- There are 5 different thermodynamic processes.

1) Adiabatic or Isentropic
2) Isothermal - (Constant temperature) process
3) Isobaric - (Constant pressure) process
4) Isochoric - (Constant Volume) process
5) Polytropic process

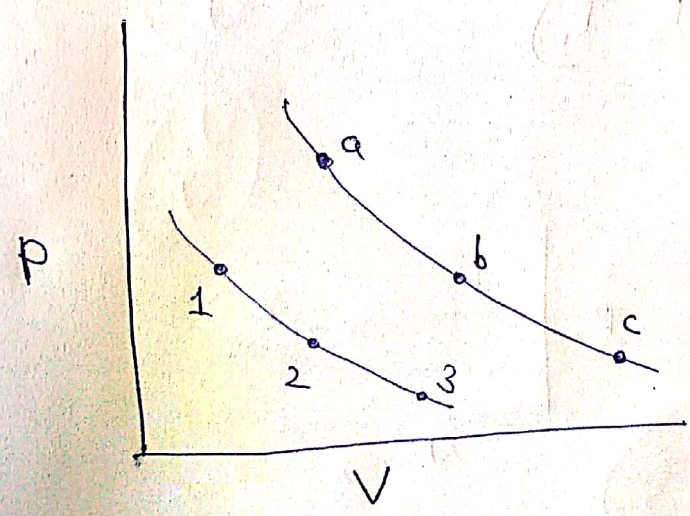
Adiabatic Process

$PV^{\gamma} = \text{Constant}$

$TV^{\gamma-1} = \text{Constant}$

$TP^{\frac{1-\gamma}{\gamma}} = \text{Constant}$

γ = Heat Capacity Ratio
= Adiabatic Index
= Isentropic expansion factor
= Ratio of specific heats
$= \frac{C_p}{C_v}$

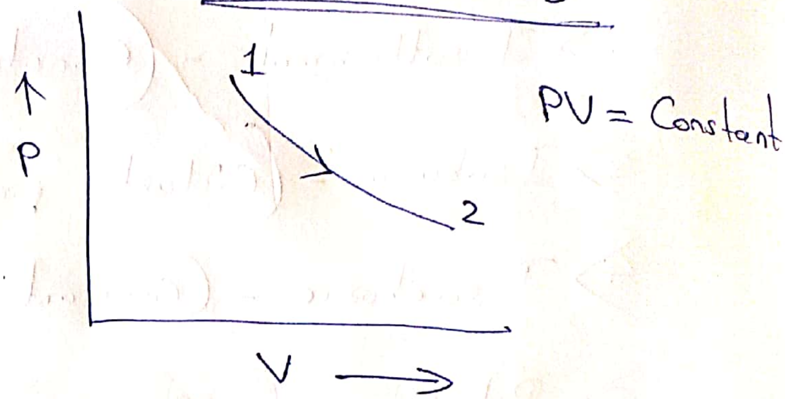


① $P_a V_a^{\gamma} = P_b V_b^{\gamma} = P_c V_c^{\gamma}$ //

② $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$ //

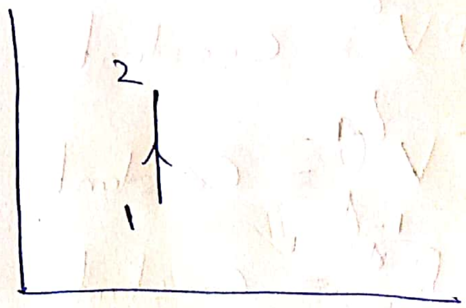
Heat addition in different processes

1. Isothermal process $\Rightarrow$ $P_1 V_1 \ln\left\{\frac{V_2}{V_1}\right\}$



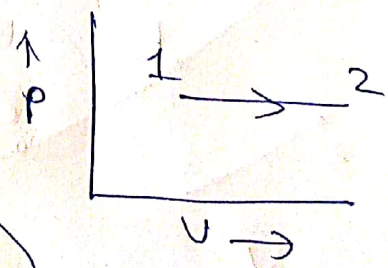
$\Rightarrow$ $P_2 V_2 \ln\left\{\frac{V_2}{V_1}\right\}$

2. Constant Volume $\Rightarrow$



$$Q_{add} = m C_v (T_2 - T_1)$$

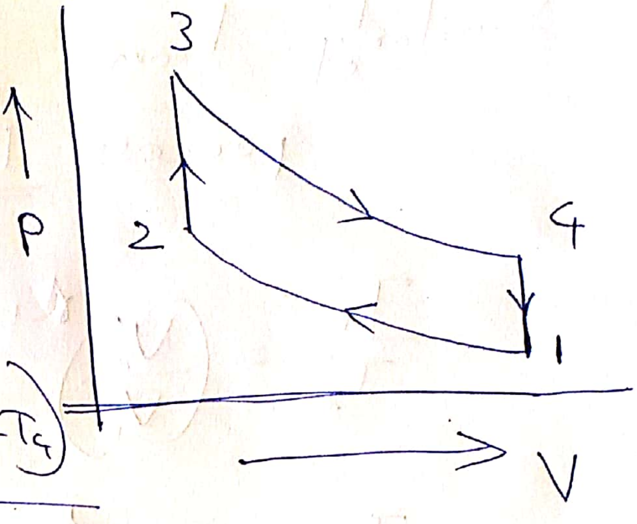
3. Constant Pressure $\Rightarrow$



$$Q_{add} = m C_p (T_2 - T_1)$$

Otto Cycle

Efficiency Derivation



$$\eta = \frac{Q_{add} - Q_{Rej}}{Q_{add}}$$

$$= \frac{m C_v (T_3 - T_2) - m C_v (T_1 - T_4)}{m C_v (T_3 - T_2)}$$

$$= \frac{(T_3 - T_2) - (T_4 - T_1)}{(T_3 - T_2)}$$

$$= 1 - \frac{(T_4 - T_1)}{(T_3 - T_2)}$$

$$= 1 - \frac{T_4}{T_3} \frac{(1 - T_1/T_4)}{(1 - T_2/T_3)} \quad \text{———} \quad (1)$$

In the adiabatic Process 3 to 4

$$T_3 V_3^{\gamma-1} = T_4 V_4^{\gamma-1}$$

$$\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma-1} \quad \text{——} \quad (2)$$

$$\boxed{\frac{V_4}{V_3} = \frac{V_1}{V_2} = r = \text{Compression Ratio}}$$

Similarly from process $\underline{\underline{1-2}}$

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1} \quad \text{——} \quad \cancel{(3)}$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} \quad \text{——} \quad (3)$$

(1)

$\Downarrow$

$$\eta = 1 - \frac{T_4\left(1 - T_1/T_4\right)}{T_3\left(1 - T_2/T_3\right)}$$

(2a)

$\Downarrow$

$$\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma-1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = r^{\gamma-1}$$

$$(3) \Rightarrow \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

From 2 & 3

$$\frac{T_3}{T_4} = \frac{T_2}{T_1}$$

$$\frac{T_1}{T_4} = \frac{T_2}{T_3} \quad \text{——— } (4)$$

Sub 2a & 4 in 1

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