

Niveau : M1PA

Durée : 01H30

Calculatrice autorisée- Pas de documents sauf les tables.

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

**Exercice :**

Soit un cycle Diesel théorique 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 :**  $C_p(\text{air}) = 1,005 \text{ kJ/kg.K}$ ,  $C_v(\text{air}) = 0,718 \text{ kJ/kg.K}$ ,  $R = 0,287 \text{ kJ/kg.K}$ ,  
et  $k = 1,4$

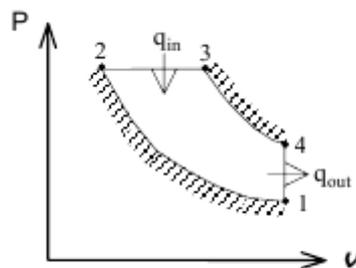


Figure 01 : Cycle de turbine à gaz.

**Problème :**

Soit un réfrigérateur fonctionnant selon le cycle à compression de vapeur idéal. Les pressions minimale et maximale du cycle sont respectivement de 0,12 MPa et de 0,7 MPa. Le débit massique du réfrigérant R134a est de 0,05 kg/s. Déterminez :

1. La puissance thermique extraite du milieu réfrigéré  $\dot{Q}_L$ .
2. La puissance consommée par le compresseur  $\dot{W}_{in}$ .
3. La puissance thermique évacuée dans le milieu extérieur  $\dot{Q}_H$ .
4. Le coefficient de performance (COP).

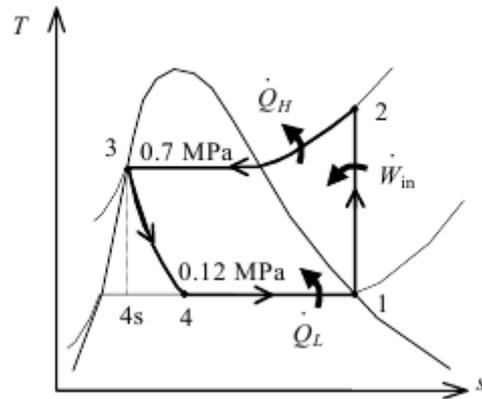


Figure 02 : Cycle de réfrigération.

« Les jours se suivent et ne ressemblent pas »

Dr H.Madani

Contrôle de Thermodynamique

**Exercice :**

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  $c_p = 1.005 \text{ kJ/kg}\cdot\text{K}$ ,  $c_v = 0.718 \text{ kJ/kg}\cdot\text{K}$ ,  $R = 0.287 \text{ kJ/kg}\cdot\text{K}$ , 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:  $P = \text{constant}$  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.

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

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

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

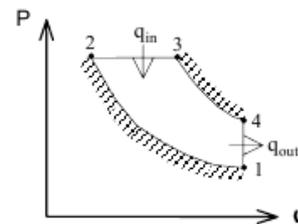
$$w_{\text{net,out}} = q_{\text{in}} - q_{\text{out}} = 1235 - 450.6 = 784.4 \text{ kJ/kg}$$

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

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

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

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



Contrôle de Thermodynamique

**Problème :**

**Analysis (a)** In an ideal vapor-compression refrigeration cycle, the compression process is isentropic, the refrigerant enters the compressor as a saturated vapor at the evaporator pressure, and leaves the condenser as saturated liquid at the condenser pressure. From the refrigerant tables (Tables A-12 and A-13),

$$\left. \begin{array}{l} P_1 = 120 \text{ kPa} \\ \text{sat. vapor} \end{array} \right\} \begin{array}{l} h_1 = h_g @ 120 \text{ kPa} = 236.97 \text{ kJ/kg} \\ s_1 = s_g @ 120 \text{ kPa} = 0.94779 \text{ kJ/kg} \cdot \text{K} \end{array}$$

$$\left. \begin{array}{l} P_2 = 0.7 \text{ MPa} \\ s_2 = s_1 \end{array} \right\} \begin{array}{l} h_2 = 273.50 \text{ kJ/kg} \quad (T_2 = 34.95^\circ\text{C}) \end{array}$$

$$\left. \begin{array}{l} P_3 = 0.7 \text{ MPa} \\ \text{sat. liquid} \end{array} \right\} \begin{array}{l} h_3 = h_f @ 0.7 \text{ MPa} = 88.82 \text{ kJ/kg} \end{array}$$

$$h_4 \cong h_3 = 88.82 \text{ kJ/kg} \text{ (throttling)}$$

Then the rate of heat removal from the refrigerated space and the power input to the compressor are determined from

$$\dot{Q}_L = \dot{m}(h_1 - h_4) = (0.05 \text{ kg/s})(236.97 - 88.82) \text{ kJ/kg} = \mathbf{7.41 \text{ kW}}$$

and

$$\dot{W}_{in} = \dot{m}(h_2 - h_1) = (0.05 \text{ kg/s})(273.50 - 236.97) \text{ kJ/kg} = \mathbf{1.83 \text{ kW}}$$

(b) The rate of heat rejection to the environment is determined from

$$\dot{Q}_H = \dot{Q}_L + \dot{W}_{in} = 7.41 + 1.83 = \mathbf{9.23 \text{ kW}}$$

(c) The COP of the refrigerator is determined from its definition,

$$\text{COP}_R = \frac{\dot{Q}_L}{\dot{W}_{in}} = \frac{7.41 \text{ kW}}{1.83 \text{ kW}} = \mathbf{4.06}$$

