Oil Hydraulics and Pneumatics

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Part 03: Reciprocating Type Air Compressor – Single and Multi–stage Piston Pump, PV Diagram and Work Done
Lecture - 25
Pneumatic Control and Pneumatic Power Source

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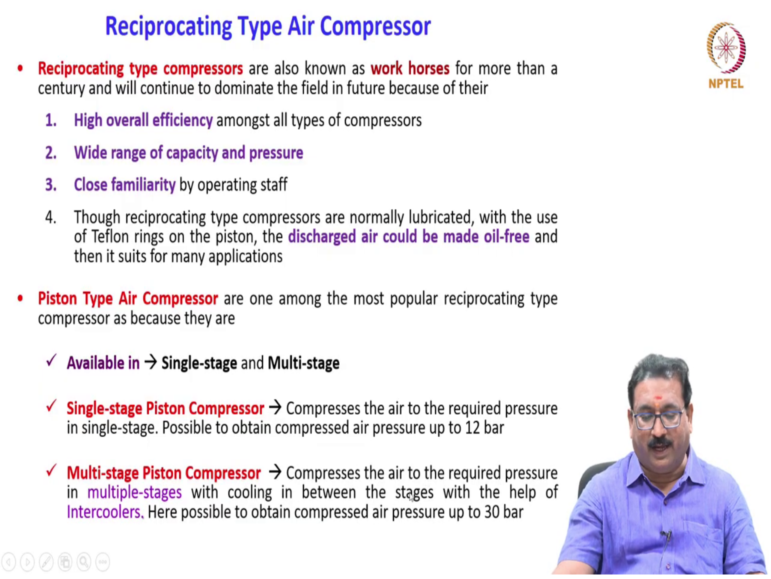

My name is Somashekar, course faculty for this course. Now, we will discuss the reciprocating type of compressors, the most popular in compressor. Let us we will see reciprocating type of compressors are also known as the work horses for more than a century and will continue to dominate in the field in future also because of their high overall efficiency amongst all types of compressors.

Wide range of capacity and a pressure. Close familiarity by operating staff. Though reciprocating type compressors are normally lubricated with the use of Teflon rings on the piston the discharged air could be made oil free and then it suits for many applications.

Piston type air compressor are one among the most popular reciprocating type of compressor as because they are available in single stage and multistage. What is this I will tell you; single-stage mean what, multi-stage means what, how air is compressed in the different stages to get the required pressure.

Single-stage piston compressor compresses is the air to the required pressure in a single stage one it will sucks and compress one cycle. It is possible to obtain the compressed air pressure up to 12 bar based on the diameter and all these thing piston diameter and many things.

Multi-stage piston compressor compresses the air to the required pressure in multiple stages multi stages with a cooling in between the stage with the help of intercoolers. Hence possible to obtain the compressed air pressure up to 30 bar.

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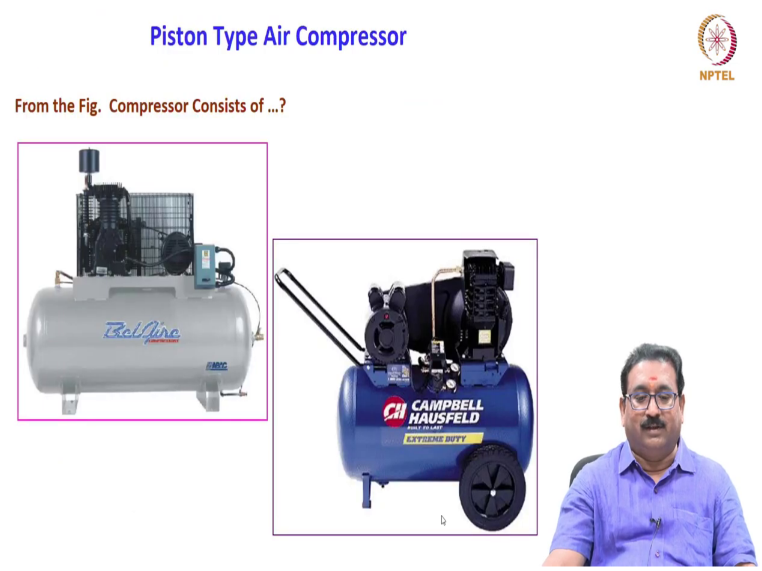

Let us we will see this what I am showing you here it is a one piston type air compressor. By seeing this as I have told you what are the main component electric motor compressor and receiver tanks and so many other devices are there. I will show you what are those in the next slide.

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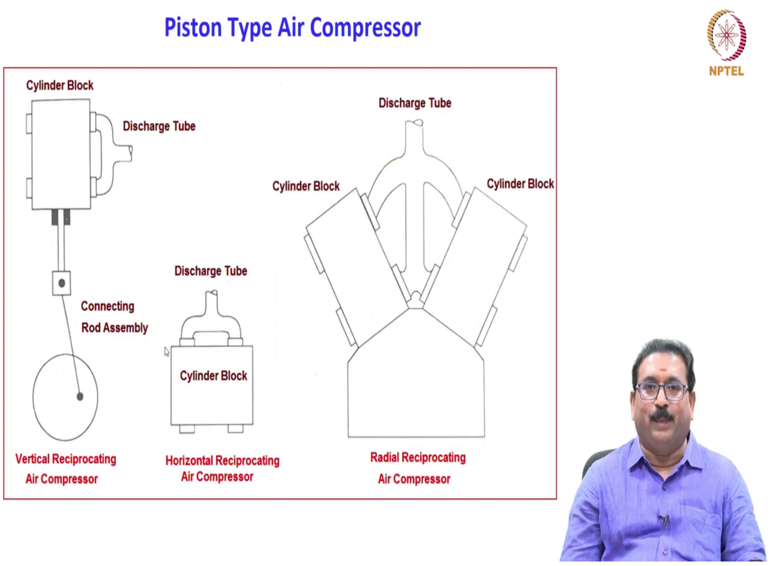

Based on the piston arrangement you will see the piston is moving up and down here they are classified as vertical reciprocating air compressor. It is a cylinder block and these are the discharge tube, this is a connecting assembly. Here the horizontal reciprocating air compressor, cylinders are mounted horizontally; here we will see the radial, radially they are mounted.

The cylinder block 1 and cylinder block 2 multiple stage, it is known as radial reciprocating air compressor based on the cylinder mounting they are classified as vertical reciprocating air compressor, horizontal reciprocating air compressor and radial reciprocating air compressor.

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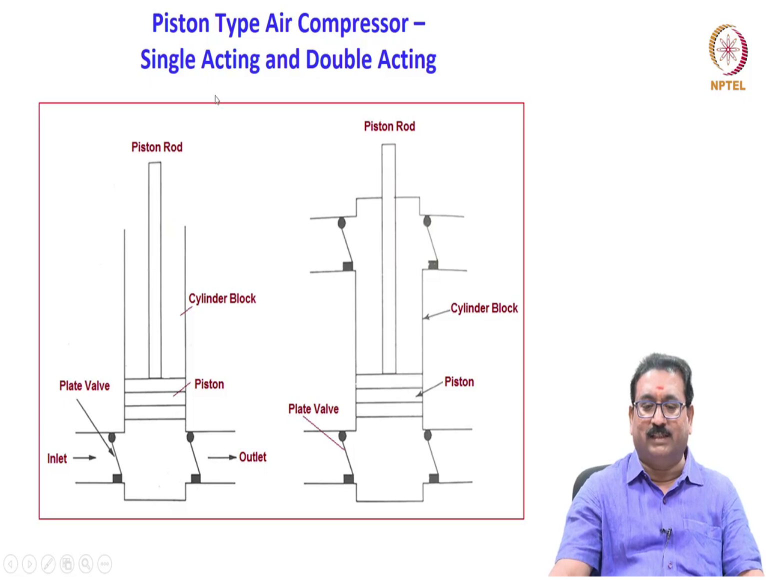

Also we will see friends what is this single acting and double acting air compressors. To explain to you very simple sketch it is. Again, it is a cylinder with piston here. The air will be sucked when the piston rod is taken out. How it is? Through the inlet air will enters when you will move up, then what happens? If you will push down, what happen? Air will go out through this valve, these are called as non-return valve; plate valves are nothing, but non-return valve.

When will piston will take up, what happen? Air will enters the cylinder, when you will push this the air will exit through the outlet. Suction and discharge will takes place, but you will see here in the another case again it is a piston and cylinders arrangement, but you will see friends here what happens when the piston is taken out what happen air will enters through this and whatever the air is present here it will exit through this.

When you will pushed in, what happen? Air will enters here and air will discharge here this is called a double acting type, it is a single acting, it is a double acting; double acting means when you will push suction a discharge will takes place in the single acting suction and discharge in one cycle, but here 2 times.

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Now, let us we will see the single stage piston type air compressor. Here are the piston is driven by rotating crank shaft to pressurize the air as I have told you. In single piston type compressor pressure up to 12 bar possible to obtain.

What are the main elements are there here friends single stage? Cylinder, piston, piston rings, connecting rod and a crankshaft. These are the very important elements in the piston type compressor. Piston is there, cylinder is there, piston rings to avoid the leakage, connecting rod and a crankshaft.

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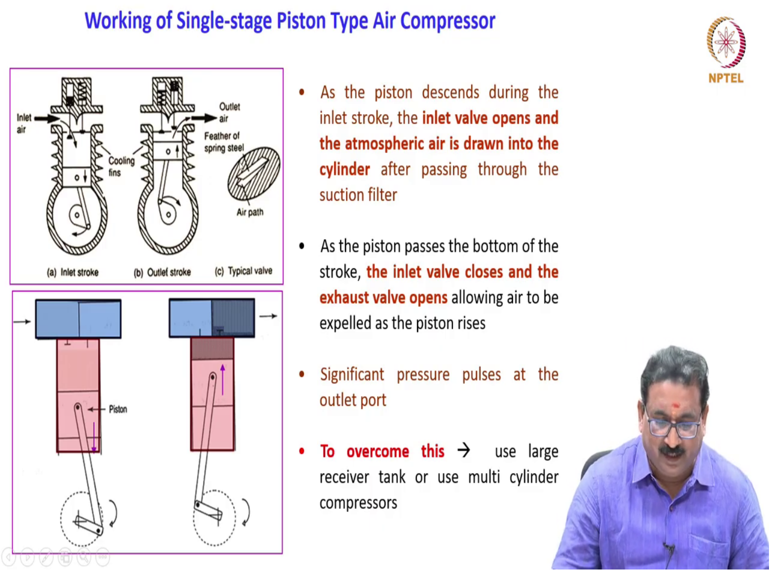

Let us we will see now schematic diagram as I have told you here. I explained already this schematic diagram. This is a inlet stroke, outlet stroke and typical valve how it is opening and closing same here also again line diagram I have drawn here. The inlet, this is a outlet this is a connecting rod and a crank rotations, how it will move from top dead center to bottom dead center, how it will draw and how it will expel the air?

Let us we will see. As the piston descends during the inlet stroke the inlet valve opens when it will move down when it will piston will move down inlet valve will opens, air will sucked in. When the piston rod is moved up what happen? The air will be compressed and discharged to the outlet valve same.

Also you will see friends here it is a what we will call significant pressure pulses at the outlet port to work on this use a large receiver tank or use a multi-cylinder compressors. Will freeze see here friends here cooling pins are there, what for it is?

To cool the compressed air. When you will compress, what happened? Volume decreases, in pressure increases, temperature increases know that is why they are providing the cooling pins cooling pins to cool the air before it is take out.

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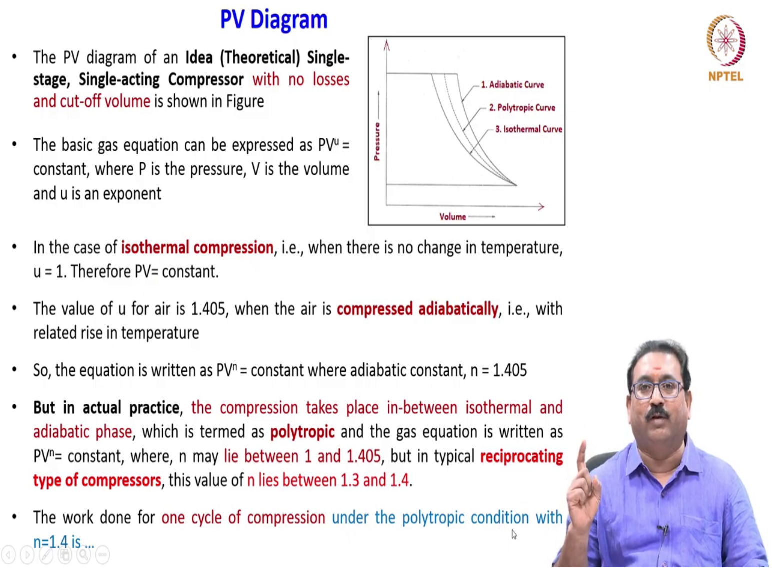

Now, we will see with the PV diagram what happens when the air is sucked and compress. You already seen in the many places in thermodynamics all. Let us very quickly I will show you the PV diagram what happens. The PV diagram of an ideal single stage, single acting compressor with no losses and cut off volume is as shown in figure here.

Here I have shown the volume and then we will compress what happens. Here I have shown the adiabatic curve then another side is isothermal curve, the in between what it is? A polytropic curve. Let us we will see this the basic gas equation can be expressed as PV raise to u is nothing, but if you want to take n is a constant it is. PV raise to u a constant, where P is the pressure, V is the volume and u is an exponent.

In the case of isothermal compression, what happen? The fixed volume will compressor isothermal compression that is when there is no change in temperature that is u equal to 1. Therefore, PV equal to constant, this is a isothermal compression u equal to 1. The value of u for the air is 1.405, when the air is compressed adiabatically you will see when you will compressed adiabatically with a related rise in temperature.

So, the equation is written as PV raise to n equal to constant where the adiabatic constant this n equal to how much? 1.405. But, in actual practice the compression takes place in-between the isothermal and adiabatic phase which is termed as polytropic and the gas equation is written as PV raise to n equal to constant, where n lie between 1 and 1.405, but in a typical reciprocating type of compressor this value of n lies between 1.3 to 1.4 in the polytropic curve middle one.

The work done for one cycle of compression under the polytropic condition with n equal to 1.4; one cycle means compress a suction and discharge.

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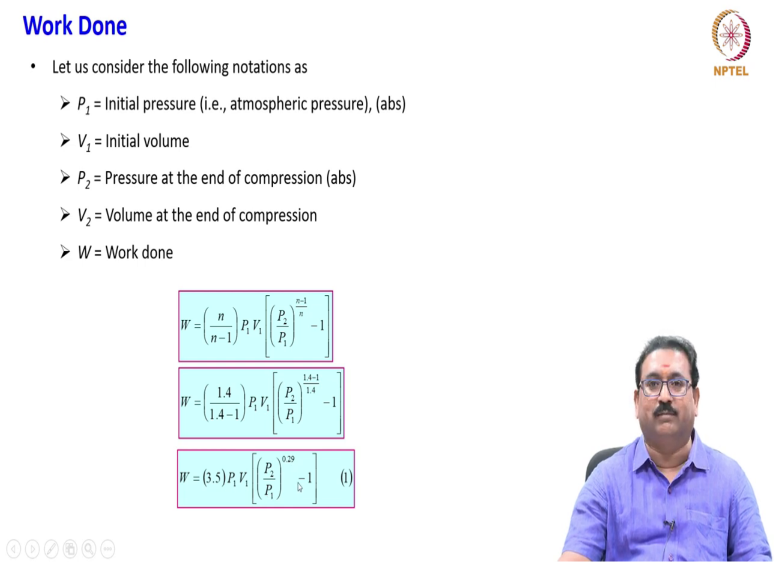

For n equal to 1.4 assuming what happens you will see the work done. Let us consider the following notation P 1 is the initial pressure, V 1 is the initial volume, P 2 is the pressure at the end of the compression, V 2 is the volume at the end of compression, W is a work done.

So, W equal to what? N divided by n minus 1 P 1 V 1 into bracket P 2 by P 1 n minus 1 divided by n minus 1. Now, substitute the value of n equal to 1.4, afterward we will get 3.5 P 1 V 1 P 2 by P 1 raise to 0.29 minus 1. This is a work done.

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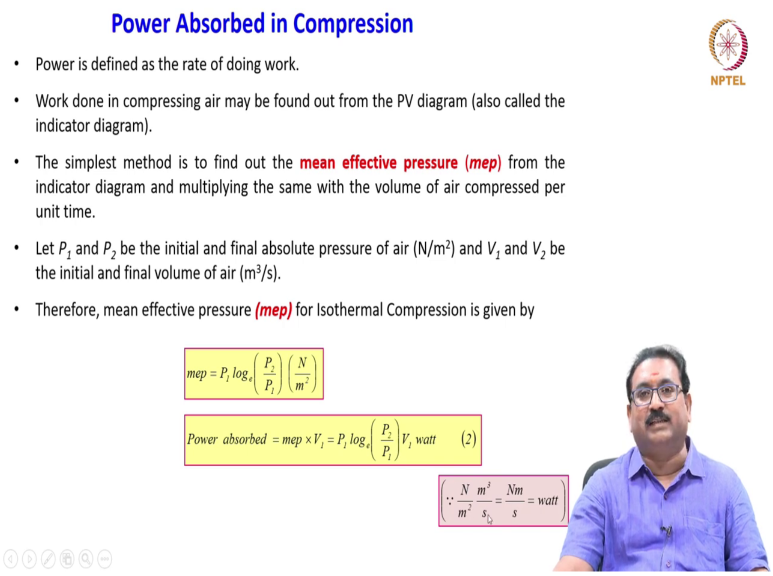

Then power absorbed in a compression, what is the powered absorbed in the compression? Power is defined as the rate of doing the work. Work done in compressing air may be found out from the PV diagram and also called the indicator diagram, both are same it is.

The simplest method is to find out the mean effective pressure mep from the indicator diagram and multiply the same with the volume of air compressed per unit time. You will find out the mean effective pressure multiplied by how much volume of air is compressed. Multiply this, you will get the power absorbed in the compression.

To do this, let us we will assume P 1 and P 2 be the initial and final absolute pressure of the air which is Newton per metre square. V 1 and V 2 be the initial and final volume of air in m cube per second. Therefore, the mean effective pressure for isothermal compression is given by mep equal to P 1 log of e P 2 by P 1, the unit is Newton per meter square.

So, power absorbed is mep multiply by the V 1 mep means P 1 log e P 2 by P 1 into V 1, it is a Watt. How you will get the watt? You will Newton per meter square is a pressure unit and m cube per second is a air volume which is gives as a Newton meter per second which is n Watt.

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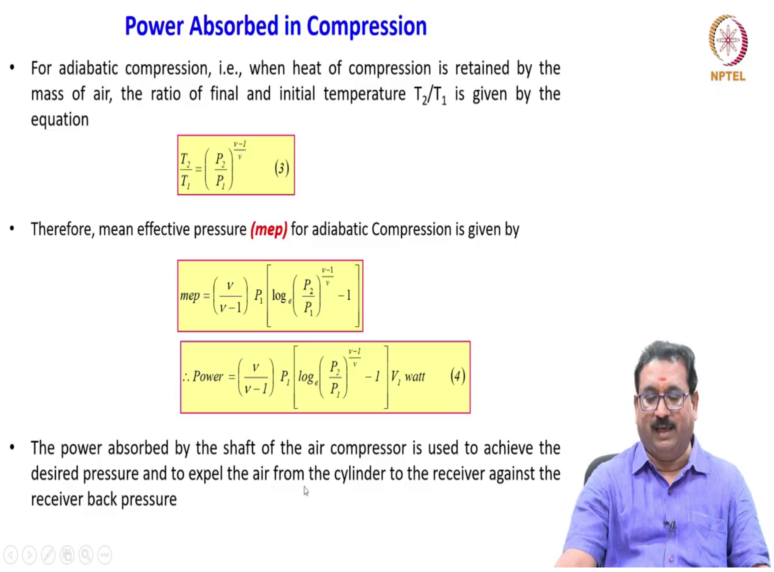

For adiabatic compression, when the heat of compression is retained by the mass of air the ratio of final and initial temperature T 2 by T 2 is given by the equation. T 2 by t 1 equal to P 2 by P 1 raise to V minus nu minus 1 by nu. Therefore, the mean effective pressure for adiabatic compression is given from the curve V nu or V whatever you will call nu divided by nu minus 1 P 1 log e P 2 by P 1 nu minus 1 into V. Then power is multiplied with how much volume you are compressed, it is in Watt.

The power absorbed by the shaft of the air compressor is used to achieve the desired pressure and to expel the air from the cylinder to the receiver against the receiver back pressure.