{\dot{m} = \rho Q}$$

$$\rho = \frac{m}{V = m \cdot v} = \frac{1}{v} \rightarrow v = \frac{1}{\rho}$$

$$h = u + pv \quad /'$$

$$dh = \underbrace{du + p\,dv}_{dq} + v\,dp \Rightarrow dh = dq + v\,dp$$

$$\boxed{W_{t12} = -v(p_2 - p_1) - \frac{1}{2}(c_2^2 - c_1^2) - g(z_2 - z_1)}$$

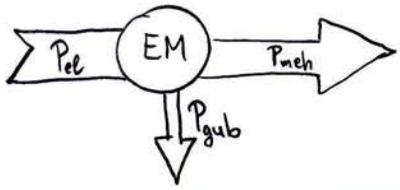
! $W_{t12} < 0 \rightarrow$ ULOŽILI RAD

$\Rightarrow \boxed{P_{t12} = \dot{m} \cdot W_{t12}} < 0$

- PROTOK: $Q = A \cdot c$

$\boxed{P_M = |P_{t12}|} \rightarrow$ MOTOR OBAVLJA RAD

ELEKTROMOTOR:



$$\boxed{\eta = \frac{\text{KORISNA ENER.}}{\text{ULOŽENA ENER.}} = \frac{P_{meh}}{P_{el}} = \frac{P_{meh}}{P_{meh} + P_{gub}}}$$

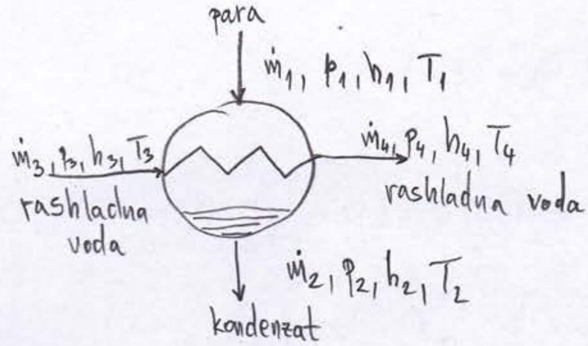
!

→ GUBITCI – toplinski gubici elektromotora → $P_{gub} = \dot{m} \cdot \Delta h$

$W_{tr} = -W_{meh} = -W_{el} = -UI\Delta t$ < 0 JER SE DOVODI U SUSTAV (ULAŽE)

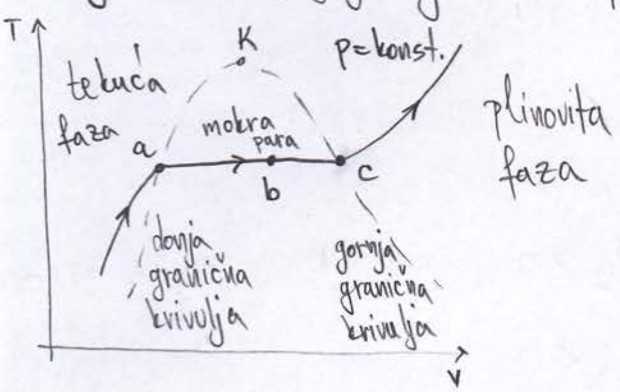
$W_{teret} = mg\Delta z$

IZMJENJIVAČ TOPLINE:



$$|\dot{m}_1(h_2-h_1)| = |\dot{m}_3(h_4-h_3)|$$

- isparavanje vode i pregrijavanje vodene pare uz konstantni tlak (T, v dijagram)



SADRŽAJ PARE:

$$\boxed{x = \frac{m''}{m' + m''}}$$

m'' ..... masa pare

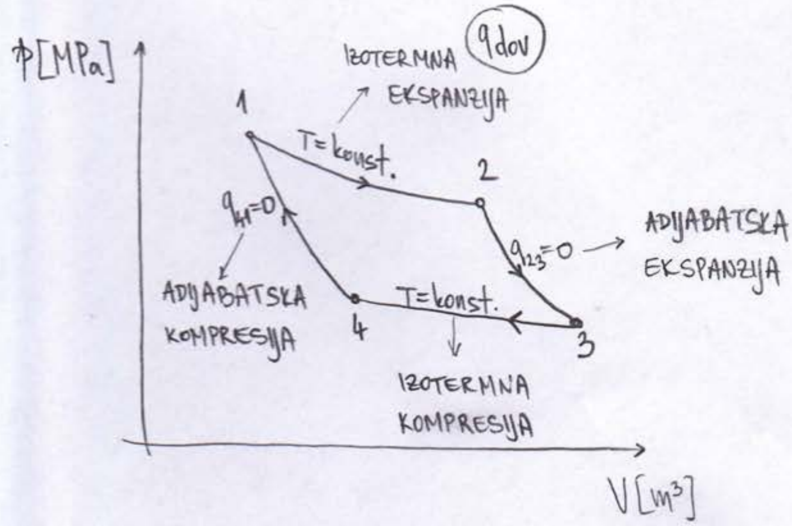
m' ..... masa zasićene tekućine (vrele kapljevine)

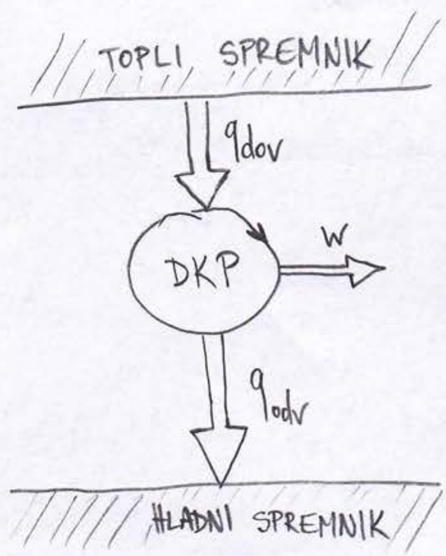
$m' + m''$ .... masa smjese

$U_b = m_t \cdot U_t + m_p \cdot U_p$ $\qquad m = m_t + m_p$

$U_c = m \cdot U_p$

CARNOTOV DESNOKRETNI KP:





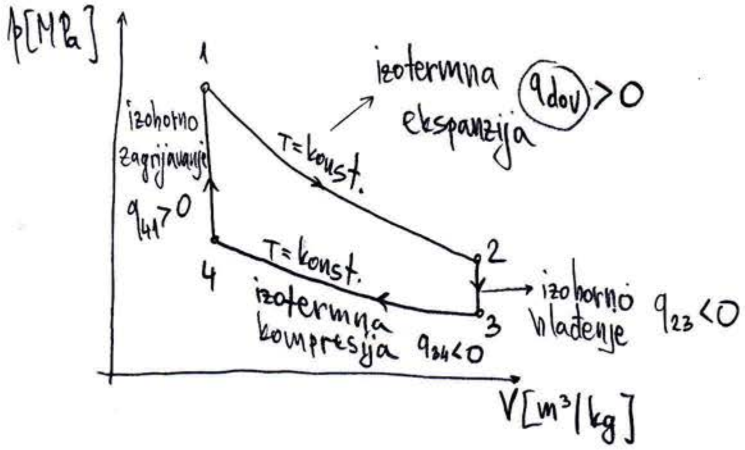
$Q_{KP_{ZS}} = W_{KP_{ZS}}$ (ZATVORENI SUSTAV)

- MEHANIČKI RAD OTVORENOG SUSTAVA JEDNAK JE TEHNIČKOM RADU

$$\boxed{W_{t12} = -\int_{p_1}^{p_2} v\,dp - \frac{1}{2}\left(c_2^2 - c_1^2\right) - g\left(z_2 - z_1\right)}$$

$Q_{KP_{OS}} = W_{KP_{OS}}$ TAKOĐER I ZA OTVORENI SUSTAV

STIRLINGOV DESNOKRETNI KP:



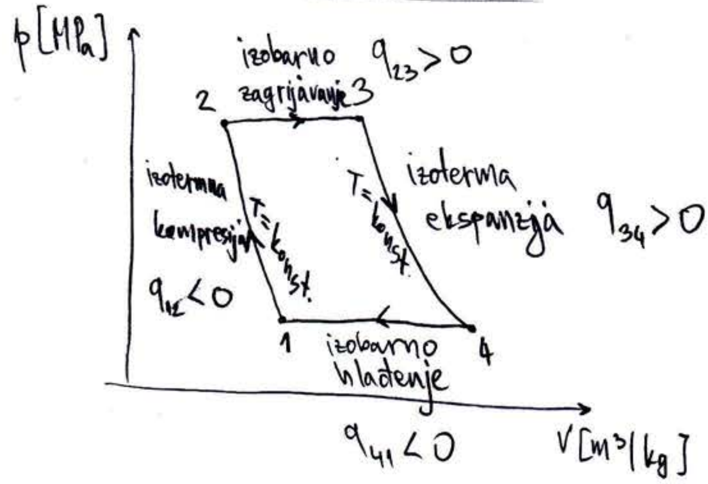
$q_{12} > 0$ DOVODI IZ TOPLOG SPREMNIKA

$q_{23} < 0$

$q_{34} < 0$ ODVODI U HLADNI SPREMNIK

$q_{41} > 0$

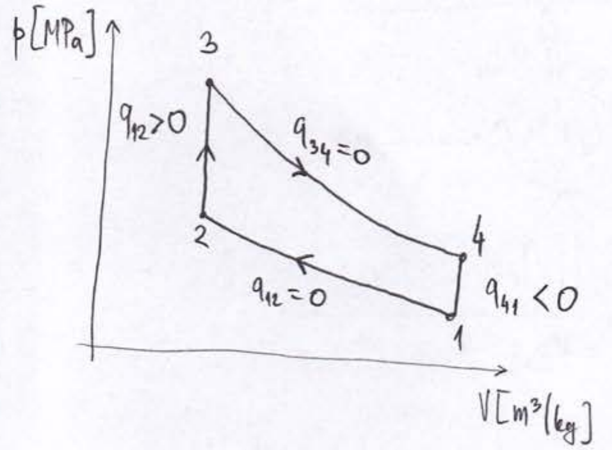
ERICSSONOV DESNOKRETNI KP:



$q_{12} < 0$ ODVODI U HS

$q_{34} > 0$ DOVOD IZ TS

OTTOV KP:



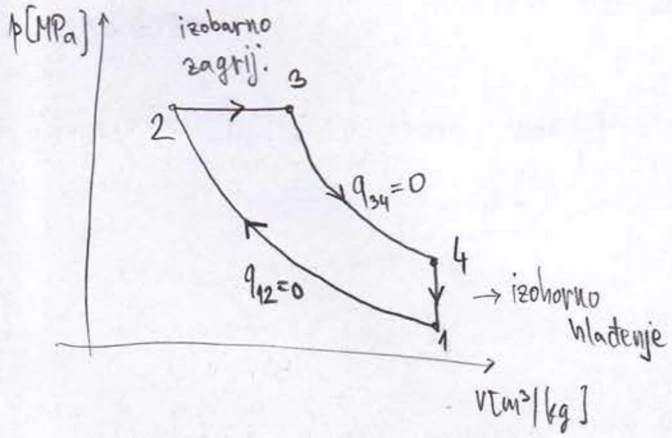
→ OMJER KOMPRESIJE – omjer volumena PRIJE i NAKON ADIJABATSKE KOMPRESIJE

$$\boxed{r_v = \frac{V_1}{V_2}} \qquad r_p = \frac{p_3}{p_2}$$

→ MEHANIČKI RAD ADIJABATSKOG OTVORENOG SUSTAVA JEDNAK JE TEHNIČKOM RADU

→ također, ukupni mehanički rad: $\boxed{W = q_{dov} + q_{odv}}$ za kp

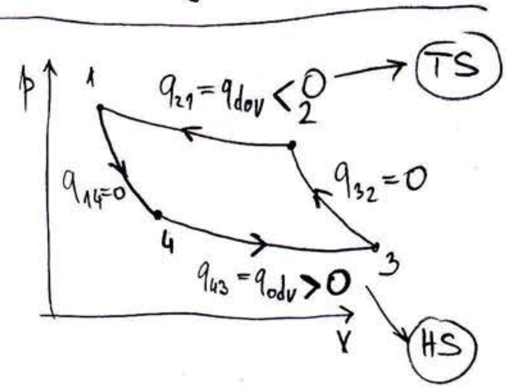
DIESELOV KP:

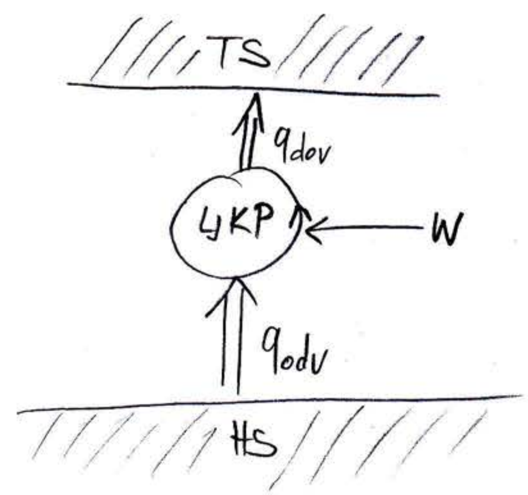


→ OMJER UBRIZGAVANJA – omjer konačnog i početnog volumena tijekom IZOBARNOG izgaranja

$$\boxed{r_u = \frac{V_3}{V_2}}$$

CARNOTOV LJEVOKRETNI KP:





→ u <u>izmjenjivaču topline</u> je toplinska snaga koju plin gubi jednaka toplinskoj snazi koju voda primi

$\Rightarrow \quad \underline{\dot{Q}_{pl} = \dot{Q}_v}$

<u>II G.S.TD</u>: $\Delta S_{uk} < 0$ → NEMOGUĆ PROCES (POVRATLJIV)

$\Delta S_{uk} > 0$ → REALAN, NEPOVRATLJIV PROCES

$\Delta S = \frac{q}{T}$ <u>SAMO ZA T = konst.</u> $\quad \Delta S_{pl} = m \cdot \Delta S_{pl} = m \cdot \Delta S_s$

ENTROPIJA JE <u>VELIČINA STANJA</u> – promjena entropije ne ovisi o procesu već samo o početnom i konačnom stanju

→ za NEKOMPRESIBILNE TVARI vrijedi da im <u>GUSTOĆA</u> tijekom procesa ostaje <u>NEPROMJENJENA</u>

$\Rightarrow \underline{dv = 0}$ → spec. volumen im se ne mijenja $\Rightarrow \underline{v_2 = v_1}$

$$ds_{nekomp.} = \frac{du}{T} = c\,\frac{dT}{T}$$

· EKSERGIJA je oblik energije koji se u povratljivom procesu može u potpunosti pretvoriti u mehanički rad.

$$\boxed{\dot{E}ks = \dot{W}_{max} = \eta_{tCKP} \cdot \dot{Q}_{DOV}}$$

· IREVERZIBILNOST : $\boxed{\dot{I} = \dot{W}_{max} - \dot{W}}$

EKSERGETSKI STUPANJ DJELOVANJA – mjera učinkovisti pretvorbe toplinske energije u mehanički rad

$$\zeta = \frac{\eta_t}{\eta_{tckp}} = \frac{\frac{w}{q_{dov}}}{\frac{w_{max}}{q_{dov}}} \qquad \eta_{tckp} = \frac{w_{max}}{q_{dov}}$$

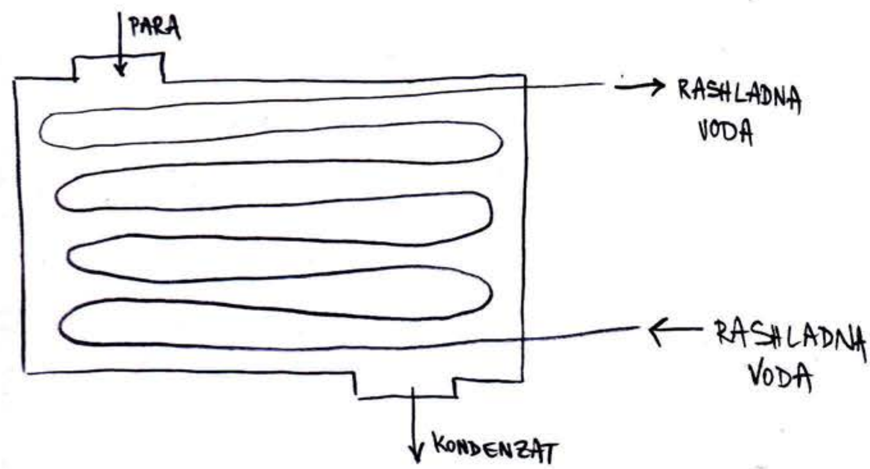
$$\zeta = \frac{w}{w_{max}}$$

$$\Delta \dot{S}_{HS} = \frac{\dot{Q}_{HS}}{T_{HS}}$$

$$\boxed{\dot{E}ks_{gub} = \dot{I} = \dot{W}_{max} - \dot{W}_{realno} = \dot{W}_{pov} - \dot{W}_{nep}}$$

$$\dot{E}ks_{gub} = T_{ok}\, \Delta \dot{S}_{uk} = T_{ok}\left(\Delta \dot{S}_s + \Delta \dot{S}_{ok}\right)$$

KONDENZATOR:

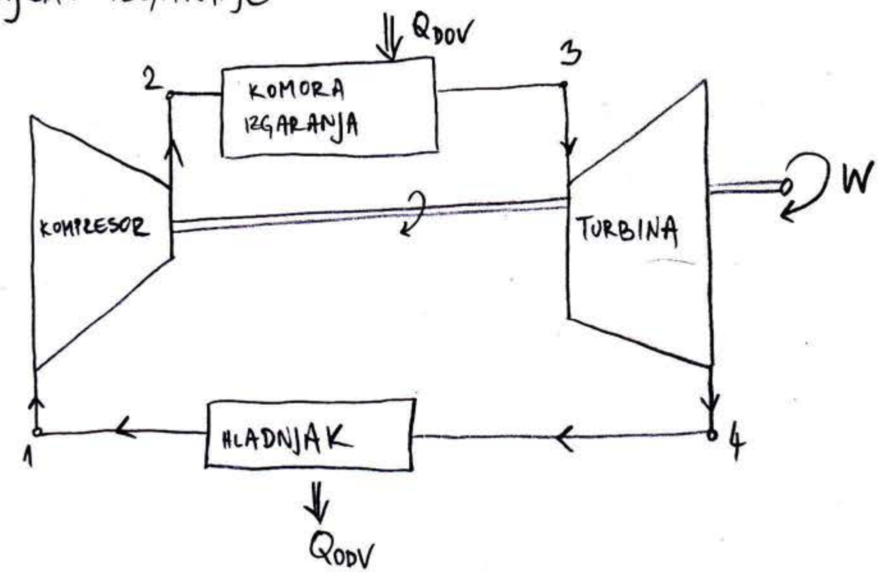


- KRUTI SPREMNIK → ZATVORENI SUSTAV

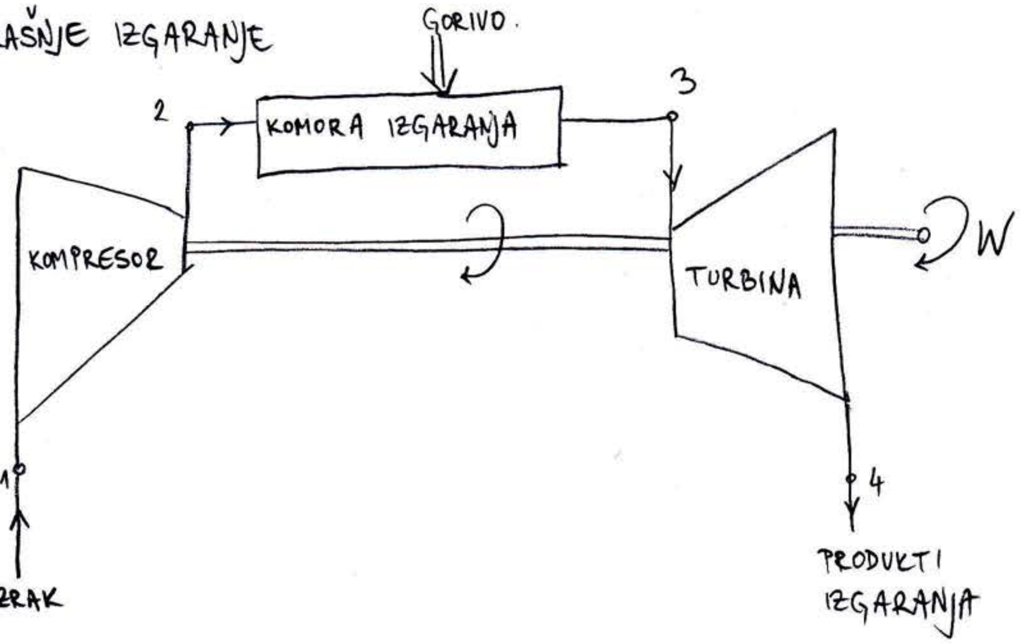
2. ENERGETSKE PRETVORBE U TERMOELEKTRANAMA

TE S PLINSKOM TURBINOM

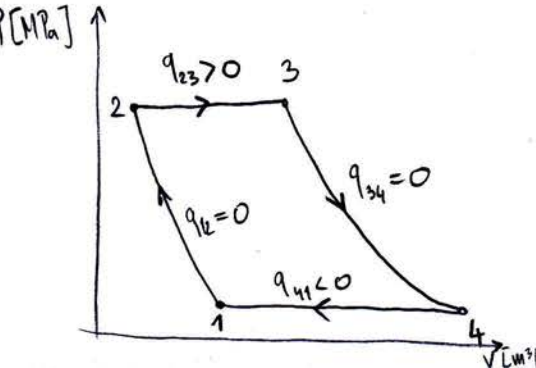
A) VANJSKO IZGARANJE



B) UNUTRAŠNJE IZGARANJE



→BRAYTONOV DESNOKRETNI KP:



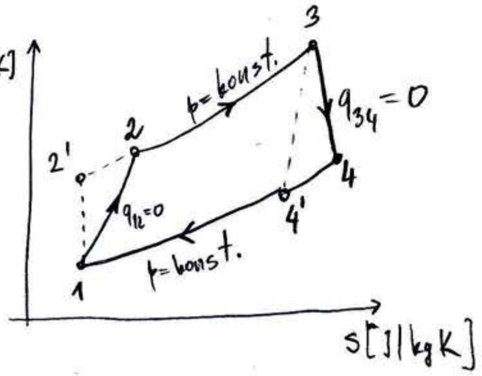
TURBINA: mehanički rad = $w_{t34} = c_p\left(T_3 - T_4\right)$

KOMPRESOR: $w_{t12} = c_p\left(T_1 - T_2\right)$

KOMORA IZG. I HLADNJAK: $w = 0$ (IZOBARNI PROCESI)
$\underline{vdp = 0}$

$$\eta_t = \frac{w_t + w_k}{q_{dov}}$$

REALNI BRAYTONOV KP: (T-s dijagram)



TURBINA

$$\boxed{\eta_{it} = \frac{W_{real\,t}}{W_{id\,t}} = \frac{T_3 - T_4}{T_3 - T_{4'}}}$$

!

$$W_{real\,t} = c_p\left(T_{ul} - T_{iz}\right)$$

IDEALNO

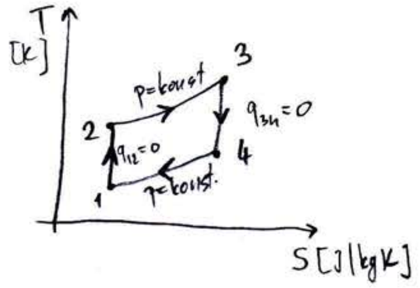
$$\boxed{\eta_t = 1 - \frac{T_1}{T_{2'}}}$$

KOMPRESOR

$$\boxed{\eta_{ik} = \frac{W_{id\,k}}{W_{real\,k}} = \frac{T_1 - T_{2'}}{T_1 - T_2}}$$

!

IDEALNI BRAYTONOV KP: (T-s)

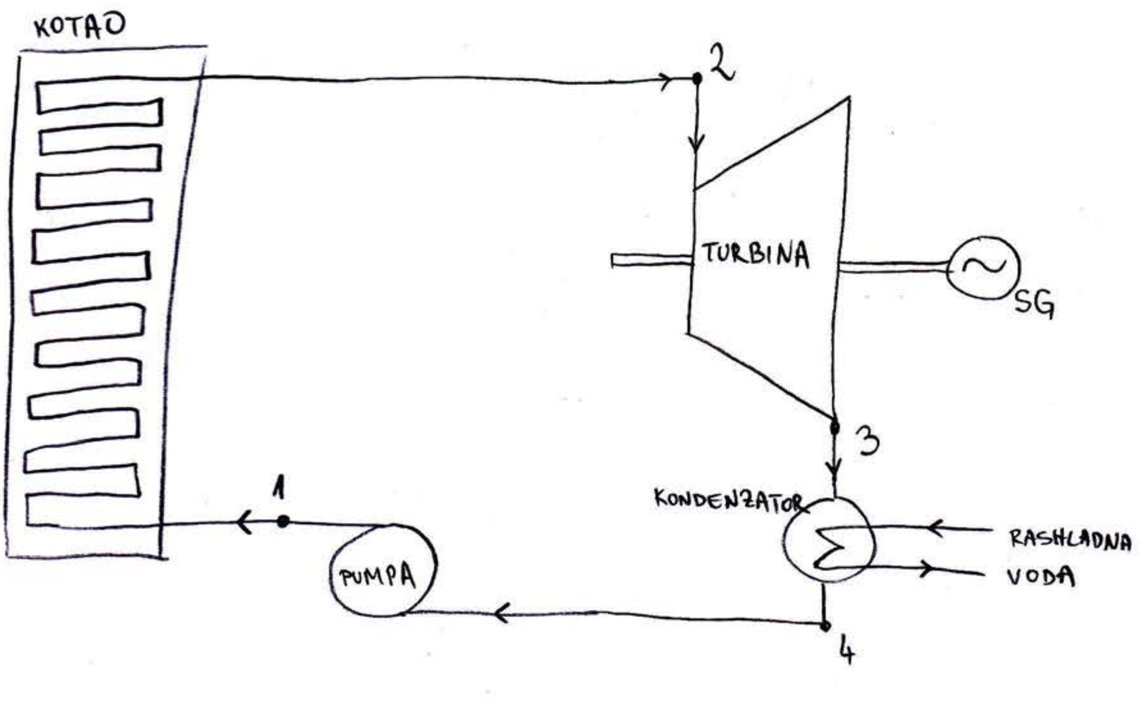


$T_{min} = T_1 = T_{\text{NA ULAZU U KOMPRESOR}}$

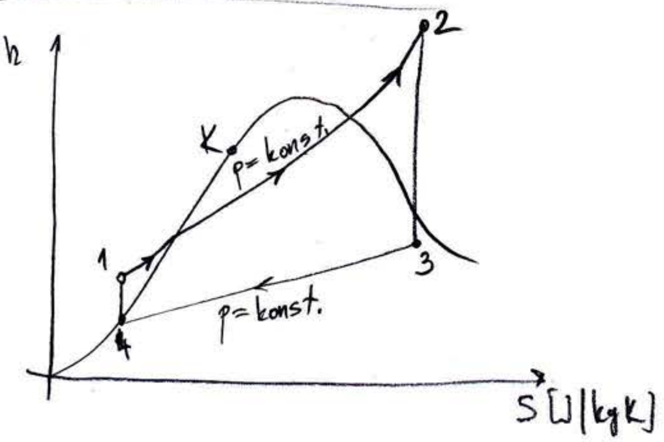
$T_{max} = T_3 = T_{\text{NA IZLAZU IZ KOMORE IZGARANJA (ULAZ U TURBINU)}}$

$$\boxed{\eta_t = 1 - \frac{T_1}{T_2}}$$

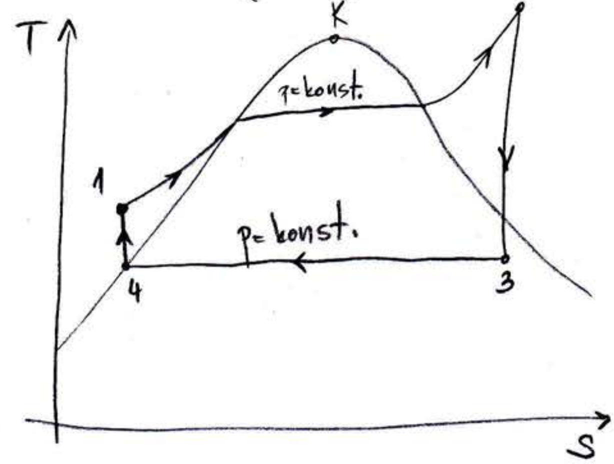
TE S PARNOM TURBINOM



IDEALNI RANKINEOV KP (h-s)



(T-S)



KOTAO:

$$\boxed{\begin{array}{l} W_{12}=0 \\ q_{12}=h_2-h_1 \end{array}}$$

q_{dov}

KONDENZATOR:

$$\boxed{\begin{array}{l} W_{34}=0 \\ q_{34}=h_3-h_4 \end{array}}$$

q_{odv}

TURBINA:

$$\boxed{\begin{array}{l} q_{23}=0 \\ W_t=W_{23}=h_2-h_3 \end{array}}$$

PUMPA:

$$\boxed{\begin{array}{l} q_{41}=0 \\ W_p=W_{41}=h_4-h_1 \end{array}}$$

$$\boxed{W_p=v\left(p_4-p_1\right)}$$!

$$P_t=W_{23}\cdot \dot{m}$$

$$\eta_t=\frac{W_t+W_p}{q_{dov}}$$

REALNI RANKINEOV KP: (h-s)

$$\eta_{it}=\frac{W_{real\,t}}{W_{id\,t}}=\frac{h_2-h_3}{h_2-h_{3'}}$$

$$\eta_{ip}=\frac{W_{id\,p}}{W_{real\,p}}=\frac{h_4-h_{1'}}{h_4-h_1}$$

$$W_{id\,p}=v\left(p_{1'}-p_4\right)$$

$$\eta_t=\frac{W_{id\,t}-W_{id\,p}}{q_{dov}}=\frac{h_2-h_{3'}-(h_{1'}-h_4)}{h_2-h_{1'}}$$

⟶ rad koji pumpa obavi NAD SUSTAVOM je NEGATIVNOG predznaka ako se gleda u odnosu na sustav

⟶ inače pozitivan   ČEŠĆE UZIMATI (+)

$$\boxed{W_p=\mp v\left(p_1-p_4\right)}$$

→ kada se za tehnički rad pumpe uzme ⊕ odnosno vrijedi

$$\boxed{W_{tp} = v(p_1 - p_4)}$$ tada za term. stupanj $$\boxed{\eta_t = \frac{W_t - W_{tp}}{q_{dov}}}$$ NAJČEŠĆE U ZADACIMA

$$\eta_t = \frac{P}{\dot{Q}_{DOV}} = \frac{P_t - P_p}{\dot{Q}_{DOV}}$$

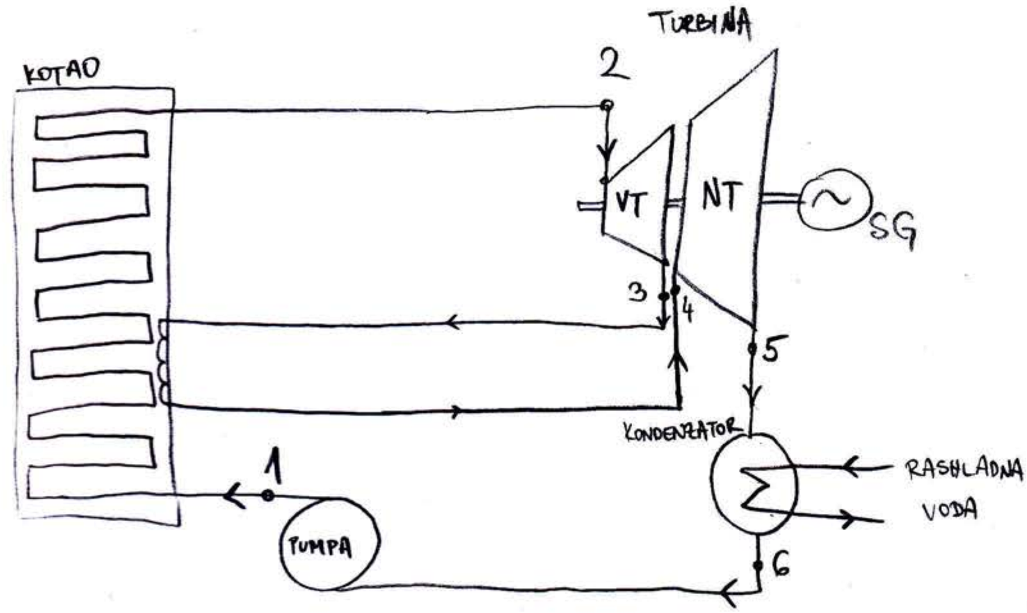
- el. snaga generatora: $$\boxed{P_{el} = \eta_{mt} \cdot \eta_g \cdot P_t}$$ η_{mt} ..... mehanički stup. djel. turbine

$$\boxed{\eta_{el} = \eta_{mt} \cdot \eta_g \cdot \eta_t}$$ ..... ukupan stupanj djelovanja elektrane na priključnicama generatora

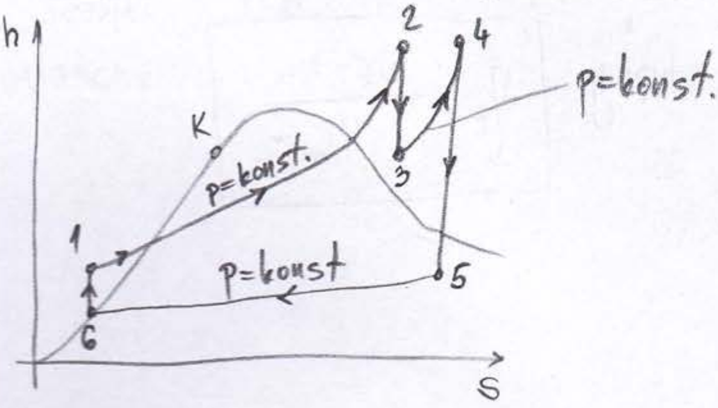
$$\boxed{\eta_{el} = \frac{P_{el}}{\dot{Q}_{DOV}}}$$

SNAGA PUMPE: $P_p = \dot{m}\, v\, \Delta p = \underline{\dot{m}\, v\, (p_{kot} - p_{kond})}$

TE S MEĐUPREGRIJAČEM:



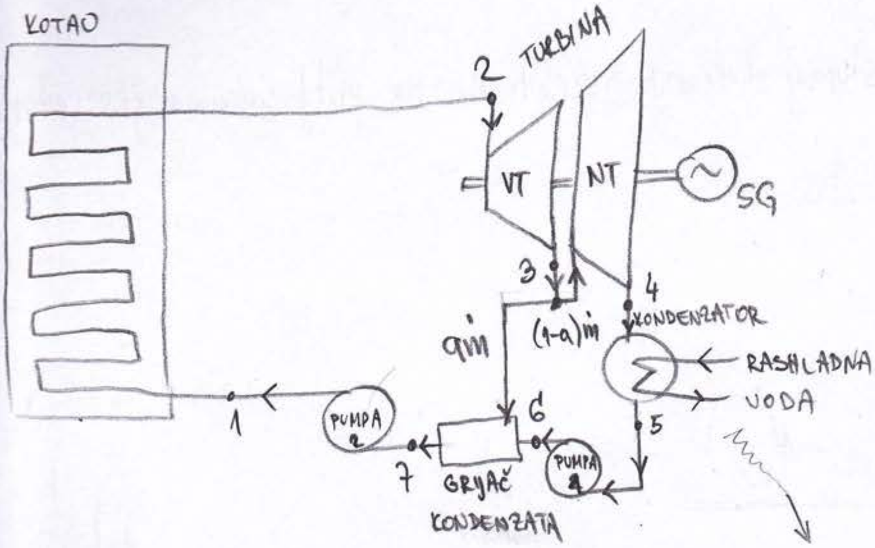
IDEALNI RANKINEOV KP S MEĐUPREGRIJANJEM PARE (h-s)



$$\boxed{\eta_t = \frac{W_{VT} + W_{NT} - W_P}{\underbrace{q_{dov1}}_{h_2-h_1} + \underbrace{q_{dov2}}_{h_4-h_3}}}$$

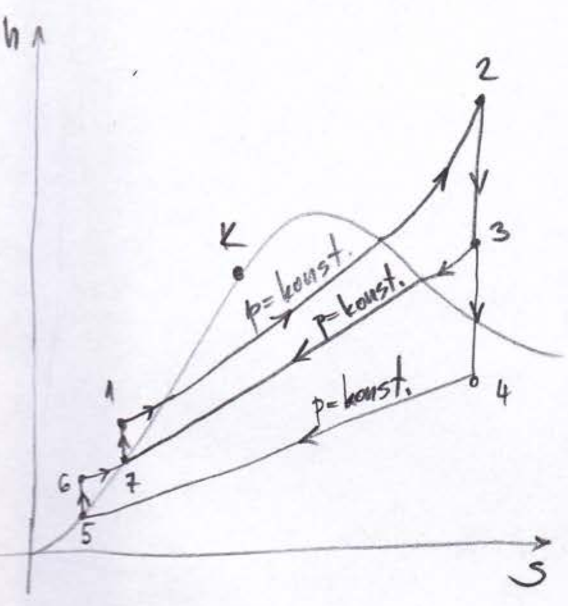
$$W_p = v\left(p_1 - p_6\right)$$

TE S GRIJAČEM KONDENZATA:



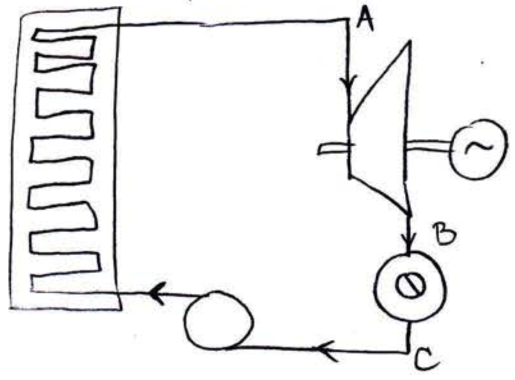
$$\boxed{a\dot{m}h_3 + (1-a)\dot{m}h_6 = \dot{m}h_7}$$

$$\boxed{\eta_t = \frac{\dot{W}}{\dot{Q}_{DOV}} = \frac{\dot{m}w_{vt} + (1-a)\dot{m}w_{nt} - (1-a)\dot{m}w_{p1} - \dot{m}w_{p2}}{\dot{m}q_{dov}}}$$



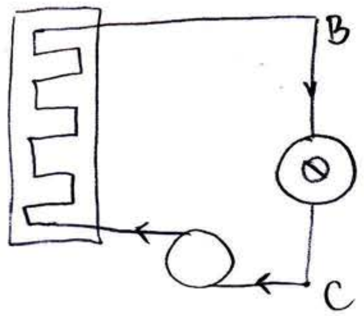
IDEALNI RANKINEOV KP SA ZAGRIJAVANJEM KONDENZATA (h-s)

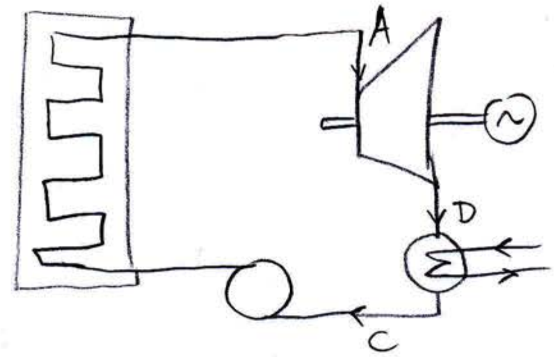
POSTROJENJE ZA KOMBINIRANU PROIZVODNJU PARE I STRUJE :



$$\eta_{KOM} = \frac{P_t + \dot{Q}_p}{\dot{Q}_{DOV}}$$

ODVOJENA POSTROJENJA ZA PROIZVODNJU PARE I STRUJE :





$$\eta_{ODV} = \frac{P_t + \dot{Q}_p}{\dot{Q}_{dov\,el} + \dot{Q}_{dov\,p}}$$

⇝ efikasnost pretvorbe el. u mehanicku energ. :

$$\eta_m = \frac{P_m}{P_{el}}$$

⇝ maseni protok pare: $\dot{m} = \rho_1 V_1 = \frac{1}{v_1} C_1 A_1$

⇝ $W_{gub} = T_{ok} \left(\Delta S_{TS} + \Delta S_{HS} \right)$

$\Delta \dot{S}_{TS} < 0$ JER SE HLADI !

$$\dot{W}_{gub} = T_{ok} \left(\Delta \dot{S}_{TS} + \Delta \dot{S}_{HS} \right) = T_{ok} \left(\frac{-\dot{Q}_{DOV}}{T_{TS}} + \frac{\dot{Q}_{OK}}{T_{HS}} \right)$$

$$P_t = \dot{Q}_{DOV} - \dot{Q}_{OK}$$

$$\rightsquigarrow \zeta = \frac{W_{t12}}{W_{max}} = \frac{P_t}{P_{max}}$$

$$\eta_t = \frac{P_t}{\dot{Q}_{dov}}$$

$$\rightsquigarrow P_{max} = \left(1 - \frac{T_{HS}}{T_{TS}}\right)\dot{Q}_{dov}$$

3. GEOTERMALNA ENERGIJA

$$\rightsquigarrow \eta_t = \frac{h_2 - h_{3'}}{h_2 - h_{3pov}}$$

$$\rightsquigarrow \dot{Q}_{dov} = \dot{m}_v c_v \cdot (T_{ulaz} - T_{izlaz})$$

$$\boxed{\dot{m}_F \cdot h_4 + \dot{m}_v \cdot h_{ul} = \dot{m}_F \cdot h_1 + \dot{m}_v \cdot h_{iz}}$$

4. NUKLEARNE ELEKTRANE

$$Q = 5{,}4 \text{ MeV} = 5{,}4 \cdot 1{,}6 \cdot 10^{-13}$$

→ TOPLINSKA SNAGA IZVORA:

$$\boxed{P = N \cdot \lambda \cdot Q}$$

$$\boxed{P = \frac{P_e}{\eta}}$$

⇝ POČETNA AKTIVNOST IZVORA:

$$\boxed{A_0 = N_0 \cdot \lambda} \quad [Bq]$$

⇝ početna raspoloživa toplin. snaga: $P_0 = A_0 \cdot Q = N_0 \cdot \lambda \cdot Q$

⇝ snaga odvedena rashladnim sustavom, pri masenom protoku $\dot{m}$ i porastu temperature ΔT:

(SUSTAV ZA ODVOĐENJE OSTATNE TOPLINE IMA 2 GRANE)

$$\boxed{P = 2\dot{m} \cdot c_p \cdot \Delta T}$$

⇝ toplinska snaga predana parogeneratorima:

$$\boxed{P_T = \dot{m}_{ukupni} \cdot (h_{ulaz} - h_{izlaz})}$$

⇝ električna snaga:

$$\boxed{P_e = \eta_{TG} \cdot (P_T - P_{KOND})} \qquad \boxed{\eta_T = \frac{P_e}{P_T}}$$

→ stupanj djelovanja na stezaljkama generatora

η_{TG} – ukupni stupanj djelovanja generatora

⇝ protok pare po parogeneratoru:

$$\boxed{\dot{m}_{sek} = \frac{\frac{P_T}{4}}{h_{sizlaz} - h_{sulaz}}}$$

$$\boxed{P_{JEZGRE} = P_T - 4 \cdot P_{PUMPA}}$$

⟶ površina presjeka gorivnog elementa: $(a_{ge})^2$

⟶ aktivni volumen jezgre: $V = \underbrace{A_j}_{\text{površina presjeka jezgre } (n \cdot (a_{ge})^2)} \cdot \underbrace{L}_{\text{visina jezgre (duljina šipke)}}$

⟶ volumna gustoća snage jezgre: $\boxed{q_v = \frac{P_t}{V}}$

⟶ linearna gustoća snage šipke: $\boxed{q_\ell = \frac{P_t}{N_{ge} \cdot N_{š} \cdot \ell_{š}}}$

⟶ toplinska snaga jezgre: $P_j = P_s \cdot m_U$

⟶ $T_{sr} = \frac{T_{ul} + T_{iz}}{2}$ $\qquad \dot{m} = \frac{P_J}{c_v \underbrace{\Delta T}_{T_{iz} - T_{ul}}}$

⟶ broj primarnih rashladnih krugova: $n_{RK} = \frac{\dot{m}}{\dot{m}_\ell}$

⟶ term. stupanj djelovanja NE:

$$\boxed{\eta_t = 1 - \frac{P_{ODV}}{P_{DOV}}} \qquad \boxed{P_{prag} = P_t \cdot \eta \cdot \eta_e - P_e}$$

$$\boxed{P_{el} = P_{DOV} \cdot \eta_{it} \cdot \eta_t}$$

⟶ stupanj djelovanja: $\boxed{\eta = \frac{P_E}{P_T}}$

⟶ $\boxed{P_{JEZGRE} = P_T - n_{petlji} \cdot P_{PUMPE}}$

$\rightsquigarrow$ SNAGA PAROGENERATORA: $\boxed{P_{PG} = \dfrac{P_T}{\eta_{petlji}}}$

$\rightsquigarrow$ efektivni toplinski otpor:

$$\boxed{R_T = \frac{\left(T_{SRP} - T_{SRS}\right)}{P_{PG}}}$$

$\rightsquigarrow$ $\underline{P_{PUMPE} = \dot{V}_{petlje} \cdot \Delta p_{pumpe}}$

$\rightsquigarrow$ $\boxed{P_{KOND} = (1-\eta) P_{SK}}$

5. HE i EES

→ PRIBRANSKA HE: $H_n = H_{B.p.}$ $\quad Q_{SR.p} = Q_{SR.p.}(H_{zah})$

→ DERIVACIJSKA HE: $H_n = H_{B.d} + \underbrace{(H_{zah} - H_d)}_{}$ → H postrojenja $\quad Q_{SR.d} = Q_{SR.d}(H_{zah})$

→ uz propuštanje biološkog minimuma:

$$Q_{SR.d-B.M} = Q_{SR.d}(H_{zah}) - Q_{BM}$$

→ tlačni tunel, turbina:

$$H_n = H_{gv} - H_t - \frac{c_t^2}{2 \cdot g}$$ → bez difuzora

$$H_n = H_{gv} - H_{dv} - \frac{c_d^2}{2g}$$ → sa difuzorom

→ $W_k = 24h \cdot P_{min}$ $\quad m = \frac{W}{24h \cdot P_{max}}$ $\quad T_{max} = \frac{W}{P_{max}}$

→ $W_v = W - W_k$

$P_v = P_{max} - P_{min}$ $\quad P_k = P_{min}$

6. ENERGIJA SUNCA I VJETRA

→ najveća proizvedena <u>električna snaga</u> po m^2:

$$\boxed{P_{el} = P_{smax} \cdot \eta_s \cdot \eta_t}$$

P_{smax} ..... najveća trenutna snaga Sunč. zračenja

→ površina zrcala: $A_z = \dfrac{P_n}{P_{el}}$

→ godišnja dozračena energija direktne komponente Sunčevog zračenja UVAŽAVAJUĆI POMICANJE ZRCALA:

$$W_{usmjereno,\,god} = \underbrace{1{,}35}_{\substack{\text{povećanje}\\\text{iskoristivosti}\\\text{direktnog}\\\text{zračenja}}} \cdot \underbrace{0{,}85}_{\substack{\text{udio}\\\text{direktne}\\\text{komponente}}} \cdot W_{h,god} \rightarrow H_{h,god}$$

$$\boxed{W_{el} = \eta_s \cdot \eta_t \cdot W_{usmjereno,\,god}}$$

$$W_{el,uk} = W_{el} \cdot A_z$$

→ površina koju bi zauzimala Sunčeva elektrana potrebna da bi se proizvela el. energija kao u baznoj elektrani snage P_n uz faktor opterećenja m:

$$\boxed{A'_{elektrane} = A_{elektrane} \cdot \frac{m \cdot P_n \cdot 8760\,h}{W_{el,uk}}}$$

→ specifična površina elektrane: $\boxed{a = \dfrac{A_{uk}}{W_{god}}}$

→ VRŠNO OZRAČENJE :

$$G_V = \frac{P_{n.t}}{A_a} = \frac{\frac{P_{n.e}}{\eta_{FN}}}{A_a} = \frac{\frac{P_{n.e}}{\eta_{FN}(1-p_g)}}{A_a}$$

→ ozračenost na horizontalnu površinu ako je povećanje za optimalni kut β , H_h

22 %

1952 kWh/m²

$$H_h = \frac{H_{\beta opt}}{\frac{H_{\beta opt}}{H_h}}$$ $= 1,22$

→ površina FN panela:

350 MW

$$A = \frac{W}{W_\beta \cdot \eta} = \frac{m_{el} P_{el} \cdot 8760h}{H_{\beta opt} \cdot \frac{H_{\beta opt}}{H_h} \cdot \eta}$$

1400 kWh/m² ; $\frac{H_{\beta opt}}{H_h} = 1.19$; $\eta = 0.09$

$P_n = A \cdot \eta \cdot G$ → vršna snaga Sunčeva zračenja na panele

P_n ↓ vršna snaga FN elektrane

$$m = \frac{W}{W_n} = \frac{m_{el} P_{el} \cdot 8760}{8760 \cdot P_n}$$

$$\boxed{P_n = f \cdot I_{KS} \cdot U_{PH}}$$

→ MAX ISKORISTIVA SNAGA VJETRA DOBIJE SE ZA $C_{p.max} = C_{p\,betz} = 0,593$!

→ NAZIVNA SNAGA VA: $P_n = \frac{W_{god}}{m \cdot t_{god}}$

7. BIOMASA, SPREMNICI ENERGIJE, EMISIJE

⟶ faktor opterećanja TE na biomasu: $m = \frac{t_m}{t_{god}}$

⟶ godišnje proizvedena toplinska energija:

$$\boxed{W_{t,god} = \underbrace{M}_{\text{prinos}} \cdot \underbrace{H}_{\text{ogrjevna vrijednost}} \cdot \frac{A_{uk}}{f_{TE}}}$$

A_{uk} ⟶ zasađena površina biomase

$$\Updownarrow$$

⟶ također, $\boxed{W_{t,god} = \frac{W_{el\,god}}{\eta}}$

⟶ specifična površina TE na biomasu: $a = \frac{A_{uk}}{W_{el\,god}}$

⟶ el. energ proizvedena pražnjenjem spremnika vode (RHE):

$$\boxed{W_{el} = \eta_{meh-el} \cdot W_{pot} = \eta_{meh-el} \cdot \rho V g h}$$

⟶ ukupna učinkovitost: $\boxed{\eta_{uk} = \frac{W_{el}}{W_{EES}} = \eta_{meh-el} \cdot \eta_p}$

⟶ ukupni gubici: $W_g = W_{EES} - W_{el}$

$\rightsquigarrow$ $\boxed{T_v = 24h - T_{min}}$

$T_{min} = $ "T_k"

$\rightsquigarrow$ $W_{preljev}$ → sa grafa površina !

$\rightsquigarrow$ $\boxed{W_{SPR} = \eta \cdot W_{PREL}}$

$\rightsquigarrow$ toplinska energija proizvedena izgaranjem (npr. metana):

$$W_t = \frac{W_{el}}{\eta}$$

$$\left.\begin{array}{l} CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O \\ 1 : 2 \longrightarrow 1 : 2 \end{array}\right\} V(CO_2) = V(CH_4)$$

$$n = \frac{m}{M} = \frac{V}{V_M} \qquad M(CO_2) = A_r(C) + 2A_r(O)$$

$\rightsquigarrow$ el. energ. proizvedena u elektrani tijekom godinu dana:

$$W_{el} = m \cdot P_{el} \cdot t_{god}$$