**Automation in Manufacturing**

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**Week – 10**
**Control valves and graphical representation**
**Lecture – 01**
**Direction control valves**

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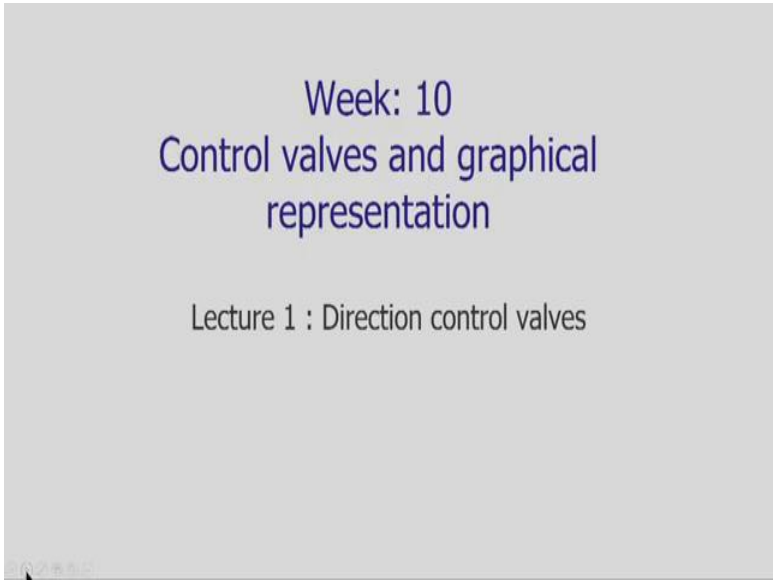


Hello and welcome you all to the week 10 of Automation in Manufacturing. In our previous week we have seen, the hydraulic systems the fundamentals of hydraulic systems and the hydraulic pumps. The next important element of a typical hydraulic system is control valves.

In this week, we will be studying various control valves and we will study how to graphically represent the control valves and hydraulic circuits? In lecture 1, we will be focusing upon the Directional control valves.

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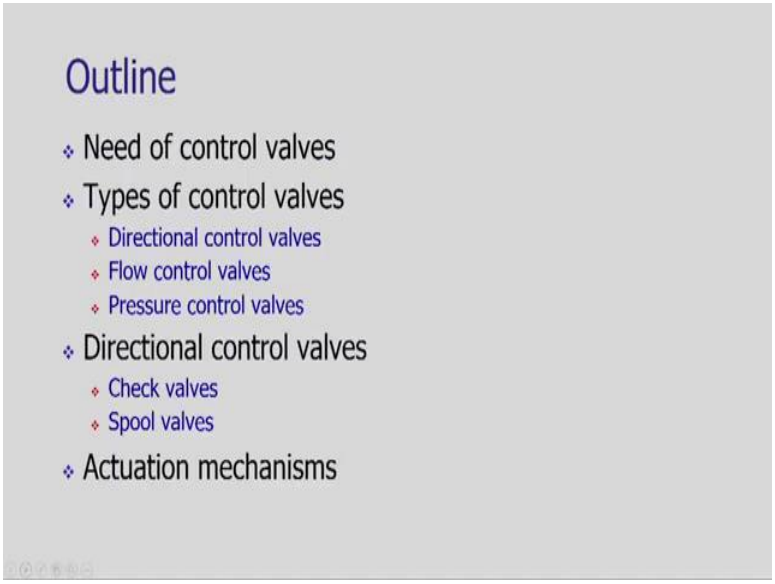


At the start of the lecture, we will have a discussion on the need of control valves, what is the importance of a control valve that to be employed or to be used in a hydraulic circuit.

There are various types of control valves being used these are directional control valve, flow control valves, pressure control valves. We will see the construction, principle of operation and application of all these control valves 1 by 1.

In this lecture we are focusing on directional control valves and these are check valves and the spool valves. At the end of the lecture, we will have a discussion on the various actuation mechanisms of this directional control valves.

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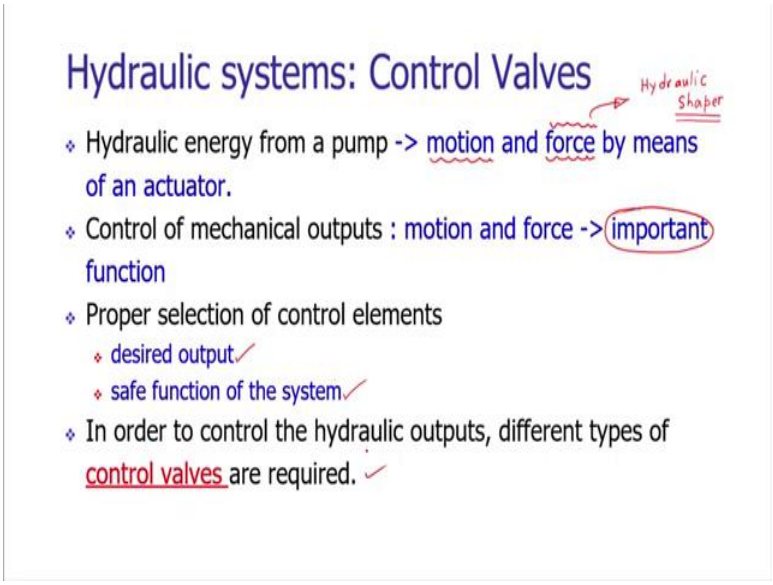


Let us begin the lecture 1. A typical hydraulic system are a machine or a mechanism, based upon the hydraulic system is basically using the hydraulic energy to actuate various elements or the mechanisms. The hydraulic energy is being generated by conversion of the electrical energy. The fundamental element, the pump is being driven by the electrical motors.

Well, what we will do with the hydraulic energy? We have to generate motions and we have to generate the force. The motion may be utilized to carry out number of operation. That motion or the movement of the linkages of the mechanism would be carried out by the converted hydraulic energy, or the force which is generated inside the mechanism, that will that will be utilized for the material processing.

A simple example is the hydraulic based shaper operation. A hydraulic shaper, shaping machine we have seen, it is a material removal machine. In this machine we are having a relative motion between the tool and the work piece.

The work piece is stationary and the tool is reciprocating, it is translating over the work piece material. That translatory cutting motion is developed by the hydraulic system hydraulic energy. The required force will be generated by the hydraulic system in the shaping machines.

When we are getting this motions and force, it is very essential for us to control this motion and force. Uncontrolled forces are not useful for us. Whatever the desired force required,

whatever the desired force is there the system should generate that required force only. For that purpose, we need certain elements and that elements are nothing, but the control elements.

These control elements are essential to be properly selected to generate the desired output and they should provide the safer or protected working environment for the user or the operator.

The safety and the desired output: these two are the essential requirement, that to be considered during the proper selection of this control elements. The fundamental control element in the hydraulic system is hydraulic valve itself.

The hydraulic valves are needed for control the flow of hydraulic fluid, inside the system to have the required pressure of the hydraulic fluid inside the system, because that fluid pressure itself is generating the required force during the application and the direction of application.

There are different types of functions being carried out by the control valves. And, there are various types of control valves are used in the industry. We will see some of the control valves in this lecture.

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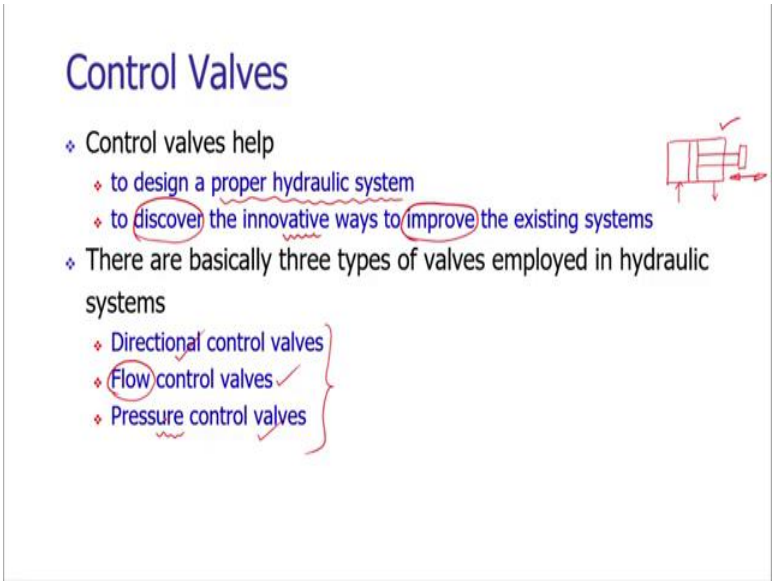


Thus, we can say that the control valves are helping us to design a proper hydraulic system. Meaning of the proper hydraulic system is that all the elements are providing or they are working to generate the output in desired manner only.

The control valves are not only helping to design a proper hydraulic system; they are helping to discover the innovative ways to improve the existing system. A typical actuator in hydraulic system is a single acting piston cylinder arrangement, to actuate a single acting piston cylinder arrangement there are various ways to get the required motion of the piston cylinder arrangement. The required motion in the piston cylinder arrangement is just the extension of the piston rod.

Let us consider typical arrangement here, a single acting cylinder. What may be the various ways to control the activity of this actuator? We can use a simple two way valve, or we can utilize a three way valve, or we can use the regenerative valves, or we can use the proportionate valves to control the activities. These different ways, these innovative ways are helpful to improve the existing system.

The same single acting cylinder can be utilized for variety of applications. It may be just to generate the on off or you can say the discrete motion, whether complete retraction of the single acting cylinder or the complete extension of the single acting cylinder, or it may be a gradual apply of the force at this end by using a proportional control valve.

Now, instead of having a simple two way valve if we can have the proportional control valve to apply the force gradually, this same system can be utilized as a the gradual force application system. That control valves are helping to carry out such operations in the hydraulic systems. In hydraulic systems basically three types of valves are used these are the directional control valves, flow control valves and the pressure control valves.

The directional control valves are controlling the direction of the fluid inside the hydraulic system. As the name suggest the flow control valves are controlling the flow of hydraulic fluid inside the hydraulic system. And, the third one that is the pressure control valve, it is utilized to control the application of pressure of hydraulic liquid at the application or the load.

Let us look at these type of valves 1 by 1, let us start with the directional control valve.

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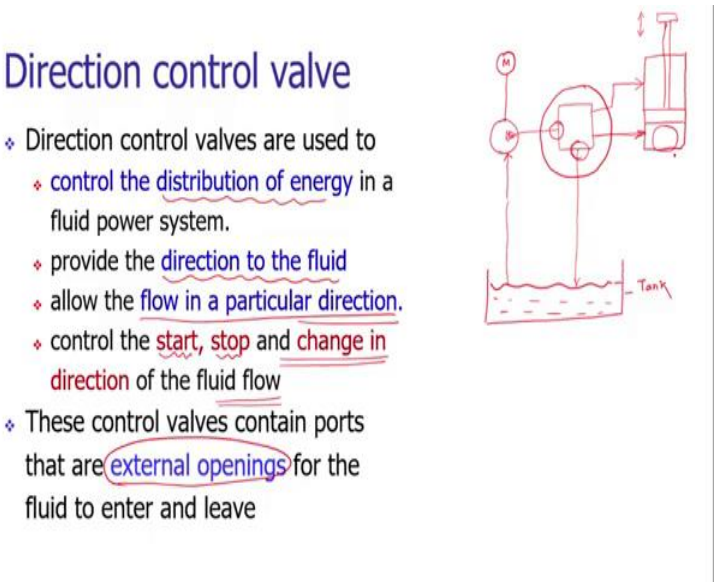


The directional control valves are basically used to control the distribution of energy inside a fluid power system. To understand the requirement of a typical hydraulic system, let us take an example. We are having a tank, the hydraulic fluid is there in the tank and, we are having an actuator.

Let us consider a single acting piston cylinder arrangement is there. And, at the end of the rod of the piston, we are applying the load. That load may be raised or that load maybe lower and for that purpose we need to carry out the hydraulic based operation.

As we have seen in our previous class, we need a motor and that motor is driving a pump. An electric motor is there and that electric motor is driving a pump, let us consider we are having a pump. This pump is getting the fluid from the tank and from the pump, now we have to distribute the energy.

We are getting the pumped fluid, but that fluid has to be distributed inside the system. Distribution of the energy will be carried out by using a unit we need mechanism; we need a mechanical unit or it may be a it may be an electromechanical unit as well.

That unit should distribute the energy. We required energy at the bottom portion of the cylinder to extend the cylinder, we also need the fluid that to be applied on the top side at the top side. That we can retract the cylinder, we can retract the piston rod inside it to reduce its length.

The fluid will be taken to the top side or to the bottom side by a mechanical unit. We also need a mechanism, so that the used fluid is to be given back to the sump or the tank itself. After usage of the hydraulic fluid it has to be taken back to the tank, further heat will be processed, it will be filtered and further processed for the desired application.

For this purpose, we need a control valve, which is distributing the energy inside the system, which is giving the direction of the fluid inside the system and it is allowing the flow in a particular direction only. In the case of the extension of the piston rod arrangement, we have to apply the fluid energy in this area.

In particular direction we need to apply the energy. That function is also to be carried out. The control valves are starting stopping and changing the direction of the fluid flow inside the system.

These control valves are having the external openings, it is having an external opening to get the fluid inside, it is having another external opening to send or to return the used hydraulic fluid inside the system. External openings are there for the fluid to enter and leave inside the direction control valve.

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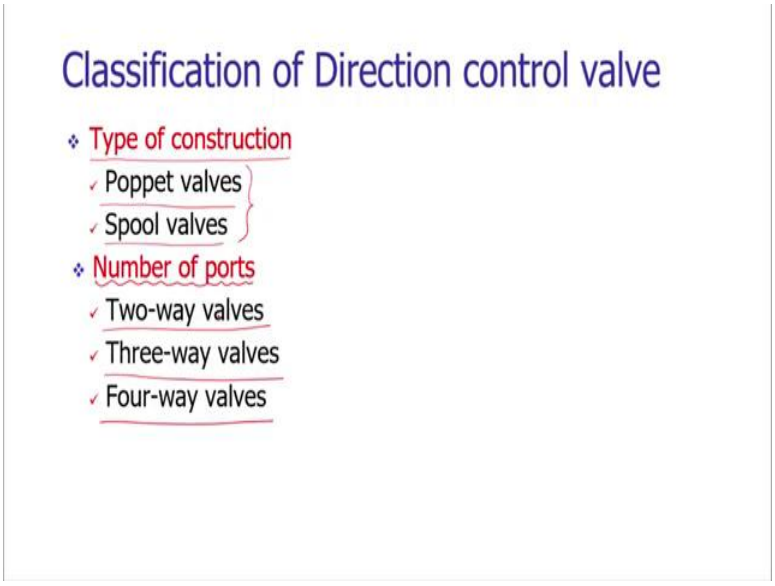


The direction control valves can be classified based on many factors, many parameters. The first factor is the type of construction. We are having two types of valves which are used in the industry, these are poppet valves and spool valves.

In poppet valve we are using small poppets, small cylindrical or spherical poppets which are used to control the flow of the fluid inside the system. The spool valves they are having a cylindrical spool, it is a cylindrical mechanical element which is controlling the flow of fluid, it is controlling the direction of the fluid inside the system.

We are also having the classification based on the number of ports. As we have seen in our previous slide, a typical control valve is having openings, external openings. Based upon the number of openings, the control valve has we can have a variety of types of valves, these are the two-way valves, three-way valves and the four-way valves. We also called these as the two port valves, three port valves or the 4 port valves.

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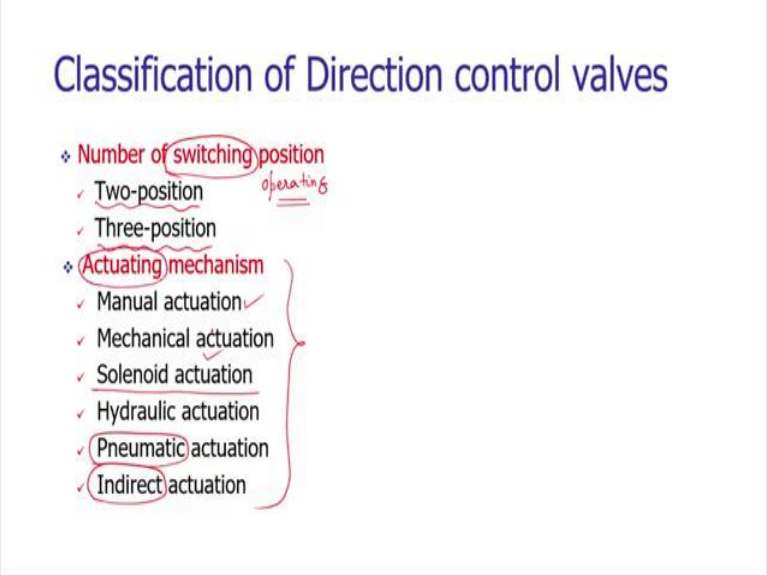


The control valves are also classified based upon the switching position or the operating position. As we have seen in the previous slide for actuation of a single acting cylinder, we need to have the two-position. In first position the fluid is passing at the top side of the piston and the second position the fluid should pass at the bottom side of the piston.

There are two switching position, that is on in the extension of the piston cylinder arrangement off means retraction of the piston cylinder arrangement. We can have the two-position. We also have a third position in which the application is you know the application will have the constant load kind of situation.

We need to hold the work piece we need to hold the force on the work piece. For that purpose a three-position valve is also incorporated. Based upon number of position we are having two-position valves and three-position valve.

Actuation mechanism: how do you actuate the directional control valve. We can have the manual actuation, mechanical actuation, or electrical actuation, that we call the solenoid actuation; we can use the hydraulic energy itself to actuate the control valves, or to operate the control valves.

We can use pneumatics, the compressed air to operate the direction control valve, these are called as the pneumatically actuated control valves, or we can have the indirect actuation, we can have use of a pilot to actuate the control valves. We will have a discussion on the various actuating mechanisms in detail in the coming slides.

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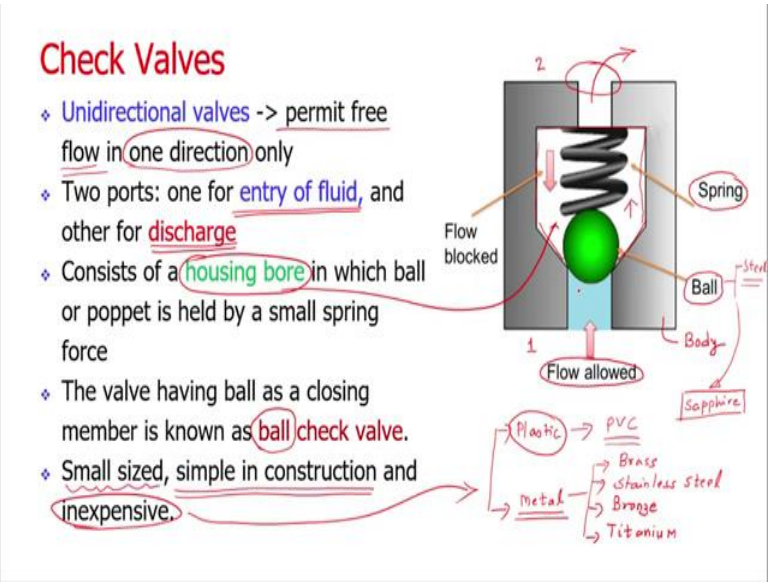


Now, let us study the first valve that is the check valve. The check valves are the unidirectional valves, the unidirectional means they are permitting the flow in only one in one direction. These type of valves are in general we use at the domestic applications as well, we need to just have only one direction flow.

A typical valve construction can be seen on our screen, this is the valve body; body of the valve. And, it is having a passage. The fluid is allowed to enter at this opening and it has another opening from where, we are getting the fluid out. Inside the valve there is a space has been

created, it has been machined, or it has been casted, to have the construction elements of the valve.

The basic construction element of a check valve is a spring. It is a spring loaded ball valve. We are using a ball to control the direction of the fluid inside the valve. The spring is having sufficient stiffness to apply a force on the ball and the ball is seated at the inlet of the valve.

In normal condition the valve is closed, the normal condition the valve is in off position. It is not allowing the fluid that to enter, if the fluid pressure is low it is at the atmospheric pressure.

If the fluid pressure is less than the pressure applied by the spring itself, but when the fluid pressure increases, when the inlet pressure increases above the pressure applied by the spring, there would be displacement of the ball against the spring due to the fluid, which is coming out. And, in that way we can have the flow of fluid from only one direction.

In other direction it is not possible. In this situation we can have the fluid that to be passed from only one direction from the end 1 to the end 2. As mentioned there are two ports, that is entry of the fluid and the other one is for the discharge.

This is the housing bore basically, housing bore is seen on our screen, see in which a ball or a poppet is held. If, we are using the ball to check the fluid flow, that that is called as the ball check valve or we can have the poppet based valves as well.

These kind of valves are small in size and they are simple in construction and they are inexpensive. For domestic purpose we are employing such kind of valves to control the flow of water for our domestic applications. These valves are generally made up of the plastic or they are made up of the metal.

The plastic in general the PVC or in metals, brass, stainless steel, bronze, or in the biomedical application, or in certain industry applications where, we need to have a non-corrosive nature of the valve titanium.

Based upon the metal that we are using, the cost of the valve is increasing. In general, the plastic valves are very inexpensive; we can also have the valves which are plated valves. The balls are made up of steel and in certain cases the balls are also made up of sapphire. Sapphire is very durable, it provides very high strength and it is chemically inert.

When we want to utilize these kind of check valves for precision application for the operations in biomedical industry, wherever it is required to protect the fluid, . so that it will not corrode the valve elements, it will not have any chemical reaction built the valve elements, it will not create any the poisonous gases, it will not get contaminated. In this situation we are using the sapphire which is the durable chemically inert and it is the high strength materials.

When we apply the high pressure here, there would be lot of wear and tear of the balls because the balls are hitting at the inlet position quite often. That is why the balls should have the sufficient strength.

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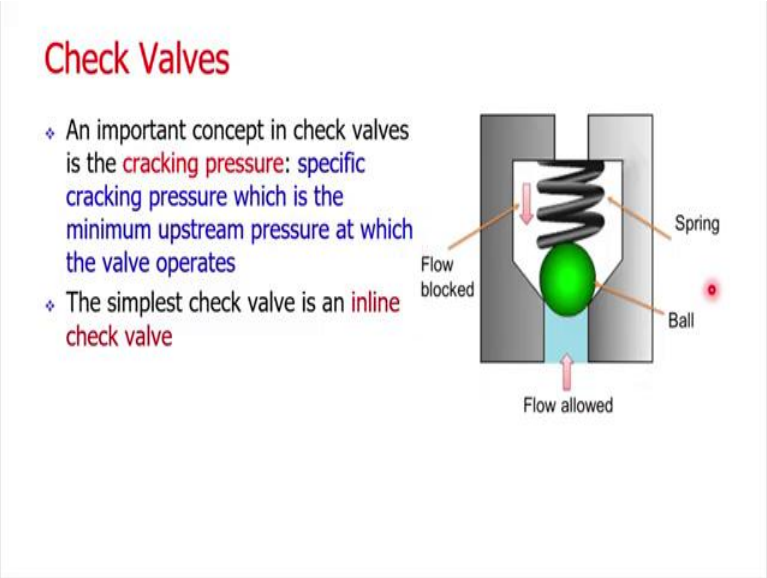


The important concept in check valves is the cracking pressure. As we have seen that the flow is allowed only in one direction and in the other direction it is blocked.

But, the flow is allowed against a spring, against a certain pressure, and when the fluid inlet pressure is more than that certain pressure, than and then only the fluid is allowed to pass through the valve. And, that particular pressure is called as the cracking pressure.

Formally we can define the cracking pressure as a specific pressure or the minimum upstream pressure at which the valve is operating. The upstream pressure the pressure in the upstream direction at which the valve is operating is nothing, but the cracking pressure and that cracking pressure is dependent upon the stiffness of the spring.

In general, a simple check valve is having only one cracking pressure, but if we want to have variable cracking pressure, then we have to use the screw based arrangement in which you can change the stiffness of the spring, you can control the stiffness of the spring. The valve which is shown on your screen it is a very basic arrangement and it is called as the inline check valve.

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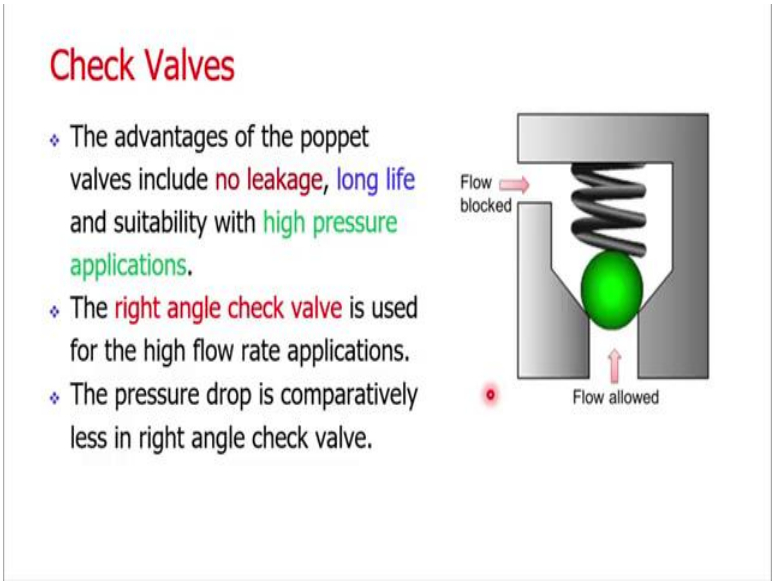


We can also have a right angle arrangement, in this arrangement the fluid flow inlet and the fluid flow outlet directions are at right angle to each other. This is the inlet along which the flow is allowed, this is ball spring and this is the outlet, from outlet to inlet the flow is blocked.

In general, the check valves offer advantages such as the leakage, the leakages less, the life of the check valve is quite long they are durable. They are very much suitable for high pressure application, but for high flowed flow rate application these valves are not that suitable, they can work for the medium to low flow application.

The inline check valves are not suitable for high flow rate applications whereas, the right angle check valves are used for high flow rate application, because the pressure drop along the right angle travel of the fluid is comparatively less than the inline flow of the fluid.

In inline flow of the fluid as we have seen that, there may be a good amount of the pressure reduction that that is been solved by using arrangement which is having the right angle flow.

This certainly reduces the pressure drop. Therefore, the right angle check valves are used for the high flow rate applications whereas; inline check valves are not that suitable for the high flow rate applications.

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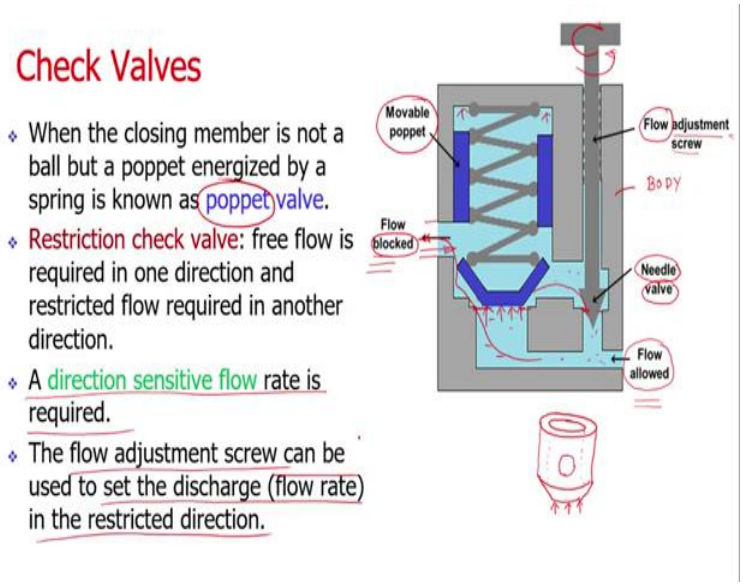


When instead of using a ball a metal ball to restrict or to control the flow of fluid inside a hydraulic valve. If, we are using a poppet a metal poppet that is called as the poppet valve. The poppet is nothing, but a cylindrical mechanical device or element, which can be seen on our screen, it is basically a hollow cylindrical device and it is having a hole as well. Inside the poppet we can accommodate the spring.

A typical construction of a poppet based check valve can be seen on our screen. It is having the body of the valve. It is having the internal spaces or the grooves. These are the internal spaces, the blue color spaces are seen here. Inside the major space provided in the check valve we are having the poppet, the poppet is movable.

Inside the poppet we are having the spring of sufficient stiffness and that stiffness of the spring itself is deciding, the pressure that to be applied during the flow. The check valve as we know that they are allowing the fluid that to be flow in check valves, we know that, the fluid is allowed to flow in only one direction. In this case the fluid is allowed to flow in this particular direction and this is the exit of the fluid flow.

The fluid is allowed only in this direction, the opposite direction fluid is blocked the flow is blocked. To control the flow a flow adjustment screw is also provided. The normal position of this valve is closed. Due to the spring pressure the poppet will sit at this space.

And, due to the spring stiffness or the pressure, it will be rested here. If the flow pressure is not sufficient to surpass the spring stiffness or the pressure given by the spring, there is no occurrence of flow across the check valve.

But, in case the pressure of the inlet is increased we are applying the high pressure fluid, which is coming out of the pump inside the valve. Then, that fluid will apply pressure against this surface of the poppet.

The poppet will try to push in upward direction, but there is a restriction from the spring, but if the fluid pressure is more than the stiffness is more than the cracking pressure of the check valve, then the poppet will be moved in upward direction. As the poppet is moving in the upward direction the fluid will just move inside the gaps and it will pass through the valve and it will be sent to the desired application.

But, during the application, we can even control the flow rate. That is not only controlling the direction of the fluid flow, we can even control the flow rate by using a flow adjustment screw.

Let us consider that this needle valve which is seen on our screen has been tighten by using a screw and this passage has been closed. If we rotate this in a in a clockwise direction, then this screw will go in downward direction this passage will be closed. The fluid pressure at the inlet minus the pressure required to surpass the spring pressure will be the outlet pressure from this particular check valve.

Consider we do not want to have the increase in pressure, if we want to just reduce the flow rate. In that case you can just move this into anti clockwise direction, this needle valve will be open and whatever the fluid which is passing through in the gap between the poppet and the valve that will be moved back to the inlet port.

In this way the pressure inside the space of the valve can be reduced by using this flow adjustment screw. The flow can flow rate can be reduced the pressure can be reduced.

Direction sensitive flow rate if it is required then we can use the flow adjustment screw and that can be set the discharge flow rate in the restricted direction, we can set the flow rate by using the flow adjustment screw.

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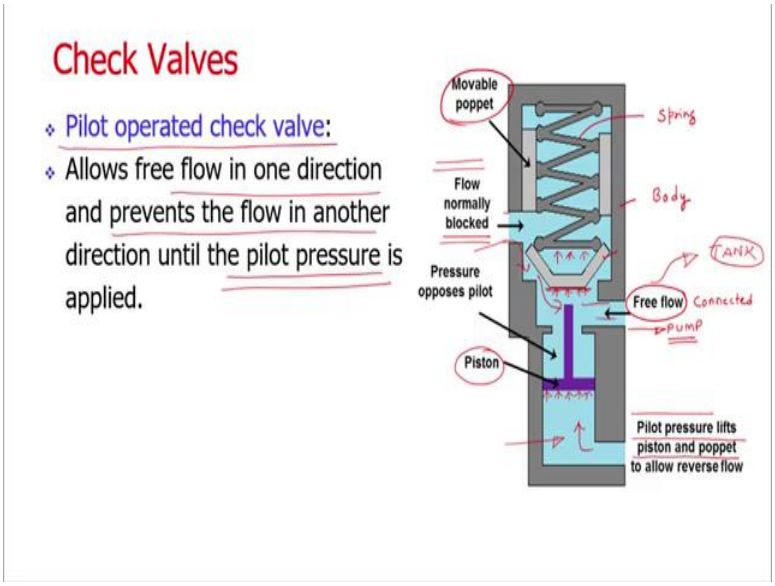


Now, instead of using the inline pressure of the fluid to operate the valve. In case we need to utilize the external pressure, the outside pressure to operate the valve. When we are using such arrangement, when we are using the pilot pressure to operate the check valve that type of valves are called as the pilot operated check valve.

The construction of pilot operated check valve can be seen on our screen, it has the body of the valve and inside the body we are having a poppet. This poppet is having the spring, the poppet is movable, we are having the inlet, the inlet is connected to the pump. This is the outlet of the valve and the reverse flow is normally blocked. The outside from the outside we are getting the pressurized fluid for the desired application.

These valves can be operated by the inline pressure itself, but we can have an external lifting arrangement by using a pilot pressure. Pilot pressure means we are making an arrangement, we are making certain arrangement here, this arrangement is having a small piston and this piston is operated by the external fluid pressure.

The fluid is applied at the side of the piston during the operation. As pressurized fluid is applied here, this piston will be moved in upward direction and that piston is applying the force on the poppet.

Due to the application of the force on this side of the poppet, the poppet would be post in upward direction, the valve will be open and the fluid from the pump will be applied to the particular load.

The advantage here is that, if the inlet pressure is not sufficient to operate we can externally apply the pressure to operate the particular valve. The pilot operated check valves allows free flow in one direction and they prevent the flow in the another direction until the pilot pressure is applied.

Tthe pilot operated check valves can also be considered as the unloading valve as well. We can just consider the case over here, the pressurized fluid is applied from the pump and when this pressurized fluid is pushing the poppet against the spring, it is allowing the pressurized fluid that to pass through the check valve.

Now, let us consider the same valve is to utilized for the unloading purpose. For unloading purpose the simple check valve is not suitable. We cannot use the simple check valve, because it is fundamentally not allowing the flow in the reverse direction. To make it allow in the reverse direction, in that case as well we can use the pilot pressure.

Pilot pressure can be applied here the, the poppet will be pushed in upward direction, as the poppet is pushed in upward direction the reverse flow can be allowed. Let us consider, we want to just unload, unload the fluid flow the fluid will come and it if this is connected to the tank. In this way we can allow the flow of fluid in a reverse direction if the pilot pressure is applied.

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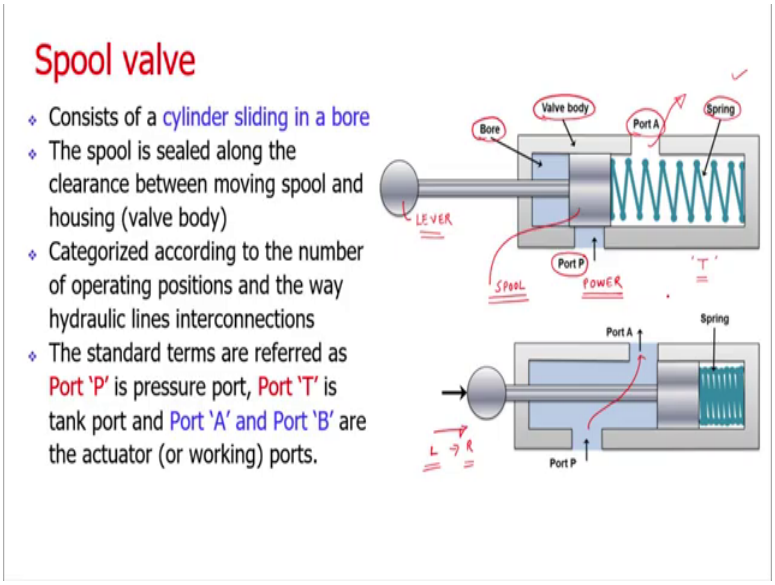


The next type of valve is spool valve. The spool is nothing, but a cylinder a cylindrical element and that cylinder is sliding inside a bore, a typical construction of the spool valve can be seen on our screen.

This is a valve body. The valve body is having a bore and inside the bore a spool is mounted the spool is having the lever and that lever is being operated by a variety of actuation methods.

The valve body is having the ports the port P is the power port, port is nothing, but the external opening. Through this port we are applying the pressurized fluid inside the valve. Port A is the application port through this port we are getting the flow of fluid for particular application. This spool is spring loaded a spring with sufficient stiffness is arranged along with the spool inside the valve.

Based upon the number of ports and based upon the number of positions, we can have a variety of spool valve configurations. There is another port that is called as the tank port. 'T' is designated for the tank that is the sump in hydraulic systems.

In pneumatic systems we are using the letter R, that is an event to the environment. On our screen, we can you can notice that, the power port is blocked. We are not getting any pressurized fluid inside the valve, because of the action of the spring force. If, we want to get the pressurized fluid for a certain application, if we want to get that pressurized fluid from the

port A, then we have to actuate we have to push the lever in this direction from left to the right, left to right.

When it is happening, then the port P will be opened to the application. The pressurized fluid is allowed to flow through the valve and it will be allowed to apply at the desired location. In this way the spool valve is working.

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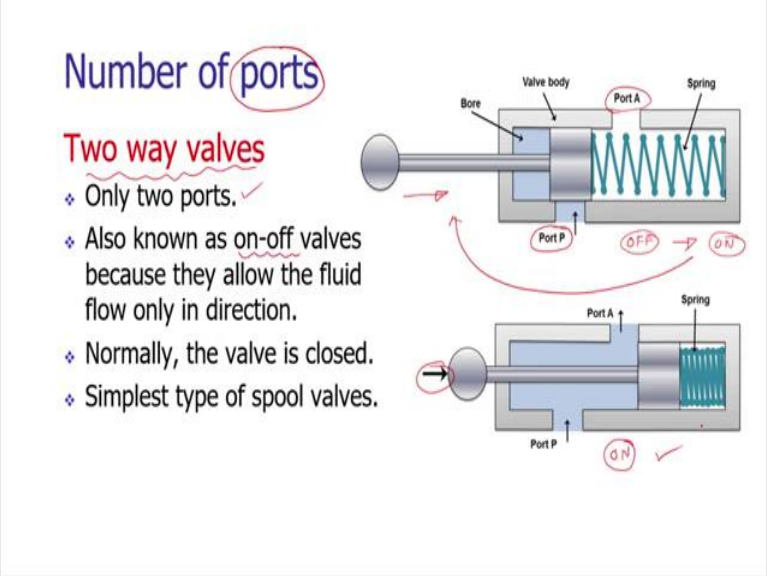


The next type of classification is based upon number of ports. As mentioned, number of ports are nothing, but number of openings to a particular valve. We can have the two way valves, when two ports are there. That that kind of valve is called as the two way valve. Here we can see two openings are provided.

This is the two way valve. This is a typical on off valve we can we can carry out a simple on off application. In normal it is the off position, as the valve is actuated that will change the off condition to the on condition, off condition will be converted into the on condition, when we apply a force at the lever.

When we apply the force at the lever as we can see here the condition is on the valve is allowing the pressurized fluid to flow through it. And, the simplest example of the two way valves is the spool valve which we have seen in the previous slide itself.

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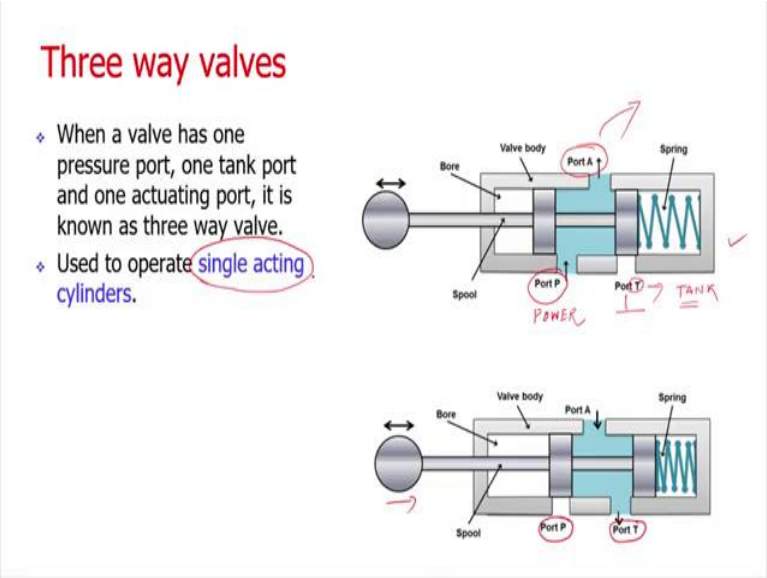


The three way valve, when we are having three openings, port A is for the application, port P is the power port, through which we are applying the pressurized fluid which is connected to the pump. Pump is operated by the motor. port T is the tank port some port during the unloading application we need to get the used fluid, that to be passed to the tank which can further be utilized for the pressure pressurization application.

Generally the three way valves are used to actuate or to operate the single acting cylinders. In this case, the power port is connected to the application port and the tank port is blocked, no fluid is coming to the tank. If, we operate the spool then the power port is blocked, no fluid is coming in from the power port, and we are getting the fluid from the port A to the tank port. This is the unloading operation in the single acting cylinders.

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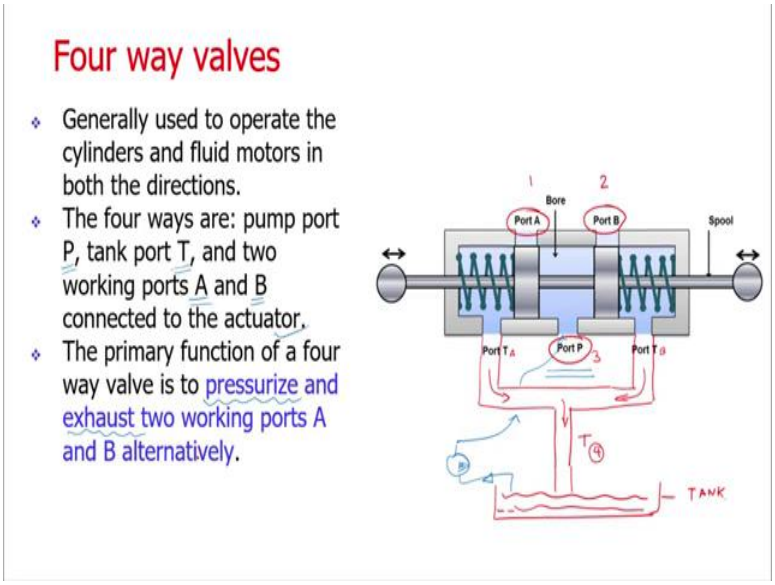


We can also have the four way valves. In the four way valves, we are using two application ports, port A and port B and we are having a power port and tank port. Here it is mentioned that, there are two tank ports can be seen. We can consider this is the tank port T A for unloading from port A and port T B, from unloading the port B.

But, internally these ports are connected to each other. We are having a common passage which is bifurcated, the inside construction is something like this. Now, the port T A and port T B are connected each other and we are having common passage to the tank.

Number of ways to be noted here are 1, 2, 3 and 4. Even though T A and T B are bifurcated it is considered as only 1 port. It is to be noted over here. The power port is connected to the pump, it is having it is separate passage we are having a pump, and then pump is connected over here. The pump is getting the fluid from the tank and it is just passing to the power port here.

There are four ways as mentioned the pump port P, tank port T and two working ports A and B, these are connected to the actuator. The primary function of the four way valve is the pressurization, it is used to pressurize, it is used to apply the pressurized fluid and it is also used to exhaust the two working ports. When the operation has been done, we can even exhaust the working port we can unload the fluid through working port.

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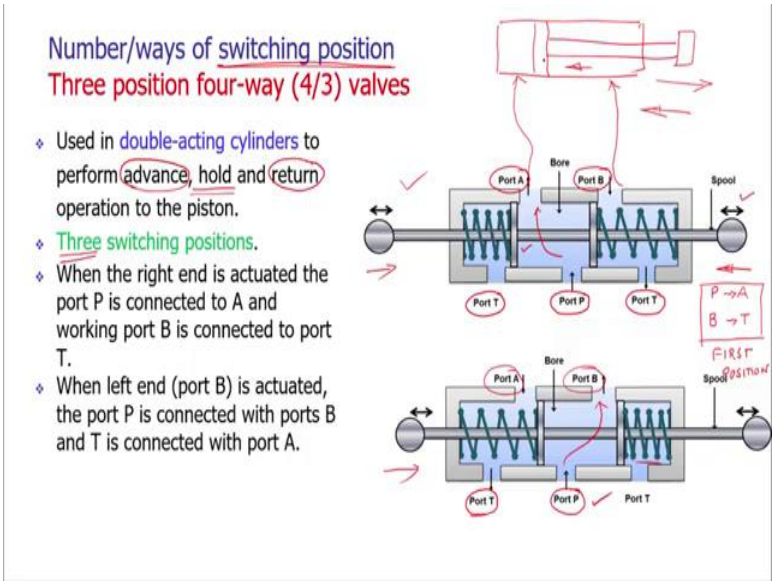


Well in the in the next type of the classification of the valves. We can categorize the valves based upon the number of switching positions. In our previous classification we have seen that number of ports or a number of openings now the number of switching position.

To operate a double acting cylinder, the fundamentally we need to you know carry out the three different applications. The advancement of the actuating cylinder, the return of the actuating cylinder, extension of the actuating cylinder, and the retraction of the actuating cylinder, that is advance and return and holding the cylinder at it is own position.

We need the three different positions of the control valve. The first in first position the control valve will actuate the cylinder to advanced it the typical arrangement is seen on our screen.

Here we can see there are four ports; port A, port B are the application ports; port P is the pump port or the power port and the port T is the tank port or the sump port. This configuration provides us the three position when we apply the force at the right end.

Here we can see the spring related to the spool the spring related to spool near to port A is compressed when the pressure is applied on the spring related to port A. The fluid port P is connected to the application port A. Here the fluid port P is connected to the application port A and the port B is connected to the tank port the P to A and B to T is the first position.

Iif we apply the pressure if you actuate the port B that is the left hand, if we apply the pressure over here. What will happen? When we are applying pressure at the left end the spring related to the spool near to port B is compressed.

Now, the port A is connected to the port T and the power port or the pump port is connected to the B. So, the pressurized fluid is moving at port B; the port B may be connected anywhere or at any side of the cylinder. Let us consider if we are having the cylinder here, the actuating cylinder which is having a piston and we can have the connections.

If this portion is connected over here and this portion is connected over. Now for now, first position when the pressurized fluid is pumped through port A, there would be extension and for the next position B, there would be retraction the B is connected over here to the power port. The pressurized fluid is applied and it is moving in the direction from right to left that is retraction or the contraction of the cylinder.

In between also we can achieve the position, that position is the holding position. That third position is applied when we are not connecting the power port with port A or port B. Iit may be situation that port B is connected to the tank port itself and port A and port B are blocked.

They are not connected to port P or they are not connected to port T, whatever the fluid inside the actuator actuating cylinder that will be there itself, or we can have a situation where the port A and port B are connected to the tank port itself.

Whatever the fluid which is there it is a relieving basically so, we are getting the pressurized fluid from both the sides of the piston and that that is going to the tank port. Based on the requirement we can have the different configuration for the third positions. Wwe will see some of the configurations in our next slide.

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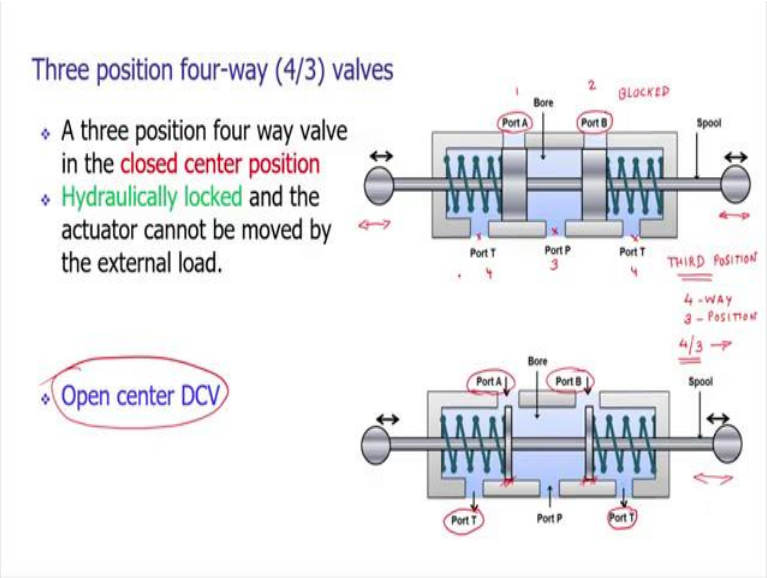


We have seen the two positions in our previous slide; the third position can be the closed center position or the open center position. In closed center position the actuator is locked. It is hydraulically locked the actuator cannot move by the external load.

To make it lock, we can see the arrangement how can we lock the cylinder? We are not moving the spool the spool is met to stand at this particular location, where the port A is blocked, port B is also blocked. They are not connected to the power port and even they are not connected to the tank port.

This situation is called as the third position. The valve is having 4 ports 1, 2, 3 and 4. It is a 4 way, but number of positions are 3, 3 position. This is called as 4 by 3, there are 3 position that to be operated by the 4 ports, that is the 4 by 3 valve, while somebody will say that I want to have a open center DC. Open center DC valve can be made by using this arrangement see here you can see.

Instead of having a very broad spool, we can have a thin spool and that thin spool can be utilized to connect the port A to tank port, and port B to the tank port during the unloading operation or due to during the relieving operation. By moving this spool we can operate the port A and port B, but at it is middle position at it is third position, we can directly connect port A and port B to the tank to relieve the pressure of the system.

These kind of valves are called as the open center direction control valves. There is a fundamental drawback or fundamental problem in the closed center position valve. The closed center position valve is not allowing the pressurized fluid that to pass through port A and port B, but the pump is continuously flowing in the pressurized fluid inside the system.

And due to the application of the continuous flow inside the system, the temperature of the system is getting increased. There is no utilization of the pressurized fluid, due to the putting up the energy inside system that will be converted into the thermal energy. The temperature may increase and that may lead to the failure of the system.

To avoid this we need to have a certain arrangement. In that arrangement the port P can be connected to the port T, so that we can produce the pressure, we can produce the thermal energy which is generated inside the system.

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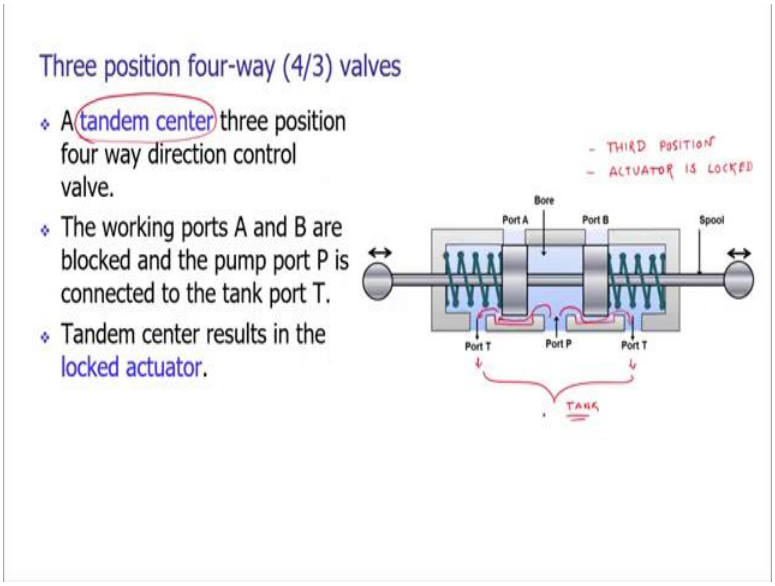


That particular arrangement is called as the third position with tandem center. Here we can see third position in tandem center. How we can achieve this? The valve is the third position, it is at third position, the actuator is locked is hydraulically locked and we need to protect the valve or the system against the building of the heat energy, the heating up the system.

Here we can see we are providing the grooves or the ports; we are providing grooves inside the system. When the third position is there, the fluid from the port P will be pass through this spaces and they will get back to the tank. During this third position, we can easily protect the

entire system from the unnecessarily heating up of the system due to the continuous pumping of energy from the pump.

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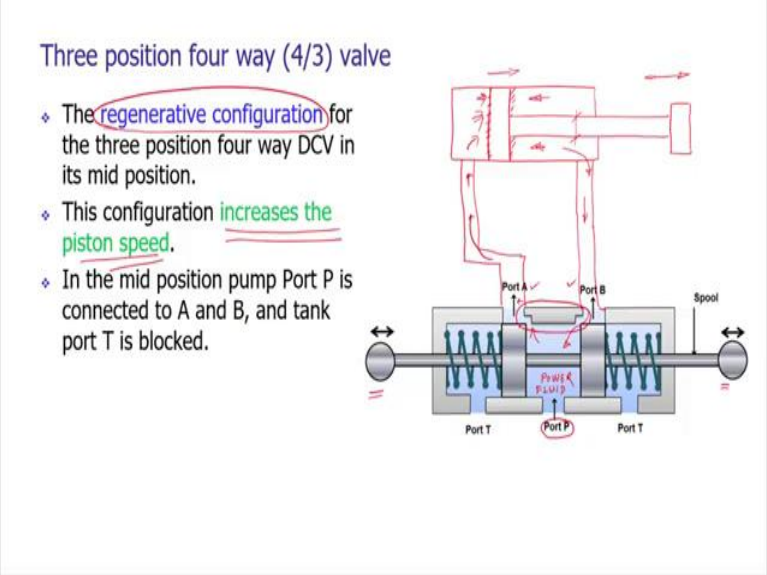


In certain cases, we are using a regenerative configuration as well. Consider we are having a piston cylinder arrangement this is piston cylinder arrangement that we do have and here it is connected to certain rod.

Now, the top center of the piston is connected to the port A and the bottom center is connected to port B. During the application of the hydraulic energy in activation of the cylinders, we have seen that we are applying the pressure as should on one side of the piston and then there is the movement of the piston inside the actuator cylinder.

We are all also applying the pressurized fluid on the other side of the cylinder and then there is the retraction of the cylinder are as well. Now, let us consider the port P is connected to the port A and port B simultaneously.

What will happen in this case, that the high pressure fluid is applied on both the side was on this side and on this side as well. As the area is more as the application area is more, the high pressure fluid will move on the on this side and it will apply the pressurized fluid on the top side of the piston.

The pressurized fluid is also there on the other side, but the area of application is less, due to some area has been consumed by the rod cross sectional area. The application area is less, due

to the less application area we are getting the pressurized fluid back from this portion to the port P itself.

The fluid which is there on the other side is coming back, it is returning back through port B and it is getting mixed at the power port itself. And, that is adding the pressure to the pressurized fluid coming from the pump.

These additional pressurized fluid is again pumping in this direction, that is increasing the pressure and due to in the increasing the pressure, we can further utilize it to increase the velocity. Thus the pressure which is generated on the rod side can be utilized to apply more pressure on the piston side. The energy which otherwise will get wasted, that energy will be getting down to the tank itself, can be utilized to apply more energy.

We can regenerate the energy; we can save the energy and that extra energy that we apply, that will certainly increase the speed. These kind of configuration is called as the regenerative configuration.

In the regenerative configuration we can have a typical arrangement which you can see here; this typical arrangement is providing us the facility, when the spool is in this position. It is helping to increase the speed of actuation, by getting the pressurized fluid from the piston rod side of the actuating cylinder and that is adding to the already pressurized fluid and that is increasing the speed of the piston.

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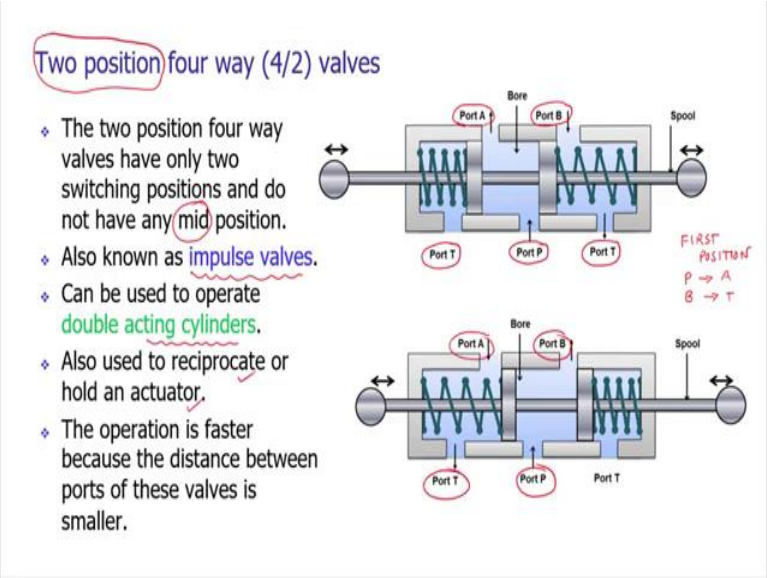

Well in the next type of configuration we are using two positions. Instead of having three position, in certain applications we need to have the two positions as well, the two position four way valve that is four by two valve can be seen on our screen.

It is having port A application port A, application port B, power port or pump port, then the tank port. Four ports are there and it is having two positions, see it will not have the mid position. Generally these kind of valves are called as the impulse valves, impulse application is here they can be used to operate the double acting cylinders.

Basically, they are used to have the reciprocation motion or the holding position of an actuator. The operation by using the two position four way valve is faster, because the distance between the ports of this valve is smaller.

At one position as you can see, in the first position the pump port P is connected to the application port A and the B is connected to the tank port. When we actuate the actuator by using the valve, when we actuate the cylinder then port P will be connected to port B, and the pressurized fluid from port A will taken back to the tank port T.

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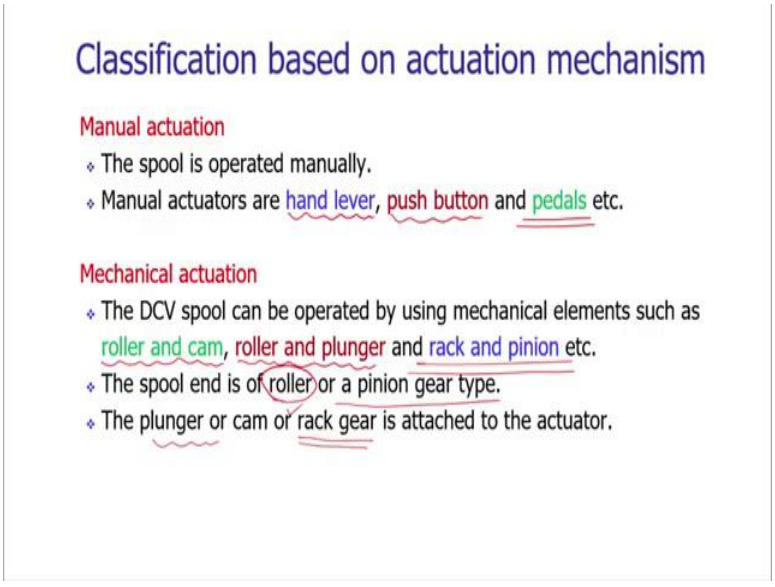


The next classification or the next groups of valves are based on their actuation mechanism. We can manually actuate the valves by using the hand lever, or by using push button, or by operating the valves using the pedals.

Mechanical actuation can also be done. To actuate the valves we are using the roller and cam mechanism, in our previous weeks we have already seen that, the roller and cam can be utilized for the actuation purpose, then roller and plunger arrangement.

Now, instead of having a cam arrangement we can have the plunger arrangement also, rack and pinion mechanisms can be incorporated to operate these valves. In the typical mechanical actuations, we can have the spool end is of roller or the pinion gear type. To this pinion gear type we are attaching the rack gear and the rack gear is actuating the pinion gear and in this way we are actuating the various valves.

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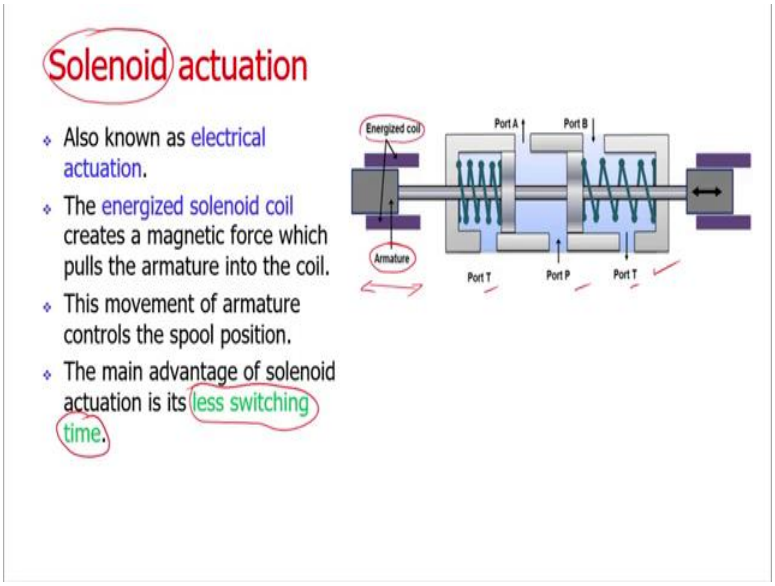


The next important group of the actuation mechanism based valve is the solenoid actuation mechanism based valve. This is an important element in the hydraulics basically the control valves are being operated by using the electrical energy. Typical arrangement of this solenoid based actuation can be seen on your screen.

We are having a valve, the valve is having it is routine ports port A B pump port P and the T. The spool of the valve is connected to solenoid actuation system. And, the solenoid actuation system is having an armature and this armature is placed inside an energized coil.

We are applying the electrical energy to the coil the coil is generating electromagnetic force and that electromagnetic force is operating the armature. The movement of the armature is

based upon the formation of electromagnetic force, the main advantage of the solenoid actuation is the switching time is less.

In mechanical actuation or in the manual actuation the switching time is little long. In the electrical actuation we have to just give the electrical pulse, electrical energy pulse to the or to the actuation system, it is immediately actuating the valves.

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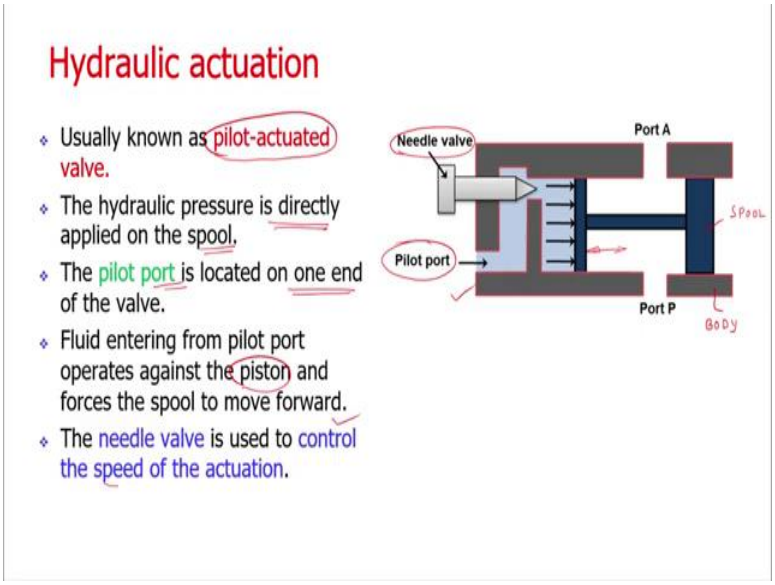


We can also have the hydraulic actuation; it is called as the pilot actuated valve. In hydraulic actuation we are applying the hydraulic energy to operate the valve. The typical arrangement can be seen on our screen. We are having a body of the valve here and inside the body of the valve, here is the internal spaces in this internal spaces we are having the spool, the spool is having an area over which we are applying external pressurized hydraulic fluid.

The external pressurized hydraulic fluid is applying the pressure on the spool and that is displacing the spool from it is the original position, it is operating the spool. The flow control of the pressurized fluid through the pilot port is controlled by a needle valve.

Already, we have seen that the screw based needle valve can be utilized to control the flow of the fluid inside the system. These kind of actuations are called as the hydraulic actuation based valves or the pilot port based valves.

The hydraulic pressure is directly applied on the spool and the pilot port is located on you know one side of the valve. It is on one side the pilot port is applied. The fluid is entering from the

pilot port and that is operating against the piston and that is forcing this spool to move in the forward direction. As mentioned the needle valve is used to control the speed of the actuation.

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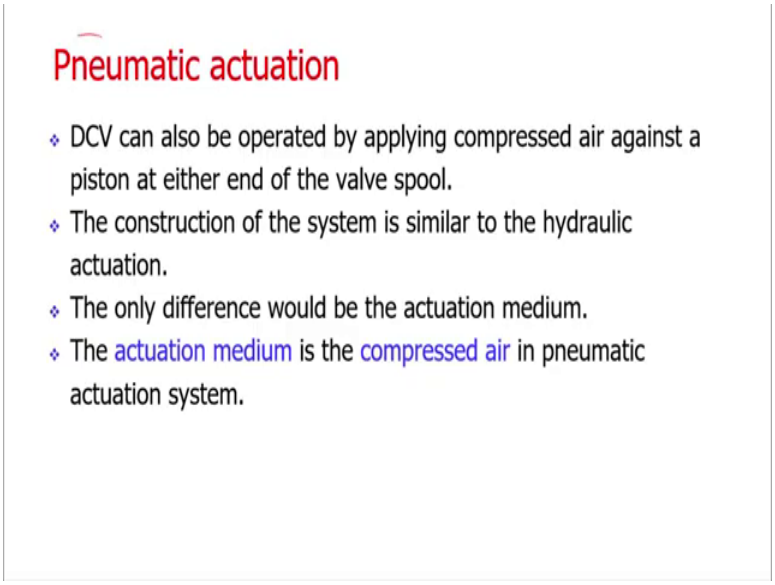


We can use pneumatic energy as well, we can use the compressed air to actuate the directional control valves by using the compressed air against the piston. Instead of having the pressurized fluid we can have the compressed air, at the piston to move the piston in particular direction. The construction of the system is similar to the hydraulic actuation system itself. We are having the similar type of construction. Instead of having a hydraulic fluid here we are using the compressed air.

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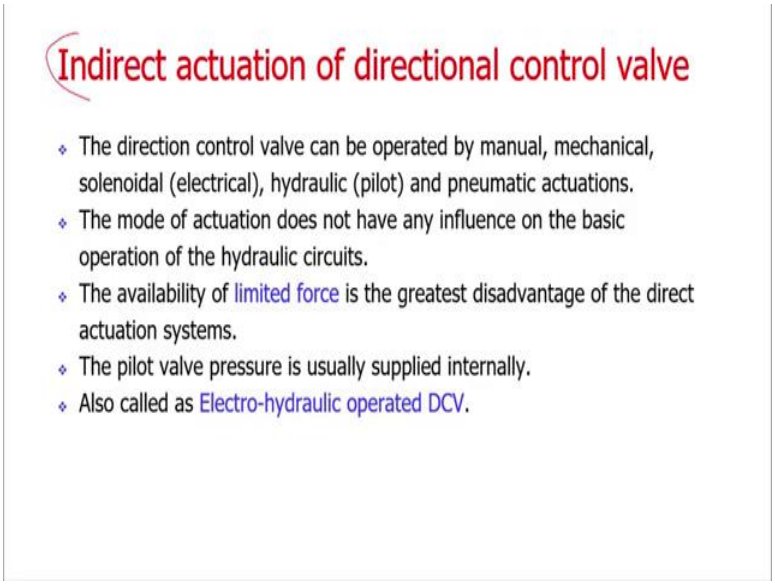


Well the next is the indirect actuation of the DCV. We have seen that manual operation mechanical operation or hydraulic or pneumatic actuation, but all they are having a limited force capability. If we consider a directional control valve for the distribution of water, the distribution of water in the very large size of the pipes. Let us consider we are using the directional control valves in a hydro power project.

There very huge valves are employed and to operate the valves we need a lot of energy. In this particular case we cannot have the direct application of the energy or we cannot have the direct actuation: may be manual or the mechanical.

To operate such a huge valves we are using another valve, we are using a supplementary valve to operate this directional control valve. And, this the extra valve which is operating the directional control valve is working based upon the electrical energy itself. These are called as the electro hydraulic operated DCVs.

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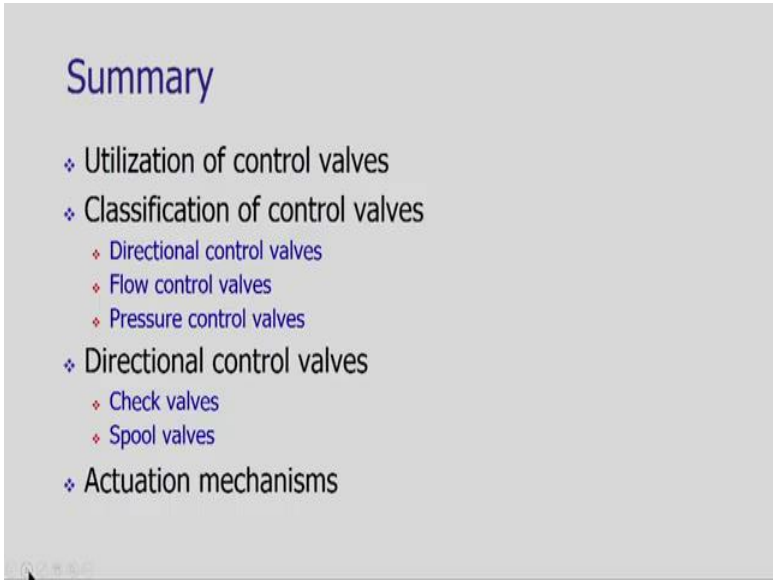


Well my friend, well my friends let me summarize the lecture 1. In this lecture we have seen the utilization of control valves what are the applications of the control valves, construction and the working details of various control valves such as the check valves and spool valves.

In addition to the directional control valves flow control valves and pressure control valves are also to be are discussed, that we are seeing in the next lecture that is lecture 2. In this lecture we also seen the actuation mechanisms, for a typical directional control valve.

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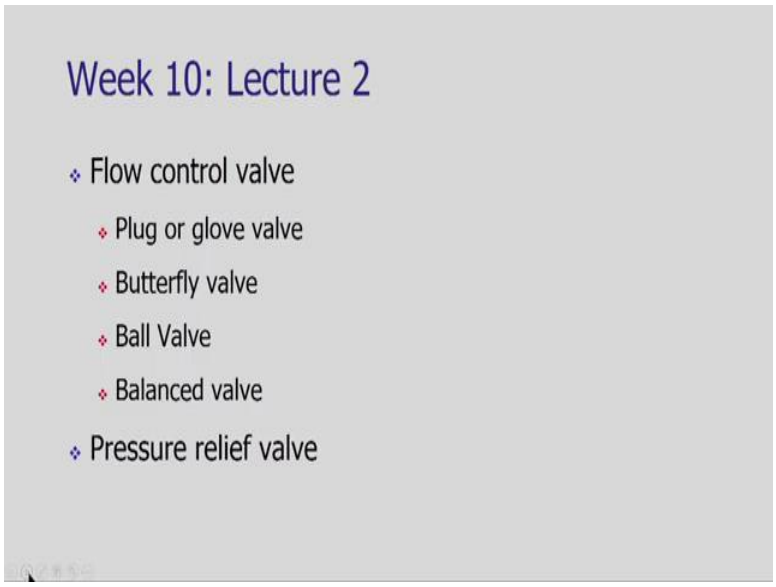

In the next lecture, that is lecture 2 we will study the flow control valve and pressure relief valve. There are various types of flow control valves are used in the industry and these are plug or a glow valves, butterfly valve, ball valve, and balanced valve.

Then, thank you and let us meet in the lecture 2.