Oil Hydraulics and Pneumatics
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Part 04: Construction and Operation of Two-stage Reciprocating type Air Compressor, Diaphragm Type Air Compressor, Rotary Vane Compressor, Twin Lobe Air
Lecture – 26
Pneumatic Control and Pneumatic Power Source

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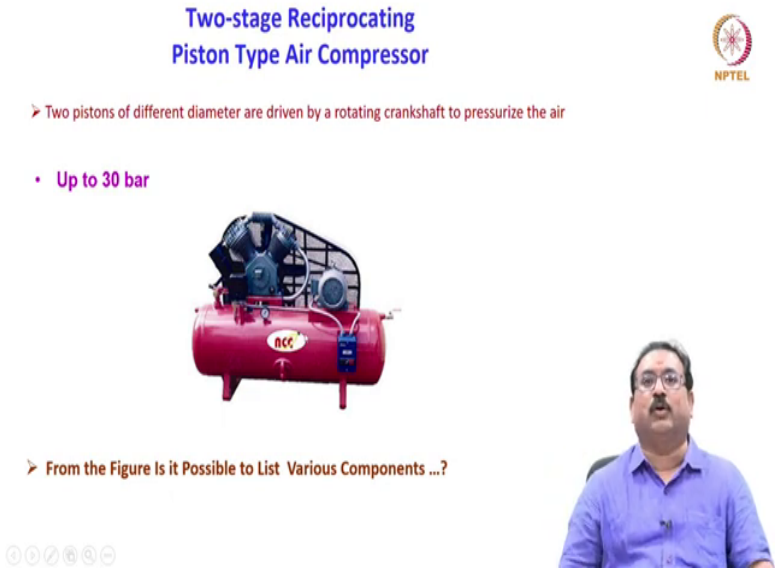

My name is Somashekhar course faculty for this course. This is in case of the single stage compressor. Now let us we will see the two stage reciprocating piston type air compressor. Here we are using the two pistons of different diameter are driven by the rotating crankshaft to pressurize the air.

Here what is the pressure rating? Up to 30 bar and even more. From the figure here I am showing you the two stage reciprocating type compressor. Can you please tell me now because these you are seen in many places in the workshop. When you are putting the air in your two wheeler or in a cycle. Then as a engineer you must know the various parts of the compressors.

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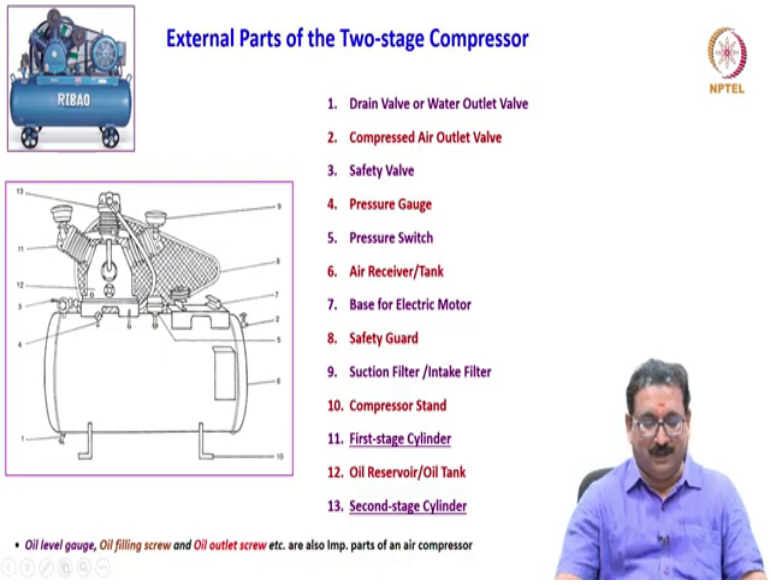

Now, let us we will see this very quickly I will show you the external parts then we will go to the internal part how it is. See here the 1st one is here we will see that drain valve or a water outlet always it is a bottom of the receiver tank that is why you should not take the dry air from here always from the top remember. 2nd one is a compressed air outlet 2nd one is a compressed air outlet always stop sides.

Then 3rd one is a safety valve as I have told you know if required pressure and volume is reached automatically it reached safety valve. Pressure gauge 4th one is a pressure gauge to monitor the pressure. What is a 5th one? Tell me here in the 5th one. The 5th one is the pressure switch to switch on and switch off the your motor here motor I have not shown here.

6th one is a this is a 6th one is a air receiver or a tank. 7th one is here you will see 7th space is provided to put to the electric motor. 8th one is this is there know safety guards 9th one is suction filter you will see here suction filter or a intake filter. 10th one is compressor stand rigidly you mount on the ground.

11th one is the first stage cylinder please see the 11th one is the first stage cylinder. 12th one is the oil receiver or oil tank here we will see the twelfth one is oil receiver or a oil tank; what for it is? For the lubrication purpose. Second stage cylinder; this is the second stage cylinder; first stage cylinder second stage cylinder.

Then also we will remember friend's oil level gauge is there, oil filling screw and oil outlet screw etcetera are also important parts of the compressor. If you will see physically the any compressor you are able to identify these are the important parts in the compressor.

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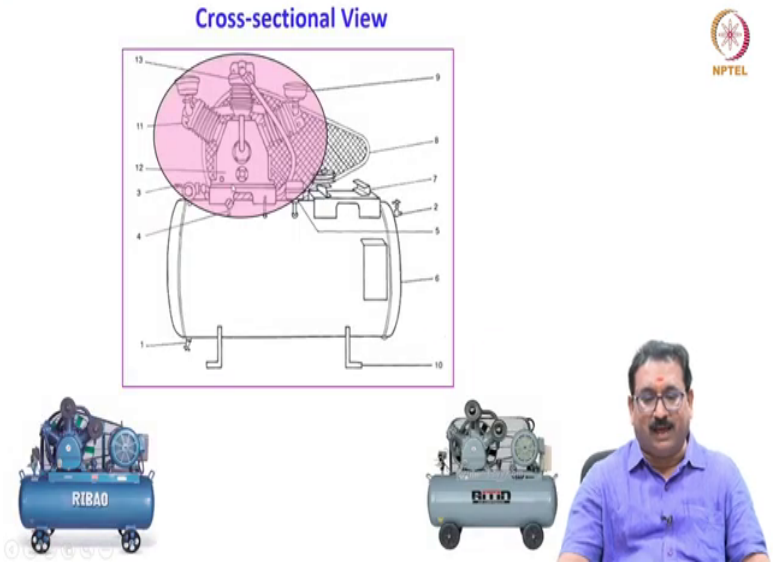

Now, if we will see this is as I have told you which includes the single stage and a two stage whatever it is. The in between the intercoolers are there many things I will show you the cut section of this now. We will see the cut section of this what I have marked here.

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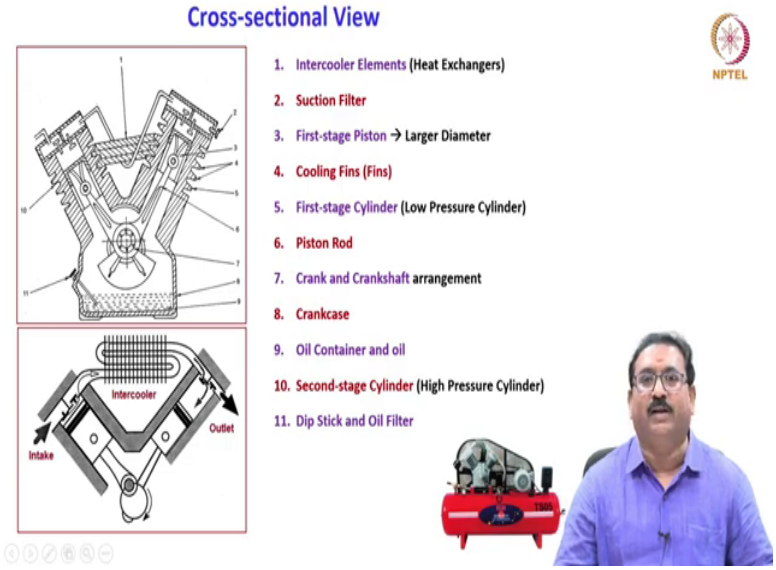

You will see here the cut section how it is. Here you will see the inlet outlet whatever it may be ok. You will see the first stage cylinder, second stage cylinder, first stage cylinder, second stage cylinder. Let us we will see now here the 1st one is what we will call the intercooler element. Intercooler nothing, but it is a heat exchanger the air will when it will move from the 1st stage to 2nd stage it should be cooled. That is why it is intercoolers or a heat exchangers are required.

Here it is a water cooled or air cooled suction filter where as a suction filter two here suction filter. 3 this is a first stage cylinder 3 I am showing you here it is a first stage here it is the other way. First stage cylinder; larger diameter you do not confused with this figure it is a larger diameter smaller diameter. The larger diameter is always a first stage smaller diameter is the second stage you see the pistons.

Then cooling fins; as I have told you cooling fins are also provided. What for cooling the compressed air. First stage cylinder 5th one is a first stage cylinder which is also known as low pressure cylinder compared to other. Then piston rods; this is a piston rods. Then crank and crank shaft arrangement we will see the 7 crank and crank shaft arrangement which is connected to both the piston rods; please see here both the piston rods are connected. Then crankcase 8th one is a crankcase full is a crankcase.

9th one is a oil container here you will see oil container with oil. Then second stage cylinder; as I have told you know second stage cylinder here in this figure it is a second stage cylinder high pressure cylinder it is again compression will take place. Then 11th one is here you will see dipstick or a oil filter.

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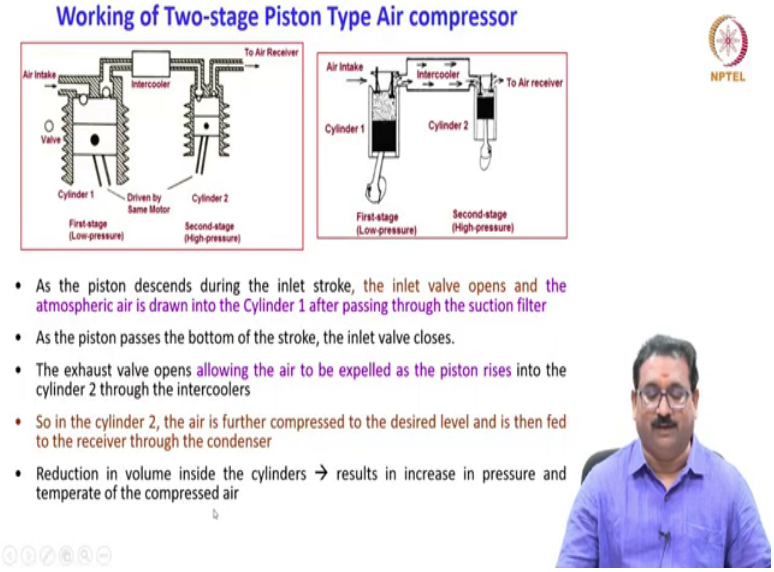

Now, how it will works? Let us, I will tell you very quickly as we know that the first stage cylinder is a larger diameter second stage cylinder is a smaller diameter piston as we know that. What is the working principle very quickly friends?

When the piston is moved down here from the top dead center to bottom dead center air is sucked through the filter filters are not shown here. Then when it will move up what happened the air sucked is discharged to this through the intercooler and it enters through the this second cylinder.

Then in it will move again it will compress second time then it will go to the receiver tank. You will see here friend's cylinder one cylinder two first stage second stage. Also same figure it is for easy understanding I have shown the inlet valve and outlet valve here.

As the piston descends during the inlet stroke. Descends means from the top to bottom the inlet valve opens and the atmospheric air is drawn into the cylinder one, after passing through the suction filter. As the piston passes the bottom of the stroke the inlet valve closes when it will move here see here inlet valve closes. The exhaust valve opens allowing the air to be expelled as the piston rises into the cylinder two through the intercoolers see here.

When it will move up this will open this will open you will see here it through the intercooler air is entering to the next cylinder. So, in the cylinder 2 the air is further compressed to the desired level and is then fed to the receiver through the condenser. Reduction in volume inside the cylinders both cylinder results in increase in pressure and temperature of the compressed air ok.

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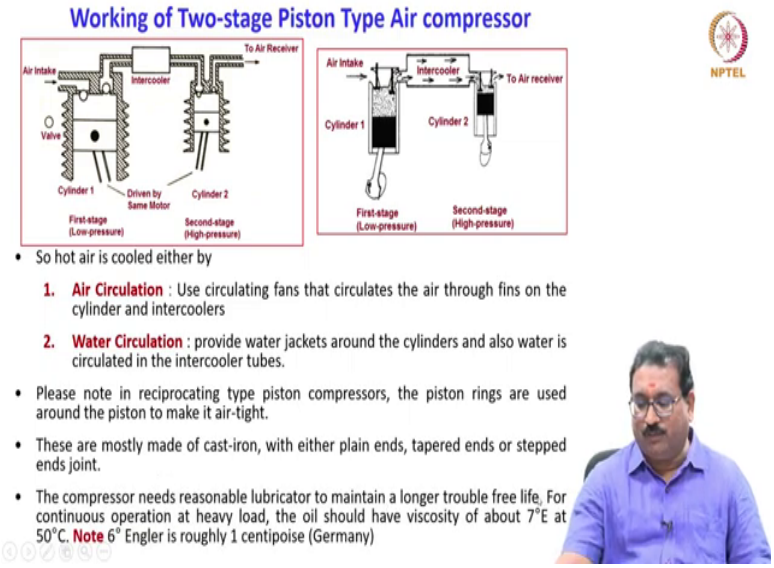

Very quickly we will see. So, the hot air is cooled either by as I have told you know intercooler. How it is? Air circulation use the circulating fans that circulates the air through the fins on the cylinder and a intercoolers or a water circulation provide a water jackets around the cylinder and also water is circulated in the intercooler tubes. Please note in a reciprocating type piston compressor the piston rings are used around the piston to make it air tight.

They are mostly made of cast iron with either a plain ends or a tapered ends or a stepped end joints. The compressor needs a reasonable lubricator to maintain the longer trouble free life. For continuous operation at a heavy load, the oil should be have a viscosity of about 7 degree E at 50 degree C.

Please note here friends 7 degree E it is a Engler degree is roughly the 1 centipoise. This is generally used in the Germany 7 degree E means what it is? The Engler degree the 6th Engler degree is equal to 1 centipoise it is the kinematic viscosity of the part.

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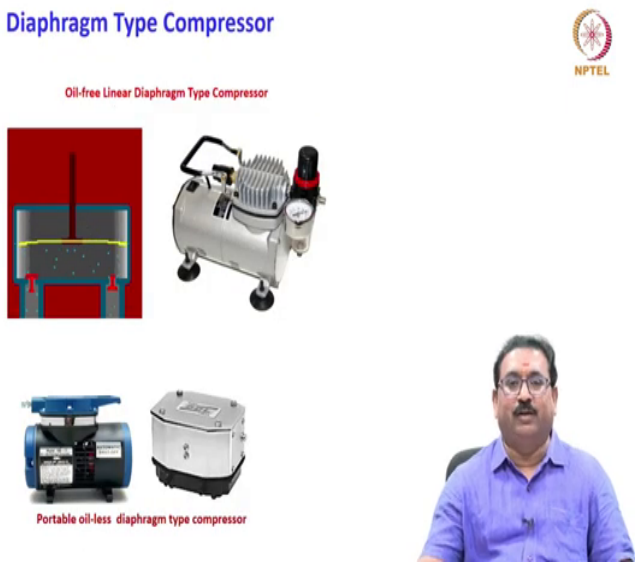

So, next we will see now very quickly we will move on to the diaphragm type compressors. You will see here it is a oil free linear diaphragm type compressor. See how it will work friends you will see here one diaphragm element is there flexible diaphragm element is there which is connected to the piston.

The other side this is a compression chamber is only the air it will not come the piston is not come into contact in the other side compression chamber. That is why here oil is the air is oil free air you will get here oil will not enter in the compression chamber. But only problem you

will see here the movement of this flexible membrane is very small it is. That is why it is used for low pressure applications.

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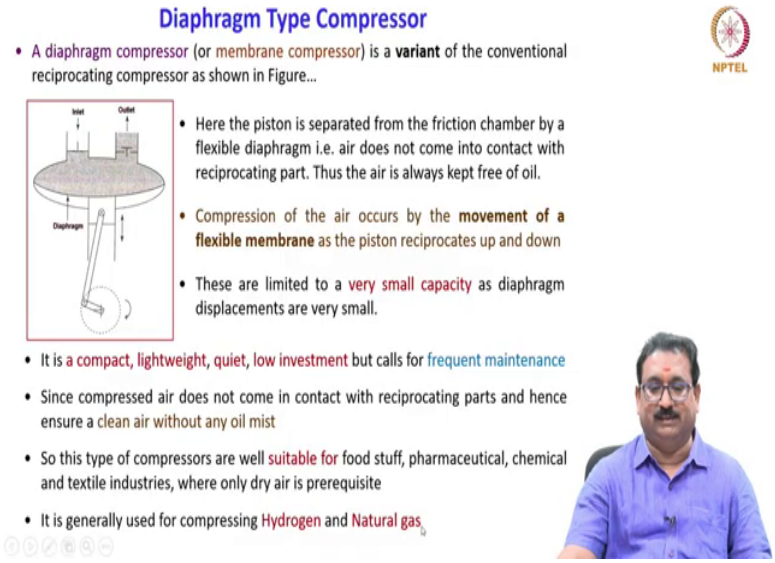

Quickly we will see this what is diaphragm type air compressor. A diaphragm compressor are also known as membrane compressor is a variant of the conventional reciprocating type compressor. It comes under the reciprocating type as I have shown you here correct. Same thing it is this is a piston, it is a diaphragm element, this is the diaphragm element this will move up and down up and down due to the movement of the piston.

Here the piston is here piston you will see the piston is separated from the friction chamber this is a friction chamber by a flexible diaphragm. That is air does not come in contact with the reciprocating parts. Thus, the air is always kept free of oil. Compression of the air occurs by the movement of flexible diaphragm as the piston reciprocates up and down. You will see

here when the piston moved down air will be sucked when it will move up air will be discharged.

These are limited to very small capacity as the diaphragm displacements are very small. It is a compact, lightweight, quiet, low investment, but calls for the frequent maintenance because a flexible diaphragm is a very sensitive. Since the compressed air does not come in contact with the reciprocating parts.

And hence ensures the clean air without oil mist. So, this type of compressors are well suited for food stuff, pharmaceutical and chemical and textile industries where only dry air is prerequisites. It is generally used for compressing the hydrogen and a natural gas.

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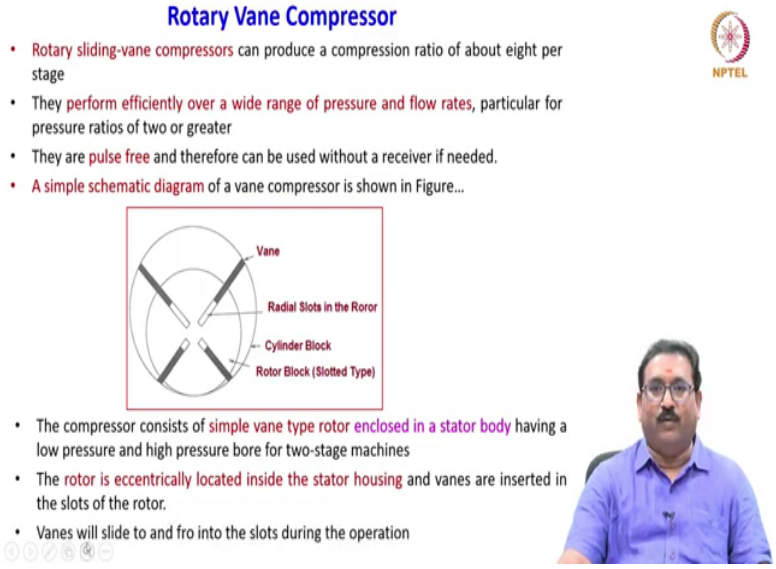

Now, let us we will move on to the rotary type compressors. What are this? Rotary sliding vane we will see now first. Here rotary sliding vane compressor can produce a compression ratio of about eight per stage. They perform efficiently over a wide range of pressure and flow rates, particularly for pressure ratios of two or greater.

They are pulse free and therefore, can be used without a receiver if needed. A simple schematic diagram of vane compressor is as shown in figure here. Please see here friends the all the arrangements here matting elements similar to your vane pump. Here you will see this is a rotor block which is a slotted rotors slotted vanes are their slotted slots are their slotted rotor it is.

Then cylinder block you will see rotor and cylinder blocks are offset you will see offset axis are offset. Then vanes are there these vanes are inserted in the radial slots of the rotor block. When the rotor will rotates vanes will be reciprocates in and out.

The compressor consists of simple vane type rotor enclosed in a stator body having a low pressure and a high pressure bore for a two stage machines. The rotor is eccentrically located inside the stator housing and vanes are inserted in the slots of the rotor. These vanes these vanes will slide to and fro into the slot during the operations.

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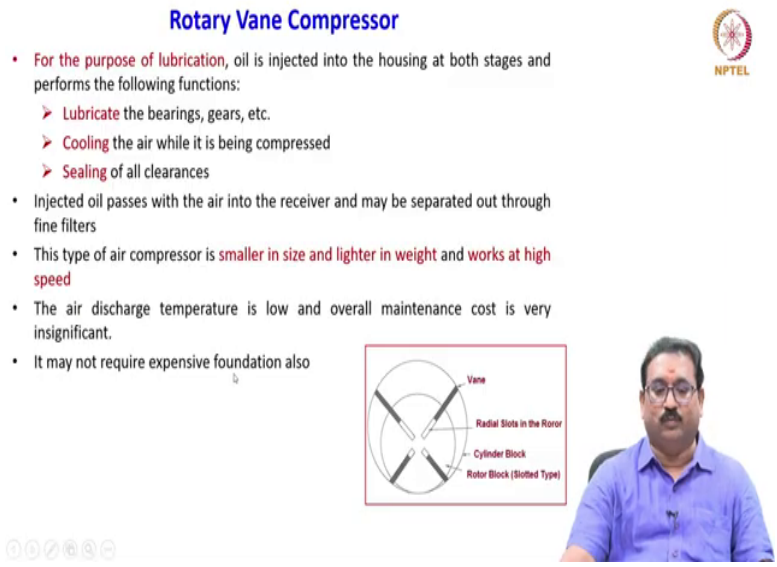

For the purpose of lubrication, oil is injected into the housing at both stages and performs the following function. What for it is? Lubricate the bearings and gears and many other parts. Cooling the air while it is being compressed, sealing of all the clearances, injected oil passes with the air into the receiver and may be separated out through the fine filters.

This type of air compressor is smaller in size and a lighter in weight and works at high speed. The air discharge temperature is low and overall maintenance cost is very significant insignificant. It may not require expensive foundation also.

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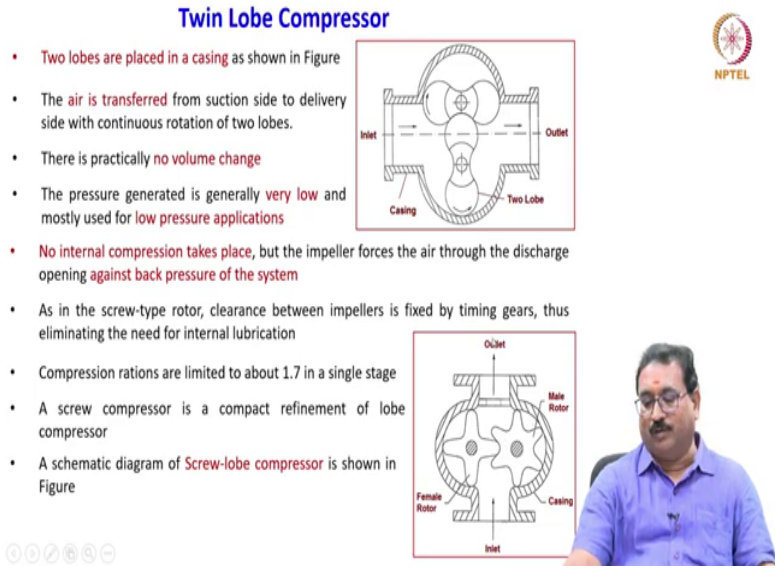

Now, we will move on to the lobe compressor as I have told you based on the lobes two lobe three lobe compressors are there. Let us we will see the two lobes it is also known as twin lobe compressors. What it is? The two lobes are placed in the casing two lobes are there the two lobe are enclosed in the casing this is a casing hole is a casing.

The air is transferred from the suction inlet to the delivery side with the continuous rotation of these two lobes they will rotate because one is connected to the rotor. Meaning electric motor when it will rotates other will move what it will do they will transport the air from suction to the discharge. There is practically no volume change here. The pressure generated is generally very low and mostly used for low pressure applications.

No internal compression takes place, but the impeller forces the air through the discharge opening against the back pressure of the system. As in the screw type rotor clearance between

the impeller is fixed by the timing gears. Thus eliminating the need for internal lubrication. Compression ratio are limited to about 1.7 in the single stage.

A screw compressor is a compact refinement of a lobe compressor. You will see a schematic diagram of screw lobe compressor is shown in figure which consists of male rotor female rotor enclosed in the house power. Air will be sucks from the inlet and only transferred from the inlet to outlet

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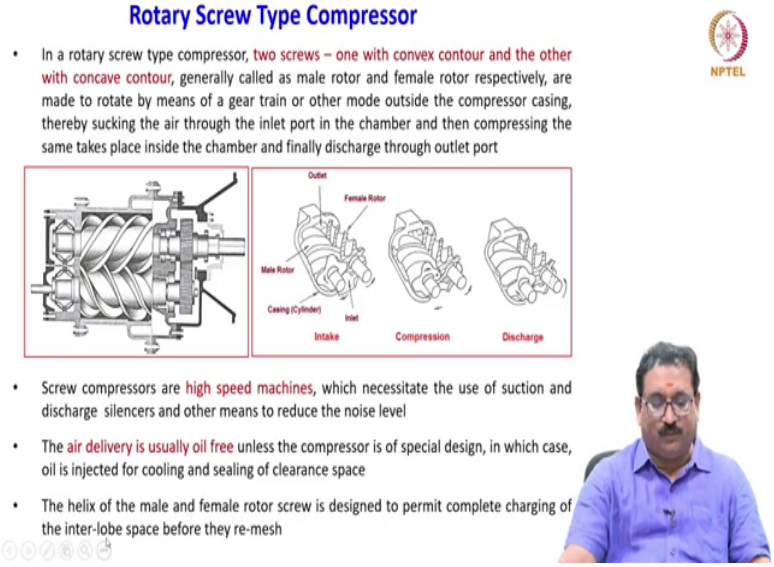

Now we will move on to the rotary screw type compressor. In the rotary screw type compressor two screws; one with convex contour and the other with concave contour. Generally called as a male rotor and a female rotor respectively are made to rotate by means of the gear train or other mode outside the compressor casing.

Thereby suction of the air through the inlet port in the chamber and then compressing the same takes place inside the chamber and finally, discharge through the outlet port. How it is? You will see the two screws are enclosed in the casing one is connected to the your electric motor shaft which will rotates the air will suck and discharged. How it will suck? You will see here as shown the intake compression and a discharge.

This is a male rotor and this is a female rotor one more air is sucked in between the pockets. You will see here in between the pockets they will transferred from the inlet to the outlet along the axis of the screws compression and discharge. Screw compressors are high speed machines which necessitate the use of suction and discharge silencer and other means to reduce the noise level.

Because it is a high speed that is why it necessitates the use of suction and discharge silencer and other means to reduce a noise level. The air delivery is usually oil free unless the compressor is of special design in which case the oil is injected for oil cooling. Meaning for the cooling purpose you have to inject the oil and sealing of clearance space. Then helix of the male and a female rotors screw is designed to permit complete charging of the inter lobe space before they re mesh.

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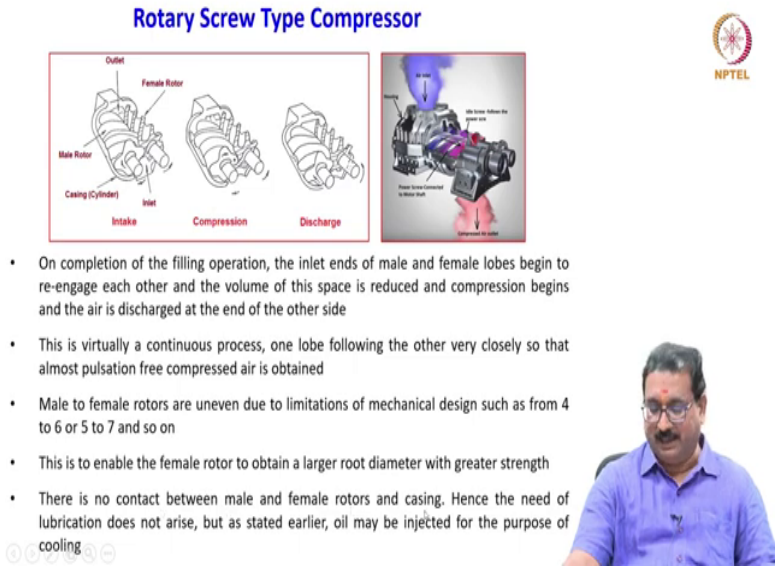

On completion of the filling operation the inlet ends of male and a female lobes begin to re engage each other and the volume of this space is reduced and compression begins and the air is discharged at the end of the other side. This is virtually a continuous process one lobe following the other very closely. So, that almost pulsation free compressed air is obtained. Male to female rotor are uneven due to limitations of mechanical design such as from 4 to 6 or 5 to 7 and so on.

This is to enable the female rotor to obtain a larger root diameter with a greater strength. There is no contact between the male and female rotors and a casings. Hence the need of lubrication does not arise, but as stated earlier oil may be injected for the purpose of cooling.

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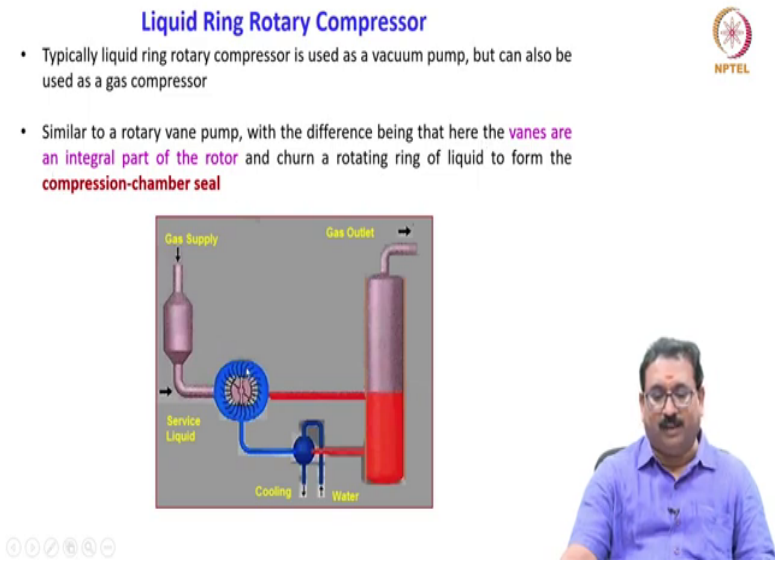

Now, we will move on to the last type of rotary compressor liquid ring rotary compressor you will see the liquid ring rotary compressor; how it is. Typically a liquid ring rotary compressor is used as a vacuum pump but can also be used as a gas compressor. Similar to a rotary vane pump with the difference being that here the vanes are an integral part of the rotor you will see the vanes are integral part of the rotor and churn a rotating ring of liquid to form the compression chamber seal.

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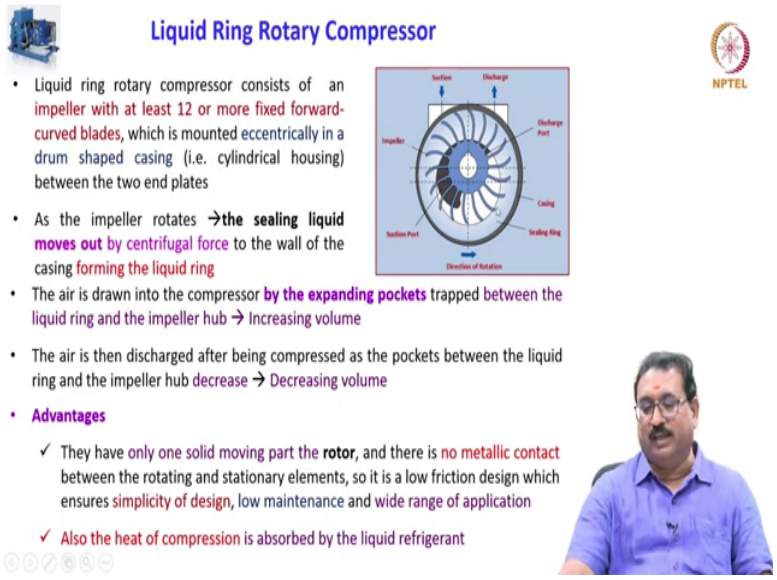

I will show you here, you will see in the all vanes are integral part of the rotor. Now let us we will see the liquid ring rotary compressor consists of an impeller with at least 12 or more fixed forward curved blades which is mounted eccentrically in the drum shaped casing between the two end plates.

You will see here this is an impeller and this is a casing both are mounted eccentrically. As the impeller rotates the sealing liquid moves out by centrifugal force to the walls of the casing forming the ring you will see this is a ring it will form. The air is drawn we will see the air is drawn into the compressor by expanding the pockets it will from the expanding the pockets trapped between the liquid ring and the impeller hub it will trapped here. Here it is the increasing volume air is trapped here between the liquid ring and this pockets.

The air is then discharged after being compressed as the pocket between the liquid ring and the impeller hub decreases you will see it decreases when it will decreases it will discharge through the discharge port. The advantage here is they have only one solid moving part the rotor whatever you will call the impeller here. And there is no metallic contact between the rotating and a stationary elements.

So, it is low friction design which ensures simplicity of design low maintenance and a wide range of application. Also the heat of compression is absorbed by the liquid refrigerant which will form the ring here they will absorb.

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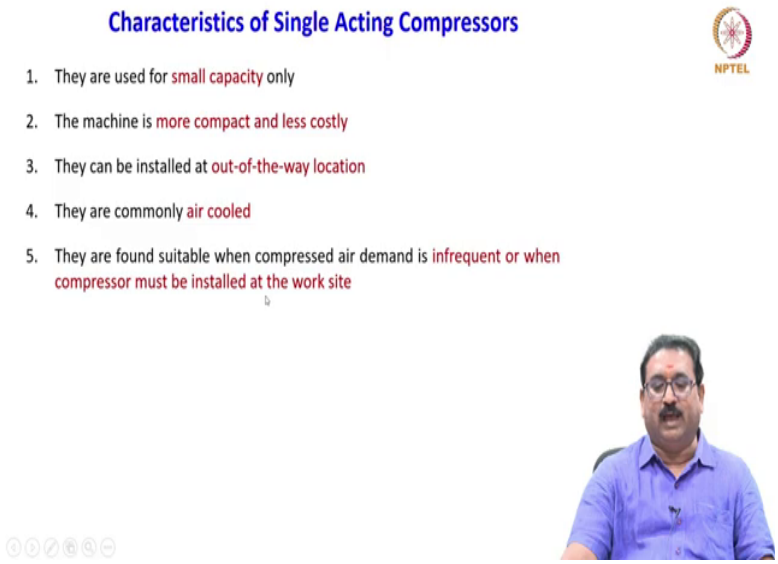

Now, quickly we will see the characteristics of single acting compressors. They are used for small capacity only the machine is more compact and less costly in single acting compressors. They can be installed at out of the way location they are commonly air cooled they are found

suitable. When the compressed air demand is infrequent or when compressor must be installed at the work site.

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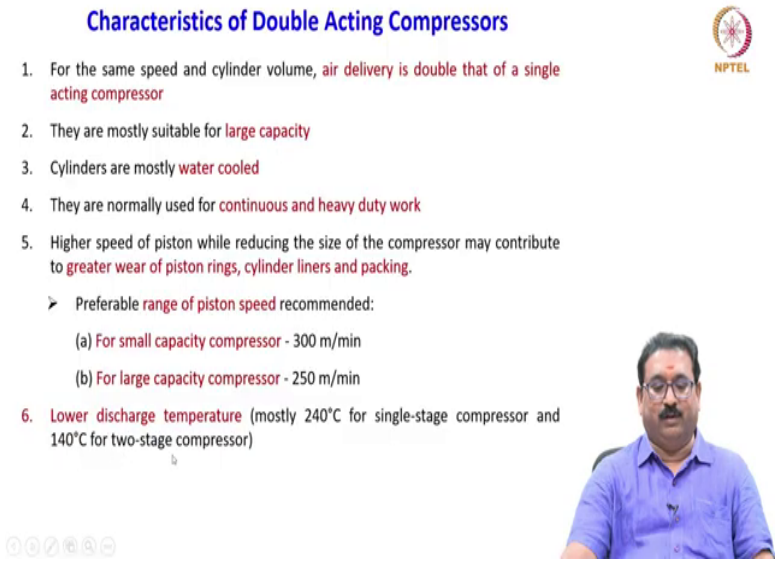

Similarly, we will see some of the characteristics of double acting compressors. For the same speed and cylinder volume, air delivery is double that of the single acting compressor they are mostly suitable for large capacity. Cylinders are mostly water cooled. They are normally used for continuous and heavy duty work.

Higher speed of piston while reducing the size of compressor may contribute to greater wear of the piston rings, cylinder liners and a packing's. Preferable range of piston speed recommended in the double acting compressors are; for a small capacity compressor 300 meters per minute. For large capacity compressor 250 meters per minute. Lower discharge

temperature mostly 240 degree centigrade for single stage compressor and 140 degree for two stage compressors.

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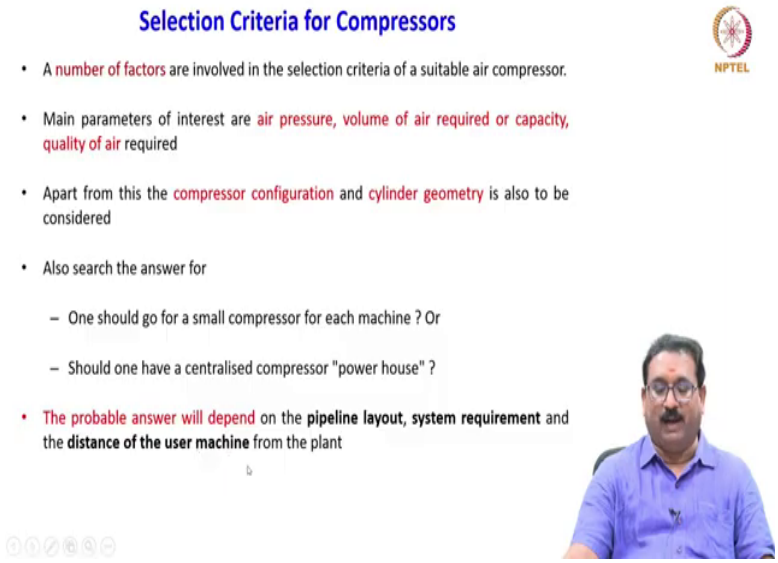

Let us we will move on to selection criteria for compressor. A number of factors are involved in the selection of suitable compressor for the particular application. The main parameter of interest are air pressure volume of air required or a capacity quality of air required.

Apart from this the compressor configuration cylinder geometry is also to be considered also search for the answer as; one should go for a small compressor for each machine or should one have a centralized compressor like a power house power house. The probable answer will depend on the pipeline layout, system requirement and the distance of the user machine from the plant.

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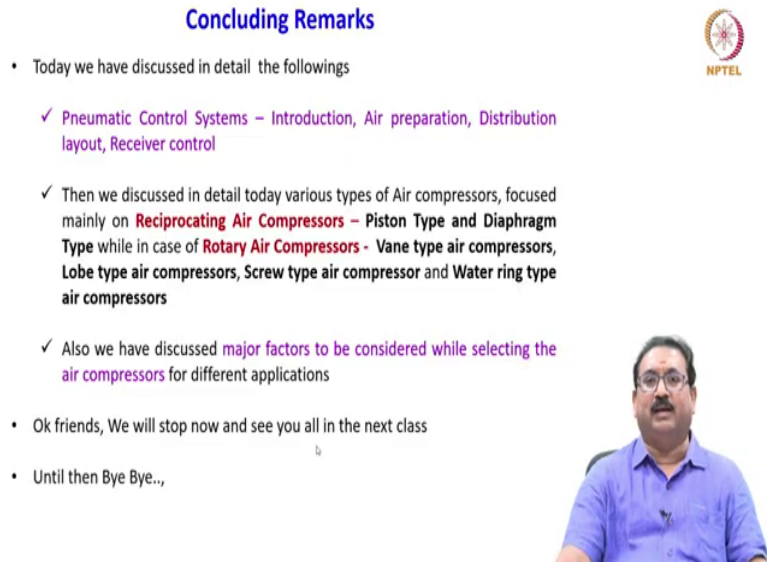

Let us we will conclude today's lecture. Today we have discussed in detail the followings; pneumatic control systems, introduction, air preparation, distribution layout, receiver control. Then we have discussed in detail in today's various types of air compressor, focused mainly on the reciprocating air compressor piston type and diaphragm type.

While in the case of rotary compressors we discussed vane type air compressor, lobe type air compressors, screw type air compressor and a water ring air compressors. Also we have discussed the major factor to be considered while selecting the air compressors for different applications. Ok friends, we will stop now and see you all in the next class, until then; bye bye.

Thank you one and all for your kind attention. [FL]