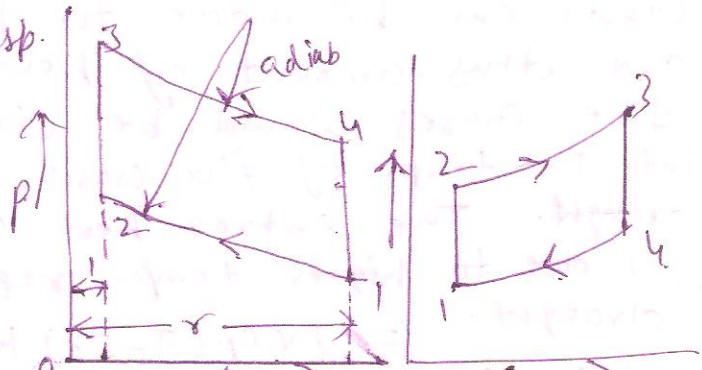


(ii) Derive an expression for air standard efficiency of Otto cycle. and comment on it.

Ans. The present day Petrol engine operates on this cycle. This is known so because it was introduced in practical form by a German Scientist Otto, in 1876. Although it was described by Beaudeloch in 1862.

Fig. Shows P-V and T-S Diagram Resp.

- 1-2 Adiabatic Compression
- 2-3 Heat addition
- 3-4 Adiabatic expansion
- 4-1 Heat rejection.



Let P_1, V_1, T_1 be the conditions of air in the cylinder initially to the point 1. The piston compressor the air adiabatically and at the end of stroke. Let the conditions are P_2, V_2 and T_2 . Let clearance volume $= V_3 = V_2 = V_4$

Ratio of Expansion during the adiabatic expansion 3-4

$$r = \frac{V_4}{V_3} = \frac{V_4}{V_1} = V_4$$

$$\therefore V_4 = r$$

Ratio of Compression during the Adiabatic Compression 1-2

$$= \frac{V_1}{V_2} = \frac{V_4}{V_3} = r \quad \left[\because \begin{matrix} V_3 = V_2 \\ V_4 = V_1 \end{matrix} \right]$$

Consider one kg of air in the cylinder

Heat supplied by hot body = Heat supplied during the const Vol. Stroke 2-3

$$= cv (T_3 - T_2)$$

Heat rejected to the cold body = Heat rejected during const Vol. 4-1

$$= cv (T_4 - T_1)$$

Work Done = Heat supplied - Heat rejected

$$= cv (T_3 - T_2) - cv (T_4 - T_1)$$

$$\text{Efficiency } (\eta) = \frac{\text{work Done}}{\text{Heat supplied}} = \frac{cv (T_3 - T_2) - cv (T_4 - T_1)}{cv (T_3 - T_2)} = 1 - \frac{T_4 - T_1}{T_3 - T_2} \quad \text{--- (i)}$$

Now Process 1-2 $\frac{T_2}{T_1} = r^{\gamma-1}$ or $T_1 = \frac{T_2}{r^{\gamma-1}} \quad \text{--- (ii)}$

Similarly Process 3-4 $\frac{T_3}{T_4} = r^{\gamma-1}$ or $T_4 = \frac{T_3}{r^{\gamma-1}} \quad \text{--- (iii)}$

Substituting the value of T_1 and T_4 from (ii) & (iii) in (i)

$$\eta = 1 - \frac{\frac{T_3}{r^{\gamma-1}} - \frac{T_2}{r^{\gamma-1}}}{T_3 - T_2} = 1 - \frac{1}{r^{\gamma-1}} \cdot \frac{T_3 - T_2}{T_3 - T_2}$$

$$\eta = 1 - \frac{1}{r^{\gamma-1}}$$