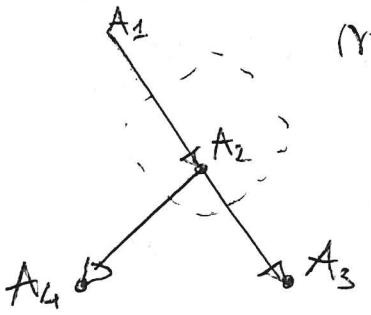
TEMA ESAME 26/07/2018

* SISTEMI ENERGETICI PER INGEGNERIA FISICA *

① $S_{(A_1-A_2)} = \frac{\pi D^2_{A_1-A_2}}{4} = 0,5027\ m^2$

$\dot{m}_{(A_1-A_2)} = \int S_{(A_1-A_2)}\, v = 1005,31\ kg/s$

BILANCIO DI MASSA



$\dot{m}_{A_1-A_2} = \dot{m}_{A_2-A_3} + \dot{m}_{A_2-A_4}$ $\quad \dot{m}_{A_2-A_4} = 0,15\,\dot{m}_{A_1-A_2}$

$\Downarrow$

$\dot{m}_{A_2-A_3} = 854,51\ kg/s$

$\dot{m}_{A_2-A_3} = \dot{m}_{S_1-S_2} = 854,51\ kg/s$

* CALCOLO DIAMETRI DEI TRATTI $(A_2-A_3) \in (S_1-S_2)$ *

$D_{A_2-A_3} = \left(\frac{4 \cdot \dot{m}_{A_2-A_3}}{\rho\, v}\right)^{0,5} = 737,56\ mm$

$D_{(A_2-A_3)} = D_{(S_1-S_2)}$ (STESSA PORTATA MASSICA E STESSA VELOCITÀ)

CALCOLO PERDITE

$Y_{A_1-A_2} = f \frac{L_{A_1-A_2}}{D_{A_1-A_2}} \frac{v^2}{2} = 26,27\ J/kg$

$Y^{conc}_{A_1-A_2} = K_c \frac{v^2}{2} = Y^{conc}_{A_2-A_3} = Y^{conc}_{S_1-S_2} = 12\ J/kg$ (STESSO K_c E v)

$Y_{A_2-A_3} = Y_{S_1-S_2} = f \frac{L_{A_2-A_3}}{D_{A_2-A_3}} \frac{v^2}{2} = 20,337\ J/kg$

$$\Delta z = Y_{TOT} + \left(\frac{P_{EL}}{\dot{m}_{A2-A3}}\right) \Big/ \eta_{ISON} \Big/ \eta_{MECC-EL} = 153{,}7\ m$$

* PRESSIONE INGRESSO DELLA TURBINA *

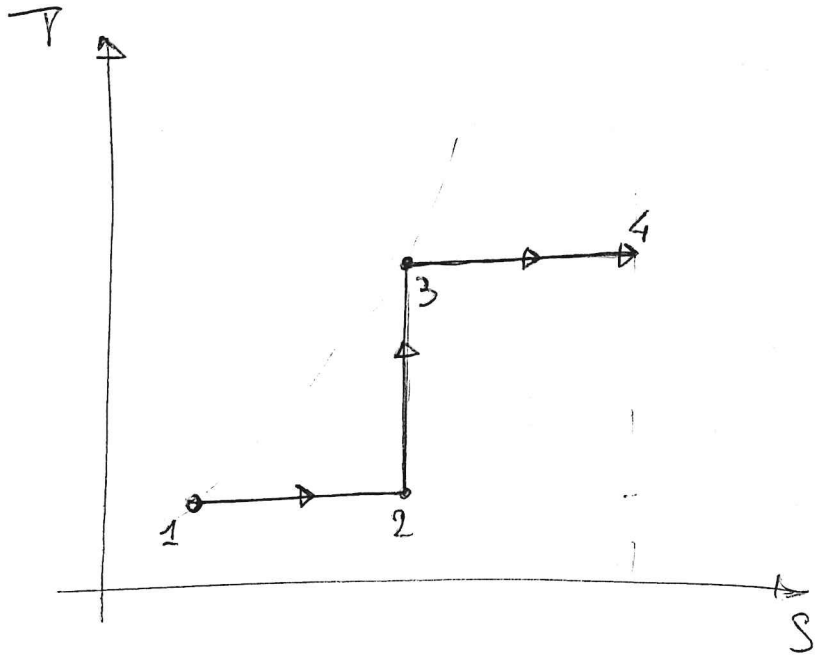
$$\frac{P_1}{\rho} + \frac{v_1^2}{2} + g z_1 + \cancel{Y_{A1-A2}} = \frac{P_{A3}}{\rho} + \frac{v_{A3}^2}{2} + g z_3 + Y_{A1-A2} + Y_{A2-A3}$$

$v_1 = 0\ m/s$

$P_1 = 1\ atm$

$$P_{A3} = 15{,}352\ bar$$

(2)



ELIO → GAS PERFETTO MONOATOMICO

$$c_p = \frac{5}{2} R^* \qquad R^* = \frac{R}{MM}$$

$$\gamma = \frac{c_p}{c_v} = \frac{5}{3}$$

$T_1 = 900°C$

$P_1 = 110\ bar$

$s_1 = 0\ KJ/Kg/K$

ESPANSIONE ISOTERMA $1 \to 2$

$P_2 = 30\ bar$

$T_2 = T_1$

$$\Delta S = c_p \ln\left(\frac{T_2}{T_1}\right) - R^* \ln \frac{P_2}{P_1} = 2{,}7\ \frac{KJ}{KgK}$$

$$q = T_1 \Delta S = 3{,}17\ \frac{MJ}{Kg}\ (\text{ENTRANTE})$$

$$l = -q = -3{,}17\ \frac{MJ}{Kg}\ (\text{USCENTE})$$

$s_2 = s_1 + \Delta S = 2{,}7\ \frac{KJ}{KgK}$

COMPRESSIONE ISOENTROPICA $2 \to 3$

$s_2 = s_3$

$P_3 = P_2 = 110\ bar$

$$\frac{T_3}{T_2} = \left(\frac{P_3}{P_2}\right)^{\frac{\gamma-1}{\gamma}} \Rightarrow T_3 = 1972{,}7\ K$$

$q = 0$

$$l = c_p\left(T_3 - T_2\right) = 4{,}15\ \frac{MJ}{kg}\ (\text{ENTRANTE})$$

* ESPANSIONE ADIABATICA →

($T_4 = T_3$ (ISOENTALPICA DI UN GAS PERFETTO COINCIDE CON UN'ISOTERMA)

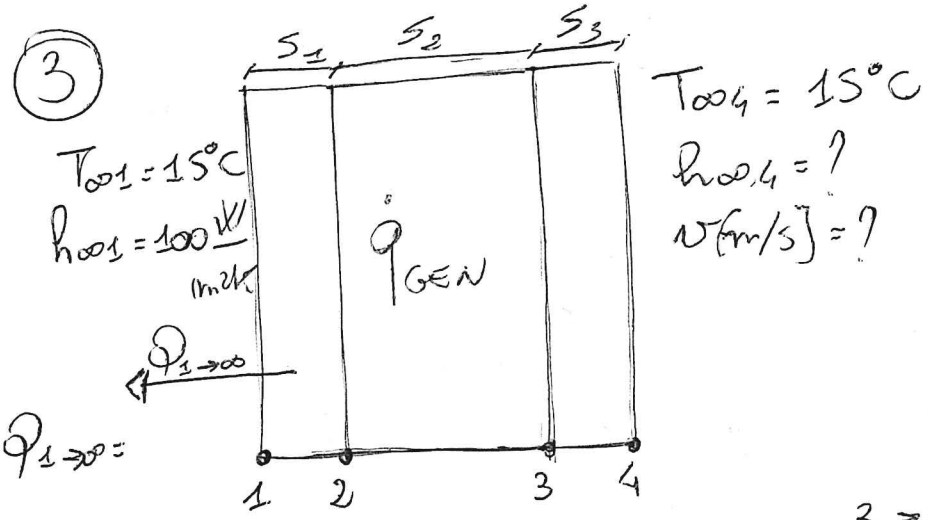
$s_4 = 2 \cdot s_2$

$$\Delta s = s_4 - s_3 = c_p \ln\left(\frac{T_4}{T_3}\right) - R^* \ln\left(\frac{P_4}{P_3}\right) \Rightarrow P_4 = 30\ bar$$

$q = 0$

$l = 0$

③

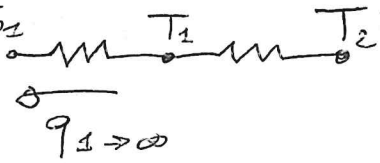


* RESISTENZE TERMICHE STRATI 1→2 3→5 →

$$R_{12} = \frac{s_1}{k_1} = 0{,}0025\ \frac{m^2K}{W} \qquad R_{34} = \frac{s_3}{k_3} = 0{,}005\ \frac{m^2K}{W}$$

$$q_{1\to\infty} = h_{\infty 1}\left(T_1 - T_{\infty 1}\right) = 300\ \frac{W}{m^2}\ (\text{dato})$$

$$T_1 = \frac{q_{1\to\infty}}{h_{\infty 1}} + T_{\infty 1} = 406°C$$



$$T_2 = T_1 + q_{1\to\infty}\cdot R_{12} = 406{,}75°C$$

- IL FLUSSO TERMICO USCENTE DALLA PARETE DI DESTRA È DATO DALLA DIFFERENZA TRA LA GENERAZIONE DI POTENZA INTERNA E IL FLUSSO $q_{1\to\infty}$

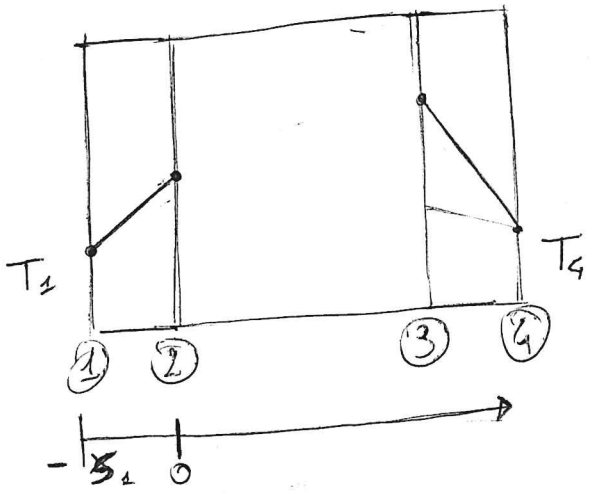
$$q_{4\to\infty} = q_{GEN}\cdot S_2 - q_{1\to\infty} = 19700\ \frac{W}{m^2}$$

$$q_{4\to\infty} = h_{\infty 4}\left(T_4 - T_{\infty 4}\right) \Longrightarrow T_4 = 406°C$$

T_4 → dato $\Rightarrow T_1 = 406°C$

$$T_3 = T_4 + q_{4\to\infty}\cdot R_{34} = 504{,}5°C$$

PROFILO DI TEMPERATURA → NON RICHIESTO ☆



- NEI 2 STRATI INTERNI IL PROFILO DI TEMPERATURA È LINEARE
- NELLO STRATO CENTRALE IL PROFILO È PARABOLICO

$$q = -K_2\frac{d^2T}{dx^2}$$

↓ INTEGRANDO 2 VOLTE

$$T(x) = -\frac{\dot{q}}{2K_2}x^2 + C_1 x + C_2$$

LE COSTANTI DI INTEGRAZIONE SI TROVANO IMPONENDO LE TEMPERATURE

$$T_2 = -\frac{\dot{q}}{2K_2}\left(0\right)^2 + C_1(0) + C_2 \Rightarrow C_2 = T_2$$

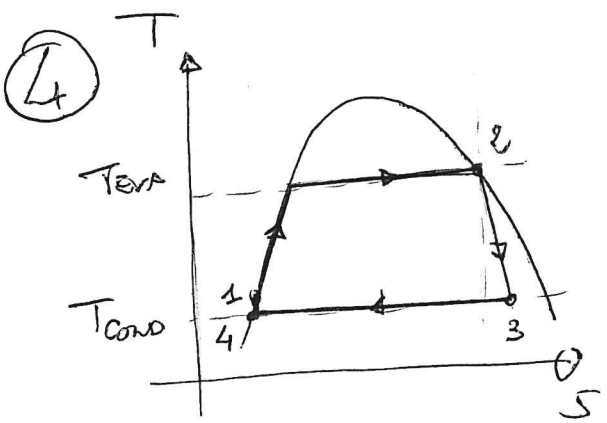
$$T_3 = -\frac{\dot{q}}{2K_2}\left(S_2\right)^2 + C_1\left(S_2\right) + C_2 \Rightarrow C_1 = \frac{\left(T_3 - T_2\right) + \frac{\dot{q}}{2K_2}S_2^2}{S_2}$$

$$h_{4\infty} = q_{4\to\infty} / (T_4 - T_{\infty 4}) = 50{,}3836 \ \frac{W}{m^2 K}$$

$$Pr = \frac{c_p \mu}{k} = 0{,}7192$$

$$Nu = \frac{h_{4\infty} L}{k} = 9615{,}197$$

$$v = \left[\frac{Nu}{Pr^{1/3} \cdot 0{,}037} \right]^{5/4} = 21{,}32 \ m/s$$



$$P_{EVA} = P_2 = P_{SAT}(22°C) = 9{,}137 \ bar = P_1$$

$$P_{COND} = P_4 = P_3 = P_{SAT}(10°C) = 6{,}150 \ bar$$

$$h_2 = h_{VS}(22°C) = 1624{,}68 \ \frac{kJ}{kg}$$

$$h_4 = h_{LS}(10°C) = 389{,}72 \ \frac{kJ}{kg}$$

ESPANSIONE $2 \to 3$ $\eta_{IS} = 0{,}88$

$$s_2 = 5{,}8245 \ \frac{kJ}{kgK} \qquad \Delta h_{IS} = 49{,}55 \ \frac{kJ}{kg} \ (dato)$$

$$\Delta h_{REALE} = \eta_{IS} \Delta h_{IS} = 43{,}60 \ \frac{kJ}{kg}$$

$$h_3 = h_2 - \Delta h_{REALE} = 1581{,}08 \ \frac{kJ}{kg}$$

→ PER DETERMINARE IL TITOLO X_3 UTILIZZO LA REGOLA DELLA LEVA

$$\Delta h_{EVA}(10°C) = (1615{,}27 - 389{,}72) \ \frac{kJ}{kg} = 1225{,}547 \ \frac{kJ}{kg}$$

$$x_3 = \frac{h_3 - h_4}{\Delta h_{EVA}} = 0{,}972$$

- Portata sentinella $\quad h_1 = 390{,}35 \ \frac{kJ}{kg}$ (dato)

$$\dot{m}_1 (h_2 - h_1) = \dot{m}_{acw} c_p (T_{in} - T_{out}) = \dot{Q}_{EVA} = 151{,}2 \ MW$$

T_{in} e T_{out} dato

$$\dot{m}_1 = \frac{\dot{m}_{acw} c_p (T_{in} - T_{out})}{h_2 - h_1} = 122{,}495 \ \frac{kg}{s}$$

Pompa circolazione acqua mare (SW)

$$P_{pompe,sw} = \dot{m}_{csw} \cdot \frac{\Delta P_{csw}}{\eta_{isn} \cdot \eta_{mg-el}} + \dot{m}_{ausw} \frac{\Delta P_{ausw}}{\eta_{isn} \cdot \eta_{mg-el}} = 1710{,}5 \ kW$$

Potenza totale turbina

$$P_{turbina} = \dot{m}_1 (h_2 - h_3) \cdot \eta_{mg} \cdot \eta_{el} = 5182{,}11 \ kW_e$$

$$P_{pompa\ sentinella} = \frac{\dot{m}_1 (h_1 - h_4)}{\eta_{mg-el}} = 82{,}46 \ kW_e$$

$$P_{netta} = P_{turbina} - P_{pompa\ sentinella} - P_{pompe\ sw} = 3389{,}18 \ kW$$

$$\eta_I = \frac{P_{netta}}{\dot{m}_{ausw} c_p (T_{in} - T_{out})} = 0{,}0224$$