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

Part 1: Introduction to pump-controlled hydraulic systems, Drive concepts: Open loop control and closed loop control
Lecture - 80
Pump-controlled Hydraulic Systems

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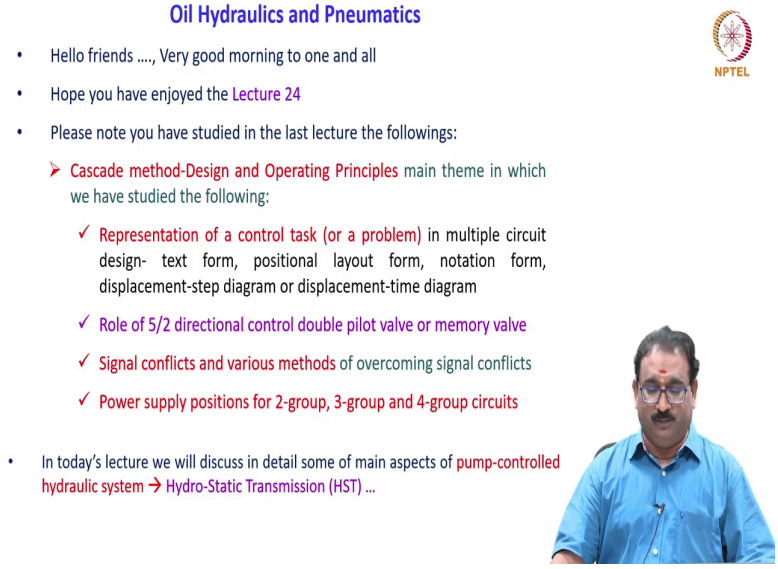

My name is Somashekhar, course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed the lecture 24. Please note, you have studied in the last lecture the followings. Cascade method design and operating principles, main theme in which we have studied the followings.

Representation of a control task or a problem in a multiple circuit design, in text form, positional layout form, notation form, displacement step diagram or displacement time diagram, if you know the time for the each activity. Now, we have seen the role of 5 by 2 directional control valve which is a double pilot valve, what we have discussed. It is also known as a memory valve.

Also we have seen signal conflicts and various methods of overcoming the signal conflicts, this is basically occurs in the pneumatics, when you are operating the multiple cylinders in the sequence based modes. Also we have seen to overcome this there are many methods are there, we have seen the power supply positions for 2 group, 3 group and 4 group circuits.

In today's lecture we will discuss in detail some of main aspects of hydrostatic transmission, which is a pump controlled hydraulic system which finds a large number of applications in construction, mobile hydraulics, and also currently in robotics also. Let us we will see this hydrostatic transmission briefly called as HST.

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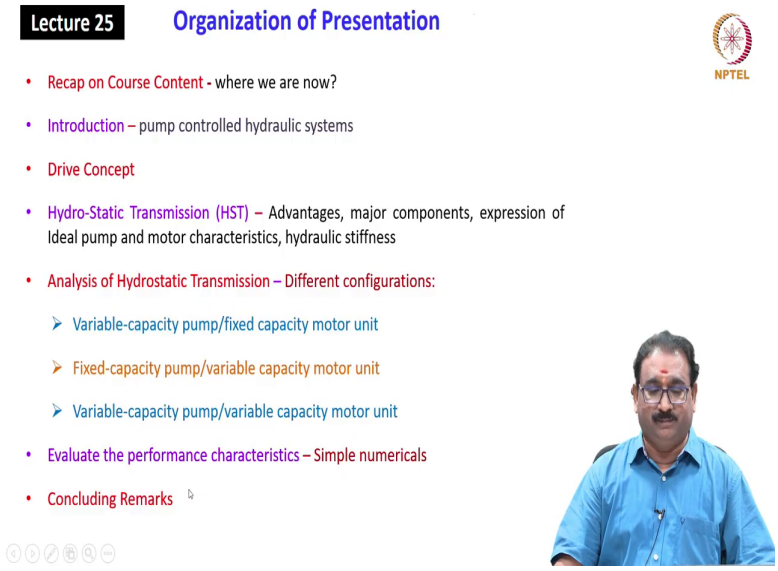

We will see the organization of presentation; let us we will recap on course content where we are now. Introduction here mainly concentrating on pump controlled hydraulic systems here, again there are two category friend cylinder controlled and a motor controlled. That is why I am telling you just I will give you introduction on pump controlled hydraulic systems how it is.

Next, we will move on to the drive concept basically in the pump controlled system. Next, we will move on to hydrostatic transmission HST here, we will discuss advantages major components, classifications, expressions for the ideal pump and motor characteristics and also the hydraulic stiffness. Next we will move on to analysis of the hydrostatic transmissions.

We will see based on the pump motor configurations, we are getting the different configurations. We will analyze that. Here variable capacity pump and fixed motor unit

understand this, fixed capacity pump, variable capacity motor unit, variable capacity pump and variable capacity motor. And, also you will get the fixed pump fixed motor configuration also, meaning here friends the hydrostatic transmission basically the pump bar motor unit it is.

Meaning if you will vary the pump fixed and variable like a motor fixed and variable, you will get the different configuration in the hydrostatic transmission. Here we are overcoming the control valves. Next we will evaluate the performance characteristics of pump control system; we will restrict our study to HST simple numerical.

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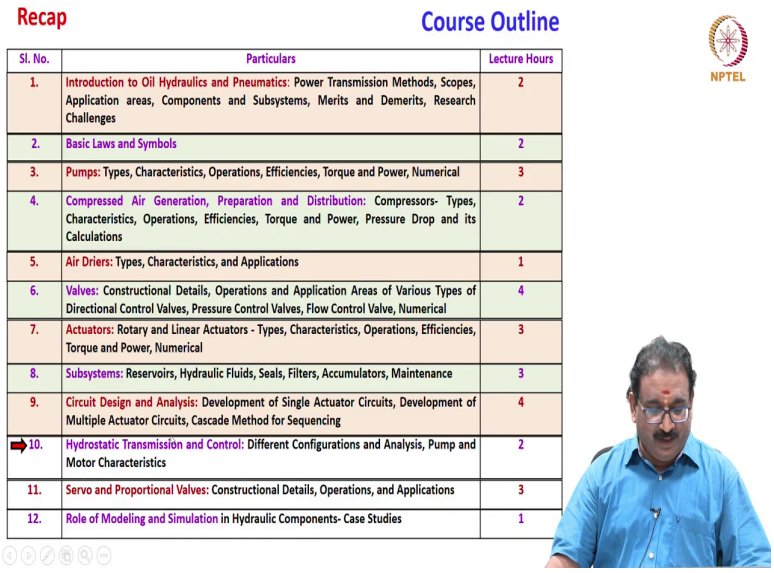

Sl. No.	Particulars	Lecture Hours
1.	Introduction to Oil Hydraulics and Pneumatics: Power Transmission Methods, Scopes, Application areas, Components and Subsystems, Merits and Demerits, Research Challenges	2
2.	Basic Laws and Symbols	2
3.	Pumps: Types, Characteristics, Operations, Efficiencies, Torque 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

Concluding remarks, friends already we moved during the course from serial number 1 to 9 already. Already we have covered the most of the syllabus for the oil hydraulics and pneumatics, we are reaching at the end all are very very important units. Now, we are here

friends hydrostatic transmission and control, as I have told you quickly see the different configuration and analysis, pump bar motor characteristics.

This is will restrict to our study to 2 hours. Next is servo and proportional valve will start, and then role of modeling and simulation.

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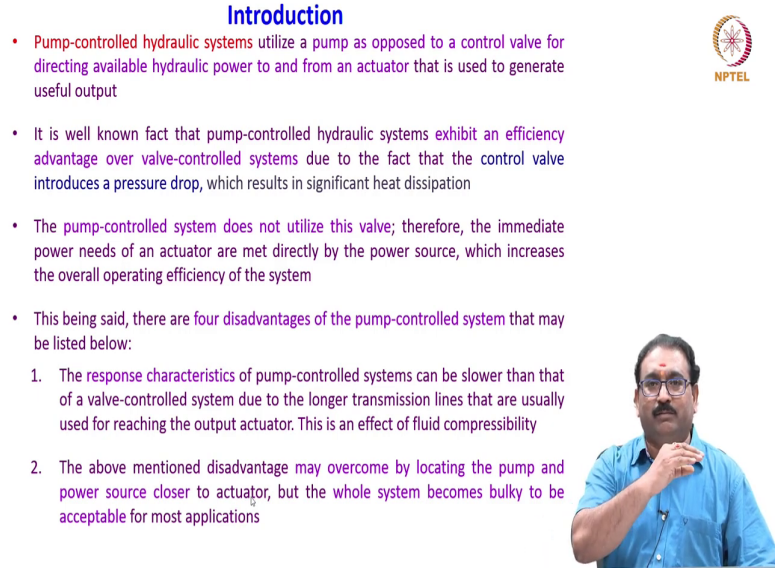

Let us we will see what is the significance of studying the hydrostatic transmissions or a pump controlled hydraulic systems? Pump controlled hydraulic systems utilize a pump, as opposed to a control valve for directing available, hydraulic power to and from an actuator that is used to generate useful outputs.

It is well known fact that pump controlled hydraulic systems exhibit an efficiency advantages over a valve controlled systems. Due to the fact that the control valves introduces a pressure drop which results in significant heat dissipation.

This is one of the critical component in the whole fluid power system is a control valves direction control valves. Now, in the hydrostatic transmission, we are not using this. Directly pump will control the flow to the motor, as well as in a cylinder. The pump control system does not utilize this valve therefore, the immediate power needs of an actuator are met directly by the power source, which increases the overall operating efficiency of the system.

This being said, there are four disadvantages of the pump controlled system that may be listed below now. The response characteristics of pump controlled systems can be slower than that of a valve controlled system. Due to the longer transmission lines, that are usually used for reaching the output actuator. Because, directly I am using pump to sent the fluid to the actuator large transmission lines are there.

So, this is an effect of fluid compressibility. Also we know that the above mentioned disadvantages may overcome by locating the pump and power source closer to the actuator. But, what happens friends? If I will move the pump and the motor near to the actuator, the whole system becomes bulky which is a difficult to use in many application.

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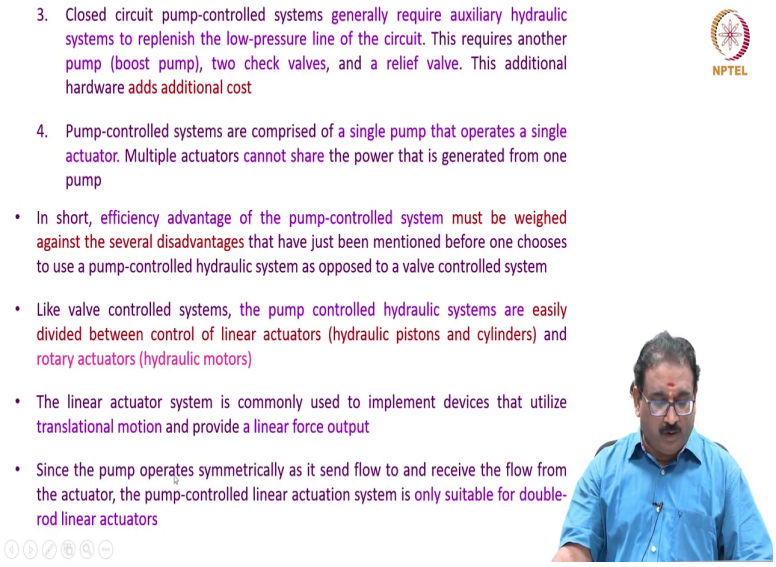

3rd problem is closed circuit pump controlled systems, generally require auxiliary hydraulic system to replenish the low pressure line of the circuit. This requires another pump that what we can call a boost pump, to act to the leakage, then two check valves and a relief valve and minimal piping's. Meaning this additional hardware adds the additional cost in the pump controlled system.

4th disadvantages is pump controlled systems are comprised of a single pump, that operates a single actuator; multiple actuator cannot share the power that is generated from one pump. In short, the efficiency advantages of the pump controlled system must be weighed against the several disadvantages that have just been mentioned before one chooses to use the pump controlled hydraulic system as opposed to a valve controlled system.

Like a valve controlled systems, the pump controlled hydraulic systems are also classified between control of linear actuators, meaning here. I am using the hydraulic pistons and cylinders and a rotary actuators meaning a hydraulic motors, valve control also like this classification.

Here based on the motion output, whether you want a linear or a force input, you may use the piston and cylinder. If you want a rotary torque and a speed, you will use a motor. The linear actuator system is commonly used to implement, the devices that utilize a translational motion, and provide a linear force output. Since the pump operates symmetrically, as it sends flow to and receives the flow from the actuator. The pump controlled linear actuation system is only suitable for double rod linear actuators.

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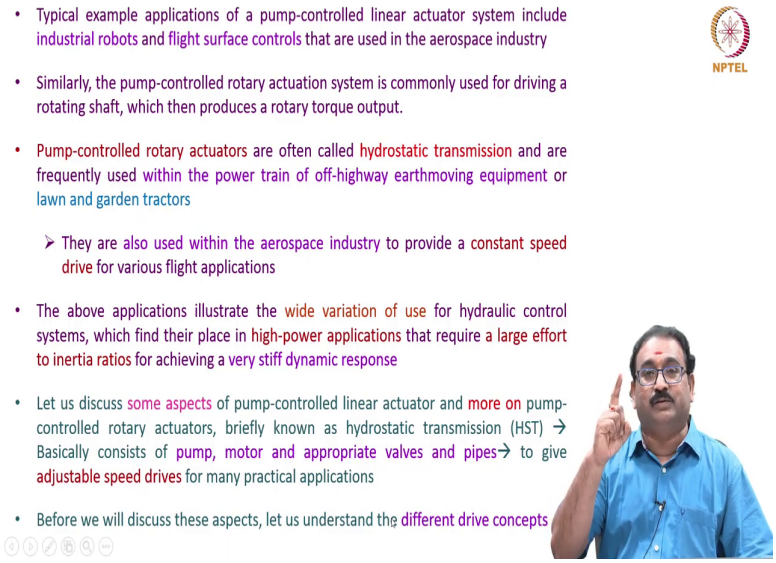

Typical example applications of a pump controlled linear actuator system include industrial robots. And, flight surface controls that are used in the aerospace industry. Similarly, the pump controlled rotary actuation system is commonly used for driving a rotating shaft, which then produces a rotary torque output. Pump controlled rotary actuators are often called a hydrostatic transmissions please remember friends. Pump controlled rotary actuators or HST hydrostatic transmissions.

And are frequently used within the power train of highway earthmoving equipment and lawn and garden tractors. They are also used within the aerospace industry to provide a constant speed drives for various flight applications.

So, the above mentioned applications as a pump controlled system, illustrates the wide variation of use for a hydraulic control system, which find their place in high power applications that require a large effort to inertia ratio for achieving a very stiff dynamic response.

Let us discuss, some aspects of pump controlled linear actuator and more on pump controlled rotary actuator, briefly known as HST which basically consists of pump, motor and appropriate valves and a pipes to give adjustable drives for many practical applications. Before we will discuss these applications, let us understand the different drive concepts in pump controlled system this is very important.

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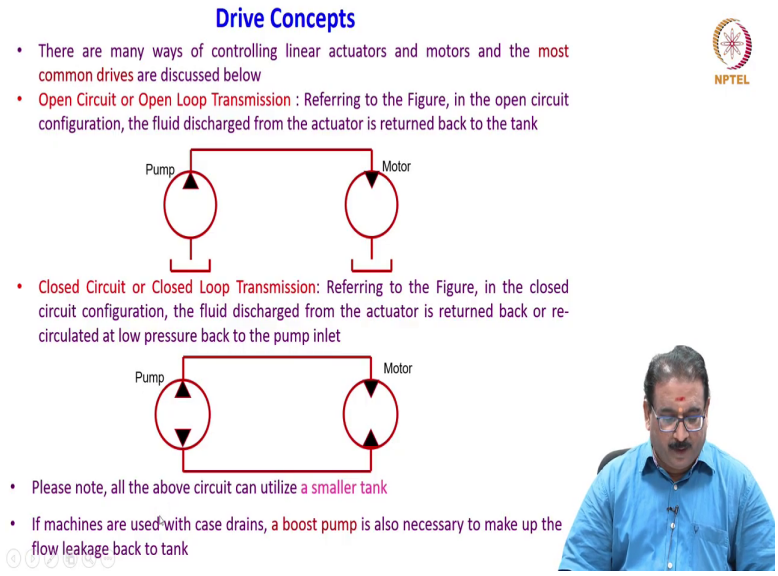

Drive concepts there are many ways of controlling linear actuator or a motors, we will discuss some of the drive concepts here. Open circuit or open loop transmission here, referring to figure here the pump motor combination is given both are a fixed displacement type.

Referring to this figure in the open loop transmission, the fluid discharged from the actuator, motor is return back to the tank no connection from the motor to pump in the open circuit configuration. Closed circuit or closed loop transmission, again I am taken here the pump motor combination, this is a bidirectional fixed displacement pump, this is a bidirectional, fixed displacement motor, referring to the figure.

Here, in the closed circuit configuration the fluid discharged from the actuator motor is return back to the pump inlet which is the low pressure site. Please note all the above circuit can

utilize a small tank in the pump controlled system. If machines are used with a case drains, a boost pump is also necessary to make up the flow leakage back to the tank.

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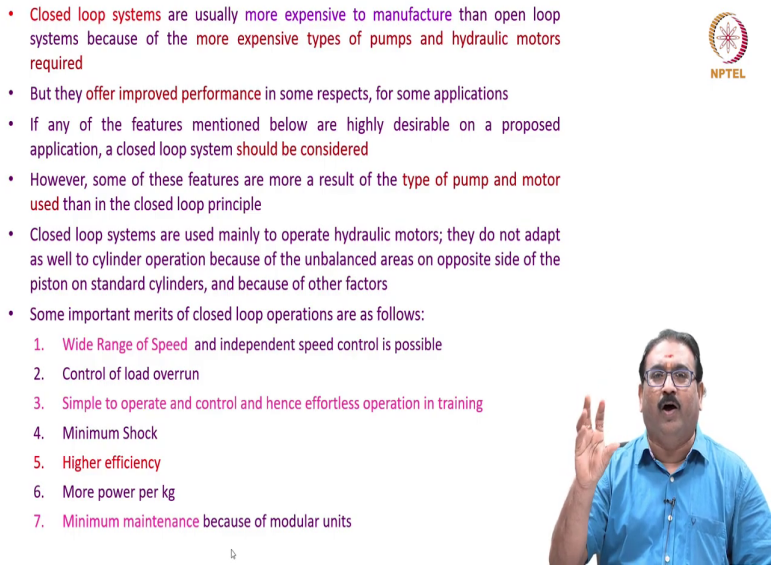

Now, let us will see compared to open loop system closed loop systems are better. Why it is? Closed loop systems are usually the more expensive to manufacture than the open loop system, because of the more expensive types of pumps and hydraulic motor are required here. But, they offer improved performance in some respects for some applications, if any of the feature mentioned below are highly desirable, on a proposed application a closed loop system should be considered.

However, some of these features are more a result of the type of pump and motor used than in the closed loop technique or a principles, closed loop system are used mainly to operate hydraulic motors.

They do not adapt as well two cylinder operation, because of the unbalanced areas on opposite side of the piston on standard cylinders and because of the other factors also. Closed loops transmission is good, if you are using the double rod cylinder meaning the equal areas on the either side of the piston.

Some important merits of closed loop operations are as follows. Wide range of speed is possible and also independent speed control is possible. As we know the pump bar motor, you used in the pump control system, either a fixed type or a variable type. Due to this you are having the variety of configuration, to get the different range of speed and also speed control is possible.

Control of load over run. Simple to operate and control and hence effortless operation in training the personnel, because they are very easy to understand also less components are involved in this. Minimum shock higher efficiency is possible more power per kg. Minimum maintenance because of the modular units, pump motor unit very simple it is, no control valves, only minimal valves like a NRV and piping and PRV s are there. In the open loop or a closed loop pump control system.

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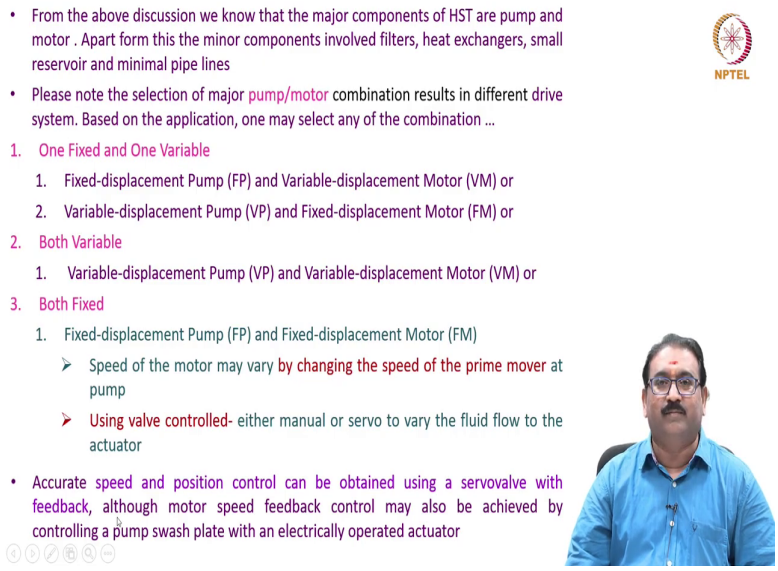

From the above discussion, we know that the major components of the hydrostatic transmission HST are pump and motor, these are the major components. Apart from this as I have told you the minor components are required like a fine filters, heat exchangers small reservoir. As I have told you in the closed loop system the oil is re circulating from the actuator end to the low pressure side of the pump it will re circulate.

And, also as I have told you no direction control valves are there here, then this power unit is very near to the actuator, the minimal piping's and connections are required. Please note the selection of major pump and motor combination results in different drive system. Based on the application one may select any of the following combination to build the pump controlled system.

You may use one fixed and one variable, here we may use fixed displacement pump and variable displacement motor, or variable displacement pump and fixed displacement motor. Or you have to use the both units pump and motor are variables. In this I may get the combination here, variable displacement pump and variable displacement motor. Or both should be fixed sometimes, meaning here fixed displacement pump and fixed displacement motor.

Now, how I will get the variability in the motor? For this the speed of the motor may vary by changing the speed of the prime mover which is driving the pump here. For example, if I am driving the fixed displacement pump using the BLDC motor. If we will vary the current input to the BLDC motor, it will rotate fast that time pump outlet you may get the more flow.

Like this you have to vary the flow rate or using a valve controlled, the many times you may use the flow control valves. Or also servo controlled to vary the swash plate of the axial piston pump, or whatever the pump you are using you have to vary the flow. Accurate speed and position control can be obtained using a servo valve with feedback.

Although motor speed feedback control may be achieved by controlling a pump swash plate with an electrically operated actuator, based on the requirement at the actuator. You may vary the swash plate angle any direction, you have to vary by giving the different current input to the controller.

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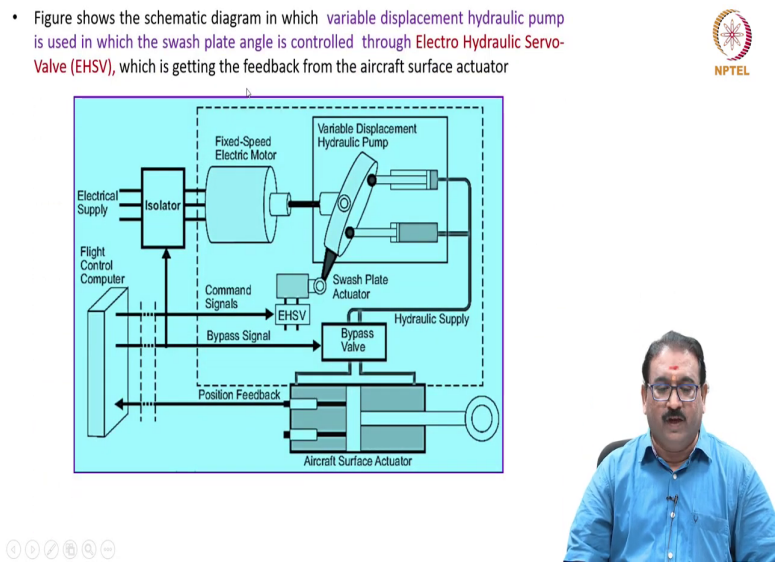

Here you will see here friends figure shows the schematic diagram in which variable displacement hydraulic pump is their piston type what I am showing you here. Here the angle is controlled using your electro hydraulic servo valve, which receives the command signal from the flight control computer, which receives the feedback from the aircraft surface actuator.

Then based on that it will generate the signals current signal to the EHSV, then EHSV will move slowly how much you want the angle of the swash plate, they are works on the closed loop system it is. You will see here in the figure the variable displacement hydraulic pump, now here controlled through the fixed speed electric motor which receives the electrical supply.