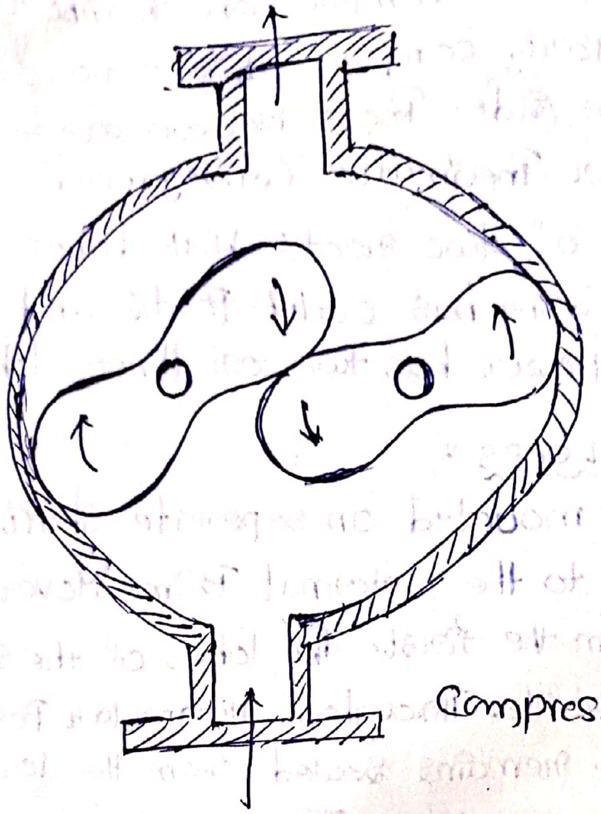
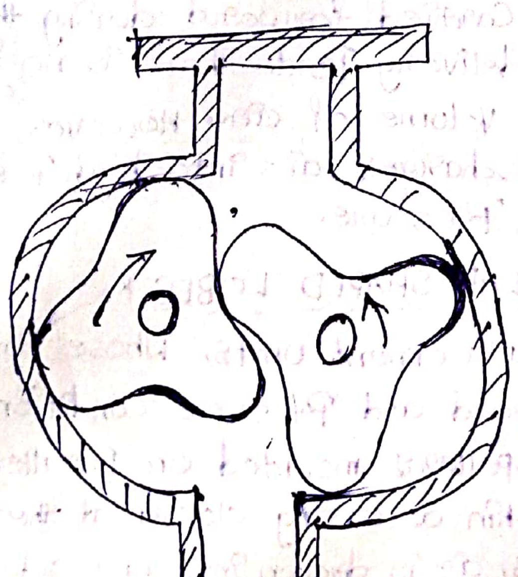
Roots Blower Compressor



Compressor with two lobes



Compressor with two triangular Shaped lobes

Root Blower Compressor:

A Root Blower is a Valve-less displacement compressor without internal compression. When the compression chamber comes into contact with the outlet Port, compressed air flows back into the housing from the Pressure side. Roots Blowers are frequently used as Vaccum Pumps and for Pneumatic Conveyance.

A Root Blower consists of two roots with Lobes rotating in a air tight Casing. The Casing has outlet Ports and inlet Ports on opposite sides. Root Blower has two or three lobes as shown.

* COMPRESSOR WITH TWO LOBES *

It has two lobes each mounted on seperate shaft. one of these shaft is connected to the external Prime Mover while the other is gear driven from the first. The lobes of the rotar are of cycloidal or Envolute Profile. Throughout all angular Positions, the High Pressure delivery side remains sealed from the low Pressure suction side by closely mating lobes. The wear between the lobes is avoided by the clearance.

Suction takes place through the intake Port. The entrapped air between the lobes and Casing is Carried forward during the rotation and is finally discharged to the delivery Port. There is no ~~flow~~ change in the flow area and no reduction of volume of air. However, when the delivary Port is opened, blower discharges air into high Pressure reservoir causing Irreversibility Pressure.

* COMPRESSOR WITH TWO TRIANGULAR SHAPED LOBES *

TRI-Lobe Blowers are Positive displacement units, whose Pumping Capacity is determined by size, operating speed and Pressure Conditions. It Employes two Tri-~~Implikes~~ Lobe impellers mounted on Parallel shafts, rotating in opposite direction within a casing closed at the ends by side plates. As the impeller rotates, air is drawn into one side of the Casing and forced out of the opposite side against existing Pressure. The differential Pressure developed, therefore depends upon the resistance of the connected system. The blowers, being Positive displacement type, do not develop Pressure within the Casing but the discharge Pressure depends upon the system resistance Pressure.

It is interesting to know that when rotating lobe uncover the exit port, Some air (under high pressure) flows back into the pocket from the receiver. It is known as backflow process. The air which flows from the receiver to the pocket, gets mixed up with the entrapped air. The backflow of air continuous, till the pressure In the pocket and receiver is equalised. Thus the the pressure of air entrapped in the pocket is increased at constant volume entirely by the backflow of air.

Let P_1 = Intake pressure of air,

P_2 = Discharge pressure of air,

γ = Isentropic index of air,

V_1 = volume of air compressed

Theoretical workdone in compressing the air

$$W = \frac{\gamma}{\gamma-1} P_1 V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1 \right]$$

Actual work $= V_1 (P_2 - P_1)$

∴ efficiency of Root blower (or) Root efficiency

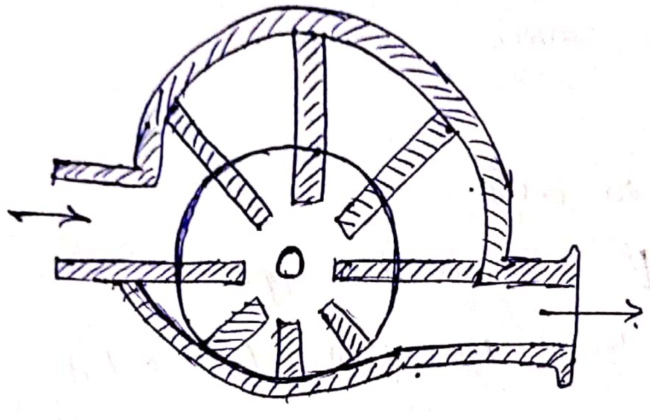
$$\eta = \frac{\frac{\gamma}{\gamma-1} P_1 V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1 \right]}{V_1 (P_2 - P_1)}$$

$$= \frac{\frac{\gamma}{\gamma-1} P_1 \left[r^{\frac{\gamma-1}{\gamma}} - 1 \right]}{P_1 \left(\frac{P_2}{P_1} - 1 \right)}$$

$$\boxed{\eta = \frac{\gamma}{\gamma-1} \times \left(\frac{r^{\frac{\gamma-1}{\gamma}} - 1}{r - 1} \right)}$$

Scanned with CamScanner

Vane Blower Compressor



Vane blower compressor consists of a rotor eccentrically housed in the casing. Rotor has several radial slots in it, each housing a spring loaded vane. These vanes are made of steel or synthetic fibrous material. Larger the number of vanes internal leakage of air decreases due to small pressure difference prevailing between the adjacent spaces around the rotor.

High pressure ratio requires large number of vanes (20 - 30). The casing has intake and delivery openings. These compressors are often used for capacities upto 150 m^3/min and for pressure ratios upto 8.5. For a given pressure ratio and FAD, vane compressor requires less work input than that for roots blower.

When the rotor rotates, vanes are driven out of the rotor towards the casing due to centrifugal force. The space between the two adjacent vanes, rotor and the casing increases creating vacuum. Thus, the gas is drawn in, from the suction opening. When the rotor crosses the point just opposite to its eccentricity, suction starts. As the rotor continues to rotate, the entrapped gas is compressed due to reduction in volume.

The high pressure gas is then discharged through delivery opening. Usually, half of the total pressure rise is developed during the internal reversible compression and the remaining pressure rise occurs irreversibly when the entrapped gas is released to the delivery side, due to back flow of high pressure air from the receiver.

Advantages

* This is oil free air output
* This is suitable for continuous air supplied.
* High power (upto 500 hp) high pressure (upto 85 bar)

Disadvantages

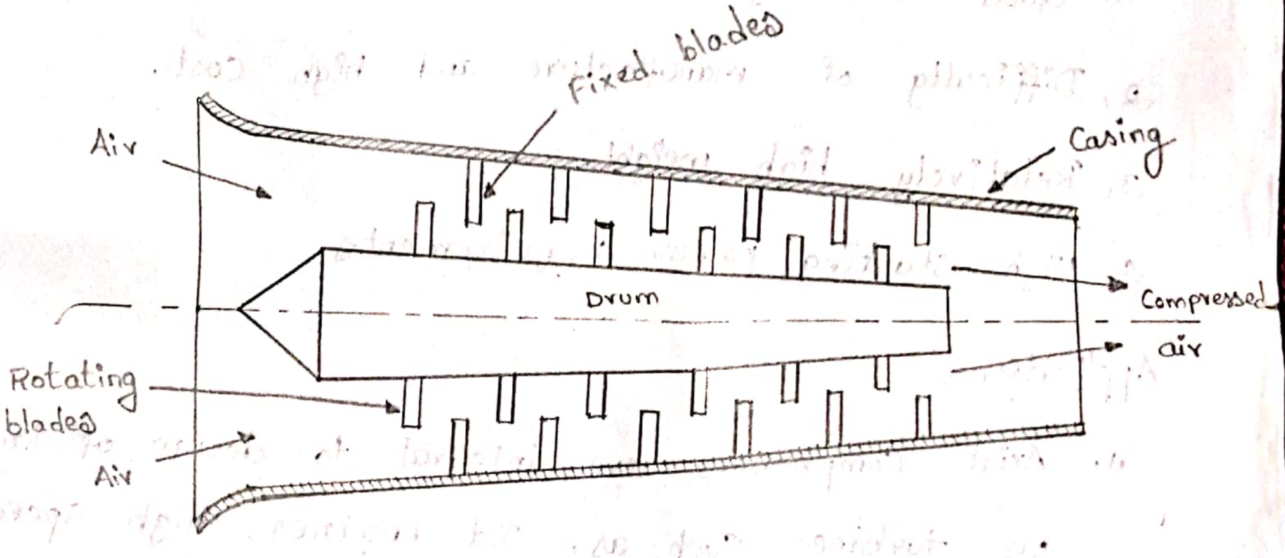
* The maintenance cost is high because have more moving parts.
* Vibration causes when reciprocation of the cylinder.

Applications:

* Agriculture
* Body shop and automotives.
* Dry cleaning
* Energy.
* Food and beverages
* Manufacturing
* Medical and dental.

Axial Flow Compressors:

An axial flow compressor, in its simplest form, consists of a number of rotating blade rows fixed to a rotating drum. The drum rotates inside an air tight casing to which are fixed stator blade rows, as shown in figure. The blades are made of aerofoil section to reduce the loss caused by turbulence and boundary separation.



The mechanical energy is provided to the rotating shaft, which rotates the drum. The air enters from the left side of the compressor. As the drum rotates, the air flows through the alternately arranged stator and rotor. As the air flows from one set of stator and rotor to another, it gets compressed. Thus successive compression of the air, in all the sets of stator and rotor, the air is delivered at a high pressure at the outlet point.

Advantages:

1. High peak efficiencies.

2. Small frontal area forgiven airflow.

3. straight - through flow, allowing high ram efficiency.

4. Increased pressure rise due to increased number of stages with negligible losses.

Disadvantages:

1. Good efficiency over narrow rotational speed range.

2. Difficulty of manufacture and high cost.

3. Relatively high weight.

4. High starting power requirements

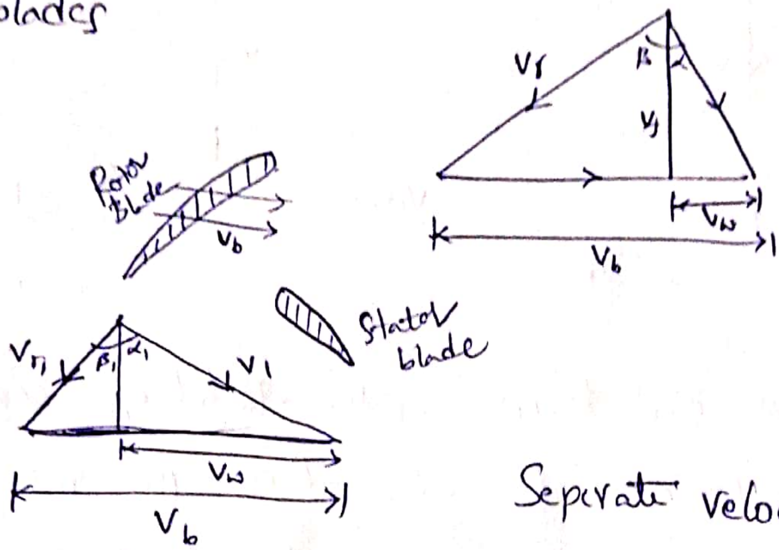
Applications:

1. Axial Compressors are integral to design of large gas turbines such as, Jet engines, high speed ship engines and small power stations.

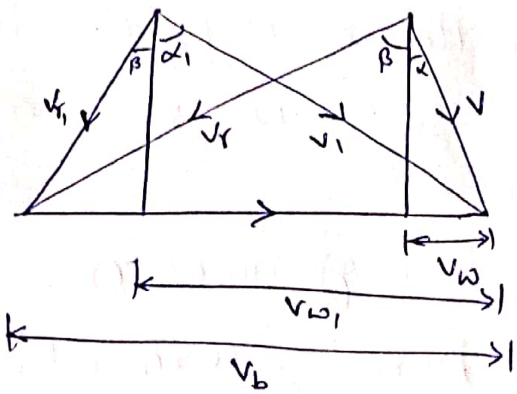
2. Industrial applications as large volume air separation plants, blast furnace air, fluid catalytic cracking air, propane dehydrogenation.

Velocity diagrams for Axial flow air compressors

In an axial-flow air compressor, the drum with rotor blades, rotates inside a casing with a fixed (or) stator blades. The inlet and outlet velocity triangles for the rotor blades



Seperate velocity diagrams



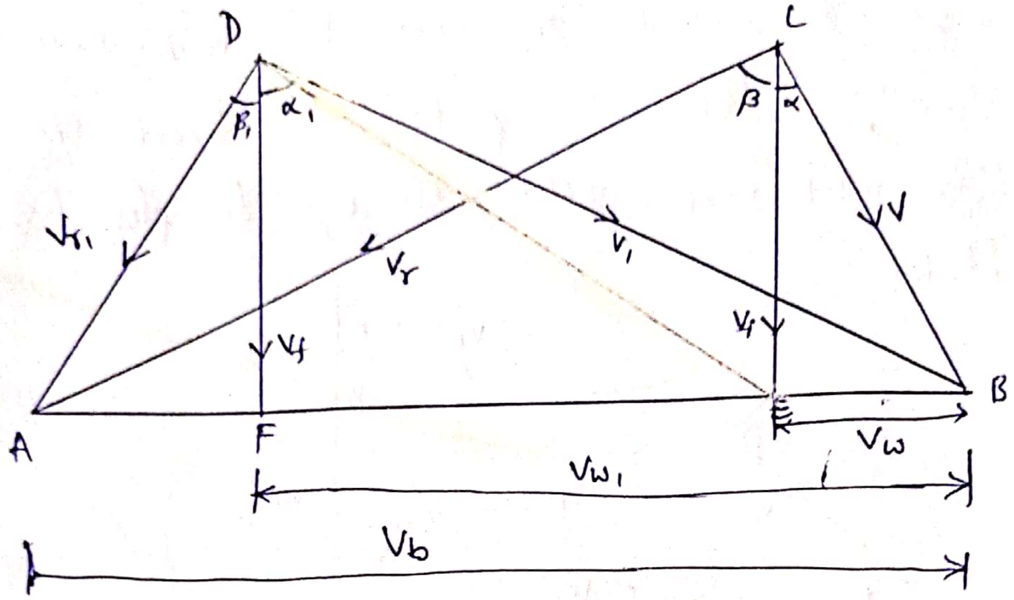
Combined velocity diagram

1. Blade velocity (V_b) for both the triangles is equal
2. velocity of flow (V_f) for both the triangles is also equal
3. Relative velocity in outlet triangle (V_{r_1}) is less than that in inlet triangle (V_r) due to friction

* W.D by Compressor per kg of air $(W) = V_b (V_{w_1} - V_w)$

* Incase of work factor (or) work input factor $(W) = V_b (V_{w_1} - V_w) \times$ work factor

Degree of Reaction



It is an important term in the field of axial flow compressor which may be defined as the ratio of pressure rise in rotor blades to the pressure rise in the compressor in one stages.

As a matter of fact, the degree of reaction is usually kept as 50% (or) 0.5 for all types of axial flow compressors.

Mathematically, degree of reaction

$$= \frac{\text{Pressure rise in rotor blades}}{\text{Pressure rise in Compressor}}$$

$$= \frac{\frac{V_r^2 - V_{r_1}^2}{2}}{V_b (V_{w_1} - V_w)}$$

$$= \frac{V_r^2 - V_{r_1}^2}{2 V_b (V_{w_1} - V_w)} \quad \text{——} \ (1)$$

first of all let us draw a combined velocity diagram for an axial flow compressor (with degree of reaction as 0.5)

from the geometry of the figure, we find

$$V_w = AB - AE$$

$$= V_b - V_f \tan\beta$$

and

$$V_{w_1} = AB - AF$$

$$= V_b - V_f \tan\beta_1$$

$$(V_{w_1} - V_w) = (V_b - V_f \tan\beta_1) - (V_b - V_f \tan\beta)$$

$$= V_f \tan\beta - V_f \tan\beta_1$$

$$= V_f (\tan\beta - \tan\beta_1)$$

Moreover, from the geometry of the figure,

$$V_r^2 = V_f^2 + (V_f \tan\beta)^2$$

$$V_{r_1}^2 = (V_f)^2 + (V_f \tan\beta_1)^2$$

$$V_r^2 - V_{r_1}^2 = \left[V_f^2 + (V_f \tan\beta)^2\right] - \left[V_f^2 + (V_f \tan\beta_1)^2\right]$$

$$= V_f^2 \left[\tan^2\beta - \tan^2\beta_1\right]$$

Now substituting the values of $(V_{w_1} - V_w)$ and $(V_r - V_{r_1}^2)$ in equation (1), we have degree of reaction

$$R = \frac{(V_f)^2 (\tan^2\beta - \tan^2\beta_1)}{2 V_b V_f (\tan\beta - \tan\beta_1)}$$

$$= \frac{V_f(\tan\beta + \tan\beta_1)}{2V_b}$$

Now substituting the value of degree of reaction as 0.5, we have

$$0.5 = \frac{V_f(\tan\beta + \tan\beta_1)}{2V_b}$$

$$\frac{V_b}{V_f} \times 2 \times 0.5 = \tan\beta + \tan\beta_1$$

$$\frac{V_b}{V_f} = \tan\beta + \tan\beta_1$$

from the geometry of the figure, we find that

$$\frac{V_b}{V_f} = \tan\alpha + \tan\alpha_1$$

$$= \tan\alpha + \tan\beta$$

$$= \tan\alpha_1 + \tan\beta_1$$

$$\therefore \quad \angle\beta = \angle\alpha_1$$

and

$$\angle\beta_1 = \angle\alpha$$

It is thus ~~obv~~ obvious that for 50% reaction the compressor will have symmetrical blades

→ 1) An axial flow Compressor, with compression ratio as 5, draw air at 20°c delivers it at 50°c, Assuming 50% degree of reaction, find the velocity of flow if the blade velocity is 100 m/s. Also find the number of stages, Take work factor = 0.85, $\alpha = 10^\circ$, $\beta = 40^\circ$, and $C_p = 1$ KJ/kg K

Sol given that,

$$\frac{P_2}{P_1} = 5$$

$T_1 = 20^\circ C + 273 = 293 K$

$T_2 = 50^\circ C + 273 = 323 K$

$R = 50\% = 0.5$

$V_b = 100$ m/s

work factor = 0.85

$\alpha = 10^\circ$

$\beta = 40^\circ$

$C_p = 1$ KJ/kgK

Sol Let,

V_f = velocity of flow.

from the geometry of the triangle

$$\frac{V_b}{V_f} = \tan\alpha + \tan\beta$$

$$= \tan 10 + \tan 40$$

$$\frac{100}{V_f} = 0.1763 + 0.8391$$

$V_f = 98.5$ m/s.

No. of Stages

W.K.T,

Total work required per kg of air

$= C_p(T_2 - T_1)$

$= 1(323 - 293)$

$= 30$ KJ/kg

from the geometry of the velocity triangles we also know that,

$V_w = V_f \tan\alpha$

$= 98.5 \tan 10°$

$= 17.4$ m/s

$V_{w1} = V_f \tan\alpha_1$

$= 98.5 \tan 40°$

$= 82.7$ m/s

... (with 50% reaction $\angle\alpha_1 = \angle\beta$)

W.K.T,

workdone per kg of air per stage

$= V_b (V_{w1} - V_w) \cdot \times$ work factor

$= 100 (82.7 - 17.4) \times 0.85$

$= 5550$ J

$= 5.55$ KJ/kg

$\therefore$ No. of stages $= \dfrac{\text{Total work required}}{\text{workdone per stage}} = \dfrac{30}{5.55}$

$= 5.4$

$= 6$