ESAME "SISTEMI ENERGETICI PER INGEGNERIA FISICA"
30/08/2019

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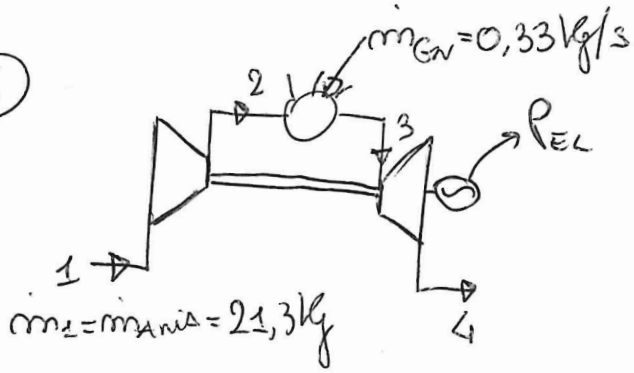


$\dot{m}_4 = \dot{m}_{FUMI} = \dot{m}_1 + \dot{m}_{GN} = 21{,}63\ kg/s$

$T_3 = 1000°C$

$T_1 = 10°C \quad P_1 = 1\ bar$

$P_1/P_2 = P_3/P_4 = 12{,}2$

COMPRESSORE

$\gamma = 1{,}4$ (dato)

$$\frac{T_{2,IS}}{T_1} = \beta^{\frac{\gamma-1}{\gamma}} = \beta^{\ominus} \Rightarrow T_{2,IS} = T_1 \beta^{\ominus} = 578{,}64\ K$$

$$\eta_{IS,COMPR} = 0{,}88 = \frac{T_{2,IS} - T_1}{T_2 - T_1} \Rightarrow T_2 = \frac{T_{2,IS} - T_1}{\eta_{IS,COMPR}} + T_1 = 618{,}93\ K$$

$$l_{COMPR} = c_p (T_2 - T_1) \qquad P_{COMPR} = \dot{m}_1 \cdot l_{COMPR} = 7{,}87\ MW$$

TURBINA

$$\frac{T_3}{T_{4,IS}} = \beta^{\ominus} \Rightarrow T_{4,IS} = T_3 / \beta^{\ominus} = 623\ K$$

$$\eta_{IS,TURB} = \frac{T_3 - T_4}{T_3 - T_{4,IS}} \Rightarrow T_4 = -\eta_{IS,TURB}(T_3 - T_{4,IS}) + T_3 = 701\ K$$

$$P_{TURB} = \dot{m}_4 c_p (T_3 - T_4) = 13{,}6\ MW$$

$$P_{NET} = (P_{TURB} - P_{COMPR}) \cdot \eta_{MECC-EL} = 5{,}57\ MW$$

- TUTTA LA POTENZA ELETTRICA PRODOTTA DAL CICLO JOULE-BRAYTON VIENE ASSORBITA DAL SISTEMA DI COMPRESSIONE DELL'He.

$$l_{\substack{COMPR,He \\ ISO-T}} = TR^* \ln \frac{P_{OUT,He}}{P_{IN,He}} = \frac{R T_{IN} \ln \beta_{COMPR}}{MM_{He}} = 1426{,}9\ \frac{kJ}{kg}$$

COMPRESSIONE ISOTERMA REVERSIBILE

$$l_{He,\,NEAT} = 1{,}3\, l^{ISO-T}_{He} = 1855\ kJ/kg$$

$$\dot{m}_{He} = \frac{P_{NET}}{l_{He,\,NEAT}} = 3\ kg/s$$

(2) 1° INTERVALLO DI TEMPO 0 – 180 s (GENERAZIONE INTERNA DI CALORE E NESSUNO SCAMBIO CON L'ESTERNO

GUSCIO ADIABATICO

$$\rho c V \frac{dT}{dt} = \dot{q}\left[\frac{W}{m^3}\right] \cdot V$$

$$V = \frac{4}{3}\pi R^3 = 6{,}54 \cdot 10^{-8}\ m^3$$

$$M = \rho V = 5{,}14 \cdot 10^{-4}\ kg$$

$$\int_{T_{t=0}}^{T_{t=180\,s}} dT = \int_0^{180\,s} \frac{\dot{q}}{\rho c}\, dt \Rightarrow \Delta T = \frac{\dot{q}}{\rho c}\Delta t \Rightarrow T_{FIN,\,180\,s} = 265\,^\circ C$$

2° INTERVALLO DI TEMPO 180 s – 240 s

(NESSUNA GENERAZIONE DI POTENZA E SCAMBIO TERMICO PER CONVEZIONE CON L'AMBIENTE ESTERNO

$T_\infty = 3\ m/s$

$T_\infty = 15\,^\circ C$

$$\rho c V \frac{dT}{dt} = hA(T - T_\infty)$$

$$\frac{T - T_\infty}{T_{t=150} - T_\infty} = e^{-Bi\,Fow}$$

$$Bi = \left(h\frac{V}{A}\right)^{*} \frac{1}{k} = 8{,}74 \cdot 10^{-}$$

* OK APPROCCIO A PARAMETRI CONCENTRATI

$$Fow = \frac{\alpha t}{L^2} = \frac{k}{\rho c}\frac{t}{L^2}$$

* CALCOLO COEFF. DI SCAMBIO TERMICO CONVETTIVO $h\left[W/m^2/K\right]$

$$Re = \frac{\rho N_\infty D}{\mu} = 1011 \qquad Pr = \frac{c_p \mu}{k} = 0{,}72$$

$$Nu = 2 + 0{,}47\, Re^{0{,}5}\, Pr^{0{,}36} = 15{,}29 = \frac{hD}{k_{ARIA}} \Rightarrow h = 76{,}55\ \frac{W}{m^2 K}$$

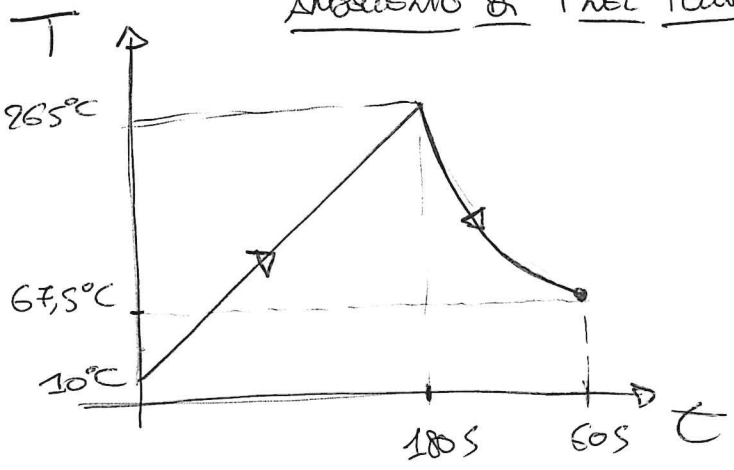
- TEMPERATURA FINALE

$$\frac{T - T_\infty}{T_{t=180s} - T_\infty} = \exp\left(-Bi\ \frac{\frac{k}{\rho c}\, 60s}{\left(\frac{V}{A}\right)^2}\right)$$

$$\Downarrow$$

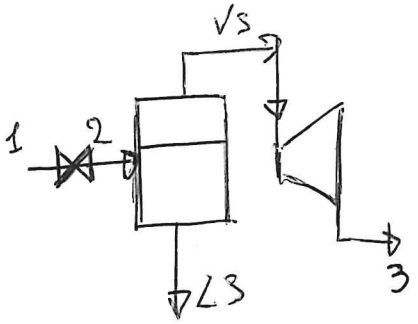
$$T_{(t=240s)} = 67{,}5\,^\circ C$$

ANDAMENTO DI T NEL TEMPO



$$Q_{\text{CEDUTA NEL RAFFREDDAMENTO}} = Mc\left(T_{(t=180s)} - T_{(t=240s)}\right) = 45{,}62\,J$$

(3)



$$h_1 = h\left(T_1;\ X_1 = 0\right) = 793{,}54\ \frac{KJ}{Kg}$$

$X_1 = 0$ (liquido saturo → dato)

COMPRESSIONE ISOENTALPICA $h_2 = h_1 = 793{,}54\ \frac{KJ}{Kg}$ $P_2 = 1$ bar

$T_2 = T(P_2; h_2) = 99{,}6\,^\circ C$ $X_2 = 0{,}167$

$\dot{m}_{LS} = \dot{m}_2\left(1 - X_2\right) = 10\ kg/s$ $\dot{m}_{VS} = 2\ kg/s$

$P_3 = P\left(T_3 = 320K;\ X = 0\right) = 0{,}1045$ bar

$\Delta h_{IS} = h_{VS}\left(P_{VS} = 1\text{bar};\ X = 1\right) - h\left(P_3;\ S_{VS}\right) = 3{,}361 \cdot 10^2\ \frac{KJ}{Kg}$

$\Delta h_{REALE} = \Delta h_{IS} \cdot \eta_{IS} = 268{,}87\ KJ/Kg$

$\mathcal{P}_{TURBINA} = \dot{m}_{VS} \left(\Delta l_{REALE} \right) = 538 \text{ kW}$

$X_3 = 0,924 \qquad V_3 = \dot{m}_{VS} \cdot v_3 \left[\frac{m^3}{kg} \right] = 25,8 \frac{m^3}{s}$

$v_3 = 12,3066 \frac{m^3}{kg}$

(4)

$l \rightarrow [+]$

$$\frac{P_1}{\rho} + \frac{v_1^2}{2} + g z_1 + l_{1D} = \frac{P_2}{\rho} + \frac{v_2^2}{2} + g z_2 \qquad z_2 = z_1$$

$$l_{1D} = \frac{P_2}{\rho} + \frac{v_2^2}{2} - \frac{P_1}{\rho} - \frac{v_1^2}{2} \qquad v_1 = 3 \text{ m/s}$$

$$\rho v_1 D_1^2 = \rho v_2 D_2^2 \qquad \frac{D_1}{D_2} = 2 \rightarrow \text{dato}$$

$$\Downarrow$$

$$v_2 = v_1 \left(\frac{D_1}{D_2} \right)^2 = 12 \text{ m/s}$$

$l_{1D} = -1230 \text{ J/kg}$ (uscente Motrice)

$Y_T = c \, \Delta T = 300 \text{ J/kg}$

$l_{REALE} = -\left(|l_{1D}| - |Y_T| \right) = -933 \text{ J/kg}$

$$\eta_{IDRAULICO} = \frac{l_{REALE}}{l_{1D}} = 0,757$$