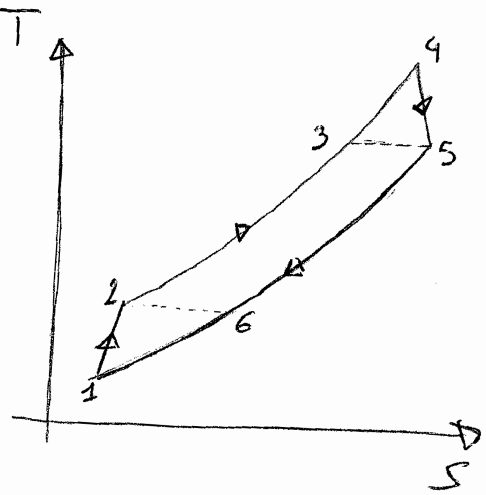
TEMA ESAME "Sistemi energetici per ingegneria fisi[ca]"

11/09/2018

(1)



$T_1 = 200°C \quad P_1 = 1\,bar$

$\frac{P_2}{P_1} = \beta_{comp} = 2,8$

$T_4 = 1200°C$

$P_6 - P_1 = 0,05\,bar = \Delta P_{rig}$

COMPRESSIONE $1 \to 2$

$$\frac{T_{2,is}}{T_1} = \beta_{comp}^{\frac{\gamma-1}{\gamma}} \Longrightarrow T_{2,is} = T_1\, \beta_{comp}^{(\gamma-1)/\gamma} \qquad \gamma = 5/3 \text{ (GAS MONOATOMICO)}$$

$$\frac{T_{2,is} - T_1}{T_2 - T_1} = \eta_{is,comp} \Longrightarrow T_2 = \frac{(T_{2,is} - T_1)}{\eta_{is,comp}} + T_1 = 501°C$$

$$P_2 = P_1 \beta_{comp} = 2,8\,bar$$

$$S_2 = c_p \ln\frac{T_2}{T_1} - R^* \ln\frac{P_2}{P_1} = 42,1\ \frac{J}{kgK}$$

ESPANSIONE $4 \to 5$

$$\frac{T_{5,is}}{T_4} = \beta_{EXP}^{\frac{1-\gamma}{\gamma}} \qquad \beta_{EXP} = \frac{P_4}{P_5} = \frac{P_2}{P_1 + \Delta P_{rig}} = 2,667$$

$$T_{5,is} = 722°C$$

$$\frac{T_4 - T_5}{T_4 - T_{5,is}} = \eta_{is,turb} \Longrightarrow T_5 = -\eta_{is,turb}(T_4 - T_{5,is}) + T_4 = 808°C$$

CICLO RIGENERATIVO IDEALE

$T_6 = T_2 \qquad T_5 = T_3 \qquad P_2 = P_1 \beta_{COMPR} \quad P_6 = P_1 + \Delta P_{RAD} = 1{,}05 \text{ bar}$

- PER IL CALCOLO DELL'ENTROPIA DEI VARI PUNTI SI UTILIZZA LA RELAZIONE RIPORTATA PER IL CALCOLO DI S_2

$$l_{NETTO} = \Big[\underbrace{c_p(T_4 - T_5)}_{ESPANSIONE} - \underbrace{c_p(T_2 - T_1)}_{COMPRESSIONE}\Big] \cdot \eta_{GEN,EL}$$

$$\dot m_{ARGON} = \frac{P_{EL}}{l_{NETTO}} = \frac{1{,}2 \text{ MWel}}{} = 26{,}54 \text{ kg/s}$$

$$\dot Q_{IN,CICLO} = \dot m_{ARGON}\, c_p (T_3 - T_2) = 5{,}407 \text{ MW}$$

$$\eta_I = \frac{P_{EL}}{\dot Q_{IN,CICLO}} = 0{,}2219$$

$$\dot Q_{RAD} = \dot m_{ARGON}\, c_p (T_6 - T_1) = 4{,}16 \text{ MW}$$

2) $$g z_A + \cancel{\frac{P_A}{\rho}} + \cancel{\frac{V_A^2}{2}} = g z_B + \cancel{\frac{P_B}{\rho}} + \cancel{\frac{V_B^2}{2}} + K_{AD}\frac{V_{AD}^2}{2} + K_{DB}\frac{V_{DB}^2}{2}$$

$V_A = V_B = 0 \text{ m/s}$ (SERBATOIO $\to \infty$) $\quad P_A = P_B = 1 \text{ bar}$

$V_{AD} = V_{DB} = V_{TUBO}$

$$V_{TUBO} = \sqrt{\frac{g(z_A - z_B)}{\left(\frac{K_{AD} + K_{DB}}{2}\right)}} = 1{,}98 \text{ m/s}$$

$$\dot m_{AD} = \rho\, V_{TUBO} \cdot \frac{\pi D_{AD}^2}{4} = 1{,}05 \text{ kg/s}$$

$$\dot m_{DB} = \dot m_{DC} = \frac{\dot m_{AD}}{2} = 0{,}525\ kg/s$$

$$D_{DB} = \sqrt{\frac{\dot m_{DB} \cdot 4}{\rho \pi}} = D_{DC} = 0{,}02121\ m$$

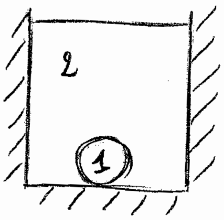
$$\cancel{\frac{P_A}{\rho}} + g z_A + \cancel{\frac{V_A^2}{2}} = \cancel{\frac{P_C}{\rho}} + g z_C + \cancel{\frac{V_C^2}{2}} + K_{AD} \frac{V_{TUBO}^2}{2} + K_{DC} \frac{V_{TUBO}^2}{2}$$

$$\Downarrow$$

$$(z_A - z_C) = \left((K_{AD} + K_{DC}) \frac{V_{TUBO}^2}{2} \right) \Big/ g = -1{,}8\ m$$

$$z_B - z_C = -0{,}2\ m$$

3) • CALCOLO TEMPERATURA DI EQUILIBRIO



LA SFERA CEDE CALORE AL LIQUIDO CONTENUTO NEL RECIPIENTE FINO AL RAGGIUNGIMENTO DELLA TEMPERATURA DI EQUILIBRIO

$$M_1 C_1 \left(T_{IN_{SFERA}} - T_{EQ} \right) = M_2 C_2 \left(T_{EQ} - T_{IN_{LIQ}} \right)$$

$$\Downarrow$$

$$\frac{M_1 C_1}{M_2 C_2} T_{IN_{SFERA}} - \frac{M_1 C_1}{M_2 C_2} T_{EQ} = T_{EQ} - T_{IN_{LIQ}}$$

$$\Downarrow$$

$$T_{EQ} = \left(\frac{M_1 C_1}{M_2 C_2} T_{IN_{SFERA}} + T_{IN_{LIQ}} \right) \Big/ \left(1 + \frac{M_1 C_1}{M_2 C_2} \right) = 108{,}1\ °C$$

• PROCESSO DI RAFFREDDAMENTO DELLA SFERA DALLA T_{EQ} FINO A 40°C

$$T_\infty = 15°C \qquad \frac{\theta_{t=5min}}{\theta_{t=0}} = e^{-Bi\,Fo} = e^{-\frac{h L_c}{K_{SFERA}} \frac{\alpha t}{L_c^2}}$$

$$L_c = \frac{\frac{4}{3}\cancel{\pi} R^{\cancel{3}}}{4\cancel{\pi} \cancel{R^2}} = \frac{R_{SFERA}}{3} \qquad \alpha = \frac{K_{SFERA}}{\rho_{SFERA} C_{SFERA}} = 5{,}06 \cdot 10^{-5} \frac{m^2}{s} \quad Fo = 607{,}29$$

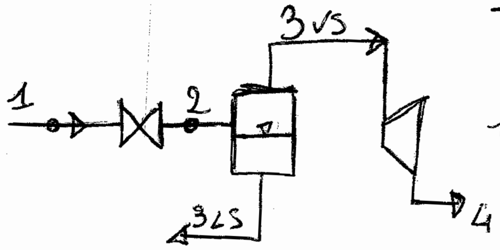
$$Bi = \ln \left(\frac{T_{5min} - T_\infty}{T_{EQ} - T_\infty} \right) \Big/ Fo = 2{,}16 \cdot 10^{-3} < 0{,}1$$ (OK APPROCCIO A PARAMETRI CONCENTRATI)

$$h = \frac{Bi\,K}{L_c} = 54,12 \frac{W}{m^2 K}$$

ENERGIA SCAMBIATA DURANTE IL PROCESSO RAFFREDDAMENTO (CEDUTA ALL'ARIA)

$$E_{SFERA} = c_{SFERA} V_{SFERA} \rho_{SFERA} \left(T_{EQ} - T_{S\,min} \right) = 2,378\,KJ$$

4



$T_1 = 460\,K \quad x_1 = 0$ (liquido saturo)

$h_1(T_1; x_1) = 793,606 \frac{KJ}{Kg}$

LAMINAZIONE ADIABATICA $\Rightarrow h_2 = h_1 \;;\; T_2 = 99,60\,°C \quad x_2 = 0,1665$

SEPARATORE

$m_2 = m_{3VS} + m_{3LS}$

$m_{3VS} = m_2 \cdot x_2 = 1,998\,Kg/s$

$h_{3VS}(P_{3VS} = P_2; x_{3VS} = 1) = 2674,95 \frac{KJ}{Kg}$

$s_{3VS}(P_{3VS} = P_2; x_{3VS} = 1) = 7,359 \frac{KJ}{Kg}$

ESPANSIONE ISOENTROPICA

$h_4(P_4; s_4 = s_{3VS}) = 2338,89 \frac{KJ}{Kg}$

$v_4(P_4; s_4 = s_{3VS}) = 12,51\,m^3/Kg$

POTENZA TERMICA GLOBALMENTE SCAMBIATA $= 0$

POTENZA MECCANICA $= m_{3VS}\left(h_{3VS} - h_4\right)$

$\dot{V}_4 = m_{3VS} \cdot v_4 = 25 \frac{m^3}{s}$