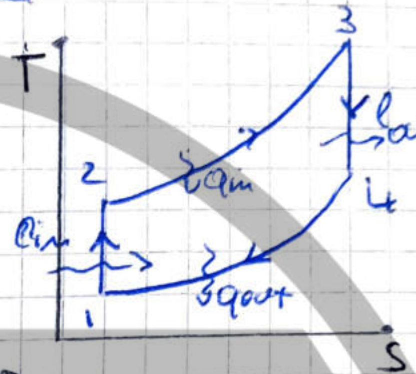
MACCHINE MOTRICI — CICLO JOULE-BRAYTON

IDEALE

Hp: GAS IDEALE (TIR) SISTEMA CHIUSO COMPOSTO, COSTITUITO DA SISTEMI APERTI CONNESSI

$S_{IRR}^{INT} = 0$



- BI°P:

$q_{in} + l_{in} = q_{out} + l_{out}$

1-2 COMPRESSIONE ISO-S
$l_{in} = h_2 - h_1 = C_P(\Delta T)$
2-3 RISCALDAMENTO ISO-P
$q_{in} = h_3 - h_2 = C_P(\Delta T)$
3-4 ESPANSIONE ISO-S
$l_{out} = h_3 - h_4 = C_P(\Delta T)$
4-1 RAFFREDDAMENTO ISO-P
$q_{out} = h_4 - h_1 = C_P(\Delta T)$

- ISOBARE

RAPPORTO COMPRESSIONE/ESPANSIONE

$\beta = \frac{P_2}{P_1} = \frac{P_3}{P_4}$

- ISOENTROPICHE

$T_2 = T_1 \cdot \beta^{\frac{\gamma-1}{\gamma}}$; $T_4 = T_3 \cdot \frac{1}{\beta^{\frac{\gamma-1}{\gamma}}}$ $\gamma = \frac{C_P}{C_V}$

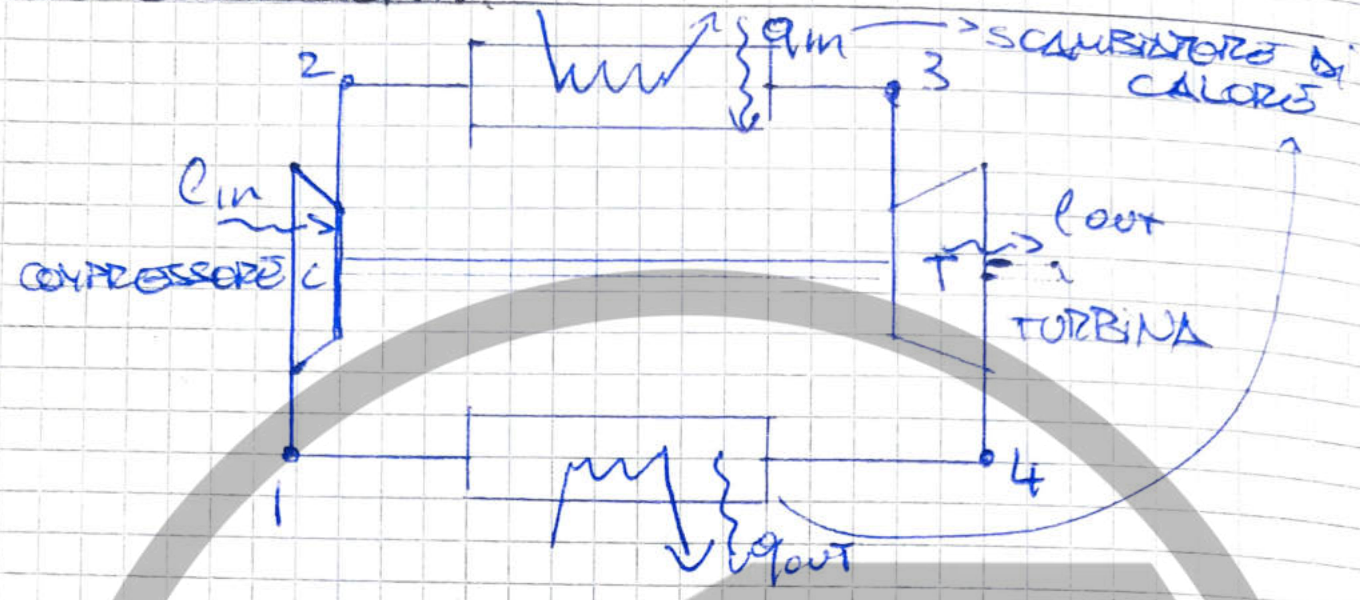
$\frac{T_2}{T_1} = \frac{T_3}{T_4}$

- RENDIMENTO

$\eta_{JB}^{ID} = \frac{l_{TOT}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{T_1}{T_2} < \eta_{CARNOT}$

$\eta_{JB}^{ID} = 1 - \frac{1}{\beta^{\frac{\gamma-1}{\gamma}}}$ $\eta_{IS} = \frac{l_{out}^{ID}}{l_{out}}$

COMPONENTI



BILANCI ENTROPICI (IDEALE)

- SISTEMA COMPLETO:

$$s_{irr} \left(= s_{irr}^{est,c} + s_{irr}^{est,f} + s_{irr}^{int \to 0}\right) = \Delta s_c + \Delta s_f$$

$$s_{irr}^{est,c} = \Delta s_c + (s_3 - s_2), \quad s_{irr}^{est,f} = \Delta s_f + (s_1 - s_4)$$

$$(s_3 - s_2) + (s_1 - s_4) = 0 \quad \Delta s_c - \Delta s_f \neq 0$$

- CICLO TERMODINAMICO

$$s_{Q_{in}} + s_{irr}^{int} - s_{Q_{out}} = 0$$

$$s_{Q_{in}} = (s_3 - s_2)$$

$$-s_{Q_{out}} = (s_1 - s_4)$$

REALE:

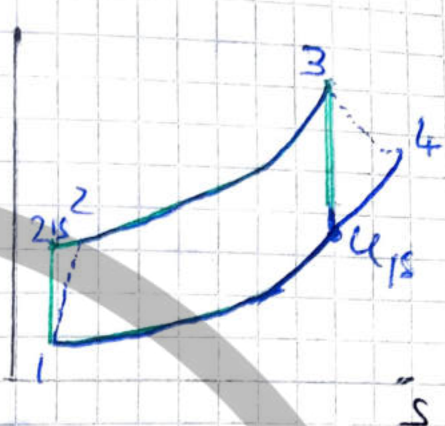
Hp: GAS IDEALE, SISTEMA CHIUSO COMPOSTO DA SOTTO SISTEMI APERTI INTERCONNESSI TRA LORO

- BI°P:

$q_{in} + l_{in} = q_{out} - l_{out}$

- COMPRESSIONE (NON-TIR) 1-2
- RISCALDAMENTO 2-3
- ESPANSIONE (NON-TIR) 3-4
- RAFFREDDAMENTO 4-1

→ TURBINA E COMPRESSORE MACCHINE NON-TIR



COMPRESSORE

STAZIONARIO

COMPRESSIONE ADIABATICA NON TIR

BII°P:

$\dot{m} \cdot s_1 + \dot{S}_{irr,c} - \dot{m} \cdot s_2 = 0$

$s_2 > s_1 \qquad \dot{S}_{irr,c} > 0$

$$\eta_{is,c} = \frac{l_{in,s}}{l_{in}} = \frac{T_{2,is} - T_1}{T_2 - T_1}$$

TURBINA.

STAZIONARIO

ESPANSIONE ADIAB. NON TIR

BII°P

$\dot{m}\, s_3 + \dot{S}_{irr,t} - \dot{m}\, s_4 = 0$

$s_4 > s_3 \qquad \dot{S}_{irr,t} > 0$

$$\eta_{is,T} = \frac{l_{out}}{l_{out,is}} = \frac{T_3 - T_4}{T_3 - T_{4,is}}$$

- ISOBARE:

$\beta = \frac{P_2}{P_1} = \frac{P_3}{P_4} \Rightarrow$ COME β^{ID}

- ISOENTROPICHE (NON) ⚠

$$T_2 = T_1 + \frac{T_{2,is} - T_1}{\eta_{is,c}} \qquad T_4 = T_3 - \eta_{is,T}(T_3 - T_{4,is})$$

$$\frac{T_4}{T_1} \neq \frac{T_3}{T_2} \qquad \frac{T_2}{T_1} \neq \frac{T_3}{T_4}$$

- RENDIMENTO:

$$\eta_{SB} = \frac{l_{TOT}}{q_{in}} = \frac{l_{OUT} - l_{IN}}{q_{in}} < \eta_{SB}^{ID}$$

- BILANCI ENTROPICI:

  - SISTEMA COMPLETO:

$$s_{irr}^{TOT} \left(= s_{irr}^{EST,c+f} + s_{irr}^{int,t+c} \right) = \Delta s_c + \Delta s_f \qquad \left(\Delta s_c = \frac{q_c}{T_c} ; \; \Delta s_f = \frac{q_f}{T_F} \right)$$

$$s_{irr}^{EST,c} = \Delta s_c + (s_3 - s_2) \; ; \; s_{irr}^{EST,f} = \Delta s_f + (s_1 - s_4)$$

$$(s_3 - s_2) + s_{irr}^{int,t+c} + (s_1 - s_4) = 0$$

COMPRESSORE $\quad s_{irr}^{int,c} = (s_2 - s_1) = c_p \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{P_2}{P_1}\right) = c_p \ln\left(\frac{T_2}{T_{2is}}\right)$

TURBINA $\quad s_{irr}^{int,t} = (s_4 - s_3) = c_p \ln\left(\frac{T_4}{T_3}\right) - R \ln\left(\frac{P_4}{P_3}\right) = c_p \ln\left(\frac{T_4}{T_{4is}}\right)$

  - CICLO TERMODINAMICO

$$s_{Q_{in}} + s_{irr}^{int,t+c} - s_{Q_{OUT}} = 0$$

$$s_{Q_{in}} = (s_3 - s_2) \quad ; \quad -s_{Q_{OUT}} = (s_1 - s_4)$$

$$s_{irr}^{int,c} = (s_2 - s_1)$$

$$s_{irr}^{int,t} = (s_4 - s_3)$$