Oil Hydraulics and Pneumatics
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Task Based Selection and Analysis of Oil Hydraulic Circuits
Lecture - 72
Part 3: Different methods used to control a double – acting cylinder

My name is Somashekhar, course faculty for this course.

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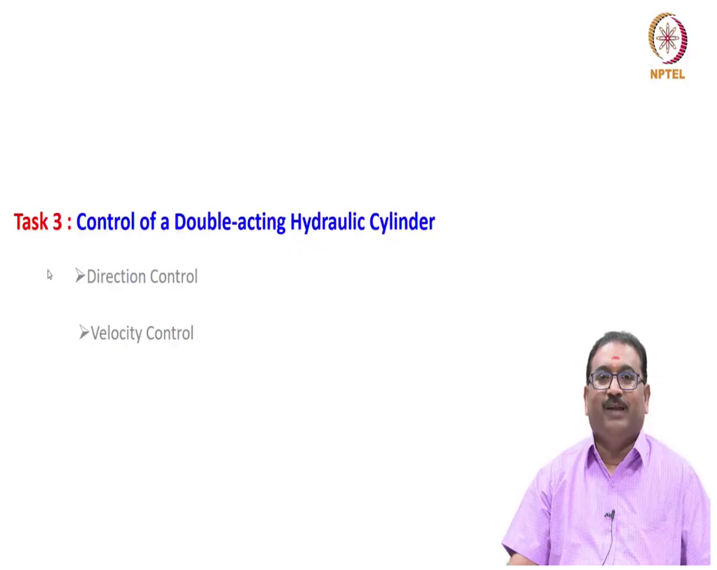

Now, you are seen the many ways to control the single acting cylinder direction as well as the speed using the flow control valve and a, the metering valves, correct friends. Now, we will see similar to that, we will have the quickly the glance on the double acting cylinder, how to control the direction as well as a velocity.

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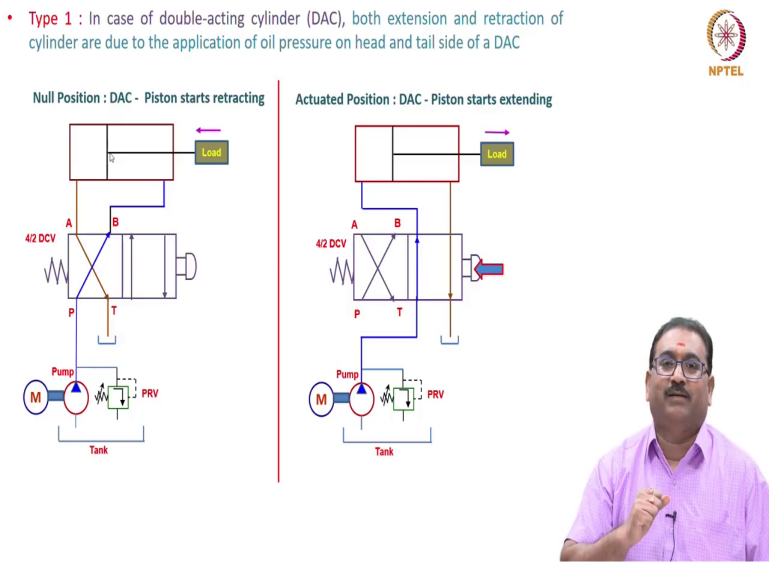

Very quickly we will see now. Type 1: case I am telling you, in case of a double acting cylinder both extension and retraction of the cylinders are due to the application of oil pressure on a head and a tail side of the DAC. Previously, I am using only on the head side fluid pressure.

Now, here in the double acting cylinder, there are the two ports are there, one port is used as a inlet other port is a return. Sometimes, this is an inlet, this is outlet. Meaning fluid in and out or in and out through the ports; meaning extension and retraction I am using the fluid pressure. Now, let us we will see the circuit how it looks.

Always you have to draw the circuit in the null position. Meaning cylinder is in the retracted position. You will see now here friends, the crossed configuration null here it is. Here P is connecting to B, meaning the pump flow is coming to the tail side then whatever the fluid is there at the head side it will pass through here goes to the tank. Meaning it is retracting. What valve I am using? I am using the 4 by 2 DCV.

Similarly, when we will press this what happen? The pump flow is connecting to the head side, whatever the flow is there at the tail side it is going to the tank, correct, very simple way. Again, you will press once again, it will shift to the left position of the DCV, again it will retract. You will see here for every instant of time it will extend, retract, correct.

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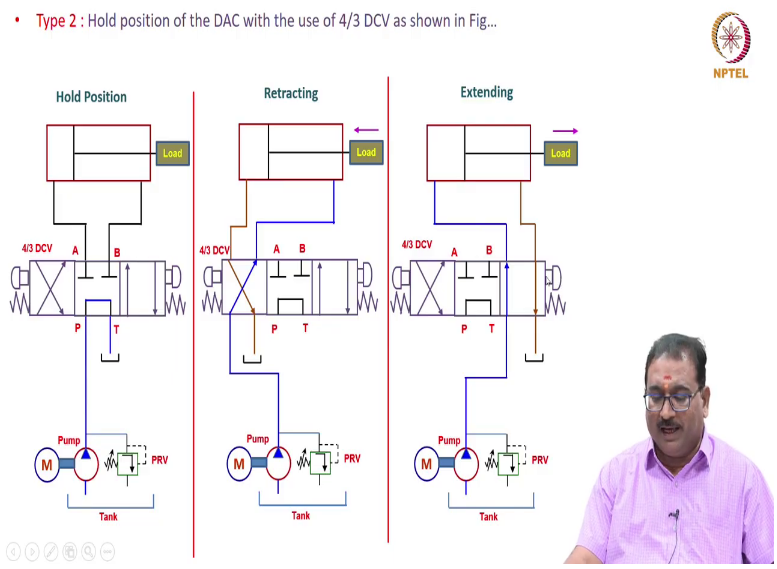

Fold position is not possible here. Fold position means I want to stop the position of the actuator at certain distance not possible in 4 by 2. How we will achieve this? I am using the 4 by 3 DCV. The middle position plays a major role to hold the actuator in any positions. How it is we will see friends here.

Here I am using the middle position, the A and B are blocked, P is connecting to T. Meaning it the tandem neutral, you are seeing the different types of neutral while studying the directional control valve. Now, I want to hold the actuator in any position for example, 10 mm, 20 mm, 30 mm if stroke length is 200.

In previous case, if you use a 4 by 2 DCV not possible, whether it will completely extent or completely retract. If you want to hold the actuator in different position not possible. Only is possible with the 4 by 3 DCV. Now, we will see this is the null position, how they will achieve? Using the two step springs. Then, when I will operate here the left button, what happens?

You will see the pump flow is coming to the tail side, from the head side oil will goes to the tank. It is retracted. In extension if I will press the right actuation button, what happen? Pump flow is going to the head side, the flow from the tail it will goes to the tank, meaning the cylinder is extending.

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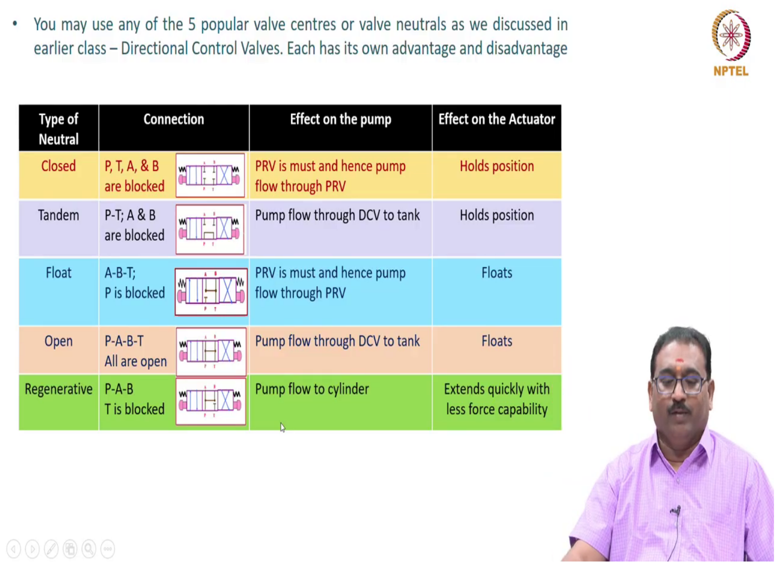

Once again you will press it, make sure that once you will press this it will go to the middle position, always. You may use any of the 5 popular valve centers or a valve neutral as we discussed in the earlier class, direction control valves, each has its own advantages and disadvantages, correct.

I am showing you here the different types of neutrals quickly for your glance, connections, port connections and the middle and effect on the pump and effect on the actuator in the middle position. Closed center what is the name itself tells us that the pressure port tank port A and B ports are blocked.

When you will do like this the PRV is must because in the middle position the pressure starts building and hence PRV is required to divert the flow from the pump to the tank through the PRV. Actuators are in the hold positions. In the tandem neutral, P is connecting to T then pressure will not builts in the pump because P is connected to the tank in the middle position. But the actuator ports are blocked.

Then they are in the hold position. In the float center, A and B are connecting to the tank. No need to worry for the actuator. Any time it will stop in the middle position both oil will connecting to the tank, meaning the low pressure one bar pressure. But PRV is required because pressure port is blocked in the middle position.

One more is there open center no need to worry for the actuator and pressure as well as a pump because all are connected in the middle position. Actuator will floats also here as shown in the floating center. Regenerative, very important in the middle position, P-A-B are connected, T is blocked here. Meaning regenerative is when I will move from one to another position middle position, what happened?

The extra fluid from the rod side is adding to the pump and then it is used along with the pump flow to extend further. Meaning, what is a regenerative? Used fluid is used to increase the velocity of the actuator. That is why I am telling you here you will see effect on the actuator extends quickly with the less force capability because more flow rate is coming from the pump as well as a return flow because it is connected here you will see friends.

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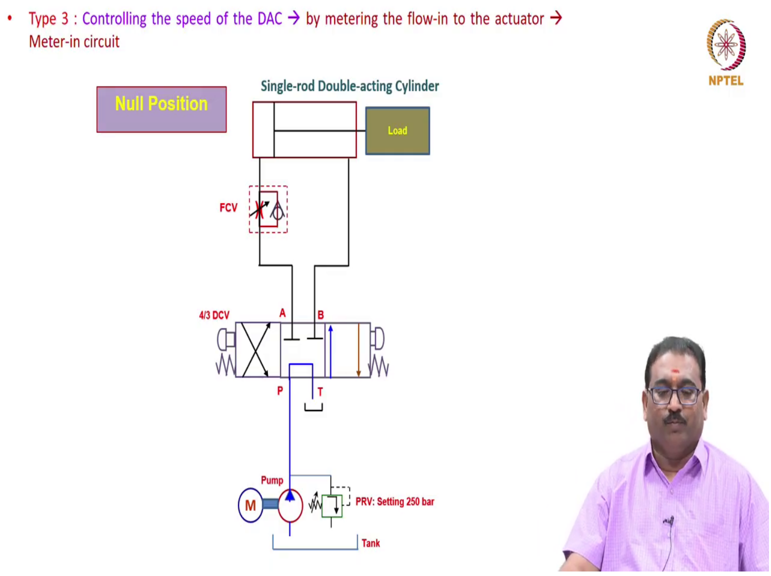

Now, we have seen in double acting cylinder changing the direction, holding position how we will achieve using the different types of valve centers. Now, I want to control the actuator speed, either in the forward direction or a return direction. Then, either you have to control the inflow or outflow. The many combinations we will get friends. Now, I will show you one by one.

Now, controlling the speed of the double acting cylinder; by metering the flow - in to the actuator, meaning a meter in circuit. Now, quickly I will show you the circuit in the null position. Here you will see single rod double acting cylinder. Again same I am using the flow control valve to control the inflow at the head side.

Here it is a 4 by 3 DCV, push button actuations, the spring returns to the middle position, middle position is a the tandem neutral, you may use any type, but I am easy understanding I will use in all the slide same type of centers the power pack remains same now here. You will see now how it operates. Now, I am able to control only inflow not the outflow. Now, we will see the different actuation positions.

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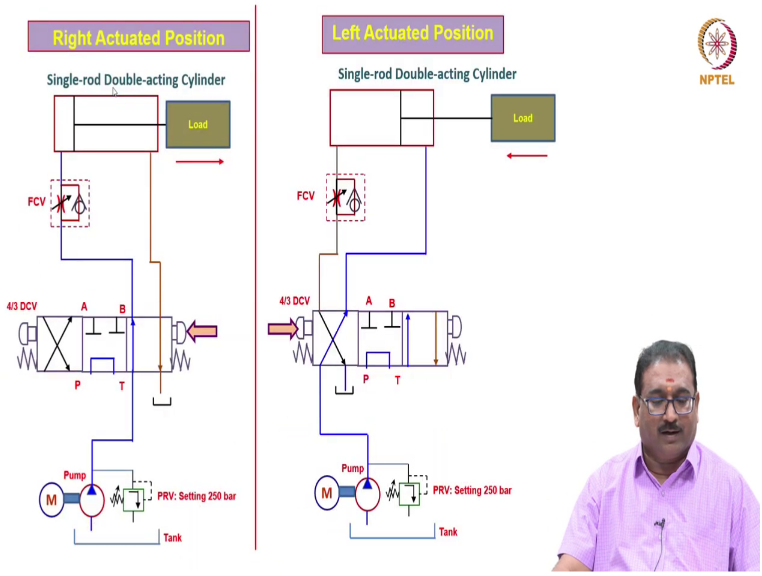

If I will operate the right actuation because I want to extend now from the null position. Now, we will see the pump flow is coming here and going here, it will not pass through the check valve because you will see the position of the check valve, it will only pass through the throttled valve than to the head side.

Meaning I am controlled here the flow in to the actuator then it will move with the required velocity then, when you will actuate the left side push button. Now, we will see the pump flow is coming here and going to the rod end, then it will pushing, whatever the fluid is there head side it will come here.

Please remember friends the check valve will get opens then it will goes to the tank. Meaning the outflow is not controlled in the return direction. Now, I am controlling only in extension the inflow to the actuator such type of circuits are known as meter-in circuits.

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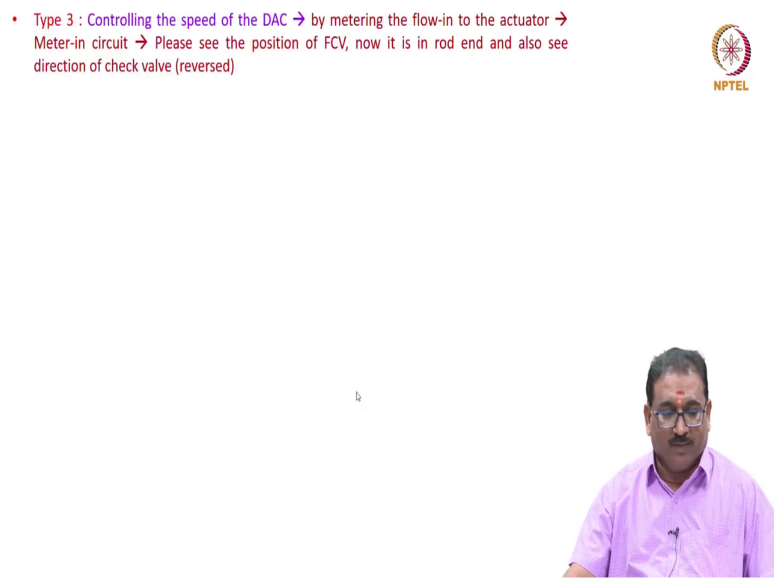

Now, we will see one more case type 3; this is type 4 I think, correct friends? Type 3 over type 4, ok. This is a type 4, I will show you.

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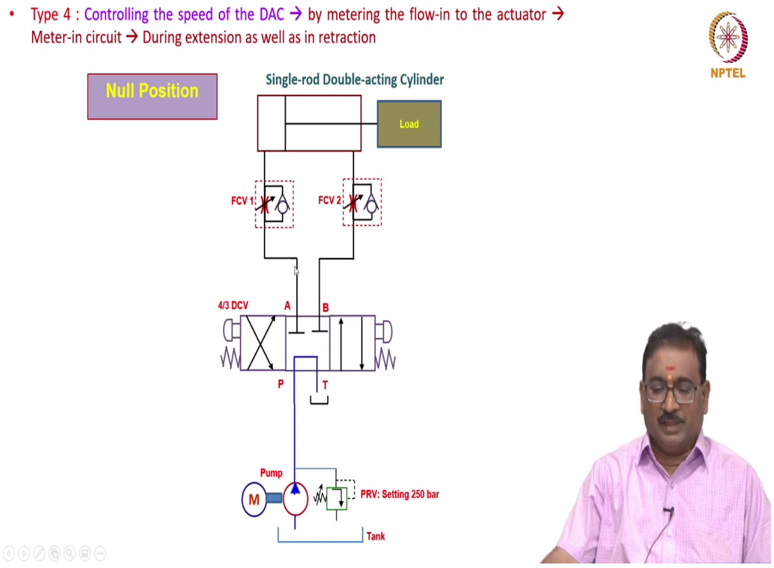

Now, we will move on to the next controlling of double acting cylinder by metering the flow into the actuator that is meter-in circuit during extension as well as in the retraction. Always as I have told you in the null condition this is a circuit.

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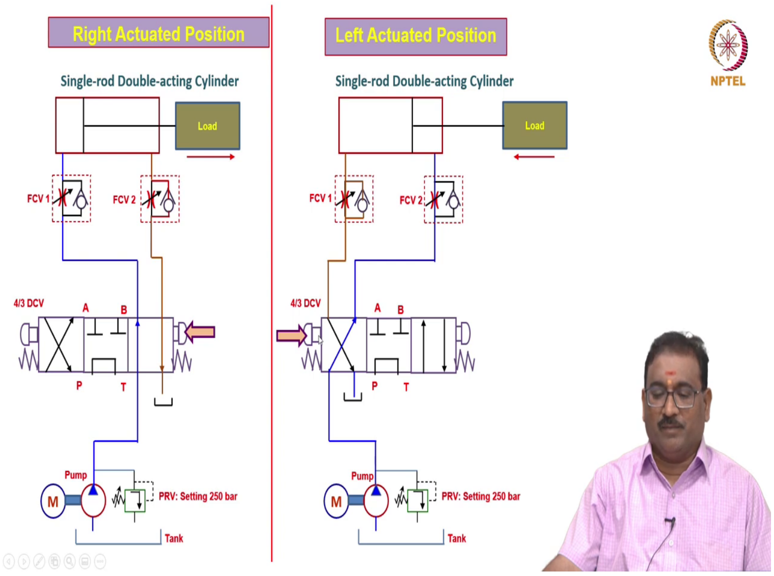

Here you will see her, when I will press the button, right side button of the DCV, the flow from the pump will goes to the head side through the metered orifice, then the piston starts moving to the right side. When you will press the left side of the DCV, what happens? It will jump to the crossed configuration the pump flow will go to the tail end or a rod end, again through the metered orifice.

Meaning in both condition you will see friends, the flow entering to the actuator is controlled. And the flow at the head side here it is bypassed through the check valve, correct. Here in both the cases, when you will operate the right actuation or a left actuation only the metered inflow is controlled and outflow is through bypassed through the check valve.

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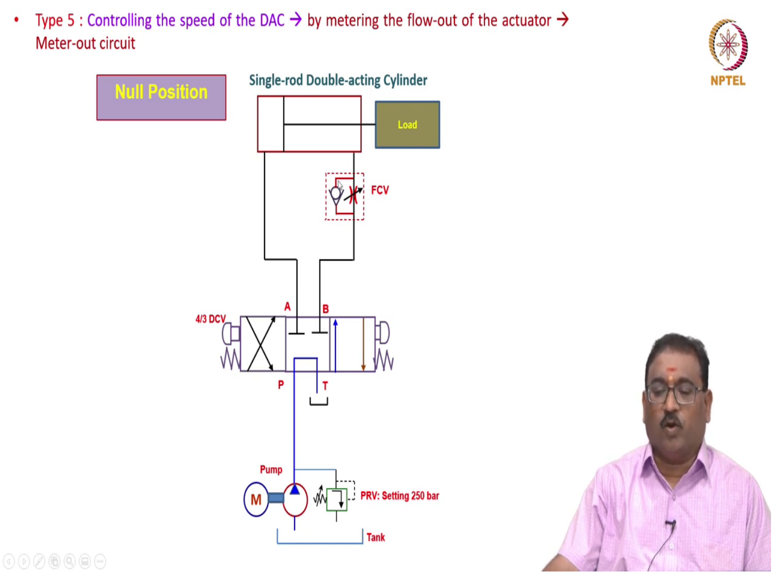

Now, we will see again type 5 here, the controlling the speed of the DAC. By metering the flow-out of the actuator, there is meter-out circuit, the null condition looks like same here, but I am placing the flow control valve at the tail end, meaning the rod side.

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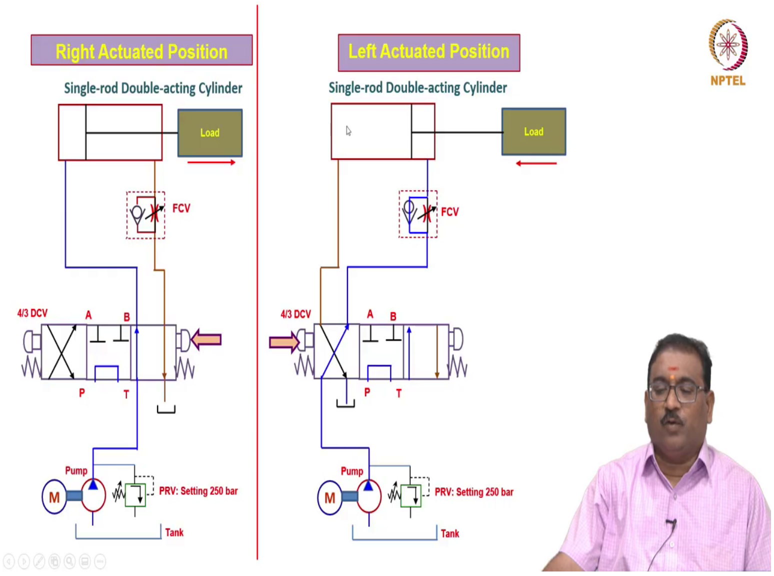

Now, we will see actuated position right side, the pump flow is exposed to the head side, the tail end is only controlled through the orifice. Then when you will press the left hand side of the DCV that time we will see the pump flow is coming to the tail side meaning rod end through the bypassing, check valve, and the flow from the head side it will goes to the tank directly.

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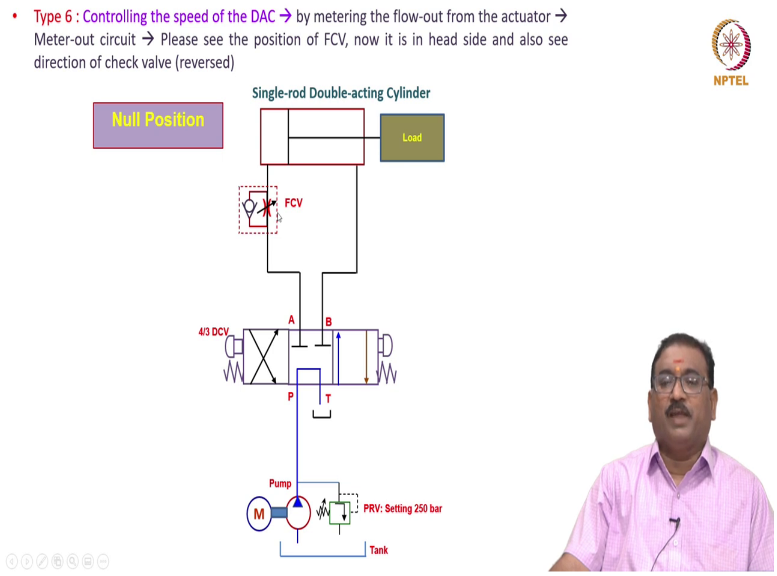

Now, type 6 we will see controlling the speed of the DAC by metering the flow-out from the actuator. Again we will draw the meter out circuit, but you will see the position of the FCV how I placed. Now, it is in the head side and also see the direction of the check valve. Now, again I am drawing the meter out flow, but I am placing the FCV at the head side. Now, we will see how it operates.

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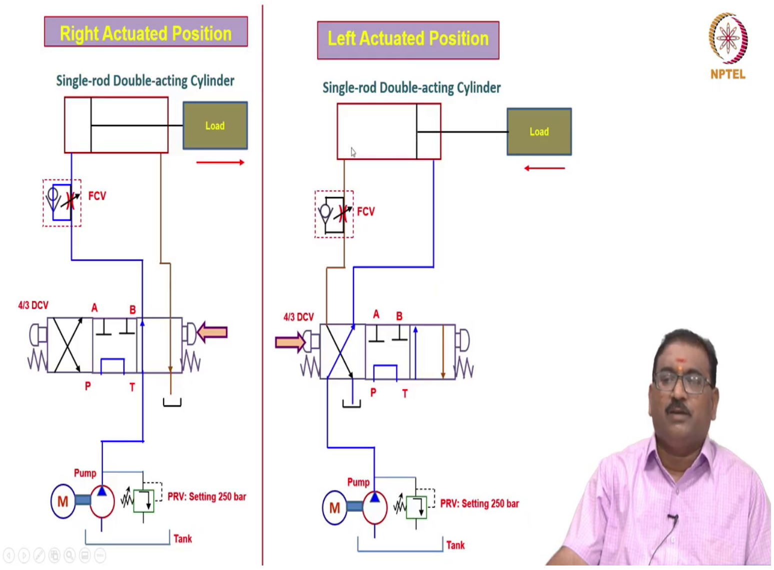

When I will press the right side of the DCV, now we will see friends, when we will press here the pump flow is coming to the head side by bypassing through the check valve, and the flow existing in the rod side it will go to the tank, correct. Now, when we will press the left side of the DCV, now we will see how it operates.

The flow is coming to the tail side free flow whatever the pump flow is coming here then the actuator will move to the left side. Then, what happens? The flow existing at the head side will pass through the metered orifice. Meaning the outflow is controlled. Please see here. It is similar to the previous one, but here I placed the FCV at the head side by controlling the flow outflow only here also.

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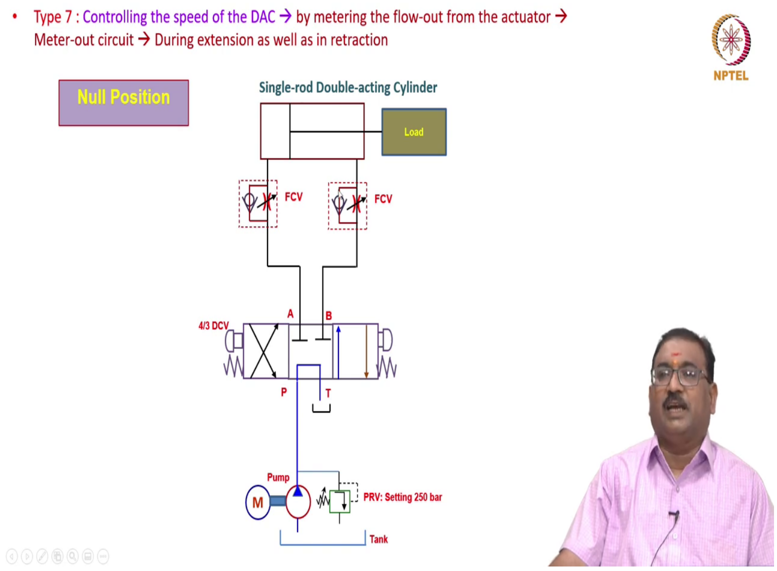

Now, we will see the type 7 how we will control the double acting cylinder: by metering the flow out from the actuator, again the meter out during extension as well as the retraction. How we will do this? As we know already I am using the two flow control valve at the head side one and a tail side one.

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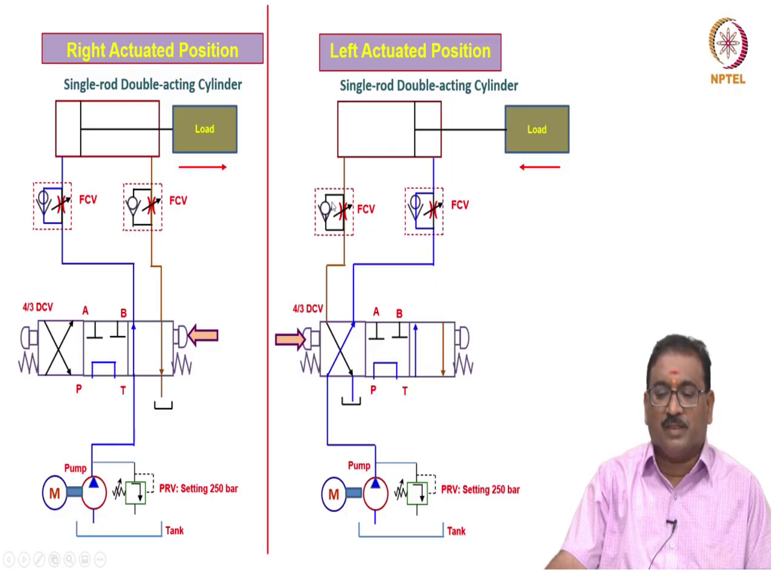

Now, we will see by operation? When I will press the, right side actuation how the flow will takes place we will see. From the pump it will go to the head side, no control, because it is bypassed through the check valve. When the piston moves extend what happens? The flow is only passed through the metered orifice, correct.

Now, speed is controlled now here outflow is controlled here. Now, we will press the left side button, what happens you will see here. The pump flow is coming to the tail side, bypassed through the check valve, whatever the flow is there here in the head side it will pass through the see here the metered orifice. Again the speed is controlled both forward as well as the return side.

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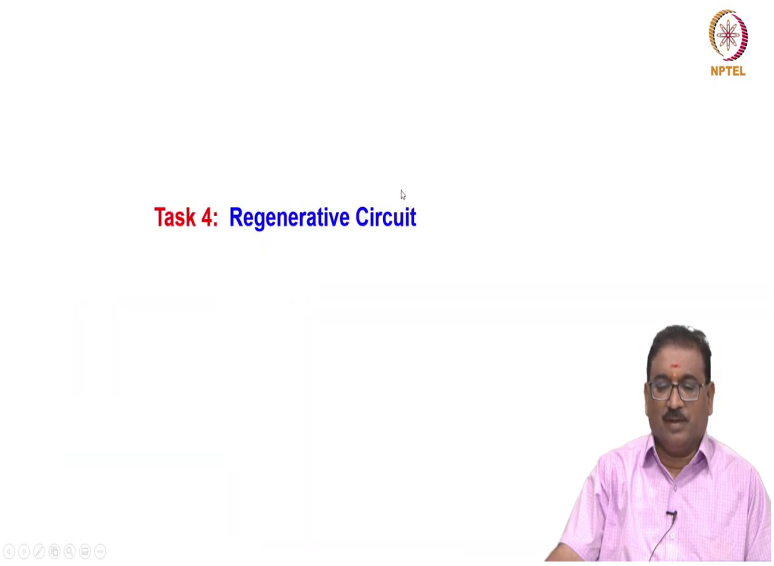

Now, let us we will see very quickly friends, regenerative circuits. Regenerative circuits are very much essential when we are supporting the pump flow during the extension, how we are placing the valves.

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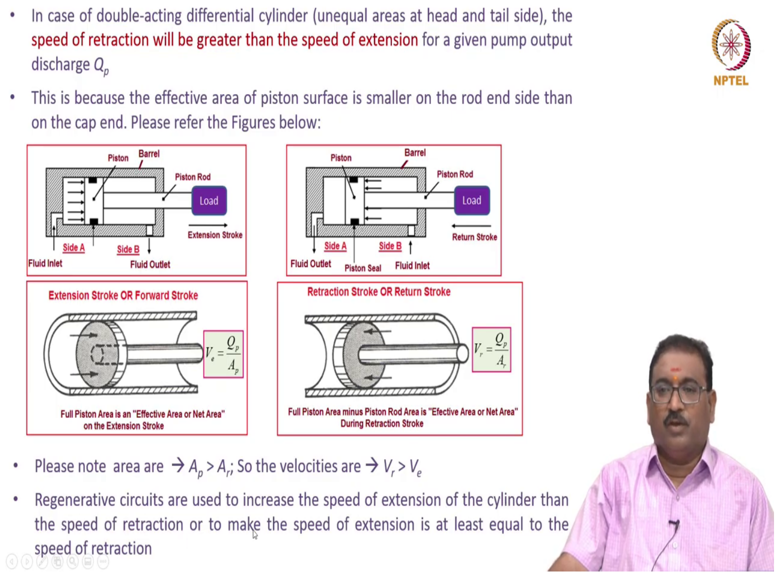

Now, we will see in case of the double acting differential cylinder, differential cylinder means unequal areas at the head and tail side, the speed of retraction will be greater than the speed of extension for a given pump output discharge Q p. This is because of the effective area of the piston surface is smaller on the rod end side than the cap end. Please refer the figure below here.

I am showing you here is the differential area. When the fluid is coming to the head side this is an effective area. You will see here effective area is a piston area pi by 4 d p square. During the forward direction this is an effective area. During the retraction you will see here the effective area the fluid exposed is the rod area you have to minus it here, meaning pi by 4 d p square minus d r square.

Here you will see friends, during the extension the complete pump flow divided by the area of the piston is the extension velocity. During the retraction, what is that? The complete pump flow, but here it is the effective area is the A r it is, pi by 4 d p square minus d r square.

Please note friend areas are like this A p is greater than A r, so the velocities are velocity of retraction is more than the velocity of extension. Regenerative circuits are used to increase the speed of extension of the cylinder than the speed of retraction or to make the speed of extension is at least equal to the speed of retraction.

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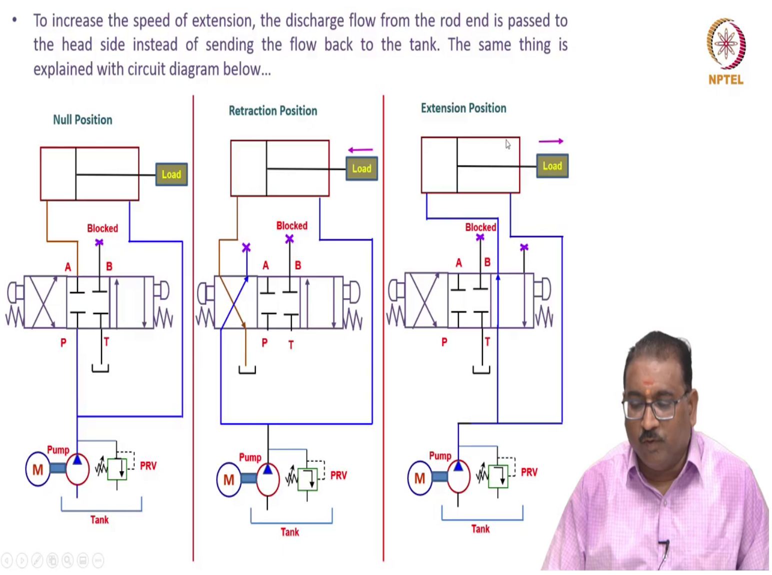

To increase the speed of extension, the discharge flow from the rod end is passed to the head side instead of sending back to the tank. The same thing is explained with the circuit diagram below. Let us consider the circuit this is a double acting cylinder connected to the DCV 4 by

3 DCV closed central. Here pump is connected to the middle position and A port is connected to the head side.

Here you will see friends, B is blocked here in this. Then B of the double acting cylinder is connected directly the pump line here. Now, let us we will see in the actuated position what happens. When I will operate the left side of the DCV push button, the pump flow is coming here and it will blocked here, but it will go to the tail side of the double acting cylinder through this then piston is retracting.

Whatever the fluid is there, it will goes to here and it will goes to the tank. When you will actuate the right button, push button, you will see pump line will come here, it will goes to the head side friends.

Now, please when the piston starts moving whatever the fluid is there at the rod end it will come here, come here, and then it will join to the pump line. Please see here friends, it will adds here. Then, what happens? Extension speed will be increased because of the pump flow plus the flow from the rod end.

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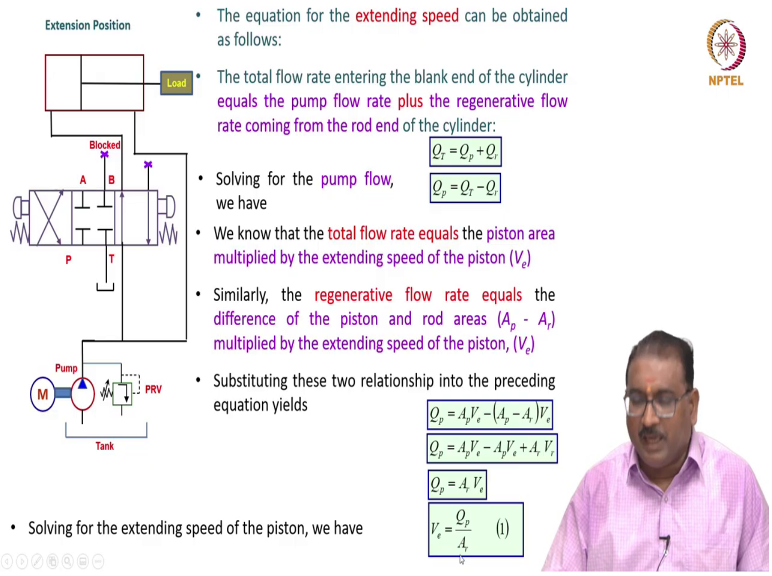

This I will explain to you how to mathematically calculate this regeneration. The equation for the extending speed can be obtained as follows. As we know already, the total flow rate entering the blank end of the cylinder equals the pump flow rate plus the regenerative flow rate coming from the rod end of the cylinder.

So, Q total equal to what? Q p pump flow plus flow from the rod end Q r. Solving for the pump flow, Q p equal to what it is? Q p equal to Q t minus Q r. So, we know that the total flow rate equals the piston area multiplied by the extension speed of the piston meaning Q equal to A into V, correct friends.

Similarly, the regenerative flow rate equals the difference of the piston and rod area meaning A p minus A r multiplied by the extension speed of the piston. Substituting these two relationship into the preceding equations yields. Q p equal to what? A p minus V e minus A p minus A r into V e, correct.

Now, what we will do? We will open the bracket here then you will get Q p equal to because this A p V e, A p V e get cancelled, we will get only what happens Q p equal to A r into V e. See friends, solving for the extending speed of the piston we have V e equal to Q p by A r. Let us we will call this equation number 1.

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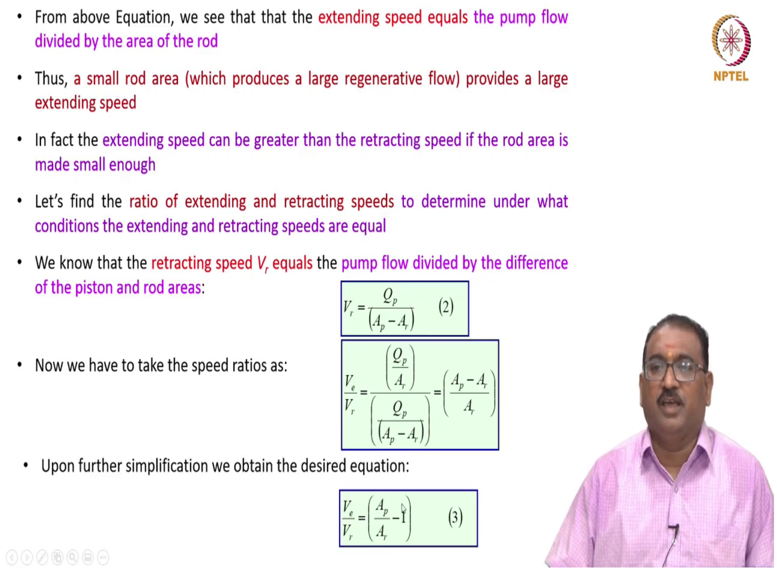

From the equation, we can see that the extending speed equals the pump flow divided by the area of the rod. Thus, a small rod area, which produces a large regenerative flow provides a large extending speeds. In fact, the extending speed can be greater than the retraction speed if the rod area is made small enough.

Let us find the ratio of extending and a retracting speeds to determine under what condition the extending and retracting speeds are equal. Let us we will see now. We know that the retraction speed V r equals the pump flow divided by the difference of the piston and rod areas. Already, we know that V r equal to Q p by A p minus A r. Let us will call equation number 2.

Now, we have to take the speed ratio, already we know velocity for extension and velocity for retraction, Q p by A p and Q p by A p minus A r. Then Q p Q p get cancelled, then this term will go up A p minus A r by A r. So, upon further simplification, we obtained the desired equation as the ratio of velocity of extension to the velocity of retraction, A p by A r minus 1. Call this equation number 3.

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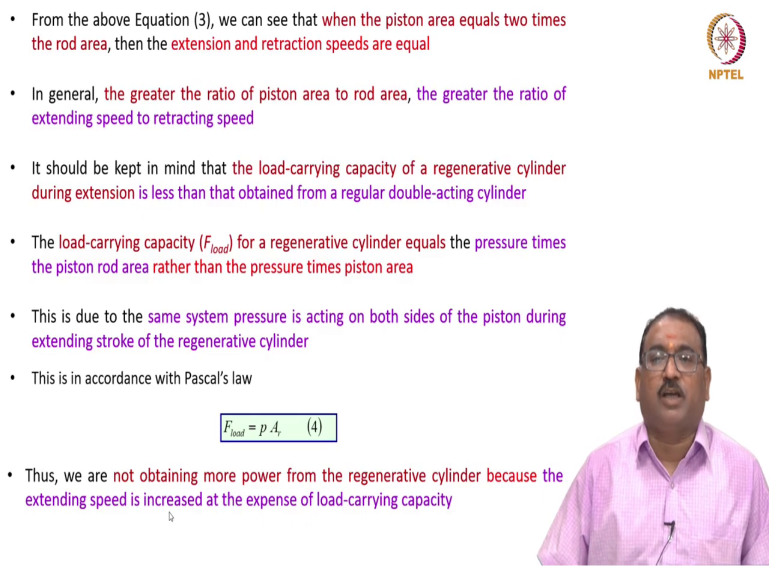

From the above equation 3, we can see that when the piston area equals 2 times the rod area, then the extension and retraction speeds are equal. In general, greater the ratio of piston area to rod area, what happens friends? The greater the ratio of extending speed to retracting speed. It should be kept in mind that the load carrying capacity of a regenerative cylinder during extension is less than that obtained from the regular double acting cylinder.

So, the load carrying capacity for a regenerative cylinder equals the pressure times the piston rod area rather than the pressure times the piston area. This is due to the same system pressure is acting on both sides of the piston during the extending stroke of the regenerative cylinder.

This is in accordance with the Pascal's law, F load equal to p into A r. Please note friends, call this equation number 4. Thus, we are not obtaining more power from the regenerative cylinder because the extending speed is increased at the expense of load carrying capacity.