**Oil Hydraulics and Pneumatics**
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**Proportional Valve Technology**
**Lecture - 86**
**Part 1: Recap on Course Content, Status and developments, Integration of electronics, Different levels of controls in various applications, Important features of proportional and servovalve, Valve configurations and characteristic curves**

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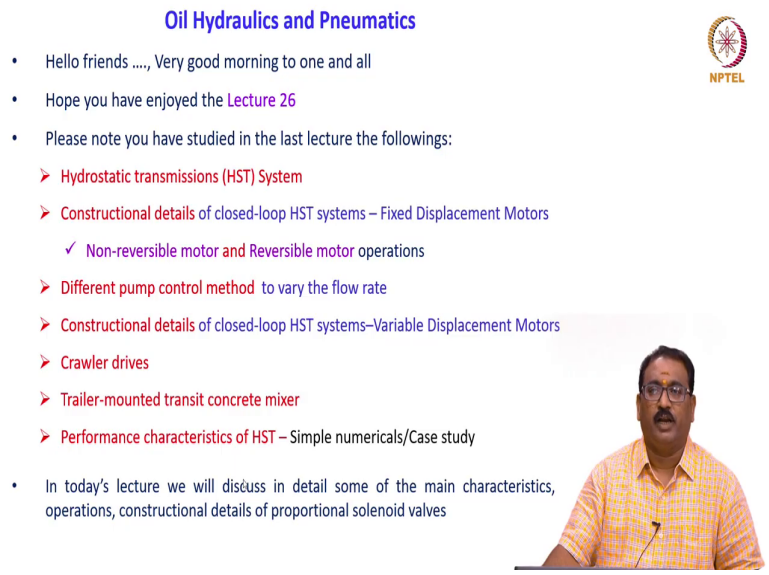


My name is Somashekhar, course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed the last lecture 26th. Please note you have studied in the last lecture the followings: Hydro static transmission system, constructional details of closed-loop HST systems-fixed displacement motors, non reversible motor and reversible motor operations.

Different pump controlled method to vary the flow rate, constructional details of closed-loop HST systems-variable displacement motors, crawler drives, trailer mounted transit concrete mixture, performance characteristics of HST, here we discussed a simple numericals. In today's lecture we will discuss in detail some of the main characteristics, operations, constructional details of proportional solenoid valves.

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Let us we will move on to organization of presentation. Here we will discuss status and development in fluid power system, integration of electronics in fluid power circuit, is it essential, different levels of controls in various applications.

Important features of proportional and servovalve, valve configurations and characteristic curves, quick glance on flapper valve and jet pipe valve, status on proportional valve technology. Move on to proportional control valves and introduction. Next signal sequence in

proportional control valves, possible functions and proportional valves, open loop and closed loop system. Later we will discuss proportional valve versus servovalve finally, I will conclude today's lecture.

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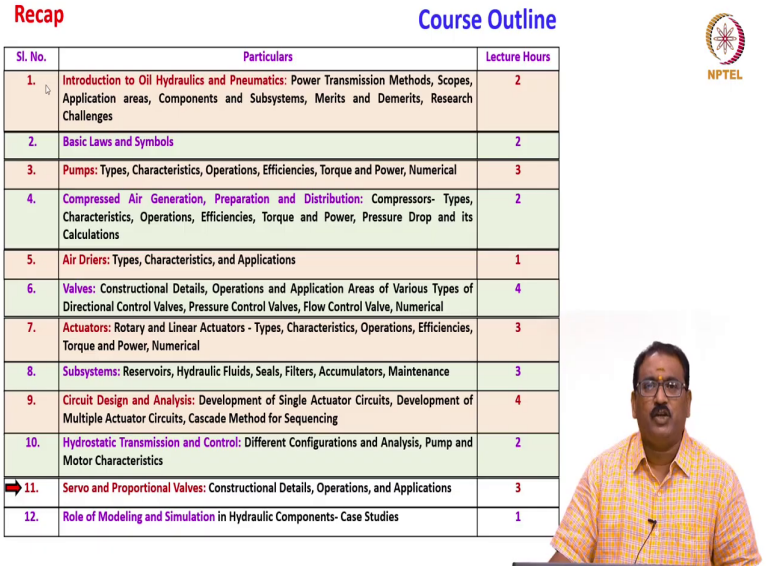


| Sl. No. | Particulars | Lecture Hours |
|---|---|---|
| 1. | Introduction to Oil Hydraulics and Pneumatics: Power Transmission Methods, Scopes, Application areas, Components and Subsystems, Merits and Demerits, Research Challenges | 2 |
| 2. | Basic Laws and Symbols | 2 |
| 3. | Pumps: Types, Characteristics, Operations, Efficiencies, Torque and Power, Numerical | 3 |
| 4. | Compressed Air Generation, Preparation and Distribution: Compressors- Types, Characteristics, Operations, Efficiencies, Torque and Power, Pressure Drop and its Calculations | 2 |
| 5. | Air Driers: Types, Characteristics, and Applications | 1 |
| 6. | Valves: Constructional Details, Operations and Application Areas of Various Types of Directional Control Valves, Pressure Control Valves, Flow Control Valve, Numerical | 4 |
| 7. | Actuators: Rotary and Linear Actuators - Types, Characteristics, Operations, Efficiencies, Torque and Power, Numerical | 3 |
| 8. | Subsystems: Reservoirs, Hydraulic Fluids, Seals, Filters, Accumulators, Maintenance | 3 |
| 9. | Circuit Design and Analysis: Development of Single Actuator Circuits, Development of Multiple Actuator Circuits, Cascade Method for Sequencing | 4 |
| 10. | Hydrostatic Transmission and Control: Different Configurations and Analysis, Pump and Motor Characteristics | 2 |
| 11. | Servo and Proportional Valves: Constructional Details, Operations, and Applications | 3 |
| 12. | Role of Modeling and Simulation in Hydraulic Components- Case Studies | 1 |

Dear friends, see here this is a course outline, where we discussed there are many things on conventional Oil Hydraulics and Pneumatics. We started with introduction to oil hydraulics and pneumatics and basic laws and symbols, pumps, compressed air generation, preparation and distribution system, air driers, various types of valves, actuators, sub systems, circuit design and analysis.

And also we discussed hydro static transmission and control in previous lecture. Now we reached here servo valve and proportional valves, here we are discussing mainly the constructional details, operations and applications. Here we are focused on 3 hours lecture in

which I am dividing the first lecture is mainly focused on proportional solenoid valves. The next lecture we will concentrate on the servo valves and third one is electro hydro static actuators.

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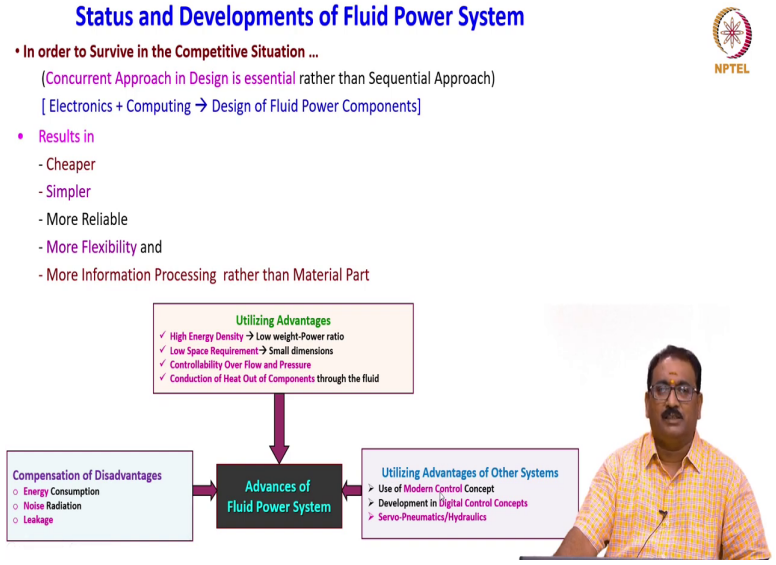


Now, we will begin today's lecture we will see status and developments of fluid power system. In order to survive in the competitive situation, as I have told you the concurrent approach in design is essential rather than a sequential approach, meaning a mechatronic approach is required in the design of fluid power components to survival for the longer duration.

So, the electronics and a computing in the design of fluid power components is an need of power, which results in cheaper, simpler, more reliable, more flexibility and more

information processing rather than a material part. So, such valves are essential in the modern industry.

So, what to do now friends? So, to advance in the fluid power system, we have to utilize the advantages gained from the fluid power system like a high energy density, low space requirement, controllability overflow and pressure, conduction of heat out of components through fluid.

Then we have to compensate the disadvantages in the fluid power system, energy consumption, noise radiation, leakage and also utilize the advantages of other technologies. The modern control concepts, development of digital control concepts, servo and proportional valves are the resultant now.

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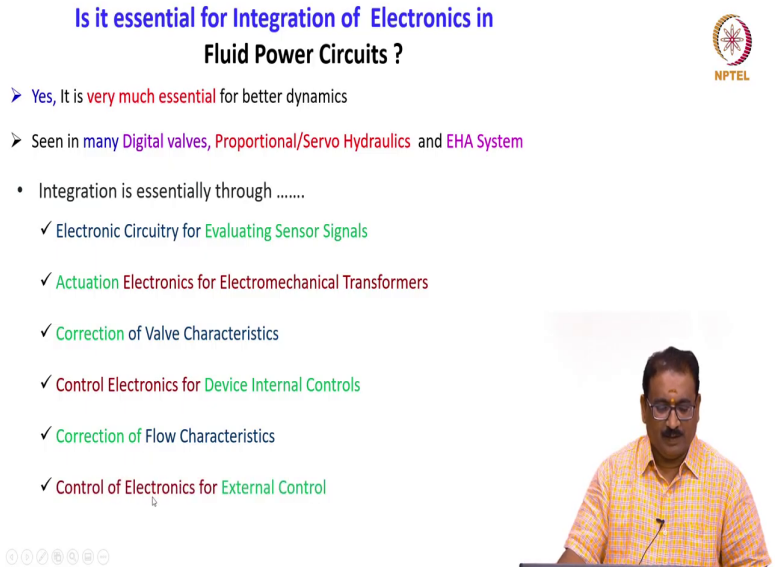

Now, we may think now in a broader way. Is it essential for integration of electronics in fluid power circuits? Yes, it is very much essential for better dynamics. Seen in many digital valves, proportional and servo hydraulics we are discussing today and EHA system electro hydro static actuator system.

So, integration is essential through, electronic circuitry for evaluating a sensor signals, actuation electronics for electromechanical transformers, correction of valve characteristics, control electronics for device internal controls, corrections of flow characteristics, control of electronics for external controls.

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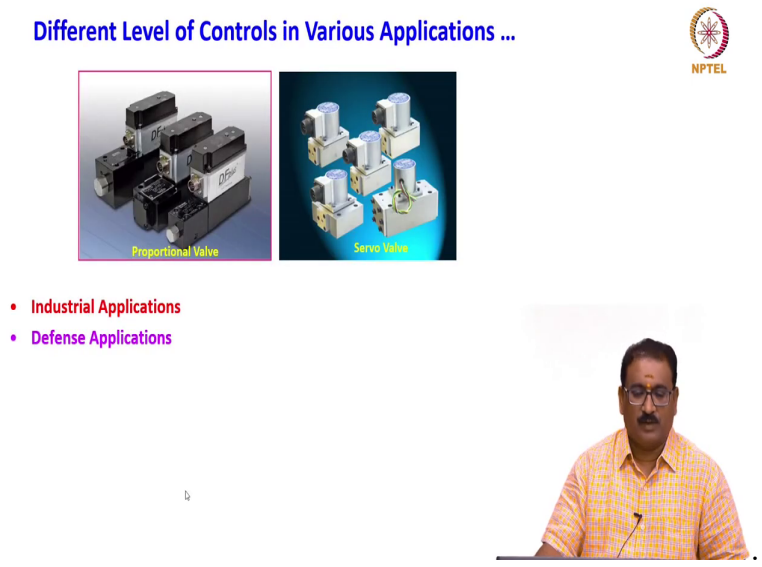

So, you will see now friends, that different level of controls are required in industry as well as in the defense, meaning large number of applications are there for the proportional valves and the servo valves.

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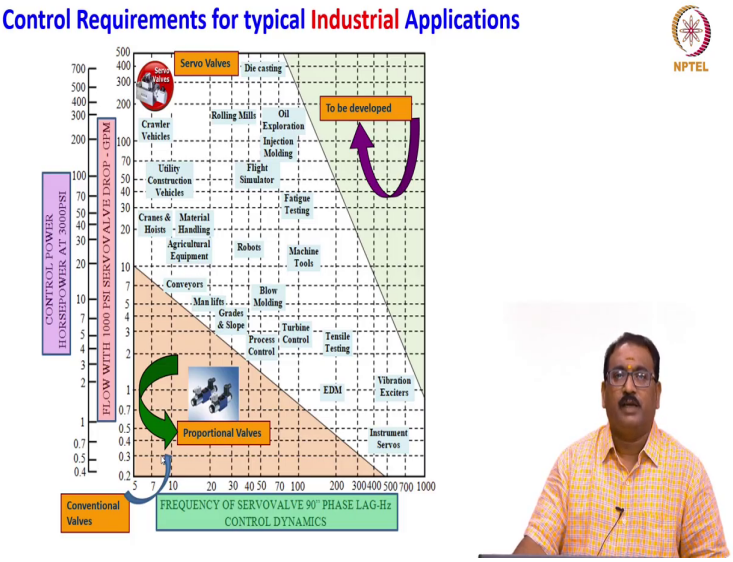


Let us we will see this the control requirement for typical industrial applications ah. Here we have discussed already in the beginning the y axis shows the flow and control power and x axis will show the frequency of servo valve correct and control dynamics basically.

Here you will see whatever we discussed now, conventional valves are having the lower frequency and lower control power. Next one is we are thinking for the electronic integration, electrical integration in the valve characteristics. So, which results in the proportional valves

which are better than the conventional valves which has the frequency response is better than the conventional valve, similarly the control power is very good.

Next one comes the servo valve, servo valves they occupy the large number of application which has a control power is very high, also the flow is controlled. Similarly, the frequency response of the valve is very good compared to the proportional valves and a conventional valves.

You will see here friends, here I am listing the large number of applications here die casting, rolling mills, oil exploration, injection molding, robots, fatigue testing, machine tools, blow molding, many machine tools in industries are drive through the servo valves. Now, people are thinking to develop the very high frequency response valve and high control power which is to be developed in the future.

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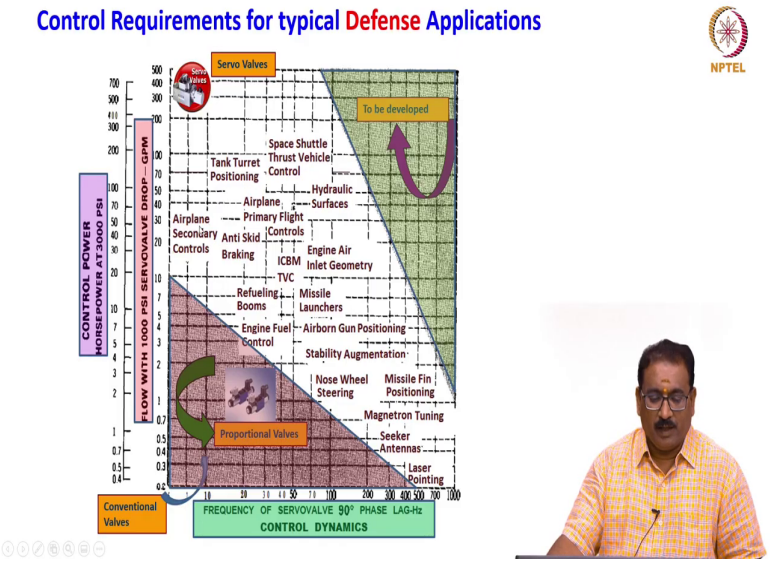

Similar to that, now we will see the control requirements for a typical defense application. The same curve it is, but I am writing here the application of servo valves in the defense applications like a tank turret positioning, airplane secondary controls, anti skid braking, refueling booms, engine fuel control, space shuttle thrust vehicle control, and many more you will see here there are the large applications of servo valve in defense.

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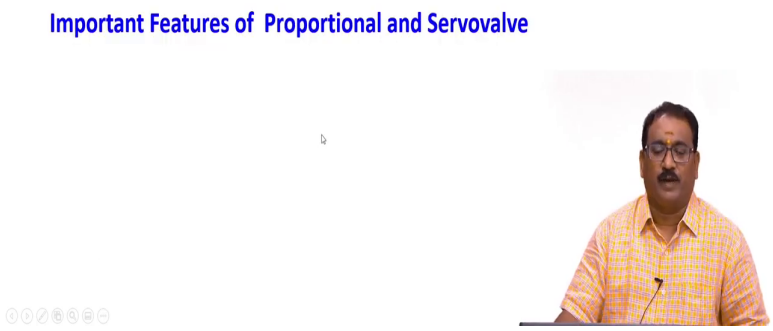


Now, we will see this friends, what is the important features of proportional and servo valve. I will give you the quick glance on one slide about this.

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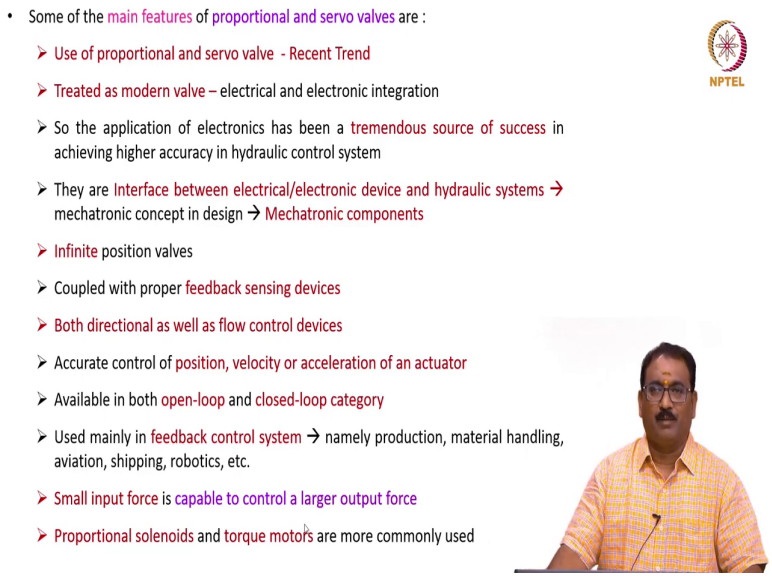


Some of the main features of proportional and servo valves are: use of proportional and servo valve is a recent trend, treated as the modern valve here electrical and electronic integration in your hydraulic component.

So, the application of electronics has been a tremendous source of success in achieving the higher accuracy in hydraulic control system. They are interface between electrical, electronic device and hydraulic systems treated as a mechatronic concept in design which results in the mechatronic components.

These proportional and servo valves are the mechatronically designed valves which integrates the mechanical, electronic and information processing in the system. Infinite position valves, they are coupled with proper feedback sensing device. They are available both directional as

well as flow control valves. Accurate control of position, velocity or acceleration of an actuator is ensured.

They are available in both open-loop and closed-loop category. But please remember friends the servo valves are always works on the closed loop category, the proportional valves are a open loop, but now they are extending to the closed loop in proportional valve also.

Used mainly in feedback control system, namely production, material handling, aviation, shipping, robotics and many places. Here advantage here is small input force is capable to control a large output force. Proportional solenoids and a torque motors are more commonly used. Please remember friends, the proportional valves works on the proportional solenoids, servo valves are drive through the torque motors.

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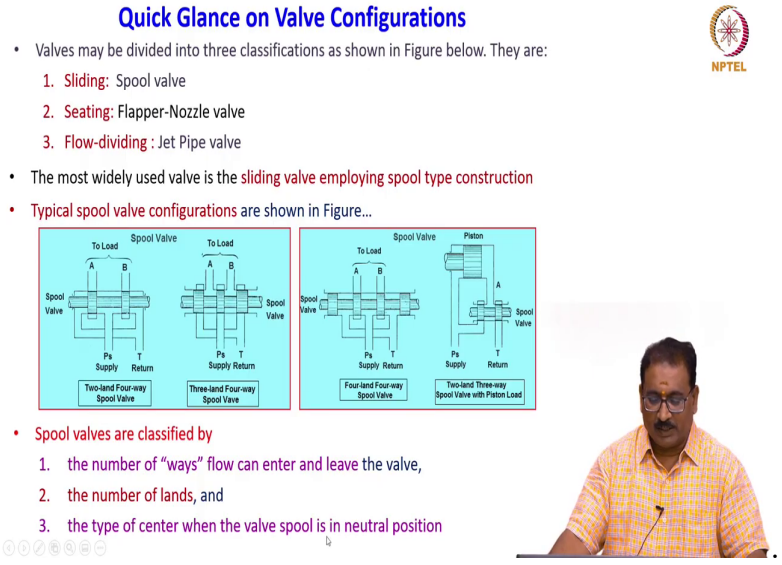

After knowing these important features of the proportional and servo valve, we will move on to the quick glance on valve configuration which is essential to understand the valve dynamics, both in case of the proportional and a servo valves. The valves may be divided into three classifications as shown in the figure below.

They are sliding type here the spool valves comes into picture, seating type here flapper nozzle valve comes into picture, flow dividing here jet pipe servo valve come into picture. These things we will discuss in the next class, but to understand the critical center valves, closed center valves, open center valve very important thing is you have to know the valve configuration in the null position.

The most widely used valve is the sliding valve employing a spool type construction. Now we will see here friends, I have shown you typical spool configurations here first one you will see here it is a spool valve this is the valve body correct, in which supply port is there, return port is there and A and B are the actuator port meaning it is goes to the load, here the two land, this is two land spool lands are there four ways spool valve because how many ports four ports Ps, T, A and B.

Now, we will see here friends next one, the three lands are there please see here three lands are there, again the four ports are there pressure port, tank port to the load through actuator port A and B correct. Now we will see here four land four way spool valve it is you will see the four lands are there meaning the land may varies based on the requirement.

Now, here you will see I have shown you the two land two land here you will see the spool two land three way spool valve with a piston load this is a piston load, on equal areas please remember here. Let us we will see the details of these spool valves are classified by the number of ways how the fluid will go and how it will exit from the valve, flow can enter and leave the valve.

The number of lands, two land, three land, four land up to five land spools are also available commercially. And the type of center this is very important when the spool is in the neutral position.

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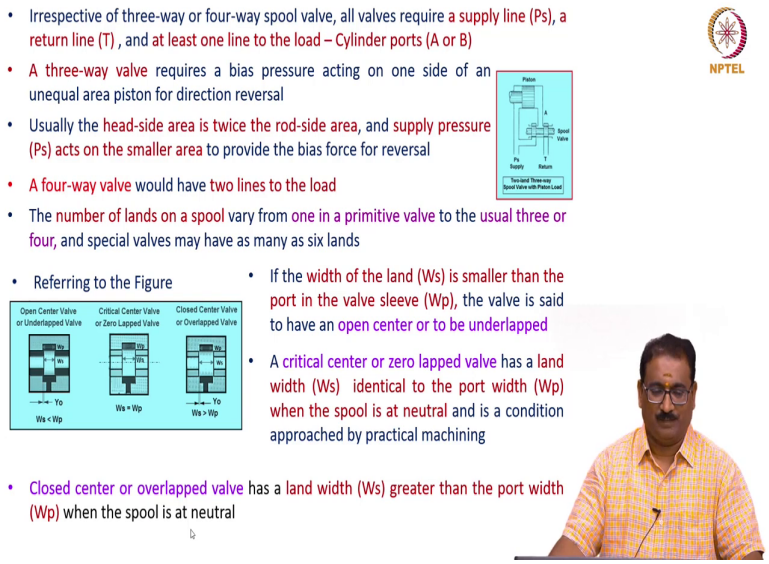


Irrespective of the three way or four way spool valve, all valves require the supply port meaning P line is required Ps, a return line what you can call it is a tank port T, and at least one line to the load.

For example in single acting cylinder only one port, double acting cylinder two ports are there. So, a three way valve requires a bias pressure acting on the one side of the unequal area piston for a directional reversal, as I have told you here supply port is here it will act here and you will see here friends this is a spool valve.

That is why one port Ps, T and one is a A which will go to the piston end. Usually the head area is twice the rod area and a supply pressure P, see here acts on the smaller area to provide the bias force for the reversal. A four way valve would have two lines to the load that is why it is a two ports A port and a B ports.

The number of lands on a spool vary from one in primitive valve to the usual three or four and a special valves may have as many as six lands also. Now, we will see this friends, when the valve is in the neutral position meaning when the spool valve is in the neutral position we have to study the flow characteristics how it behaves.

Now, I am showing you here the many things here, you will see here the one land I am taking here it is a valve port is Wp I am taking, Ws is a width of the spool and Wp is a width of the port, A and B what you can call it as. Now we will see the open center valve first what is the open center valve you will see here open center valve meaning here Ws width of the spool is less than the width of the port, meaning in the null position itself the flow is taking place on either side of the spool land.

Now next one you will see Ws width of the spool is equal to the width of the port, meaning it is a critical center valve or a zero lapped valve. This can be achieved by manual machining like a lapping and honing many process they will adapt for this.

Now, one more I have shown you here, here what it is Ws width of the spool is greater than the width of the ports, meaning it is a closed center valve or overlapped valve. Now as I have told you this thing if the width of the land is smaller than the width of the sleeve, the valve is said to be open center or a under lapped valve.

A critical center or a zero lapped valve has a land width Ws identical to the port width Wp when the spool a is at the neutral and at the condition approached by practical machining as I have told you. The closed center or a over lapped valve has a land width Ws greater than the port width Wp when the spool is at the neutral position.

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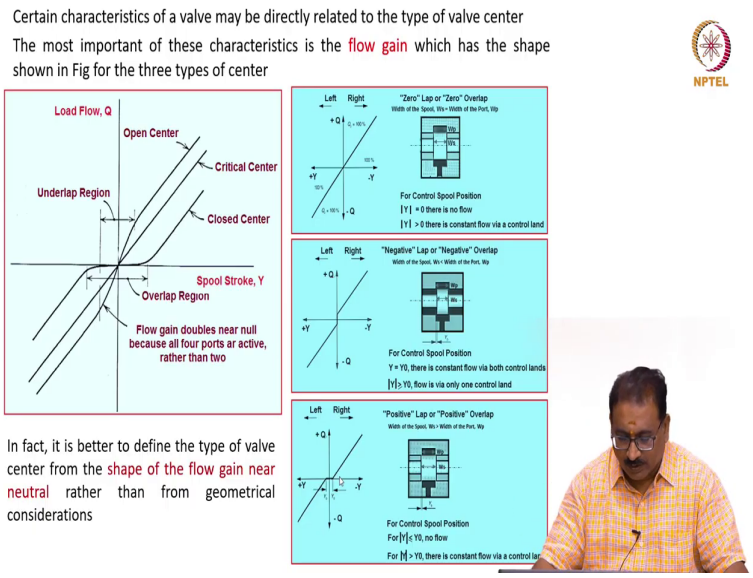


Certain characteristics of a valve may be directly related to the type of valve center. The most important of these characteristics is the flow gain which has the shape shown in figure for three types of centers. You will see here, here the load flow along the y axis Q and along the x axis the spool stroke Y I am taking. Here you will see friends lines you will see on either sides spool will move on the your right side this is a flow characteristics for the critical center, open center and a closed center. When the spool is stroked in the other direction the flow will be in the replica of this.

Now, let us we will understand this, what are this. In fact, it is better to define the type of valve center from the shape of the flow gain near the neutral position, what happens here for all the valve center rather than from the geometrical consideration. Let us we will see the flow

characteristics in the flow gain near the neutral, what happens here you will see here as I have told you in the first I am showing you here the zero lap or a zero over lap.

Meaning here width of the spool is equal to width of the port, width of the spool width of the port are equal now. For the control spool position, Y is plus or minus equal to 0, there is no flow, no flow here, please remember. A Y modulus of Y is meaning it will move plus or minus is greater than 0 there is a constant flow via a control land as soon as it will move the flow takes place. How it is, linearly see here linearly it will takes place.

Now, we will see the negative lap, what is a negative lap? Meaning Ws is less than the Wp, it is also known as negative lap or a negative over lap. For a condition spool position you will see here the beginning itself it is opened, if Y equal to Y 0 there is a constant flow via both control lands on either side flow is taking place in the null position itself.

Y is greater than or equal to Y 0, flow is via only one control port and it will starts moving this side flow is taking place from the only one control port. The flow characteristics you will see beginning itself we are getting the more flow then as the spool will stroke move the flow is taking place linearly.

Now, in one more case you will see here friends, the positive lap. What is the positive lap? Width of the spool Ws is greater than the width of the port Wp. Here overlap is there please see here friends for a control spool position, if modulus of Y is less than or equal to Y 0. no flow friends here until the dead band meaning the spool over lap will cross there is no flow. After crossing only the flow will takes place linearly with respect to the spool stroke please understand, this is known as a dead bands.

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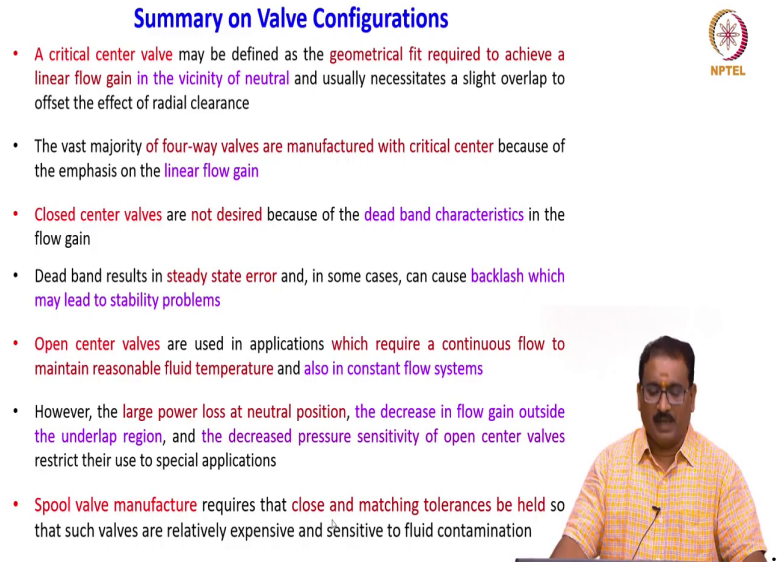


Now, quickly I will summarize this, what we have studied in the one configurations. A critical center valve may be defined as the geometrical fit required to achieve a linear flow in the vicinity of neutral and usually necessitates a slight overlap to offset the effect of radial clearance. The vast majority of four way valves are manufactured with critical center because the emphasis on the linear flow gain.

Closed center valves are not desired because of the dead band characteristics in the flow gain. Dead band results in steady state error and, in some cases, can cause a backlash which may lead to stability problems. Open center valves are used in applications which require a continuous flow to the actuator to maintain a reasonable fluid temperature and also in constant flow systems.

However, the large power loss at a neutral position. The decrease in flow gain outside the under lap region, and the decreased pressure sensitivity of open center valves restricts their use to special applications. Spool valve manufacturer require that close and a matching tolerances be held so that such valves are relatively expensive and a sensitive to fluid contamination.