Otto Cycle (constant volume cycle): The present day petrol engine operates on this cycle.

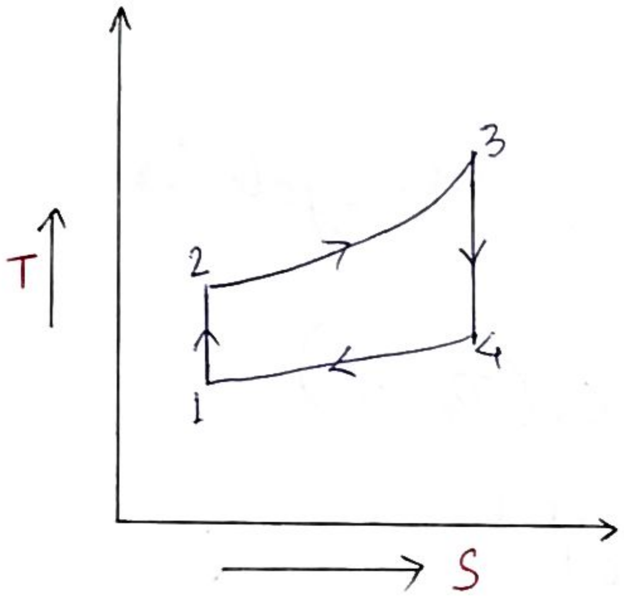


Fig: 1

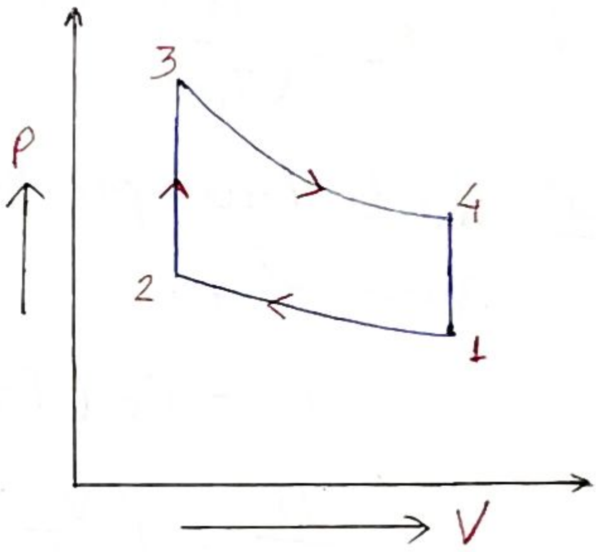


Fig: 2

The ideal cycle which is shown in fig 1 & 2 on T-S and P-V diagrams resp. consists of the following operation.

1-2 : Adiabatic compression

2-3 : Heat addition at const. volume

3-4 : Adiabatic expansion

4-1 : Heat rejection at const. volume

* Q. Show that compression ratio R_C for the max^m work to be done per kg of air in an engine working on otto cycle bet^n upper and lower units of absolute temp^r of T_3 & T_1 is given by $R_C = \left(\frac{T_3}{T_1}\right)^{\frac{1}{2(\gamma-1)}}$

Sol^n Work done per kg of air in the cycle is given by,

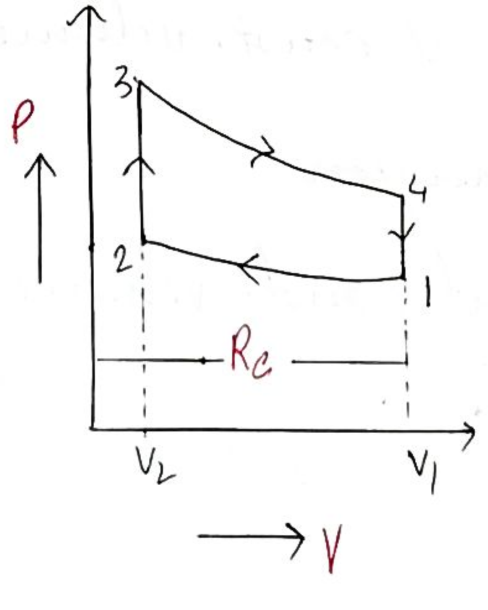
$$W = C_V(T_3 - T_2) - C_V(T_4 - T_1)$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = (R_C)^{\gamma-1}$$

$$T_2 = T_1 \times (R_C)^{\gamma-1}$$

Similarly, $T_3 = T_4 \times (R_C)^{\gamma-1}$

$$W = C_V\left[T_3 - T_1(R_C)^{\gamma-1} - \frac{T_3}{(R_C)^{\gamma-1}} + T_1\right]$$



In the above eq^n as upper and lower temp^s are fixed, therefore, W is a function of R_C.

For maximum value of W, $\frac{dW}{dR_C} = 0$

$$\Rightarrow -C_v T_1 (\gamma-1)(R_c)^{\gamma-2} - C_v(1-\gamma) T_3 (R_c)^{1-\gamma-1} = 0$$

$$\Rightarrow -C_v T_1 (\gamma-1)(R_c)^{\gamma-2} + C_v(\gamma-1) T_3 (R_c)^{-\gamma} = 0$$

$$\Rightarrow T_3 (R_c)^{-\gamma} = T_1 (R_c)^{\gamma-2}$$

$$\Rightarrow R_c = \left(\frac{T_3}{T_1}\right)^{1/2(\gamma-1)}$$