Université de Batna 2 Mardi 15 Octobre 2019
Faculté de Technologie Département d'Electronique

Rattrapage de Thermodynamique

Niveau : M1ELM Durée : 01H30

Calculatrice autorisée. Mise en garde : **Attention !** Aucune communication entre les candidats **ne sera tolérée.**

## Exercice 01 :

Soit *un cycle Diesel théorique* (Figure 01) dont le taux de compression est de 20. Au début de la compression, l'air se trouve à 95 kPa et à 20°C. En supposant que la température maximale dans le cycle ne peut dépasser 2200 K. Déterminez :

1. Le rendement thermique du cycle ;
2. La pression moyenne effective.

*Admettez les hypothèses d'air standard simplifiées.*

**Données :** $C_p$(air) = 1,005 kJ/kg.K, $C_v$(air) = 0,718 kJ/kg.K , R = 0,287 kJ/kg.K, et k = 1,4

## Exercice 02 :

*En admettant les hypothèses d'air standard,* considérez un cycle fermé. Le système contient 0,003 kg d'air. Les trois évolutions du cycle sont :

1-2 : un apport de chaleur à volume constant de 95 kPa et de 17°C à 380 kPa ;

2-3 : une détente isentropique à 95 kPa ;

3-1 : une évacuation de chaleur à pression constante jusqu'à l'état initial.

1. Montrez le cycle dans un diagramme P-v et T-s ;
2. Déterminez le travail net produit en kJ ;
3. Déterminez le rendement thermique du cycle

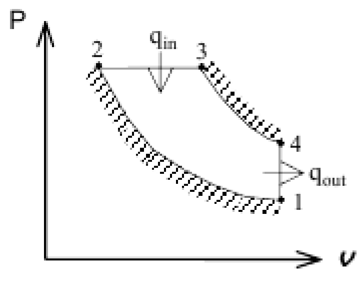



Figure 01 : Cycle Diesel Théorique

*«Les jours se suivent et ne ressemblent pas »*

Pr H.Madani

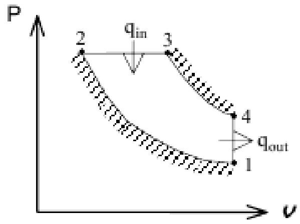
**Exercice 01 :**

An ideal diesel engine with air as the working fluid has a compression ratio of 20. The thermal efficiency and the mean effective pressure are to be determined.

***Assumptions*** **1** The air-standard assumptions are applicable. **2** Kinetic and potential energy changes are negligible. **3** Air is an ideal gas with constant specific heats.

***Properties*** The properties of air at room temperature are $c_p$ = 1.005 kJ/kg·K, $c_v$ = 0.718 kJ/kg·K, $R$ = 0.287 kJ/kg·K, and $k = 1.4$ (Table A-2).

***Analysis*** (*a*) Process 1-2: isentropic compression.




$$T_2 = T_1\left(\frac{v_1}{v_2}\right)^{k-1} = (293\text{ K})(20)^{0.4} = 971.1\text{ K}$$

Process 2-3: $P$ = constant heat addition.

$$\frac{P_3 v_3}{T_3} = \frac{P_2 v_2}{T_2} \longrightarrow \frac{v_3}{v_2} = \frac{T_3}{T_2} = \frac{2200\text{K}}{971.1\text{K}} = 2.265$$

Process 3-4: isentropic expansion.

$$T_4 = T_3\left(\frac{v_3}{v_4}\right)^{k-1} = T_3\left(\frac{2.265 v_2}{v_4}\right)^{k-1} = T_3\left(\frac{2.265}{r}\right)^{k-1} = (2200\text{ K})\left(\frac{2.265}{20}\right)^{0.4} = 920.6\text{ K}$$

$$q_{in} = h_3 - h_2 = c_p(T_3 - T_2) = (1.005\text{ kJ/kg}\cdot\text{K})(2200 - 971.1)\text{K} = 1235\text{ kJ/kg}$$

$$q_{out} = u_4 - u_1 = c_v(T_4 - T_1) = (0.718\text{ kJ/kg}\cdot\text{K})(920.6 - 293)\text{K} = 450.6\text{ kJ/kg}$$

$$w_{net,out} = q_{in} - q_{out} = 1235 - 450.6 = 784.4\text{ kJ/kg}$$

$$\eta_{th} = \frac{w_{net,out}}{q_{in}} = \frac{784.4\text{ kJ/kg}}{1235\text{ kJ/kg}} = \mathbf{63.5\%}$$

(*b*)

$$v_1 = \frac{RT_1}{P_1} = \frac{(0.287\text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(293\text{ K})}{95\text{ kPa}} = 0.885\text{ m}^3/\text{kg} = v_{max}$$

$$v_{min} = v_2 = \frac{v_{max}}{r}$$

$$\text{MEP} = \frac{w_{net,out}}{v_1 - v_2} = \frac{w_{net,out}}{v_1(1-1/r)} = \frac{784.4\text{ kJ/kg}}{(0.885\text{ m}^3/\text{kg})(1-1/20)}\left(\frac{\text{kPa}\cdot\text{m}^3}{\text{kJ}}\right) = \mathbf{933\text{ kPa}}$$

**<u>Exercice 02 :</u>**

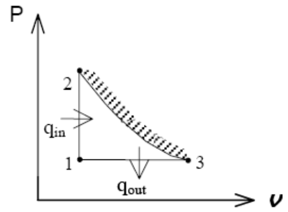
Rattrapage de Thermodynamique

The three processes of an air-standard cycle are described. The cycle is to be shown on *P*-$v$ and *T*-*s* diagrams, and the net work per cycle and the thermal efficiency are to be determined.

***Assumptions*** **1** The air-standard assumptions are applicable. **2** Kinetic and potential energy changes are negligible. **3** Air is an ideal gas with variable specific heats.

***Properties*** The properties of air are given in Table A-17.

***Analysis*** (*b*) The properties of air at various states are

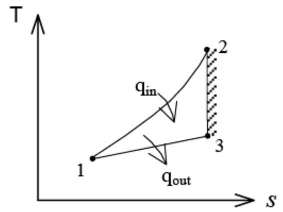



$$T_1 = 290 \text{ K} \longrightarrow \begin{array}{l} u_1 = 206.91 \text{ kJ/kg} \\ h_1 = 290.16 \text{ kJ/kg} \end{array}$$

$$\frac{P_2 v_2}{T_2} = \frac{P_1 v_1}{T_1} \longrightarrow T_2 = \frac{P_2}{P_1} T_1 = \frac{380 \text{ kPa}}{95 \text{ kPa}} (290 \text{ K}) = 1160 \text{ K}$$

$$\longrightarrow u_2 = 897.91 \text{ kJ/kg}, \; P_{r_2} = 207.2$$

$$P_{r_3} = \frac{P_3}{P_2} P_{r_2} = \frac{95 \text{ kPa}}{380 \text{ kPa}} (207.2) = 51.8 \longrightarrow h_3 = 840.38 \text{ kJ/kg}$$




$$Q_{in} = m(u_2 - u_1) = (0.003 \text{ kg})(897.91 - 206.91) \text{kJ/kg} = 2.073 \text{ kJ}$$

$$Q_{out} = m(h_3 - h_1) = (0.003 \text{ kg})(840.38 - 290.16) \text{kJ/kg} = 1.651 \text{ kJ}$$

$$W_{net,out} = Q_{in} - Q_{out} = 2.073 - 1.651 = \mathbf{0.422 \text{ kJ}}$$

(c) $$\eta_{th} = \frac{W_{net,out}}{Q_{in}} = \frac{0.422 \text{ kJ}}{2.073 \text{ kJ}} = \mathbf{20.4\%}$$