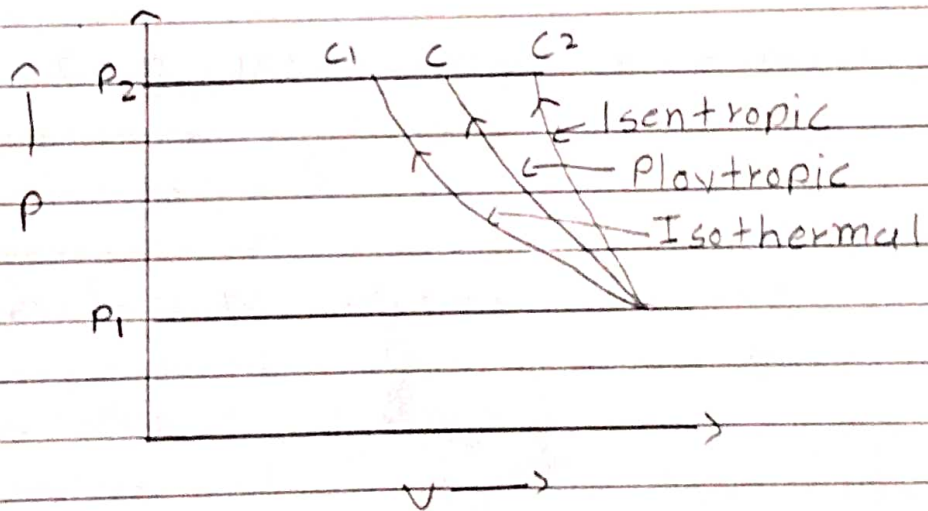


## Air Compressor

1 Derive equation for workdone in single stage reciprocating compressor without clearance.

The working of reciprocating compressor includes three operations.

- 1) Suction
- 2) Compression
- 3) discharge of Compressed Fluid.



Let  $P_1$  is Suction Pressure,  
 $V_1$  is volume suction and  
 $T_1$  is Suction Temperature

and  $P_2$  is Compression after Pressure  
 $V_2$  is After Compression Volume and  
 $T_2$  is After Compression Temperature

$r$  is a compression ratio =  $P_2 / P_1$

=> Workdone During Isothermal Process.

Workdone during the suction,

$$W_1 = P_1 V_1$$

Workdone during the Compression,

$$W_2 = P_1 V_1 \log_e \left( \frac{V_1}{V_2} \right)$$

Workdone during the discharge compressed

$$W_3 = P_2 V_2$$

=> Total Workdone  $W = W_3 + W_2 - W_1$

$$\therefore W = P_2 V_2 + P_1 V_1 \log_e \left( \frac{V_1}{V_2} \right) - P_1 V_1$$

Since  $P_1 V_1 = P_2 V_2$  and  
 $P_1 V_1 = mRT_{1,2,3}$

$$\therefore W = mRT_{1,2,3} \log_e \left( \frac{V_1}{V_2} \right)$$

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

$$\therefore W = mRT_{1,2,3} \log r$$

⇒ Workdone during Polytropic Process.

Workdone during the suction,

$$W_1 = P_1 V_1$$

Workdone during the Compression

$$W_2 = \frac{P_2 V_2 - P_1 V_1}{n-1}$$

Workdone during the discharge

$$\therefore W_3 = P_2 V_2$$

⇒ Total Workdone  $W = W_3 + W_2 - W_1$

$$W = P_2 V_2 + \frac{P_2 V_2 - P_1 V_1}{n-1} - P_1 V_1$$

$$W = \frac{P_2 V_2 (n-1) + P_2 V_2 - P_1 V_1 - P_1 V_1 (n-1)}{n-1}$$

$$W = \frac{n}{n-1} (P_2 V_2 - P_1 V_1)$$

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

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Polytropic process  $P_1 V_1^\eta = P_2 V_2^\eta$

$$\therefore \frac{V_2}{V_1} = \left( \frac{P_1}{P_2} \right)^{\frac{1}{\eta}}$$

$$\therefore W = \frac{\eta}{\eta-1} P_1 V_1 \left( \frac{P_2}{P_1} \left( \frac{P_1}{P_2} \right)^{\frac{1}{\eta}} - 1 \right)$$

$$\Rightarrow \therefore W = \frac{\eta}{\eta-1} m R T_1 \left( \left( \frac{P_2}{P_1} \right)^{\frac{\eta-1}{\eta}} - 1 \right)$$

$$\text{Since } \left( \frac{P_2}{P_1} \right)^{\frac{\eta-1}{\eta}} = \frac{T_2}{T_1}$$

$$\therefore W = \frac{\eta}{\eta-1} m R T_1 \left( \frac{T_2}{T_1} - 1 \right)$$

$$\Rightarrow \therefore W = \frac{\eta}{\eta-1} m R (T_2 - T_1)$$

$\Rightarrow$  Work done during Isentropic Process

The work done equation is similar to that of during polytropic Process

$$\therefore W = \frac{\gamma}{\gamma-1} m R (T_2 - T_1)$$

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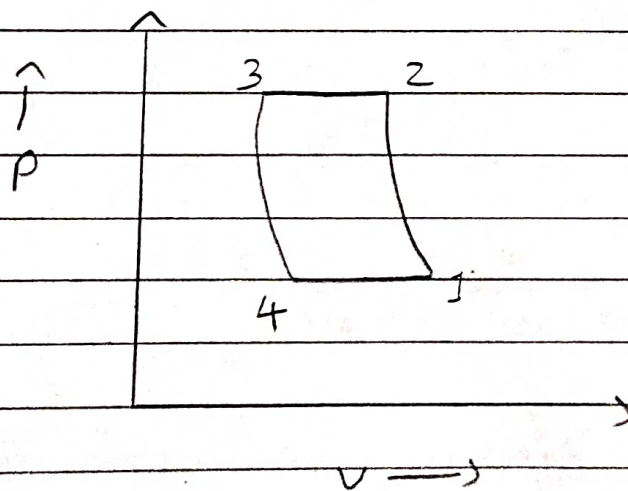
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$$\text{Here } R = C_p - C_v = C_p \left( \frac{\gamma - 1}{\gamma} \right)$$

$$\therefore W = \frac{\gamma}{\gamma - 1} m C_p \left( \frac{\gamma - 1}{\gamma} \right) (T_2 - T_1)$$

$$\therefore W = m C_p (T_2 - T_1)$$

2. Derive Equation of volumetric Efficiency of a single stage reciprocating air compressor.



Here,  $V_c = \text{Clearance Volume } (V_3)$

$V_s = \text{Swept Volume } (V_1 - V_3)$

Clearance ratio =  $\frac{\text{Clearance Volume}}{\text{Swept Volume}}$

$$C = \frac{V_c}{V_s} = \frac{V_3}{V_1 - V_3}$$

### Volumetric Efficiency

$$\eta_{vol} = \frac{\text{Free air Delivered}}{\text{Swept Volume}}$$

$$\therefore \eta_{vol} = \frac{V_1 - V_4}{V_1 - V_3}$$

$$= \frac{(V_1 - V_3) + (V_3 - V_4)}{V_1 - V_3}$$

$$= 1 + \frac{V_3}{V_1 - V_3} - \frac{V_4}{V_1 - V_3}$$

$$= 1 + \frac{V_c}{V_s} - \frac{V_4 V_3 / V_3}{V_1 - V_3}$$

$$= 1 + \frac{V_c}{V_s} - \frac{V_c}{V_s} \times \frac{V_4}{V_3}$$

For Polytropic Process  $\frac{V_4}{V_3} = \left( \frac{P_3}{P_4} \right)^{1/n}$

$$\therefore \eta_{vol} = 1 + C - C \left( \frac{P_3}{P_4} \right)^{1/n}$$

Here  $P_3 = P_2$  and  $P_4 = P_1$

$$\therefore \eta_{vol} = 1 + C - C \left( \frac{P_2}{P_1} \right)^{1/n}$$

3 With neat sketch explain Centrifugal Compressor.

Centrifugal Compressor is sometimes called radial Compressor.

Centrifugal Compressor is a type of dynamic Compressor or turbo compressor.

=>

=> Construction :

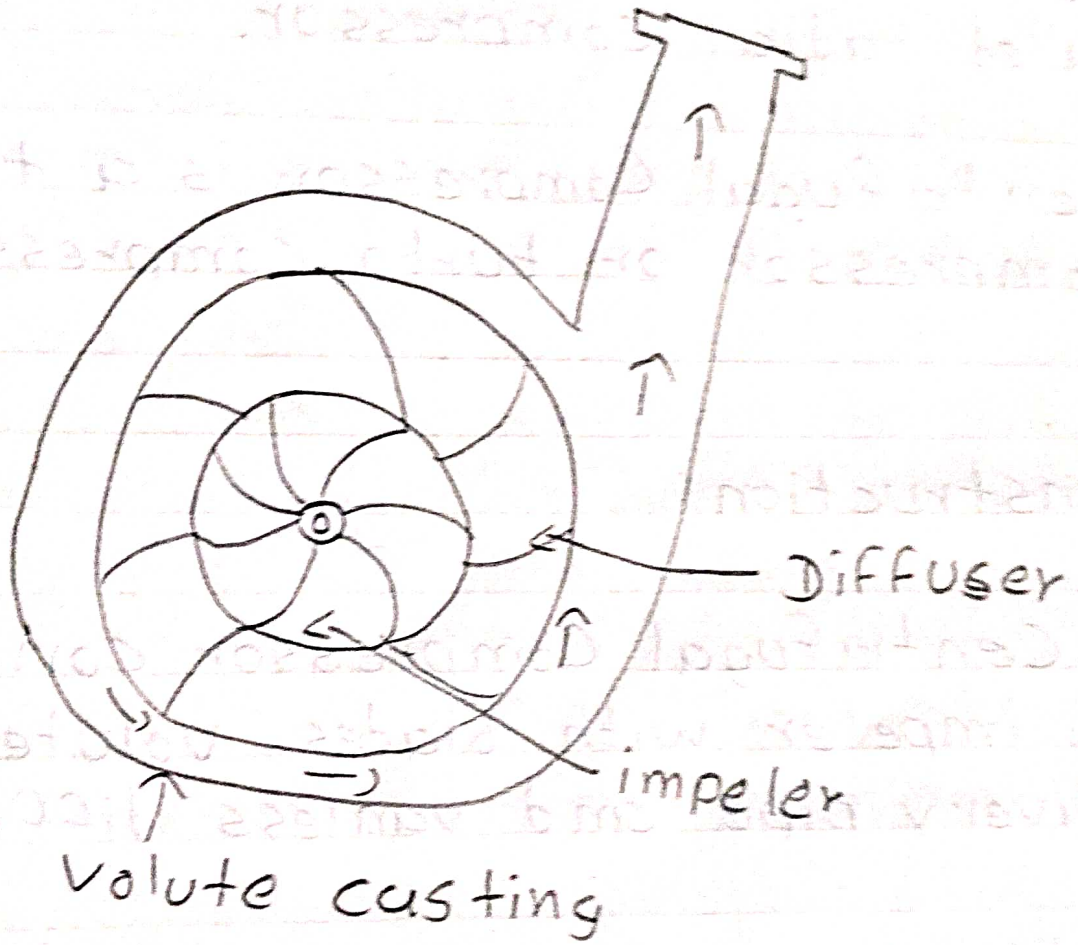
A Centrifugal Compressor consists inlet pipe, an impeller with blades, volute casting, delivery pipe and vanless diffuser.

=> Working :

In Centrifugal Compressor air is drawn into the center of a rotating impeller with blades.

It is pushed toward the center by centrifugal force.

This radial movement of air increase pressure and generation of kinetic energy.



## Centrifugal Compressor



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Before the air is led into the center of the impeler, the kinetic energy is converted into pressure.

=> Advantages

• Low weight and Easy to design and manufacture

• High Flow rate than the positive displacement compressor.

=> limit:

• Centrifugal Compressors can be sized for an inlet flow of 400000 rpm in a single body.

=> Use: Gas turbines and Automobiles.