التجربة رقم (1)

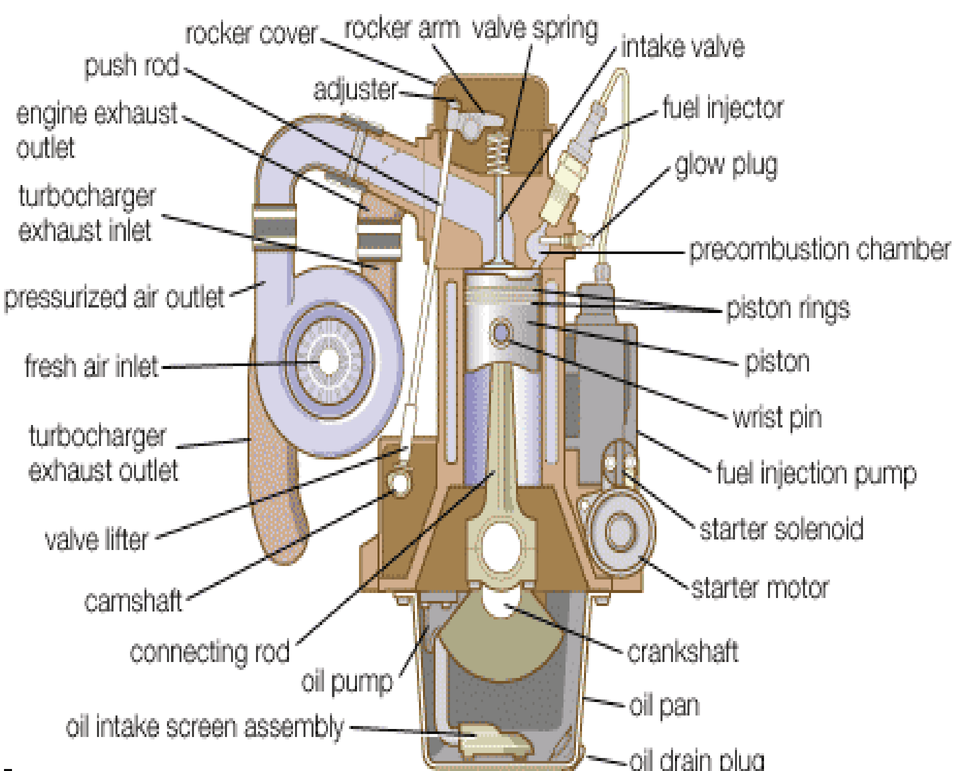
ا-اسم التجربة: "Engine Components"& "Otto and Diesel Cycles"

ب -الغرض من التجربة:

1. التعرف على محركات الاحتراق الداخلي وأنواعها وطرق تصنيفها وخواصها الرئيسية
2. التعرف على مبدأ عمل محرك الاتقاد بالشرارة (SI) ومحرك الاتقاد بالضغط (CI).
3. الشاحن الفائق (Supercharger) و الشاحن التوربيني (Turbocharger).

جـ -وصف الجهاز:

1. محرك الاحتراق الداخلي: هو ذلك المحرك الحراري (Heat Engine) الذي يتم فيه احتراق الوقود والماد المؤكسدة (الهواء عادة) في حيز مغلق يسمى غرفة الاحتراق (Combustion Chamber). هذا التفاعل الحراري يؤدي الى تكوين غازات في درجة حرارة وضغط عاليين حيث تتوسع هذه الغازات لتضغط على المكبس المرتبط بعمود المرفق والذي بدوره يحول الحركة الترددية للمكبس الى حركة دورانية يمكن الاستفادة منها في توليد الطاقة أو تدوير بعض الأجزاء ... الخ.



2. Main Engine Components:

a) Block body of engine containing the cylinders made of cast-iron or aluminum. The block of water –cooled engine includes a water jacket cast around the cylinders. On air cooler engines, the exterior surface of the block has cooling fins.

b) Camshaft: rotating shaft used to push open valves at the proper time in the engine cycle either directly or through mechanical or hydraulic linkage (push rod, rocker arms). Camshafts are generally made of forged steel or cast-iron and are driven off the crankshaft by means of belts or chain. In four stroke engines, the camshaft rotates at half engine speed.

c) Combustion Chamber: the end of the cylinder between the head and the piston face where combustion occurs. The size of the combustion chamber continuously changes from a minimum volume when the piston is at TDC, a maximum value of volume is when the piston at BDC.

d) Connecting Rod: rod connecting the piston with the rotating crankshaft. Usually made of steel or alloy forging in most engines, but may be aluminum in some small engines.

e) Crankcase: part of the engine block surrounding the rotating crankshaft. In many engines, the oil pan makes up part of the crankcase housing.

f) Crankshaft: rotating shaft through which engine work output is supplied to external system. The crankshaft is connected to the engine block with the main bearings. It is rotated by reciprocating pistons through connecting rods connected to the crankshaft, offset from the axis of rotation. This offset is sometimes called crank throw or crank radius. Most crankshafts are made of forged steel, while some are made of cast-iron.

g) Cylinders: the circular cylinders in the engine block in which the pistons reciprocating back and forth. The walls of the cylinders have highly polished hard surfaces. Cylinders may be machined directly in the engine block, a hard metal (drown steel) may be pressed into the softer metal block.

h) Exhaust Manifold: piping system which carries exhaust gases away from the engine cylinders, usually made of cast-iron.

i) Head: the piece which closes the end of the cylinders usually containing part of the clearance volume of the combustion chamber.

j) Intake Manifold: piping system which delivers incoming air to the cylinders usually made of cast-iron metal, plastic, or composite material. The individual pipe to a single cylinder is called runner.

k) Piston: is cylindrical-shaped mass that reciprocates back and forth in the cylinder transmitting the pressure forces in the combustion chamber to the rotating crankshaft. The top of the piston is called the (crown) and the sides are called the (skirt). Pistons are made of cast-iron, steel or aluminum.

l) Piston Rings: metal rings that fit into circumferential grooves around the piston and form a sliding surface against the cylinder walls. Near the top of the piston are usually two or more compression rings made of highly polished hard chrome steel. The propose of these is to form a seal between the piston and cylinder walls and to restrict the high pressure gases in combustion chamber from leaking past the piston into the crankcase. Below the compression rings on the piston is at least one oil ring which assists in lubricating the cylinder walls and scrapes away excess oil to reduce oil consumption.

m) Push Rods: mechanical linkages between the camshaft and valve.

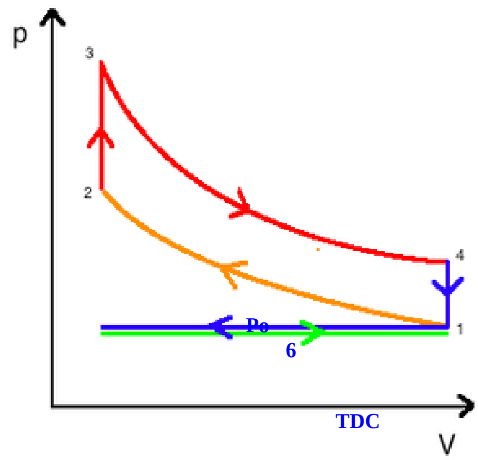
n) Spark Plug: electrical device used to initiate combustion in a spark ignition engine (SIE) by creating a high-voltage discharge across an electrode gap. Spark plugs are usually made of metal surrounded with ceramic insulation.

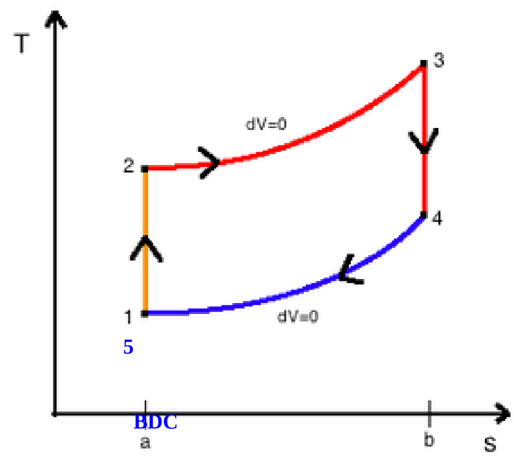
o) Valves: used to allow flow into and out of the cylinder at the proper time in the cycle. Most engines use vales, which are spring loaded closed and pushed open by camshaft action. Valves are usually made of forged steel. Surfaces against which valves close are called valve seats and are made of hardened steel or ceramic. Rotary valves sometimes used, but are much less common.

p) Water Jacket: system of liquid flow passages surrounding the cylinder, usually constructed as part of engine block and head. Engine coolant flows through the water jacket and keeps the cylinder walls from overheating. The coolant is usually a water-ethylene glycol mixture.

3. Otto Cycle:

In 1876 Otto build a four-stroke internal combustion engine that compressed the air and gas before ignition.





$s_1 = s_2$ $\qquad$ $s_3 = s_4$

Process (6-1): Constant pressure intake of air at (P_o). Intake valve open and exhaust valve is closed.

$$P_1 = P_6 = P_o$$

$$w_{6-1} = P_o.(v_1 - v_6)$$

Process (1-2): Isentropic compression stroke. All valves are closed.

$$Q_{1-2} = 0$$

$$w_{1-2} = \frac{P_1.v_1 - P_2.v_2}{\gamma - 1} = \frac{R.(T_1 - T_2)}{\gamma - 1}$$

$$w_{1-2} = (u_1 - u_2) = C_v.(T_1 - T_2)$$

Process (2-3): Constant-volume heat input (combustion). All valves are closed.

$$v_3 = v_2 = v_{TDC}$$

$$w_{2-3} = 0$$

$$Q_{2-3} = Q_A = m_f.H_L.\eta_C = m_m.C_v.(T_3 - T_2) = (m_a + m_f).C_v.(T_3 - T_2)$$

$$H_L.\eta_C = (AF + 1).C_v.(T_3 - T_2)$$

Where: m_m =maximum mass of mixture.

$$q_{2-3} = q_A = C_v.(T_3 - T_2) = (u_3 - u_2)$$
$$T_3 = T_{max} \ \& \ P_3 = P_{max}$$

Process (3-4): Isentropic power or expansion stroke. All valves are closed.

$$q_{3-4} = 0$$

$$T_4 = T_3.\left(v_3 / v_4 \right)^{\gamma} = P_3.\left(v_3 / v_4 \right)^{\gamma-1} = T_3.\left(1 / r_C \right)^{\gamma-1}$$

$$P_4 = P_3.\left(v_3 / v_4 \right)^{\gamma} = P_3.\left(v_3 / v_4 \right)^{\gamma} = P_3.\left(1 / r_C \right)^{\gamma}$$

$$w_{3-4} = \frac{P_4.v_4 - P_3.v_3}{1-\gamma} = \frac{R.(T_4 - T_3)}{1-\gamma}$$

$$w_{3-4} = (u_3 - u_4) = C_v.(T_3 - T_4)$$

Process (4-5): Constant-volume heat rejection (exhaust blow down). Exhaust valve open and intake valve is closed.

$$v_5 = v_4 = v_1 = v_{BDC}$$
$$w_{4-5} = 0$$

$$Q_{4-5} = Q_R = m_m.C_v.(T_5 - T_4) = m_m.C_v.(T_1 - T_4)$$
$$q_{4-5} = q_R = C_v.(T_5 - T_4) = C_v.(T_1 - T_4) = (u_5 - u_4)$$

Process (5-6): Constant-pressure exhaust stroke at (P_o). Exhaust valve open and intake valve is closed.

$$P_5 = P_6 = P_o$$

$$w_{5-6} = P_o.(v_6 - v_5) = P_o.(v_6 - v_1)$$

$$\eta_{th})_{otto} = \frac{w_a}{q_A} = 1 - \frac{q_{out}(q_{reject})}{q_A} = 1 - \left[C_v(T_4 - T_1) / C_v(T_3 - T_2) \right] = 1 - \left[(T_4 - T_1) / (T_3 - T_2) \right]$$

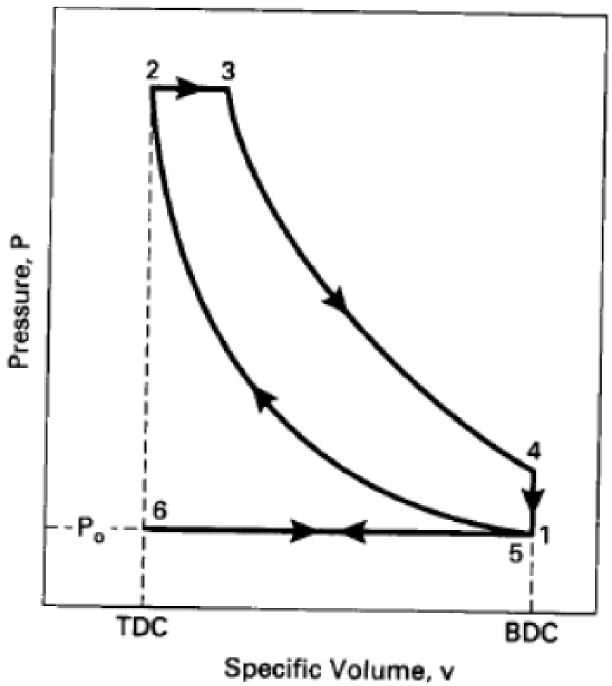
$$\eta_{th})_{otto} = 1 - \frac{T_1}{T_2}$$

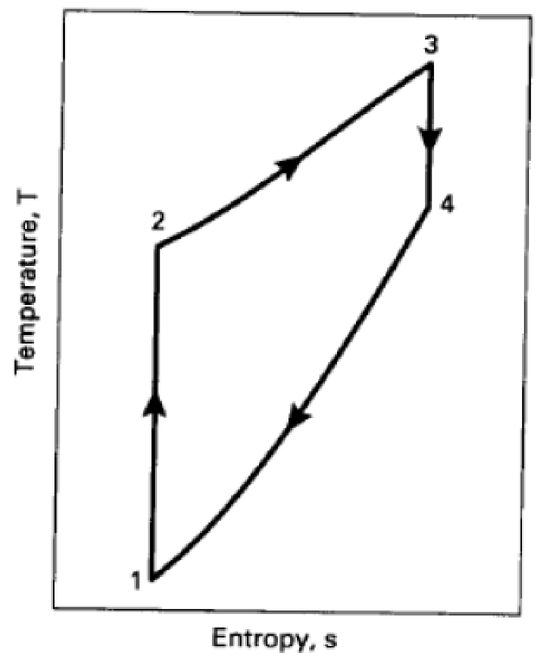
Using the above equations:

$$\eta_{th})_{otto} = 1 - \left(\frac{1}{r_C}\right)^{\gamma-1}$$

4. Diesel Cycle:

In 1890/1892 Rudolf Diesel and Akroyd Stuart planed and produced a new type of engine which was burning coal dust as fuel.





Process (6-1): Constant pressure intake of air at (P_o). Intake valve open and exhaust valve is closed.

$$P_1 = P_6 = P_o$$

$$w_{6-1} = P_o.(v_1 - v_6)$$

Process (1-2): Isentropic compression stroke. All valves are closed.

$$V_2 = V_{TDC} \; \& \; q_{1-2} = 0$$

$$w_{1-2} = \frac{P_2.v_2 - P_2.v_2}{1-\gamma} = \frac{R.(T_2 - T_1)}{1-\gamma}$$
$$w_{1-2} = (u_1 - u_2) = C_v.(T_1 - T_2)$$

Process (2-3): Constant-pressure heat input (combustion). All valves are closed.

$$P_3 = P_2$$

$$Q_{2-3} = Q_A = m_f.H_L.\eta_C = m_m.C_p.(T_3 - T_2) = (m_a + m_f).C_p.(T_3 - T_2)$$
$$H_L.\eta_C = (AF + 1).C_p.(T_3 - T_2)$$
$$q_{2-3} = q_A = C_p..(T_3 - T_2) = .(h_3 - h_2)$$

$$w_{2-3} = q_{2-3} - .(u_3 - u_2) = P_2..(v_3 - v_2)$$
$$T_3 = T_{\max}$$

Process (3-4): Isentropic power or expansion stroke. All valves are closed.

$$q_{3-4} = 0$$

$$w_{3-4} = \frac{P_4.v_4 - P_3.v_3}{1-\gamma} = \frac{R.(T_4 - T_3)}{1-\gamma}$$
$$w_{3-4} = (u_3 - u_4) = C_v.(T_3 - T_4)$$

Process (4-5): Constant-volume heat rejection (exhaust blow down). Exhaust valve open and intake valve is closed.

$$v_5 = v_4 = v_1 = v_{BDC}$$
$$w_{4-5} = 0$$

$$Q_{4-5} = Q_R = m_m.C_v.(T_5 - T_4) = m_m.C_v.(T_1 - T_4)$$
$$q_{4-5} = q_R = C_v.(T_5 - T_4) = C_v.(T_1 - T_4) = (u_5 - u_4)$$

Process (5-6): Constant-pressure exhaust stroke at (P_o). Exhaust valve open and intake valve is closed.

$$P_5 = P_6 = P_o$$

$$w_{5-6} = P_o.(v_6 - v_5) = P_o.(v_6 - v_1)$$

$$\eta_{th})_{Diesel} = \frac{w_a}{q_A} = 1 - \frac{q_{out}(q_{reject})}{q_A} = 1 - \left[C_v(T_4 - T_1) \big/ C_p(T_3 - T_2) \right] = 1 - \left[(T_4 - T_1) \big/ \gamma.(T_3 - T_2) \right]$$

$$\eta_{th})_{Diesel} = 1 - \frac{1}{\gamma}\left[\frac{\left(T_4/T_1 - 1 \right)}{\left(T_3/T_2 - 1 \right)} * \frac{T_1}{T_2} \right]$$

$$T_1/T_2 = \left(v_2/v_1 \right)^{\gamma-1} \ \& \ \left(v_3/v_4 \right)^{\gamma-1} = T_4/T_3$$

$$v_3/v_2 = T_3/T_2 \ \& \ v_4 = v_1$$

With rearrangement, this can be shown to equal:

$$\eta_{th})_{Diesel} = 1 - \frac{1}{\gamma}\left[\frac{\left(v_3/v_2 \right)^{\gamma} - 1}{\left(v_3/v_2 \right) - 1} \right] * \left(v_2/v_1 \right)^{\gamma-1}$$

$$\therefore \eta_{th})_{Diesel} = 1 - \left(\frac{1}{r_C} \right)^{\gamma-1} * \left[\frac{\beta^{\gamma} - 1}{\gamma(\beta - 1)} \right]$$

Where: $\beta = \text{Cutoff Ratio} = \frac{v_3}{v_2} = \frac{T_3}{T_2}$

Cutoff ratio is defined as the change in volume that occurs during combustion.

د. المناقشــة:

1. قارن بين محرك الاتقاد بالشرارة (SI) ومحرك الاتقاد بالضغط (CI)
2. ما هو الفرق بين الــ Supercharger و الــ Turbocharger
3. ما هو الفرق بين المحركات ثنائية الأشواط والمحركات رباعية الأشواط
4. أثبت أن: $\eta_{th})_{otto} = 1 - \frac{T_1}{T_2}$
5. دائمـاً: $1 < \beta < r_c$، لمــاذا؟
6. بين فائدة كل من الأجزاء التالية: **أ)** ذراع التوصيل، **ب)** عمود الحدبات، **ج)** حلقات المكبس، **د)** القرص الدوار، **هـ)** المكبس.
7. لماذا تعمل معظم المحركات الصغيرة على الدورة الثنائية، بينما تعمل معظم المحركات الكبيرة على الدورة الرباعية.
8. لماذا صمام الإدخال في محركات الاحتراق الداخلي يكون حجمه أكبر قياسا الى صمام الإخراج.
9. عدد أجزاء المحرك وتصنيف المحركات بالتفصيل.