TYPES OF COMPRESSORS USED IN CHEMICAL INDUSTRY

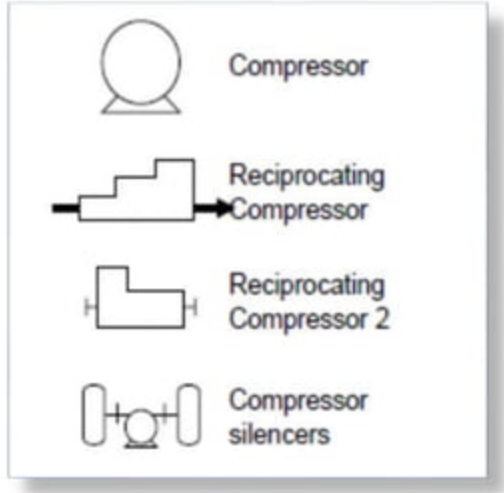
CHEMICAL PROCESS TECHNOLOGY

COMPRESSORS

Compressors are machines designed to deliver gas at a pressure higher than that originally existing.

Compressor forces more and more air into a storage tank, increasing the pressure. When tank pressure reaches its upper limit the air compressor shuts off. The compressed air, then, is held in the tank until called into use. The energy contained in the compressed air can be used for a variety of applications, utilizing the kinetic energy of the air as it is released and the tank depressurizes. When tank pressure reaches its lower limit, the air compressor turns on again and re-pressurizes the tank.

SYMBOL



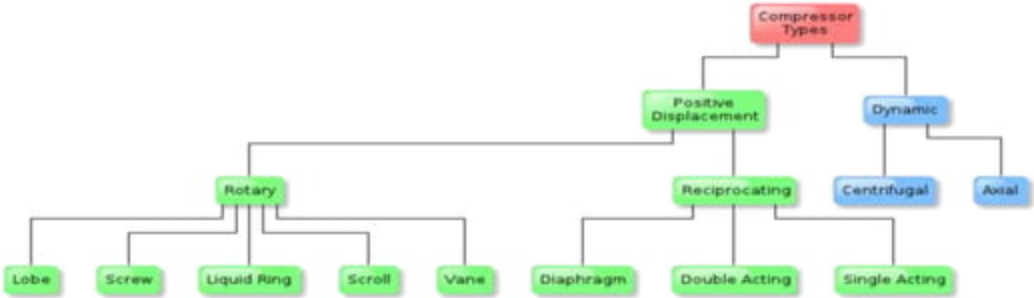
Compression methods

The methods employed to achieve compression are:

- Trap consecutive quantities of gas in some type of enclosure, reduce the volume, thus increasing the pressure, then push the compressed gas out of the enclosure.
- Trap consecutive quantities of gas in some type of enclosure, carry it without volume change to the discharge opening, compressing the gas by overcoming back flow from the discharge system and pushing the compressed gas out of the enclosure.
- Compress the gas by the mechanical action of rotating impellers or bladed rotors that impart velocity and pressure to the flowing gas. Additional velocity energy in the gas is converted to pressure in an adjacent stationary diffuser or blade.

What are its various types?

Compressor classification can be described by following flow chart:



Positive displacement compressors

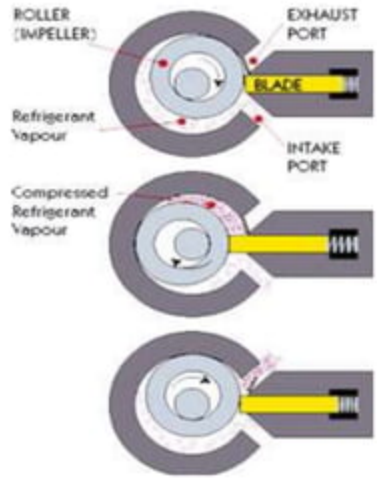
- Positive displacement compressors causes movement by trapping a fixed amount of air then forcing (displacing) that trapped volume into the discharge pipe. Positive displacements machines work by mechanically changing the volume of the working fluid.

It can be further classified according to the mechanism used to move air.

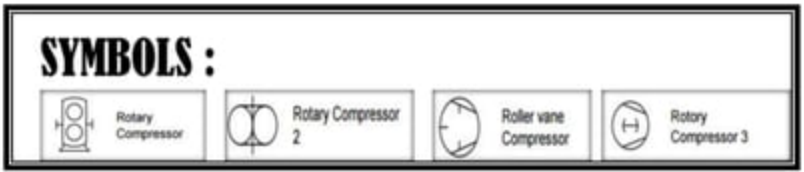
- Rotary Compressor
- Reciprocating compressor

Rotary compressors

- The gas is compressed by the rotating action of a roller inside a cylinder.
- The roller rotates off-centre around a shaft so that part of the roller is always in contact with the cylinder.
- Volume of the gas occupies is reduced and the refrigerant is compressed.
- High efficient as sucking and compressing refrigerant occur simultaneously.

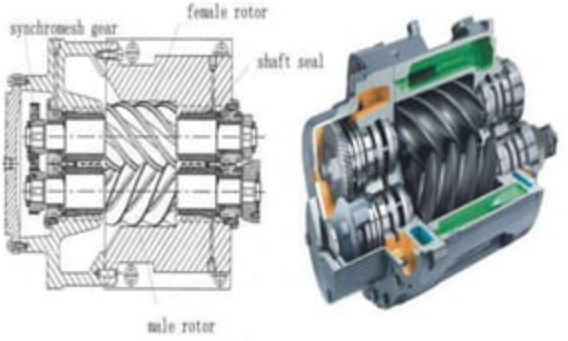


SYMBOLS :



ROTARY SCREW

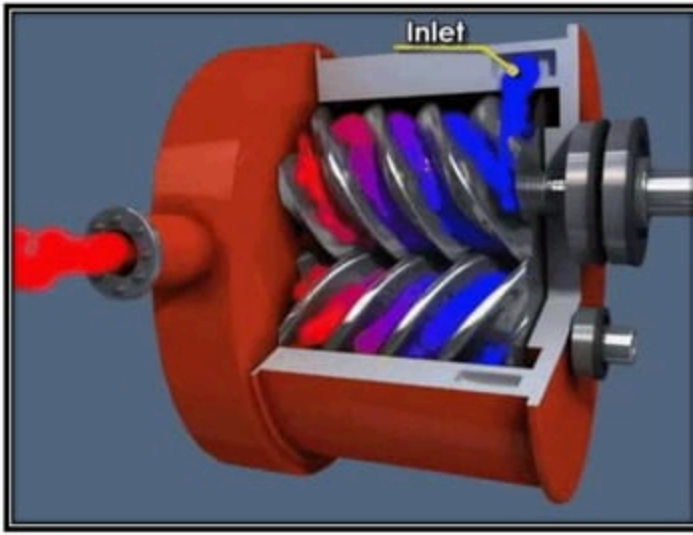
Rotary compressors are the another type of famous compressors.It uses two Asymmetrical rotors that are also called helical screws to compress the air.
The rotors have a very special shape and they turn in opposite directions with very little clearance between them.The rotors are covered by cooling jackets.Two shafts on the rotors are placed that transfer their motion with the help of timing gears that are attached at the starting point of the shafts/compressor.



Screw Compressor Structure

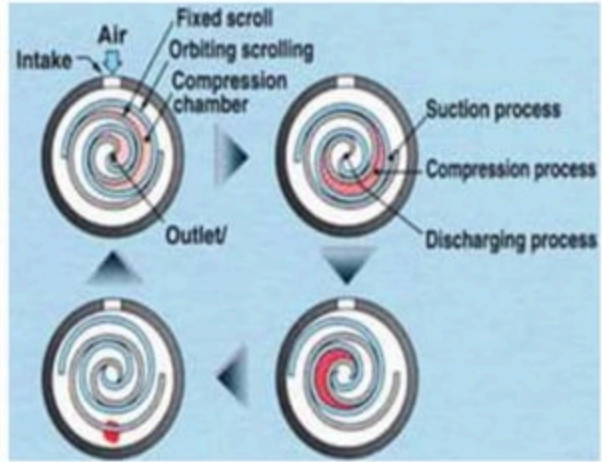
WORKING PRINCIPLE

- Air sucked in at one end and gets trapped between the rotors and get pushed to other side of the rotors .The air is pushed by the rotors that are rotating in opposite direction and compression is done when it gets trapped in clearance between the two rotors.Then it pushed towards pressure side.



ROTARY SCROLL

- They are one of the best compressor type in rotary compressors.The air is compressed using two spiral elements. One element is stationary and the other one moves in small eccentric circles inside the spiral.Air gets trapped inside the spiral way of that element and get transported in small air-pockets to the center of the spiral.
- Simply air gets trapped at the outer edge and get compressed due to reduction of are as it travels from outer edge to inner edge . It takes about 2 to 3 turns for the air to reach the pressure output in the center.



VANE TYPE

- This is an another type of rotary compressor.There is a fixed casing in Vane type compressor in which a rotary rotor disc is placed which has slots that are used for holding the sliding plates.

WORKING

Whenever rotor rotates the disc also rotates thus allowing the sliding plates to slide as the inner surface of casing is eccentric.Whenever the plates moves away from the center a huge amount of air get trapped inside it and with the rotation the sliding plates converge due to its shape and the trapped air get compressed.This results in compression of air.

LOBE TYPE

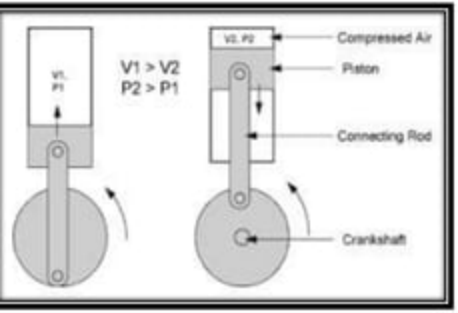
- This is one of the simpler compressor type.In this there is no complicated moving part.There are two lobes attached to the driving shaft by the prime mover.These lobes are displaced with 90 degrees to one another.Thus if one of the lobe is in horizontal direction the other lobes will be exactly positioned at 90 degree i.e in vertical direction.

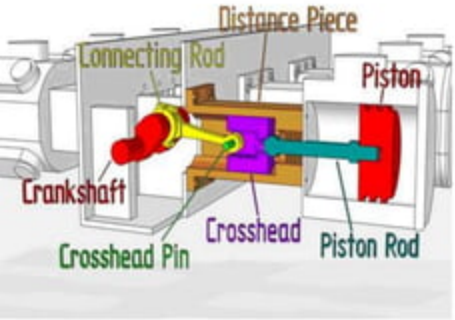
WORKING

The air gets trapped from one end and as the lobes rotates the air gets compressed as shown in image.The compressed air is then delivered to delivery line.

Advantages and disadvantages of positive displacement type compressor

	Advantages	Disadvantages
Reciprocating	•Wide pressure ratios •High efficiency •Relatively Cheap •Easy maintenance •Suitable for high pressure	•Heavy foundation required •Flow pulsation •Sounds too much.You have to arrange a room for it or put it into isolating box. •High outlet temperature of compressed air. •High oil content in air piping.
Rotary	•Less noisy. •These are called the work-horses as they supply large amount of compress air. •More energy efficient as compared to piston type compressors. •The air supply is continuous as compared to reciprocating compressors. •Relatively low end temperature of compressed air.	•Expensive then piston-type compressors. •More complex design. •The maintenance is very important. •Minimum one day use is important in a weak to avoid rusting

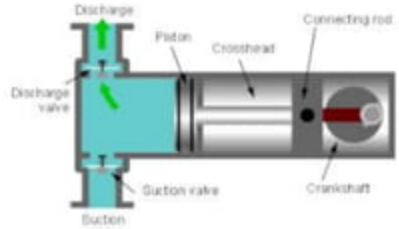




Reciprocating compressor

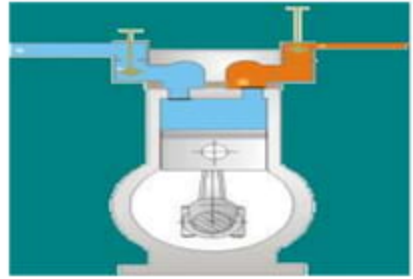
Reciprocating compressor

- Whenever something moves back and forth it is considered as moving in reciprocating motion.
- Piston-cylinder arrangement to compress the air.
- Similarly in this type piston move back and forth inside the cylinder and compress the air. There are two sets of valves that take care of air intake and exhaust.



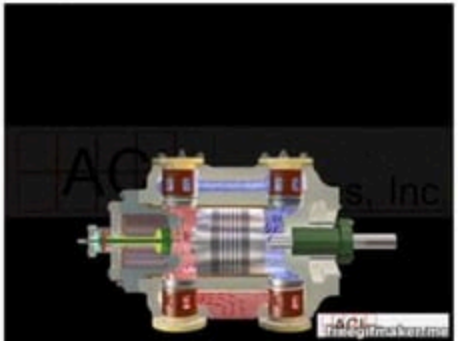
WORKING

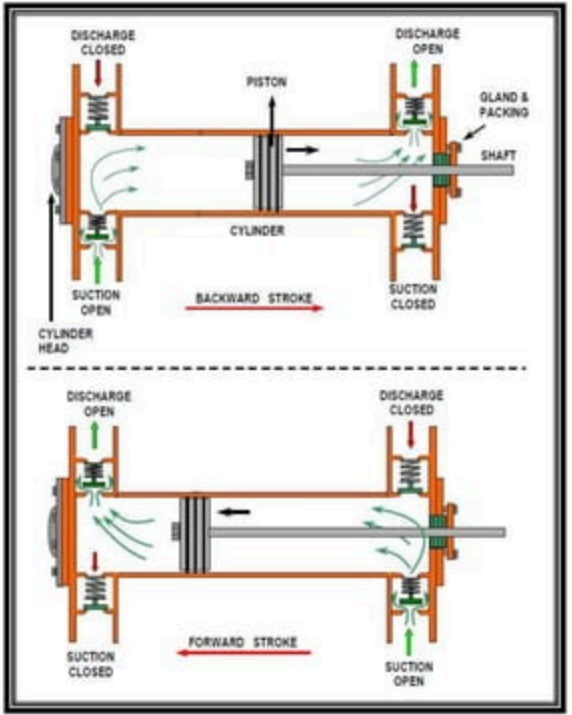
- The compressor takes inside successive amount of volume of air from intake valve and confined it in closed surface at that time piston moves downward with the closure of intake valve.Then there is compression of air by reducing its volume .Now the piston moves upward and compress the air and then displace the compressed air through exhaust valve.And then again intake take place and cycle repeat itself.
- The reciprocating compressor is single acting when the compressing is accomplished using only one side of piston and double acting when both the sides of piston used.



Double acting reciprocating compressors

- As from its name it uses its both sides to compress the air. These type of compressors have two sets of suction/intake and delivery/exhaust valve on both sides of the piston.As the piston moves up and down,both sides of the piston is utilized in compressing the air. The intake and exhaust valve operates corresponding to the movement of the piston or with the stroke of the compressor.The air is compressed accordingly and delivered continuously as compared to single-acting air compressor.

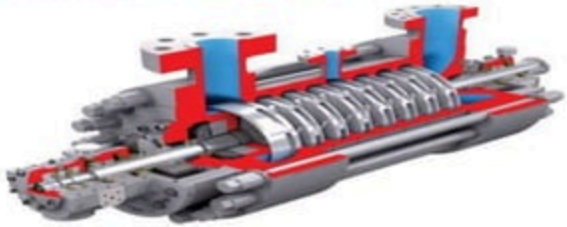




Multistage compressor

- When air is compressed, its temperature increases. High temp rise leads into limitation for the maximum achievable pressure rise.
- A multistage centrifugal compressor compresses air to the required pressure in multiple stages.
- Compressing in multiple stages allows cooling to occur between the stages, which saves work in the compression process.

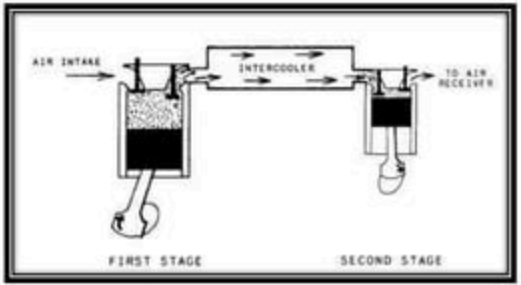
Multistage Compressor fig.

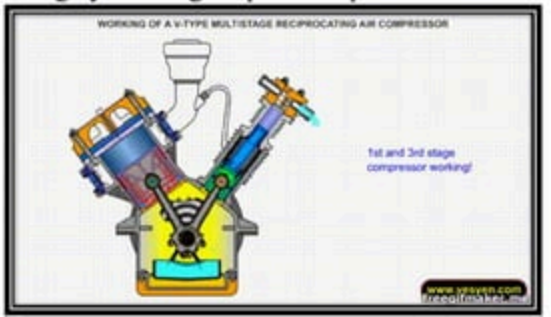


Intercooler

Multiple stage compression

- two-stage compressor--- air is partially compressed using isentropic compression and then Intercoolers are used in between each stage to removes heat and decrease the temperature of gas so that gas could be compressed to higher pressure without much rise in temperature.
- This brings the compression process closer to isothermal (constant temperature) compression, which is more efficient.
- A multiple-stage compressor pumps up the air to one pressure, and then uses another cylinder with a smaller diameter to pump to a higher pressure.
- A two-stage pump pumps to a higher pressure. Normally with single-acting recips the max pressure for a single stage is about 125 psi. With two stage you can get up to 175 psi.





Advantages of multistage compression over single stage compression

1. Less power is required to deliver same quantity of air at the same delivery pressure.
2. It increases the volumetric efficiency for the same compression ratio.
3. The size of the two cylinders may be adjusted to suit the volume and pressure of air.
4. In each stage the pressure range may be kept within the desired limits. It reduces the leakage loss considerably.
5. Effective lubrication due to low temperature.
6. It provides the facility to install an intercooler between the stages.
7. It reduces the cost of compression

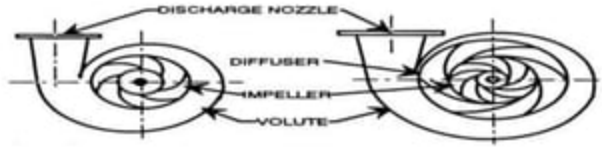
What are dynamic compressors?

The dynamic compressor is continuous flow compressor is characterized by rotating impeller to add velocity and thus pressure to fluid.

It is widely used in chemical and petroleum refinery industry for specific services.

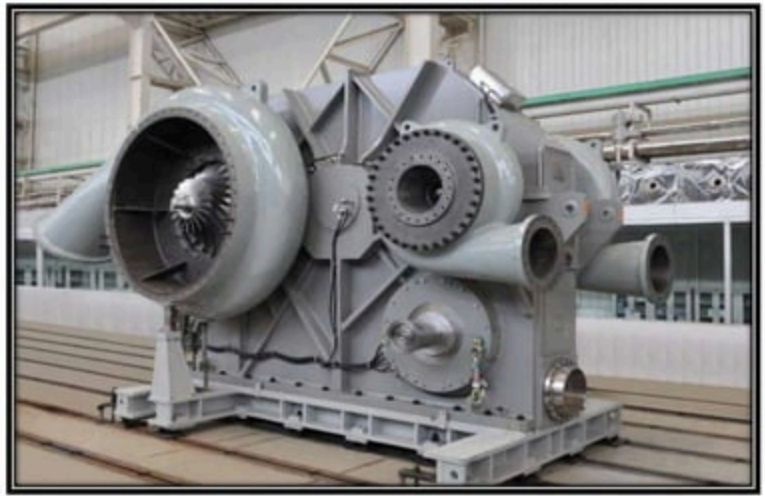
There are two types of dynamic compressors

- Centrifugal Compressor
- Axial Flow Compressor

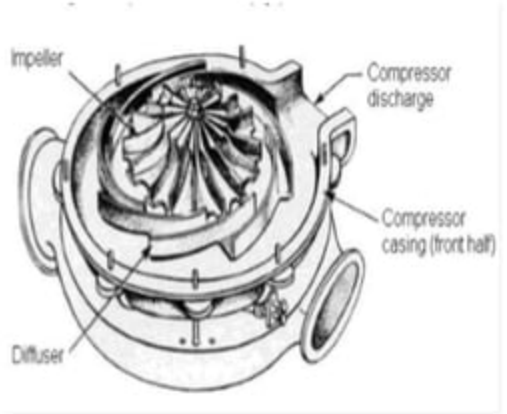


CENTRIFUGAL COMPRESSOR

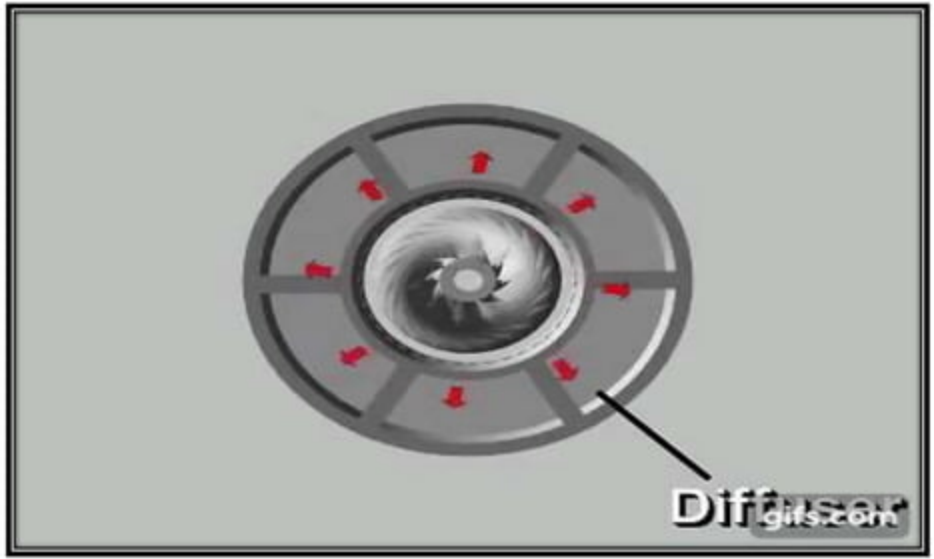
- The centrifugal compressor is a dynamic machine that achieves compression by applying inertial forces to the gas by means of rotating impellers.



- A centrifugal compressor has a simple rotating element,mounted onto the shaft which is usually connected directly to the prime mover. The compressor is divided into four parts.
- Volute
- Centrifugal impeller,
- Diffuser, and the
- Discharge nozzle.

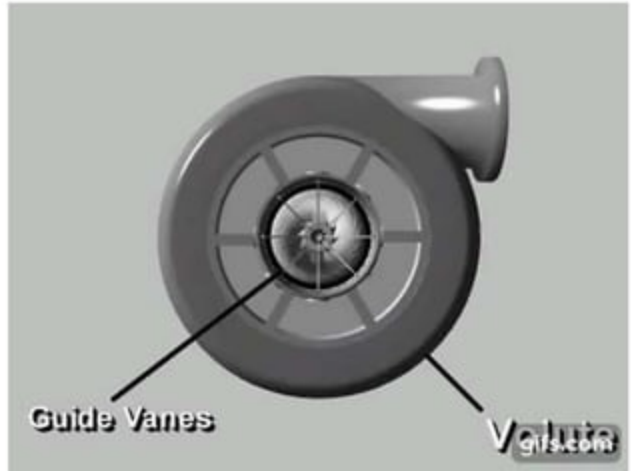


WORKING



GUIDE VANES

- By the help of vanes we can change the capacity of compressor.



APPLICATION

Vertically split process centrifugal compressors (BCH)

- These are used for many applications in oil refineries and desulfurization plants, synthetic gas plants, various types of natural gas plants, chemical plants, etc.

Horizontally Split Process Centrifugal Compressors (MCH)

- These are used in ethylene plants, ammonia plants, oil refineries, and chemical plants.

Overhung Centrifugal Compressors (POB)

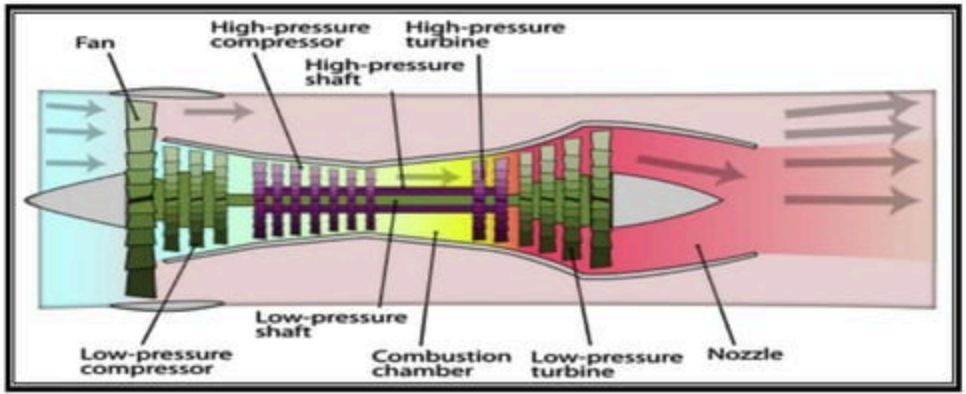
Mainly used for EO/EG plants, propylene plants, and other chemical plants.

BCH

MCH

POB

AXIAL COMPRESSOR

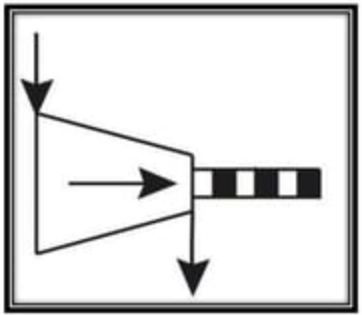


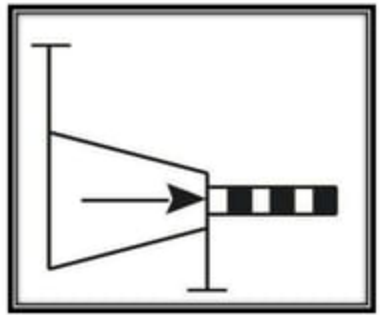
Axial compressors are somewhat similar to centrifugal compressor.It is the compressor that continuously compress air.It is a rotating airfoil-based compressor in which gas or air flows parallel to the axis of rotation.

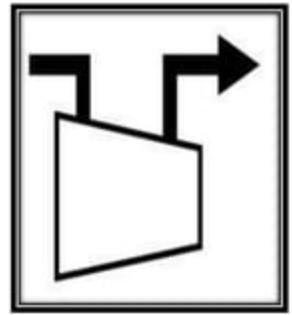
There are a set of rotating blades and a set of stationary blades.Both have different operations.

SYMBOLS OF AXIAL COMPRESSOR :

Following are the symbols of axial compressor ;

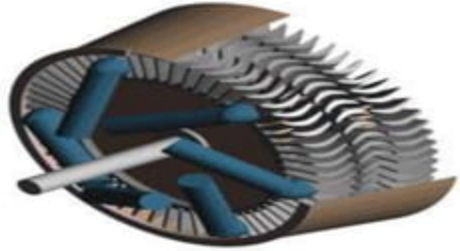






Working principle

As the compressor sucks the air axially and increases its energy level by flowing air through the rotor blades that rotates and exert a torque on the air.Now the stationary blades slow down the speed of the fluid and converts the circumferential component of air into the pressure.So the air get compressed in this way.



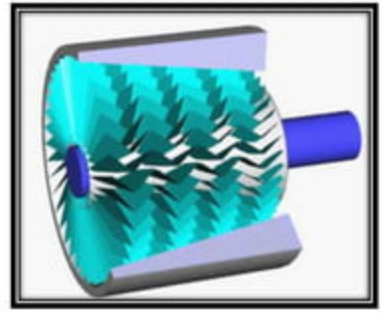
Axial flow compressors produce a continuous flow of compressed gas and have the benefits of high efficiency and large mass flow rate, particularly in relation to their size and cross-section. They do, however, require several rows of airfoils to achieve a large pressure rise, making them complex and expensive relative to other designs (e.g. centrifugal compressors).

The rotating airfoils also known as blades or rotors accelerate the fluid. The stationary airfoils also known as stators or vanes, convert the increased rotational kinetic energy into static pressure through diffusion and redirect the flow direction of the fluid, preparing it for the rotor blades of the next stage.

These forces can manifest themselves as tension (axial force), compression (axial force), shear, and bending, or flexure (a bending moment is a force multiplied by a distance hence producing torque).

In axial flow centrifugal pumps the rotor is a propeller. Diffusion vanes are located in the discharge port of the pump to eliminate the rotational velocity of the fluid imparted by the propeller. Axial flow compressors are also used to pump gases.

Axial compressors have relatively high peak efficiency. On the other hand, their efficiency is good over a narrow rotational speed range. Their big weight, combined with their high starting power requirements are some of their drawbacks.



APPLICATIONS :

Some applications of axial compressors are given below;

1. Blast furnaces.
2. Air separation plants.
3. Fluid catalytic cracking units.
4. Nitric acid plants.
5. Gas turbines such as jet engines
6. High speed ship engines.
7. In small scale power stations.

Advantages and Disadvantages of dynamic compressors

	Advantages	Disadvantages
Dynamic Compressors		
Centrifugal	•Wide operating range •High reliability •Low Maintenance	•Instability at reduced flow •Sensitive to gas composition change
Axial	•High Capacity for given size •High efficiency •Heavy duty •Low maintenance	•Low Compression ratios •Limited turndown •High starting power requirements

REFERENCES

http://aermech.com/?s=rotary+compressors&submit=Search

https://www.youtube.com/watch?v=s-bbAoxZmBg

http://turbomachinery.man.eu/products/compressors/axial

http://turbolab.tamu.edu/proc/turboproc/T21/T21183-188.pdf

https://www.slideshare.net/sleath_29/compressor