Oil Hydraulics and Pneumatics
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Electro Hydraulic Servo Valve (EHSV)
Lecture - 89
Part 1: Introduction, Hydraulic servo actuators and Applications, Electrohydraulic Servovalve (EHSV), Typical applications of EHSV, Block Diagram of EHSV

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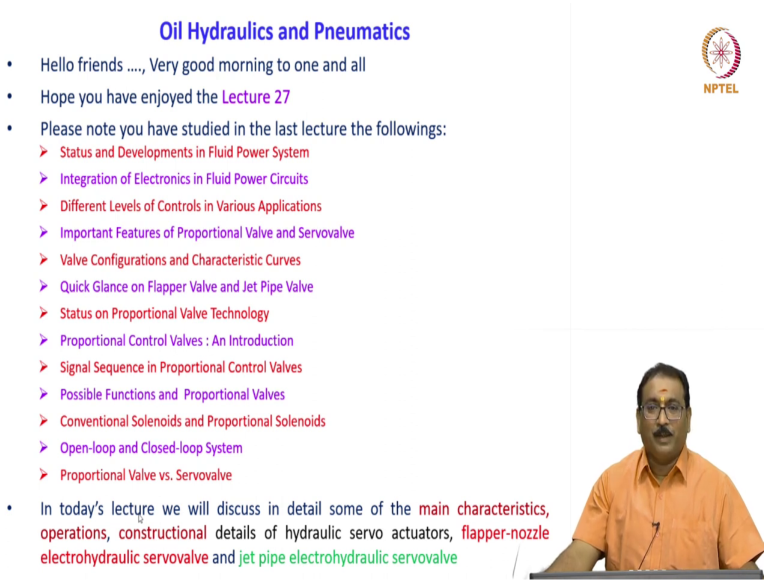

My name is Someshekhar course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed the lecture-27. Please note you have studied in the last lecture the followings.

Status and development in fluid power system, integration of electronics in fluid power circuits, different levels of controls in various applications, important features of proportional valve and a servo valve, valve configurations and characteristic curves for the under lap valve, null cut valve, overlapped valve. Quick glance on flapper valve and a jet pipe valve. Today, we will discuss in detail about these valves.

Status on proportional valve technology, proportional control valves we are given the importance in the lecture-27, signal sequence in proportional control valves, possible functions and a proportional valves. Conventional solenoids and a proportional solenoids. Also we have seen open loop and a closed loop systems; proportional valve versus servo valve.

Ok friends, in today's lecture, we will discuss in detail some of the main characteristics, operations, constructional details of beginning I will take you one or two slide on hydraulic servo actuator, but today's lecture focused on the flapper-nozzle electro hydraulic servo valve, and a jet pipe electro hydraulic servo valve.

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Begin with organization of presentation; quickly I will give you the introduction, then hydraulic servo actuators – construction and typical applications very quickly because these are the mechanical servos. Next we will move on to the electro hydraulic servo valve, typical applications of electro hydraulic servo system, block diagram of electro hydraulic servo systems, servo valve constructions – here we will see the different stages.

Flapper-nozzle electro hydraulic servo valve – we will see here constructional details operations. Later we will move on to jet pipe electro hydraulic servo valve; here also we will see the constructional details operations. Finally, I will conclude the today's lecture.

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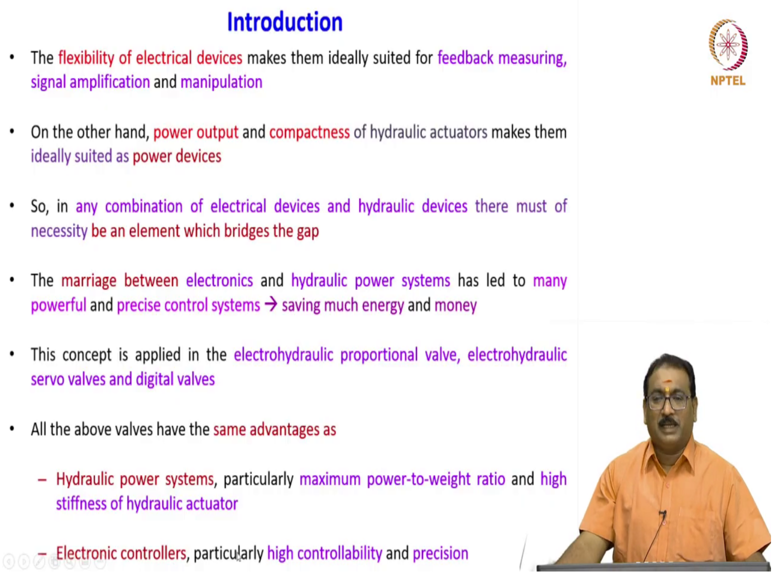

The flexibility of electrical devices makes them ideally suited for feedback measuring, signal amplification and manipulations. On the other hand, power output and compactness of hydraulic actuators makes them ideally suited as a power sources or a power devices. So, in any combination of electrical devices and a hydraulic devices there must of necessity be an element which bridges the gap.

The marriage between the electronics and hydraulic power systems has led to many powerful and precise control systems which results in saving of much energy and a money. This concept is applied in the electro hydraulic proportional valve, electro hydraulic servo valves and a digital valves.

All the above valves have the same advantages as hydraulic power systems, particularly maximum power-to-weight ratio and high stiffness of hydraulic actuator. Same advantages as electronic controllers particularly high controllability and a precision.

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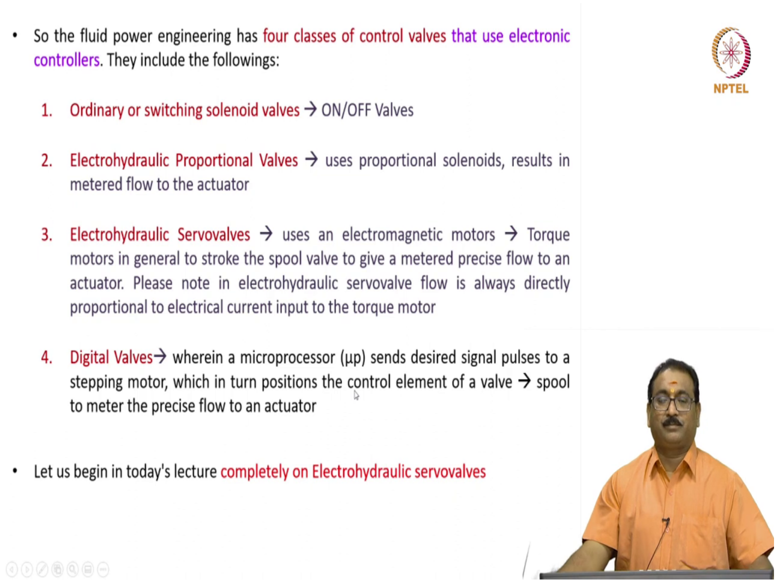

So, the fluid power engineering has four classes of control valves that use the electronic controllers. They include the followings. Ordinary or a switching solenoids meaning they also known as ON-OFF valves. Second category – electro hydraulic proportional valves uses a proportional solenoids, results in a metered flow to the actuator – meaning the in between positioning of the spool is possible; in the ordinary switching valve, it is not possible.

Next category is electro hydraulic servo valves uses an electromagnetic motors, generally, the torque motor to stroke the spool valve to give a metered precise flow to an actuator. Please note friends in the electro hydraulic servo valve flow is always directly proportional to the electric current input to the torque motor.

Next category of valve is digital valves wherein the micro processor sends desired signal pulses to a stepping motor, which in turn positions the control element of a valve meaning it is the spool to meter the precise flow to an actuator.

Let us begin in today's lecture completely on electro hydraulic servo valve. Before that as I have told you the mechanical servo actuators we will see because they find a large number of application still in industry.

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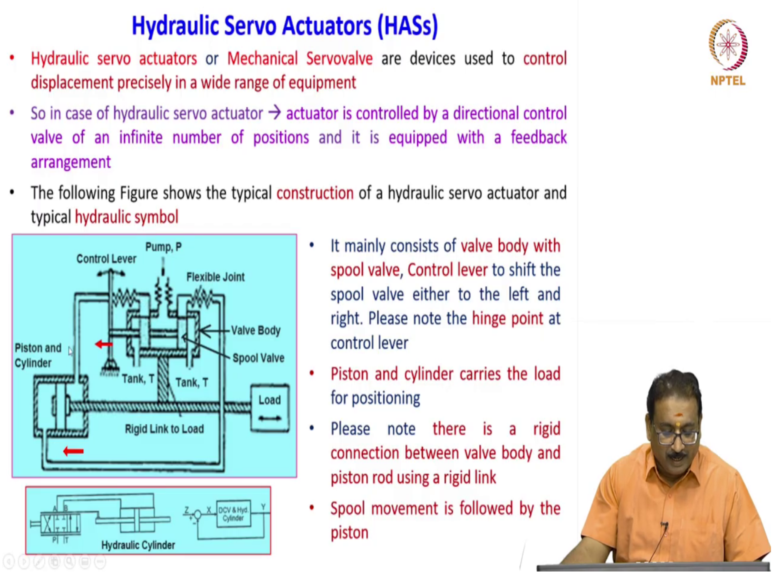

Hydraulic servo actuator they are also known as HAS. Hydraulic servo actuators as I have told you also known as mechanical servo valve or devices used to control displacement precisely in a wide range of equipment. So, in case of hydraulic servo actuator, actuator is controlled by a directional control valve of an infinite number of positions and it is equipped with the feedback arrangement. The following figure shows the typical construction of a hydraulic servo actuator and a typical hydraulic symbol.

Let us we will see here friends. The so many items are there here, but very simple it is. Please remember this is very, very important the valve body with the spool. And then this is the actuator piston and cylinder actuator.

I will tell you all these things no need to worry how it is. It mainly consists of the valve body with a spool valve. Control lever, you will see here control lever coupled to the spool valve, to shift the spool valve either to the left or the right. Please note the hinge point, see here the hinge point at the control lever.

Piston and cylinder carries the load for positioning through the piston rods. Please note here friend there is a rigid connection between the whole valve body and the piston rod using a rigid link very important it is. Spool movement is followed by the piston.

Now, I have shown you here the two arrow mark to illustrate when the lever is push to the left side. What happen? You will see here the pump port is there here middle, the two tank ports here. Please see here this is a spool valve, assumed to be when now we will see here all ports are blocked P port is blocked to the actuator port also, this is also blocked. But when will move the lever it should be moved in the left side or a right side, it will rotate around the hinge point please remember this. When it will move to the left side, what happens here? The pump flow will come here, it will enter through this, and it will come to the tail side.

Then what happens the piston will starts moving please remember whatever the flow is there, it will come here, it will go here, then it is opened know because I moved here it will go through this to the tank. Please remember friends the piston follows the spool motion, both will move in the same direction.

As it will move, what happens you will see here it is moving know the whole body is also moving – meaning here this lever whatever you moved it will bring back to the null position. Feedback is there that is why I am telling please understand this very carefully.

Now, you will see here I have shown you the symbol. This is a middle position, ports are blocked here, friends correct ports are blocked. Then if you will move here – crossed configuration, parallel configuration, this is a lever to move it correct. Now, I am showing you here the push button, but you will see here the whole units how it is integral. It is precisely controlled. This is I have shown you here it is a the double rods cylinder.

But main objective is here if you will give the z input to this – meaning it will results in the port opening, correct, port opening X. Then what happen it will go from the direction control valve to the actuator. Then after moving it will be feedback as I have told you know it will feedback it is mechanical feedback, both will match. Please understand the how it is closed loop is achieved in the mechanical servo valve.

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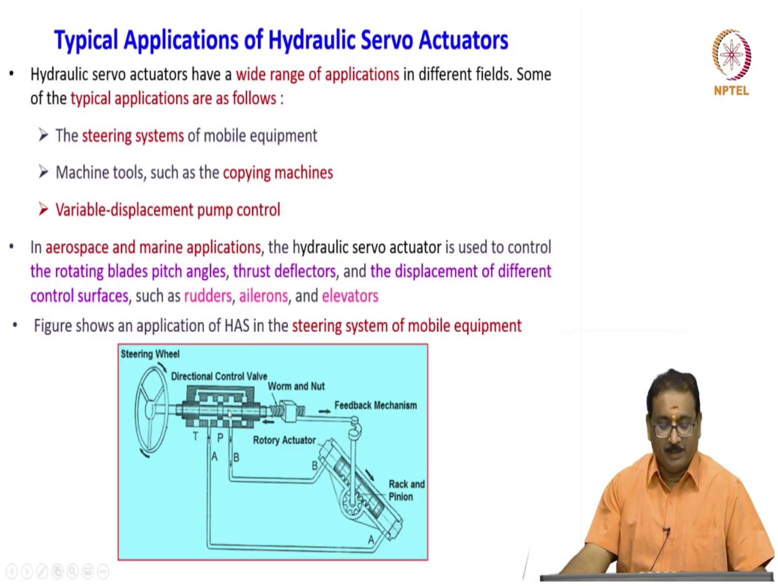

Now, quickly I will show you the typical applications of hydraulic servo actuators. Hydraulic servo actuators have a wide range of applications in different fields. Some of the typical applications are as follows. The steering systems of mobile equipment, machine tools such as a copying machines, variable-displacement pump control is also achieved through the servo actuator.

Quickly, I will show you these things. In aerospace and marine applications, the hydraulic servo actuator is used to control rotating blades, pitch angles, thrust deflectors, and the displacement of different control surfaces, such as rudders, ailerons, and elevators. Figure shows an application of HAS in the steering system of a mobile equipment.

Here it consists of a directional control valve which has a valve body with a ports – P port, A port, B port, and a tank ports correct. And then this spool valve is connected at one side the steering wheel and other side worm and nut mechanism. Then it is connected to the feedback mechanism ok, very simple it is friends.

When the steering wheel will move, assumed to be it will moved like this, then what happen, pump flow will come here, come here and go to the B side. Then this will move and whatever the fluid is there, come here, come here, it will go to the tank.

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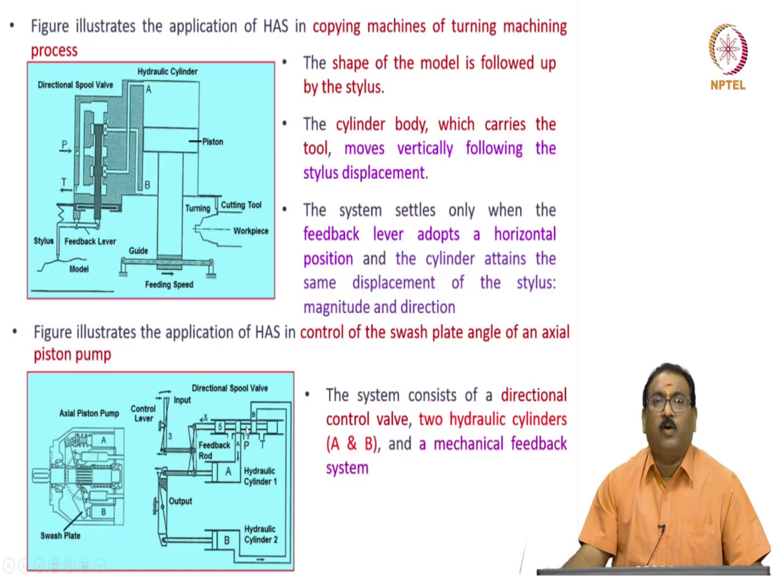

Another example is figure illustrates the application of HAS in a copying machine of a turning machining process. Here you will see friends here; similarly a directional control valve is there. Here it is connected to the you know hydraulic cylinder correct. Hydraulic cylinder is connected through the cutting tool. This is the work piece. This is the tool in the turning process.

Then you will see here this is the feedback speed is monitored – meaning mechanical feedback again this is a feedback lever. Then please remember friends during the operation, the cutting tool follows the stylus positions. This is the feedback lever correct.

Let us we will see the shape of the model is followed by the stylus. The cylinder body which carries tool, moves vertically following the stylus displacement. Stylus displacement lead to the movement of the spool valve, in turn flow is going to the A side or B side. Same way the tool will also follows the stylus displacement.

The system settles only when the feedback lever you will see the feedback lever adopts a horizontal position and the cylinder attains the same displacement of the stylus, in terms of magnitude and a direction very, very simple it is. It is a copying mechanisms. Here again directional spool valve is use to in the turning machining operation.

Now, one more is figure illustrates the application of HAS in the control of the swash plate angle of the axial piston pump. Swash plate angle as you know when will vary, the flow will varies. Whenever it is the middle position – center no flow correct. How to achieve this? You will see here I am shown the axial piston pump; here it is the swash plate correct. This swash plate movement is altered using the hydraulic servo actuator. Here you will see this is a directional spool valve, then which is connected to the hydraulic cylinder 1 and hydraulic cylinder 2 which in turn connected to the output and the input. You will see here the lever, lever to move correct, the to move the spool valve.

Then what happens, it will follows the flow. For example, you will see friends here when I will push this, what happen, when you will push this spool valve, the flow is coming from the pump and it will come here. Then what happens? You will see here both are hinged. Then due to this pushing, it will make the feedback, it will make the vertical. Always, whenever the vertical, no flow.

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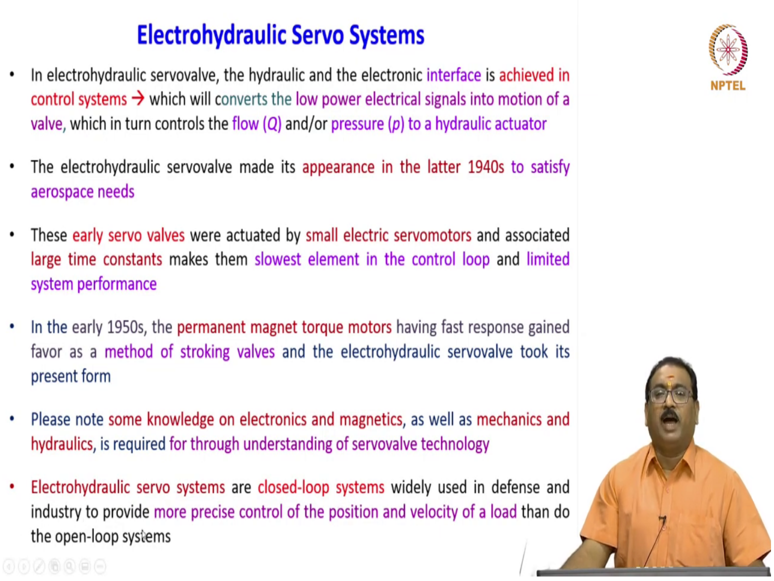

After knowing the hydraulic servo actuator, quickly we will move onto the electro hydraulic servo systems. In electro hydraulic servo valve, the hydraulic and electronic interface is achieved in control systems which will convert the low power electrical signal into motion of a valve, which in turn controls the flow and or a pressure to the hydraulic actuator.

The electro hydraulic servo valve made its appearance in the later 1940s to satisfy the aerospace needs. These early servo valves were actuated by a small electric servo motors and associated large time constants makes them slowest element in the closed loop and limited system performance. In the early 1950s, the permanent magnet torque motors having fast response gained a favor as a method of stroking the valves and the electro hydraulic servo valve took its present form.

Please note some knowledge on electronics and magnetics as well as mechanics and hydraulics is required for thorough understanding of servo valve technology. Electro hydraulic servo systems are the closed-loop systems widely used in defense and industry to provide more precise control of the position and velocity of a load than do the open-loop systems.

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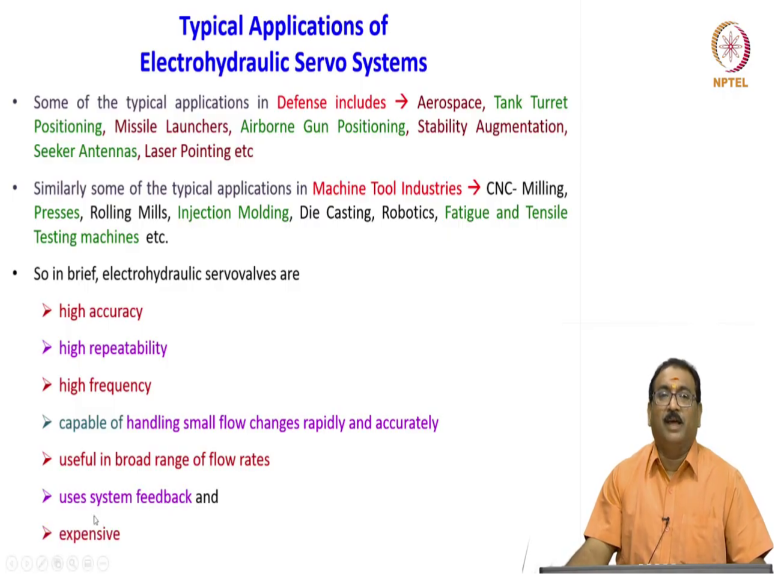

Now, let us we will quickly see the typical applications of electro hydraulic servo systems. Some of the typical applications in defense includes aerospace to controlling the control surfaces, tank turret positioning, missile launchers, airborne gun positioning, stability augmentation, seeker antennas, laser pointing and many more.

Similarly, some of the typical applications in machine tool industry – CNC milling, presses, rolling mills, injection molding, die casting, robotics, fatigue and tensile testing machines, and many more.

So, in brief electro hydraulic servo valves are high accuracy, high repeatability, high frequency, capable of handling small flow changes rapidly and accurately, useful in broad range of flow rates, uses a systems feedback and they are expensive.

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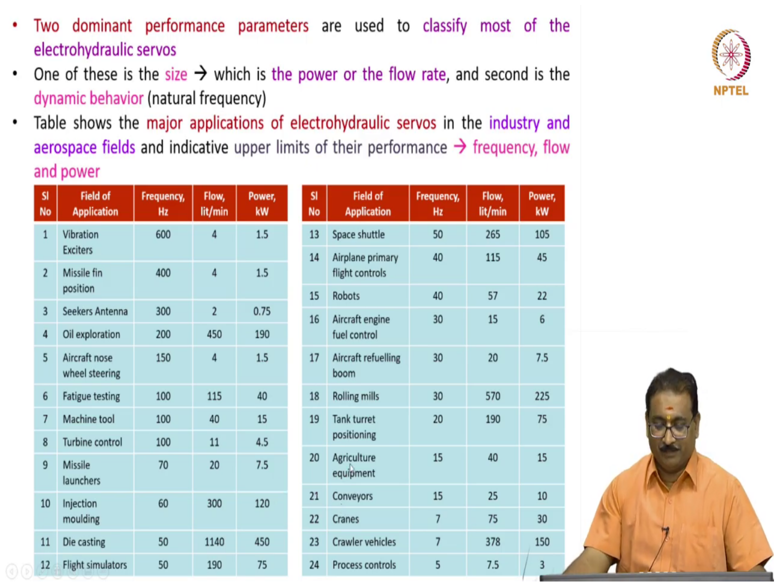

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1	Vibration Exciters	600	4	1.5
2	Missile fin position	400	4	1.5
3	Seekers Antenna	300	2	0.75
4	Oil exploration	200	450	190
5	Aircraft nose wheel steering	150	4	1.5
6	Fatigue testing	100	115	40
7	Machine tool	100	40	15
8	Turbine control	100	11	4.5
9	Missile launchers	70	20	7.5
10	Injection moulding	60	300	120
11	Die casting	50	1140	450
12	Flight simulators	50	190	75

Sl No	Field of Application	Frequency, Hz	Flow, lit/min	Power, kW
13	Space shuttle	50	265	105
14	Airplane primary flight controls	40	115	45
15	Robots	40	57	22
16	Aircraft engine fuel control	30	15	6
17	Aircraft refuelling boom	30	20	7.5
18	Rolling mills	30	570	225
19	Tank turret positioning	20	190	75
20	Agriculture equipment	15	40	15
21	Conveyors	15	25	10
22	Cranes	7	75	30
23	Crawler vehicles	7	378	150
24	Process controls	5	7.5	3

Two dominant performance parameters are used to classify most of the electro hydraulic servos. One of these is the size, which is the power or the flow rate. And second is the dynamic behavior generally known as a natural frequency of the valves. So, the table shows the major applications of electro hydraulic servo valves in the industry and aerospace fields.

And here I am showing the indicative upper limits of their performance in terms of frequency, flow and a power.

Let us we will see here I am given the various applications. And they are having the frequency response, flow rate and a power. You will see here friends there are a large number of applications in industry as well as a defense field.

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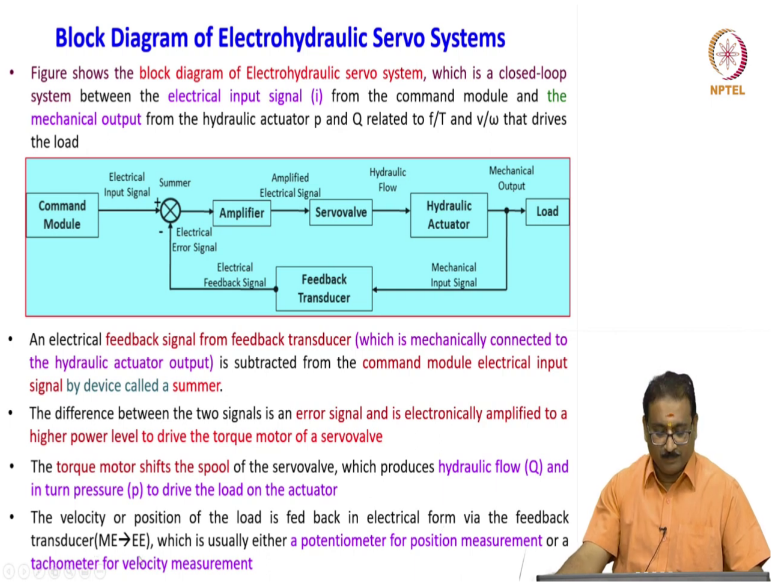

Now, quickly I will show you the block diagram of electro hydraulic servo systems. How they will work? As I have told you it is a closed-loop system correct. So, figure shows the block diagram of electro hydraulic servo systems which is a closed-loop system between the electrical input signal i from the command module and the mechanical output from the actuator P and Q related to force and torque and velocity and angular velocity that drives the load.

Now, you will see hear friends I am showing you the command module is there, summer is there which will summer will generate the error signal from the desired input, from the feedback mechanical feedback received through the feedback transducer. Now, how it is going on friends here? You will see here the electrical input signal is an input here, then it is amplifying to drive the servo valve.

Servo valve means generally it is a torque motor here. When the spool valve will move, hydraulic flow is going to the actuator side. Then actuator will move, then you will capture the displacement, velocity, acceleration, whatever you want as a mechanical output, and fed back here through the feedback transducer.

Feedback transducer will convert the mechanical input into the electrical feedback signal which will go to the summer. Always, it will generate the error signal. Until error is 0, there is a error signal between the command desired input and feedback input. So, an electrical feedback signal from the transducer is subtracted from the command module electrical input by the device called a summer as I have already told you.

The difference between the two signal is the error signal and is electronically amplified to a higher power level to drive the torque motor of the servo valve. The torque motor shifts the spool valve which produces a hydraulic flow, and in turn the pressure to drive the load. The velocity or the position as I have told you is fed back in electrical form via the feedback transducer, which usually either the potentiometer for the position measurement or the tachometer for the velocity measurement.

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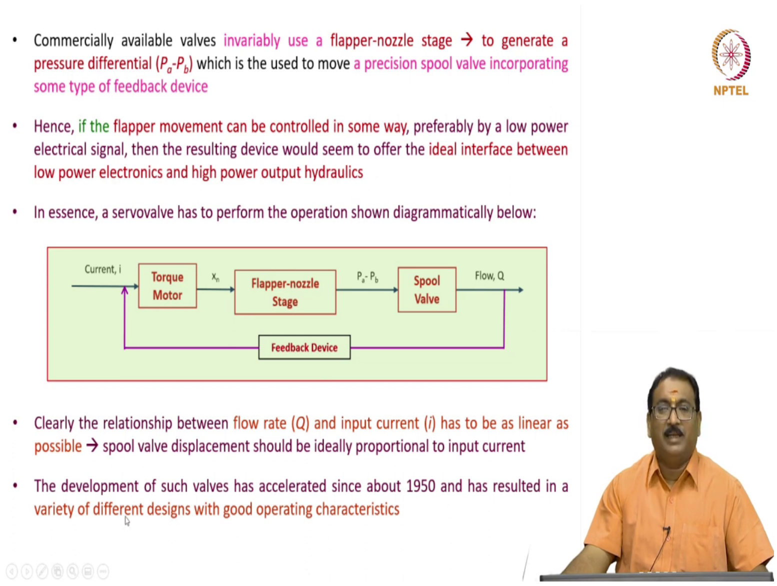

Commercially available valves invariably use a flapper-nozzle stage – to generate a pressure differential P a minus P b across the spool valve it is, which he used to move the precision spool valve incorporating some type of feedback.

Hence, if the flapper movement can be controlled in some way, preferably by a low power electrical signal, then the resulting device would seem to offer the ideal interface between the low power electronics and high power output hydraulics. In essence, a servo valve has to perform the operation shown diagrammatically. Here you will see flapper-nozzle stage I have used. It may be also the jet pipe type.

Here you will see the current input to the torque motor, which will deflects the flapper. When the flapper will move, it will results in the differential pressure across the spool valve. Then spool valve will move. As the spool valve will move, flow takes place. Then you will take the mechanical feedback here, and fed back to the here. This is similar to previous one what I have shown. Here I am showing you for the flapper-nozzle value. If you will replace this jet pipe stage, then it is jet pipe servo valve, other things are same it is. There also torque motor is there everything is there.

Clearly the relationship between the flow rate Q and the input current i has to be as linear as possible – spool valve displacement should be ideally proportional to input current. The development of such valve has accelerated since about 1950s and has resulted in a variety of different designs with good operating characteristics.