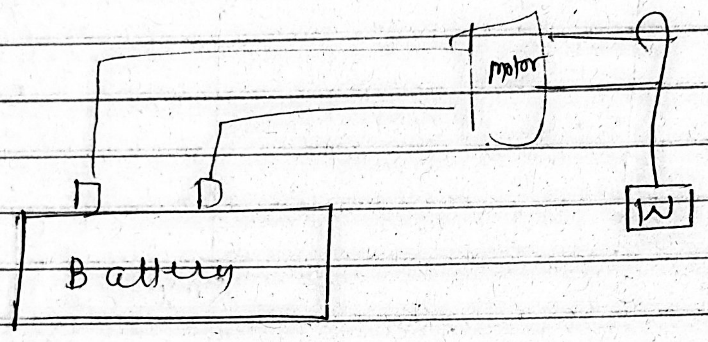
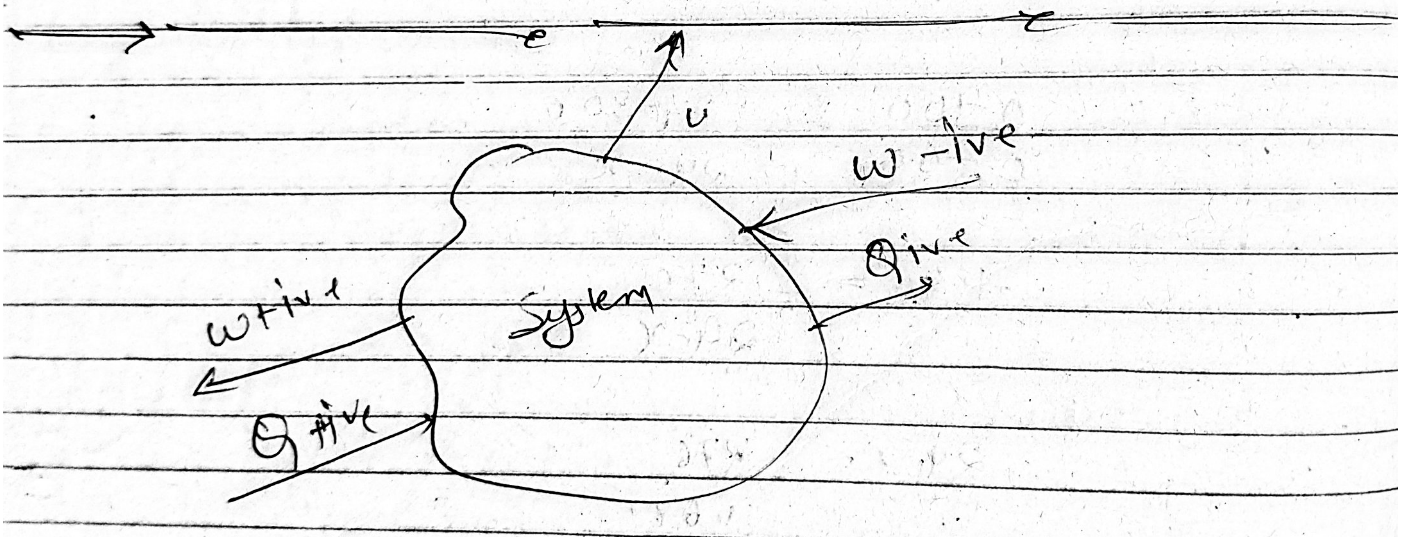
Heat & Work

Work:- Work is said to be done by system, if whole effect on the things external to the system getting reduced to rising of weight



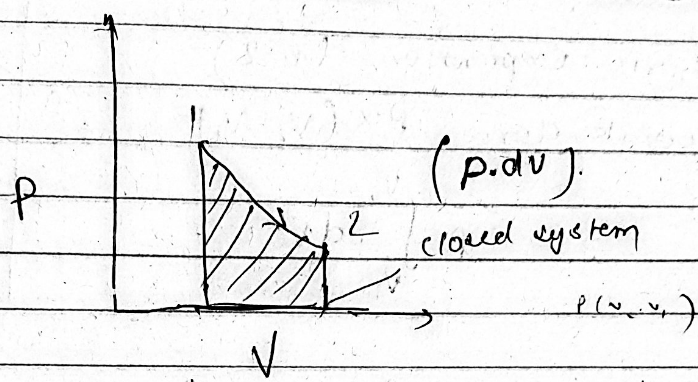


Turbine - work producing (closed sy

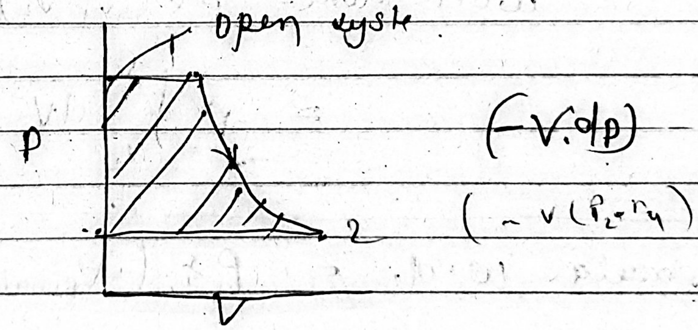
Pump - work consuming (open

Type of work :- (closed system work]

In the case of closed system work we project an area on x - axis or volume - axis



Open system work (flow work system



For closed system

1. Isobaric process or Isometric process :-

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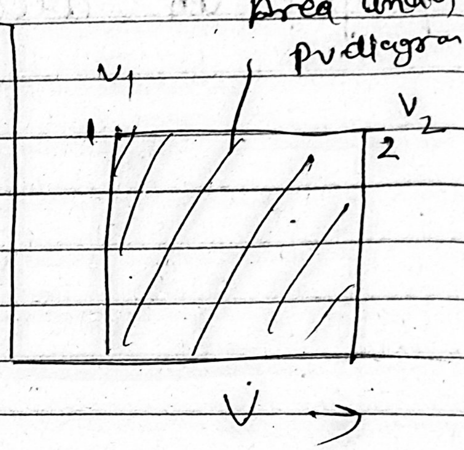
Isoboric expansion (1-2)

work done = $p \times (V_2 - V_1)$

$$= p \int_{V_1}^{V_2} dV$$



-ive

Isoboric compression (2-1)

work done = $p \times (V_1 - V_2)$ (negative work

$$= p \int_{V_2}^{V_1} dV$$

$$\boxed{\text{formula w.d.} = P \times (V_{final} - V_{inial})}$$

2. Isochronic process (const. volume process) :-

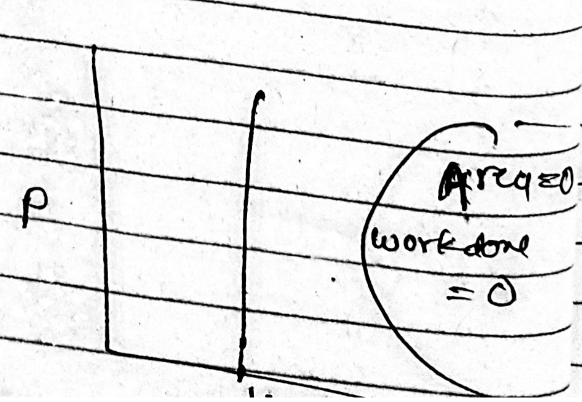
$W = p \cdot dV$

$\boxed{W.d. = 0}$

$dv = V_2 - V_1$

$= V_2 - V_2$

$= 0$

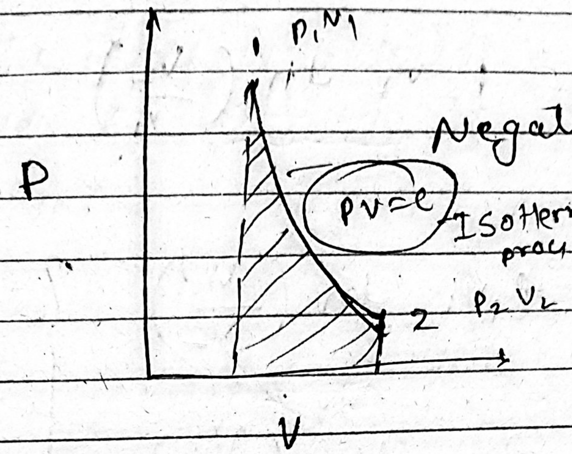


Isothermal process :-

$P_1V_1 = mRT$

$P_1V_1 = RT$ — ①

$P_2V_2 = RT$ — ②



Negative Rectangular Hyperbola (SSC 2014)

$$\boxed{P_1V_1 = P_2V_2} = \text{Const.}$$

$PV = C$

$P = C/V$

Work done $= \int_1^2 P \cdot dv$

$= \int_1^2 \frac{C}{V} \cdot dv$

$= C \ln (v)_1^2$

$= C \ln (V_2 - V_1)$

$= C (\ln V_2 - \ln V_1)$

$= C \ln \left(\frac{V_2}{V_1}\right)$

Only in Expansion process

$$\left.\begin{aligned} &= P_1 V_1 \ln\left(\frac{V_2}{V_1}\right) \\ &= P_2 V_2 \ln\left(\frac{V_2}{V_1}\right) \end{aligned}\right\} \text{——— (1)}$$

Only in compression process

$$\left.\begin{aligned} &= P_1 V_1 \ln\left(\frac{V_1}{V_2}\right) \\ &= P_2 V_2 \ln\left(\frac{V_1}{V_2}\right) \end{aligned}\right\}$$

Generalised formula

imp

$$\boxed{P_1 V_1 \ln \frac{V_F}{V_I} = P_2 V_2 \ln \frac{V_F}{V_I}}$$

$$P_1 V_1 = P_2 V_2$$

$$\boxed{\frac{P_1}{P_2} = \frac{V_2}{V_1}}$$

in eq. (1)

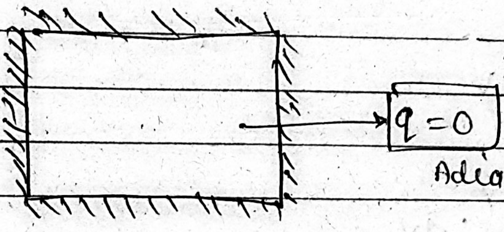
$$= P_1 V_1 \ln\left(\frac{V_2}{V_1}\right)$$

$$\boxed{= P_1 V_1 \ln\left(\frac{P_1}{P_2}\right)}$$

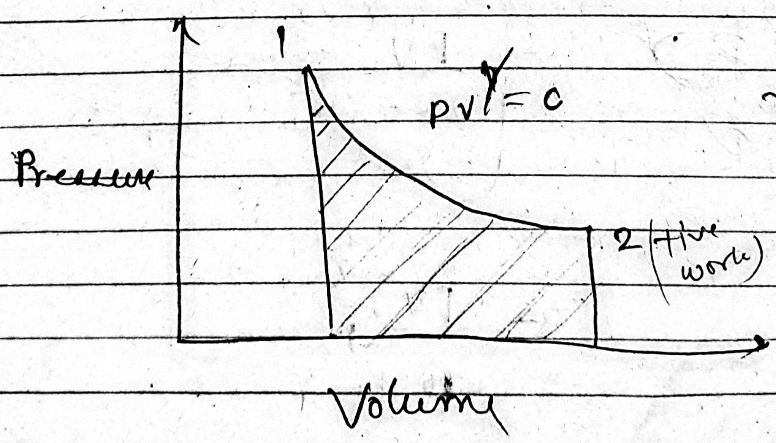
GENERALIZed equation

M.Temp $\boxed{P_1V_1 \ln \frac{P_I}{P_F} = P_2V_2 \ln \frac{P_I}{P_F}}$ Compres

Adiabatic process :-



A adiabatic process is assume to be an ideal process which is not possible in real ~~body~~ world. In this process there is no heat low (heat transfer) as well as the process ~~the~~ Isentropic process.



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

$C_p = \frac{KJ}{Kg\text{-}K}$

$${}_1W_2 = \int_1^2 P \times dV$$

$$PV^{\gamma} = C \qquad P = \frac{C}{V^{\gamma}}$$

$$= \int_1^2 P \times dV$$

$$= \int_1^2 \frac{C}{V^{\gamma}} \cdot dV$$

$$= C\int_1^2 V^{-\gamma} \cdot dV$$

$$= C\left[\frac{V^{-\gamma+1}}{-\gamma+1}\right]_1^2$$

$$= \cancel{PV^{\gamma}} \quad = \left[\frac{PV^{\gamma-\gamma+1}}{-\gamma+1}\right]_1^2$$

$$= \frac{(PV)_1^2}{1-\gamma}$$

$$= \left(\frac{P_2V_2 - P_1V_1}{1-\gamma}\right)$$

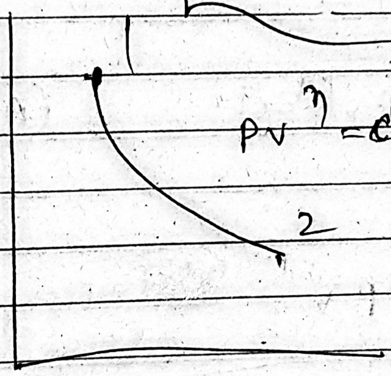
$n = 1.2$ से 1.39 $\quad \gamma = 1.4$

Work done $\quad \boxed{{}_1W_2 = \frac{P_1V_1 - P_2V_2}{\gamma - 1}}$

adiabatic W.D.

polytropic process:-

100%. It is real time (work) process)



imp

polytropic $\quad \boxed{{}_1W_2 = \frac{P_1V_1 - P_2V_2}{n-1}}$ $\quad$ Work done

24-0 0

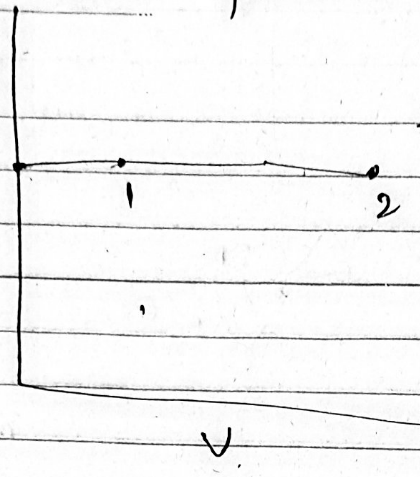
$\int P dV$

$V dp$

Open system work done :-

(a) Isobaric :- (Const. pressure process)

P



$\boxed{\text{Work Done} = 0}$

$W.D = 0$

$= \int V \cdot dp$

$= \int V \cdot (P_1 - P_2)$

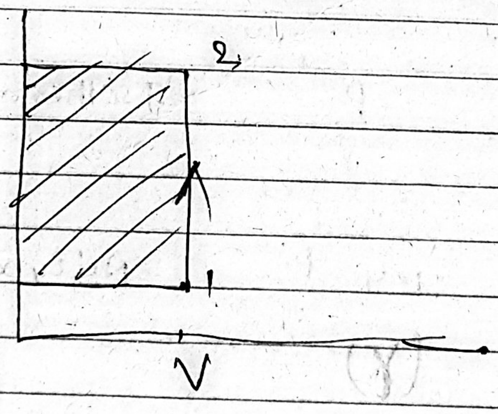
$= 0$

(b) 2016 Isochoric Process or Const. volume process.

work done $= -\int V \cdot dp$

$= -\int_{P_1}^{P_2} V \cdot dp$

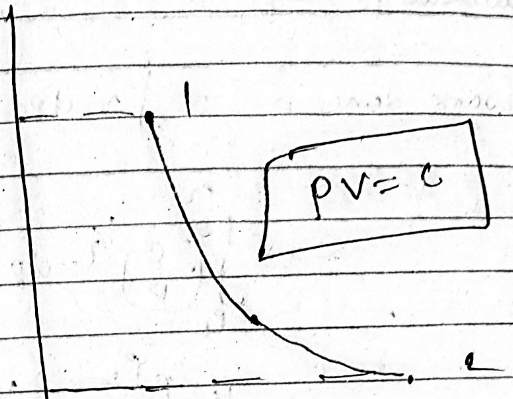
P



$\boxed{W.D. = -[V(P_2 - P_1)]}$

M.Imp [Work done is ~~similar~~ same for closed system as well as open system. (In Isothermal)]

(C) Isothermal ~~Adiabatic~~ process:-



$$= -\int v\,dp$$

$$= -\int_{P_1}^{P_2} \frac{c}{P}\,dP$$

$$= -C\int_{P_1}^{P_2} \frac{dP}{P}$$

$$= -C\left[\ln P\right]_{P_1}^{P_2}$$

$$= -C(\ln P_2 - \ln P_1]$$

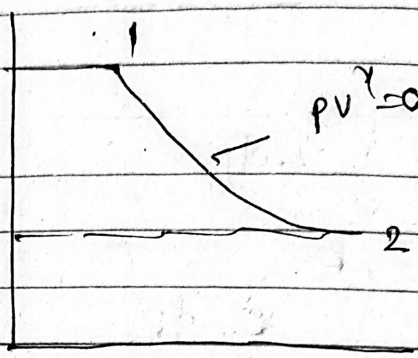
$$= C[\ln P_1 - \ln P_2)$$

$$\boxed{\text{Work done} = P_1V_1 \ln \frac{P_1}{P_2}}$$ (open system)

$$P_1V_1 = P_2V_2$$

$$\frac{P_1}{P_2} = \frac{V_2}{V_1}, \quad \boxed{P_1V_1 \ln \frac{V_2}{V_1}}$$

g) <u>Adiabatic process:-</u>



work done $= -\int v \cdot dp$

$$= -\int_{P_1}^{P_2} \left(\frac{C}{P}\right)^{1/\gamma} \cdot dp$$

$$= -C^{1/\gamma} \int_{P_1}^{P_2} \left(\frac{1}{P}\right)^{1/\gamma} \cdot dp$$

$$= -C^{1/\gamma} \left[\frac{P^{-1/\gamma + 1}}{-1/\gamma + 1}\right]_{P_1}^{P_2}$$

$$= -C^{1/\gamma} \left[\frac{P^{\frac{-1+\gamma}{\gamma}}}{\frac{-1+\gamma}{\gamma}}\right]_{P_1}^{P_2}$$

$$= -C^{1/\gamma} \left[P^{\frac{\gamma-1}{\gamma}}\right]_{P_1}^{P_2} \times \left(\frac{\gamma}{\gamma-1}\right)$$

$$= -(PV^{\gamma})^{1/\gamma} \left[P^{\left(\frac{\gamma-1}{\gamma}\right)}\right]_{P_1}^{P_2} \times \frac{\gamma}{\gamma-1}$$

$$= -V\left[P^{1/\gamma} \times P^{\left(\frac{\gamma-1}{\gamma}\right)}\right]_{P_1}^{P_2} \times \frac{\gamma}{\gamma-1}$$

$$= -V\left[P^{\left(\frac{1}{\gamma}+\frac{\gamma-1}{\gamma}\right)}\right]_{P_1}^{P_2} \times \frac{\gamma}{\gamma-1}$$

$$= -V\left[P^{\frac{\cancel{1}+\cancel{\gamma}-\cancel{1}}{\cancel{\gamma}}}\right]_{P_1}^{P_2} \times \frac{\gamma}{\gamma-1}$$

$$= -\left[VP\right]_{P_1}^{P_2} \times \frac{\gamma}{\gamma-1}$$

$$= -\cancel{(P_2 - P_1)}\frac{\gamma}{\gamma-1} = -\left[P_2V_2 - P_1V_1\right] \times \frac{\gamma}{\gamma-1}$$

$$= \cancel{V(P_1 - P_2) \times \frac{\gamma}{\gamma-1}} = \left[P_1V_1 - P_2V_2\right] \times \frac{\gamma}{\gamma-1}$$

$$\boxed{(\text{Work done})_{\text{open}} = \left(\frac{P_1V_1 - P_2V_2}{\gamma-1}\right) \times \gamma}$$

$$\boxed{W_{\text{open}} = \gamma \times (\text{Work done})_{\text{closed system}}}$$

Polytropic process :- $W = \left(\frac{P_1 V_1 - P_2 V_2}{n-1} \right) \times n$

$$\boxed{\left(\text{Work done}\right)_{open} = n \times \left(\text{Work done}\right)_{closed}}$$