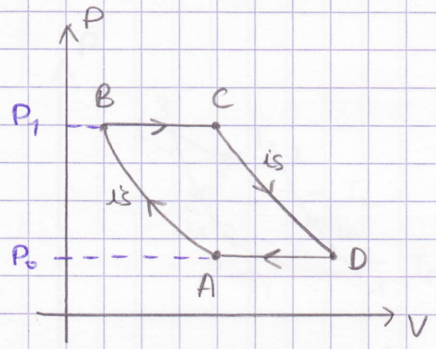
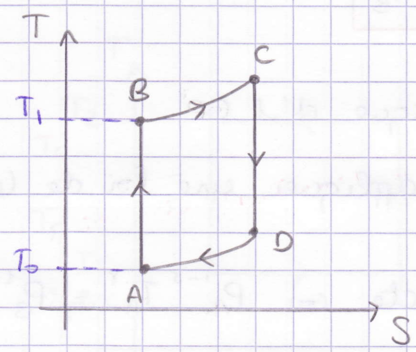
Ex TS_6. Turbomoteur.

1)





$\mathcal{S} = \{m, \text{GP}, \gamma, n\}$

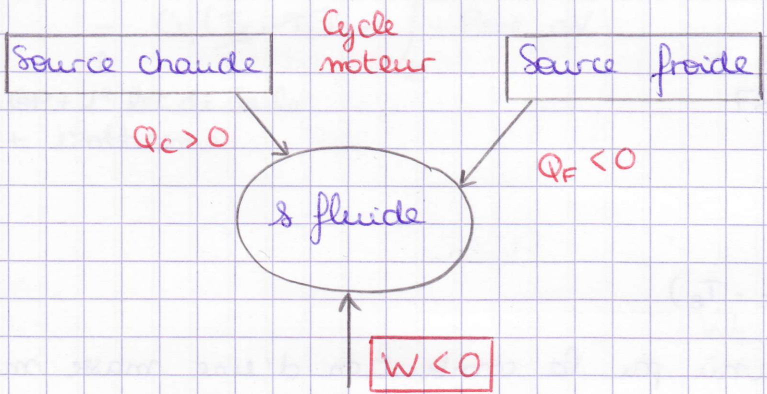
$$\boxed{b = \frac{P_1}{P_0} = 5}$$

Justification → cf cours

2) Cycle moteur.

$$\eta = \frac{\text{grdeur utile}}{\text{grdeur coûteuse}} = \frac{-W}{Q_C} \underset{\uparrow}{=} 1 + \frac{Q_F}{Q_C}$$

(1P) $W + Q_F + Q_C = 0$



$Q_C = Q_{AB} + Q_{BC}$

$Q_F = Q_{CD} + Q_{DA}$

car $\begin{cases} Q_{AB} = 0 \text{ (adiabatique "car" isentropique)} \\ Q_{BC} = Q_{BC,P} = \Delta H_{BC} = C_p(T_C - T_B) > 0 \\ \qquad \text{2e loi Joule pr 1 GP} \\ Q_{CD} = 0 \text{ (ad)} \\ Q_{DA} = Q_{DA,P} = \Delta H_{DA} = C_p(T_A - T_D) \end{cases}$

$$\boxed{\eta = 1 + \frac{T_A - T_D}{T_C - T_B}}$$

A → B : isentropique d'1 GP

↳ on peut appliquer une loi de Laplace.

$$P^{1-\gamma} T^{\gamma} = cte \Leftrightarrow P_A^{1-\gamma} T_A^{\gamma} = P_B^{1-\gamma} T_B^{\gamma}$$

$$T_A^{\gamma} = T_B^{\gamma} \left(\frac{P_B}{P_A}\right)^{1-\gamma}$$

$$\boxed{T_A = T_B (b)^{\frac{1-\gamma}{\gamma}}} \quad \text{car} \quad \frac{P_B}{P_A} = \frac{P_1}{P_0} \equiv b$$

de m̂ pour C → D : $P_D^{1-\gamma} T_D^{\gamma} = P_C^{1-\gamma} T_C^{\gamma}$

$$\boxed{T_D = T_C \left(\frac{P_D}{P_C}\right)^{\frac{1-\gamma}{\gamma}}} = \boxed{T_C (b)^{\frac{1-\gamma}{\gamma}}} \quad \text{car} \quad \frac{P_D}{P_C} = \frac{P_1}{P_0} \equiv b$$

$$\eta = 1 + \frac{(T_B - T_C) b^{\frac{1-\gamma}{\gamma}}}{T_C - T_B}$$

$$\boxed{\eta = 1 - b^{\frac{1-\gamma}{\gamma}}} = 0,37$$

3) $Q_C = \begin{cases} Q_{BC,P} = C_P (T_C - T_B) \\ \text{chaleur fournie par la combustion d'une masse } m_1 \text{ de carburant} \end{cases}$

$$Q_C = \begin{cases} \frac{\gamma n R}{\gamma - 1}(T_C - T_B) = \frac{m}{M} \frac{\gamma R}{\gamma - 1}(T_C - T_B) = m\, c_p (T_C - T_B) \\ m_1 \underbrace{q}_{\text{pouvoir calorifique massique du carburant}} \end{cases}$$

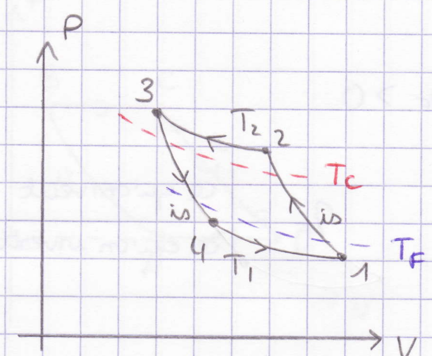
$$c_p = \frac{1}{M} \frac{\gamma R}{\gamma - 1} = 1,003 \text{ kJ.K}^{-1}.\text{kg}^{-1}$$

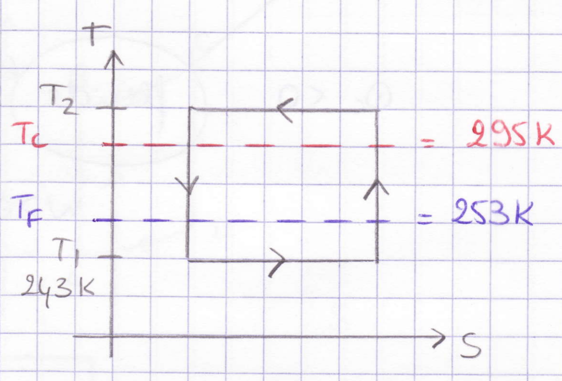
$$\rightarrow \boxed{T_C = \frac{m_1 q}{m\, c_p} + T_B = \frac{m_1}{m} q M \frac{\gamma - 1}{\gamma R} + T_A b^{\frac{\gamma - 1}{\gamma}}} \qquad T_C = 2950 \text{ K}$$

avec $T_B = T_A b^{\frac{\gamma - 1}{\gamma}}$

Ex TS 8. Frigopompe.

1)





Rq : Ce n'est pas le cycle de Carnot car les isothermes ne sont pas réversibles (si elles l'étaient il y aurait équilibre thermique avec les 2 sources càd $T_1 = T_F$ et $T_2 = T_C$).

2) 2 adiabatiques : $Q_{12} = Q_{34} = 0$

$$Q_{23} \underset{(1P)}{=} \Delta U_{23} - W_{23}$$

$$\underset{\text{GP + 1e loi de Joule + isotherme}}{=} C_V(\cancel{T_3 - T_2}) - \int_2^3 -P_{ext}\, dV$$

$$W_{23} = \int_2^3 \delta W = \int_2^3 -P_{ext}\, dV$$

$$\underset{TQS}{=} \int_2^3 -P\, dV$$

$$\underset{GP}{=} \int -\frac{nRT}{V}$$

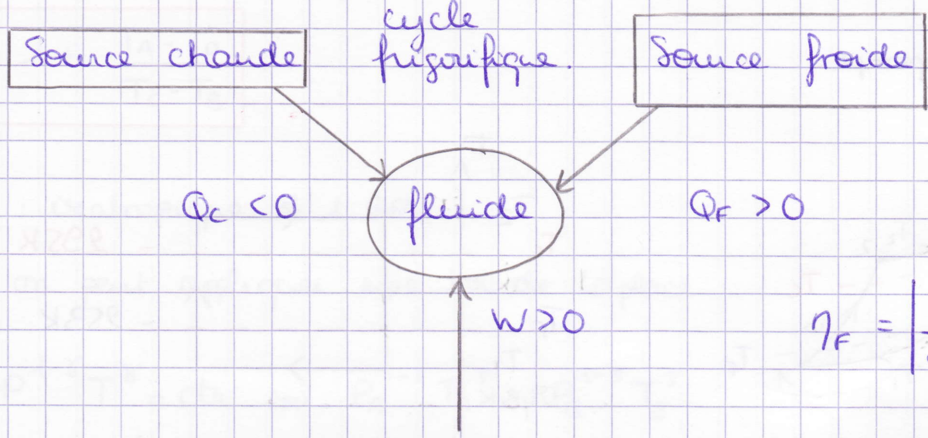
$$\underset{isoth}{=} -nRT_2 \int_2^3 \frac{dV}{V}$$

$$W_{23} = -nRT_2 \ln \frac{V_3}{V_2}$$

or $\dfrac{V_3}{V_2} = \dfrac{\cancel{nRT_3}}{P_3} \dfrac{P_2}{\cancel{nRT_2}} = \dfrac{P_2}{P_3} = \dfrac{1}{3}$

donc $\boxed{W_{23} = nRT_2 \ln 3} > 0$ (compression isotherme)

↳ $\boxed{Q_C = Q_{23} = -W_{23} = -nRT_2 \ln 3 < 0}$



$$\eta_F = \left| \frac{\text{ce qu'on veut}}{\text{ce qu'on investit}} \right|$$

$$Q_F = Q_{41} \underset{(1P)}{=} \Delta U_{41} - W_{41} \underset{\substack{\text{isoth} + GP \\ + 1^{e} \text{ loi de Joule}}}{=} 0 - W_{41}$$

Par un raisonnement similaire au calcul précédent :

$$W_{41} = -nRT_1 \ln \frac{V_1}{V_4} \quad \text{avec} \quad \frac{V_1}{V_4} = \frac{nRT_1}{P_1} \frac{P_4}{nRT_4} = \frac{P_4}{P_1}$$

$$\boxed{Q_F = -W_{41} = nRT_1 \ln\left(\frac{P_4}{P_1}\right) > 0} \quad \text{car } P_4 > P_1$$

3) $1 \to 2$ isentropique d'un GP : → loi de Laplace

$$P_1^{1-\gamma} T_1^{\gamma} = P_2^{1-\gamma} T_2^{\gamma}$$

$$\boxed{P_2 = P_1 \left(\frac{T_1}{T_2}\right)^{\frac{\gamma}{1-\gamma}} = 1{,}74 \text{ bar}}$$

$3 \to 4$ isentropique d'un GP → loi de Laplace.

$$P_4 = P_3 \left(\frac{T_3}{T_4}\right)^{\frac{\gamma}{1-\gamma}} = 3P_2 \left(\frac{T_2}{T_1}\right)^{\frac{\gamma}{1-\gamma}}$$

$$\boxed{P_4 = 3P_1} \cancel{\left(\frac{T_1}{T_2}\right)^{\frac{\gamma}{1-\gamma}} \left(\frac{T_2}{T_1}\right)^{\frac{\gamma}{1-\gamma}}}$$

$$\rightarrow \boxed{Q_F = nRT_1 \ln 3 > 0} \qquad \boxed{Q_C = Q_{23} = -W_{23} = -nRT_2 \ln 3 < 0}$$

$$\boxed{\eta = \left|\frac{Q_F}{W}\right| = \frac{Q_F}{-Q_F - Q_C} = \frac{\cancel{nR}T_1 \cancel{\ln 3}}{\cancel{nR}(T_2 - T_1)\cancel{\ln 3}}} \boxed{= 3{,}9 < \eta_C = \frac{T_F}{T_C - T_F} = 6}$$