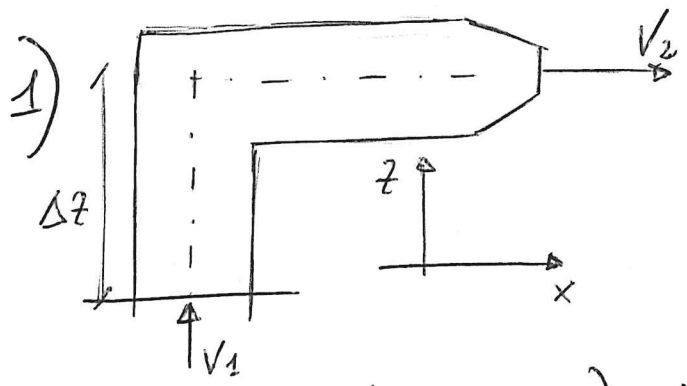
ESAME "SISTEMI ENERGETICI PER INGEGNERIA FISICA"

10/01/2020



$\rho = 900\ kg/m^3$ $\Delta z = 1\ m$

$\frac{S_1}{S_2} = 4$ $D_1 = 0{,}3\ m$

$Vol = 3\ m^3$ $P_2 = 1\ bar$

- EQ. CONTINUITÀ (STAZIONARIO) $\dot{m}_1 = \dot{m}_2 = \dot{m}$

$$\dot{m} = \rho S_1 V_1 = \rho S_2 V_2 \Rightarrow V_1 = \frac{\dot{m}}{\rho S_1}$$

$$\frac{V_1}{V_2} = \frac{S_2}{S_1} = \frac{1}{4}$$

$$S_1 = \frac{\pi D_1^2}{4} = 0{,}0707\ m^2 \Rightarrow V_1 = 2{,}358\ m/s \quad V_2 = 9{,}431\ m/s$$

$$\dot{V}_1 = S_1 V_1 = S_2 V_2 = \dot{V}_2 = 0{,}167\ m^3/s$$

- CONSERVAZIONE ENERGIA SISTEMI APERTI (FLUIDO INCOMPRIMIBILE)

$$\frac{P_1}{\rho} + \frac{V_1^2}{2} + g z_1 + \cancel{\ell} = \frac{P_2}{\rho} + \frac{V_2^2}{2} + g z_2 \qquad \ell = 0 \text{ (NESSUNA MACCHINA)}$$

$$P_1 = \left[\frac{P_2}{\rho} + \left(\frac{V_2^2}{2} - \frac{V_1^2}{2}\right) + g(z_2 - z_1)\right]\rho = 1{,}463\ bar$$

- CALCOLO DELLA SPINTA S

$|\vec{G}| = Vol \cdot \rho \cdot g = 26487\ N$ $G_x = 0$ $G_z = -26487\ N$

$|\vec{\Pi_1}| = P_1 \cdot S_1 = 10345\ N$ $\Pi_{1,x} = 0$ $\Pi_{1,z} = -10345\ N$

$|\vec{\Pi_2}| = P_2 S_2 = 1767\ N$ $\Pi_{2,x} = 1767$ $\Pi_{2,y} = 0$

$|\vec{M_1}| = \dot{m} v_1 = 353{,}7\ N \quad M_{1,x} = 0 \quad M_{1,z} = 353{,}7\ N$

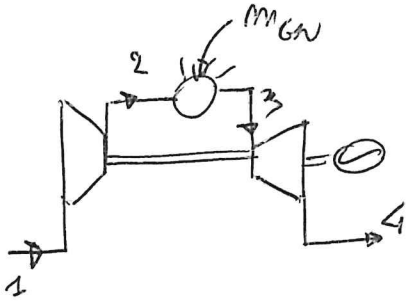
$\vec{S} = \vec{G} - \vec{\Pi_1} - \vec{\Pi_2} + \vec{M_1} - \vec{M_2} \qquad |\vec{M_2}| = |\dot{m} v_2| = 1414{,}7\ N \quad M_{2,x} = 1414{,}7\ N$

$S_x = |-\vec{\Pi_2}| - |\vec{M_2}| = -3181{,}9\ N$

$S_y = 0$

$S_z = |-\vec{G}| + |\vec{\Pi_1}| + |\vec{M_1}| = -15788\ N$

2)



$\dot{m}_1 = 6{,}44\ kg/s \quad T_1 = 15°C \quad \eta_{IS,C} = 0{,}82$

$\dot{m}_{GN} = 0{,}1\ kg/s \quad T_3 = 1100°C \quad \eta_{IS,EXP} = 0{,}88$

$P_1 = 1\ bar \quad \beta = 7 \quad \eta_{GEN} = 0{,}975$

$c_p = 1{,}08 \frac{kJ}{kg\,K}$ (aria; gas combusti) $\qquad MM = 27{,}7\ kg/kmol$

→ Bilancio di massa

$\dot{m}_3 = \dot{m}_2 + \dot{m}_{GN} = 6{,}54\ kg/s$

→ $T_4 = ?$

$\frac{T_3}{T_{4,IS}} = \beta^{\Theta}$ (espansione isentropica) $\qquad \Theta = \frac{\gamma - 1}{\gamma} \Rightarrow \gamma = \frac{c_p}{c_v} = \frac{c_p}{c_p - \frac{R}{MM}} = 1{,}38$

$T_{4,IS} = \frac{T_3}{\beta^{\Theta}} = 799\ K$

$\eta_{IS,EXP} = \frac{T_3 - T_4}{T_3 - T_{4,IS}} \Rightarrow T_4 = T_3 - \eta_{IS,EXP}(T_3 - T_{4,IS}) = 868\ K$

→ $\dot{V}_4 = \dot{m}_4 \cdot v_4 = \dot{m}_4 \underbrace{\left(\frac{R^* T_4}{P_4}\right)}_{\text{GAS PERFETTO}} = 17{,}04\ m^3/s$

- POTENZA ELETTRICA

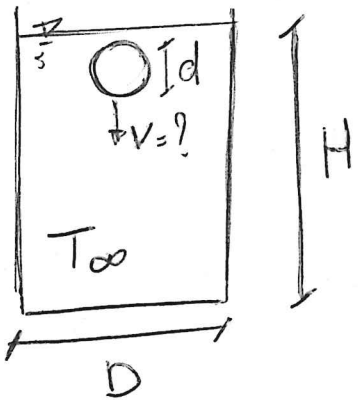
$$P_{exp} = \dot{m}_4 c_p (T_3 - T_4) = 3565{,}2\ kW$$

$$P_{comp} = \dot{m}_1 c_p (T_2 - T_1)$$

$$T_{2,IS} = T_1 \beta^{\frac{\gamma-1}{\gamma}} = 494{,}85\ K \qquad T_2 = T_1 + \frac{(T_{2,IS} - T_1)}{\eta_{IS,comp}} = 540{,}2\ K$$

$$P_{EL} = (P_{exp} - P_{comp})\,\eta_{GEN} = 1766\ kW \quad (\text{eq. 4})$$

3)



$d = 0{,}05\ m$ $\quad k_s = 100\ \frac{W}{mK}$

$L = 0{,}2\ m$ $\quad \rho_s = 8000\ kg/m^3$

$H = 1{,}5\ m$ $\quad c_s = 400\ J/kgK$

$D = 1\ m$ $\quad T_\infty = 4^\circ C$

- APPROCCIO A PARAMETRI CONCENTRATI (VERIFICA A POSTERIORI)

$$\frac{\Theta}{\Theta_i} = e^{-Bi\,Fo} \qquad \Theta_i = 35^\circ C - 4^\circ C = T_i - T_\infty = 31^\circ C$$

$$\Theta = T(t) - T_\infty = 11^\circ C$$

$$-\ln\frac{\Theta}{\Theta_i} = \frac{h L_c}{k_s}\frac{\alpha_s t}{L_c^2} = \frac{h}{k_s}\frac{k_s t}{\rho_s c_s L_c} = \frac{h t}{\rho_s c_s L_c} = \frac{4ht}{\rho_s c_s d}$$

$$\frac{V}{S_{LAT}} = \frac{d}{4} = 0{,}0125\ m$$

$$t_{CADUTA} = \frac{(H-d)}{v} \quad \left(\begin{array}{l}\text{TEMPO PER}\\ \text{TOCCARE IL FONDO}\end{array}\right) \rightarrow \text{VELOCITÀ COSTANTE}$$

$$Nu = a\,Re^{0,5}\,Pr^{0,37} = \frac{h d}{k} = a\left(\frac{\rho v d}{\mu}\right)^{0,5} Pr^{0,37} \quad \left(\begin{array}{l}\text{CONVEZIONE}\\ \text{FORZATA}\end{array}\right)$$

$$h = \frac{k}{d}\,a\left(\frac{\rho v d}{\mu}\right)^{0,5} Pr^{0,37}$$

$$-\ln\frac{\Theta}{\Theta_i}\frac{\rho_s c_s d}{4\Phi t} = \frac{k}{d}a\left(\frac{\rho v d}{\mu}\right)^{0,5} Pr^{0,3\overline{7}}\cdot\left(\frac{H-d}{v}\right)$$

$$-\ln\frac{\Theta}{\Theta_i}\frac{\rho_s c_s}{4\Phi t}\frac{d^2\,\mu^{0,5}}{k a\sqrt{\rho d}\cdot Pr^{0,3\overline{7}}(H-d)} = v^{-0,5}$$

$$\Downarrow$$

$Pr = \left(\frac{c_p\mu}{k}\right)_{H_2O} = 11,7$ (PROPRIETÀ DELL'ACQUA) $\quad a = 0,51$ (CONVEZIONE)

$$\Downarrow$$

$v = 0,008\ m/s \qquad t_{CADUTA} = \frac{H-d}{v} = 181,45\ s$

$$h = \frac{k}{d}0,51\left(\frac{\rho v d}{\mu}\right)^{0,5} Pr^{0,3\overline{7}} = 228,53\ \frac{W}{m^2K}$$

$Bi = \frac{h L_c}{k} = 0,028 < 0,1$ (OK APPROCCIO PARAMETRI CONCENTRATI)

T_∞ È COSTANTE?

$$\Delta T_{H_2O} = \frac{\rho_s V_s \cdot c_s (35°C - 15°C)}{c_{H_2O}\rho_{H_2O}V_{H_2O}} = 0,005°C$$ (OK ASSUMERE COSTANTE T_∞)

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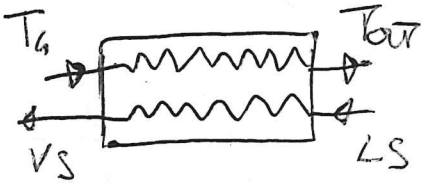
* 

$P_{VAP} = 10$ bar

LA MASSIMA POTENZA PRODUCIBILE SI OTTIENE RAFFREDDANDO I FUMI FINO A $T_{SAT}(10\,bar) = 179,9°C$

$$\dot{m}_4 c_{p\,FUMI}(T_4 - T_{SAT}) = \dot{m}_{VAP}\underbrace{(h_{VS}(10\,bar) - h_{LS}(10\,bar))}_{2014\ kJ/kg\ (DIAGRAMMA)}$$

$$\Downarrow$$

$\dot{m}_{VAP} = 1,456\ kg/s$