ESAME 29/07/2019 "SISTEMI ENERGETICI PER INGEGNERIA FISICA"

① FORZA PESO (DIRETTA $-\vec{z}$) $= V_{TUBO} \cdot \rho_f \frac{\pi D^2}{4} \cdot L \rho_f = 433\,N = \vec{G}$

• CASO STAZIONARIO → FLUIDO INCOMPRIMIBILE NO VARIAZ. SEZIONE $V_1\left[\frac{m}{s}\right] = V_2\left[\frac{m}{s}\right]$

$$\vec{G} + \vec{R} - \vec{\Pi}_1 - \vec{\Pi}_2 + \vec{M}_1 - \vec{M}_2 = 0$$

$-\vec{\Pi}_1 - \vec{\Pi}_2$ (LUNGO X)

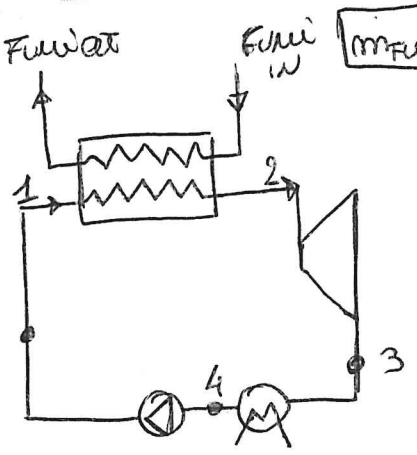
$$\left| -\vec{\Pi}_1 - \vec{\Pi}_2 \right| = \sqrt{|\vec{R}|^2 - |\vec{G}|^2} = 249{,}3\,N = \Delta P_{12} \cdot \frac{\pi D^2}{4}$$

$$\Delta P_{12} = f \frac{L}{D} \frac{V^2}{2} \cdot \rho \Rightarrow f = \frac{64}{Re}\ (\text{se laminare}) = \frac{64\mu}{\rho V D} \rightarrow V \text{ INCOGNITA}$$

$$\Delta P_{12} = \frac{64\mu}{\rho V D} \frac{L}{D} \frac{V^2}{2} \cdot \rho = \frac{\mu 64 L}{\rho D^2} \frac{V}{2} \rho \Rightarrow V = 1{,}57\,m/s \qquad f = \frac{64}{Re} = 0{,}027$$

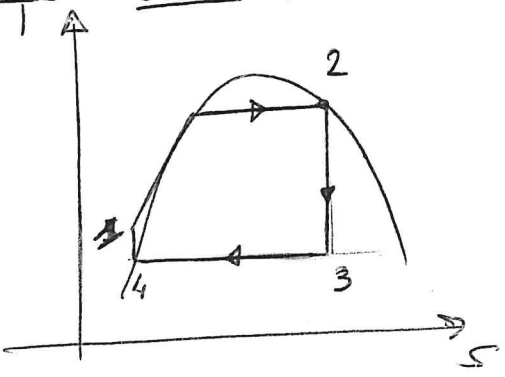
VERIFICA MOTO LAMINARE $Re = \frac{\rho V D}{\mu} < 2300$

②



$\dot{m}_{FUMI} = \dot{m}_{GAS} + \dot{m}_{ARIA}$

CICLO RANKINE SEMPLICE



$h_2\,(T_2 = 240°C;\ X = 1) = 2802{,}21\ \frac{kJ}{kg}$ $\quad s_2 = 6{,}14059\ \frac{kJ}{kgK}$

$P_2 = 33{,}48$ bar

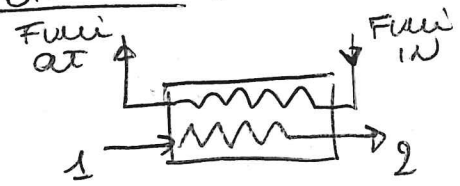
$T_4 = 45°C$ $\quad h_4\,(T_4 = 45°C;\ X = 0) = 188{,}351\ \frac{kJ}{kg}$ $\quad P_4 = 0{,}09582$ bar

$P_1 = P_2$

$\Delta P_{PALA} = P_1 - P_4 \Rightarrow \Delta h_{PALA} = \frac{\Delta P_{PALA}}{\rho}$

$h_1 = h_4 + \Delta h_{PALA} = 191{,}77 \frac{KJ}{Kg}$

BILANCIO GENERATORE DI VAPORE



$\dot{m}_1 (h_2 - h_1) = \dot{m}_{FUMI}\, c_{p\,FUMI} (T_{IN} - T_{OUT})$

$\Downarrow$

$\dot{m}_1 = \frac{\dot{m}_{FUMI}\, c_{p\,FUMI} (T_{IN} - T_{OUT})}{h_2 - h_1} = 7{,}44 \frac{Kg}{s}$

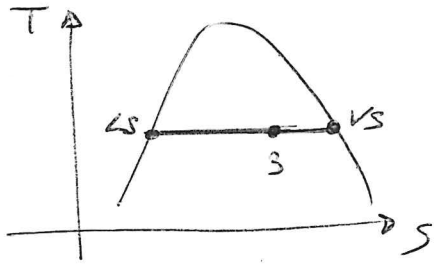
$\dot{m}_{FUMI} = \dot{m}_{ARIA} + \dot{m}_{GN} = 186 \frac{Kg}{s}$

↑ BILANCIO MASSE COMBUSTIONE

ESPANSIONE ISOENTROPICA $2 \rightarrow 3$

$S_2 = S_3 \quad 6{,}1409 \frac{KJ}{KgK}$

$S_{LS}(T = 45°C;\ X = 0) = 0{,}6383 \frac{KJ}{KgK} \quad S_{VS}(T = 45°C;\ X = 1) = 8{,}1607 \frac{KJ}{KgK}$



$\frac{(S_{LS} - S_3)}{S_{VS} - S_{LS}} = X = 0{,}73$ (TITOLO DI VAPORE BASSO → POSSIBILI PROBLEMI SULLA TV)

$h_3 = (h_{VS} - h_{LS}) X + h_{LS} = 1939{,}3 \frac{KJ}{Kg}$

$h_{VS} = 2583 \frac{KJ}{Kg} \quad h_{LS} = 188{,}351 \frac{KJ}{Kg}$

$P_{TV} = \dot{m}_1 (h_2 - h_3) = 6{,}43\,MW$

$P_{PALA} = \dot{m}_1 \Delta h_{PALA} = 24{,}84\,KW$

$P_{NETTO} = P_{TV} - P_{PALA} = 6{,}404\,MW$

$Q_{IN} = \dot{m}_1 (h_2 - h_1) = 19{,}4\,MW$

$\eta_{NETTO} = \frac{P_{NETTO}}{Q_{IN}} = 0{,}329$

$$\eta_{REV} = 1 - \frac{T_{ml}}{T_{AMB}} = 0{,}31738 \qquad T_{ml} = \frac{T_{IN,FUMI} - T_{AMB}}{\ln \frac{T_{IN,FUMI}}{T_{AMB}}} = 444\ K$$

LO CICLO TRIANGOLARE (FUMI RAFFREDDATI FINO A T_{AMB})

$$P_{MAX} = \eta_{REV} \cdot Q_{MAX} = \eta_{REV}\ \dot{m}_{FUMI}\ c_{p\,FUMI} \left(T_{IN,FUMI} - T_{AMB}\right) = 19{,}7\ MW$$

③ $\dot{m}_{TURB} = 50\left[\frac{m^3}{h}\right] \cdot \frac{1}{3600}\left[\frac{h}{s}\right] \cdot \rho\left[\frac{kg}{m^3}\right] = 13{,}9\ kg/s$

$\dot{m}_{TURB} = \dot{m}_{4-5} = \dot{m}_{2-3} = 13{,}9\ kg/s$

$\dot{m}_{1-2} = \dot{m}_{TURB} / (1 - 0{,}3) = 19{,}84\ kg/s \quad (\dot{m}_{TURB} = \dot{m}_{1-2} - 0{,}3\,\dot{m}_{1-2})$

$$v_{4-5} = v_{2-3} = \frac{\dot{m}_{4-5}}{\rho \frac{\pi D^2}{4}} = 1{,}13\ m/s$$

$$v_{1-2} = \frac{\dot{m}_{1-2}}{\rho \frac{\pi D^2}{4}} = 1{,}617\ m/s$$

BILANCIO TRA $1 \to 2$

$$\frac{p_1}{\rho} + \frac{v_1^2}{2} + g z_1 = l_T + \frac{p_2}{\rho} + \frac{v_2^2}{2} + g z_2 + Y \qquad \Delta z_{12} = 60\ m$$

$$Y_{4-5\ DISTR} = f \frac{L}{D} \frac{v_{4-5}^2}{2} = Y_{2-3} = 10{,}98\ J/kg \qquad Y_{4-5\ CONC} = K_c \frac{v_{4-5}^2}{2} = 4{,}483\ J/kg$$

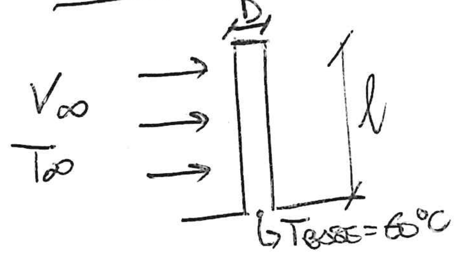
$$Y_{1-2\ DISTR} = f \frac{L}{D} \frac{v_{1-2}^2}{2} = 22{,}22\ J/kg \qquad Y_{1-2\ CONC} = K_c \frac{v_{1-2}^2}{2} = 3{,}15\ J/kg$$

$$l_T = (g\,\Delta z_{12}) - Y_{TOT} = 526\ J/kg \quad (\text{calcolo perdite turbina})$$

$Y_{TOT} = Y_{1-2} + Y_{2-3} + Y_{4-5}$ (tutte le distribuite)

~~$P_{EL} = \frac{\dot{m}_{TURB}\, l_T}{\eta_{ION}\, \eta_{ORG-ELE}}$~~ $P_{EL} = \dot{m}_{TURB} \cdot l_T \cdot \eta_{ION}\, \eta_{MECC-EL} = 5{,}7\ kW$

(4) SINGOLA ALETTA CILINDRICA



$Re = \frac{\rho V_\infty D}{\mu} = 674$

$Pr = \frac{c_p \mu}{k} = 0{,}721$

$\Big\} \; Nu = a Re^b Pr^{1/3}$

$Nu = \frac{hD}{k} \Rightarrow h = \frac{Nu\, k}{D} = 63{,}8\ W/m^2K$

~~AREA ALETTE TOTALE~~

$\Phi_{ALETTA,\ ISOTERMA} = \pi D l h_{sc} (T_{BASE} - T_\infty) = 1{,}7543\ W$ — h_{sc}: COEFF. SCAMBIO CONVETTIVO $30\ W/m^2K$

$\Phi_{ALETTA,\ REALE} = \sqrt{h P K A_{SEZ}}\,(T_{BASE} - T_\infty)\, tgh(m l) = 1{,}43\ W$

$P = \pi D \qquad A_{SEZ} = \frac{\pi D^2}{4} \qquad m = \sqrt{\frac{hP}{KA}} = 16{,}8\ 1/m$

$\eta_{ALETTA} = \frac{\Phi_{ALETTA,\ REALE}}{\Phi_{ALETTA,\ ISOTERMA}} = 0{,}816$

$\Phi_{NON\ ALETTATA} = \left[(BASE \cdot ALTEZZA) - n_{ALETTE}\, A_{AREA\ ALETTA}\right] h_{NON\ ALETTATA}\, (T_{BASE} - T_\infty)$

$\Phi_{TOT} = \underbrace{\Phi_{NON\ ALETTATA}}_{2{,}11\ W} + \underbrace{\Phi_{ALETTA\ REALE} \cdot n_{ALETTE}}_{35{,}8\ W} = 37{,}9\ W$