MINISTERE DE L'ENSEIGNEMENT SUPERIEUR ET DE LA RECHERCHE SCIENTIFIQUE
Université de MILA
Faculté des Sciences et de la Technologie
Département de Génie Mécanique
3eme Année Génie Mécanique : Energétique
A.U 2019/2020, Semestre 1

TD N 02 : Cycle Otto et cycle diesel

Module : **Moteurs à Combustion interne**
Responsable du module : **A.E. BOUCHOUCHA**

Exercice 01.

1. Le taux volumétrique de compression

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} \Rightarrow \frac{T_2}{T_1} = \varepsilon^{\gamma-1} \Rightarrow \varepsilon = \left(\frac{T_2}{T_1}\right)^{\frac{1}{\gamma-1}} = \left(\frac{586}{293}\right)^{\frac{1}{1,4-1}} = \mathbf{5,42}$$

2. Le rendement du cycle :

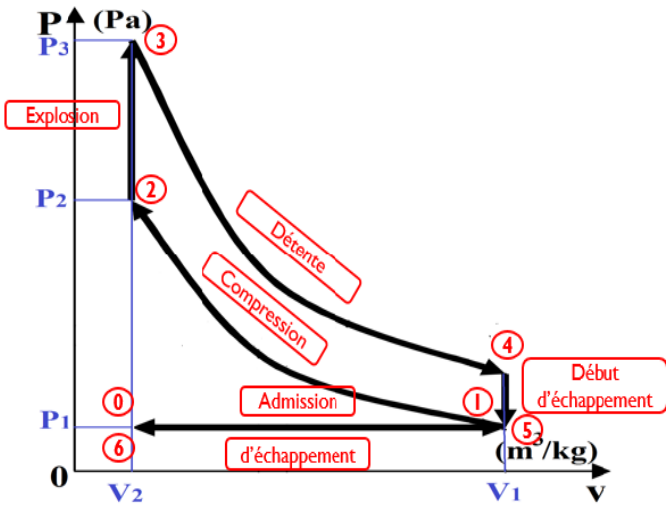
$$\eta_{th} = 1 - \frac{T_1}{T_2} = 1 - \frac{1}{\varepsilon^{\gamma-1}} = 1 - \frac{1}{5{,}42^{1,4-1}} = \mathbf{0,4914 = 49,14\ \%}$$

Exercice 02.

1. La pression et la température à chaque point du cycle.

A. Point 1 :

P_1= **95 kPa.** T_1= **300 K.**



B. Point 2 :

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} \Rightarrow T_2 = T_1 \times \left(\frac{V_1}{V_2}\right)^{\gamma-1} = \mathbf{689,2\ K}$$

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} \Rightarrow P_2 = P_1 \times \left(\frac{V_1}{V_2}\right)^{\gamma} = \mathbf{1746,02\ kPa}$$

P_2 = **1746.02 kPa.** T_2= **689.2 K.**

C. Point 3 :

$P_2 = P_3$ = **5719,81 kPa.**

$$q_1 = C_v \times (T_3 - T_2) \Rightarrow T_3 = \frac{q}{C_v} + T_2 = \mathbf{1734\ K}$$

$$\frac{T_3 V_3}{P_3} = \frac{T_2 V_2}{P_2} \Rightarrow P_3 = \frac{T_3}{T_2} P_2 = \mathbf{4392\ kPa}$$

P_3 = **4392 kPa.** T_3= **1734 K.**

D. Point 4 :

$$\frac{P_3}{P_4} = \left(\frac{V_4}{V_3}\right)^{\gamma} \Rightarrow P_4 = P_3 \left(\frac{V_3}{V_4}\right)^{\gamma} = \mathbf{239\ kPa}$$

$$\frac{T_3}{T_4} = \left(\frac{V_3}{V_4}\right)^{\gamma-1} \Rightarrow T_4 = T_3 \times \left(\frac{V_4}{V_3}\right)^{\gamma-1} = \mathbf{755\ K}$$

P_4 = **239 kPa.** T_4= **755 K.**

2. Le travail per unité de masse

$$q_2 = C_v \times (T_4 - T_1) = \mathbf{327\ kJ/kg}$$

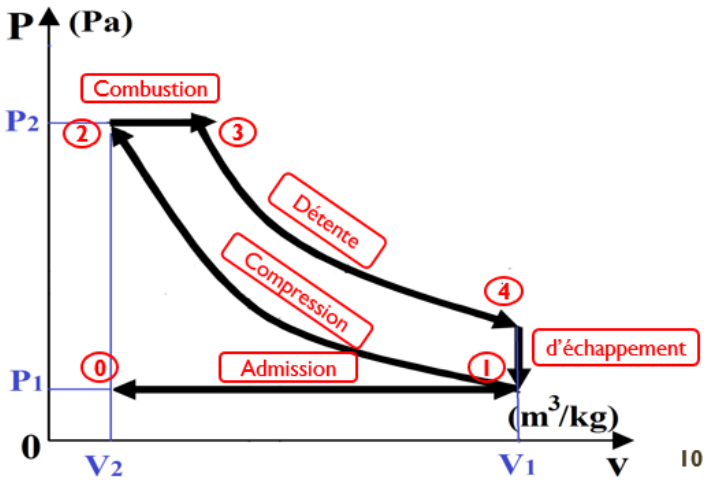
$$w = q_1 - q_2 = \mathbf{423\ kJ/kg}$$

3. Le rendement thermique du cycle.

$$\eta_{th} = \frac{w}{q_1} = 0{,}564 = \mathbf{56{,}4}\ \%$$

Exercice 03.

1. La pression, le volume spécifique, et la température à chaque point du cycle.



A. Point 1 :

$$P_1 v_1 = RT_1 \Rightarrow v_1 = \frac{RT_1}{P_1} = \frac{0{,}287 \times 288}{100} = 0{,}827\ m^3/kg$$

P_1= **100 kPa.** T_1= **288 K.** v_1= **0,827 m³/kg.**

B. Point 2 :

$$\varepsilon = \frac{v_1}{v_2} \Rightarrow v_2 = \frac{v_1}{\varepsilon} = \frac{0.827}{18} = 0{,}046\ m^3/kg$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} \Rightarrow T_2 = T_1 \times \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 288 \times 18^{1{,}4-1} = 915{,}17\ K$$

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} \Rightarrow P_2 = P_1 \times \left(\frac{V_1}{V_2}\right)^{\gamma} = 100 \times 18^{1{,}4} = 5719{,}81\ kPa = 5{,}72\ MPa$$

P_2 = **5719,81 kPa.** T_2= **915,17 K.** v_2= **0,046 m³/kg.**

C. Point 3 :

P_2 = P_3 = **5719,81 kPa.**

$$q = C_p \times (T_3 - T_2) \Rightarrow T_3 = \frac{q}{C_P} + T_2 = \frac{1800}{1} + 915{,}17 = 2715{,}17\ K$$

$$P_3 v_3 = RT_3 \Rightarrow v_3 = \frac{RT_3}{P_3} = \frac{0{,}287 \times 2715{,}17}{5719{,}81} = 0{,}1362\ m^3/kg$$

P_3 = **5719,81 kPa.** T_3= **2715,17 K.** v_3= **0,1362 m³/kg.**

D. Point 4 :

v_4 = v_1 = **0,827 m³/kg.**

$$\frac{P_3}{P_4} = \left(\frac{V_4}{V_3}\right)^{\gamma} = \varepsilon'^{\gamma} \Rightarrow P_4 = \frac{P_3}{\varepsilon'^{\gamma}} = \frac{5719{,}81}{6{,}072^{1{,}4}} = 457{,}85\ kPa$$

$$P_4 v_4 = RT_4 \Rightarrow T_4 = \frac{P_4 v_4}{R} = \frac{457{,}85 \times 0{,}827}{0{,}287} = 1319{,}31\ K$$

P_4 = **457,85 kPa.** T_4= **1319,31 K.** v_4= **0,827 m³/kg.**

2. Le rendement thermique du cycle.

$$\eta_{th} = 1 - \frac{1}{\gamma}\frac{(T_4 - T_1)}{(T_3 - T_2)} = 1 - \frac{1}{1{,}4}\frac{(1319{,}31 - 288)}{(2715{,}17 - 915{,}17)} = \mathbf{0{,}5908 = 59{,}08}\ \%$$

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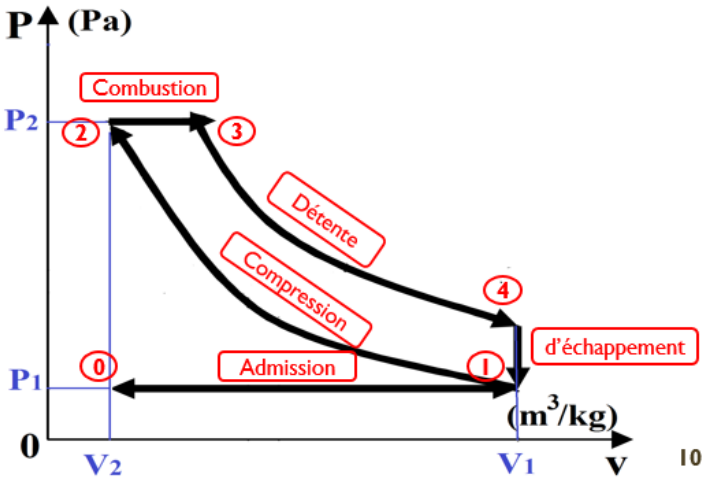
Exercice 04 :



1. Le rapport V_3/V_2

T_1= 22 °C=295 K $\Rightarrow V_{r1} = 647{,}9, u_1 = 210{,}49$ kJ/kg

$$V_{r2} = \left(\frac{V_2}{V_1}\right) V_{r1} \Rightarrow V_{r2} = \left(\frac{1}{\varepsilon}\right) V_{r1} = \left(\frac{1}{18}\right) 647{,}9 = 36$$

Avec le tableau A-17, $V_{r2} = 36$
Avec l'interpolation linéaire

$x_a = V_{ra} = 36{,}61$ $\quad y_a = T_a = 880\ K$
$x_2 = V_{r2} = 36$ $\quad y_2 = T_2 = ?$
$x_b = V_{rb} = 34{,}31$ $\quad y_b = T_b = 900\ K$

$$\boldsymbol{T_2} = T_a + (T_b - T_a) \times \frac{V_{r2} - V_{ra}}{V_{rb} - V_{ra}} = 880 + (900 - 880) \times \frac{36 - 36{,}61}{34{,}31 - 36{,}61} = \boldsymbol{874{,}7\ K}$$

$\boldsymbol{T_2 = 874{,}7\ K}$

Avec l'interpolation linéaire

$x_a = V_{ra} = 36{,}61$ $\quad y_a = h_a = 910{,}56\ kJ/kg$
$x_2 = V_{r2} = 36$ $\quad y_2 = h_2 = ?$
$x_b = V_{rb} = 34{,}31$ $\quad y_b = h_b = 932{,}93\ kJ/kg$

$$\boldsymbol{h_2} = h_a + (h_b - h_a) \times \frac{V_{r2} - V_{ra}}{V_{rb} - V_{ra}} = 910{,}56 + (932{,}93 - 910{,}56) \times \frac{36 - 36{,}61}{34{,}31 - 36{,}61} = \boldsymbol{916{,}49\ kJ/kg}$$

$\boldsymbol{h_2 = 916{,}49 kJ/kg}$

$$\frac{P_3 V_3}{T_3} = \frac{P_2 V_2}{T_2} \Rightarrow \frac{V_3}{V_2} = \frac{T_3}{T_2} = 2{,}027\ (P_2 = P_3, Transformation\ isobare)$$

2. La chaleur ajoutée par unité de masse

Avec le tableau A-17, $V_{r2} = 36$
Avec l'interpolation linéaire

$x_a = T_a = 1750\ K$ $\quad y_a = h_a = 1941{,}6\ kJ/kg$
$\boldsymbol{x_3 = T_3 = 1773\ K} y_i = \boldsymbol{h_3} = ?$
$x_b = T_b = 1800\ K$ $\quad y_b = h_b = 2003{,}3\ kJ/kg$

$$\boldsymbol{h_3} = h_a + (h_b - h_a) \times \frac{T_3 - T_a}{T_b - T_a} = 1941{,}6 + (2003{,}3 - 1941{,}6) \times \frac{1773 - 1750}{1800 - 1750}$$

$$\boldsymbol{h_3 = 1969{,}98 kJ/kg}$$

$$q_1 = h_3 - h_2 = 1969{,}98 - 916{,}49 = \mathbf{1053{,}49\ kJ/kg}$$

3. Le rendement du cycle

Avec l'interpolation linéaire

$x_a = T_a = 1750\ K$ $\qquad y_a = V_{ra} = 4{,}328$

$\boldsymbol{x_3 = T_3 = 1773\ K}$ $\boldsymbol{y_i = V_{r3}}$ =?

$x_b = T_b = 1800\ K$ $\qquad y_b = V_{rb} = 3{,}994$

$$\boldsymbol{V_{r3}} = V_{ra} + (V_{rb} - V_{ra}) \times \frac{T_3 - T_a}{T_b - T_a} = 4{,}328 + (3{,}994 - 4{,}328) \times \frac{1773 - 1750}{1800 - 1750} = 4{,}1743$$

$$\boldsymbol{V_{r3} = 4{,}1743}$$

$$V_{r4} = \left(\frac{V_4}{V_3}\right) V_{r3} \Rightarrow V_{r4} = \left(\frac{V_4}{2{,}027 \times V_2}\right) V_{r3} = \left(\frac{\varepsilon}{2{,}027}\right) V_{r3} = \left(\frac{18}{2{,}027}\right) 4{,}1743 = 37{,}068$$

$$\boldsymbol{V_{r4} = 37{,}0683}$$

$x_a = V_{ra} = 39{,}12$ $\qquad y_a = u_a = 641{,}40\ kJ/kg$

$x_2 = V_{r4} = 37{,}068$ $\qquad y_2 = u_4$ =?

$x_b = V_{rb} = 36{,}61$ $\qquad y_b = u_b = 657{,}95\ kJ/kg$

$$\boldsymbol{u_4} = u_a + (u_b - u_a) \times \frac{V_{r4} - V_{ra}}{V_{rb} - V_{ra}} = 641{,}4 + (657{,}95 - 641{,}4) \times \frac{37{,}068 - 39{,}12}{36{,}61 - 39{,}12} = \mathbf{654{,}93\ kJ/kg}$$

$$\boldsymbol{u_4 = 654{,}93\ kJ/kg}$$

$$q_2 = u_4 - u_1 = 654{,}93 - 210{,}49 = \mathbf{444{,}44\ kJ/kg}$$

$$w_{net} = q_1 - q_2 = 1053{,}49 - 444{,}44 = \mathbf{609{,}05\ kJ/kg}$$

$$\eta_{th} = \frac{w_{net}}{q_1} = \frac{609{,}44}{1053{,}49} = \mathbf{0{,}5785} = \mathbf{57{,}85}\ \%$$