LECTURE 05

April 11, 2020

lecture – 5

Work done in different Thermodynamic process for gases: –

Work done for expansion of gas; $W = -P\Delta V$

In Expansion ΔV = +ve] work done by the gas.
W = -ve

When gas is Compressed: ΔV = -ve] work done on the gas
W = +ve

In other word we can say when gas is Compressed we say work is don on the System, but when gas expands we say work is done by the System.

Convension

Work done by the System = -ve
Work done on the System = +ve.

1. Work done in Isobaric process: –
It take place at Constant ~~volume~~ Pressure.
So $\Delta P = 0$.

$$W = P_{ext} \times \Delta V.$$

or $$W = -\int_{V_1}^{V_2} P_{ext}\, dV$$

11. Work done in Isochoric process:
It take place at Constant volume.
So $\Delta V = 0$.

$$W = -P_{ext} \times \Delta V$$
$$W = 0 \quad (\because \Delta V = 0).$$

Work done in Isothermal expansion.
It take place at constant temperature.

1) Reversible Isothermal expansion:

$$w = \int P_{ext}\, dv = -\int_{V_1}^{V_2} \frac{nRT}{V}\, dv$$

$$w = -nRT \int_{V_1}^{V_2} \frac{dv}{V}$$

$$= -nRT \ln \frac{V_2}{V_1}$$

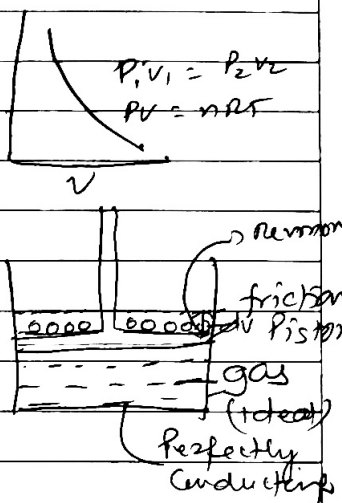
$$= -nRT \left[\ln V\right]_{V_1}^{V_2}$$

$$= -nRT \left[\ln V_2 - \ln V_1\right]$$

$$\boxed{w = -nRT \ln \frac{V_2}{V_1}}$$

OR $$\boxed{w = -2.303\, nRT \log_{10} \frac{V_2}{V_1}}$$

or $$\boxed{w = -2.303\, nRT \log_{10} \frac{P_1}{P_2}}$$



When a small object is removed from the surface of piston it goes up, gas expands, so temperature decreases, & hence wall will absorb heat from the system, & it make the temperature constant. & equilibrium is maintained, process was slow so it is reversible.

Note: Instead of nRT we can write PV also, because $PV = nRT$.

Irreversible expansion work done:

1) Vacuum or (free expansion)

$P_{ext} = 0$,

So $w = 0$.

ii) $P_{ext} << P_{gas}$

$w = -P_{ext} \times \Delta V$

Adiabatic expansion: (Reversible)

$q = 0$

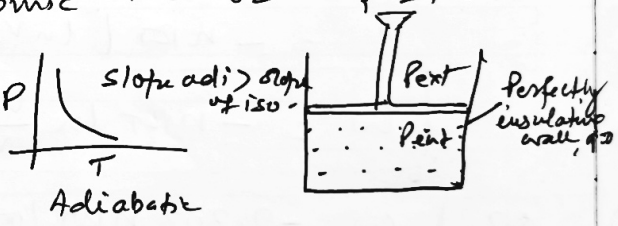
For adiabatic expansion, we can use Poisson's rule

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

When $\gamma = \frac{C_p}{C_v}$, for Monoatomic i.e H_2, N_2, Ar, $\gamma = 1.66$

Diatomic i.e N_2, O_2 $\gamma = 1.4$

Triatomic i.e CO_2 $\gamma = 1.33$



$w = -P_{ext} \times \Delta V$

$$w = \int_{V_1}^{V_2} P_{ex}\, dV$$

$$= -\int_{V_1}^{V_2} \frac{K}{V^{\gamma}} \cdot dV \quad (\because PV^{\gamma} = \text{const}) \quad \left(P = \frac{K}{V^{\gamma}}\right)$$

$$= \int_{V_1}^{V_2} V^{-\gamma}\, dV$$

$$= -K \left[\frac{V^{-\gamma+1}}{-\gamma+1}\right]_{V_1}^{V_2}$$

$$= \frac{K}{\gamma-1} \cdot \left(V_2^{-\gamma} V_2 - V_1^{-\gamma} V_1\right)$$

$$= \frac{K V_2^{-\gamma} V_2 - K V_1^{\gamma} V_1}{\gamma-1}$$

$w = \frac{nR}{\gamma-1}(T_2 - T_1)$ Adiabatic reversible.

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$$= \frac{P_2 V_2^{\gamma} V_2^{-\gamma} V_2 - P_1 V_1 V_1^{-\gamma} V_1}{\gamma-1}$$

$$= \frac{P_2 V_2 - P_1 V_1}{\gamma-1}$$

$$= \frac{nR(T_2 - T_1)}{\gamma-1} \quad (\because PV = nRT)$$

Work done in irreversible adiabatic

$w = -P_{ext} \times \Delta V$.