Oil Hydraulics and Pneumatics
Prof. Somashekhar S
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Part 1: Introduction, Classification, Check valves, Standard design variations and Applications
Lecture - 32
Directional Control Valves

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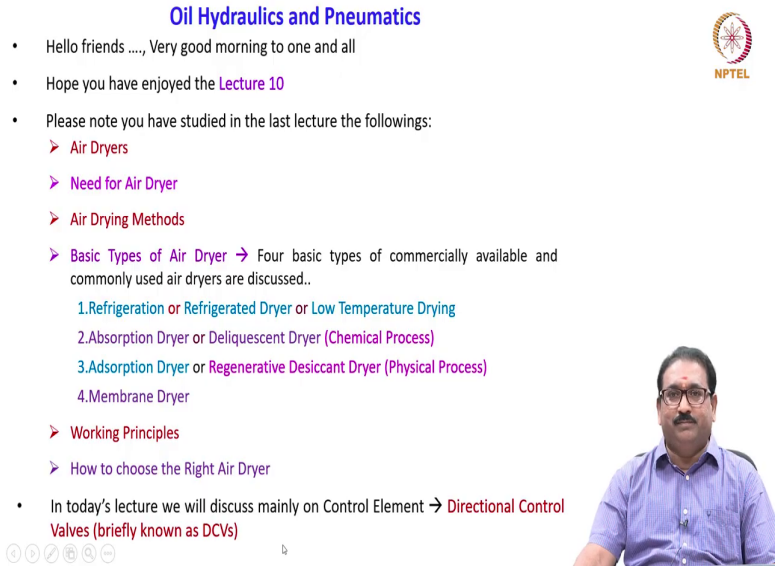

My name is Somashekhar, course faculty for this course. Hello, friends very good morning to one and all. Hope you have enjoyed lecture 10. Please note, you have studied in the last lecture the followings. Air dryers; need for air dryer; air drying methods; basic types of air driers – four basic types of commercially available and commonly used air driers are discussed.

It includes refrigeration or refrigerated dryer or a low temperature drying. Absorption dryer deliquescent dryer based on the chemical process of moisture absorption. 3rd one – adsorption dryer or regenerative desiccant dryer, works on the principle of physical process of moisture absorption. 4th category is membrane dryer.

Working principles of these driers we are discussed; how to choose the right air dryer for the applications. In today's lecture, we will discuss mainly on control element directional control valves briefly known as DCVs.

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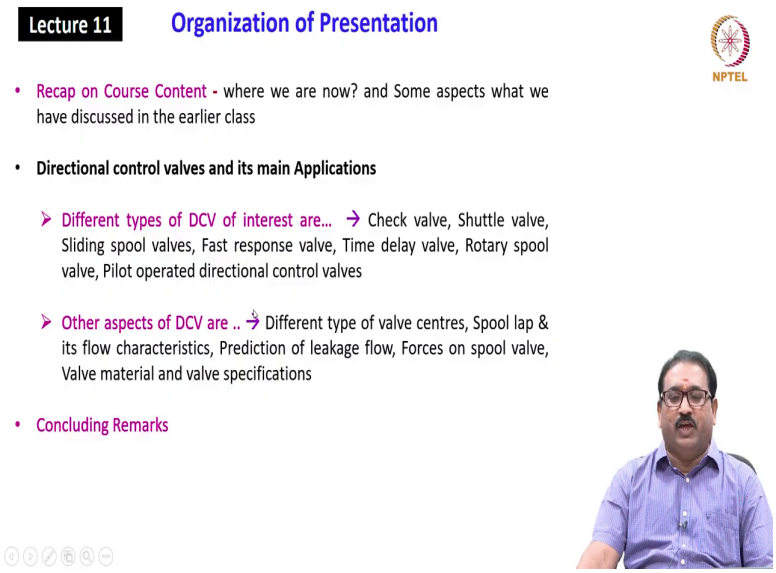

Move on to my organization of presentation of today's lecture. Recap on course content – where we are now? And some aspects what we have discussed in the earlier class. Move on to directional control valves and its applications. Here we will discuss different types of DCVs

of interest are check valve, shuttle valve, sliding spool valves, fast response valve, time delay valve, rotary spool valve, pilot operated directional control valves.

Later we want to other aspects of DCVs are different types of valve centres, spool lap and its flow characteristics, prediction of leakage flow, forces on spool valve, valve material and valve specifications. Finally, I will conclude today's lecture.

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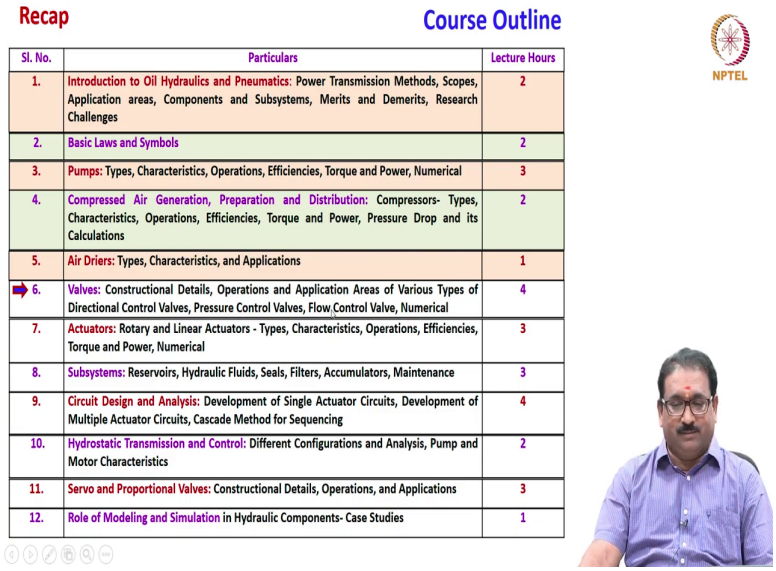

Sl. No.	Particulars	Lecture Hours
1.	Introduction to Oil Hydraulics and Pneumatics: Power Transmission Methods, Scopes, Application areas, Components and Subsystems, Merits and Demerits, Research Challenges	2
2.	Basic Laws and Symbols	2
3.	Pumps: Types, Characteristics, Operations, Efficiencies, Torque and Power, Numerical	3
4.	Compressed Air Generation, Preparation and Distribution: Compressors- Types, Characteristics, Operations, Efficiencies, Torque and Power, Pressure Drop and its Calculations	2
5.	Air Driers: Types, Characteristics, and Applications	1
6.	Valves: Constructional Details, Operations and Application Areas of Various Types of Directional Control Valves, Pressure Control Valves, Flow Control Valve, Numerical	4
7.	Actuators: Rotary and Linear Actuators - Types, Characteristics, Operations, Efficiencies, Torque and Power, Numerical	3
8.	Subsystems: Reservoirs, Hydraulic Fluids, Seals, Filters, Accumulators, Maintenance	3
9.	Circuit Design and Analysis: Development of Single Actuator Circuits, Development of Multiple Actuator Circuits, Cascade Method for Sequencing	4
10.	Hydrostatic Transmission and Control: Different Configurations and Analysis, Pump and Motor Characteristics	2
11.	Servo and Proportional Valves: Constructional Details, Operations, and Applications	3
12.	Role of Modeling and Simulation in Hydraulic Components- Case Studies	1

This you are seen in the first lecture. Now, we are in the 6th serial number. We have discussed introduction to oil hydraulics and pneumatics; basic laws and symbols; pumps; compressed air generation, preparation and distribution; air driers.

Now, onwards we will discuss the various types of valves in four lecture hours which includes the constructional details, operations and application areas of these valves basically directional control valves, pressure control valves, flow control valves and simple numericals.

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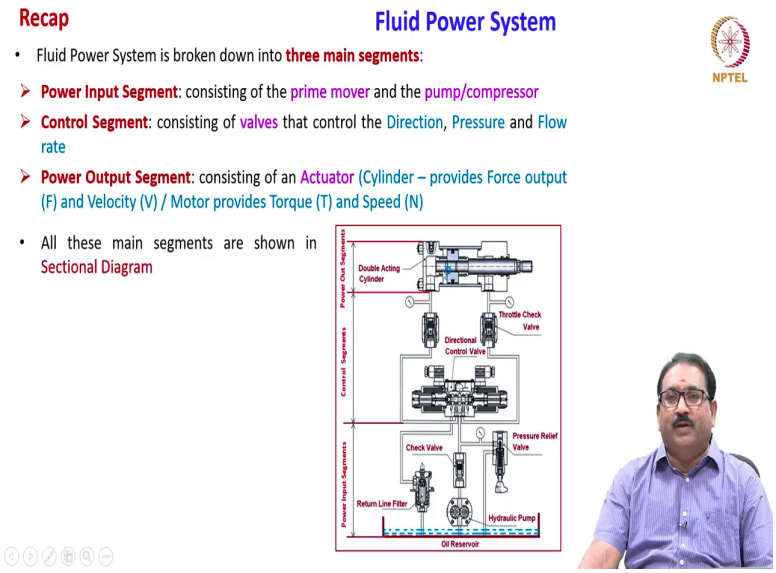

Friends, already we know that fluid power system is broken into three main segments. Power input segment: consisting of prime mover pump in case of hydraulics and compressor in case of pneumatics. Control segment: consisting of valves that control the direction, pressure and flow rate. Power output segment: consisting of an actuator cylinder which provides the force output F and velocity V, motor provides the torque and a speed.

All these main segments are shown in the sectional diagram here which will completes our circuit. That is why I am telling you the power input segment is a first and foremost thing

which includes the prime mover and the various types of valves like a check valves, pressure release valves and return line will comes under the primary input segments section.

And, control segment includes the direction control valves, throttle valves and many more and the final segment power output segment includes generally the actuator. Here what we have shown is a the double acting cylinder.

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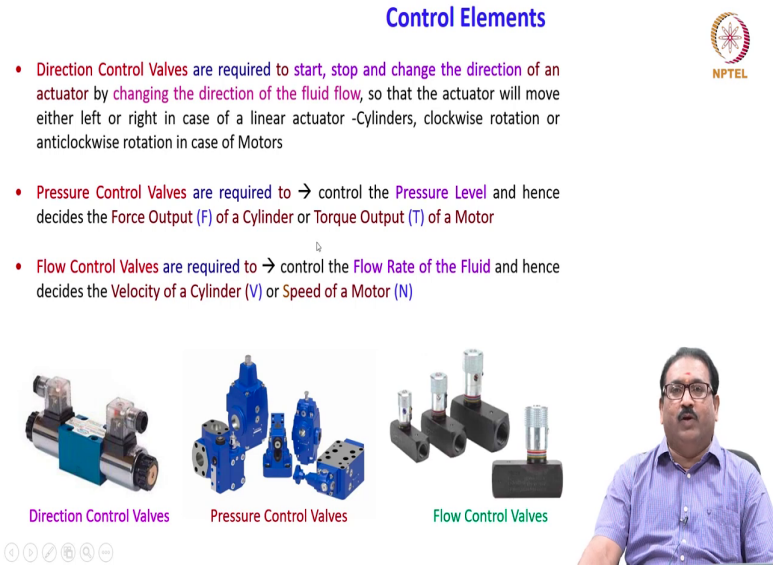

Now, we will begin with the control elements which is the heart of the fluid power system also most of the components are common to oil hydraulics and a pneumatic systems. First one is direction control valves are required to start, stop and change the direction of an actuator by changing the direction of the fluid flow so that the actuator will move either left or right in case of the linear actuator – cylinders, clockwise rotation or anti clock wise rotation in case of the motors.

Next comes pressure control valves. These are required to control the pressure level and hence besides the force output F of a cylinder or a torque output of the motor. Next comes to the flow control valves are required to control the flow rate of the fluid and hence decides the velocity of the cylinder or speed of the motor.

These are available in varieties commercially some of the valves are shown here directional control valve it is the solenoid operated whereas varieties of pressure control valves are available in the market along with the flow control valves also. We will discuss one by one in the today's class.

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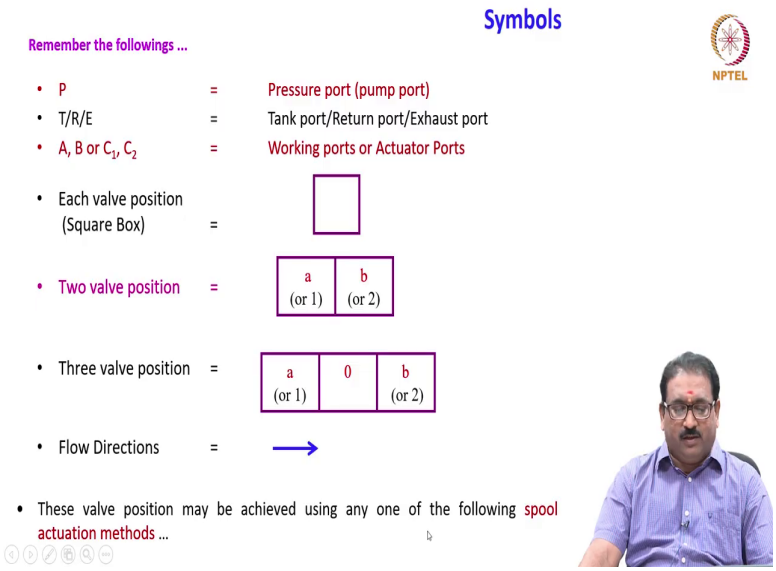

Remember friends, some of the symbols P is a pressure port or a pump port; T or R or E it is a tank port return port also called a exhaust port. You will see here some of the symbols like a capital A, B or C 1 and C 2 are known as the working ports or a actuator ports.

Next each valve positions are represented using a square box here. Two valve positions are represented using the two square box. They are represented by small a or b or 1 or a 2. Three valve positions are represented by the three square boxes – the left position is represented a, right position is represented b; the middle position is represented as a 0 which is a null position or a center positions. The flow directions is represented using the arrow mark. These valve positions may be achieved using any one of the following spool actuation methods.

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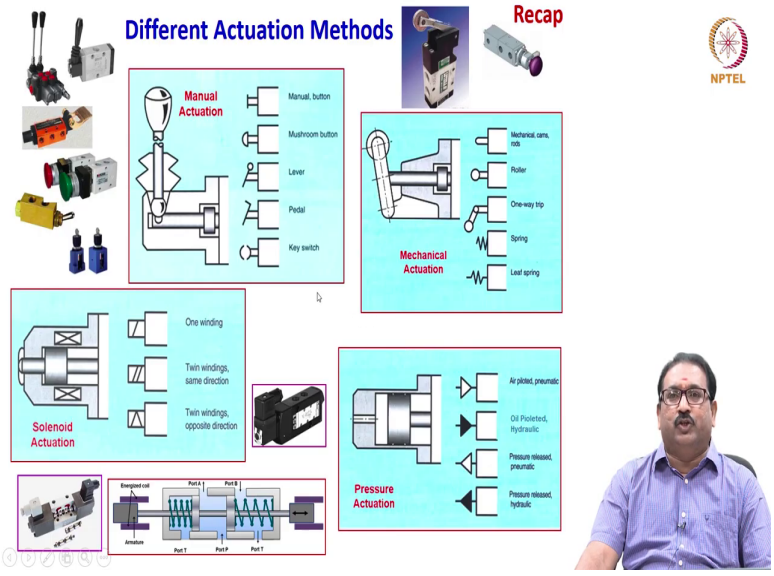

Like a manual actuation methods are there. You will see here manual button is there, mushroom button, lever, pedal, key switch – these are all manual actuations. Similarly, you

will see the mechanical actuation like a mechanical camps or a rods, roller, one way trip, spring, leaf spring.

Now, we will see the solenoid actuation which are electrically ablated valves one winding or a two windings the same directions, twin windings opposite directions. Similarly, pressure actuation methods are there which are air pilot pneumatics triangle not filled, oil piloted hydraulic the triangle filled.

If you will place these direction of the triangle away pressure released pneumatic, if triangle is not filled pressure released hydraulic triangle is away. These are the different actuation methods for each spool positions or a valve positions.

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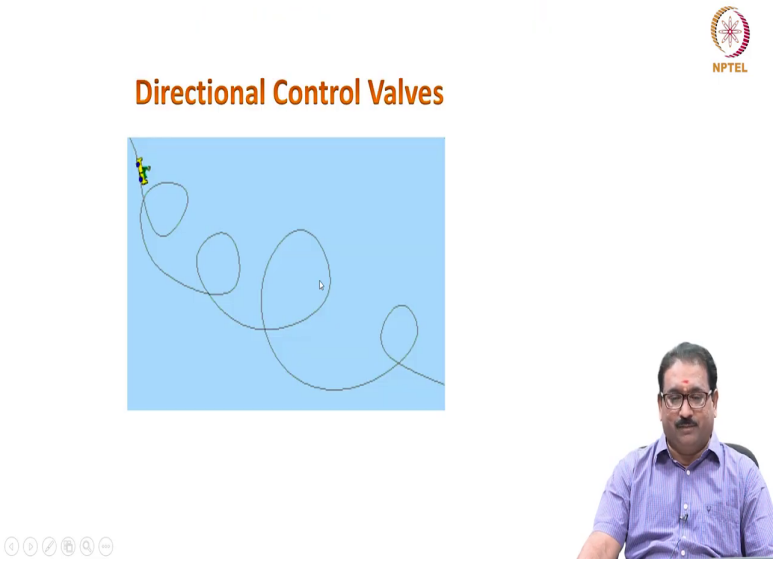

Let us we will begin the different types of directional control valves, constructional feature, operation and application.

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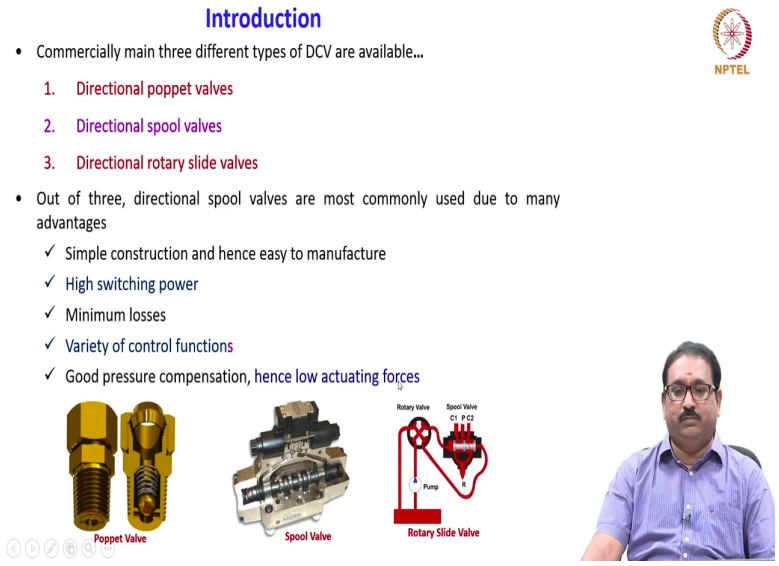

Before that you will see commercially main three different types of DCVs are available. 1st one is a directional poppet valves, directional spool valves, directional rotary slide valves. These are some of the photographic views showing the directional poppet valve design, see here; spool valve design and a rotary slide valve.

Out of three the directional spool valves are most commonly used due to many advantages. Simple construction and hence easy to manufacture; high switching power; minimum losses; variety of control functions; good pressure compensation and hence low actuating forces.

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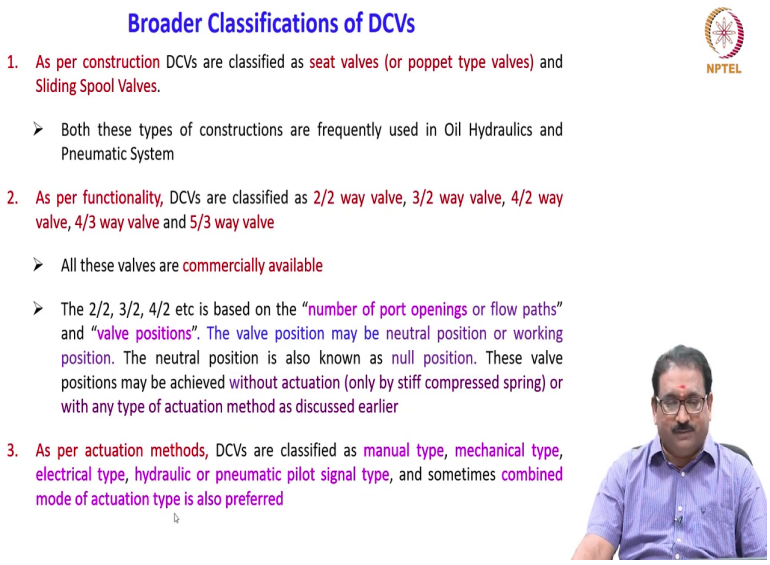

Now, we will move on to broader classification of DCVs. As per the construction, DCVs are classified as seat valves also known as a poppet type valves and a sliding spool valves. Both these types of constructions are frequently used in oil hydraulics and pneumatic systems.

2nd category as per the functionality DCVs are classified as 2 by 2 way valve, 3 by 2 way valve, 4 by 2 way valve, 4 by 3 way valve and 5 by 3 way valve. All these valves are commercially available in the market. The 2 by 2, 3 by 2, 4 by 2 etcetera is based on the number of port openings or a flow paths and valve positions.

The valve positions may be neutral position or a working position. The neutral position the null position what you can call these valve positions may be achieved without actuation.

How? Only by using the stiff compressed spring in the valve body or with any type of actuation method as discussed earlier.

3rd category is as per the actuation methods DCVs are classified as manual type, mechanical type, electrical type, hydraulic or a pneumatic pilot signal type and sometime I sometimes combined mode of actuation type is also preferred.

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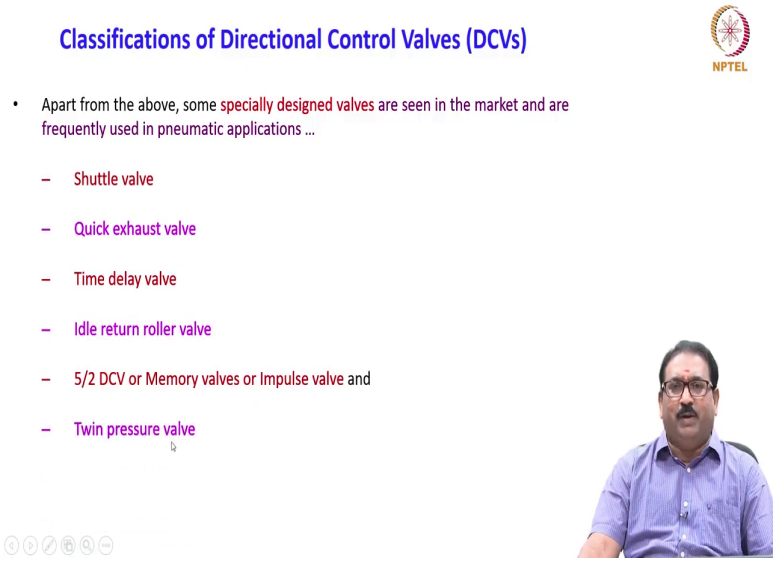

Apart from the above, some specially designed valves are seen in the market and are frequently used in pneumatic applications. These includes shuttle valve; quick exhaust valve also known as first response valve; time delay valve to achieve the time based sequences of operations – this is basically used in the multiple cylinder operations; idle return roller valve; 5 by 2 DCV or a memory valves or impulse valves and twin pressure valves. Many are there like this, friends.

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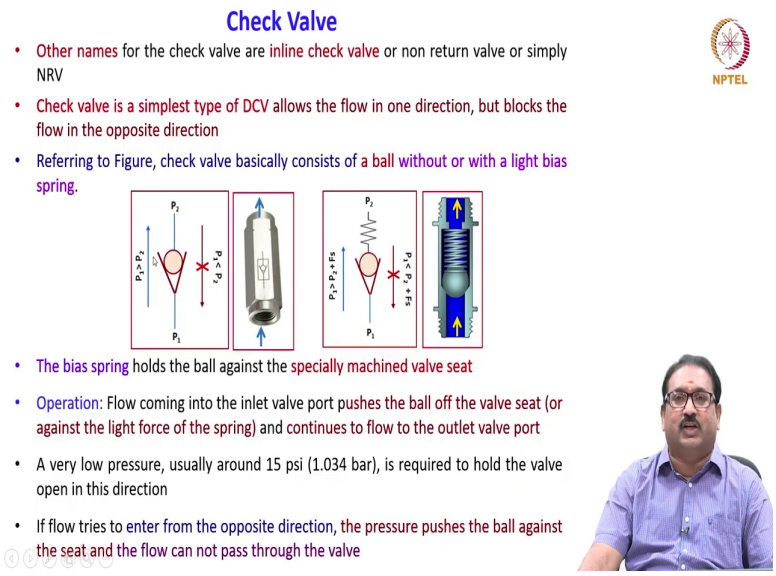

Basically, these are used to control the direction of the fluid flow. Let us we will begin with first and foremost simple type of check valve is used for the direction of flow. Other names for the check valve are inline check valve or non return valve or simply known as NRV.

Check valve is a simplest type of DCV allows the flow in one direction, but blocks the flow in the other direction. Referring to figure, here check valve basically consists of a ball without or a with light bias spring. The bias spring here holds the ball against the specially designed valve seat.

Operation of this valve is very simple. The flow coming into the valve body pushes the ball off the valve seats. When it is see here P 1 is greater than P 2 flow will takes place in this

direction. Here P 1 is greater than P 2 plus F s; F s is a spring force, then flow will take place from the inlet to outlet.

Please remember friends, a very low pressure usually 15 psi pounds per square inch or a 1 bar is required to hold the valve open in this direction. If flow tries to come in the opposite direction the pressure of the fluid pushes the ball against the valve seat, the flow cannot pass through the valve. That is why it is called a uni-directional valve flow always takes from this direction, not in the opposite direction.

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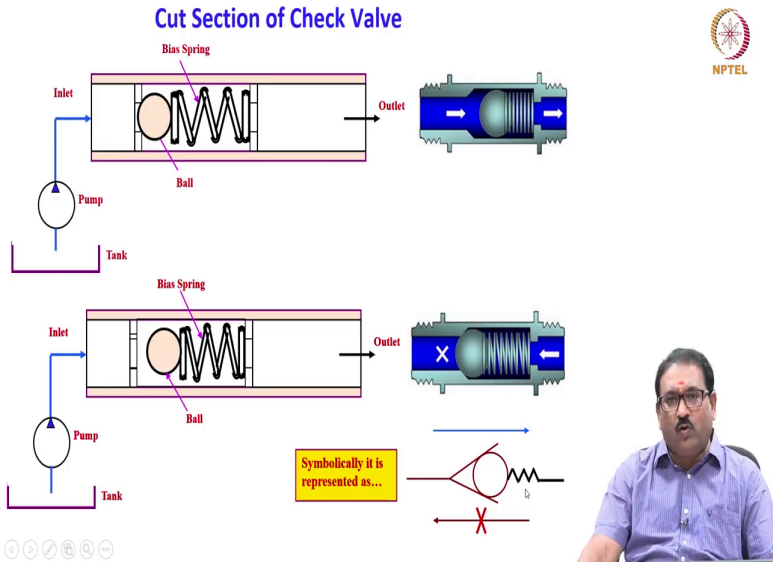

See here cut section model is shown here the ball fitted over the valve seat and held in position using the bias spring and it is connected to the inlet port. The small pressure is sufficient to lift the ball and flow is moving to the exit side, outlet port.

When the flow is trying to come back what happens friend? You will see here the ball is pressed over the ball seat and no flow in the reverse direction only in the forward direction. Symbolically, the check valves are represented like this. Flow is only taking place left to right to left is not allowed. Here a spring loaded NRV it is, without spring also available commercially.

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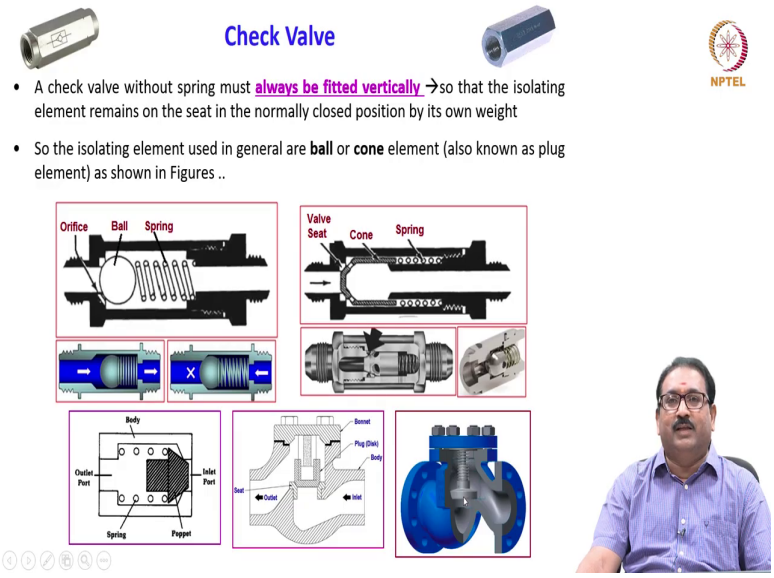

A check valve without spring must always be fitted vertical direction. So, that isolating element the valve remains on the valve seat in the normal position by its own weight. So, the isolating element used in general are a ball or a cone type element it is also known as a plug element as shown in the figure below.

You are seen already the ball with a spring fitted over the valve seat. Here it is a cone element, see friends here it is a cone element different types of cones you will see here cone elements, cone elements, cone elements. These are also available commercially.

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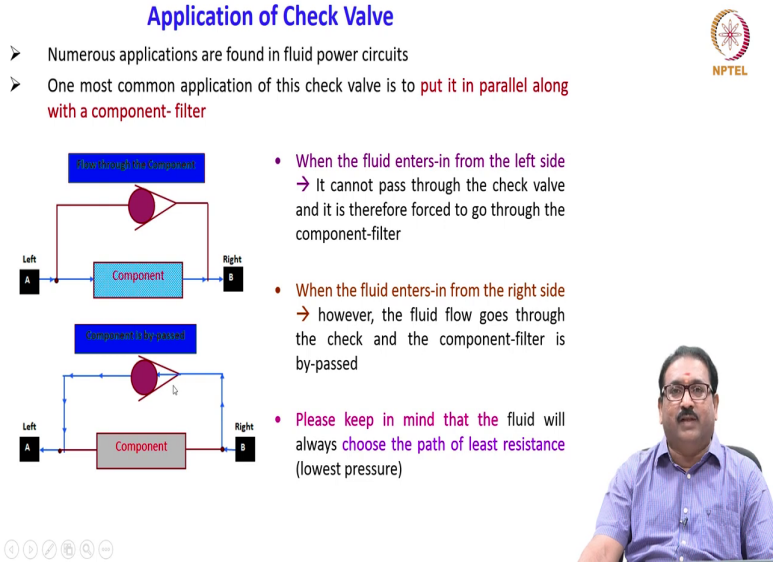

Application of this check valve we will see – numerous applications are found in fluid power circuits. One most common application of this check valve is to put it in parallel along with the component. Now, I am showing you here I am putting the check valve parallel to the filter element. You will see here this is the filter element; this is my check valve parallel to this I am putting. Let us we will see how it operates.

When the fluid enters in from the left side it cannot pass through the check valve because ball is press fitting over the valve seat. So, it is therefore, forced to go through the component, the filter here.

When the fluid enters from the right side however, the fluid goes through the check valve and the component filter is by-passed as because please keep in mind friend, the fluid will always follows the path of least resistance that is the lowest pressure.

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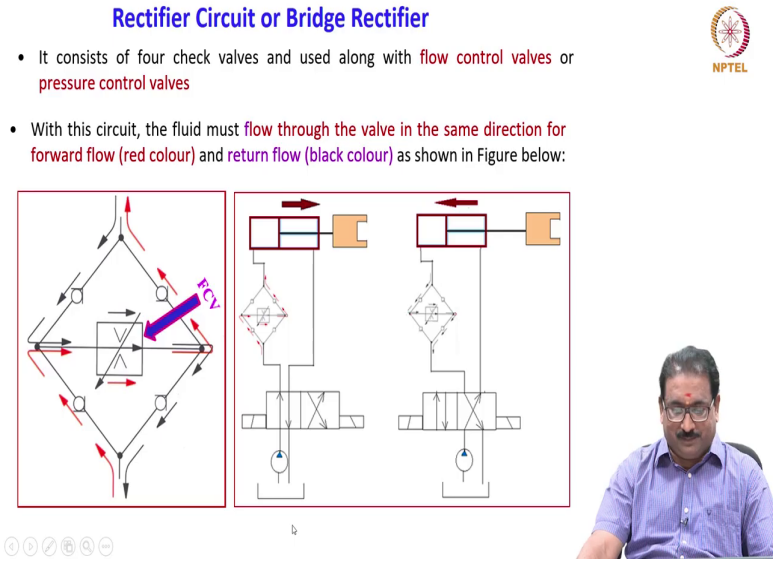

Another application of check valve used in rectifier circuit or a bridge circuit – it consists of four check valves and used along with flow control valves or a pressure control valves. With this circuit the fluid must flow through the valve in the same direction for forward flow here I

show you red colour, and return flow black colour as shown in the figure. Here you will see the four check valves are used here 1, 2, 3, 4 across the flow control valve.

Now, you will see the flow is taking place in this direction red colour whatever I marked same path; return flow not through this it follows through the valve and then to the exit. This is known as the rectifier circuit or a bridge rectifier, used to control the here I have shown you double acting cylinder with the loads. Here you will see this is the solenoid actuated 4 by 2 way valve I will tell you later this is a pump symbol and a tank.

When this solenoid is actuated the flow is going to red direction through the orifices and to the head side, this is the head side. Whatever the fluid is there in the tail side or a rod side, it will goes to the tank directly. Similarly, in the other directions what I have marked.

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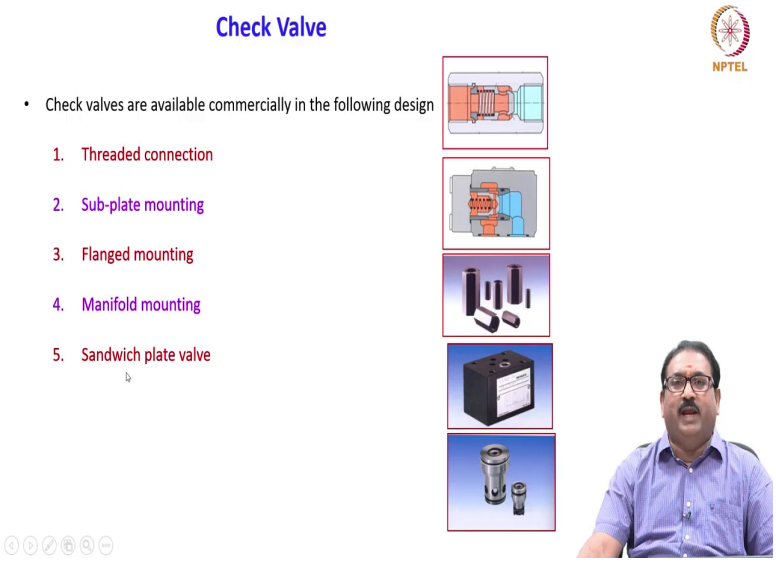

These check valves are available commercially in the following design – threaded connection, sub-plate mounting, flanged mounting, manifold mounting, sandwich plate valve.

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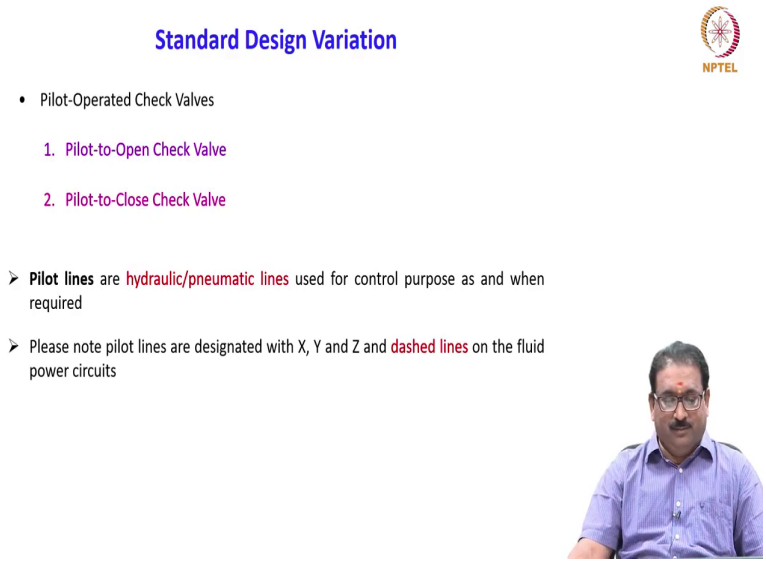

Then standard design variations of the check valve generally these are pilot operated check valves. Here pilot-to-open check valve and pilot-to-close check valves as we know pilot lines or a hydraulic or a pneumatic lines used for control purpose as and when required. These are represented using capital X, capital Y, capital Z with dotted lines.

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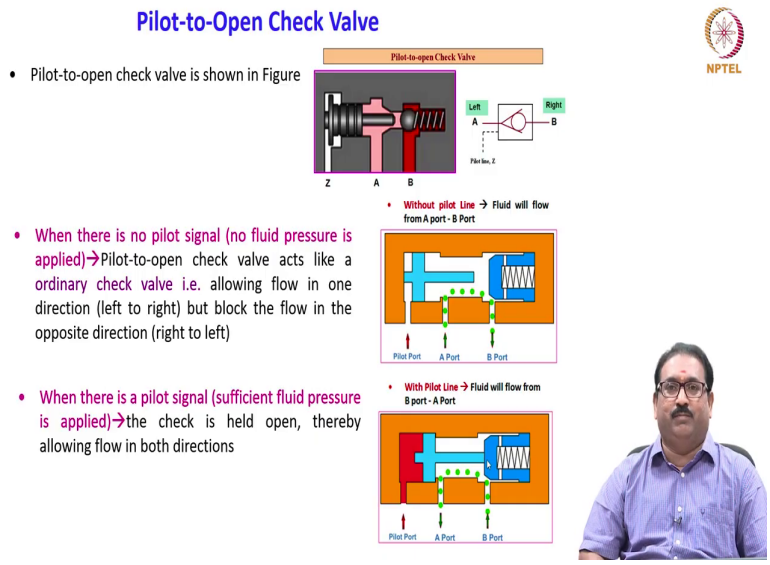

Now, let us we will see pilot-to-open check valve, what is the role of pilot here? Pilot-to-open check valve is shown in figure here. What are the things are there you will see friends here? The three ports are there in the valve body, this is the valve body. Z is a pilot port and then movable body is there with valve stem and this is a ball with a spring fitted over the valve body and A and B are the ports.

Now, we will see how it operates. This is pilot lines are used to open the check valve. You will see here the symbolic representation like this here. Understand this A to B pilot line is here. I will explain to you now. When there is no pilot line assume to be when there is no pilot line here that is low fluid pressure is applied to Z. Pilot-to-open check valve acts like a ordinary check valve meaning what it is? It allows the flow from left to right, no fluid flow from B to A.

When there is a pilot line meaning sufficient fluid pressure is applied the check valve will opened you will see here the check valve will opened here, then flow is taking place from B to A also. Here this is a different poppet it is, here it is a valve. See here the pilot signals are used to open; look here it is kept open here.

When pilot signal is removed what happen? This spring will push back and acts as a ordinary check valve meaning pilot lines are required here as and when required to open the valve to sent the flow in the both direction possible.

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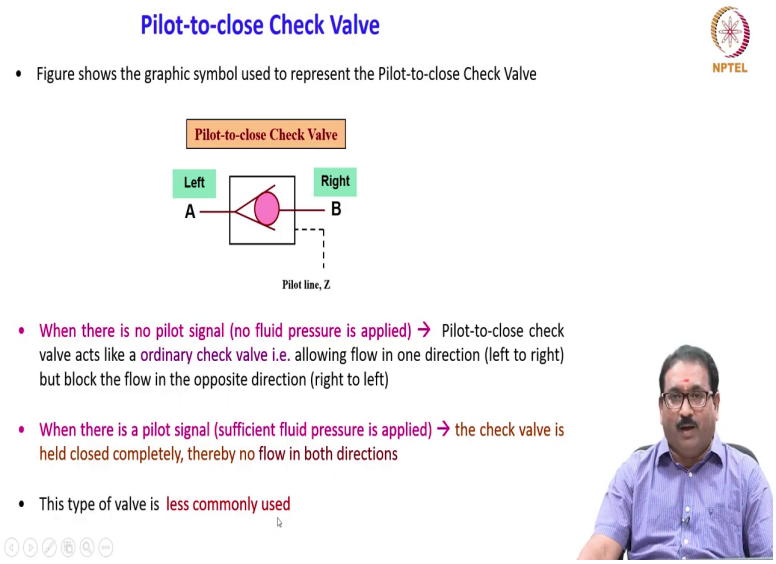

Next one is a pilot-to-close check valve. Figure shows the graphical symbol for the pilot-to-close check valve. Here the pilot signal you will see friends exactly opposite to previous one pilot signal is applied here. How it operates? When there is no pilot line

meaning no pressure in the port Z pilot-to-close check valve acts like a ordinary check valve meaning allows the flow in A to B, B to A is not possible.

But, when there is a pilot signal here what happens here, friends? The valve is fitted over the valve seat then flow will not takes place from A to B also. That is why it is pilot line is used to close the flow. This type of valve less commonly used in the fluid power system.

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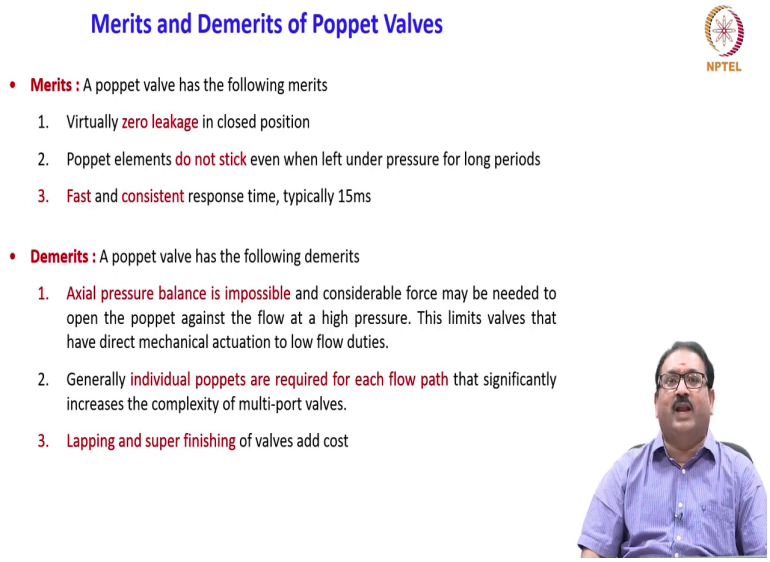

Quickly, we will see some merits and demerits of the poppet valves. A poppet valve has the following merits virtually zero leakage in closed position. Poppet elements do not stick even when left under pressure for a long periods. Fast and consistent response time typically the 15 millisecond.

Demerits are axial pressure balance is impossible and considerable force may be needed to open the poppet against the flow at a high pressure. This limits the valves that have direct mechanical actuation to low flow duties.

Generally individual poppets are required for each flow path that significantly increases the complexity of multi-port valves. As I have told you the specially designed valve seats are machined with lapping and super finishing which will add the cost to the valves.