

**INDIAN INSTITUTE OF TECHNOLOGY  
KHARAGPUR**

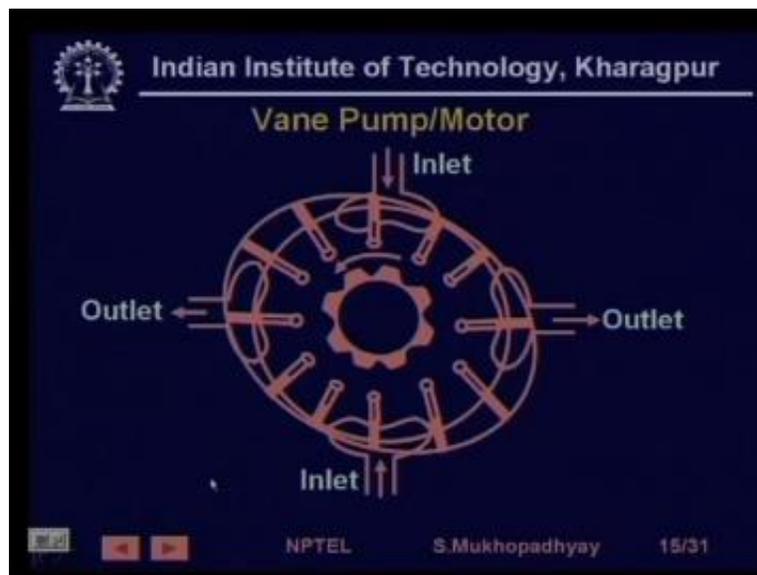
**NPTEL  
ONLINE CERTIFICATION COURSE**

**On Industrial Automation and  
Control**

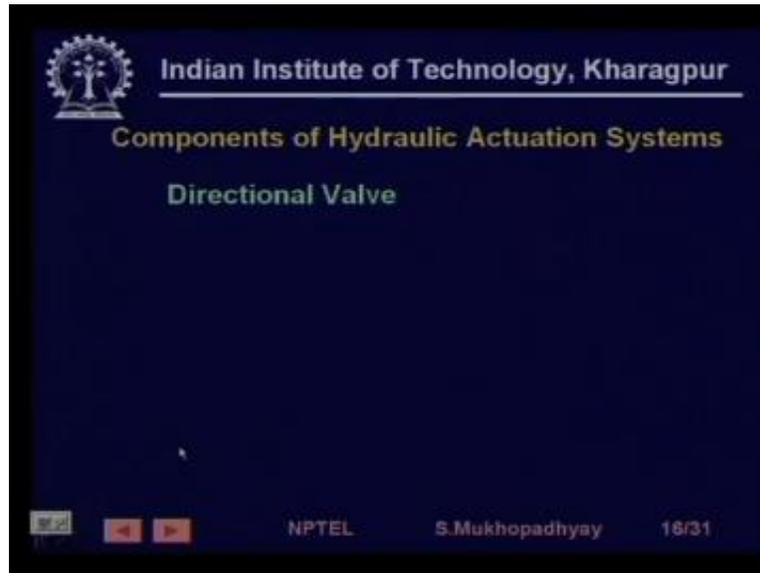
**By Prof. S. Mukhopadhyay  
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**Topic Lecture – 35  
Hydraulic Control Systems – I  
(Contd.)**

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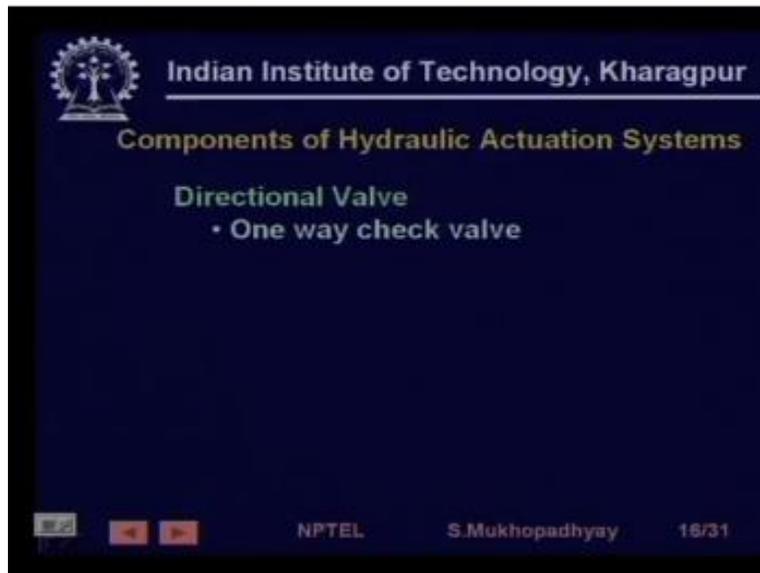


So having seen these three kinds of pumps we would take a look at now we will take a look at now this we have seen that how the fluid is pressurized and pressurized will be generated, we have also seen the motor which where the pressurized fluid can be can create a rotational motion we will see another kind of actuator when it creates linear motion. We basically need this these two kind of things.

Sometimes we can transfer I mean we can convert rotational motion into linear motion using, you know things like lead screws. But we can also create direct linear motion using what are known as cylinders. Now in between these two that is where the between the pump and the actuator which can be a motor or which can be a cylinder the fluid has to pass and there are, it has to pass in various ways, pressure has to be controlled.

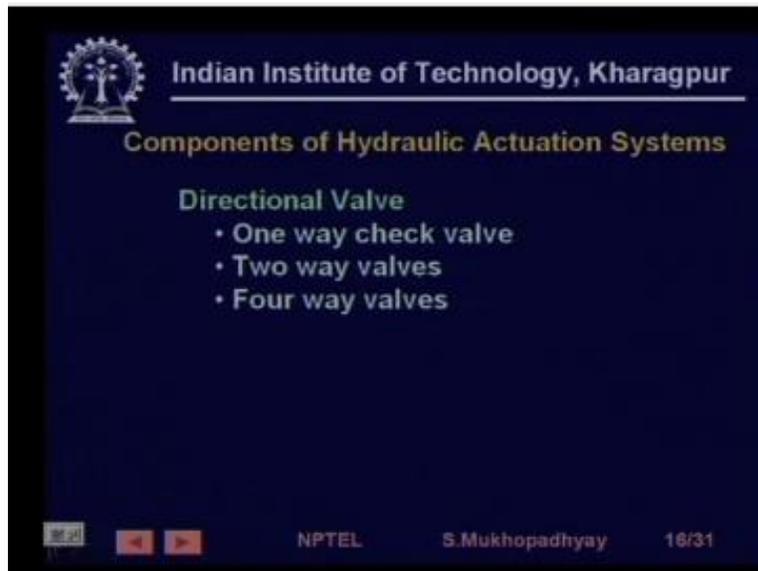
So various types of components have to be put in it, in the path of its journey from the pump to the actuator. So we need various kinds of typically we need various kinds of valves for this and one of the major category of valves is are called directional valves.

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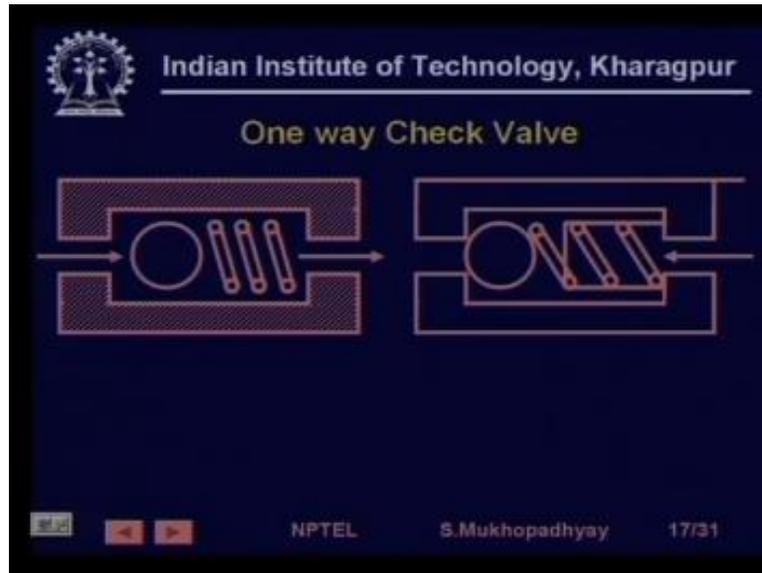
Whose job it is to control the direction of the flow so which way it will move, will it move from the that is the flow direction because the flow direction is very much related to the direction of motion. Now we want to create motion in various ways sometimes we want to create back and forth motion. So if you want to create back and forth motion then we have to continuously change the direction of flow automatically. So for using doing these valves are required.

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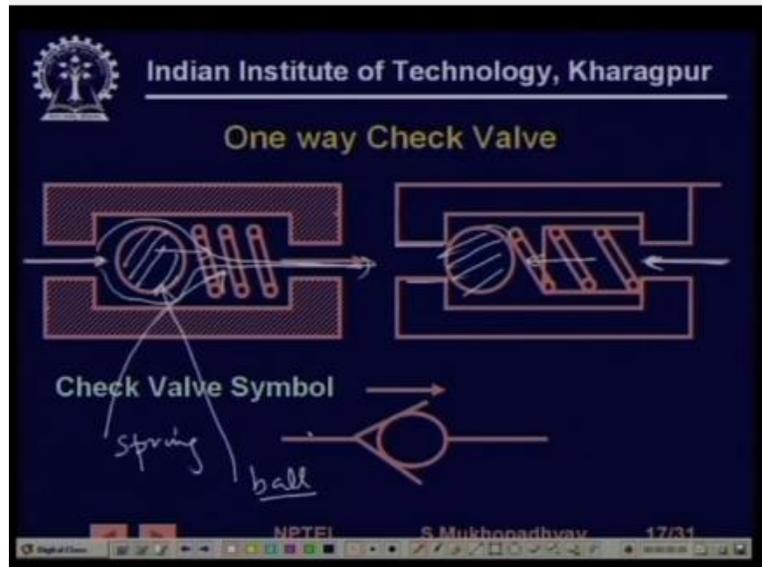
So we have various kinds of directional valves we are going to look at these three, so the first one is a one way check valve, the second one is the two way valve, and the third one is called a four way valve.

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So first the check valve, so the check valve what does it do, it will allow flow in one direction but not the other direction, and it is, so you see how it works very simple this is one of the construction there are various kinds of check valves in fact, the mechanical design of hydraulic systems are very complicated, they require very precision manufacturing and so there are various constructions possible but we are going to see mainly schematics, so this is one schematic where we use a ball type check valve, we can also use a puppet type check valve various kinds.

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So here what is happening is that this is a spring and this is a ball this is actually a ball solid ball may be balls so what is happening is that if you if the flow is in this direction then the ball will be pushed along the spring and it will be the water the fluid will flow through this like this through the spring but when it will be when the flow will be in this direction then the ball will be pushed in this direction and it will come and settle and close this port this port so fluid cannot flow from this direction to this way while it can flow freely through this. So this is a symbol which shows that the flow direction is this and this way it cannot pass.

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Having seen one way check for sometimes we need valves you know we will demonstrate a case of pilot operated valves because sometimes we also want that in the normal condition it flow will be in this direction but under certain special conditions the flow can be made in the reverse direction also so how do we ensure that so sometimes we because remember that these all this hydraulic equipment can actually be quite far away from the operators where the operatives working. They can be you know near the machine etc...

So there are needs by which the operator from a from a relatively remote action it can operate you can change the mode of working of the valve so for this reason pilot operated valves are used where by applying an external pressure possibly from a remote source one can change the mode of operation of the valve so let us give an example so here you have a valve you can see that the this is the port and this is a this is a my you know the member which controls the flow this is a spring and this is a cylinder which separates these two this is my pilot port and this is a drain port.

You know in these valves remember that suppose the pump is trying to deliver fluid through a load and the load is moving now suppose suddenly the load gets mechanically jammed then what

is going to happen the pump is trying to drive fluid and the load is not moving so the fluid will immediately tend to get pressurized because you see because it is incompressible very high pressure will generate and these very high pressures can actually be very detrimental they can open, they can damage seals, fittings they can create explosions etc, so therefore pressure has also always to be in all this equipment if the pressure suddenly tends to be very high.

Because it is incompressible so the pressure can very quickly rise to high values sometimes if there is I mean, so therefore there are always mechanisms such that such pressures can be released.

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So here is a so there this is the that mechanism brain, so now what is happening is that initially so this is also a little part and this is the port this is this is the, okay. So in each normally what is happening is that this spring is pressing so this is so this port is these are actually solid parts is a knot unit this is the hollow part whether the fluid exists, these are solid parts, metallic part. So normally what is happening is that this is the position of the valve.

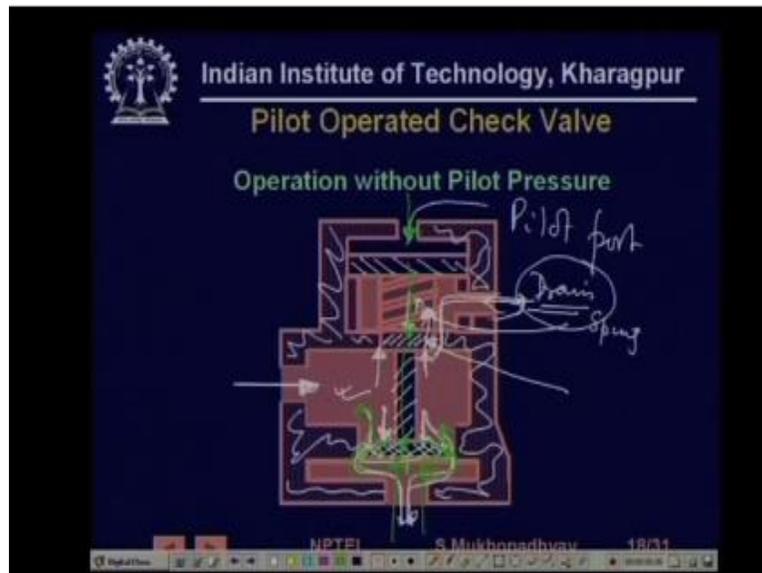
What is that called stem and the so now when the fluid is coming here the fluid is pushing and this will come down if there is a certain amount of pressure, so there will be a certain amount of force on this and this spring force will be overcome and the fluid will flow out through this, this is the normal flow direction on the other hand if the if the pressure becomes too much here then it may happen that the force is also here.

So the force on the so the now because of the spring force so if you see free body diagrams the spring force is here and the pressure forces are here also on these. So now if sometimes it may happen that the pressure here may move the spring up in which case this will be this will open this will suppose the fluid may pass out from in this way through the drain in other cases now suppose you apply up suppose we apply a pilot pressure.

Then what will happen, now that will come later so we can see that if we apply fluid flow here the fluid will freely pass on in this direction now what happens but it cannot pass in the other direction why it cannot pass in the other direction because if let me let me change the color to mark the other direction, so if the if the fluid now charged tries to enter this port here then this is going to get pressed.

And this will close this will close so fluid cannot pass in this direction that is why it is a check valve, on the other hand you see in certain conditions we want that under certain we want to convert this valve from we also want reverse flow so in that case we can apply pilot pressure here.

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If you apply pilot pressure than this whole thing by pilot pressure will come down so the so this thing now that that I think we have a diagram you have a separate diagram for the pilot pressures.

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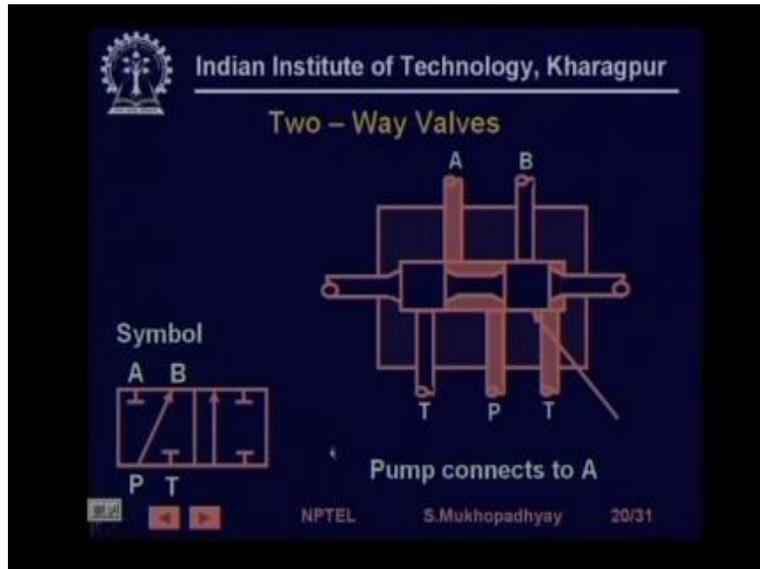
So we will show that.

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So when we have pilot pressure then this is the pilot port so you have pressure so this spring will be pressed and this will actually come out at the bottom not like exactly aligned maybe somewhere over here so now the fluid now this opening is opened this these openings are open so the fluid will pass and can flow through these they can also fill opens they can also get drained okay so you see so this is a typical pilot operated check valve similarly.

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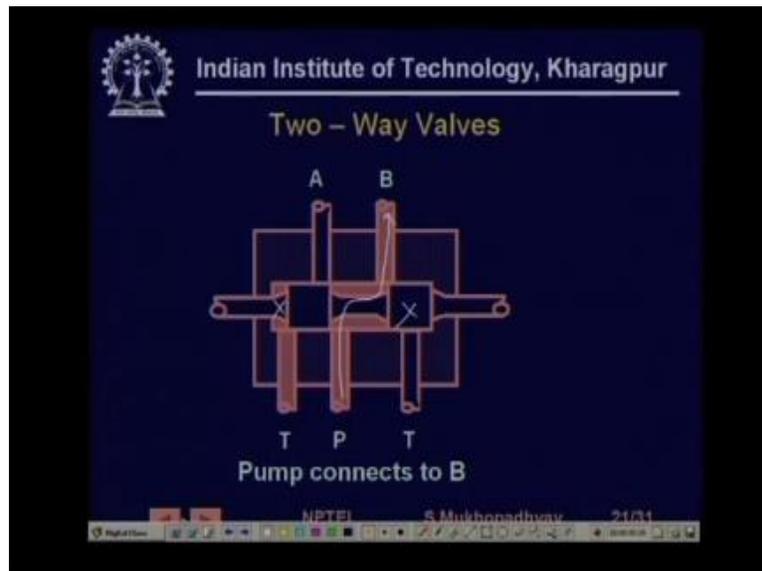


There are situations where we need to change flow directions so typically we have to use two-way valves and four-way valves and we must see so these are this T means tank this P means pump and this A and B at the load ports load or system ports so now you see that this valve has two positions okay so if in this position you see that the pump is actually connected to the port A how it is going to come back to the tank is not through this but through some other path which is not shown so you see that we draw it there are two positions.

So we draw it by two boxes sometimes you may have three boxes in which there is a central position neutral on one side we have pump and tank on another side we have the load ports and this arrow indicates that in which in each of these positions which port is connected to which port so in this position pump is connected to be in the in this particular position actually this should have been a if you correspond to this and this should have been actually so this means that this diagram actually corresponds to this particular box.

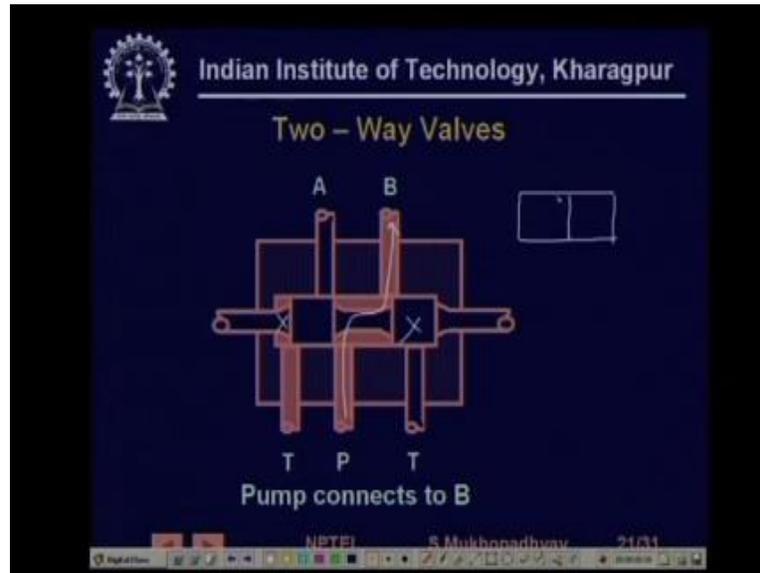
Where this is P this is A and this is tank is sealed so the tank is sealed and B is also sealed so these are sealed as you can see on the other hand.

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In the next position see just the reverse so that is now it is in the right position so in the right position pump is connected to B and A and tank are sealed so you have the other box of the diagram so you see that a particular what I what have we achieved that by moving the spool just by moving the spool of the valve you can connect either port A to pump or port BTW this is what you have achieved and how do you move the spool there are a variety of ways to move the spool so for example.

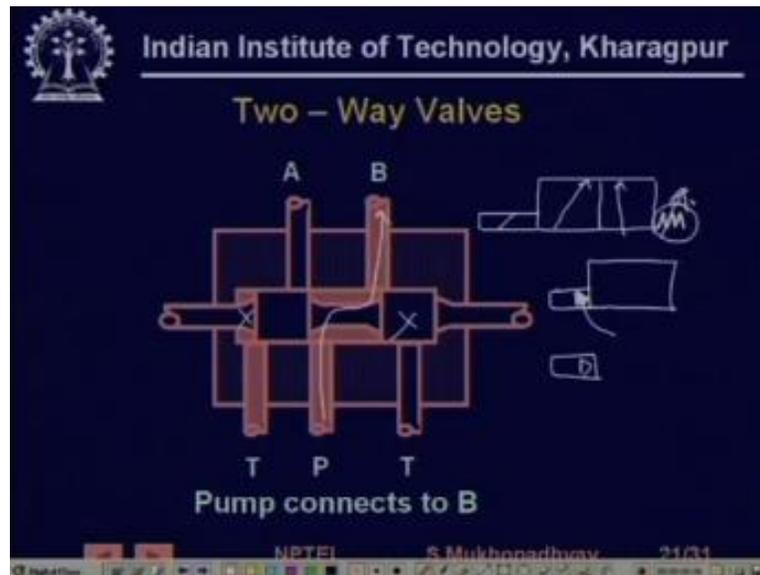
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The spool may be moved sometimes you know when we draw the symbol suppose we draw this symbol then how do we move the spool we may be moving the spool by a solenoid, okay. So we moving if we write like this a solenoid symbol, sometimes we may be using if there are if these valves are big it requires force to move the spool, so the spool maybe moved by either so this triangle means they are moved by hydraulics and pneumatics if this is filled up this is a hydraulically moved spool.

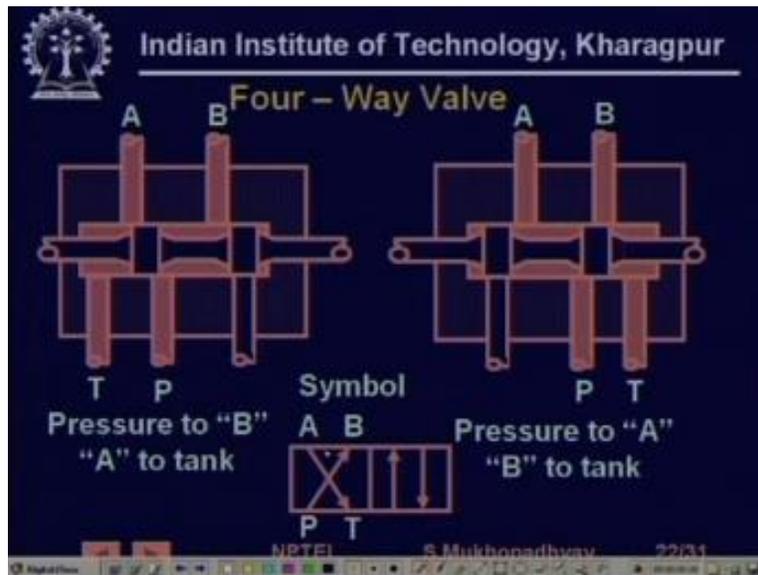
So the sometimes this direction valves can be very large and to move the spool itself you need another hydraulic force so this is the hydraulically moves spool triangle field.

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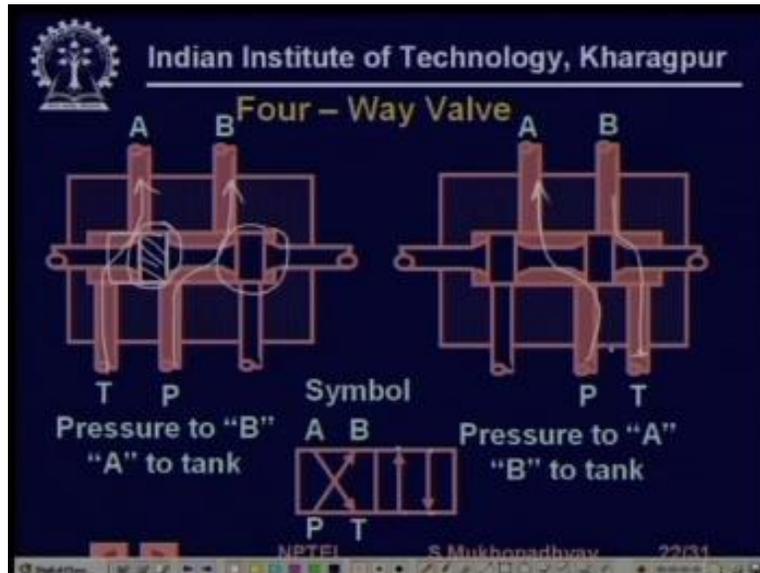
If the triangle is hollow then it is a pneumatically field, pneumatically operated valve sometimes so these are very typical situation sometimes we may have an, we may have this means that there is a spring so you only need to pull it in this direction then return is by spring. Sometimes we may have an adjustable spring so there are all kinds of spool moving actuation mechanism are there with this valve. You may also like to remove it mechanically just by hand or by pushing something drawn pulling a lever.

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So coming to, then we come to four way valves, so in four way valves it is exactly similar only thing is that now in each position both A and B are connected to pump and tank so in this position pump is connected to B tank is connected to A.

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While in this position pump is connected to A and tank is connected to B is connected to tank, so how, so you see that now by construction this is exactly similar so the same valve is becoming two way or four way basically depending on the geometry then how why it is this, is the same type of figure only thing is that previously we had this one has very wide.

So therefore A was sealed, now we have this one as a narrow one, so in this position pump is connected to B and tank is connected to A. While on the if you move it to the left then pump is connected to A and tank is connected to B, so this is a four-way valve.

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Components of Hydraulic Systems

Pressure Relief Valve

- Locally operated adjustable spring loaded
- Pilot operated

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Now as I said that you in many cases you need to control the pressure or the flow through the valve sometimes you know velocity has to be controlled if you are moving a very high load sometimes want that it moves that only at a certain speed, so for that you have to do flow control. If you want to and pressure control is very much needed so we have the other kinds of valves which are called pressure relief valves and flow control valves so we will look at some of them.

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**Components of Hydraulic Systems**

**Pressure Relief Valve**

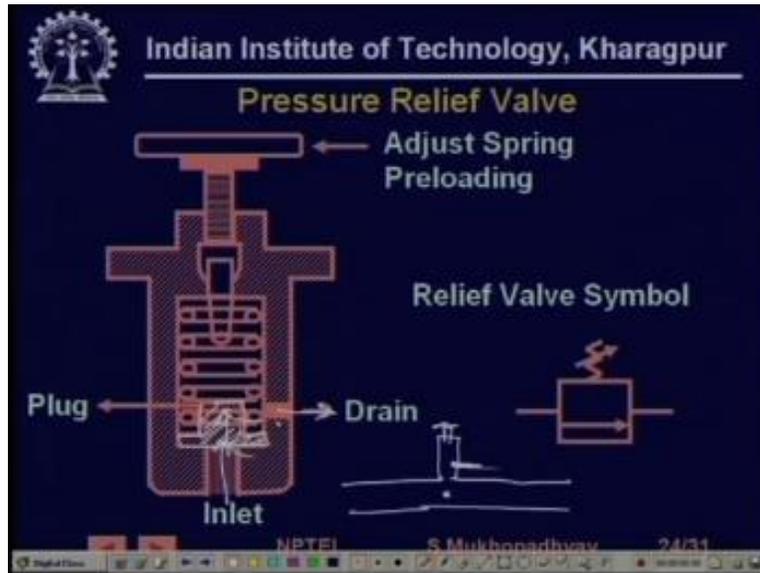
- Locally operated adjustable spring loaded
- Pilot operated

**Flow Control Valve**

- Restrictor type
- Bypass Type

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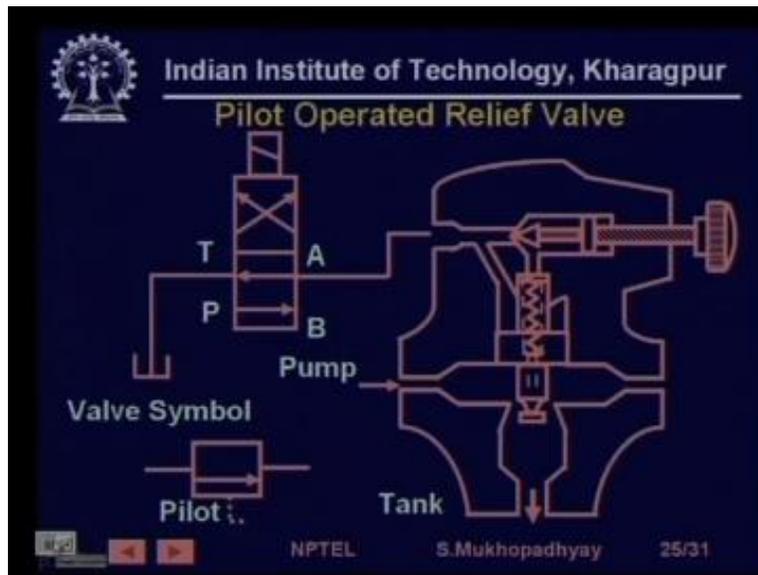
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So this is a simple pressure release valve so you see that this is the inlet, this is the inlet so very simple this is the drain, right. So actually this valve can be connected across a pipeline if you connected across a pipeline this is your drain. So if the pressure here increases too much then this particular poppet, this will push up and therefore the fluid will pass through the drain. So since the drain is at a low pressure immediately pressure will fall. So high pressure cannot be created.

And at what pressure this poppet will start moving and will open the line to the drain that depends on the spring and this and this pressure can be adjusted by tightening this screw. So if you tighten the screw the spring can be pre-loaded to a value and then at that adjustable, adjusted value if the pressure goes beyond that then the fluid will be connected to drain. So this is shown by the symbol that this is the relief direction and this shows that there is an adjustable spring here. So this is a very simple pressure relief valve.

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Then we have a pilot operated relief valve see, so that is more complex. So here what we are doing is that very, this operation is interesting. So initially what happens is that by this spring action you see here there is actually a small orifice which is not drawn in the diagram the person who drew it missed it. So normally because the fluid pressure here for steady pressure and the fluid pressure here are same.

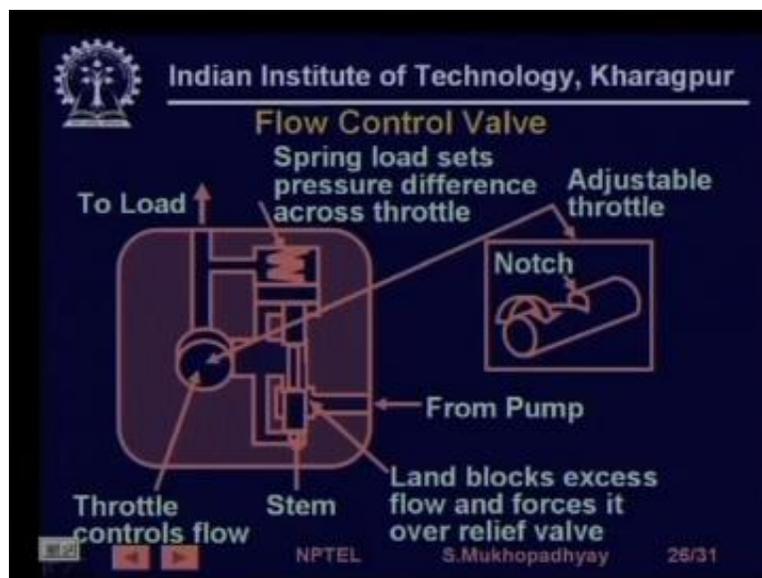
So therefore this is being pressed by this spring and this is actually closed this comes and sits on this. So the fluid is passing like this, now if there is a sudden suddenly pressurizes then what will happen is that because this is narrow orifice so the pressure here and here will not be same. So suddenly if the pressure rises is high here this will be pushed up by that force and naturally this opening will be opened and fluid will drain to tank, this is tank.

So therefore, sudden pressure rises can be controlled, second thing is that if there is now the pressure suppose the pressure rises slowly then that phenomenon will not occur, but then at a certain value suppose this phase sealed for example in this position it is connected to tank, but in this position suppose this is a, this valve is in this position therefore, this is connected to the pump, this is the pump put.

So therefore, when leave in this position this then this connected to some pressure point. So suppose we, or we might have sealed it so then what happens is that as this pressure rises this pressure will also keep rising and they will balance each other at a certain point of time the pressure here will be too much for this needle valve to resist. So the needle valve will open, and then the fluid this is actually a hollow see the dotted lines so there is a hollow opening through this.

So then this fluid will flow through this, through this, and we will go out to the time. So even steady very high pressures cannot be sustained.

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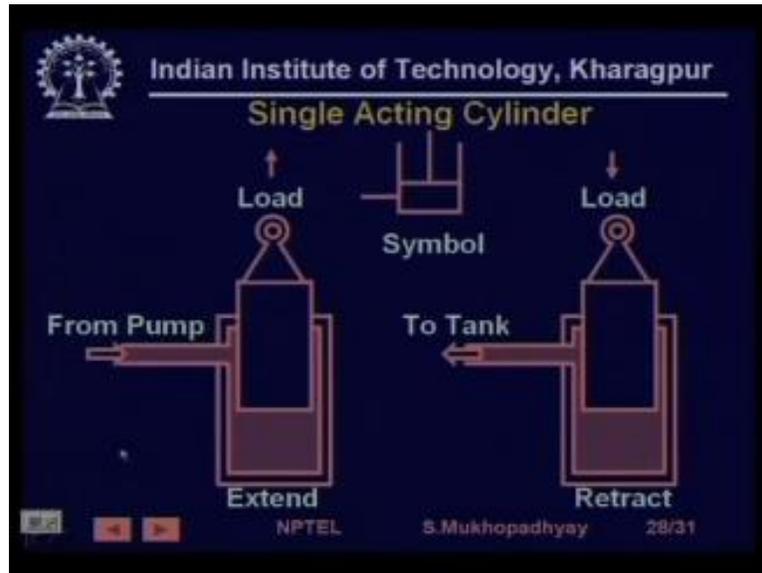
So lastly we have a flow control valve now what is happening here is that here we want to we want to control flow, so you see okay, what we will do is we are actually running out of time. So we will consider the flow control valve in the next lecture. So in the next lesson we will actually begin with the flow control valve, so I will skip this for the time being.

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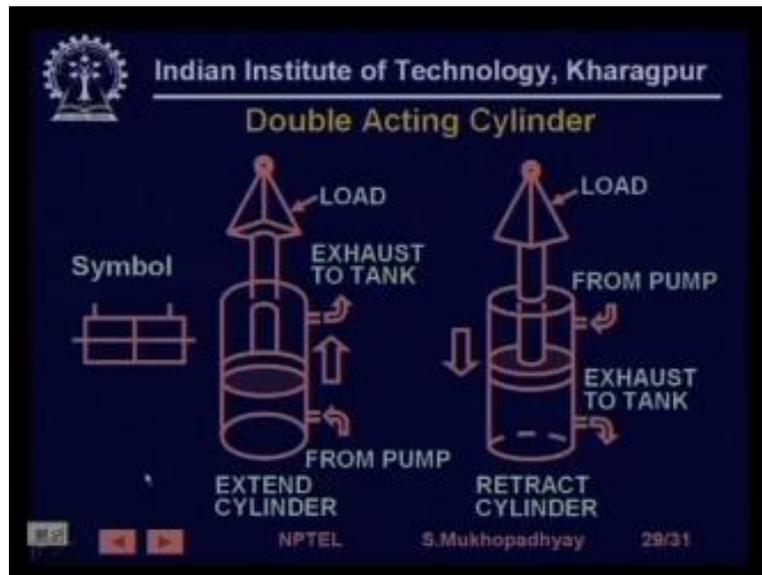
This is cylinder.

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So we can talk about the cylinder later.

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So this is this from the last three four slides.

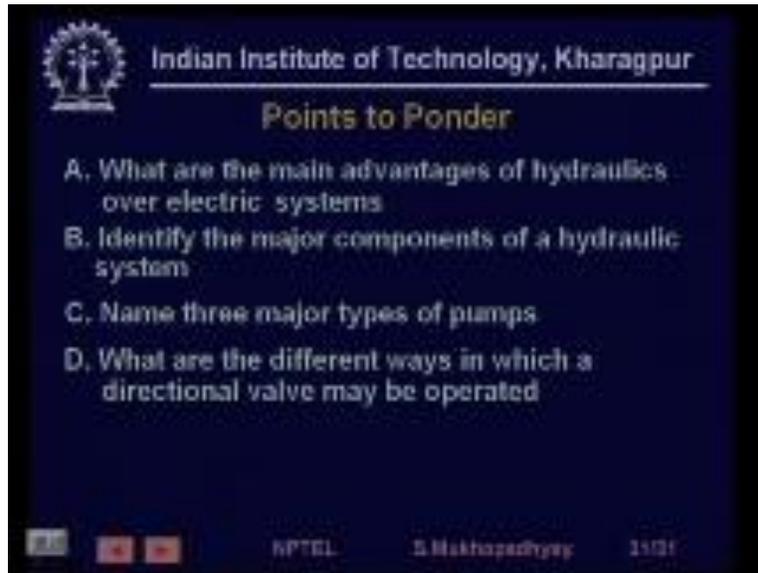
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We will take up in the next lecture so not now let us come to the lesson review. So what have you done today? So we have, today we have seen the basic hydraulic system principles that some pressures, pressured fluid is created using a pump and that fluid flows through the that pressure is transmitted by taking the fluid through lines and is applied on the load to create various kinds of motion and we see that it is it is possible to amplify force but at the same time energy is conserved so therefore the velocity that we are we can create gets limited by the flow rate that can be delivered by the pump at that pressure.

We have also seen that for making an effective system we need to have various kinds of components we need the fluid we need the lines we need the ceilings we of course we need pumps and the actuators the motor we also need to control the floors flow of the fluid we need various kinds of valves and among the valves there are some valves which control the direction of flow and there are some valves which control the pressure and the flow. So we will continue with this we have seen pumps and motors and we have seen part of the Valve's some bits are left and finally we will see the cylinders in the next lecture.

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**Points to Ponder**

- A. What are the main advantages of hydraulics over electric systems
- B. Identify the major components of a hydraulic system
- C. Name three major types of pumps
- D. What are the different ways in which a directional valve may be operated

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So you may ponder what are the main advantages of hydraulics over electric systems there are some advantages I have already told the major advantage of hydraulic systems is that they can handle much more power at using much more low sizes therefore prime importance and then used in aerospace, we will discuss this in the next lesson we have identify the major components of hydraulic system if you want to build one and three major types of pumps we have discussed it and what are the different ways in which directional valves may be operated. So there are various types of differ directional valves one way to way four way so that is all for today thank you very much we will continue with this in the next lesson.