ESAME SISTEMI ENERGETICI PER INGEGNERIA FISICA 01/02/2021

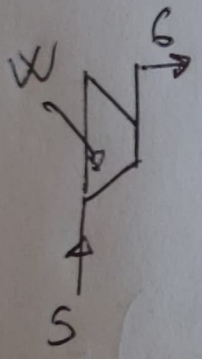
① a) N_2 come gas ideale biatomico

$$c_v^* = \frac{5}{2}R \qquad c_p^* = \frac{7}{2}R \left[\frac{J}{kmol\,K}\right]$$

$$\gamma = c_p/c_v = \frac{7}{5}$$

$$c_p = \frac{c_p^*}{MM_{N_2}} = 1039{,}25 \left[\frac{J}{kg\,K}\right]$$

$$\Theta = \frac{\gamma - 1}{\gamma} = 0{,}2857$$



$$T_{6,IS} = T_5 \beta^{\Theta} = 725{,}25\ K$$

$$T_6 = T_5 + \frac{(T_{6,IS} - T_5)}{\eta_{IS,C}} = 829{,}52\ K$$

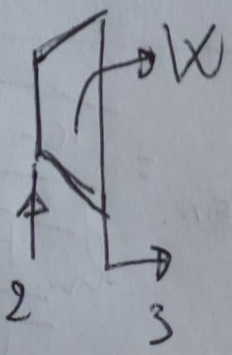
$$W_{comp} = \dot{m}_{N_2} c_p (T_6 - T_5) = 16{,}254\ MW$$

b) $W_{TV} = W_{comp} = \dot{m}_{VAP} \Delta h_{2-3} = 16{,}254\ MW$

$$= \dot{m}_{VAP} \Delta h_{IS\,2-3} \cdot \eta_{IS,TV}$$

$$\Downarrow$$

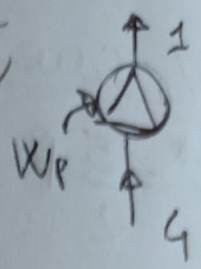
$$\dot{m}_{VAP} = 12{,}86\ \frac{kg}{s}$$



c) $\Delta P_{PALETTA} = P_1 - P_4 = 99{,}95 \text{ bar}$

• ACQUA LIQUIDA TRATTATA COME LIQUIDO $\rho = \text{cost}$

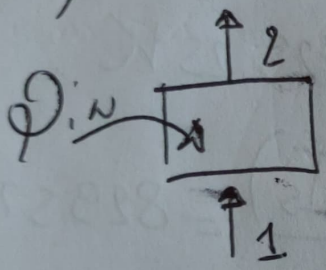
$$\Delta h_{ID,1-4} = \frac{\Delta P_{PALETTA}}{\rho_{H_2O}} = 9995 \frac{KJ}{Kg}$$



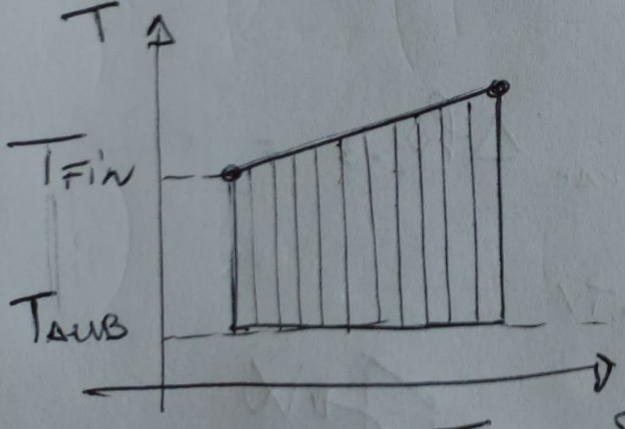
$$\Delta h_{REALE\ 1-4} = \frac{\Delta h_{ID,1-4}}{\eta_{ISO}} = 12{,}81 \frac{KJ}{Kg}$$

$$h_1 = h_4 + \Delta h_{REALE} = 150{,}61 \frac{KJ}{Kg}$$

d) $Q_{IN} = m_1 (h_2 - h_1) = 42{,}83 \text{ MW}$



e) $Q_{RECUPERATO\ N_2} = \dot{m}_{N_2} c_p (T_6 - T_{FIN}) = 15{,}48 \text{ MW}$

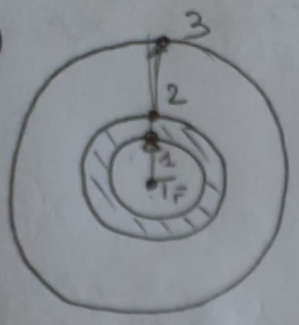


$$\eta_{MAX} = 1 - \frac{T_{AMB}}{T_{ml\ 6-FIN}} = 0{,}43$$

$$W_{MAX} = \eta_{MAX} Q_{RECUP\ N_2} = 6{,}7 \text{ MW}$$

$$T_{ml\ 6 \to FIN} = \frac{T_6 - T_{FIN}}{\ln \frac{T_6}{T_{FIN}}} = 544{,}1 \text{ K}$$

(2)



$T_{FLUIDO} = 5°C$;

$T_\infty = 25°C$

$v_\infty = 1\ m/s$

a) $Nu = 0{,}683\ Re^{0{,}466}\ Pr^{1/3}$

$Pr_{aria} = \frac{c_p \mu}{k} = 0{,}722$

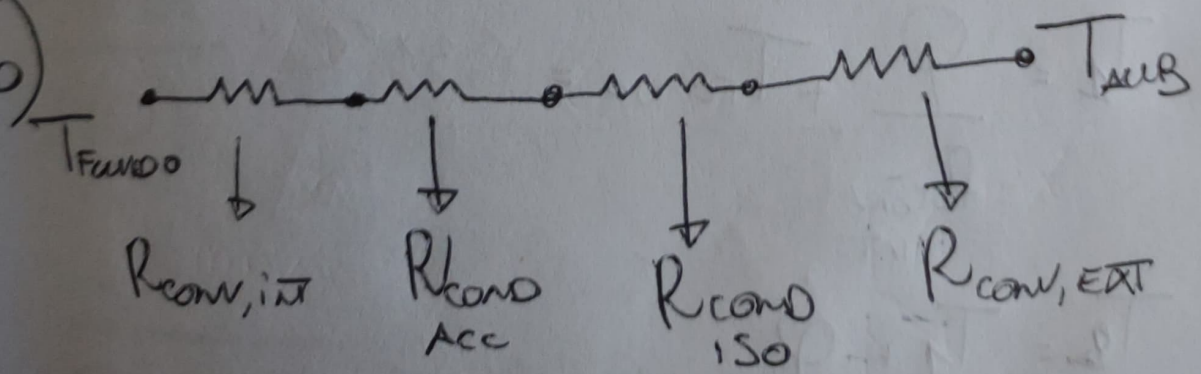
$Re_{aria} = \frac{\rho v D_{EXT}}{\mu} = 1447{,}9$

$\rho = \frac{P}{R^* T} = 1{,}18\ \frac{kg}{m^3}$ (aria trattata come gas ideale)

$Nu = \frac{h D_{EXT}}{k} = 0{,}683\ Re^{0{,}466}\ Pr^{1/3} = 18{,}2$

$h_{EXT} = 20{,}7\ \frac{W}{m^2 K}$

b)



$$R_{conv,int} = \frac{1}{h_{int} 2\pi D_{int} L} = 0{,}0523\,S \frac{K}{W}$$

$$R_{cond\ ACC} = \frac{\ln\left(\frac{D_{int} + 2S_{ACC}}{D_{int}}\right)}{2\pi K_{ACC} L} = 0{,}00134 \frac{K}{W}$$

$$R_{cond\ ISO} = \frac{\ln\left(\frac{D_{int} + 2S_{ACC} + 2S_{ISO}}{D_{int} + 2S_{ACC}}\right)}{2\pi K_{ISO} L} = 0{,}0456 \frac{K}{W}$$

$$R_{conv,EXT} = \frac{1}{h_{EXT} 2\pi D_{EXT} L} = 0{,}6993 \frac{K}{W}$$

$$R_{TOT} = R_{conv,int} + R_{cond\ ACC} + R_{cond\ ISO} + R_{conv\ EXT} = 0{,}798 \frac{K}{W}$$

$$\dot{Q} = \left(R_{TOT}\right)^{-1} \left(T_{EXT} - T_{FLUIDO}\right) = 25{,}04\,W$$

c) $$T_1 = \frac{\dot{Q}}{\left(R_{conv\ INT}\right)^{-1}} + T_{FLUIDO} = 6{,}31\,^{\circ}C$$

$$T_2 = T_1 + \frac{\dot{Q}}{\left(R_{cond\ ACC}\right)^{-1}} = 6{,}34\,^{\circ}C$$

$$T_3 = T_4 + \frac{\Phi}{R_{cond,iso}} = 7{,}49\,°C$$

d) se $s_{iso} \uparrow$ $R_{cond,iso} \uparrow$ $R_{conv\,EXT} \downarrow$

x semplificare i calcoli esprimo $h = aD^n$

$$h = \underbrace{\left[0{,}683\left(\frac{\lambda}{\nu}\right)^{0{,}466} Pr^{1/3}\right] K_{aria}}_{a} D^{\frac{0{,}466-1}{n}}$$

$$R_{cond,iso} = \frac{h\,\underbrace{D_3}_{w}/D_2}{2\pi K_{iso}\cdot L} = \frac{h\,D/D_2}{2\pi K_{iso}\cdot L}$$

$$R_{conv,EXT} = \frac{1}{\pi D L a D^n} = \frac{1}{\pi L a D^{n+1}}$$

$$R_{TOT} = R_{cond,iso} + R_{conv,EXT} + R_{cond,Acc} + R_{conv\,INT}$$

$$\frac{d R_{TOT}}{d(D)} = \frac{d\left(R_{cond\,iso} + R_{conv\,EXT}\right)}{d\,(D)} =$$

$$= \frac{1}{D\,2\pi K_{iso} L} + \frac{(-n-1)\,D^{(-n-2)}}{\pi L a} = 0$$

$$\Rightarrow \frac{a}{2} - K_{iso}(n+1)D^{-n-1} = 0$$

$$D = \left(\frac{a}{2K_{iso}(n+1)}\right)^{-\frac{1}{n+1}} = 0{,}0476\,m$$

DIÂMETRO LIMITE