Oil Hydraulics and Pneumatics
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Hydrostatic Transmissions
Lecture - 85
Part 3: Simple Numerical/Case Study

My name is Somashekar, course faculty for this course.

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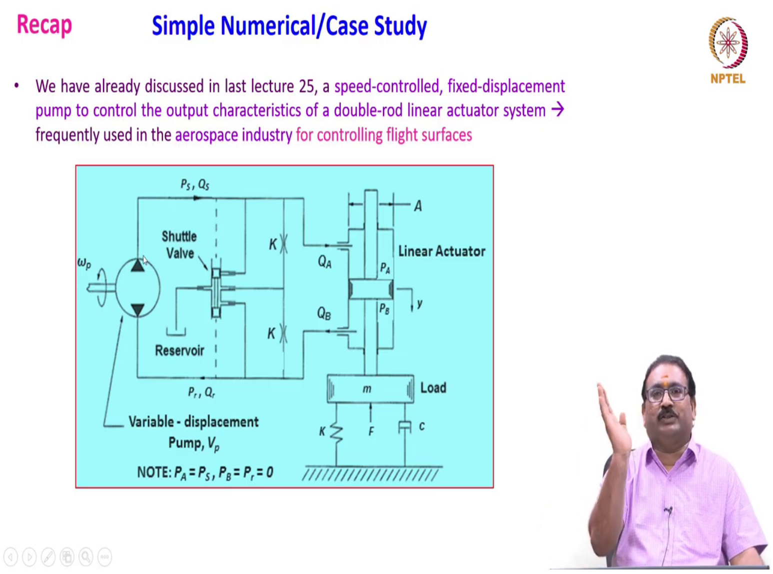

Now, let us we will see some of the Simple Numerical to predict the performance parameters. Now, due to the time restrictions, I will take two important Case Studies. This two case studies is based on the previous lecture where we have discussed the pump controlled linear actuator and another one is a pump controlled motors.

Let us we will see the one by one these as a case study. As I have told you earlier these things we have discussed in the lecture 25, a speed-controlled, the fixed-displacement pump to control the output characteristics of a double-rod linear actuator system frequently used in the aerospace industry for controlling the flight surfaces.

As we have seen friends here, this is a pump controlled actuator system. Here you will see the linear actuator as we have discussed in the last class please recap or review the lecture 25 for better understanding the numericals. This is based on this configuration here as we have seen this is a bi-directional, the variable displacement pump, which will ejects the flow Q S with P S. It will go to the one end of the linear actuator, this actuator is symmetric.

The rod is projecting in both side, one end is connected to the loading system m K C with a disturbance force F, we have seen already in the last class. This K is to model the leakage. Also you will see the shuttle valve, it is a pressure sensing from the top circuit or a bottom circuit based on the cross center of the pump. Let us we will see this case study.

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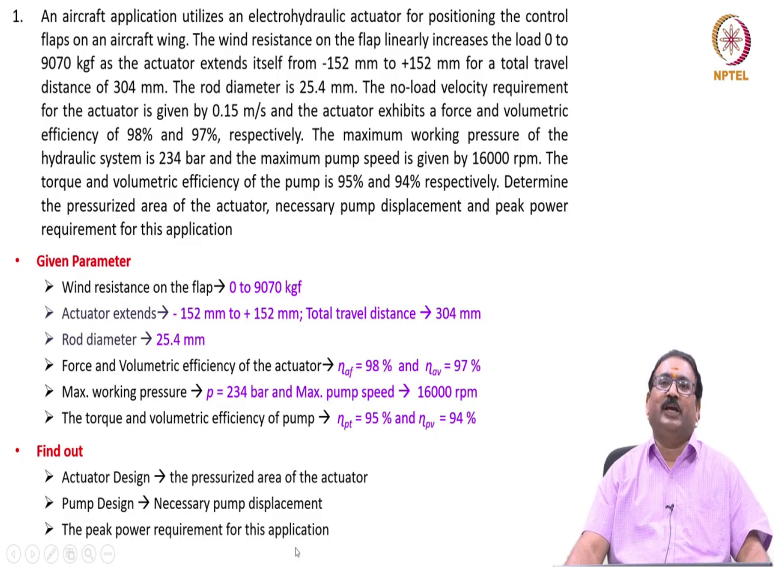

The problem is like this, friends. An air craft application utilizes an electrohydraulic actuator for positioning the control flaps on an aircraft wing. The wind resistance on the flap linearly increases the load 0 to 9070 kgf as the actuator extends itself from minus 152 millimeter to plus 152 millimeter for a total travel distance of, add these two we will get 304 mm. The rod diameter is given as 25.4 mm.

The no load velocity requirement for the actuator is given by 0.15 meters per second and the actuator exhibits a force and volumetric efficiency of 98 percent and 97 percent, respectively. The maximum working pressure of the hydraulic system is 234 bar and the maximum pump speed is given by 16000 rpm. The torque and volumetric efficiency of the pump 95 percent and 94 percent respectively.

Determine the pressurized area of the actuator, necessary pump displacement and a peak power requirement for this applications. Now, as we have seen this detailed analysis in the lecture 15 to determine or sizing the actuator, pump and the input power requirement, same thing we have to carry out here friends. First let us we will list the important given parameters.

The wind resistance on the flap is given this is from 0 to 9070 kgf; actuator extends minus 152 mm to 152 other side because it is a double rod side as we have seen in the previous slide, from the center it will move plus 152 and another side minus 152. But total travel is how much it is 304 mm.

Then a rod diameter is given 25.4 mm, approximately it is a 1 inch. The force and volumetric efficiency of the actuator is given; already we know that they are 98 percent, 97 percent I am written here. Maximum working pressure p equal to 234 bar and a maximums pump speed is 16000 revolutions per minute.

The torque and volumetric efficiency of the pump they are given as 95 percent and 94 percent here nu pt and nu pv, the convention is for the pump nu af and a nu av for the actuator. What is our duty? Our duty is to find out the actuator design in which we have to find out the pressurized area of the actuator. And then in the pump design we have to find out the necessary pump displacement to meet these requirements. Also, the peak power requirement for thisapplication.

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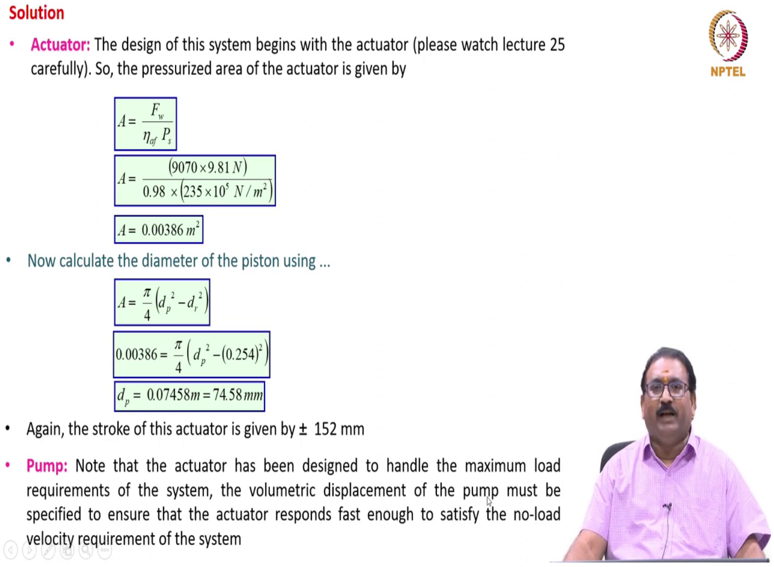

Let us we will begin this: Actuator the design of this system begins with the actuator. So, the pressurized area of the actuator is given by A equal to F w by nu af into P s substitute the values, but take care here kgf is given I am converting into Newton by multiply 9.81 this is given. The P s is given in the bar I am converted into Newton per meter square. I will get area is 0.00386 meter square. Please take care friends units are very very important.

Now, calculate the diameter of the piston using area equal to pi by 4 d p square minus d r square; d r is given in the problem. Substitute the values, then I will get d p equal to 0.07458 meter converting into mm 74.58 millimeter. Again, the stroke of this actuator is given by plus or minus 152.

Now, we will see the after knowing the actuator, let us we will see the pump note that the actuator has been designed to handle the maximum load requirements of the system. The volumetric displacement of the pump must be specified to ensure that the actuator responds fast enough to satisfied the no load velocity requirement of the system.

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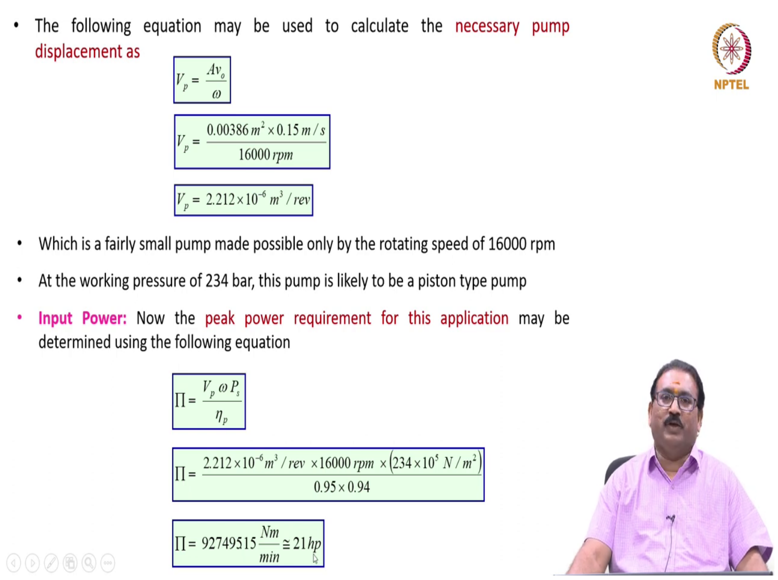

The following equation may be used to calculate the necessary pump displacement as V p equal to already we know that Av naught by omega. Substitute the values; A already we are calculated in the previous one substitute here. The velocity is given and then the angular velocity also given, substitute here I will get 2.212 into 10 to the power of minus 6 m cube per revolutions.

Which is fairly a small pump made possible only by rotating speed of 16000 rpm. At the working pressure of 234 bar, this pump is likely to be the piston type of pump. While selecting you have to use the higher pressure it is higher pressure is always possible with the piston pump.

Then, input requirement what it is? Now, the peak power requirement for this application maybe determined using the following equation pi equal to V p omega P s by this is a total pump efficiency nu p it is. Now, substitute all the values. nu p equal to nu o minus the mechanical efficiency and volumetric efficiency multiplied. Substitute all the values. I will get 927495.15 Newton meter per minute. Convert this one into the horsepower, I may get approximately 21 hp.

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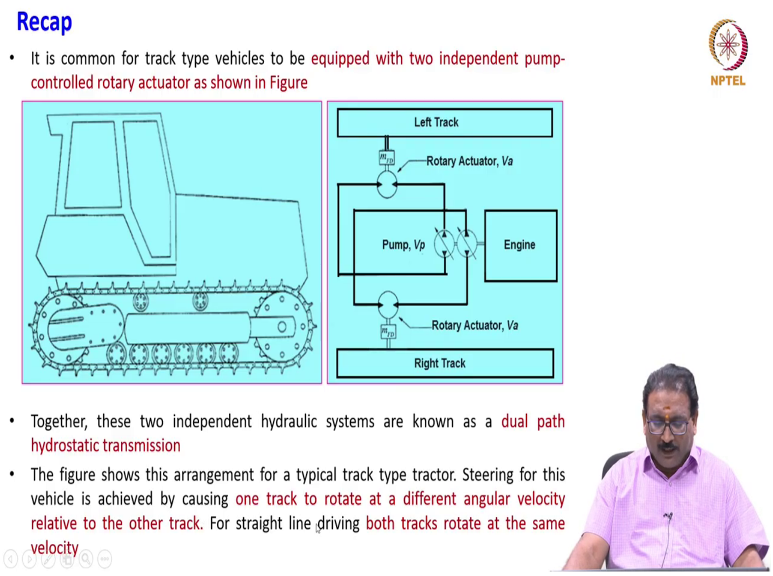

Now, one more case study as we have seen, the pump controlled rotary actuator. This is common in the track type vehicles. This is a track type vehicles. See kindly please observe the vehicle here. It is a common for track type vehicles to be equipped with the two independent pump controlled rotary actuator as shown in the figure.

This is a schematic diagram of the track type vehicles. Here I have shown the hydraulics circuit. Here what it is friends? There are the two motors, each for the left track as well as right track. See here it is a fixed displacement rotary actuator. Displacement is represented Va, then you will see friends here these are the two pumps.

The all are both are variable displacement bi-directional pumps. These two are drive through the engine which may be the gasoline engine or a IC engine or a motor electric motor. Now, let us we will see this also you will see I have represented m FD. What is this, I will tell you. Together these two independent hydraulic systems are known as a dual path hydrostatic transmissions.

The figure shows this arrangement for a typical track type tractor. Steering for this vehicle is achieved by causing one track to rotate at a different angular velocity relative to the other track. For a straight line driving both tracks rotate at the same velocity. But, when you are taking the cornering, when you are turning one is rotating at the higher speed another is rotating at the rotors smaller speed. This is very easily achieved using the hydro static transmissions.

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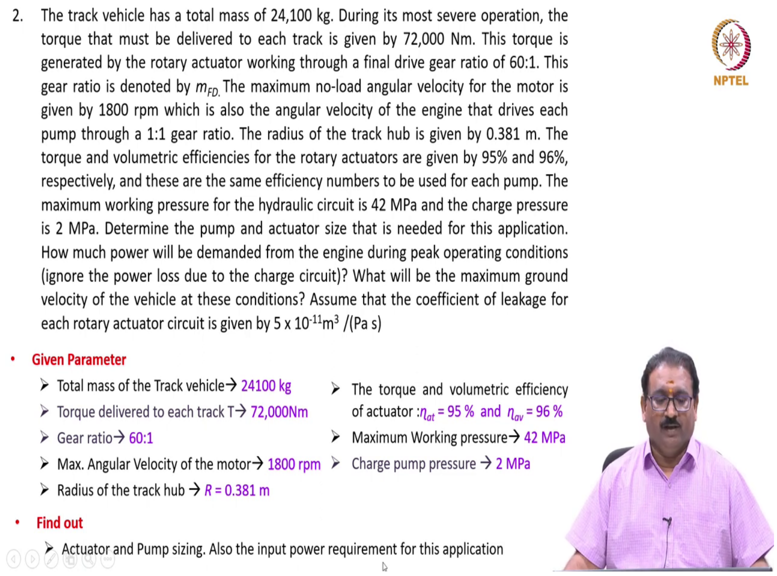

Now, let us we will see simple numerical. The track vehicle has a total mass of 24,100 kg. During its most severe operation, the torque that must be delivered to each track is given by 72,000 Newton meter. This torque is generated by the rotary actuator working through a final drive gear ratio of 60 is to 1. This gear ratio is denoted by m FD.

The maximum no load angular velocity for the motor is given by 1800 rpm which is also the angular velocity of the engine that drives each pump through a 1 is to 1 gear ratio. The radius of the track hub is given by 0.381 meter. The torque and volumetric efficiencies for the rotary actuators are given by 95 percent and 96 percent respectively, and these are the same efficiency numbers to be used for each pump.

The maximum working pressure for the hydraulic circuit is 42 mega Pascal and the charge pump pressure is 2 MPa. Determine the pump and actuator size that is needed for this application. How much power will be demanded from the engine during peak operating conditions? Here you will ignore the power loss due to the charge circuit. What will be the maximum ground velocity of the vehicle at these conditions?

Assume that the coefficient of leakage for each rotary actuator circuit is given by this much. Let us we will quickly list the given parameter as total mass of the track vehicle is 24,100 kg. Torque delivered to each track 72,000 Newton meter; gear ratio 60 is to 1; maximum angular velocity of the motor is 1800 rpm; radius of the track hub is capital R, we are taking as 0.381 meter.

And the torque and volumetric efficiency of the actuator is 95 and 96 this is also same for the pump. Maximum working pressure is 42 MPa, charge pump pressure is 2 MPa. What we have to find out, friends? Actuator and pump sizing, also, the input power requirement for this application.

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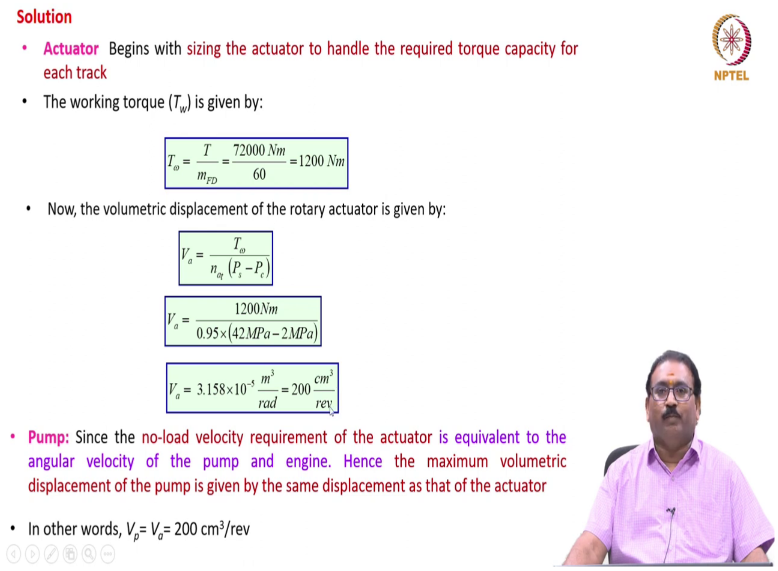

Let us we will begin the solution. Actuator begin with sizing the actuator to handle the required torque capacity for each track. The working torque T w is given by T w equal to T by m FD. They are given here 60 and here 72,000 Newton meter. I will get 1200 Newton meter. Now, the volumetric displacement of the rotary actuator is given by V a equal to T w by n nu at P s minus P c. Substitute all the values, friends. After substituting all the values here I may get V a equal to the 200 centimeter cube per revolution.

We move on to the pump, how to size the pump here. Since the no-load velocity requirement of the actuator is equivalent to the angular velocity of the pump and engine. Hence the maximum volumetric displacement of the pump is given by the same displacement as that of the actuator. So, in other words, the V p equal to V a that is equal to what we are getting here 200 centimeter cube per revolutions.

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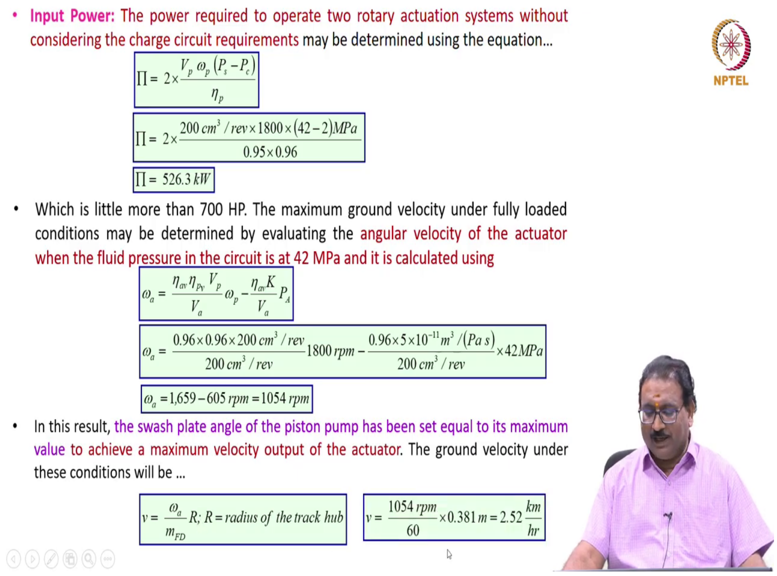

The input power the power required to operate the two rotary actuation system without considering the charge circuit requirement may be determined using the equation pi equal to 2 into V p omega p P s minus P c by total efficiency of the pump. Substitute all the values. I will get the input power is 526.3 kilo watt which is a little more than the 700 hp.

The maximum the ground velocity under fully loaded condition may be determined by evaluating the angular velocity of the actuator when the fluid pressure in the circuit is at 42 MPa and it is calculated using omega a. Substitute all the values here, correct? This formula we know already. We already derived this in the last class. Substitute all the values here friends, take care for the units. Then I will get the angular velocity of the actuator is 1054 revolutions per minute.

In this result, the swash plate angle of the piston pump has been set equal to its maximum value to achieve a maximum velocity output of the actuator. So, the ground velocity under these conditions will be v equal to what omega a, what I am calculating divided by m FD into R, R is a radius of the track hub. Substitute all the values here. I may get the ground velocity equal to 2.52 kilometer per hour.

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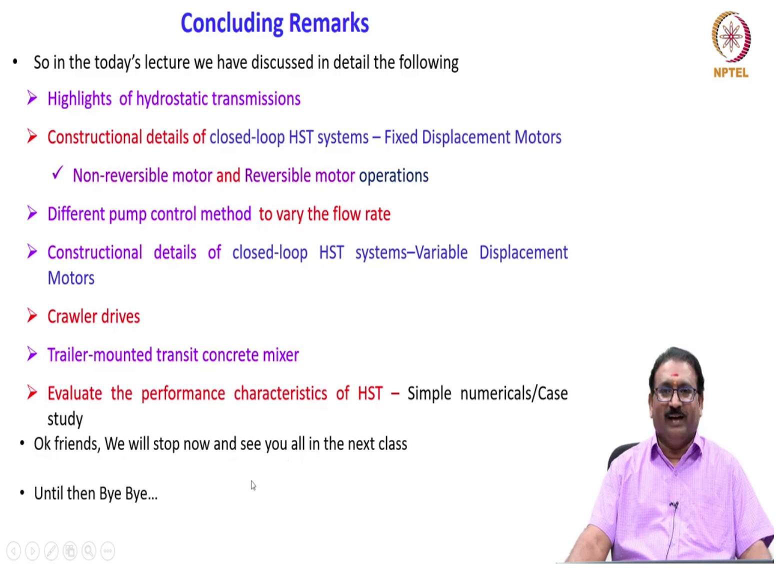

Now, we will move on to the concluding remarks of this lecture. So, in the today's lecture we have discussed in detail the followings. Highlights of the hydrostatic transmissions, and constructional details of closed loop hydrostatic systems. Here we will discussed the two important things – one is a fixed displacement motors, here we discussed the non reversible motors and a reversible motor operations.

Different pump control method to vary the flow rate, then constructional details of closed-loop HST systems here you will see here the variable displacement motors. Crawler drives, trailer-mounted transit concrete mixer, then evaluate the performance characteristics of the HST. Discussing the two simple numericals, please recap again and again this to understand the role of HST. Ok friends, we will stop now and see you all in the next class. Until then, bye bye.

Thank you, one and all for your kind attention [FL].