"SISTEMI ENERGETICI PER INGEGNERIA FISICA" 18/02/2019

1° ESERCIZIO

(1) DA $t=0$ s A $t=t_1$ = (ACQUA CIRCOLA NEL TRATTO A-C-D)

$$\cancel{\frac{P_A}{\rho}} + g z_A + \cancel{\frac{v_A^2}{2}} = \cancel{\frac{P_D}{\rho}} + g z_D + \frac{v_D^2}{2} + Y_{AC} + Y_{CD}$$

$P_A = 1$ atm (SERBATOIO ATMOSFERICO) $P_D = 1$ atm (DATO)

$v_A = 0$ m/s (SERBATOIO $\rightarrow \infty$) $z_A - z_D = \Delta z_{AD} = 2$ m (DATO)

$$g\,\Delta z_{AD} = \frac{v_D^2}{2} + f\frac{L_{AC}}{D_{AC}}\frac{v_D^2}{2} + f\frac{L_{CD}}{D_{CD}}\frac{v_D^2}{2} \qquad v_{CD} = v_{AC} = v_D$$

STESSO DIAMETRO E STESSA PORTATA

$$\Downarrow$$

$$v_D = \left[(g\,\Delta z_{AD}) \Big/ \left(\frac{1}{2} + f\frac{L_{AC}}{D_{AC}\cdot 2} + f\frac{L_{CD}}{D_{CD}\cdot 2} \right) \right]^{0,5} = 3,271 \text{ m/s}$$

$$\dot m_1 = \rho\, v_D \frac{\pi D_D^2}{4}$$ (PORTATA MASSICA NEL PRIMO INTERVALLO DI TEMPO)

$M_{riemp,1} = \dot m_1 \Delta t_1 = 5,78$ kg

(2) DA $t = t_1$: A $t = t_{FINE,RIEMPIMENTO}$

(ACQUA CIRCOLA NEI DUE TRATTI AC E B-C IN PARALLELO, SI MISCELA E PROSEGUE NEL TRATTO C-D)

$$\cancel{\frac{P_A}{\rho}} + g z_A + \cancel{\frac{v_A^2}{2}} = \cancel{\frac{P_D}{\rho}} + g z_D + \frac{v_D^2}{2} + f\frac{L_{AC}}{D_{AC}}\frac{v_{AC}^2}{2} + f\frac{L_{CD}}{D_{CD}}\frac{(2v_{AC})^2}{2}$$

$2v_{AC}$

ESSENDO I TUBI IN // $v_{AC} = v_{BC} \Rightarrow v_{CD} = 2v_{AC}$

$$v_{AC} = \left[(g\,\Delta z_{AD}) \Big/ \left(2 + f\frac{L_{AC}}{D_{AC}\cdot 2} + f\frac{L_{CD}}{D_{CD}}\cdot 2 \right) \right]^{0,5} =$$

$v_D = 2v_{AC}$ $\quad \dot m_2 = \rho\, v_D \frac{\pi D_D^2}{4} = 0,752$ kg/s

$$\Delta t_{FINE,RIEMP} = \left\{ \left[\frac{\pi d_{cil}^2}{4} \cdot h \cdot \rho \right] - M_{riemp,1} \right\} \Big/ \dot m_2 = 24,94 \text{ s}$$

- TEMPERATURA FINALE

$$\left[M_{miscel\,1} \cdot c_p T_A + M_{miscel,\,2} \cdot c \cdot \left(\frac{T_A + T_B}{2}\right)\right] / (M_{TOT} \cdot c) = 21{,}9\,°C$$

2° ESERCIZIO

$$R^* = \frac{R}{MM} = 99{,}215 \frac{J}{kgK} \quad c_v = \frac{3}{2} R^* \qquad c_p = \frac{5}{2} R^* = 248{,}037 \frac{J}{kgK}$$

(1 → 2) $S_1 = 0\ J/kg/K$ COMPRESSIONE ISOTERMA

$P_1 = 5\,bar \quad T_1 = 50°C \longrightarrow P_2 = 45\,bar \quad T_2 = T_1 = 50°C$

$$S_2 = \cancel{c_p \ln\left(\frac{T_2}{T_1}\right)} - R^* \ln\left(\frac{P_2}{P_1}\right) = -218 \frac{J}{kgK} \qquad q_{1\to 2} = T(S_2 - S_1) = -70{,}4 \frac{kJ}{kg}$$

(2 → 3) $P_3 = P_2 \qquad T_3 = 350°C$ ISOBARA

$$S_3 = c_p \ln\left(\frac{T_3}{T_1}\right) - R^* \ln\left(\frac{P_3}{P_1}\right) = -55{,}1 \frac{J}{kgK} \qquad q_{2\to 3} = c_p(T_3 - T_2) = 74{,}4 \frac{kJ}{kg}$$

(3 → 4) $T_4 = T_3 \qquad P_4 = P_1$ (LAMINAZIONE ADIABATICO GAS PERFETTO ≡ ISOTERMA)

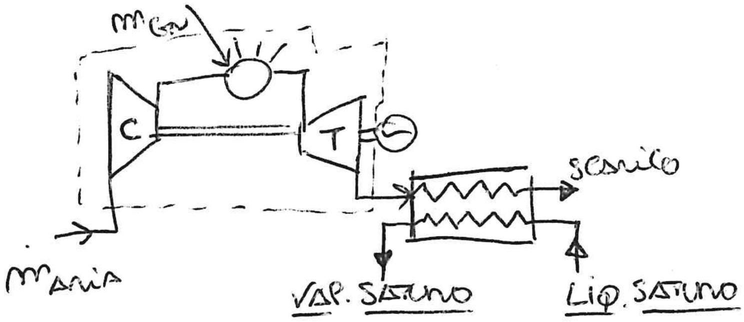
$$S_4 = c_p \ln\left(\frac{T_4}{T_1}\right) - \cancel{R^* \ln\left(\frac{P_4}{P_1}\right)} = 163 \frac{J}{kgK}$$

$$q_{netto} = |q_{2\to 3}| - |q_{1-2}| = 3{,}97 \frac{kJ}{kg}$$ (CALORE NETTO ENTRANTE)

$$\dot{m} = \frac{\dot{Q}_{netto}}{q_{netto}} = 100{,}875 \frac{kg}{s} \qquad \dot{V}_1 = \dot{m} \frac{R^* T_1}{P_1} = 6{,}47 \frac{m^3}{s}$$

$P_{mecc} = \dot{m}(q_{1\to 2}) = 7{,}11\,MW$ (CALORE SOLO x LA COMPRESSIONE ISOTERMA)

ESERCIZIO 3



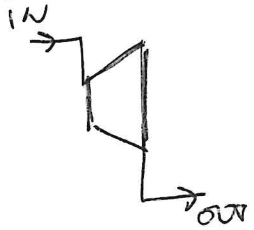
$$P_{EC} = \Phi_{IN} \cdot \eta_{TG} = 1{,}19\ MW_e$$

$$\dot m_{GAS,SCARICO} = \dot m_{GN} + \dot m_{ARIA} = 6{,}54\ kg/s$$

ESPANSIONE IN TURBINA $\quad \beta_{EXP} = 6{,}7 \quad T_{IN} = 1100°C \quad \theta = \frac{\gamma - 1}{\gamma} = 0{,}2779$

$c_p = 1{,}08\ kJ/kgK$

$c_v = c_p - \frac{R}{MM^*} =$



$$T_{OUT,IS} = T_{IN} \left(\beta_{EXP}\right)^{-\theta} = 809{,}36\ K$$

$$T_{OUT,EXP} = T_{IN} - \left(T_{IN} - T_{OUT,IS}\right) \cdot \eta_{IS} = 877\ K$$

- CALCOLO TEMPERATURA DI SCARICO

$$\Delta h_{EV} = h_{\substack{VAP\\SAT}}\left(P_{IN},\ x = 1\right) - h_{\substack{LIQ\\SAT}}\left(P_{OUT},\ x = 0\right) = 1946{,}4\ \frac{kJ}{kg}\ \text{(da diagramma)}$$

$$T_{SCARICO} = -\frac{\dot m_{VAP} \cdot \Delta h_{EV}}{\dot m_{GAS,SCARICO} \cdot c_{p\,\substack{GAS\\SCARICO}}} + T_{OUT,EXP} = 328\ °C$$

- $\Phi_{VAP} = \dot m_{VAP} \cdot \Delta h_{EV}$

$$\eta_{CICLO} = \eta_{II} \cdot \underbrace{\left(1 - \frac{T_{AMB}}{T_{VAP}}\right)}_{\eta_{CARNOT} = 0{,}36} = 0{,}214$$

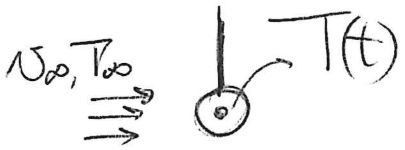
$$P_{CICLO} = \Phi_{VAP} \cdot \eta_{CICLO} = 416{,}88\ kW$$

ESERCIZIO 4

GRADINO DI TEMPERATURA DA MISURARE $T_{\infty 1} - T_{\infty 2}$

AL $t=0$ LA TEMPERATURA DELLA SONDA È UGUALE A $T_{\infty 1} = T(t=0)$.

• APPLICO L'APPROCCIO A PARAMETRI CONCENTRATI (VERIFICA A VALLE)



$$\frac{\theta}{\theta_0} = \frac{T(t) - T_{\infty,2}}{T(t=0) - T_{\infty,2}} = \frac{T(t) - T_{\infty,2}}{T_{\infty 1} - T_{\infty 2}} = e^{-Bi\,Fo}$$

$$Fo = \frac{\alpha t}{L_c^2} \qquad \alpha = \frac{K}{\rho c_p} = \qquad L_c = \frac{V_{SFERA}}{S_{SFERA}} = \frac{r}{3} = 0{,}167\,mm$$

$t = 10\,ms$ (DATO) $\qquad Fo = 11{,}538$

$$\frac{\theta}{\theta_0} = 0{,}995 \text{ (DATO)} \Longrightarrow Bi = -\ln\left(\frac{\theta}{\theta_0}\right) \Big/ Fo = 4{,}36 \cdot 10^{-4}$$

$$Bi = \frac{hd}{K} \Longrightarrow h = \frac{Bi\,K}{d}$$

(COEFF. SCAMBIO TERMICO CONVETTIVO
↓
DIPENDE DALLA VELOCITÀ)

$$\rightarrow Nu = \frac{hd}{K_{FLUIDO}} = 2 + 0{,}47\,Re^{0{,}5}\,Pr^{0{,}36}$$

$$\Downarrow$$

$$\left[\left(\frac{hd}{K_{FLUIDO}} - 2\right) \Big/ \left(0{,}47\,Pr^{0{,}36}\right)\right]^2 = Re = \frac{\rho v d}{\mu}$$

$$Pr = \frac{c_p \mu}{K} = 0{,}72 \Longrightarrow Re = 405{,}095 \qquad v = \frac{Re\,\mu}{d\,\rho_{ARIA}} = 6{,}01\,m/s$$

$$\dot{m} = \rho v \frac{D_{TUBO}^2}{4} \pi = 5{,}71 \cdot 10^{-2}\,kg/s$$