Oil Hydraulics and Pneumatics
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Part 1: Introduction, Classification, Construction, Operation and Application of Pressure Relief Valve, Opening and Closing Characteristics
Lecture - 37
Pressure Control Valves

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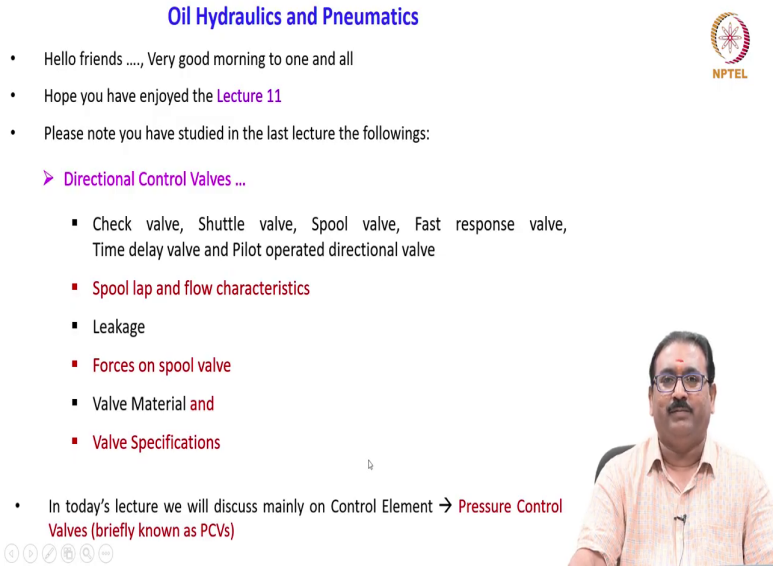

My name is Somashekhar; course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed the lecture 11. Please note you have studied in the last lecture the followings; directional control valves, basically we studied check valve, shuttle valve, spool valve, fast response valve, time delay valve, and pilot operated directional valves.

Also we have studied various types of spool lap, overlap, under lap, null cut valve, and their flow characteristics. Also we studied the leakage is a one of the important phenomenon in a spool valve, how to empirically derive the leakage flow in the spool type of valves. Also we have studied forces on the spool valve, and valve material, and valve specifications.

In today's lecture, we will discuss in detail one more control element pressure control valves briefly known as PCVs.

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So, quickly we will move on to organization of today's presentation. Quickly I will recap on directional control valves, pressure control valves, and its main applications. Here we will discuss different PCVs of interest in today's class are pressure relief valve, unloading valve,

pressure reducing valve, sequence valve, counterbalance valve, and finally, break valve. I will conclude today's lecture after studying all these pressure control valves.

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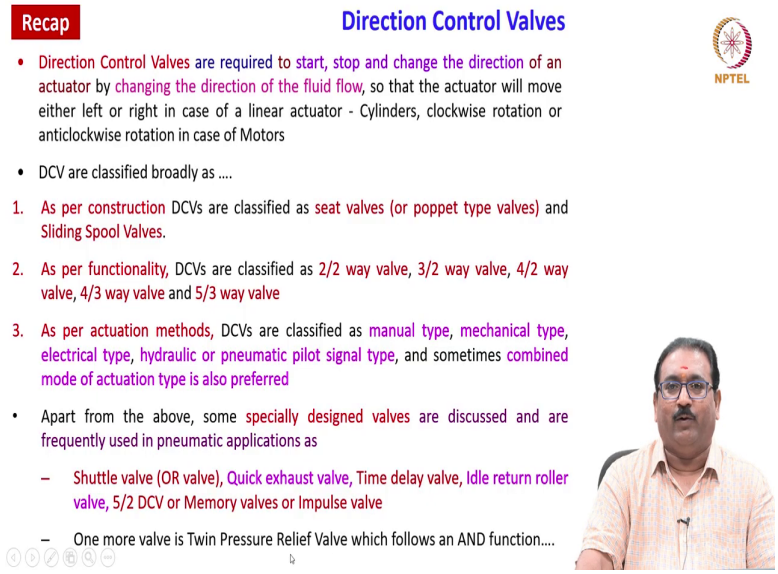

Quickly we will recap in the last class what we have studied on direction control valves. Directional control valves are required to start, stop, and change the direction of an actuator by changing the direction of the fluid flow, so that the actuator will move either left to right in case of the linear actuator – cylinders, clockwise rotation or anti clockwise rotation in case of motors.

DCVs are broadly classified as per the construction. DCVs are classified as seat valves or poppet valves and sliding spool valves. As per functionality, DCVs are classified as 2 by 2 DCV, 3 by 2 way valve, 4 by 2 way valve, 4 by 3 way valve, and 5 by 3 way valve. As per the actuation method of the spool, DCVs are classified as manual type, mechanical type,

electrical type, hydraulic or a pneumatic pilots signal type, and sometimes a combined mode of actuation is also preferred.

Apart from the above valve, some spatially designed valve also we are discussing in the last class and frequently used in the pneumatic applications. As shuttle valve also known as OR valve because it will do the OR function, then quick exhaust valve, time delay valve, idle return roller valve, then 5 by 2 DCV – it is also known as a memory valve or an impulse valve.

One more valve as I have depicted in the last lecture which is a twin pressure relief valve which follows the AND function. I will quickly show how the valve construction it is therefore that let us we will see the pneumatic OR valve, already we have seen it is also known as shuttle valve which has here the port 2 receive the flow either from the port 12 or a port 14 whichever pressure is highest.

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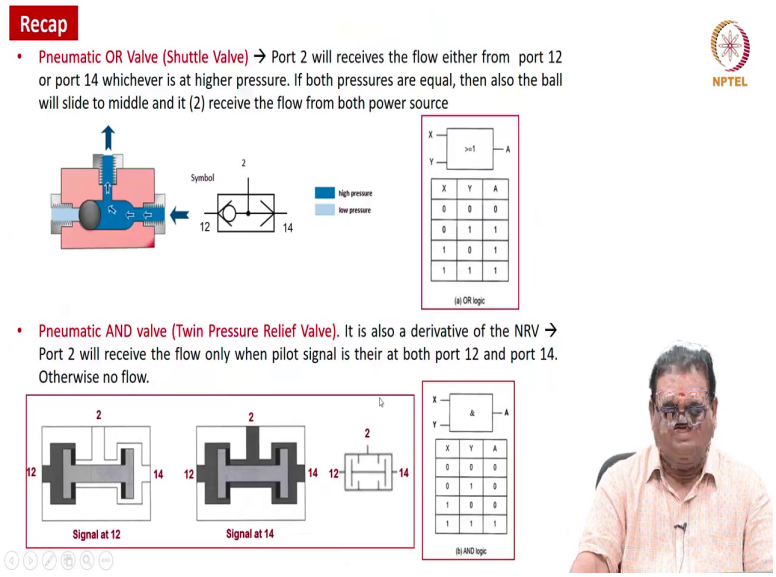

Or when port 12 and 14 are equal pressure, ball will move to the center then also 2 receives the flow that is why it is known as the OR function, OR logic. As I have told you X and Y are the signal corresponding to 12 and 14. A is nothing but here the 2. 2 will receives the flow either from Y or X, or whenever both are high that is why it is follows the OR logic function.

Similarly, as I have told you pneumatic and valve it is a twin pressure relief valve it is also a derivative of NRV. Here you will see friends, port 2 will receives the flow only when pilot signal 12 and 14 are present that is why I am telling you this is AND function.

Whenever 12 or a 14 is present, A will not receives the flow; A will receives the flow only when both signals are present, that is why it is called as the pneumatic AND valve. Here I have shown you the AND logic function here you will see X and Y corresponding to 12 and

14. 2 is A, A will receives the flow only when both signals are present. Please note the ISO symbol for the pneumatic AND valve.

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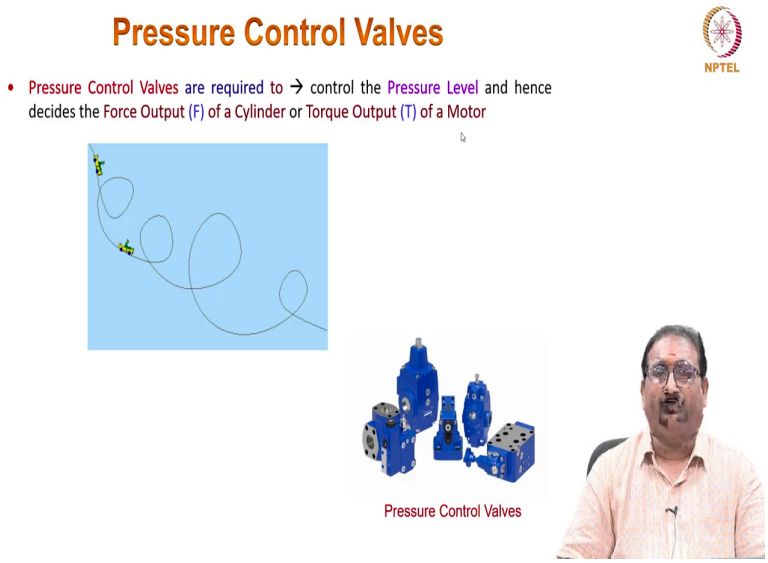

After this now we will move onto the pressure control valves. Already we know that. Pressure control valves are required to control the pressure level and hence, decides the force output of a cylinder or a torque output of a motor.

If you precisely control the pressure, you are able to control the very small load to very large load; similarly, very small torque to large torque based on the requirement. Now, in this today's class we are studying the different types of pressure control valves are there, we will discuss today.

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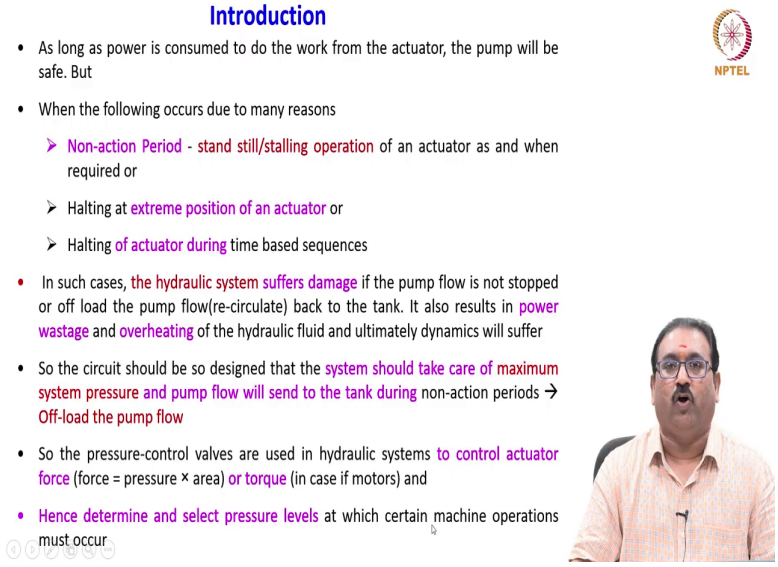

Already we know that friends as long as power is consumed to do the work from the actuator the pump will be safe. But when the following occurs due to many reasons, what are those I will tell you. Non-action periods that is standstill or a stalling operation of the actuator as and when required, or halting at extreme position of the actuator, or halting of actuator during time based sequences.

What happens? In such cases, hydraulic systems suffers damage if pump flow is not stopped or off load the pump flow meaning you have to re-circulate once the desired pressure set reached. It also results in power wastage and also the overheating of the hydraulic fluid and ultimately dynamic will suffer that is why avoid these conditions during the operations.

But it is unavoidable. Sometimes we have to come across these things. In such cases, we have to safeguard the pump and also saves the energy. So, the circuit should be so designed that the

system should take care of maximum pressure and pump will send the flow to the tank during the non-action periods that is off-load the pump flow to the tank.

So, the pressure-control valves are usually a hydraulic system to control the actuator force as we know that the pressure multiply an area in case of cylinder piston area or a rod area during the return motion, similarly in torque in case of the motor. And hence determine and select the pressure levels at which the certain machine operations must occur.

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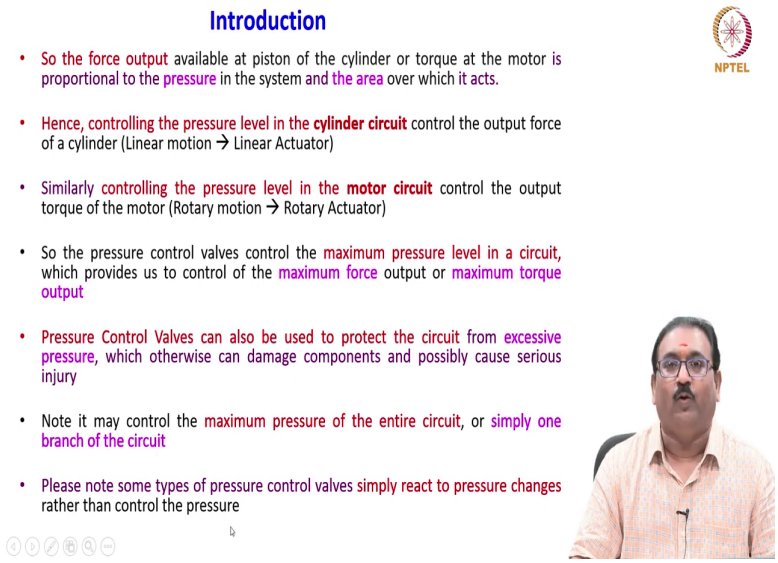

So, the force output available at piston of the cylinder or a torque at the motor is proportional to the pressure in the system and the area over which it acts. Hence, controlling the pressure level in the hydraulic circuit control the output force of the cylinder, that is a linear motion in case of linear actuator.

This is also meant for pneumatic actuator also. Please remember friends all the control valves what we are discussing it is also applicable to pneumatic valves also. But there is a only one difference is the pressure ratings are very low that is why the constructional futures even though all are same the materials are different for the valve bodies.

Similarly, controlling the pressure level in the motor circuit controls the output torque of the motor as in case of rotary motion rotary actuators. So, the pressure control valves control the maximum pressure level in the circuit which provide us to control of the maximum force output or a maximum torque output.

Pressure control valves can also be used to protect the circuit from excessive pressure, which otherwise can damage the component and possibly cause a serious injury either to the machine or to the operator. Note it may not it may control the maximum pressure of the entire circuit, or simply one branch of the circuit. Please note some types of pressure control valves simply react to pressure changes rather than the control the pressure.

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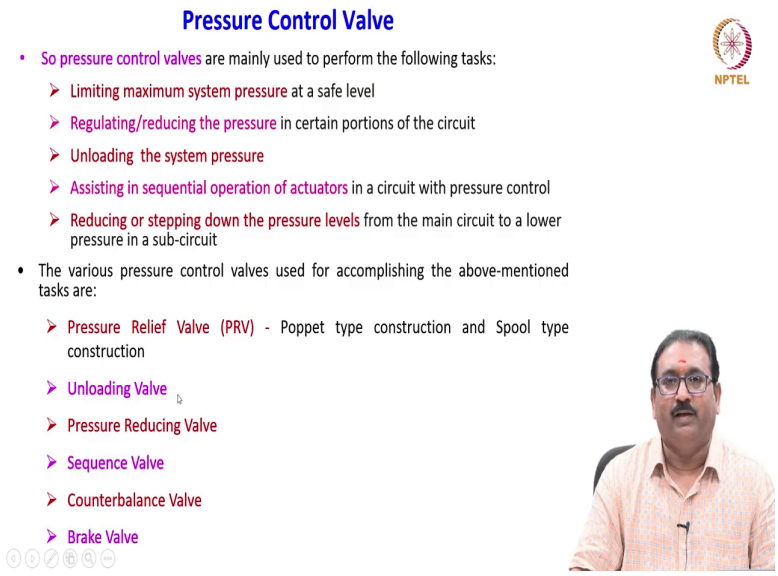

So, pressure control valves are mainly used to perform the following tasks. Limiting the maximum system pressure at a safe level, regulating or reducing the pressure in certain portions of the circuit, unloading the system pressure as and when required, assisting in sequential operation of the actuator in a circuit with pressure control, reducing or stepping down the pressure levels from the main circuit to a lower pressure in a sub circuit.

So, the various pressure control valves are used for accomplish the abovementioned task. They are pressure relief valve. Here you may get different varieties. The poppet type construction or you may also get the spool type of construction. Each has it is own advantage and disadvantage.

Unloading valve, pressure reducing valve, sequence valve, counterbalance valve, break valves; let us we will see these valves in the next slide it is constructional details, operations and applications, which are the need of the time now.

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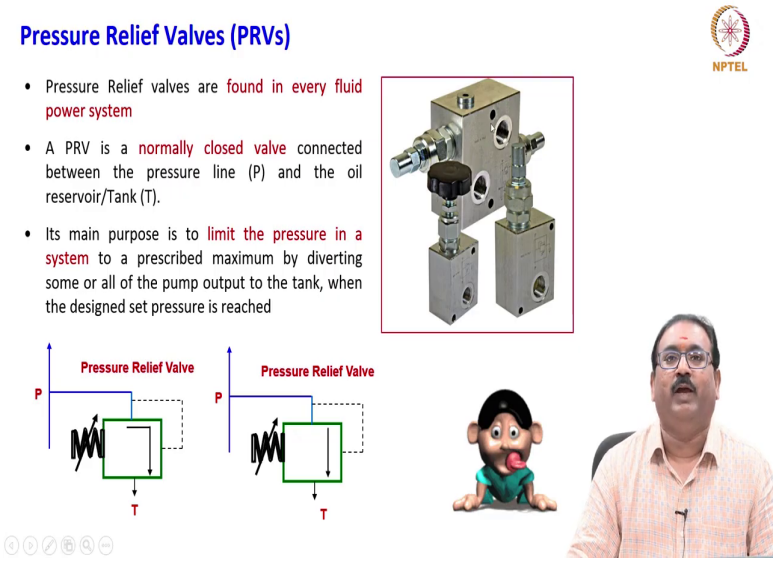

Pressure relief valves also briefly known as PRVs. The valve body looks like this friends as I have shown you. The pressure relief valves are found in every fluid power system, because as we know the pump used in the hydraulics is a fixed displacement pump always it will sucks the fluid and sense the flow, sucks the fluid sense the flow. The resistance to this flow builds the pressure. Then you have to safeguard the pump as and when it reaches the maximum level; otherwise the pump will burst.

A PRV is normally closed valve it is connected to the pressure line P pump port P and the oil reservoir or a tank port. Please remember friends these PRVs are having two important ports;

P – pump port, and T – tank port; two important ports are there. I have shown you here the graphical symbol representing the pressure relief valve.

In some of the textbooks they are representing like this also. This is also allowed, but currently the ISO is representing pressure control valves using the one horizontal line here. This is very important. This will to represent the valve will open before whatever you set pressure here that is why always they will represent the horizontal line here. Valve is always a closed one. This one what I have shown here it is a pump line P which will go to the system. One is a what we will call p port another is a tank port.

It is main purpose is to limit the pressure in a system to a prescribed maximum by diverting small or all of the pump output to the tank, when the designed set pressure is reached. Now, we will see friends here this is the ISO symbol for the pressure relief valve which has a two ports P and T, and pressure setting is done through the this spring.

Then over which I placed one arrow here meaning you have to adjust the set pressure to minimum to maximum which is specified in the valve while purchasing. This valve may stand for 250 bar if you will buy it, you will set the pressure for 50 bar, 100 bar, 150 bar using this adjustable spring. It is a very stiff spring which is making the valve should be closed in the normal positions.

Let us we will see now also you will see the pump line always monitored and fed to the valve. Once the pressure in the system increases, beyond this pressure set here, the valve get opens. Then flow is going from P to T. I will tell you in the next slide. When we are discussing the constructional details of PRV you will come to know that in detail how it will diverts the flow when the system pressure reaches the maximum pressure.

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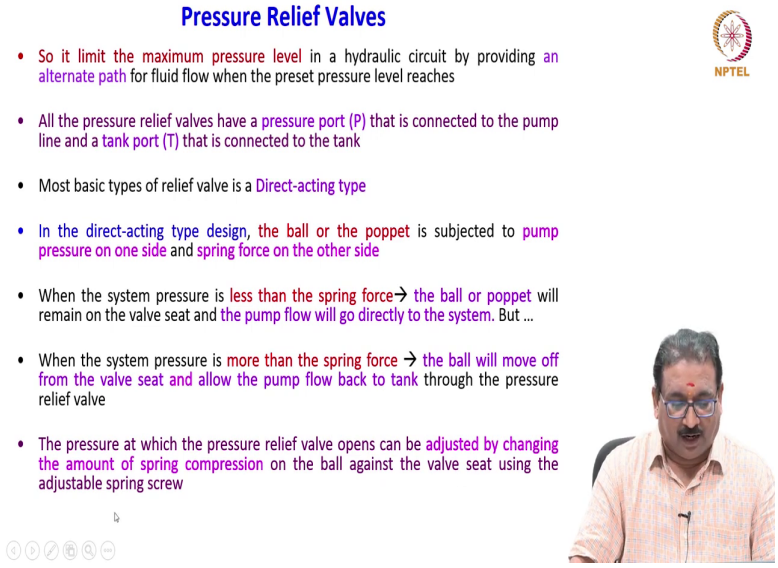

So, the pressure relief valves limit the maximum pressure in the hydraulic circuit by providing an alternative path of the fluid flow when the preset pressure reaches. All the pressure relief valves have the pressure port that is connected to the pump line and a tank port T that is connected to the tank or oil reservoir.

Most basic types of relief valve is a direct-acting type. In the direct-acting type design, the ball or the poppet is subjected to a pump pressure on one side and a spring force on the other side. When the system pressure is less than the spring force, the ball or a poppet will remain on the valve seat and the pump flow will go directly to the system where it required the flow and pressure.

But when the system pressure is more than the spring force, the ball will move off from the valve seat and allows the pump flow back to the tank through the pressure relief valve. The

pressure at which the pressure relief valve opens can be adjusted by changing the amount of spring compression on the ball against the valve seat using the adjustable spring screw is there.

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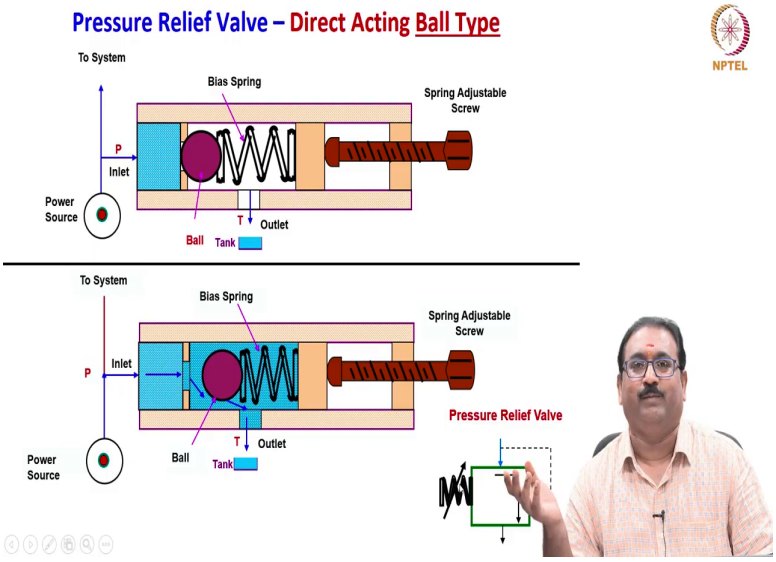

I am showing you here schematically the pressure relief valve direct-acting type ball, meaning we will see friends here this is a valve body in which the ball is sitting over the specially designed valve seat. Then other side you will see here one block is there, and spring adjustable screw is there.

Meaning if you will rotate this, it will compress the spring. Meaning it exert the force on the ball to sit over the valve seat. This is what we will call the bias spring very stiff spring it is. Then it one end is connected to the P port, and other end you will see here it is a tank port.

Then whatever the pressure you will set here which is known as a system pressure. Until that you do not worry all the pump flow will go the go into the system.

Once the system pressure starts building due to the unavoidable situation as we discussed in the first slide, what happen? The maximum pressure will push this ball off the valve seat then flow is going to the tank am shown here. This is a direct-acting ball type. ISO symbol is like this. Please remember friend the pressure relief valve is always a closed one in the null position. It has a two ports pressure port and a tank port. And look here the adjustable spring is there. How it is adjustable?

One arrow is putting here. But commercially the fixed type pressure relief valves are also available, in such time you should not place the arrow here – only it is a fixed type. If arrow you will see here, you will adjust from minimum to maximum they will specify while buying the pressure relief valve.

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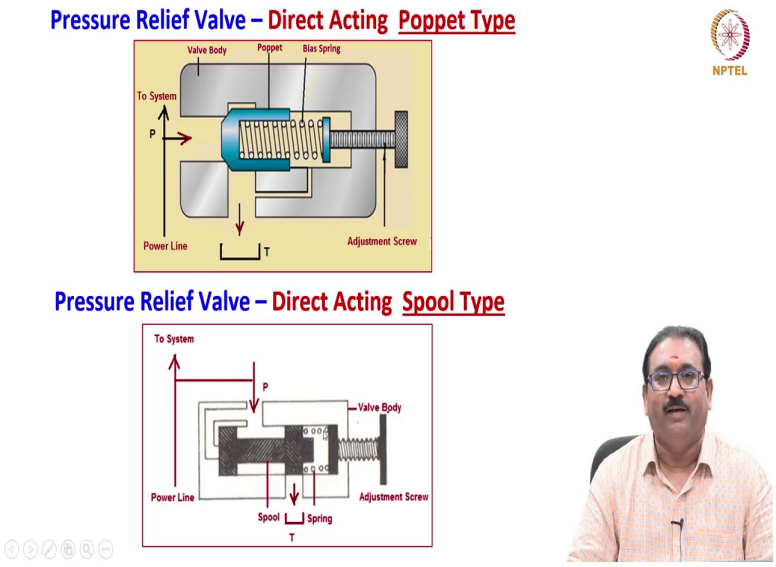

Now, we will see friends now, now here it is a poppet type design it is. Now, previously you are seen the ball over the valve seat, now you will have specially designed poppet is sitting over the valve seat. Again it is one side – is a system pressure what you will call the pump pressure is acting; on other side is one, one more port is connecting to the tank. And this poppet is always held in position using the bias spring. The spring force is adjusted using the adjustable screw.

Similarly, you will see one more type design. Here is spool friends; these are the ball and poppet type. Now, here it will see spool. Spool and one other side is a spring stiff spring is there which can be adjustable using the adjustment screw is there. This is a valve body. Valve body has a P port and a T port. P port always connected to the power line, power line is nothing but the pump line, and it will monitor.

Once it exceeds the set pressure here, what happens, spool will move this compress this then flow is going to the tank. There are various designs are there based on this elements what are they are using.

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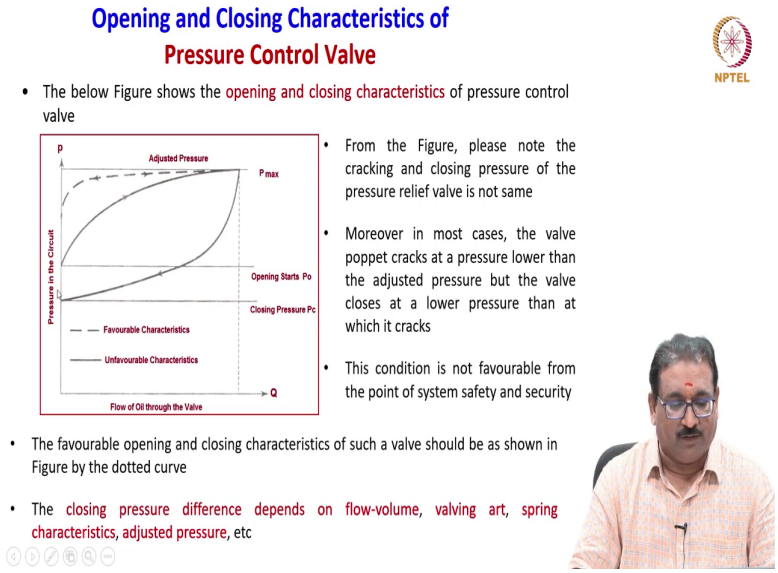

Then you will see the opening and closing characteristics of the pressure control valve. This is a very important curve what I have shown here. Here you will see here the P versus Q characteristics. This is a pressure in the circuit, and flow of oil through the valve.

You will see here, the P, the oil the pressure will start building here. And then once it is maximum is reached, it will open. Meaning you will see friends here the opening starts here at this pressure P o and a closing pressure is P c meaning the closing pressure of the valve is lesser than the opening of the valve.

But actually this is undesirable characteristics. The favorable characteristics is like this. It will goes on building, then it will be this is very good characteristics. From the figure, please note that the cracking and the closing pressure of the pressure relief valve is not same. Moreover in most cases, the valve poppet cracks at a pressure lower than the adjusted pressure but the valve closes at lower than at which it cracks. This condition is not favorable from the point of system safety and security.

So, the favorable opening and closing characteristics is always this as I have shown you. This is a favorable characteristics in the P versus Q. This is not a favorable characteristics, but most of the times it will happen like this meaning the closing pressure is less than the opening pressure. The closing pressure difference meaning this the closing pressure difference delta P depends on the flow-volume, valving art, spring characteristics, adjusted system pressure, and many more parameters.