For perfect gas $U = m C_v T$

Gain in internal Energy.

$$U_2 - U_1 = m C_v (T_2 - T_1)$$

Relationship between two specific Heats.

Consider a perfect gas being heated at constant Pressure from T_2 to T_1

$$Q = (U_2 - U_1) + W$$

$$U_2 - U_1 = m C_v (T_2 - T_1)$$

$$Q = m C_v (T_2 - T_1) + W$$

For Constant Pressure. Work, $W = P(V_2 - V_1)$
$= mR(T_2 - T_1)$

$$Q = m C_v (T_2 - T_1) + mR(T_2 - T_1)$$
$$= m(C_v + R)(T_2 - T_1) \quad \text{—①}$$

but for constant Pressure $= m C_p (T_2 - T_1)$ —②.

$$\boxed{C_v = \frac{R}{\gamma - 1}}$$
$$\boxed{C_p = \frac{\gamma R}{\gamma - 1}}$$

equating equ. ① & ②

$$m(C_v + R)(T_2 - T_1) = m C_p (T_2 - T_1)$$

$$\boxed{C_v + R = C_p}$$

~~[illegible]~~ or $C_p - C_v = R$.

$$\therefore \gamma = \frac{C_p}{C_v}$$

$$\frac{C_p}{C_v} - 1 = \frac{R}{C_v} \Rightarrow \gamma - 1 = \frac{R}{C_v}$$

Enthalpy :- The fundamental quantities which occur invariably in thermodynamics is the sum of internal energy (u) and pressure volume product (pv). This sum is called Enthalpy (h)

$$[h = u + pv]$$

or

$$H = U + PV \quad \text{where } H = mh$$

from

$$h = u + pv$$

$$= C_v T + RT \Rightarrow (C_v + R) T$$

$$h = C_p T$$

or

$$H = m C_p T$$

* **Application of Ist law in non flow or closed system.**

(1) Heat transfer in Reversible Const Volume (Isochoric) Process (v = Const.)

$$[\delta Q = du + \delta W]$$

$$Q_{1-2} = (u_2 - u_1) + W \qquad W = \int_1^2 P dv = 0$$

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

or

$$\boxed{Q = m C_v (T_2 - T_1)}$$

2→ Reversible Const. Pressure (Isobaric) Process ($P =$ const)

$$\delta Q = du + \delta W$$

$$Q = (u_2 - u_1) + W$$

$$Q = (u_2 - u_1) + P(V_2 - V_1)$$

$$Q = u_2 - u_1 + P_2V_2 - P_1V_1$$

$$= (u_2 + P_2V_2) - (u_1 + P_1V_1)$$

$$\underline{Q = (h_2 - h_1)}$$ $\because h = C_pT$

$$Q = C_p(T_2 - T_1)$$

3→ <u>For Isothermal</u>

$$\delta Q = \cancelto{0}{du} + \delta W$$ $u = f(T)$

$$Q = W$$

W for isothermal

$$= P_1V_1 \ln\frac{V_2}{V_1}$$

$$\boxed{Q = P_1V_1 \ln\frac{V_2}{V_1}}$$

or

$$\boxed{Q = P_1V_1 \ln\frac{P_1}{P_2}}$$

4. Reversible Adiabatic Process ($pv^{\gamma} = const$)

$$Q = (U_2 - U_1) + W$$

For Adiabatic Process heat transfer is 'zero'

$$0 = (U_2 - U_1) + W$$

or

$$du + \int P dv = 0$$

$$C_v dT + \left(\frac{P_1 v_1 - P_2 v_2}{(\gamma - 1)}\right) = 0$$

$$C_v (T_2 - T_1) = \frac{P_2 v_2 - P_1 v_1}{\gamma - 1}$$

$$C_v \cancel{(T_2 - T_1)} = \frac{R \cancel{(T_2 - T_1)}}{(\gamma - 1)}$$

$$\boxed{C_v = \frac{R}{\gamma - 1}}$$

5 Polytropic process

$$\delta Q = du + \delta W$$

$$Q = C_v(T_2 - T_1) + \frac{R(T_1 - T_2)}{n-1}$$

$$Q = \frac{R(T_1 - T_2)}{n-1} - C_v(T_1 - T_2)$$

$$\boxed{C_v = \frac{R}{\gamma - 1}}$$

$$Q = \frac{R}{n-1}(T_1 - T_2) - \frac{R}{\gamma - 1}(T_1 - T_2)$$

$$Q = R(T_1 - T_2) \cdot \left(\frac{1}{n-1} - \frac{1}{\gamma - 1}\right)$$

$$= R(T_1 - T_2)\left(\frac{\gamma - 1 - n + 1}{(\gamma - 1)(n-1)}\right).$$

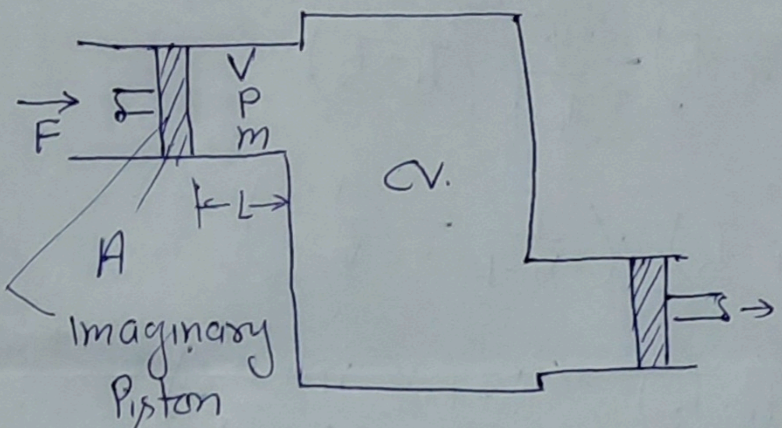
$$= \frac{R(T_1 - T_2)(\gamma - n)}{(\gamma - 1)(n-1)}$$

$$Q = \frac{(\gamma - n)}{(\gamma - 1)} \cdot \frac{R(T_1 - T_2)}{(n-1)}$$

$$\boxed{Q = \frac{(\gamma - n)}{(\gamma - 1)} \cdot W}$$

Flow Work

Unlike closed system, Control Volume involve mass flow across their boundaries and some Work is required to Push / Thrust / Impel the mass into or out of the Control volume. This Work is known as flow Work or flow energy.



The force applied on the fluid element by the Imaginary Piston is

$$F = PA$$

To Push the entire fluid element into the Control Volume, this force must be act through a distance 'L' so the Work done in Pushing the fluid element across the boundary.

$$W_{flow} = PA.L \Rightarrow PV \quad (KJ)$$

Per unit mass $\quad Pv \quad (KJ/kg)$