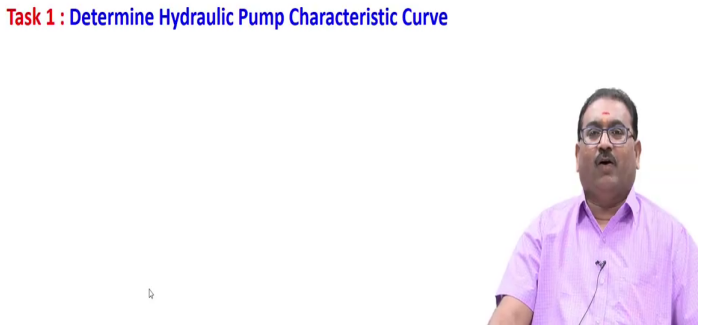
Oil Hydraulics and Pneumatics
Prof. Somashekhar S
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Part 2: Hydraulic pump characteristic curve, Different methods used to control a single-acting cylinder
Lecture - 71
Task Based Selection and Analysis of Oil Hydraulic Circuits

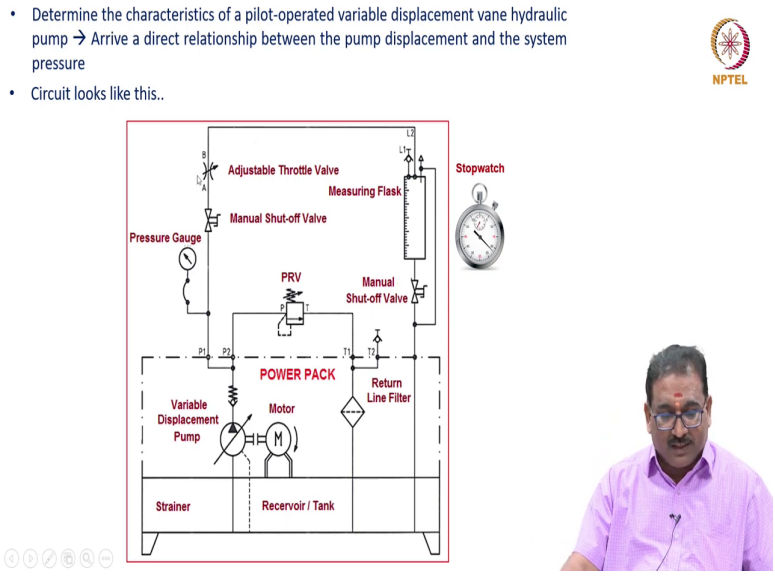
(Refer Slide Time: 00:23)



My name is Somashekhar course faculty for this course. After knowing all aspects to represent the hydraulic circuit for to perform its intended task efficiently and effectively all these details are very very essential. Now, I will show you very quickly analyze the circuits how it looks for the various task.

I will show you based on the task how you will select the component, how to assemble, how the energy will flow from the pump to the actuator, whether it will performs or not properly by actuating the different positions of the direction control valves. Let us we will begin now task 1: Determine Hydraulic Pump Characteristics this is very very important. When you will buy the power pack you have to understand the pump characteristics curve.

(Refer Slide Time: 01:33)



How they are doing determine the characteristics of a pilot operated variable displacement vane hydraulic pump, arrive here a direct relationship between the pump displacement and the system pressure. For this statement the circuit looks like this please identify the components here friends, it is the power pack.

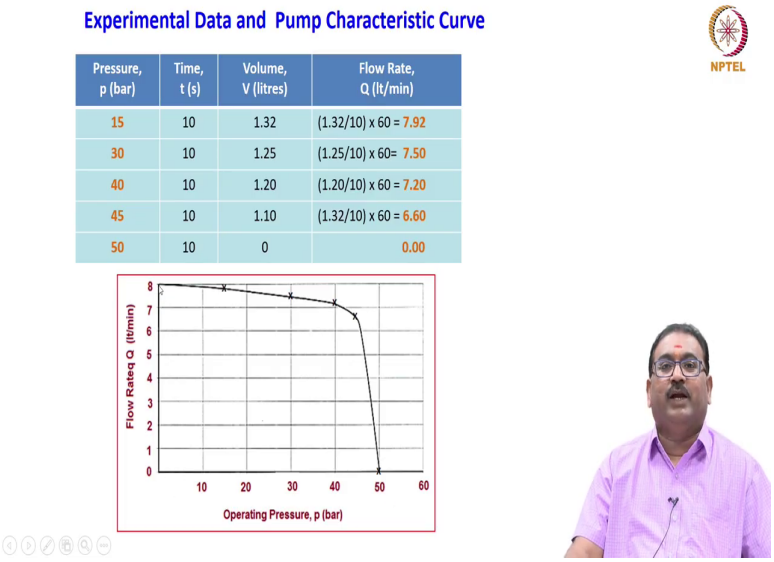
Already we know that power pack contains the variable displacement vane pump it is, drives through the motor pump will sucks the fluid from the receiver and then it will goes to the rest

of the system. Here I am using the various component pressure relief valve to set the maximum pressures in the system and then here the pressure gauge is there to monitor at the outlet of the pump pressure side.

Then here you will see the manual shut off valve open and close, once it is opened flow will goes to the adjustable throttle orifice then it will go to the measuring task. What I am doing in this experiment is I will vary this adjustable throttle, which in turn gives the resistance to the flow.

Then I am measuring the pressure for every time then how much flow is collected I am doing here. For this I am using the stopwatch for the particular amount of time for every resistance what I am setting here I am measuring the flow rate.

(Refer Slide Time: 03:22)



Now, we will see friends, some of the experimental data and pump characteristic curve what we are getting? You will see here the pressures 15, 30, 40, 45, 50 is a maximum pressure I am setting in the pressure relief valve. For every 10 seconds I am noting down the volume of fluid collected in the measuring flask in terms of the liters, then I want to calculate the flow rate.

This is a very important thing flow rate or it will varies with the different pressures correct by this immediately we will see when the maximum pressure is 50 reaches. What happens? Zero flow because flow is passing through the pressure relief valve to the tank. But, you will see here the maximum flow rate for here 7.92, these are the conversion factor 7.5, 7.20, 6.60 then further 50 it will reduces.

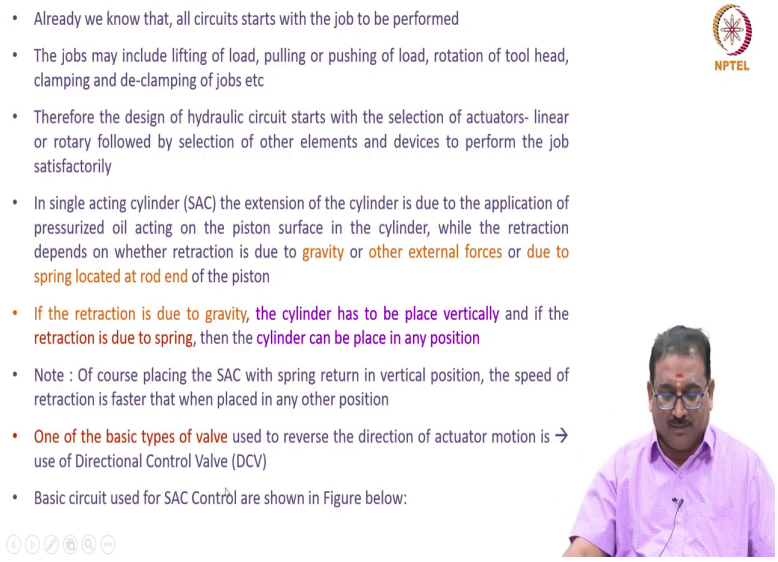
Now, I am drawn the curve here same curve flow rate versus operating pressure same flow rate versus operating pressure. The characteristics curve we will see friends, these are the (Refer Time: 04:33) points are there know, this is the flow rates for the particular operating pressures. I have marked here you draw the smooth curve, then you will see at the lowest pressure the flow rate is very high. As the pressure starts building flow rate reduces, it will be 0 when the pressure setting at the PRV reaches in the system, ok.

(Refer Slide Time: 04:58)

Now, I will show you some other circuits which are very essential to understand when we are operating the different types of actuators. Now, let us we will see the task 2: control of a single acting hydraulic cylinder, single acting hydraulic cylinder, meaning single port is there that is head side or a tail side. But, now I am taking the head side is a input port meaning the pressurized fluid is taken and acting on the complete piston area then it will extend.

Then question arises how to bring back either the gravity or an external load or a spring. If you want to use the gravity or external load you have to mount the cylinder in the vertical position. If you are using the spring bring to bring the piston back, then you have to mount it in any direction generally people are preferring to put it in the horizontal directions.

(Refer Slide Time: 06:19)



Now, I will show you how we will control the direction as well as the velocity of the single acting hydraulic cylinder, various ways are there I will show you different variations here. Already we know that all circuit starts with the job to be performed. Now, I already told you the single acting cylinder I am using to extend and retract, then question arises whether it is a pull load or a push load or many thing vertical load or a horizontal load many things.

The jobs may include lifting of load, pulling or pushing of load or rotation of tool head, clamping or de-clamping of jobs and many.

Therefore the design of hydraulics circuit starts with the selection of actuator, linear or a rotary followed by the selection of other elements and devices to perform the job satisfactorily this is a mandate. In a single acting cylinder I will write SAC the extension of

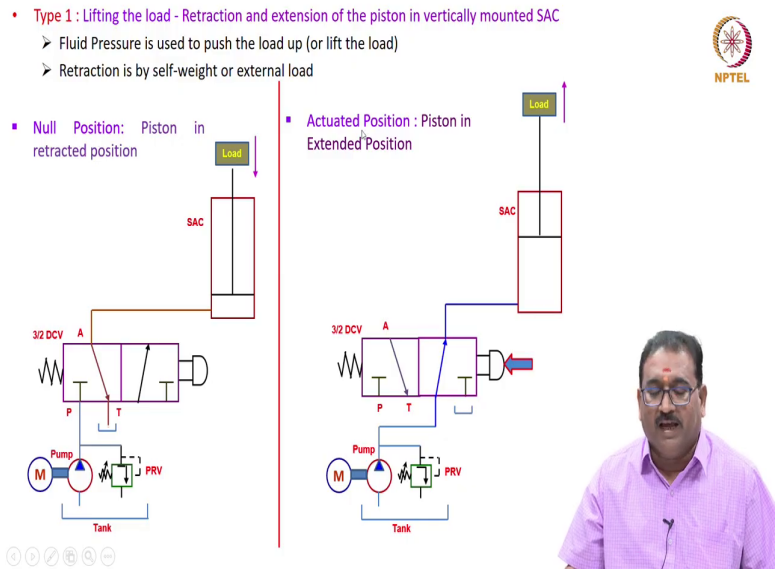
the cylinder is due to the application of pressurized oil acting on the piston surface of the cylinder pi by 4 d p square is an effective area in the extension.

What I am taking down while the retraction depends on whether retraction is due to the gravity or other external forces are due to spring located at the rod end of the piston. Now, let us we will see if the retraction is due to the gravity, the cylinder has to be placed vertically and if the retraction is due to spring then the cylinder can be placed in any positions.

Note: Of course, placing the single acting cylinder with spring return in vertical direction, the speed of the retraction is faster that when placed in any other position. One of the basic types of valves used to reverse the direction of the actuator motion is use of directional control valve. As I have told you extension retraction how we will achieve something is required correct that time I am using the directional control valves.

When we are operating the single acting cylinder directional control valves are different, when you are operating the double acting cylinder directional control valves are different correct friends. So, the basic circuit used for single acting cylinder control meaning the extension retraction is as shown in the figure below.

(Refer Slide Time: 09:00)



Now, here the I am showing you different cases here now. Now I am type 1 is lifting the load retraction and extension of the piston in a vertically mounted single acting cylinder. Here the fluid pressure is used to push the load up I am using the fluid pressure to lift the load, retraction is by self weight of the piston or some external load.

Now, we will see how the circuit looks friends here please remember here the hydraulic power pack this I am using many times common it is meaning I am showing you the minimum elements here. The pump drive through the prime mover and then very important element is pressure relief valve; you have to set the operating pressure here maximum operating system pressure.

Then this is a common you remember tank with this then it is a suitable selection of the directional control valve. Now, I am used the 3 by 2 DCV 3 ports 2 position this position and

this position, where the spring is there already we know that it is a null position. Here in this case the null position pressure port is blocked, correct.

Now, you will see friends, always the null position is 1 while drawing the circuit you have to remember this null position the actuator in the retracted position always you have to draw not write in the extended position in the null position. Now, we will see here piston in the retracted position.

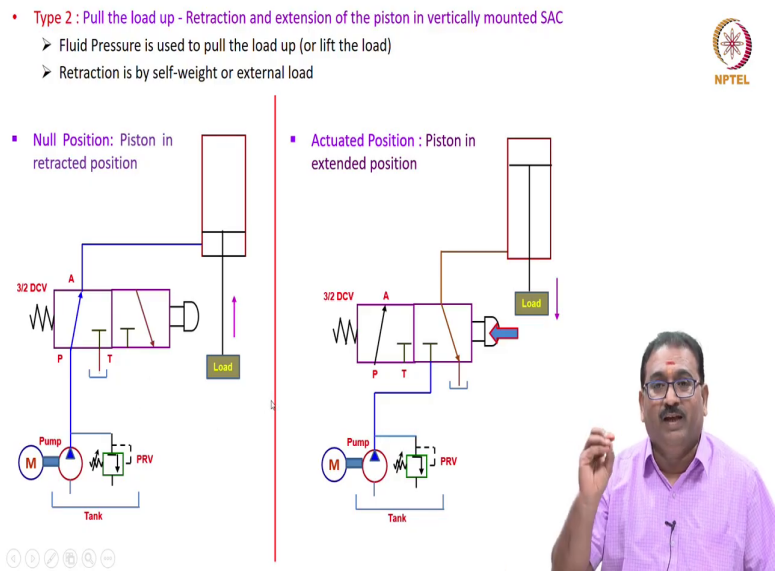
How it is the oil whatever is there in the head side, head side is a piston side and tail side here this is a tail side. Then here the whatever the oil is look here it is taking it out, always you have to draw the null circuit like this. One circuit is enough you no need to show the actuator position, every design engineers or every fluid power engineer knows once I will press the button whatever it is here it is a push button.

You have come across the different types of the spool actuation, this is a push type button or a lever type, button plunger type, solenoid type, pilot operated type, hydraulic type many things are there you have discussed these things in the topic directional control valves in the previous class.

The various I am showing you here in all the circuit very simple thing the manually operated push button. When I will push this button you will see friends what happen fluid flow is diverting now to the head side of the single acting cylinder only 1 port please remember only 1 port. Then what happened due to the fluid pressure? The load will be lifted up.

Then how to lower it? You will cut off the fluid how to cut off one more pressing of the push button immediately shift to the left position of the DCV. That time what happen whatever the fluid is there it is taking to the tank, due to the self weight it will come down remember this is a null position this is an actuated position.

(Refer Slide Time: 12:27)



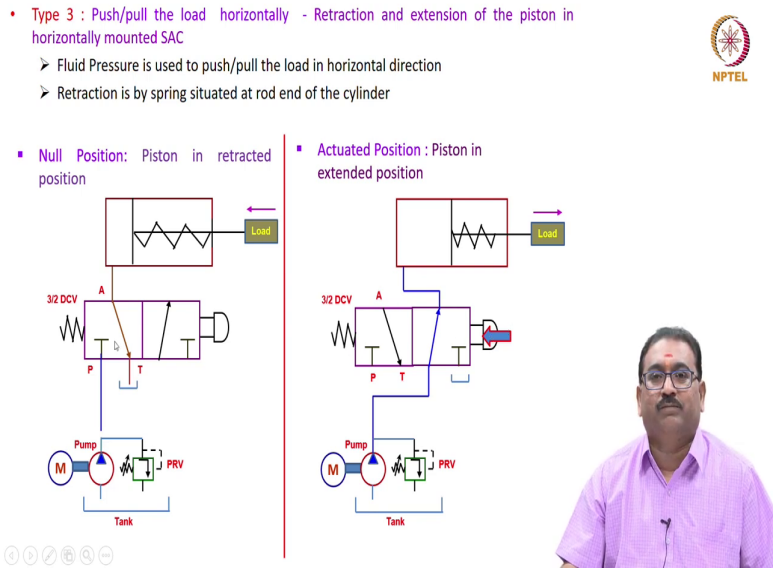
Now, we will see now here the type 2 I am showing pull the load up, meaning how you will mount the single acting cylinder matters friends please remember. Now, previously I am lifting the load now you may based on the application I am reversing the single acting cylinder to lift the load or what you will pull the load. Meaning again I am showing you retraction and extension of the piston in a vertically mounted single acting cylinder.

Here fluid pressure is used to pull the load up or lift the load retraction is by self weight or a external load. See now friends, here cylinder I am inverting this is based on the applications that is why I am telling you, you will see now here always what I am doing here. Now one more thing you will remember friends the null position what while selecting whether a pump port is block or a pump port is open that will matters.

Now, you will see again the 3 by 2 DCV using the spring center P is always open, meaning what it is 3 by 2 DCV the open type, open type means pressure port is open in the null position itself I am showing you here. Now, what happens here the piston is retracting inside you will see the fluid pressure is coming to the tail end, tail end effective area is pi by 4 d p square minus d r square rod area then what happen it is piston is moving inside the cylinder correct.

When you will press this button what happens whatever the fluid is there at the tail end it is taking out to the tank, then here piston is extending. How I am playing? I am playing with the components please remember this is a very simple basic circuits I am showing you now.

(Refer Slide Time: 14:35)



Now, you will see I am showing you one more thing push and pull the load horizontally now. Meaning retraction and extension of the piston in a horizontally mounted single acting

cylinder; previously you are seen mounting like this or a like this reverse. Now, I will mount horizontally, whether it is a pushing the load in extension or sometimes it is retracting the load based on your requirement.

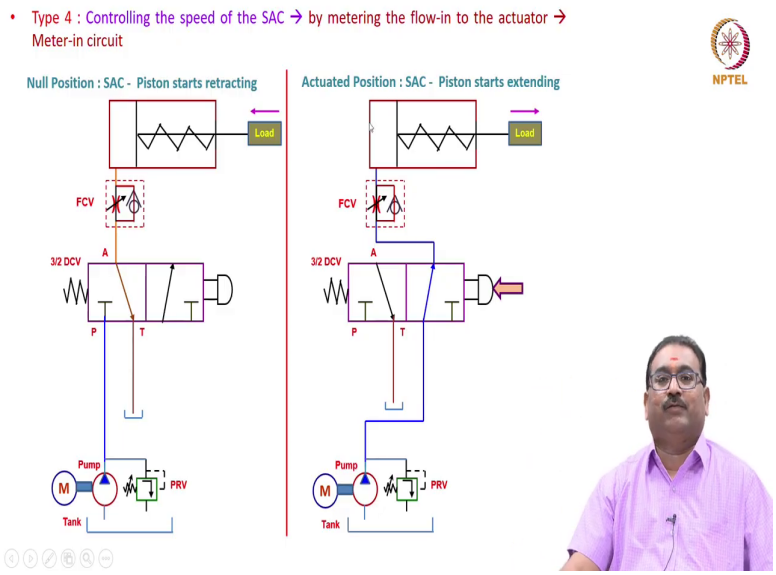
The fluid pressure is used to push or pull the load in a horizontal direction, retraction is by spring situated at the rod end of the cylinder. See the circuit here same type now, here you will see friends a single acting cylinder only 1 port and the rod end I am having the stiff spring. What for it is once the flow is cut off the spring is pushing back the piston to the null position. Now, null position is piston in the retracted position I am showing you here.

Now, you will see the pressure port is blocked many various types are their valves based on your requirement you will use. Now, we will see the a port meaning A port is nothing but the head side here connected to the tank oil will be taken out. How the piston is pushed back through the stiff spring. If you want to extend this what I will do? I will press this button actuate this manual operated button here, then pump flow is diverting to the head side.

Then what happens? The piston will be pushed pushing the piston then spring will be compressed.

Once you will cut off the flow how will cut off press one more time automatically it will shift to this position left position, then whatever the fluid is there they are taking it out and piston will come back to the null position through the stiff spring. When you are using the spring return these things will mount horizontally or a vertically, horizontally people are using more using the stiff spring they will bring back.

(Refer Slide Time: 16:44)



Now, I am showing you the type 4 controlling the speed of the single acting cylinder, previously you are seen only direction you are seen. Now, I am showing you the speed of the single acting cylinder. How to do it this? Now, I am showing you by metering the flow in to the actuator, I want to meter in the flow in or a meter out the flow various types are there correct.

Now, I am doing the meter in the flow to the actuator the type of things are known as meter-in circuit, meter in circuit meter-in the flow to the actuator to move the piston. How it looks you will see I am using the flow control valves, already we know that the flow control valve is a throttle valve with a check valve.

Now, we will see again I am drawn the here figure the null position, again the null position pressure port is blocked due to the spring it will retract. Whatever the flow is there now we

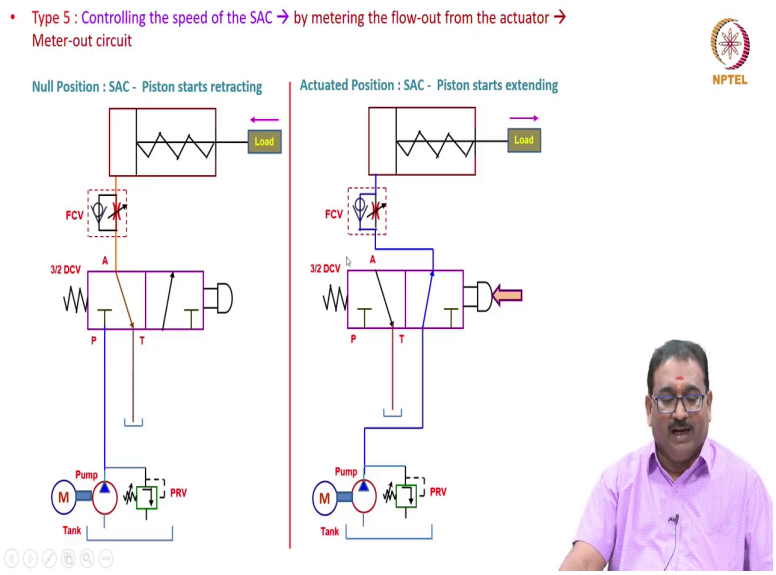
will see friends, how it will go? It will not goes through the metered orifice, it will bypass through the check valve. What is the use of check valve here? You will see in the retraction time the output flow it will bypass to the tank through the check valve.

Now, we will see friends when I will push the right side button, then what happens the pump flow is passing through the flow control valve through the metered orifice not through the check valve, then to the head side of the single acting cylinder, then piston will be pushed out. Then, when you will cut off this flow pump flow how? By pressing one more time automatically it will shift to the left side actuation like this.

Then whatever the fluid is there at the head side it will goes through the check valve to the tank very simple it is. Now, what I am doing here friends, you will remember I am controlling the metered flow through the orifice opening, then based on the velocity required you have to keep opens the FCV throttling here, this is a speed control. If you will open more, more fluid will come here then actuator will move very fast.

If you will precisely control the small amount of flow then it will move, meaning I am controlling the velocity of the actuator, which depends on the flow rate. Remember friends, because q equal to A into v velocity is q by A; A is nothing but here head side no there are pi by 4 dp square, but return is always the spring force.

(Refer Slide Time: 19:48)



Now, we will move on to now controlling the speed of single acting cylinder. Now, I am controlling same way how it is by metering the flow out from the actuator. I will control the flow out from the actuator now previously I have controlled the flow into the actuator now another ways flow out from the actuator that is known as meter-out circuit. How it is we will see now here.

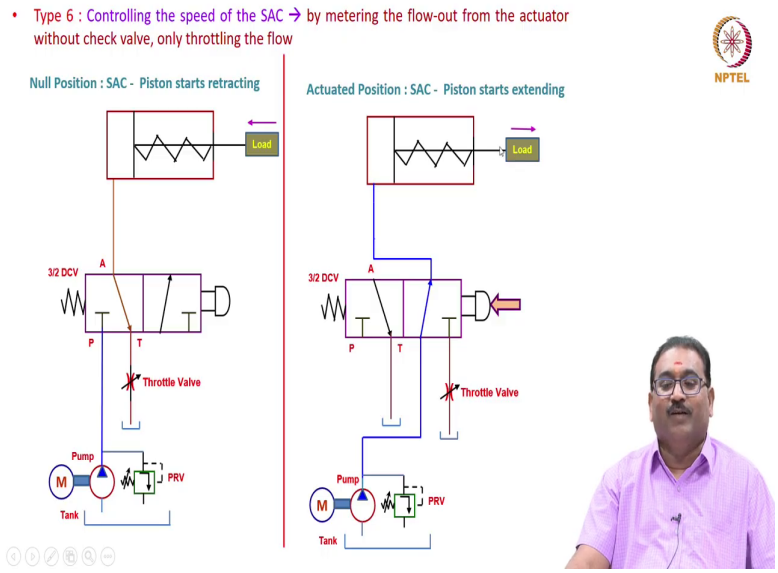
Now, same here I changed the direction please see here friends I am change the direction of the flow this is check valve. Now, we will see again same here the 3 by 2 DCV the pressure port is blocked in the null position correct. Here whatever the fluid is there it will come here please see here friends, it will not pass through the check valve.

Now, it will pass through the metered orifice, how much you kept open even though it is pushing but the fluid is going through the orifice. Meaning what I am doing here, I am

controlling the returned flow that is why it is a meter out circuit. When you will push this button what happened you will see the pump flow will come here then it will not pass through the opened orifice.

It will bypass as because the path of least resistance is a check valve, valve will lift open then it will enter from the head side it will push very fast no control of input flow to the actuator. Only once you will one more time pressing it will shift to the left side position then whatever the flow is there at the head side it will goes through the metered orifice, meaning meter out circuit it is. Meaning how you are placing the flow control valve will matters ok, remember this.

(Refer Slide Time: 21:49)



Now, I will show you one more case type 6, here controlling the speed of the single acting cylinder by metering the flow out from the actuator without the check valve. How to do it

this? Only throttling the flow, how you will do it now? If you will place it in the head sides the metered orifice, then inflow and as well as outflow is passing through that where to place the location of this matters.

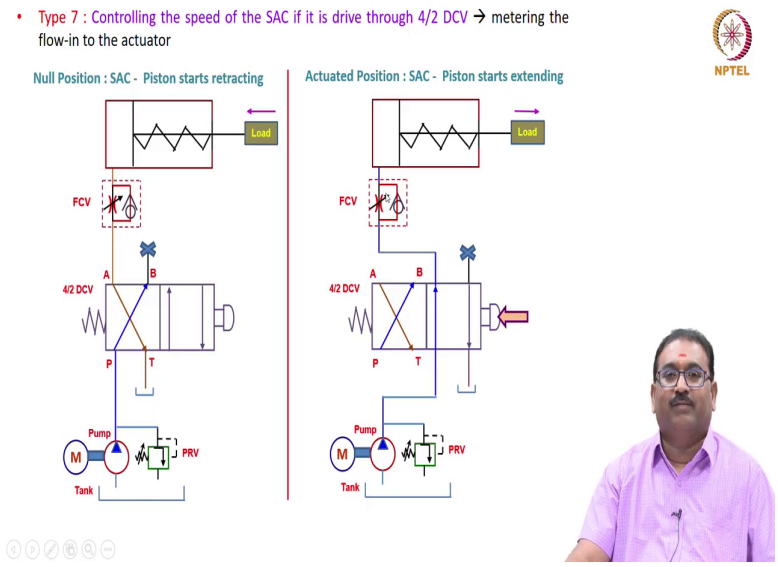
Now, we will see in this circuit friends where I need only throttle valve no check valve integral here, now what I did I placed in the return line after the DCV. Now, we will see friends in the middle position the pump port is blocked then it is actuator is returning back through the spring, whatever the fluid is there at the head side it will goes to the DCV and then to the see here throttle valve how much it is opened flow is going through metered-in, metered-out here now it is.

The fluid is passing through the valve open here, how much it is? Meaning the output flow from the actuator is controlled, when you will press the button here actuate the DCV the pump flow is going here see here no throttle is coming here it will go here, then it will extend. Once you will release this, what happen it will shift here, see now how it is it will pass through the throttle valve only.

Meaning again you will remember the flow is controlled in the retractor position return flow. How it is are placing the throttle valve here do not place the throttle valve here, if you will place it here then you know every in is controlled correct, also here also controlled.

If you will place shift it here what happens when it is retracting again it will pass through this, then here or again here also same it is not a way. Now, we have to if it is a FCV meaning throttle valve with a check valve you will use it here, if you want to control the speed of the single acting cylinder you have to use throttle valve after the DCV like this.

(Refer Slide Time: 24:36)



Then I will show you one more type 7, there are different ways I am showing controlling the speed of a single acting cylinder. If it is drive through the 4 by 2 DCV as we already know that 4 by 2 DCV means 4 ports are there for 2 positions, 4 ports here it is how many ports here only cylinder port and I required the pressure port and tank port.

But, I am not having 3 by 2 way valve I am giving you to 3 by 2 DCV to control the single acting cylinder. How to do it friends? You will see here I am using the 4 by 2 DCV, in the null position where the spring is there P is connecting to B, A is connecting to T.

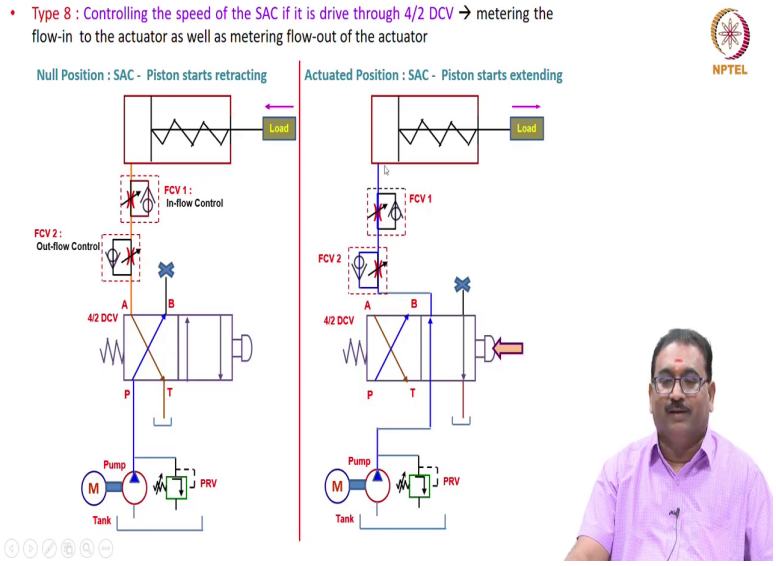
Now, what I am doing here you will see here I am not using the B port I will block here in the null position. Now, you will see friends the pump flow is coming a null position here it is

blocked no need to worry, due to the spring action it will push whatever the flow is there what happened it will by pass through the check valve to the tank it will return very fast.

When we will push this button what happens you will see; when we will push this button what happens the pump flow is going to the head side through the metered orifice. Then it will move with the required velocity.

What I am doing here I am controlling the single acting cylinder using the 4 by 2 DCV 1 port I am not using I am blocking this you remember this. The same effect I am getting when I am using the 3 by 2 DCV sometimes valves are not there no that time you have to operate like this.

(Refer Slide Time: 26:28)



Now, let us we will move the type 8 case in the single acting cylinder. Controlling the speed of a single acting cylinder if it is drive through the 4 by 2 DCV, metering the flow into the actuator as well as metering out of the flow from the actuator. How to do now? Now, we will see how I am doing I am using the FCVs you will see the positions you will see the direction.

I am using the FCV in the head side 2 FCVs one is used to control the inflow and other is to control the outflow; again it is same here 4 by 2 DCV 1 port I am blocking here. You will see now friends here in the null position the actuator is retracting, whatever the flow is there it will come here you will see here the path of least resistance is a check valve, the ball will lift it will move correct.

Now, if you will press this button what happens you will see friend, the pump flow is coming here it will pass through this then you will see here it will lift, valve will lift FCV 2 then again it will pass through here. Meaning here in both the cases the inflow and outflow is controlled how I am doing I am using the FCV 1 and FCV 2 only. What it will matters friends the position of the check valve, we will see in which direction you have to place that will matters.