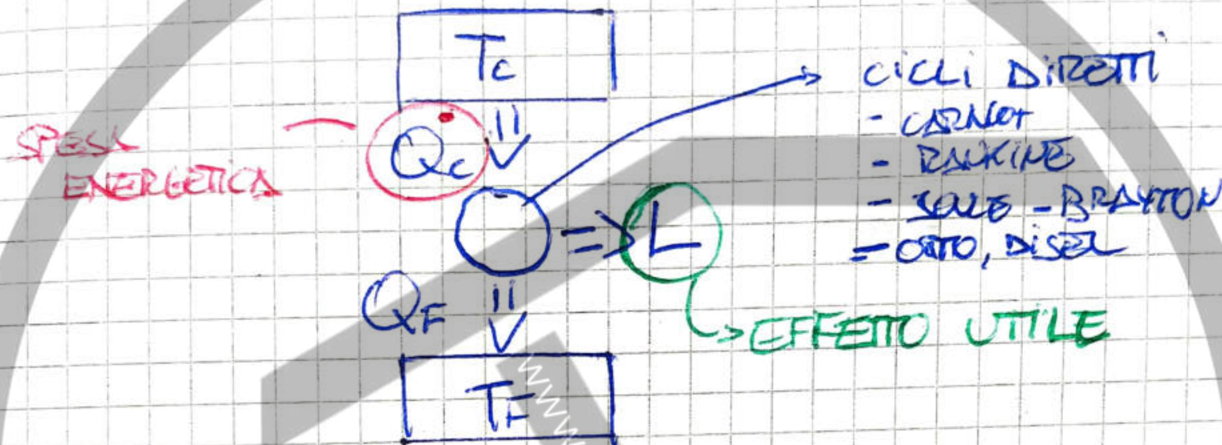
CICLI TERMODINAMICI

TIPI DI MACCHINE:

- MOTRICI — PRODUZIONE LAVORO MECCANICO
- OPERATRICI — TRASFERIMENTO DI CALORE.

1) MACCHINE MOTRICI

PRODUCONO LAVORO MECCANICO



PARAMETRO DI MERITO:

RENDIMENTO: $\eta = \frac{L}{Q_c}$ $\quad 0<\eta<1$

2) MACCHINE OPERATRICI.

«TRASFERIMENTO» DI CALORE.

SONO:
- POMPA DI CALORE
- FRIGORIFERO

PARAMETRO DI METRO:

COEFFICIENT OF PERFORMANCE (COP)

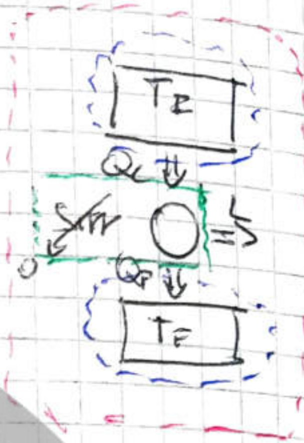
$$COP = \frac{Q_{c,f}}{L}$$

- $COP_f > 0$
- $COP_{pdc} > 1$

MACCHINA MOTRICE (MOTRICE)

- IDEALE: NO S

CASO REVERSIBILE: $S_{irr}^{(int+est)} = 0$



- BILANCIO ENTROPIA:

  + SISTEMA COMPLESSIVO:

  $S_{irr} = \Delta S_{tot} \Rightarrow \Delta S_C^{id} = \Delta S_F^{id}$

  ($S_{irr} = 0$)

  + SERBATOI TERMICI:

  $$\Delta S_C^{id} = -\frac{Q_C^{id}}{T_C} \quad ; \quad \Delta S_F^{id} = \frac{Q_F^{id}}{T_F}$$

- BILANCIO DI ENERGIA (MACCHINA CICLICA)

  $$L^{id} = Q_C^{id} - Q_F^{id}$$

- RENDIMENTO IDEALE: $\rightarrow$ (IRR EST + INT = 0)

  $$\eta^{id} = \frac{L^{id}}{Q_C^{id}} = 1 - \frac{T_F}{T_C} \qquad 0 < \eta^{id} < 1$$

- REALE:

CASO IRREVERSIBILE: $S_{irr}^{(int+est)} > 0$

- BILANCIO ENTROPIA SIST. COMPLESSIVO:

  $\Delta S_{ciclo} = 0$

  $S_{irr} = \Delta S_{tot} \Rightarrow \Delta S_F = -\Delta S_C + S_{irr}$

  SE:

  $Q_C = Q_C^{id}$
  $\Delta S_C = \Delta S_C^{id}$ $\longrightarrow L < L^{id}$

- RENDIMENTO I° P:

$$\eta = \frac{L}{Q_C} < \eta^{ID} \qquad \left(\eta^{ID} = 1 - \frac{T_L}{T_C}\right) \qquad 0 < \eta < \eta^{ID}$$

- RENDIMENTO II° P:

$$\eta_{II} = \frac{\eta}{\eta^{ID}} \qquad 0 < \eta^{II} < 1$$

↳ PERMETTE DI CAPIRE QUALE TRA LE MACC. MOTRICI DATE È LA MIGLIORE

MACCHINA FRIGORIFERA (OPERATRICE)

- IDEALE:

CASO REVERSIBILE:

$$S_{IRR}^{(INT+EST)} = 0$$

- BILANCIO ENTROPIA:
  - $\forall$ S. COMPLESSIVO:

$$\Delta S_{TOT} = 0 \Rightarrow \Delta S_C^{ID} = -\Delta S_F^{ID}$$

  - $\forall$ SERB. TERMICI

$$\Delta S_F^{ID} = -\frac{Q_F^{ID}}{T_F} \quad ; \quad \Delta S_C^{ID} = \frac{Q_C^{ID}}{T_C}$$

- BILANCIO DI ENERGIA (MACCH. CICLICA)

$$L^{ID} = Q_C^{ID} - Q_F^{ID}$$

- COP

$$COP_F^{ID} > 0$$

$$COP^{ID} = \frac{Q_F^{ID}}{L^{ID}} = \frac{T_F}{T_C - T_F}$$

$$COP_F^{ID} = \frac{Q_F^{ID}}{L^{ID}} = \frac{T_F}{T_C - T_F}$$

$$COP_{PdC} = \frac{Q_C^{ID}}{L^{ID}} = \frac{T_C}{T_C - T_F}$$

- REALE:

CASO IRREVERSIBILE:

$$S_{IRR}^{(INT+EST)} > 0$$

- BILANCIO ENTROPIA (SIST. COMPL)

$$\Delta S_C = -\Delta S_F + S_{IRR}.$$

$\Delta S_{CICLO} = 0$ PERCHÉ OPER. CICLICA

$$Q_F = Q_F^{ID} \longrightarrow L > L^{ID}$$

$$\Delta S_F = \Delta S_F^{ID}$$

- COP I° PRINC.

$$COP_f = \frac{Q_f}{L} \neq \frac{T_f}{T_C - T_F}$$

$0 < COP_f < COP_f^{ID}$

$COP > 0$

- REND. II PRINC:

$$\eta_{II} = \frac{COP_f}{COP_f^{ID}}$$

$0 < \eta_{II} < 1$

POMPA DI CALORE (MACCHINA OPERATRICE)

- IDEALE:

CASO REV:

$$S_{IRR}^{(INT+EST)} = 0$$

- BILANCIO ENTROPIA S. COMPL

$$\Delta S_C^{ID} = -\Delta S_F^{ID}$$

- BILANCIO ENTROPIA SERB. TERMICI

$$\Delta S_F^{ID} = -\frac{Q_F^{ID}}{T_F} \quad ; \quad \Delta S_C^{ID} = \frac{Q_C^{ID}}{T_C}$$

- BILANCIO ENERGIA SU MACC. CICLIC.

$$L^{ID} = Q_C^{ID} - Q_F^{ID}$$

- COP IDEALE:

$COP_{PdC} > 1$

$$COP_{PC}^{ID} = \frac{Q_C^{ID}}{L^{ID}} = \frac{T_C}{T_C - T_F}$$

- REALE:

CASO IRREVERSIBILE:

$$S_{irr}^{(INT+EST)} > 0$$

- B. E. S. COMPL.

$$\Delta S_{irr}^{(INT+EST)} = \Delta S_{TOT} \Rightarrow \Delta S_C = \Delta S_F \pm S_{irr}$$

$\Delta S_{CICLO} = 0$ PERCHÉ OP. CICLICA

SE

$Q_C = Q_C^{ID}$

$\Delta S_C = \Delta S_C^{ID}$ $\rightarrow L > L^{ID}$

- COP_{PC} I° PRINC.

$$COP_{PC} = \frac{Q_C}{L} < COP^{ID} \qquad COP > 1$$

$$\neq \frac{T_C}{T_C - T_F}$$

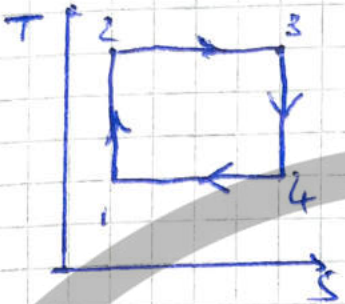
$$0 < COP_{PC} < COP_{PC}^{ID}$$

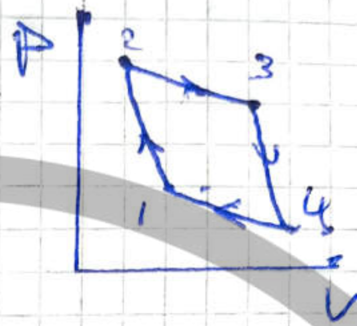
- REND. II° P.

$$\eta_{II} = \frac{COP_{PC}}{COP_{PC}^{ID}} \qquad 0 < \eta_{II} < 1$$

CICLO DIRETTO DI CARNOT

Hp: G.I. ; TIR => $S_{irr}^{int} = 0$





- COMPRESSIONE (4-2)
  - ISOT (4-1) + ADIAB (1-2)
- ESPANSIONE (2-4)
  - ISOT (2-3) + ADIAB (3-4)
- BILANCIO I° P.

$$q_c + l_{in} + l_f = q_f + l_{out} + l_c$$

1-2 / 3-4: $l_{in} = c_p (T_2 - T_1) = l_{out}$ ISO-S

2-3: $q_c = T_2 (s_3 - s_2) = l_c$ } ISO-T

4-1: $q_f = T_1 (s_4 - s_1) = l_f$ } ISO-T

$$\eta = 1 - \frac{T_1}{T_2} \quad \frac{\sim T_f}{\sim T_c}$$

- B. ENTROPIA SU S. COMPLETO:

$$\Delta_{irr} = \Delta s_C + \Delta s_f$$

- B. E. SU SCAMBI TERMICI

$$s_2 - s_3 + s_{irr}^{EST, C} = \Delta s_C$$

$$s_4 - s_1 + s_{irr}^{EST, F} = \Delta s_f$$

- LAVORO TOTALE

$$l_{TOT} = l_C - l_F = (T_2 - T_1)(s_3 - s_2)$$

- RENDIMENTO IDEALE

$$\eta_{CARNOT} = 1 - \frac{T_1}{T_2} = \frac{l_{TOT}}{q_C}$$