

## Basics of Mechanical Engineering-3

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### Lecture 46: Basics of Compressors

Welcome to the new topic on compressors. The name itself clearly says compress or press. So here, the fluid can be pressed, or the air can be pressed. So, we use this compressor in multiple places. For example, if you want to push air into a cycle tube, you need to use a spray paint. In fact, when we try to use scent, we compress the gas and fill it inside a bottle. Whenever you press the knob, you get a spray of scent or aromatic air. So, compressors play a part and parcel role in many heavy machines.

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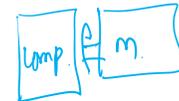
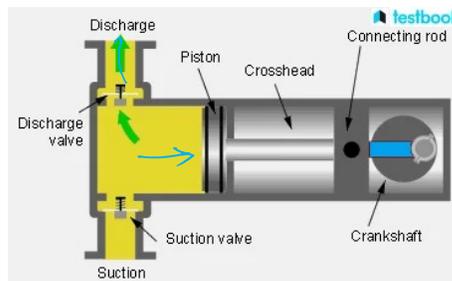
In this topic, we will try to understand the basics of compressors. Then, what are the different types of compressors? We will try to discuss only two compressors. One is the

positive displacement compressor. The other one is the dynamic compressor. Then, we will try to see what surging and choking in compressors are, and then intercooling. Finally, how do you calculate the efficiency of a compressor, and a few applications?

## Introduction to Compressors



- Compressors are devices used to increase the pressure of a fluid. (Liquid/Air)
- While pumps perform a similar function for liquids, and fans or blowers are used for gases to achieve slight or moderate pressure increases, compressors are specifically designed to compress gases to very high pressures.
- This process involves supplying work to the device, typically through a rotating shaft from an external source.



<https://blogmedia.testbook.com/blog/wp-content/uploads/2023/02/reciprocating-air-compressor-4b18a0b7.gif>

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A compressor is a device used to increase the pressure of a fluid. The fluid can be a liquid or it can be air. While pumps perform a similar function for liquids, fans or blowers are used for gases to achieve slight or moderate pressure increases. When you use a blower, there is an increase in pressure.

But compressors are specifically designed to compress gas to very high pressures. So you should understand that when we use a blower, you also increase the pressure. But when you use a compressor, it goes to very high pressure. This process involves supplying work to the device. Typically, this is done through a rotating shaft from an external source. So what we are trying to say is you will have a motor which is attached to a compressor. So, that is what we said: typically through a rotating shaft from an external source.

So, if you look at a typical compressor, there is a piston which compresses. When it compresses, it tries to pressurize air, and the air is discharged. So, this is the outlet, and here is the suction when the piston draws back inside a cylinder. At a certain pressure, the suction valve will open and allow the air to go inside. In the same way, once a critical

pressure is reached, the discharge valve will open, and the air gets out. So, this piston is attached to a crankshaft. So, this crankshaft is in turn attached to a motor.

Compressors, being a type of fluid machine that adds energy to the gas, fall into two broad categories. One is called a positive displacement compressor. The second one is called a dynamic compressor. In a positive displacement compressor, you can go from low pressure to very high pressure. The capacity will always be constant. For a fixed capacity to achieve varying pressure, we use positive displacement compressors. Dynamic compressors, where the capacity can be changed, allow pressures to start from a higher value and then drop. Generally, what we do is choose in this range, where the capacity can be varied, and the pressure is almost a straight line.

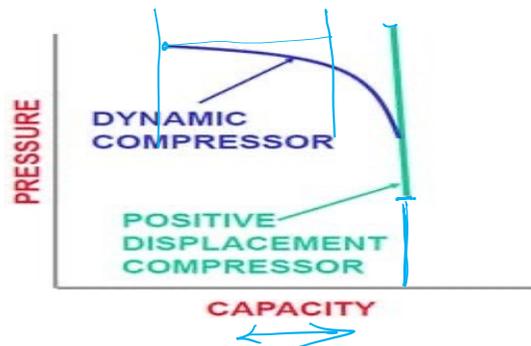
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## Classification of Compressors



Compressors, being a type of fluid machine that adds energy to a gas, fall into two broad categories:

- ✓ • Positive-Displacement Compressors (PDCs)
- ✓ • Dynamic Compressors



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So these are the two main classifications of compressors: positive displacement compressors and dynamic compressors.

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## Positive-Displacement Compressor



- These devices operate by trapping a volume of gas and then mechanically reducing that volume, forcing the gas to higher pressure.
- **The process involves distinct volume changes within a cavity.**
  - Reciprocating types include piston or plunger, and diaphragm compressors.
  - Rotary types feature mechanisms like sliding vanes, screws, or lobes.
- **Operating Principle:** They rely on volume changes in a closed cavity to force the gas along. A cavity opens to admit gas, then closes to compress and expel it.
- **Flow Characteristics:** Typically deliver a pulsating or periodic flow.
- **Viscosity Handling:** They can effectively handle a wide range of fluid viscosities
- **Flow Rate Control:** The flow rate of a PDC can only be varied by changing its displacement or operating speed.



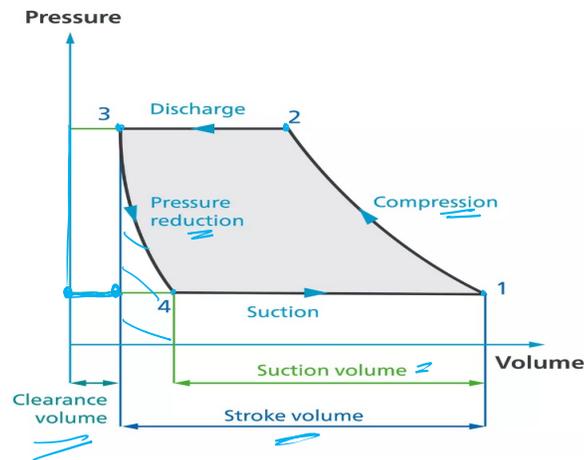
Now, let's gain a little more understanding of positive displacement compressors. These devices operate by trapping a volume of gas. Then, they mechanically reduce that volume, forcing the gas to a higher pressure, which is done by the compressor. The process involves distinct volume changes within a cavity. So here, it can be a reciprocating type or a rotary type. The reciprocating type includes a piston or a plunger. When we talk about diesel injection, it is a plunger. And when we talk about air, we predominantly look at a piston and a diaphragm compressor.

When we talk about rotary, they feature mechanisms like sliding vane, screw, and lobes. The operating principle for all these positive displacement compressors is that they rely on volume change in a closed cavity to force the gas along. So this is what is shown here. They rely on volume changes in a closed cavity to force the gas along. A cavity opens to admit gas, then closes to compress, and then it expels.

The flow characteristics typically follow delivery, a pulsating or periodic flow. So naturally, if you want to have a continuous flow, you put an accumulator and then extract air. The viscosity handling: they can effectively handle a wide range of viscosities depending upon the fluid. For example, oil can be compressed. I was talking about scent, which can be compressed. Water can be compressed, right? Then you want to go to gas; it can be done. Steam can be done. So, viscosities of varying ranges can be handled by using these positive displacement compressors. The flow rate control: the flow rate of

PDC, positive displacement compressors, can only be varied by changing their displacement or operating speeds. Flow control can be done only by changing these things.

## Positive-Displacement Compressor



<https://atlasopco.scene7.com/is/image/atlasopco/piston-compressor-theoretical-pv-diagram-text-wiki?Slandscape16005>

So, here is a PV diagram, which clearly demonstrates the function of a compressor. So, we can start from 1. This is the starting stage. So, from 1, I try to compress the air or the fluid. Let us assume it is air here. I compress it to position 2. The action is compression. I use a compressor here.

From 2 to 3, there is a discharge happening; there is constant pressure, and the volume is reduced. Then, from 3 to 4, there is a pressure reduction falling from 3 to 4, and the volume is expanding. And again, from 4 to 1 is suction. So, from 4 to 1 is called the suction volume. From 3 to 1 is called the stroke volume. The difference between suction volume and stroke volume is nothing but a small difference here, right?

So this is to be carefully handled. From 0, from this edge to 3, this one is called the clearance volume, or from here to here is called the clearance volume, which comes at the top. So if you look at this PV diagram, it clearly demonstrates the compressor's function. What happens to the volume? What happens to the pressure?

# Positive-Displacement Compressor



1. Suction (4→1): The piston moves down, drawing in the gas at low pressure and increasing the volume.
2. Compression (1→2): The piston moves up, reducing volume and increasing the pressure of the trapped gas.
3. Discharge (2→3): The compressed gas is expelled at high pressure as the piston reaches the top.
4. Pressure Reduction (3→4): The remaining gas expands back to the starting pressure but within a small "clearance volume" that never leaves the cylinder.



So suction happens from 4 to 1. The piston moves down, drawing the gas at low pressure and increasing the volume. It sucks. Like when you try to pressurize air or when you try to suck air. The liquid inside a water gun cylinder. So that's 4 to 1. So at low pressures, the liquid gets inside the water gun. Here it is air. Then it is compressed. Then you try to compress 1 to 2.

The piston moves up, reducing the volume because there can be volume front and there can be air. So, reducing the volume increases the pressure of the trapped gas. So once you try to push it to a certain level, the droplet that comes out of your water gun or the small amount of air comes out—until then, it is compression. Then it starts discharging. So I try to press, and there is a discharge of air.

The compressed gas is expelled at a higher pressure as the piston reaches the top end. So you keep on moving, and there is a discharge happening. The pressure reduction happens between 3 to 4. So, at 3, there is a discharge happening, and there is a pressure reduction happening from 3 to 4. The remaining gas expands back to the starting pressure but within a small clearance volume that never leaves the cylinder.

So, that is called the clearance volume, 3 to 4, right—a small one. So the next option—this is a straightforward, simple thing.

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# Dynamic Compressors



- These machines continuously add momentum to the gas through fast-moving blades or vanes.
- The high velocity imparted to the gas is then converted into a pressure increase as it flows into a diffuser section.
- Rotary designs, often called rotodynamic compressors, include centrifugal (radial exit flow), axial flow, and mixed flow (a combination of radial and axial) types.
- **Operating Principle:** They impart momentum to the gas using fast-moving blades, which is then converted into a pressure increase within a diffuser section. There is no enclosed volume involved in the compression process.
- **Flow Characteristics:** Generally provide a much steadier discharge.
- **Viscosity Handling:** They are less effective with high-viscosity gases, and high viscosity can significantly degrade their performance.

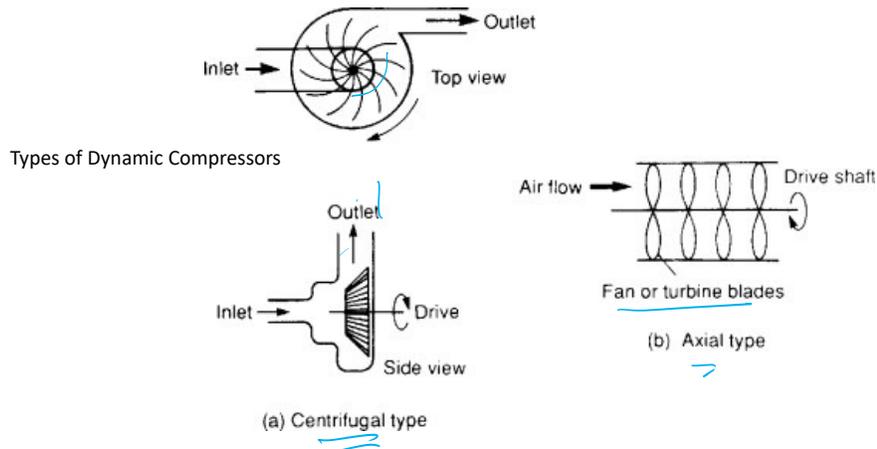


Let us try to understand dynamic compressors. These machines continuously add momentum to the gas through a fast-moving blade or a vane. The high velocity imparted to the gas is then converted into a pressure increase as it flows into a diffuser section.

Friends, I am sure you will remember what a diffuser is. The high velocity imparted to the gas is then converted into a pressure increase, as it flows into a diffuser section. The diffuser is this diffuse. The rotary design, often called a rotodynamic compressor, is what this dynamic compressor includes: centrifugal flow, axial flow, and a mixture of centrifugal and axial, which is the mixed flow. The operating principle is that they impart momentum to the gas using fast-moving blades, as we will see in the figure, which is then converted into a pressure increase within a diffuser section.

There is no enclosed volume involved in the compression process. So the flow characteristics generally provide a much steadier discharge. Viscosity handling: they are less effective with highly viscous gas. High viscosity can significantly degrade their performance. So this is a compressor. So let me go back. So the operating principle is that they impart momentum to the gas using fast-moving blades.

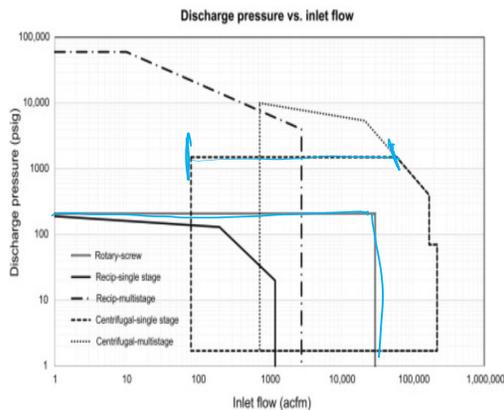
# Dynamic Compressors



See here, there is a blade which is fast-moving, and it is then converted into a pressure increase within a diffuser section. This is a diffuser section; it is thrown out, okay. So, there is no enclosed volume involved in the compression process, as it happens in positive compressing. So this is a blade-assisted, rotodynamic compressor.

You can also have a centrifugal compressor; the air comes inside, the shaft rotates, so the air gets thrown in and then it gets thrown out where the pressure increases. The other way around, axial is where there is something like suction happening from one end. You have a rotor which rotates, and then you try to get the airflow outside. So this happens typically in fans or turbine blades.

# Dynamic Compressors



- Dynamic compressors work by imparting velocity (kinetic energy) to the gas using rotating impeller blades, then converting the velocity to pressure in a diffuser.
- The graph reflects this principle by showing the typical operating regions: high flows, lower pressures for single-stage; higher pressures achievable with multistage.
- The shape of the performance zones (broad horizontal range, limited vertical range) matches the fundamental behavior of dynamic compressors, where stable operation is maintained over a narrower pressure range at high volumes.

So here is a plot which clearly shows the discharge pressure with the inlet flow. The dynamic compressor work by imparting velocity which is known as kinetic energy to the gas using a rotating impeller blade. So, this one.

Then converting the velocity to pressure in a diffuser. So, the imparting velocity to the gas using rotating impeller blade which then converts into a velocity to pressure in the diffuser. Now, the graph drawn here reflects this principle by showing a typical operating range.

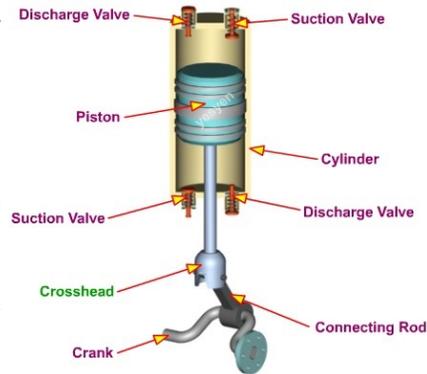
So, you can see here inflow. A typical operating range: high flow, low pressure for a single stage; high pressure achievable with multiple stages. So, low pressure, high flow for a . Then, higher pressure is achievable with multiple stages. So, you can have a single-stage and a multiple-stage compressor.

So the shape of the performance zone—broad horizontal range, limited vertical range—you can see here: broad horizontal range, limited vertical range—matches the fundamental behavior of the dynamic compressor, where stable operation is maintained over a narrow pressure range at higher volumes.

# Reciprocating Compressors

## Working Principle:

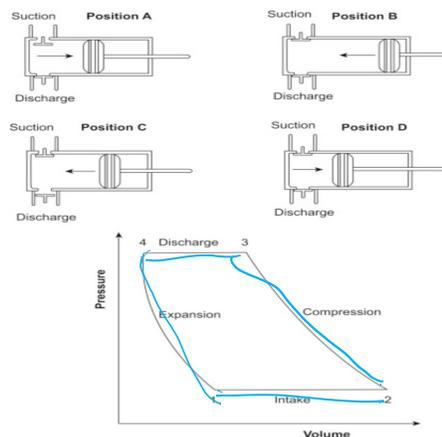
- Reciprocating compressors are a type of positive-displacement compressor (PDC).
- Their fundamental principle involves forcing the gas along by changes in volume.
- A cavity opens to admit the gas, then closes to mechanically reduce that volume, thereby squeezing the gas to a higher pressure before expelling it through an outlet.
- **This mechanism results in a pulsating or periodic flow.**



Clear? So, reciprocating compressor. Reciprocating compressors are a type of positive displacement compressor (PDC). Their fundamental principle involves forcing the gas along by changing the volume. So, the cavity opens to admit gas, then closes to mechanically reduce that volume, thereby squeezing the air to high pressure before expelling it through the outlet. The mechanism results in pulsating or periodic flow.

# Reciprocating Compressors

A reciprocating compressor works by sucking in gas, squeezing it to raise its pressure, and then releasing the compressed gas. The piston repeats this cycle over and over to supply high-pressure air or gas.

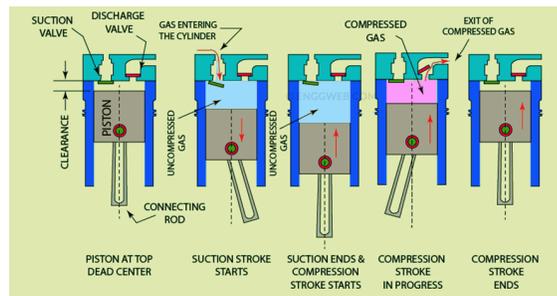


So, these are the four stages of a reciprocating compressor. So, 1 to 2 is the intake of air. So, the volume increases, and the pressure is almost constant. Then, 2 to 3 is compression, which happens here in position B. And then, 3 to 4 is discharge, which happens at C, right? And D is this, where again the pressure reduces and the intake volume increases. So, 1, 2, 3, 4, A, B, C, and D.

## Reciprocating Compressors



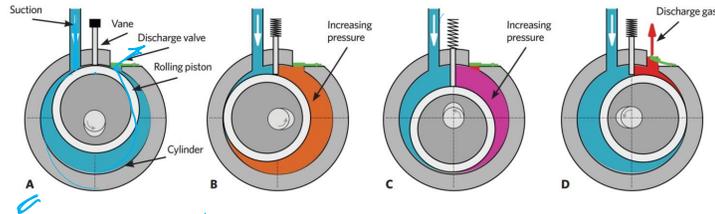
- They deliver a pulsating or periodic flow.
- If the outlet is shut off, they can generate immense pressures, necessitating sturdy construction and the use of pressure relief valves to prevent damage.
- The flow rate can only be varied by changing the displacement or the operating speed.



Now, this is something we can also try to take in the IC engine part for a petrol engine. So, they deliver a pulsating or periodic flow. If the outlet is shut off, they can generate immense pressure, necessitating sturdy construction and the use of a pressure release valve to prevent damage. The flow rate can only be varied by changing the displacement or the operating speed.

# Rotary Compressors

- Rotary compressors, like reciprocating compressors, fall under the category of positive-displacement.
- Their working principle involves forcing the gas along by volume changes within a confined cavity.
- The process involves a cavity opening to admit gas, then closing to compress and expel it.
- Similar to reciprocating types, they deliver a pulsating or periodic flow.



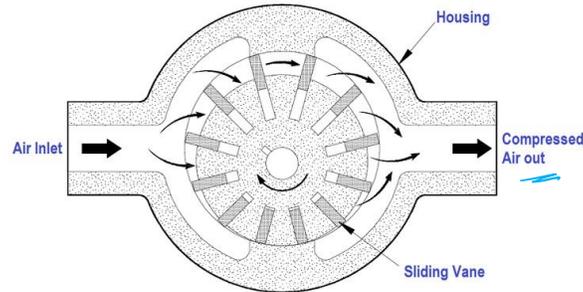
This is for rotary compressors. Like reciprocating compressors, rotary compressors fall under the positive displacement category. The working principle involves forcing the gas along by volume change within a confined cavity. So here, the gas is forced. You can see here the gas is getting sucked inside. It then enters a shell where this rotary mechanism operates. They try to compress it and expel it through a relief.

You can see stage A, where air comes in. Stage B shows how the air enters and the rotary vane or roller piston moves to one side. They increase the pressure, and then the air enters, further increasing the pressure. At some stage, once the break-even is reached, the discharge occurs. The process involves a cavity opening to admit gas, then enclosing to compress and expel it. It is similar to reciprocating, but the machine functions in a rotary manner. Here, you will also observe pulsating and periodic flow.

## Rotary Compressors

The sources classify various rotary positive-displacement mechanisms, which are applicable to compressors when handling gases:

- **Single Rotor Types:** Include sliding vane and screw mechanisms.
- **Multiple Rotor Types:** Include gear, lobe, and screw mechanisms. These mechanisms trap and compress gas through their continuous rotary motion.

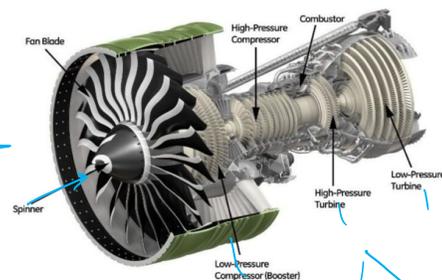


As I mentioned, there are single-stage and multiple-stage rotors. The rotary compressor, the sources classify various rotary positive displacement mechanisms which are applicable to compressors when handling gases. Single rotary type and multi-rotary type are available. They include single rotary, which includes sliding vane and a screw mechanism.

When we talk about multiple rotary type, it includes gear, lobes, and screw mechanism. These mechanisms trap and compress air through continuous rotary motion. So, air inlet—you can see air coming in, then it gets compressed, and then it is thrown out.

## Axial Flow Compressors

- Axial flow compressors force gas to move axially through multiple stages of blades.
- Like centrifugal types, they are dynamic machines that add momentum to gas.
- Gas passes through alternating rows of fixed stator and moving rotor blades, each pair forming a stage.
- Rotors increase kinetic energy, and stators convert it into pressure while redirecting flow for the next stage.
- Though each stage gives a small pressure rise, multiple stages result in significant pressure increase.



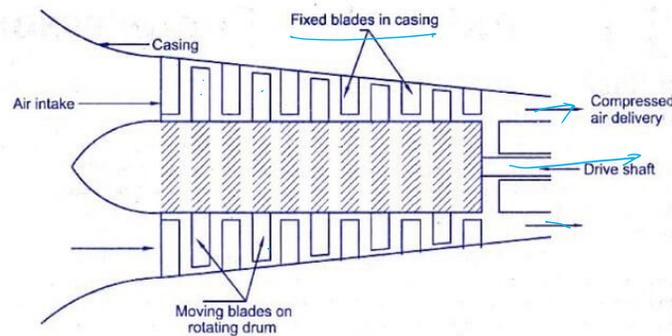
$$D + \Delta = \Delta$$

Handwritten diagram showing a blue arrow pointing to the left, a blue arrow pointing to the right, and a blue 'X' mark below the equation.

So, this is the axial flow type. We saw the classification: axial, centrifugal, radial. So, axial flow type. This is used in planes. Axial flow compressors force gas to move axially through multiple stages. You can see there are multiple stages. Low-pressure turbine, high-pressure turbine, high-pressure compressor. Like the centrifugal type, which was here—the centrifugal type—they are dynamic machines that add momentum to the gas.

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## Axial Flow Compressors



Axial compressor schematic diagram

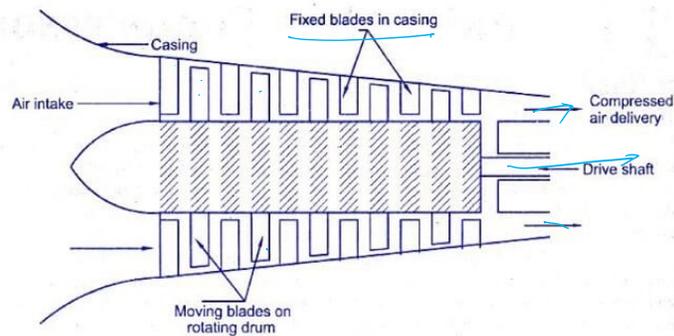


The gas passes through alternating rows of fixed stator and moves through rotary blades, each pair forming a stage. So, this point is important.

Alternating rows of fixed stator and rotating rotor blades. This is stator and moving rotor blades. So, alternating rows of fixed stator and moving rotor blades, each forms the stator and the rotor forms a stage. The rotor increases kinetic energy, and the stator converts it into pressure while redirecting flow for the next stage. So, one stage moves to the next stage.

Though each stage gives you a small pressure rise, multiple stages add significant value to the pressure increase. So,  $\Delta x$  plus  $\Delta x$ ,  $\Delta x$  plus  $\Delta x$ , right? This equals it gives you a larger  $x$ , something like that. So, each stage, multiple stages, each stage, small pressure rise, multiple stages, a huge pressure rise. So, that is what is told here.

# Axial Flow Compressors



Axial compressor schematic diagram

So, this is what typically happens: the air intake happens, this is the casing, and you have these rotors, right? So, moving blades in a rotating drum. So, each one, this is a stator rotor. So, it compresses, pushes to the next, pushes to the next fixed blade in the casing you have. So, whatever you get out is a compressed air delivery which happens, and this is a drive shaft.

# Surging and Choking in Compressors

## Surge:

- This occurs on the low flow side and is characterized by blade stall and vibration.
- It represents an unstable operating condition where the flow can reverse direction, leading to significant pressure and flow oscillations.

## Choking:

- This phenomenon occurs on the high flow side when the Mach number reaches 1.0 somewhere in the system.
- In compressible flow, where fluid velocity is comparable to its speed of sound, density changes become significant.
- **Choking signifies a sharp limit on the duct flow rate due to the sonic condition.**

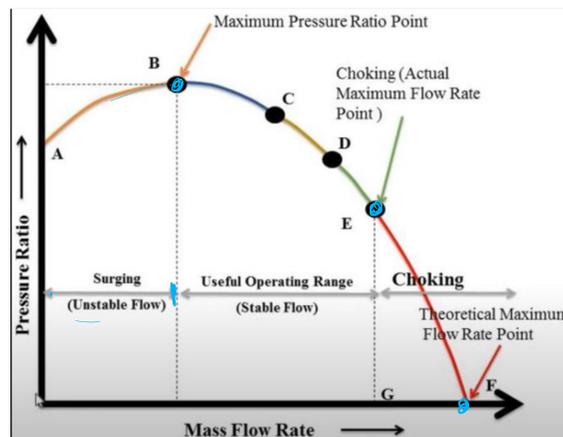
Surging and choking in compression. Surging occurs on the low flow side and is characterized by blade stall and vibration. So, on the low flow side means in the intake

itself, it can happen. This occurs on the low flow side surge and is characterized by blade stalling and vibration. This represents an unstable operating condition. Whereas the flow can reverse direction and lead to significant pressure and flow oscillations.

Surge is something very important when we start working on turbines and compressors. It represents an unstable operating condition. It vibrates. Because on the low flow side, there is a stall happening. Leading to significant pressure and flow oscillations. Choking. Choking is when you try to block the flow. This phenomenon occurs on the high flow side. Surge happens on the low flow side. Choke happens on the high flow side when the Mach number reaches 1 somewhere in the system.

In compressible flow where high velocity is comparable to the speed of sound, density changes become significantly high. So when the Mach number goes to 1, the density change happens significantly. The choking signifies a sharp limit on the duct flow rate due to the sonic condition. So these two are to be avoided in a compressor.

## Surging and Choking in Compressors



So when you try to see a typical compressor pressure ratio versus mass flow rate ratio, pressure ratio is inlet by outlet, and mass flow rate is also there. So you can see there are three segments or three zones forming. So zone 1 is surging unstable flow, zone 2 is the useful flow which is always tried to be used or this limit is used in compressors, and the last one is choking which happens at the end. So A to B is the maximum pressure ratio point. So until it reaches the maximum pressure ratio point, surging can happen, and

unsteady flow can occur. From there, the pressure ratio, you can see, falls down as the mass flow rate increases.

So C, D, E, till E, B to E, there is a reduction in the pressure ratio, but there is an increase in the mass flow rate ratio, right? Mass flow rate is increased. So after E comes the choking. So, choking is the actual maximum flow point. What is choking? Choking occurs in the compressive flow where the fluid velocity is comparable to the speed of sound, and density changes become significant.

So, that is why the mass flow we have measured falls down drastically afterward. So, this is the theoretical maximum flow rate point you can have, but we generally operate between B to E.

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## Surging and Choking in Compressors



This image explains how a compressor works, especially what happens during surging and choking:

### Surging (left side of the graph):

- Happens at low mass flow rates when the compressor tries to push against very high pressure.
- The flow becomes unstable and can reverse direction, causing vibrations and loud noises.
- It's a dangerous operating condition compressors should avoid running here.



This image explains how a compressor works, especially what happens during surging and choking. Surging happens at a low mass flow rate when the compressor tries to push against very high pressure. This is surging. The flow becomes unstable and can reverse direction, causing vibration and noise. So, there is a flow of air, and there is high pressure there. So, this flow will try to push it back. So, the flow becomes unsteady and can reverse direction, causing vibration and loud noise. It is dangerous to operate the compressor in this condition; it should avoid running at the surging point.

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## Surging and Choking in Compressors



### Choking (right side of the graph):

- Happens at very high mass flow rates when the compressor can't push any more air through the flow hits its maximum limit.
- Pressure drops sharply, and the compressor can't increase flow any further, even if you try.
- The air is moving so fast that increasing speed doesn't help; you've reached the "choked" maximum.



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The choking point, on the right side of the graph, happens at a very high mass flow rate where the compressor cannot push any more air through the flow path, reaching its maximum limit. You are trying to throttle it to reach the maximum limit of mass flow rate. At this point, the compressor also fails. The pressure drop is very sharp, and the compressor cannot increase the flow any further if you try. And the air moves so fast that increasing the speed does not help. So you reach a choking point, or this is called a choked maximum.

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## Intercooling



- Cooling a gas as it is compressed is highly desirable as it significantly reduces the required work input to the compressor.
- Multistage compression with intercooling is a practical and effective technique to achieve this.
- The process involves compressing the gas in stages and cooling it between stages by passing it through a heat exchanger called an intercooler.
- **Intercooling and reheating always decrease the thermal efficiency of the cycle unless they are accompanied by regeneration.**
- This is because intercooling reduces the average temperature at which heat is added to the cycle.



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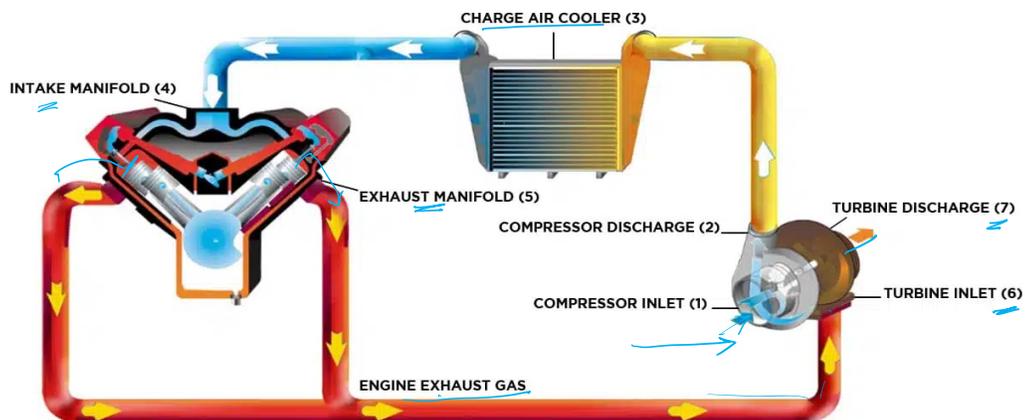
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Intercooling is very important because cooling a gas as it is compressed is highly desirable, as it significantly reduces the required work input to the compressor. When you try to pressurize air, a lot of heat is generated that has to be cooled out. So cooling a gas as it is compressed is highly desirable. Otherwise, what happens? The temperature phenomenon occurs.

This temperature phenomenon is going to rupture the casing, as it significantly reduces the required work input to the compressor. A multi-stage compressor with intercooling is a practical and effective technique to achieve the best out of it. The process involves compressing the gas in stages. And cooling it between stages by passing it through a heat exchanger is called an intercooler. One stage of compression, then before it moves, you cool it.

So the temperature falls down, but the rest pressure and velocity do not change. Intercooling and reheating always decrease the thermal efficiency of the cycle unless they are accomplished by regeneration. So you are trying to cool or trying to extract heat. This extracted heat, if I can use it for some other purpose, then it is good. Otherwise, it is a loss of thermal efficiency. This is because intercooling reduces the average temperature at which heat is added to the cycle.

## Intercooling



So this is a typical intercooling circuit you have. So let us start from the compressor. Right. So the compressed air inlet is going on. So it is trying to pressurize the air. High-pressure air is sent through the compressor to an air charge air cooler. This is a heat exchanger like a refrigerator. It passes through your distinct refrigerator. So the temperature of the hot air now becomes blue and cool.

And this cold air, or the temperature-reduced air, is then passed into the inlet manifold of a machine. So once there is work done, there is a release of air at a higher temperature. This goes into the compressor once again. So from here, it goes to the compressor once again. So you can see here happening: one cycle this way, one cycle that way.

The heat or the hot air exhaust from the engine is what is called engine exhaust gas. This gas goes back to the compressor. As it goes back to the compressor or to the turbine, air is pushed inside through the compressor. There is a mixing of fresh air and this process, and then the system continues. You have an exhaust manifold and an intake manifold. The exhaust manifold leads to gas, and there is a compressor that operates a turbine. This is done, and then we try to use it. The turbine inlet is here, the turbine discharge is here, and then you try to get it. Intercooling is a very important stage.

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## Applications of Compressors



- Compressors are widely used across various engineering and industrial applications.
- Some notable applications include:
  - Jet engines, rockets, and spacecraft.
  - Industrial facilities where compressed air is used for tasks like cleaning, operating pneumatic equipment, and refrigeration.
  - Refrigeration and air-conditioning systems, where compressors are fundamental components in vapor-compression refrigeration cycles.
  - Gas-turbine engines.
  - Natural gas pipelines for gas compression.

Now, coming to the last part of the discussion: where can the compressor be used? Compressors are used in various engineering and industrial applications. You name it: IC engines, DG sets (diesel generators), trains, or any processing industry. If you are using it at home, we use a compressor.

For your AC, we use a compressor. So, it is used everywhere. Some notable applications include jet engines, rockets, and spacecraft. We also use compressors. Industrial facilities use compressed air for tasks like cleaning, operating pneumatic equipment, and refrigerators. When you are trying to open and close a pneumatic system, compressors are used. Compressed air is used in a pneumatic system.

In refrigeration and air conditioning systems, we also use compressors, which follow the vapor compression refrigeration cycle. We have seen that. Gas turbine engines use compressors. Natural gas pipelines also use compressors. Compressors are one of the major mechanical engineering systems used in real-time applications.

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## *To Recapitulate*



- What are Compressors?
- Describe various types of Compressors.
- What do we understand by a Positive Displacement Compressor?
- What is a Dynamic Compressor?
- State and describe the phenomena of Surging and Choking.
- What is Intercooling and what is an Intercooler?

To recap what we discussed in this chapter: we went through what compressors are, different types of compressors (positive displacement and dynamic), two major issues in a compression cycle (surging and choking), and finally, the need for intercooling and the applications of compressors.

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## References



1. Patrick Chassaing, 2023. Fundamentals of Fluid Mechanics\_ For Scientists and Engineers-Springe.
2. Frank M. White, 2017. Fluid mechanics-McGraw-Hill Education.
3. Kundu, P.K., Cohen, I.M., Dowling, D.R. and Capecelatro, J., 2024. Fluid mechanics. Elsevier.
4. Munson, B.R., Okiishi, T.H., Huebsch, W.W. and Rothmayer, A.P., 2013. Fluid mechanics (pp. 271-274). Singapore: Wiley.
5. Nakayama, Y., 2018. Introduction to fluid mechanics. Butterworth-Heinemann.
6. Shaughnessy, E.J., Katz, I.M. and Schaffer, J.P., 2005. Introduction to fluid mechanics (Vol. 8). New York: Oxford University Press.
7. Anderson, J. D. Jr. , 2016. Fundamentals of Aerodynamics (6th ed.). McGraw-Hill Education.



These are the references used for making these slides.

Thank you very much.