Oil Hydraulics and Pneumatics
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Part 4: Construction and Application of different valve centres, Rotary spool valve and Pilot operated DCV
Lecture - 35
Directional Control Valves

My name is Somashekhar, course faculty for this course.

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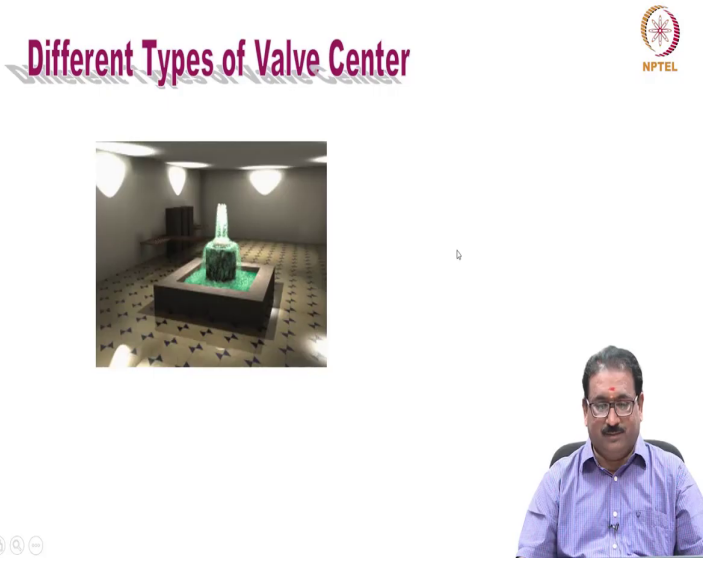

Now, let us we will see the different types of valve center, why it is required different centers. Quickly we will see friends.

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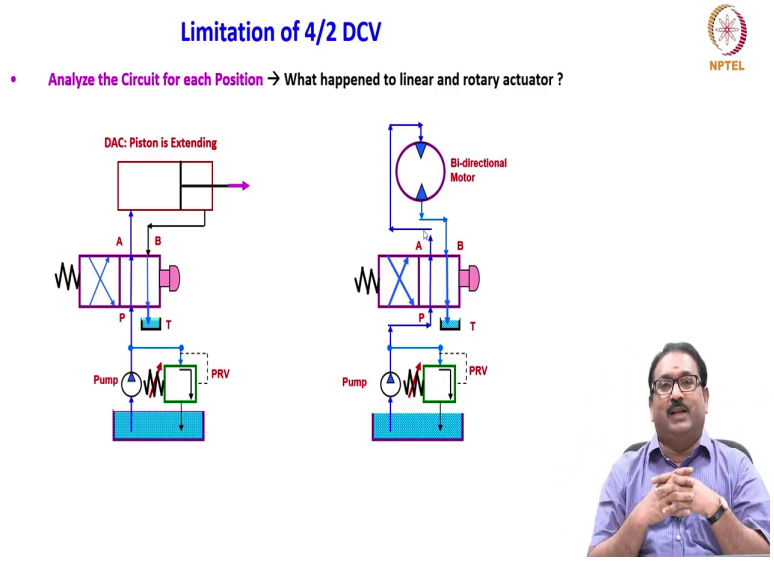

To understand the different types of valve center at the middle position see the limitations of 4 by 2 DCV, then you are understanding why one more position is required in the valve. See here analyze the circuit for each position. What happened to linear or a rotary actuator in this position what I have shown also you are seen in the previous slides.

You see here friends, in the actuated position what is going on friends? Pump flow is sending to the head side then it will extend the flow at the rod side it is moving. When one more pressing what happens? It will retract. Meaning in each position the cylinder will extends retract, extends retract. No null positions understand until you will switch off the your power source or pump.

Otherwise, it is extending retracting, extending retracting because each valve position is like this whether sending the flow to the head side or to the tail side. Similarly, we will see the bi

directional motor it is rotating in clockwise direction one side. In another position it will rotate in the anti clockwise direction.

Then this is a biggest problem to control the valves. Then what is required friends? I required the one more positions that is what we will call the third position. What is that? We will see now.

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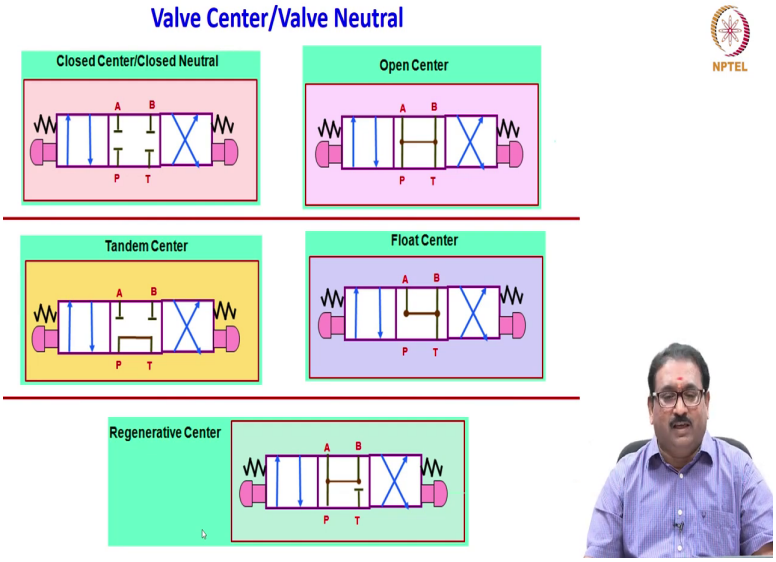

For that there are different types of valve centers are there to suit the customers. Each center has its own advantages and disadvantages. We will see now. The first center is we will see here the 1 and 2, middle one is a 0, null position. This is null position, what happened here friends? A, B, P, T all are blocked. How it is blocked? Using the spool land all ports are blocked in the middle position.

How it is? That is why I am telling you look here. Two stiff springs are there on either side of the spool valve. When you will press this button for example, left side the parallel configuration takes place. When you will press this button what happened? Crossed configuration will take place. One more time you will press it automatically it will go to the center position.

Meaning in the center position it will held blocked. It is known as closed central or a closed neutral; closed center or a closed neutral. For this you know there are various combinations are there. Correct friends? You will connect all together, it is known as open center. You see here open center all are connected. Then you will connect P and T you will see P and T I am connected, A and B are blocked this is known as tandem center.

Then one more possibilities are there many possibilities are there correct, you will see. A and B are connected to tank, P is blocked. Then what happens friends? It is a float center. Then one more combination: A and B connected to the P, T is blocked; this is known as regenerative centers. You will see friends, how many types of configurations of valves are available in the market to suit the variety of customers.

All are at the concentrating mainly on the center position whether all ports are blocked, all ports are opened or P and T only connected or A and V are connected to the tank. What happened? Or A and V are connected to the pump line. There are five different combinations are possible each having its own advantages and disadvantages. Quickly we will see these things friends.

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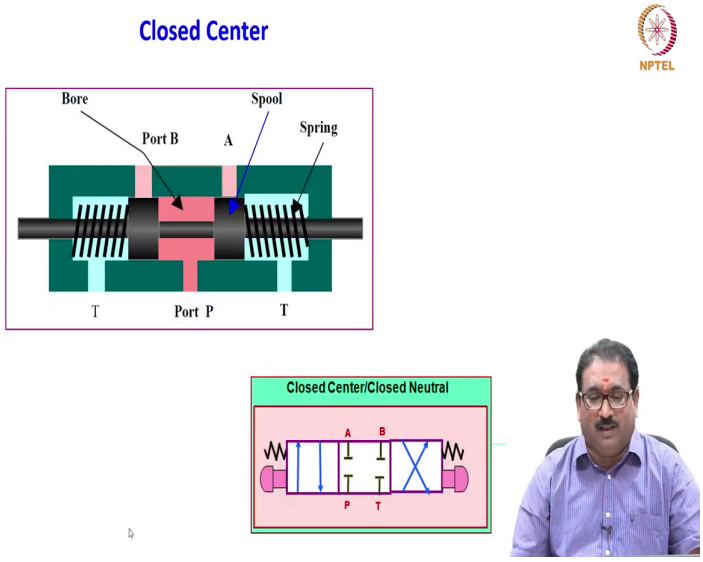

Let us we will see the closed center. As I have told you using the spool lands to stiff springs I am blocking all the ports. You will see all the ports are blocked here correct, using the stiff spring.

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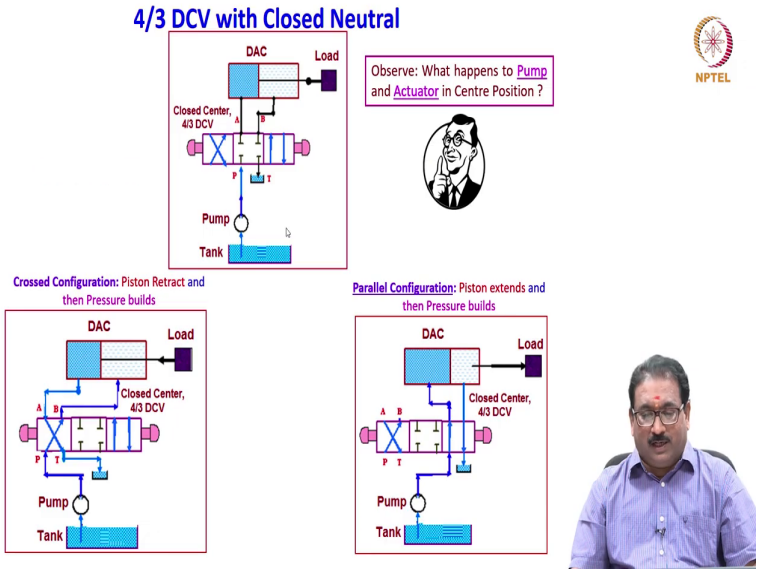

Correct? It is a middle position what I have drawn here. Then how to analyze this? Please observe friend in all the cases only middle position you will concentrate that is very important. Which type of valve is good, which type of valve is having disadvantages, you have to see the things. What you will see?

When I moving from one position to another position what happens to my pump, similarly what happens to my actuator at the center position you have to think. Let us we will move now. When I pushed this button left side button, the cylinder will retract. When I will push this button what happen? Cylinder will extends, but when I will push to the center position, pump is sending the flow, but I am not using the flow in the middle position.

Energy will go as a waste. Also the pump used here it is a positive displacement pump. No space is there to go to the tank. What happens? Pump will burst friends. That is why to

safeguard such type of pump always the outlet of the pump is connected to the pressure relief valve. Correct friends?

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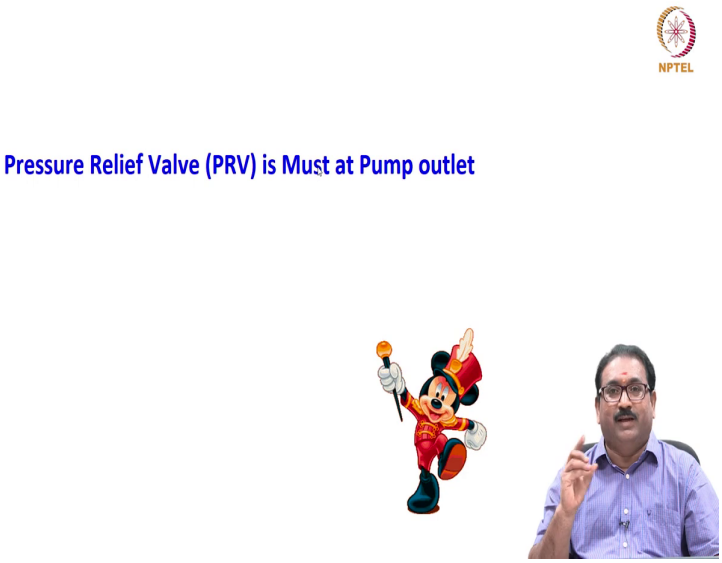

Now, let us we will see this pressure relief valves are must when you are using the closed center because pressure will builds in the center position. As because all parts are all ports are blocked pump is sending the flow, no recirculation will it accumulate at the exit in the middle position.

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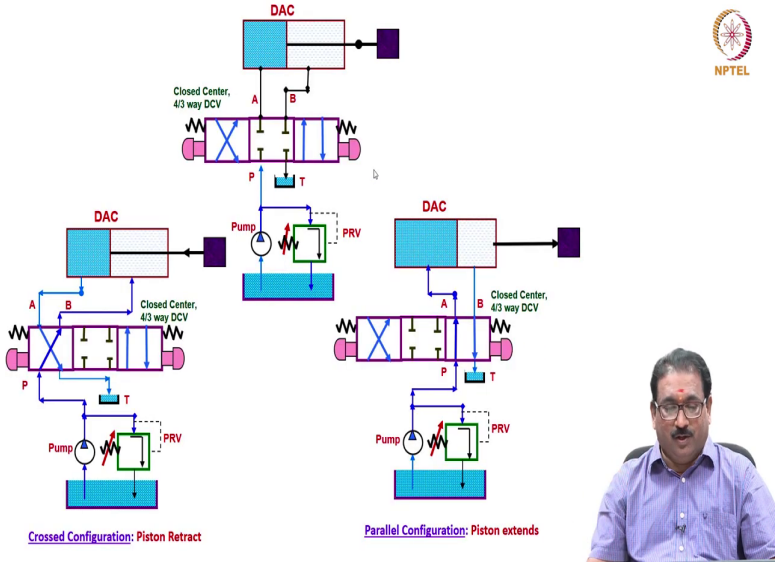

So, that is why you will see here friends pressure relief valves are must when you are using the closed neutral or a closed center.

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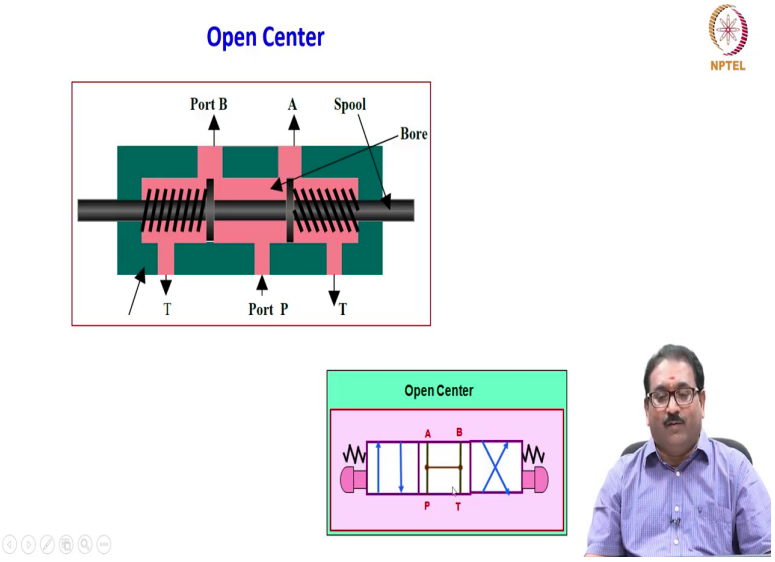

Then what happens to open center? You will see the spool size here all ports are connected. You will see here P is connecting to A and all are connected interconnected inside.

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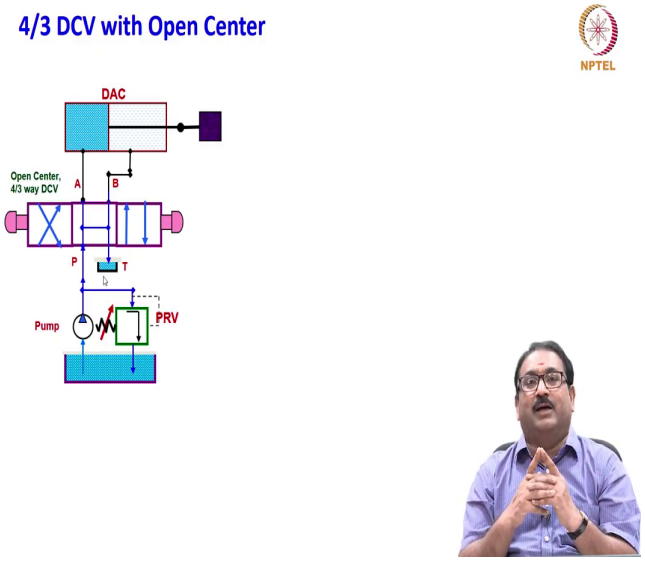

Then what is the advantage here friends you will see? What happens to the pump and the actuator? You will see here when I will move from one position to another position no need to worry, pump will not be get pressurized because the flow is going to the tank.

Similarly, you will see the actuator whatever the actuator pressures are there they are released, but you will see the closed center whenever you will move from one position to another position in the closed center actuator ends are subjected to the heavy pressure.

But, in the closed center no need to worry about the actuator ends because all are connected to the each other going to the tank. Also pump you need not necessarily to worry because pump is sending the flow to the tank. But, only worry is if you are keeping the circuit for longer time in the middle position then energy goes as a waste.

Because pump a sending the flow then you are sending to tank, pump is sending a flow sending to tank. This will makes the increase in the temperature of the oil then viscosity changes then dynamics will get affected. That is why based on how much time you are stand still in the middle position will matters.

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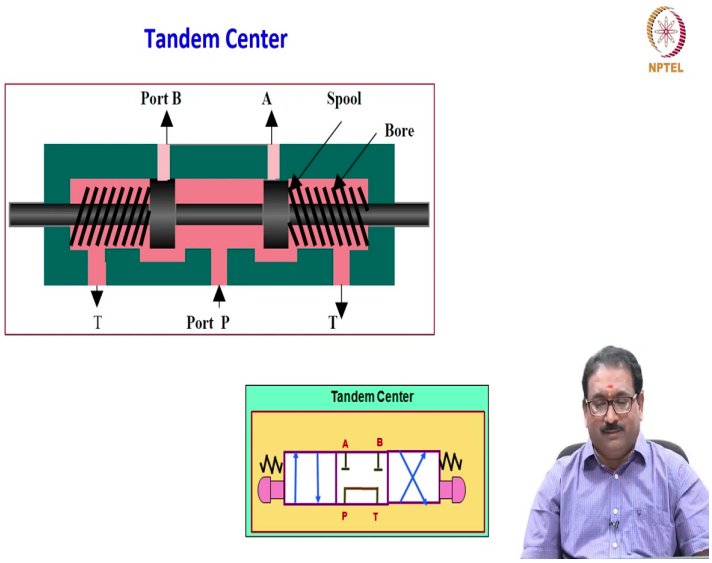

Next one is a tandem center valve. What is this tandem center valve friends here? P is connecting to T, you will see P is connecting to T and A and B are blocked, very good. P is no need to worry because in the middle position you are sending the flow to the tank, but actuator again it is pressurized when you will move from one position to another position.

I am sending, stopped immediately, the pressure what you are working it is held. At the two ends of the cylinder are high pressures, but no need to worry in case of the pumps, correct.

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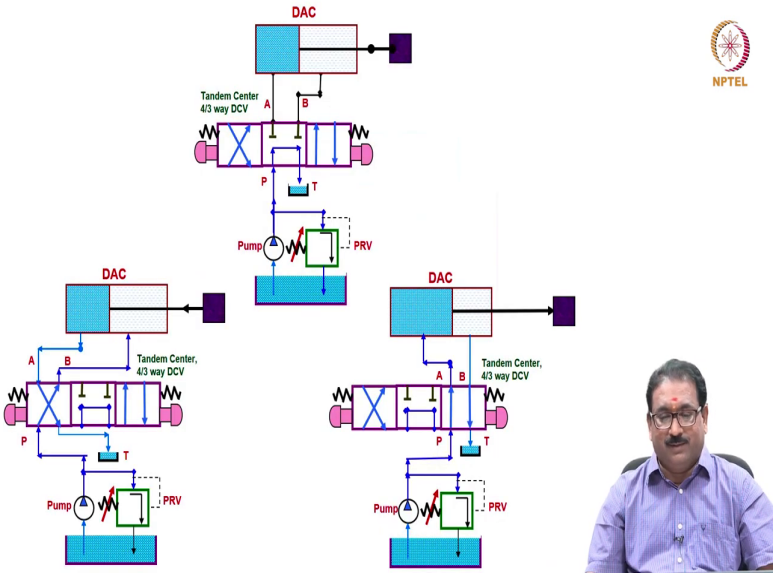

Then again as I have told you the energy waste: sending the flow going to the tank, sending the flow going to the tank happens in case of the tandem center also. Again temperature of the oil will increase, viscosity effect, all the things will happens.

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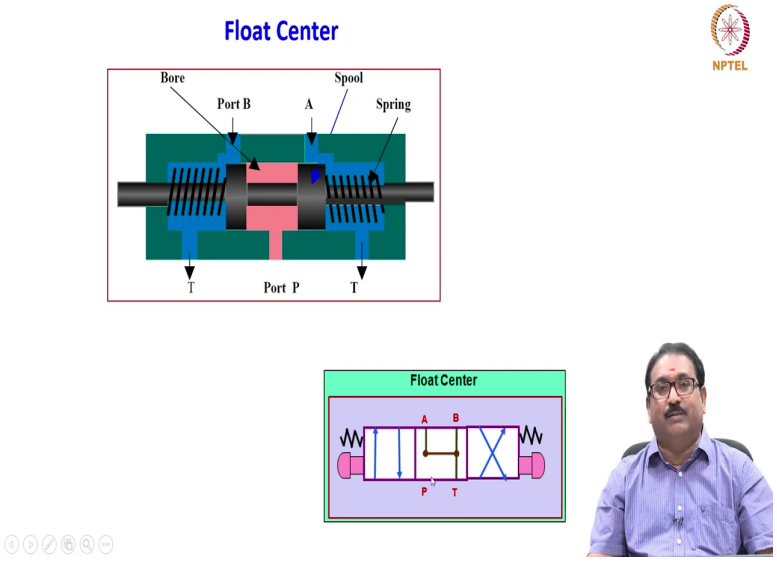

Float center: What is the condition here float center? A and B actuator ends are connecting to the tank then P is blocked ah. P is blocked here P is blocked.

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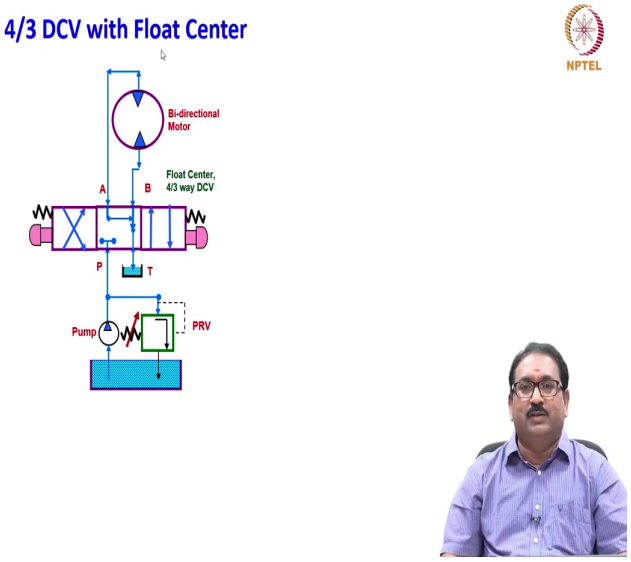

Then you will see what happens, friends. This is basically and very beautifully used along with the bi directional motor. Because when you will move from one position to another position what happened? For example, I am moved here left position, the hydraulic motor or pneumatic motor rotating at certain velocity.

When immediately moved to the center if it is the closed center it will be subjected to the high pressure, dynamics will get affected. Meaning, the rotary thing should come back slowly to the rest. This is only possible in case of the float center. The fluid is rotating. Stop immediately what happens?

In other conditions either it is a tandem center closed center difficult, dynamics will get affected. But, if we will into the float center even though it will rotate at very high speed.

Bring to the middle position, floats A and B are connecting to tank slowly the speed will come to the normal positions. The float centers always used to control the motors.

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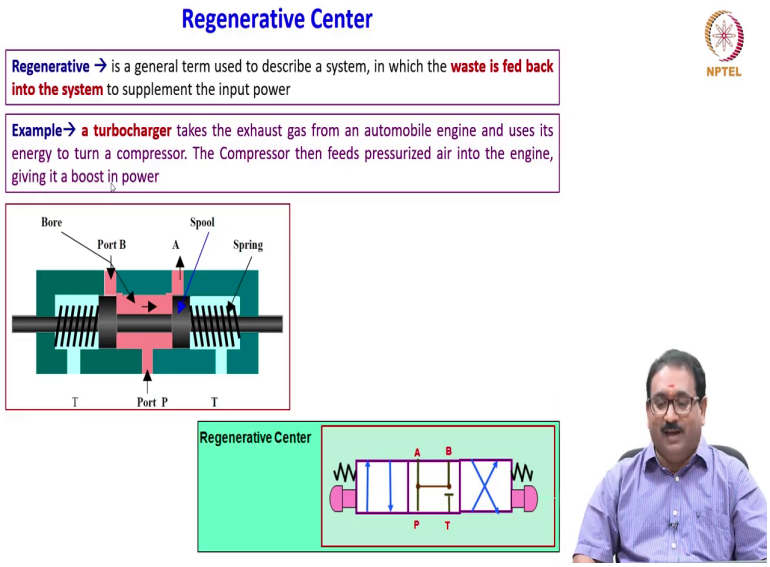

Then you will see regenerative center. Regenerative meaning you will see. A and B are connecting to P, A and B are connecting to P. Then please understand what is this regenerative. Already we know that the regenerative term is a general term used to describe a system in which the waste is fed back into the system to supplement the input power.

Example, a turbocharger takes the exhaust gas from an automobile engine and uses its energy to turn a compressor. The compressor then feeds pressurized air into engine giving it a boost in power. Same way I am doing here. The waste fluid instead of sending to the tank I am supplement to the tank to feed forwards.

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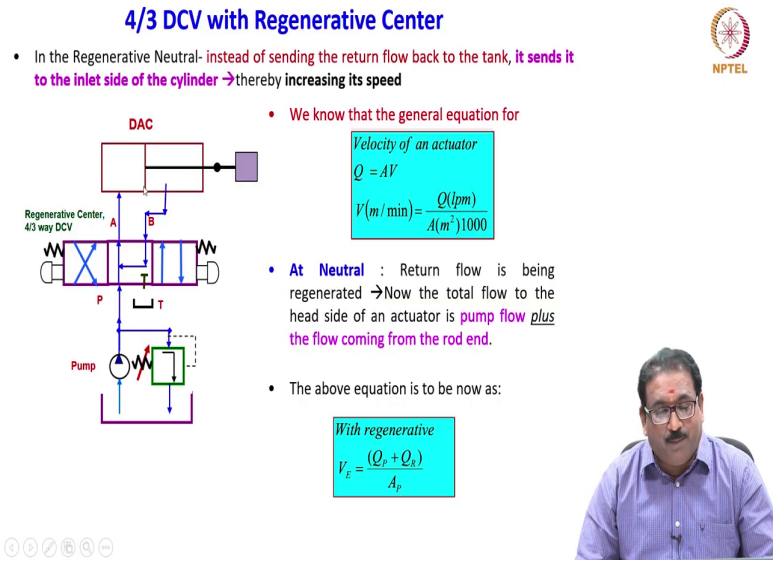

Let us will see how regenerative center will works. With the same regenerative neutral it is always you will think for the center position. In a regenerative neutral instead of sending the flow back to the tank it sent to the inlet side of the cylinder thereby increasing the speed of the actuator. Let us see I will see now.

We know that the general equation already we know velocity as the actuator is based on Q equal to A to V continuity equation. A is a area of the piston; pi by 4 dp square, dp is a piston. Then here it is how much? Pi by 4 dp square minus dr square rod square. Here velocity of an actuator Q equal to A into V velocity equal to Q by A. At a neutral position what happens we will see. This is a general equation to calculate the velocity.

At a neutral the return flow is being regenerated. Correct friends, regenerated. Now, the total flow to the head side of an actuator is the pump flow plus the flow coming from the rod side,

it is adding here. So, the above equation is written as the velocity for extension in the middle position is Q P pump flow plus Q R return flow divided by the A P head side.

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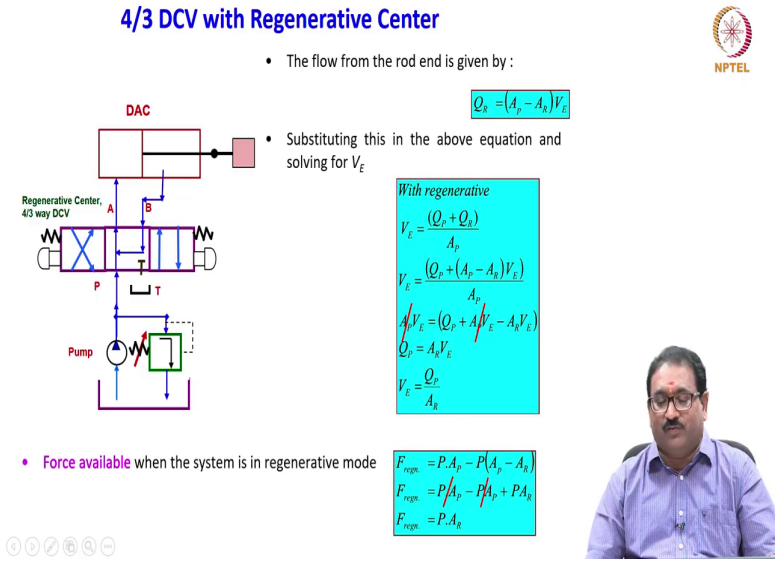

The flow from the rod side, as I have already told you; Q R equal to A P minus A R into velocity at the extension. Substituting this in the above equation, I am substituting all the values. And after simplification I will get the velocity of extension at the middle position is Q P by A R.

So, the force available when the system is in the regenerative mode F regenerative equal to P into A P minus P into A P minus A R. make the simplification, I will get the force for regeneration is P into A R, very simple calculation friends.

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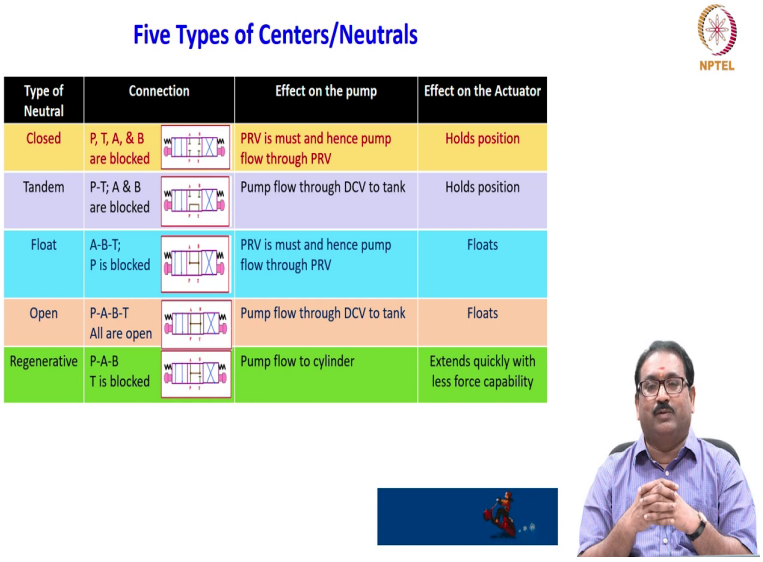

Now, quickly I will recap. Now, we will see the five types of centers or a neutral what you have studied. Here I am giving you a big table that types of neutral, connection how it is the, effect on the pump and effect on the actuator. This is a very very important. Closed center: P, T, A and B all blocked, this is a sketch. Effective PRV is must to safeguard the pump, but effect on the actuator is holds condition.

Tandem: center P is connecting to T, A and B are blocked. Pump flow through the DCV to tank, no need to worry for the pressure relief valve here, it is a holds positions, pressurized condition. Float: AB are connecting to tank, P is blocked then PRV is must and hence pump flow through the n PRV, here floats. Open center: all are connected interconnected. Then from flows through the DC V to tank, no need to worry for the pressure relief valve, here it will floats.

Regenerative: P is connecting to A and B, A; meaning B is connecting to this all A P A B, T is blocked here. Pump flow to the cylinder because this is more than the return flow that is why it is going, extends quickly with less force capability.

Please remember friends irrespective of the valve center generally to safeguard the pump because pump is a positive displacement pump. In the hydraulic circuit always it is equipped with the pressure relief valve except in the pressure compensated pumps.

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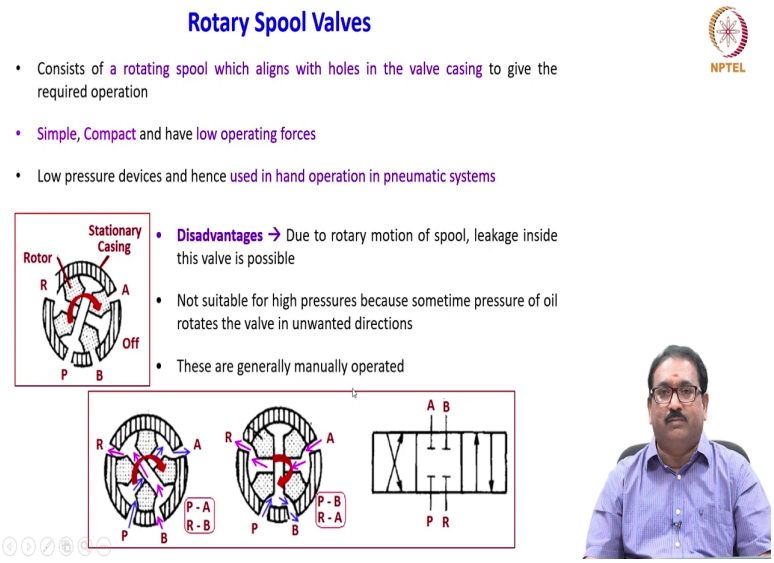

Quickly we will see the rotary spool valves, see the constructional future rotary spool while sliding. It is rotating to get connected with the ports. It consists of a rotating spool, it is what we will call the rotor and a stationary housing. Stationary housing having the port A, B, P port

and a return port and this rotor will makes the port connection by rotating inside the stationary casing.

How it is, you will see now. You will see here these type of constructions are very simple, compact and low operating forces are required. You see here in this position when it will rotate; when it will rotate inside the stationary casing; nowadays all ports are blocked here, you will see all ports are blocked now.

When it will rotate like this what happens friends? P is connecting to A then B is connecting to R. When still further rotates it is what happens? P is connecting to B. See here P is connecting to B, A is connecting to return. Correct? Here I am written the complete valve representation is like this. Same as that center in the middle position all ports are blocked.

If you will go to the left side crossed configuration, if to the left side it is a parallel configuration ok. The low these are the low pressure devices, hence used in the hand operation in a pneumatic systems. The disadvantages of the rotary spool valves: due to rotary motion of the spool, leakage inside this valve is possibilities. Not suitable for high pressures because sometimes pressure of oil rotates the valve in unwanted directions. These are generally manually operated things.

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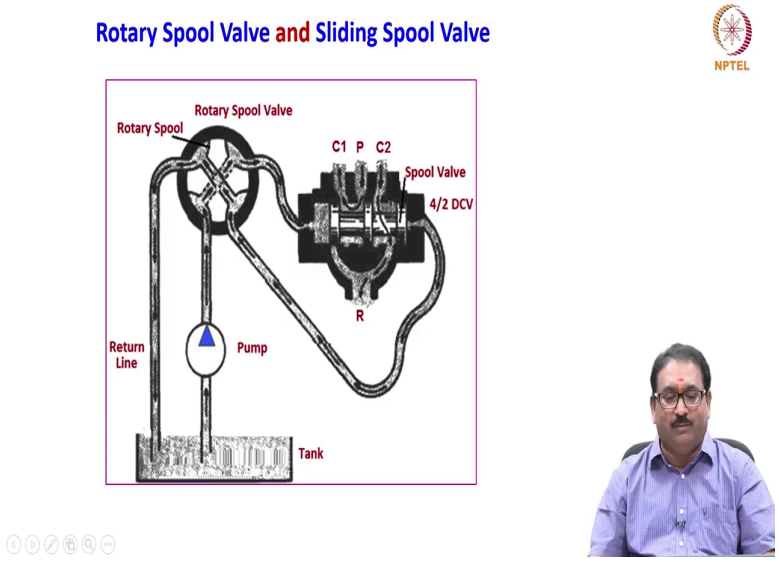

Quickly I will show you the rotary spool valve used along with the sliding spool valve how it is. You will see friends here pump flow is connecting to your rotary spool valve. You see one return line is there here and it is connecting to the sliding spool valve sliding. Spool valve already you are seeing how it is. C 1 and C 2 are the control ports, P is a pressure port, R is the return port. By moving this, the flow is going to the 4 by 2 DCVs.

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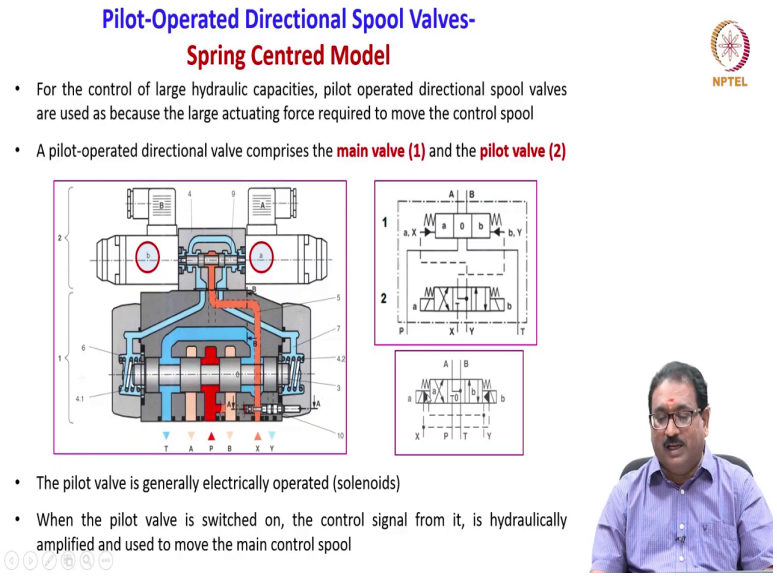

Quickly we will move on to the pilot operated directional valves. I already told you pilots are the signals to move the spool valve. How it is we will see. There are different categories are there. Now, I will show you the spring centered model. For the control of large hydraulic capacities, pilot operated directional valves are used as because the large actuating force required to move the control spool. A pilot operator directional valve comprises the main valve and the pilot valve.

Here you will see friends here this is the main valve main spool. These are the ports; A and B control ports, P is a pressure port, T is a tank port, X and Y are the pilot signals and 2 is a pilot valve. Pilot valve in term again consists of the spool valve spool valve here. Correct friend? This is a complete symbol what I have shown you here. The 1 is correspond this is corresponding to what it is?

The pilot operated DCV, left position, right position, middle one is a center position. Center position how it is achieved? Using the two stiff spring at the spool end main spool valve, you will see; two stiff springs are there and the middle position is a float center. Varieties are also available here.

The whole thing is simply represented like this also, the simple sketch it is ok. You will see here it is triangle field. These are the solenoid, hydraulic operated pilot operated valves it is. The left side here you will see crossed configuration A and B is a parallel configuration, middle one is 0, correct.

I will quickly I will tell you this. The pilot valve this is as I have told you the this is the pilot valve, this is the main valve. The pilot valve is generally electrically operated solenoids. These are the solenoid friends. A is a one solenoid and B is a one more solenoid. When the pilot valve is switched on, the control signal from it is hydraulically amplified and is used to move the main spool valve that is why it is called hydraulic signal cities.

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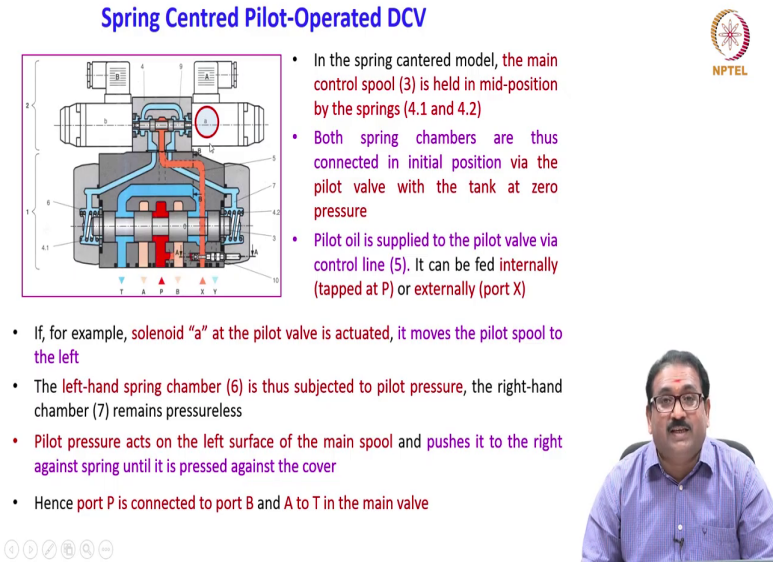

How it is I will tell you, no need to worry friends. In the spring centered model the main control spool this is the main control spool is held in the mid position by the springs 4.1 and 4.2 or the two stiff springs to achieve the mid positions. Both spring chambers here spring chambers are there are thus connected initial position via the pilot tube. Here we will see the pilot tubes pilot valve with a tank at a zero pressure.

See here connected to the zero pressure. Pilot oil is supplied to the pilot valve this is a pilot valve it is. How it is supplying? Oil is supplying through this, you will see here one port is there, how it is connecting. This is the pilot oil is supplied to this valve to move left or right through this that is why it is called X is there. You will see friends X is a pilot signal will go to move the pilot valve.

Then based on this it is moving that is why I am telling. It can be fed internally tapped through the P port or now it is I am showing you here externally tapped X. For example, I will show one example. Please understand here very quickly friends. For example, solenoid a, here you will see solenoid a actuated now at the pilot valve is actuated. It moves the pilot spool to the left side because this is used to pull it is. It will move the spool to this side.

Left the left and spring chamber, when it will move here, what happens? The flow will go to the left hand spring chamber 6 is subjected to pilot pressure this pilot pressure. When you will push the air the flow will come here subjected to the pilot pressure. The right hand side chamber 7 remains pressure less.

Pilot pressure acts on the left surface of the main spool and pushes it to the right against the spring until it is pressed against to the cover. Hence, the P is connected to the port B and A is connected to the tank. When it will push here what happen? P is connecting to B, A is connecting to tank when A is energized. When the solenoid de energized what happened friends? When the solenoid de energized means automatically this oil will be cut.

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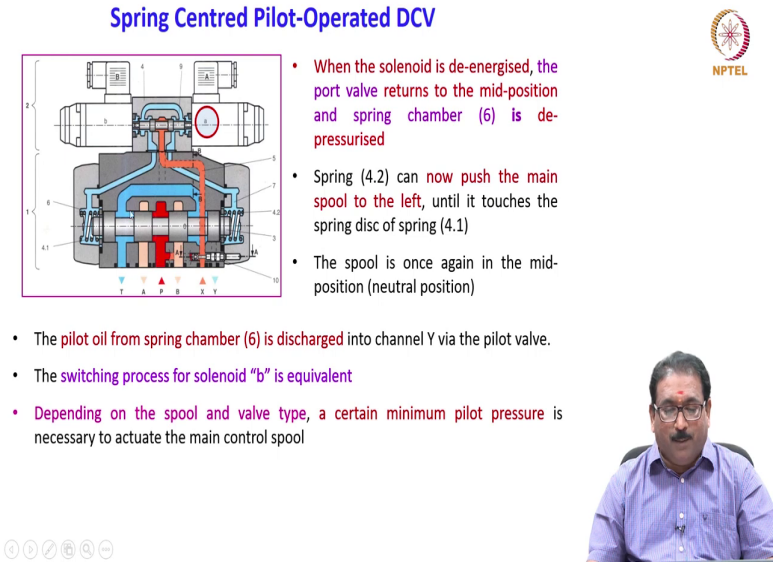

The port valve returns to the mid position this and spring is de pressurized. Spring 4.2 now pushes this back until it touches the spring disc spring disc of a spring 4.1. The spool is once again in the mid position meaning, neutral position when I will remove this signal. The pilot oil from the spring chamber 6 is discharged through the Y pilot oil.

The switching process for the B is also same. If B is energized then flow is the this is going to this side then it will compress. When you will remove then it will come to the middle position. Depending on the spool and a valve type, a certain minimum pilot pressure is necessary to actuate the main spool valve.

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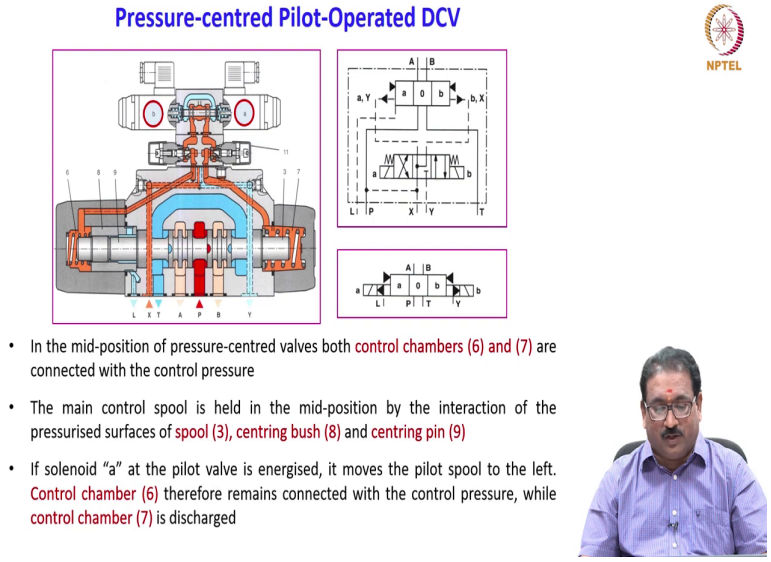

The one more position what I am showing you here is here you will see the both side the pressure, pressure centered it is, the pressure centered. In the mid position the pressure centered valves both control chambers 6 and 7 are connected with the control pressure. Control pressure hydraulic pressure is available here. It is a pressure centered. Previously your seeing spring centered. Using the hydraulic oil the oil is always balanced available 6 and 7 at the main spool valve end.

The main control spool is held in the mid position by the interaction of the pressurized surfaces of a spool and the central bush 8, this is the center bush and a centering spring, it is a centering pin it is; centering's pin, centering bush and this is a main spool. If a is energized it moves the pilots spool to the left automatically left control chamber 6. Therefore, remains connected with a control pressure while the control pressure 7 is discharging.

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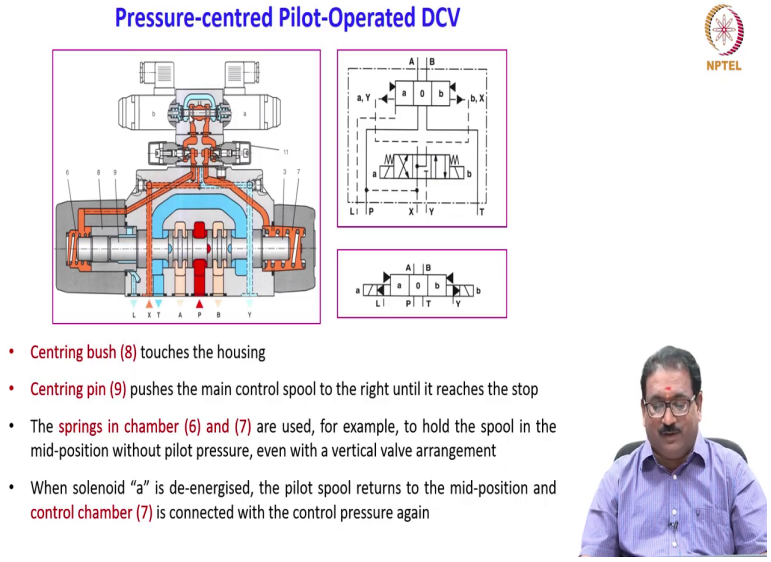

Centering bush touches the housing. Centering pin pushes the main spool to the right side until it reaches the stop. The springs in chamber 6 and 7 are used, for example, to hold the spool in the mid position without pilot pressure even with a vertical valve arrangement. When solenoid a is de energized, the pilot spool returns to the mid position pilot spool comes to the mid position and the controlled chamber 7 is connected with the control pressure again.

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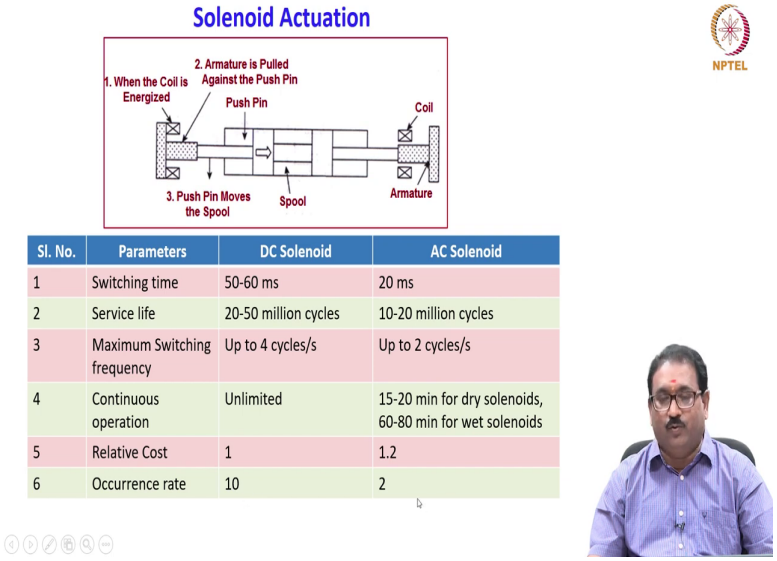

Sl. No.	Parameters	DC Solenoid	AC Solenoid
1	Switching time	50-60 ms	20 ms
2	Service life	20-50 million cycles	10-20 million cycles
3	Maximum Switching frequency	Up to 4 cycles/s	Up to 2 cycles/s
4	Continuous operation	Unlimited	15-20 min for dry solenoids, 60-80 min for wet solenoids
5	Relative Cost	1	1.2
6	Occurrence rate	10	2

Either pressure centered or a spring centered pilot operated valves are there; main spool valve and the pilot spool valve. Pilots spool valve will control the moment of the flow in the left direction or a right directions. Now, we will see what is this solenoid actuation. Quickly we will see friends.

It is a spool valve what I have shown. It is connected through the one rod to the arrangement solenoid. Solenoid nothing but, it consists of the armature and coil. When you will supply the current here electromotive force pushes the spool if it is left is energized. If right is energized then electromotive force generated on the armature will push the spool like this.

In this sketch what I have shown you here? It is a left solenoid is actuated. When the coil is energized by supplying the current what happened? Armature is pulled against the pushpin.

Quickly I will tell you whether it is a DC operated or AC operated solenoids are there in the pilot operated valve.

Some of the parameters I will show you here. Switching time in the DC solenoid is 50 to 60 millisecond, 20 millisecond in AC solenoid. Service life 20 to 50 million cycles, here 10 to 20 million cycles. Maximum switching frequency up to 4 cycles per second, here up to 2 cycles per second. Continuous operation is unlimited; here it is 15 to 20 minute for dry solenoids and 60 to 80 minute for wet solenoids. The relative cost is 1 is to 1.2, occurrence rate is 10 is to 2.

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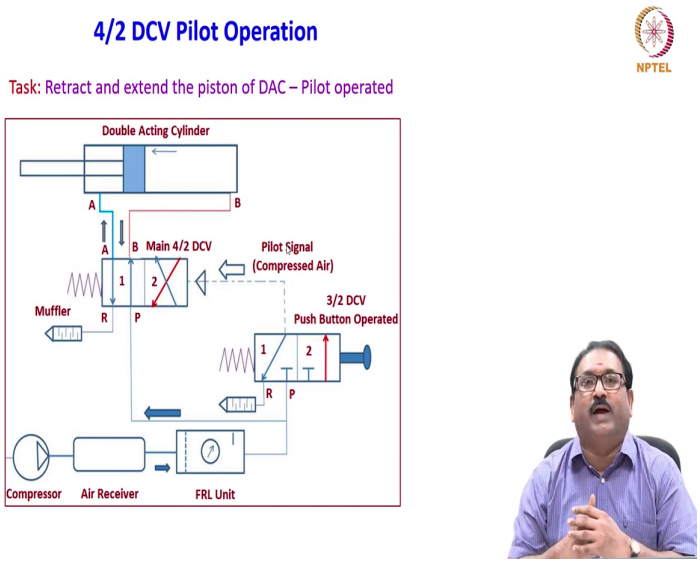

Quickly we will see now here, you are seen 4 by 3 pilot operated valve, here I am showing you the main 4 by 2 pilot operated valve controlled through the 3 by 2 push button actuated

valve. Here I am controlling the double acting cylinder friends. Here extending and retracting the DCV pilot operated.

You will see here it is a pneumatics compressor is there, air receiver, FRL is must. Before going to the control valves what we have seen? In the null position what happen? No signal to this, no pilot signal, you will see here all our venting. Then this is only active, only air is coming here, it is going to the head side then it will extend.

Whatever the air is at roadside it will go through the muffler because always it is making the sound. To overcome the sound the mufflers are used. When it will activate? When you will push this button what happened friends? The 2 is actuated. When 2 is actuated the pilot signal will come then the flow is going to the tail side and head side flow is going to the tank. But you will see here friends why I have shown.

This is a pilot operated 4 by 2 a valve. These 4 by 2 a valve is operated using the pilot meaning pilot spool is there. The moving this pilot controls the 4 by 2 DCV.