ESAME "SISTEMI ENERGETICI PER INGEGNERIA FISICA"

04/02/2020

(1) $P_1, v_1 \longrightarrow \boxed{M} \longrightarrow P_2, v_2$

$P_1 = 19\,bar \quad P_2 = 3\,bar \quad v_1 = 2\,m/s$

$\rho = 800\,kg/m^3 \quad c = 2{,}5\,\frac{kJ}{kgK} \quad S_1 = 0{,}1\,m^2$

EQ. CONTINUITÀ (REGIME STAZIONARIO)

$\dot{m} = \rho v_1 S_1 = 160\,kg/s \qquad v_2 = v_1 \frac{S_1}{S_2} = 6\,m/s$

EQ. CONS. ENERGIA (FLUIDO INCOMPRIMIBILE) IDEALE

$$\frac{P_1}{\rho} + \frac{v_1^2}{2} + \cancel{g z_1} + l_{ID} = \frac{P_2}{\rho} + \frac{v_2^2}{2} + \cancel{g z_2} \qquad z_1 = z_2 \qquad \downarrow l \ \boxed{+}$$

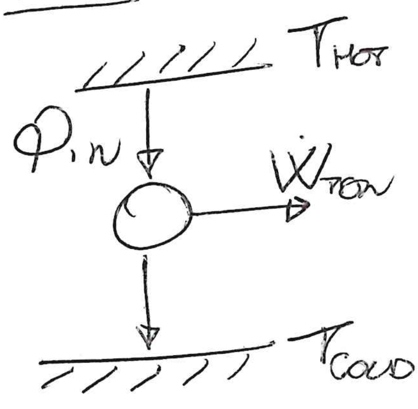
$$l_{ID} = \left(\frac{P_2}{\rho} - \frac{P_1}{\rho}\right) + \left(\frac{v_2^2}{2} - \frac{v_1^2}{2}\right) = -1984\,J/kg \quad \text{(macchina motrice)}$$

$$l_{REALE} = l_{ID} \cdot \eta_{ID} = -1626{,}88\,J/kg$$

$$\frac{|l_{REALE} - l_{ID}|}{c} = \Delta T = 0{,}14\,°C$$

$$P_{OT,REALE} = \dot{m}\, l_{REALE} = -260{,}3\,kW$$

CICLO TERMODINAMICO



$$\underbrace{\dot{W}_{TOT,CARNOT}}_{\text{massima potenza possibile}} = \Phi_{IN} \cdot \eta_{CARNOT} = \Phi_{IN} \cdot \underbrace{\left(1 - \frac{T_{COLD}}{T_{HOT}}\right)}_{0{,}52}$$

$\dot{W}_{TOT,CARNOT} < P_{OT,REALE}$

IMPOSSIBILE

(2) CALCOLO ENTALPIA h_6 E h_7 (MANDATA POMPE) (LIQUIDO IDEALE)

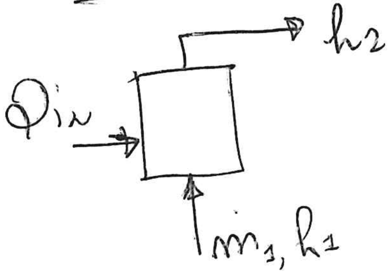
$$\Delta h_{id,65} = \frac{\Delta P_{65}}{\rho} = 0{,}995\ \frac{kJ}{kg} \qquad \Delta h_{reale,65} = \frac{\Delta h_{id,65}}{\eta_{ion}} = 1{,}29\ \frac{kJ}{kg}$$

$$h_6 = h_5 + \Delta h_{reale\,65} = 193{,}1\ \frac{kJ}{kg}$$

$$\Delta h_{id,71} = \frac{\Delta P_{71}}{\rho} \qquad \Delta h_{reale,71} = \frac{\Delta h_{id,71}}{\eta_{ion}} = 17{,}98\ \frac{kJ}{kg}$$

$$h_1 = \Delta h_{id,71} + \underbrace{h_7(P_7;\ x_7 = 0)}_{762{,}68\ \frac{kJ}{kg}} = 780{,}66\ \frac{kJ}{kg}$$

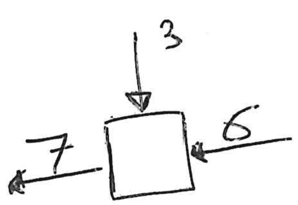
BILANCIO GENERATORE DI VAPORE



$$\dot{Q}_{in} = \dot{m}\,(\underbrace{h_2}_{h(P_2,\,T_2) = 3494{,}4\ \frac{kJ}{kg}} - h_1) \Longrightarrow \dot{m} = \frac{\dot{Q}_{in}}{(h_2 - h_1)} = 293{,}5\ \frac{kg}{s}$$

$$\dot{m}_1 = \dot{m}_7 = \dot{m}_2 = 293{,}5\ \frac{kJ}{kg}$$

BILANCIO RIGENERATORE A MISCELA



$$\begin{cases} \dot{m}_3 + \dot{m}_6 = \dot{m}_7 \quad \text{(BILANCIO MASSA)} \\ \dot{m}_3 h_3 + \dot{m}_6 h_6 = \dot{m}_7 h_7 \end{cases}$$

$$\dot{m}_3 h_3 + (\dot{m}_7 - \dot{m}_3)\, h_6 = \dot{m}_7 h_7$$

$$\dot{m}_3 h_3 + \dot{m}_7 h_6 - \dot{m}_3 h_6 = \dot{m}_7 h_7$$

$$\dot{m}_3 = \dot{m}_7 \frac{(h_7 - h_6)}{(h_3 - h_6)} = 46{,}93\ \frac{kg}{s}$$

POTENZA ELETTRICA NETTA

$$P_{EL,NETTA} = \left[\dot{m}_2 (h_2 - h_3) + (\dot{m}_2 - \dot{m}_3)(h_3 - h_4)\right] \eta_{GEN,EL} - P_{POMPA,1} - P_{POMPA,2}$$

$$P_{POMPA,1} = \frac{\Delta h_{65} \cdot \dot{m}_4}{\eta_{EL,MECC}} \qquad P_{POMPA,2} = \frac{\dot{m}_1 (\Delta h_{71})}{\eta_{EL,MEC}}$$

$$P_{EL,TV} = 232{,}7\,MW$$

$$P_{EL,NETTA} = 228\,MW \Longrightarrow \eta_{EL,NETTO} = \frac{P_{EL,NETTA}}{\dot{\phi}_{IN}} = 0{,}35$$

③ CONVEZIONE FORZATA

$$Re = \frac{\rho N_\infty H}{\mu} = \qquad Pr = \frac{c_p \mu}{K} = 0{,}717$$

$$Nu = \left(0{,}037\, Re^{0,8} - 871\right) Pr^{1/3} = 568{,}56$$

$$Nu = \frac{hH}{K} \Longrightarrow h_{conv} = \frac{Nu\, K}{H} = 6{,}82\ W/m^2K$$

_ POTENZA GENERATA INTERNAMENTE $= \dot{\phi} = \dot{q}_{GEN} \cdot V = \dot{q}_{GEN} \cdot (H^2 \cdot L_A)$

$$\dot{\phi} = h_{conv} \cdot A_{SCAMBIO} \left(T_{(x = L_A + L_B)} - T_\infty\right)$$

$$\Downarrow$$

$$T_{(x = L_A + L_B)} = \frac{\dot{\phi}}{h_{conv} A_{SCAMBIO}} + T_\infty = 54{,}31\,°C$$

– RESISTENZA TERMICA ISOLANTE

$$R_B = \frac{L_B}{K_B} = 0,1 \, \frac{m^2K}{W}$$

$$\rightarrow \Delta T_B = \dot{Q} R_B = 20°C$$ (DIFFERENZA DI T ALL'INTERNO DELLO STRATO DI ISOLANTE)

$$\Delta T_{RES,\,CONTATTO} = \dot{Q} R_{CONT} = 4°C$$ (DIFFERENZA DI T DOVUTA ALLA RESISTENZA DI CONTATTO)

• NELLO SPESSORE A SI GENERA UNIFORMEMENTE POTENZA $\dot{q}_{GEN}$

$$\frac{d^2T}{dx^2} + \frac{\dot{q}}{k} = 0 \qquad \frac{dT}{dx} = -\frac{\dot{q}}{k}x + C_1 \Rightarrow T = -\frac{\dot{q}}{2k}x^2 + C_1 x + C_2$$

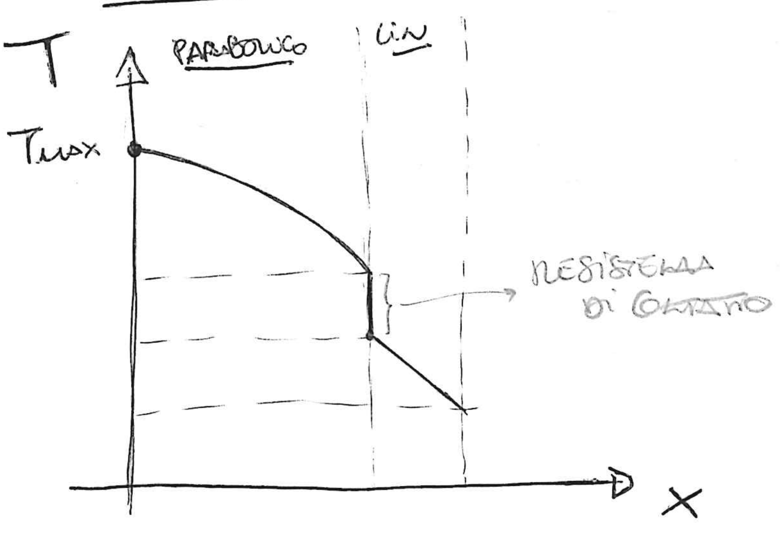
COND. CONTORNO

$$\left(\frac{dT}{dx}\right)_{x=0} = 0$$ (SUPERFICIE ADIABATICA) $\Rightarrow C_1 = 0$

$$T_{(x=L_A)} = T_{(x=L_A+L_B)} - \Delta T_B - \Delta T_{RES\,CONTATTO} = 78,3°C$$

$$T_{(x=L_A)} = -\frac{\dot{q}}{2k}L_A^2 + C_2 \Rightarrow C_2 = T_{(x=L_A)} + \frac{\dot{q}}{2k}L_A^2 = 98,3°C$$

PROFILO DI TEMPERATURA $T(x)$



TEMP. MASSIMA

$$\left(\frac{dT}{dx}\right) = 0 \Rightarrow x = 0$$

$$T_{MAX} = C_2 = 98,3°C$$