ESAME 29/08/2017

(1) FLUIDO INCOMPRIMIBILE REGIME STAZIONARIO

– CALCOLO PORTATA MASSICA:

$$v_{scarico} = 1{,}8\ m/s \qquad A_{scarico} = \frac{\pi D_{scarico}^2}{4} = 0{,}2375\ m^2$$

$$\Downarrow$$

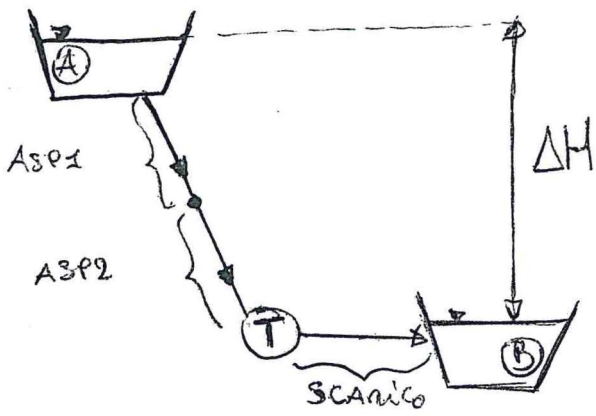
$$\dot{m} = \rho A_{scarico} v_{scarico} = 427{,}65\ kg/s$$

$$\dot{m}_{scarico} = \dot{m}_{ASP1} = \dot{m}_{ASP2} = \dot{m} \quad \text{(CONSERVAZIONE MASSA)}$$

$$v_{ASP1} = \frac{\dot{m}}{\rho \frac{\pi D_{ASP1}^2}{4}} = 2{,}178\ m/s \qquad v_{ASP2} = 3{,}4\ m/s$$

– CALCOLO MASSIMA POTENZA

$$P_A = P_B = 1\ atm$$
$$v_A = v_B = 0\ m/s$$



$$l_{IDEALE} = g\,\Delta H = 7357{,}5\ J/kg$$

$$P_{IDEALE} = \dot{m}\, l_{IDEALE} = 3146{,}43\ kW$$

– CALCOLO PERDITE DI CARICO

ASPIRAZIONE ⟹ $Y_{ASP} = Y_{ASP1,D} + Y_{ASP1,C} + Y_{ASP2,D} + Y_{ASP2,C} =$

2 TUBI IN SERIE

$$= f\frac{L_{ASP1}}{D_{ASP1}}\frac{v_{ASP1}^2}{2} + K_c\frac{v_{ASP1}^2}{2} + f\frac{L_{ASP2}}{D_{ASP2}}\frac{v_{ASP}^2}{2} + K_c\frac{v_{ASP_2}^2}{2} =$$

$Y_{ASPIR} = 1009.98$ J/kg

SCARICO: $Y_{SCARICO} = f \frac{L_{SCARICO}}{D_{SCARICO}} \frac{V_{SCARICO}^2}{2} + K_C \frac{V_{SCARICO}^2}{2} = 12,67$ J/kg

$Y_{LUBRIFICATO} = 1022$ J/kg

$l_{REALE} = l_{IDEALE} - Y_{LUBRIFICATO} = 6334.85$ J/kg $\quad \eta_{PENDOTE} = \frac{l_{REALE}}{l_{IDEALE}} = 0.86$

$P_{ELETTRICA\ REALE} = P_{IDEALE} \cdot \eta_{ORG-EL} \cdot \eta_{ION,TURBINA} \cdot \eta_{PENDOTE} = 2250.85$ kW

$\eta_{TOTALE,LUBRIFICATO} = \frac{P_{ELETTRICA,REALE}}{P_{IDEALE}} = 0.7155$

(2) He → GAS PERFETTO MONOATOMICO $\quad C_{V_{MOL}} = \frac{3}{2} R = 12,471$ J/kmolK

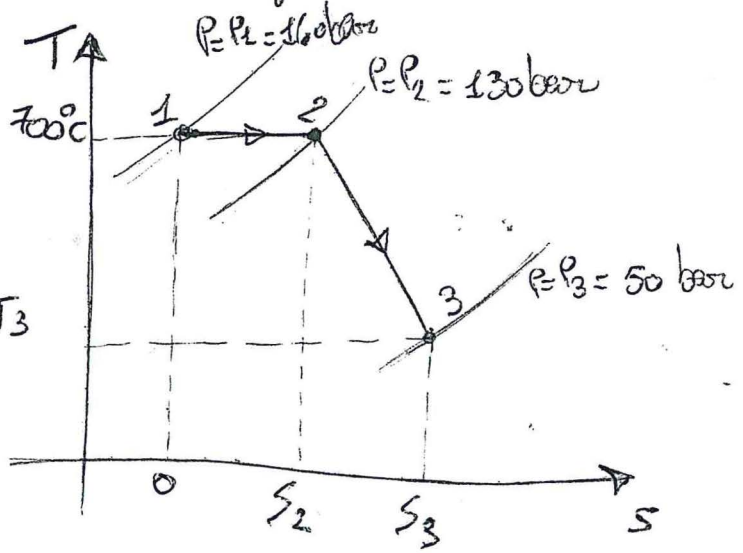
$C_{P_{MOL}} = C_V + R = 20785$ J/kmolK

$C_{P_{MASS}} = C_{P_{MOL}} / MM_{He} = 5196,25$ J/kgK

$C_{V_{MASS}} = C_{V_{MOL}} / MM_{He} = 3117,5$ J/kgK

$\gamma = \frac{C_P}{C_V} = 1,6667$

$\Theta = \frac{\gamma - 1}{\gamma} = 0,4$



TRASFORMAZIONE 1 → 2 COMPRESSIONE ISOENTALPICA → ISOENTROPICA x GAS PERFETTO

$T_2 = T_1 = 700°C \quad P_2 = 130 bar$

$S_1 = 0 \ J/kgK$

$\Delta S_{12} = c_p \ln \frac{T_2}{T_1} - R^* \ln \frac{P_2}{P_1} = 154,0334 \ J/kgK \quad S_2 = 154,0334 \ J/kgK$

TRASFORMAZIONE 2 → 3 ESPANSIONE con $\eta_{IS} = 0,88$

$\beta_{23} = \frac{P_2}{P_3} = \frac{130 bar}{50 bar} = 2,6$

$\frac{T_2}{T_{3IS}} = \beta^{\frac{\gamma-1}{\gamma}} = 1,4655 \Rightarrow T_{3IS} = 666,03 K$

$\Delta T_{IS} = T_2 - T_{3IS} = 309,11 K$

$\Delta T_{REALE} = \Delta T_{IS} \cdot \eta_{IS} = 272,022 K \quad (GAS PERFETTO)$

$T_3 = T_2 - \Delta T_{REALE} = 427,98 K$

$\Delta S_{23} = c_p \ln \frac{T_3}{T_2} - R^* \ln \frac{P_3}{P_2} = 282,45 \ J/kgK$

$S_3 = S_2 + \Delta S_{23} = 436,49 \ J/kgK$

$\dot{Q}_{12} = \dot{m} q_{12} = 0 \quad (\text{compressione adiabatica})$

$l_{12} = 0 \quad (\text{compressione adiabatica})$

$P_{23} = \dot{m} l_{23} = \dot{m} c_p (T_2 - T_3) = 978.35 \ MW$

$\rho_1 = \frac{P_1}{R^* T_1} = 6.92 \ kg/m^3 \quad \dot{m} = \dot{V}_1 \cdot \rho_1 = 692.15 \ kg/s$

③ $q = \frac{\Phi}{S_{CHIP}} = 11250 \frac{W}{m^2}$ ($\Phi \to 9\,W$)

- LA POTENZA TERMICA GENERATA DAL CHIP VIENE DISSIPATA ATTRAVERSO LE ALETTE

$$\eta_{ALETTA} = \frac{\dot{\Phi}}{\dot{\Phi}_{ALETTA\ ISOTERMA}} = 0,7\ (DATO)$$

$$\Downarrow$$

$$\eta_{ALETTA} = \frac{\dot{\Phi}}{hA(T_B - T_\infty)}$$

$$T_B = \frac{\Phi}{\eta_{ALETTA} \cdot hA} + T_\infty = 35,29°C$$

(T_B: TEMPERATURA BASE; Φ: 9 W; T_∞: 25°C; η_{ALETTA}: 0,7; h: 125 $\frac{W}{m^2K}$; A: 10000 mm^2)

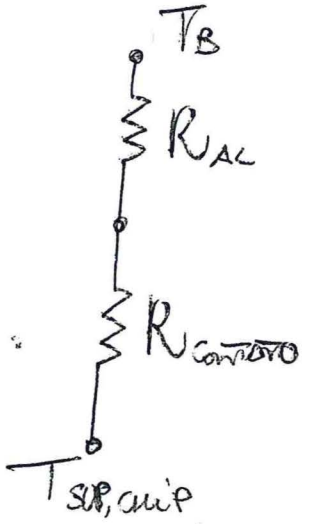
$$R_{AL} = \frac{S_{PESS,AL}}{K_{AL}} = 2,222 \cdot 10^{-5} \frac{m^2K}{W}$$

$$R_{CONTATTO} = 1e^{-4} \frac{m^2K}{W}$$

$$R_{TOT} = R_{AL} + R_{CONTATTO} = 1,222 \cdot 10^{-4} \frac{m^2K}{W}$$

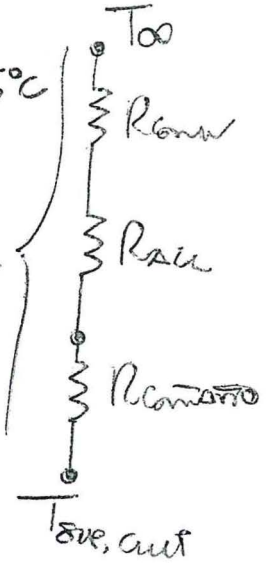
$$\Delta T = q R_{TOT} = 1,38°C$$

$$T_{SUP,CHIP} = T_B + \Delta T = 36,7°C$$



NEL CASO non ci fosse L'ALETTA

$$T_{SUP,out} = q\left(R_{ALL} + R_{CONTATTO} + \frac{1}{h_{\#}}\right) + T_\infty = 116°C$$



3 RESISTENZE IN SERIE

④ $P_{TG} = \Phi_{INTG}\,\eta_{TG} = 516\,MW \cdot 0{,}394 = 202{,}516\,MW$

$$\dot{m}_{GC} = \dot{m}_{ARIA} + \dot{m}_{GN} = 615\,kg/s \quad \text{(CONSERVAZIONE MASSA)}$$

- PER IL CALCOLO DELLA PORTATA DI VAPORE

$h_2 = 3358{,}052\ \frac{kJ}{kg}$ (ENTALPIA VAPORE IN INGRESSO NELLA TURBINA A VAPORE)

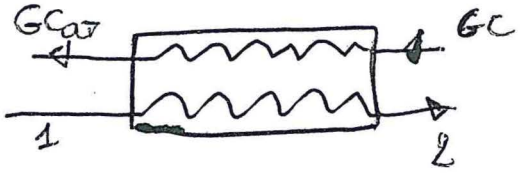
$$\Delta h_{IS,POMPA} = h_{1,IS} - h_4 = 1{,}992\ kJ/kg$$

$$\Delta h_{REALE,POMPA} = \frac{\Delta h_{IS,POMPA}}{\eta_{IS,POMPA}} = 2{,}62\ kJ/kg$$

$$h_1 = h_4 + \Delta h_{REALE,POMPA} = 165{,}986\ kJ/kg$$

$$\Delta h_{GEN\ VAP} = h_2 - h_1 = 3192{,}066\ kJ/kg$$

$$\Phi_{GEN\ VAP} = \dot{m}_{VAP} \cdot \Delta h_{GEN\ VAP} = 207484{,}28\,kW$$

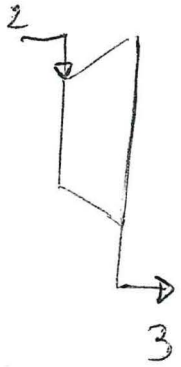


$$\dot{m}_{VAP}(h_2 - h_1) = \dot{m}_{GC}\, c_{p_{GC}} (T_{GC} - T_{GC,out})$$

$$T_{GC,out} = T_{GC} - \frac{\Phi_{GEN,VAP}}{c_p\, \dot{m}_{GC}} = 160{,}6$$

(TEMPERATURA FUMI USCITA SCARICO)

473°C



$\Delta h_{23} = \Delta h_{IS,TV} \cdot \eta_{IS} = 963{,}398 \ kJ/kg$

$P_{TV} = \dot{m}_{VAP} \Delta h_{23} \cdot \eta_{EL,TV} \cdot \eta_{ORC,TV} = 6075{,}74 \ kW$

$P_3 = 0{,}01 \ bar \quad T_3 = 39°C \quad h_3 = h_2 - h_{23} = 2396{,}55 \ kJ/kg$

$x_3 = 0{,}9265$ (TITOLO VAPORE SATURO)

$P_{PAUSA} = \dfrac{\dot{m}_{VAP} (\Delta h_{PAUSA})}{\eta_{ORC,EL,PAUSA}} = 182.17 \ kW$

$P_{NETTA\ VAP} = P_{TV} - P_{PAUSA} = 60572.48 \ kW$

$\eta_{NETTO} = \dfrac{P_{NETTA,VAP} + P_{TG}}{\dot{Q}_{IN}} = 0.5118$