Oil Hydraulics and Pneumatics
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Part 2: Axial Piston Pump – Construction and Operating principles of Bent and Swash plate type pump
Lecture - 21
Piston Pumps

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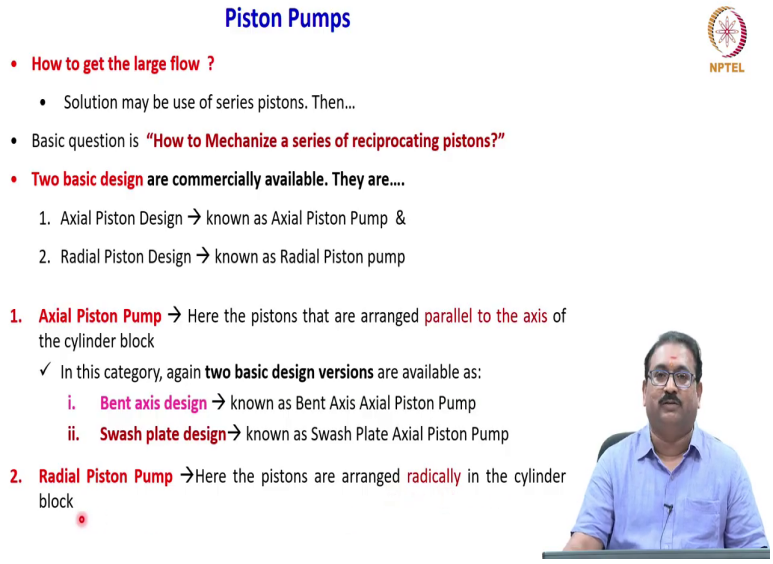

My name is Somashekhar, course faculty for this course. Now, quickly you will see now friends, how to get a large flow? Previously, you are seeing in the hand pump, the diameter and the stroke will decides the flow only one piston. Now, I want the large flow and withstanding for the large pressure. How to do this? This is very important things. Solution maybe you will use a series of pistons, then basic question is how to mechanize a series of reciprocating pistons?

Two basic designs are commercially available in the market. They are axial piston design, also known as axial piston pump and radial piston design, also known as a radial piston pumps. In axial piston pump, what is the meaning of axial piston pumps here friends?

Here, the pistons that are arranged parallel to the axis of the cylinder block. In this category again, we are having the two basic design versions; one is called a bent axis design. They are also known as bent axis axial piston pumps and another one is a swash plate design also known as swash plate axial piston pump.

In these categories you may get the pressure compensated pumps also to suit the requirements of the industries. In radial piston pump pistons are arranged radially in the cylinder block. Here, axially they are arranged series of pistons, here they are radially arranged in the cylinder block.

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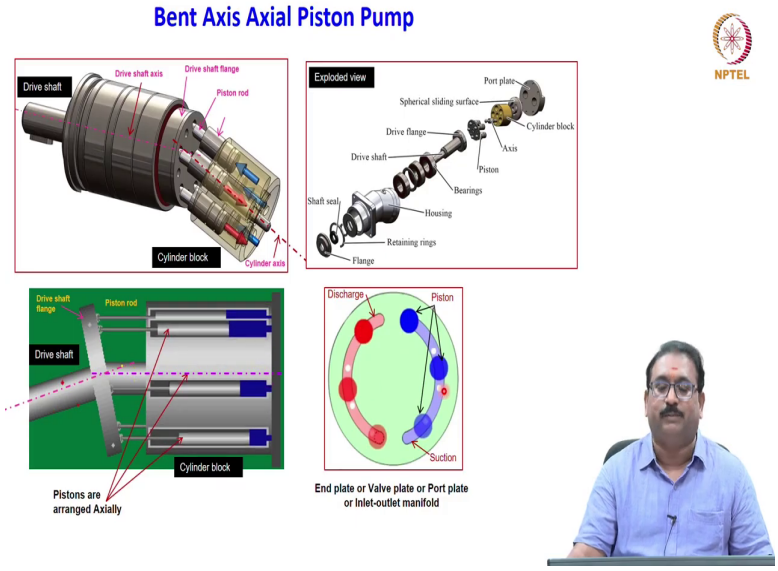

Let us we will see one by one. First category is bent axis piston pump; what is the meaning of here you will see. The axis of the drive shaft axis and cylinder block axis is inclined. You will see here friends for better understanding I have taken some of the pictures from the different sources, I am showing you here exploded views as well as some of the animations for better understanding. You will see here this is called a cylinder block.

Cylinder block and driveshaft always there with inclination, fixed or a variable based on the customers demand. Now, assumed to be there is an angle between the cylinder block and a drive axis and see here cylinder block contains the various grooves in which pistons are inserted, then you will see here the piston rods are connected to the drive shaft flange using the joints, what is that I will tell you in the next slide.

Please understand here friends, when there is an inclination the cylinder block is also rotating along with the driveshaft meaning; what happened some pistons are coming out, some pistons are pushed in. When the pistons are drawn out, what happens here you will see suction will takes place.

When in from here assume to be here, from here to here it will move, what happens the pistons are sucking the fluid. When they are moving down what happens? It will down here, the pistons are pushed in during other half, the discharge will takes place. Now, we will see friends now, here the end plate what we can call a kidney shaped port openings are there in which fluid will be taken out and fluid will be discharged through this plate.

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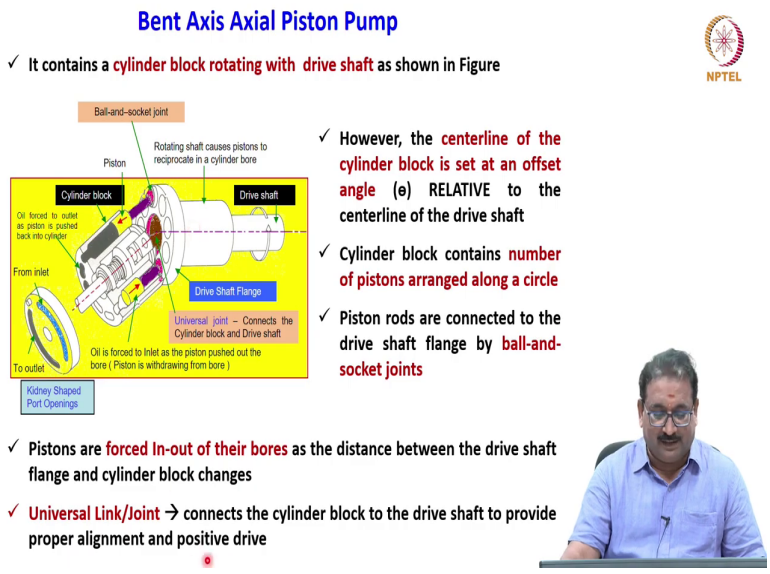

Now, quickly you will see the constructional details, I am showing you for detailed here. It contains as I have told you the bent axis, piston pump contains the cylinder block rotating

with a drive shaft. Here, it is the drive shaft; however, the centerline of the cylinder block you will see centerline of the cylinder block is set at an angle offset angle. It is called theta, relative to the centerline of the drive shaft.

Cylinder block contains a number of pistons arranged in the circle. So many pistons are there. Piston rods here you will see this is called a yellow mark, what I have shown two piston only, I have shown here these are the piston rods, piston rods connected to the driveshaft flange.

This is a driveshaft flange by pitch joint as I have told you ball and socket joint. Pistons are forced in and out they will move in and out, because of this inclination when the cylinder blocks rotating with the drive shaft. Then one more thing we will remember friends a universal link or a joint connects this cylinder block to the drive shaft axis.

You will see here, this is a universal joint is there which will connects the cylinder block and the drive shaft axis for the alignment and the positive drive. Pistons are connected to this through ball and socket joint. The whole cylinder block is connected to the drive shaft axis through the universal joint for the better alignment between this and this as well as what is that positive drive.

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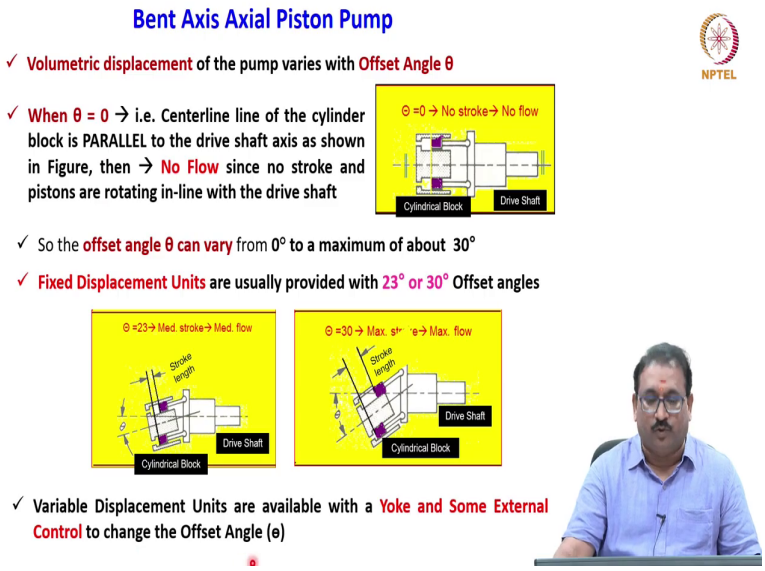

The volumetric displacement of the pump varies with offset angle, if the angle between the drive shaft axis and cylinder axis increases the volumetric displacement increases, because the stroke varies, if drive shaft axis and cylinder axis coincides what happened no stroke, it will rotates. I will show you now here, when theta is 0, what is the meaning of thetas?

Cylinder block axis and driveshaft axis are in a line then what happened? This piston this piston will rotate in the same line, no increasing volume, no decreasing volume, no stroke, that is why no flow.

So, the offset angle theta can vary from 0 degree to maximum of about 30 degree. Fixed displacement units are usually provided with 23 degree offset angle and 30 degree offset

angles commercially. You will see 23 degree offset angle which will give you is the certain flow when if theta is more as you will get the maximum flow.

Also you will remember friends these are the fixed displacement category. As I have told you it can vary from 0 to 30, you can vary it that is what you will do. You have to make the arrangement to adjust the offset angle, then what they are doing they are using the some mechanisms like a yoke and some external control to change the offset angle.

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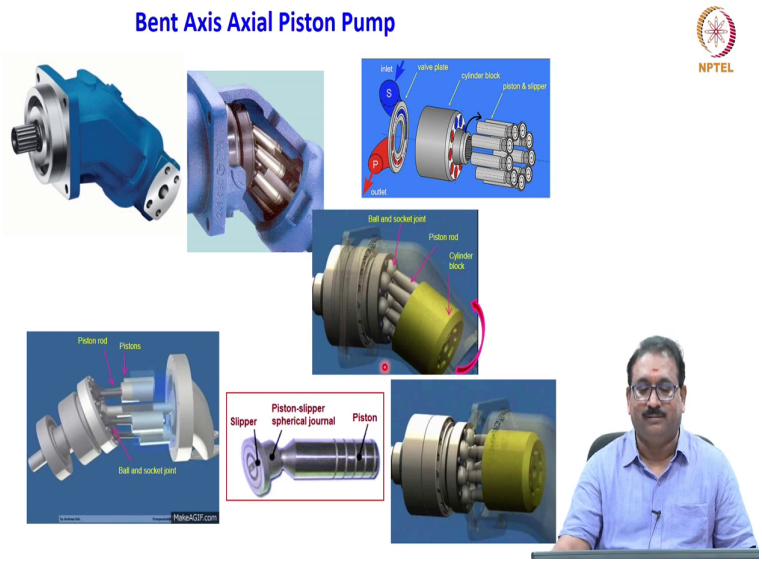

Quickly you will see some of the figures for the understanding with the casing it is. This is a cut section model. You will see the drive shaft and the cylinder axis how it is, you will see the inlet and outlet this is a cylinder block, these are the pistons with slippers, then you will see the arrangements ball and socket joints. For easy understanding, I have borrowed some of the

figures, actual figures to explain to you people; cylinder block and a ball and socket joint, pistons, then also you will see here the how the arrangements are made.

Always the inclination between the driveshaft axis and the cylinder block, then if you will see the one piston how it is piston, it is this is called a piston and slipper spherical journal. This is a slipper; it will go here to the cylinder block. See the arrangements here; see how the arrangements are made here.

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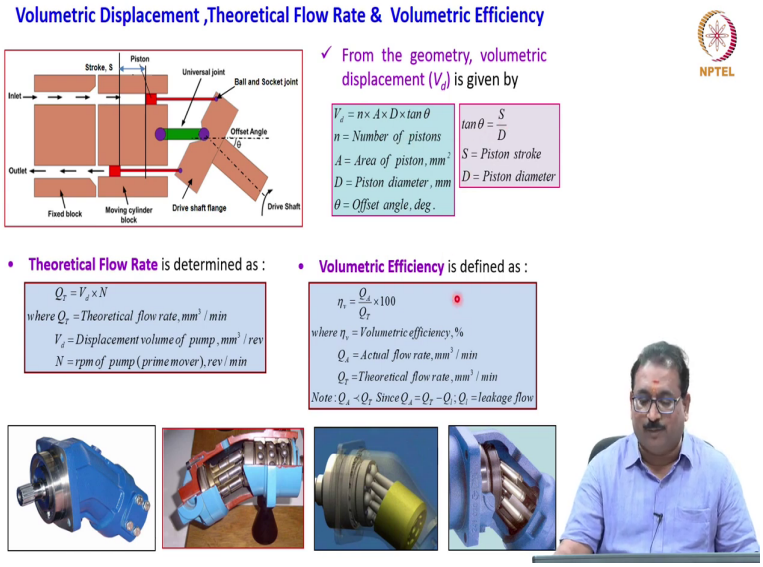

Now, quickly we will derive the volumetric displacement, theoretical flow rate, volumetric efficiency of the piston pumps. How it is; we already we are seen, this is what we will call the cylinder block and this is a driveshaft. Here, you will see I marked the one piston whenever it is there it is pushing the fluid then oil will go here another one is it is drawing the fluid that is inlet.

The distance between this and this it is called a stroke S, the angle between the cylinder block and the driveshaft is a theta, offset angle. So, from the geometry the volumetric displacement V d is given by what is that? V d equal to N into A into D tan theta, because this theta the N means number of pistons.

Here, I am taken 2 pistons, 6 pistons, 7 pistons, many pistons are there, there are number of pistons and A is the area of pistons as we know pi by 4 D p square and piston diameter D into offset angle theta.

This tan theta is given by S by D; S is a stroke angle and D is a piston diameter. Already we know that theoretical flow rate Q T equal to V d into N the N is a drive shaft speed. Volumetric efficiency Q A by Q T always QA is less than the Q T, because in the Q T I am using the only geometrical relationship, but in actually the leakage is prone to occur.

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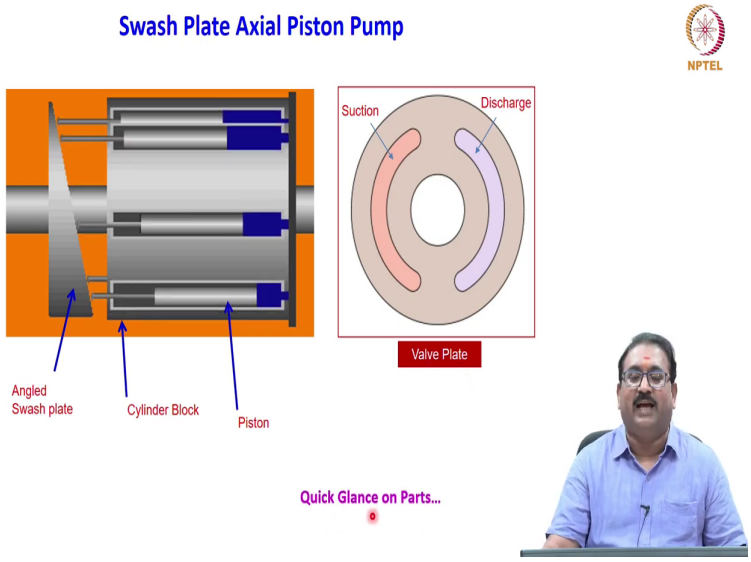

Now, we will move on to the swash plate axial piston pump. See here friends swash plate axial piston pump. Now, what is the difference between this and that here you will see the cylinder block and the driveshaft axis are on the same line, but how the stroke is getting you will see one angled swash plate is there.

Here also inlet and outlets are same when it will move from top dead center to bottom dead center half 180 degree that time suction takes place, when it will move other side discharge takes place through the kidney shaped port openings. They are provided in the valve plate. Very quickly you will see the quick glance of the parts for better understanding.

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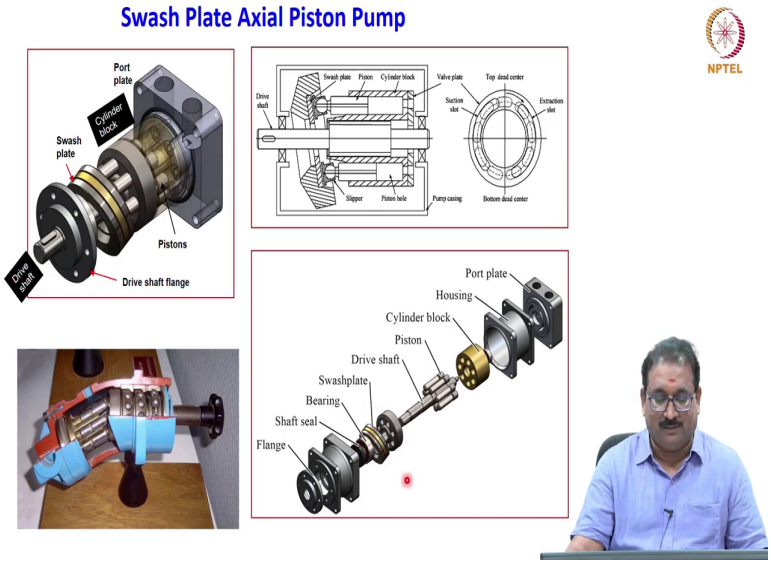

You will see here now it is a this is a cylinder block friends. There are various types of cylinders are there and aligned with the swash plate very important it is. Swash plate which is very-very essential to give the required stroke, then this is a driveshaft, then the port plates are here.

Then you will see the schematic diagram here also, you will see the swash plate it is, then here see piston, then it is a port plates. Here also we will see friends for better understanding, you will see here these are the pistons and you will see here the exploded views of the things where it is a swash plates is very important part here.

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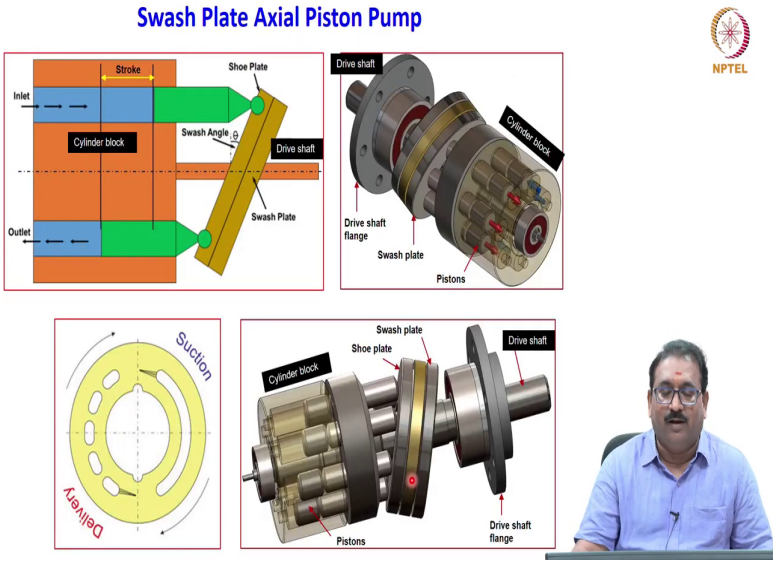

Now, quickly we will see friends now the swash plate some more figures for better understanding this is a what we will call swash plate. The stroke is getting through this angle only. This is a cylinder block, the one piston, second piston I have shown. This is a stroke, when the piston is taken out meaning when it will rotate, when it will rotate cylinder block rotate along with the driveshaft axis, when it will move up what happen? Pistons are taking out that time suction will take place through the ports.

When it will move down what happen? Pistons are pushed in, what happens the fluid will be ejected through the ports, discharge ports you will see here cylinder block swash plate for better understanding driveshaft. You will see here how the arrangements are made. Swash plate is very-very important.

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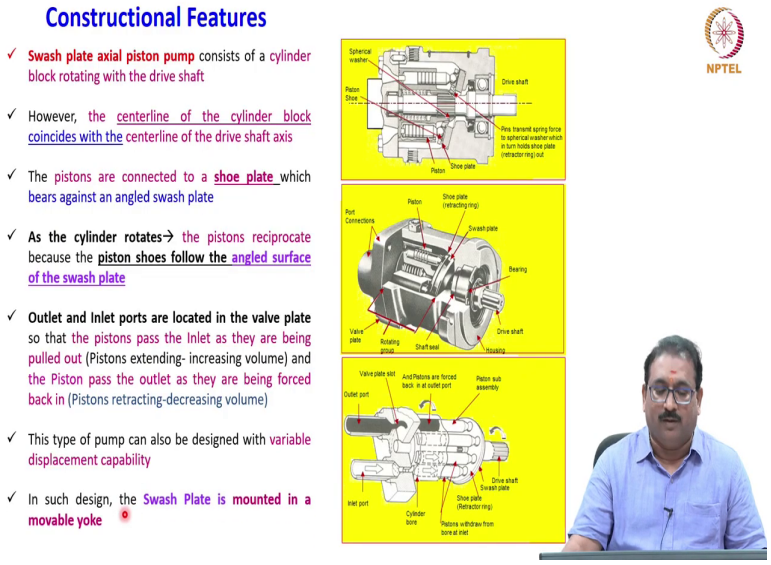

Now, quickly you will see now constructional details with respect to the some schematic diagram here. You will see friends here what I have drawn here. Here is a please, very important here, it is a driveshaft, then it is a cylinders, then you will see here it is a plate, swash plate, you will see here it is what I have shown here it is a swash plate, these are the pistons.

But you will understand the drive shaft axis and cylinders are on same line, but piston rods shoes are on the what will shoe plates. It is also known as the retracting ring. You will see here, I am marked here, inlet and outlet, this is a swash plate, driveshaft, cylinder block.

Let us we will see the construction. Swash plate axial piston pump consists of a cylinder block rotating with the drive shaft similar to previous one; however, the centerline of the

cylinder block coincides with the centerline of the drive shaft axis. The pistons are connected to a shoe plate which bears against the angled swash plate.

As the cylinder block rotates the pistons reciprocates, because the piston shoe follows the angled surface of the swash plate. Outlet and inlet ports are located in the valve plate so that the piston passes the inlet as they are being pulled out, meaning what? Pistons extending increasing volume and suction takes place and the piston passes the outlet as they are being forced backed in to the cylinder. Meaning, what it is?

Decreasing volume, they will ejects the sucked fluid through the discharge port. This type of pump can also be designed with a variable displacement capability. How in such type of pump the swash plate is mounted on a movable yoke meaning; you have to adjust the swash plate whatever angle you want.

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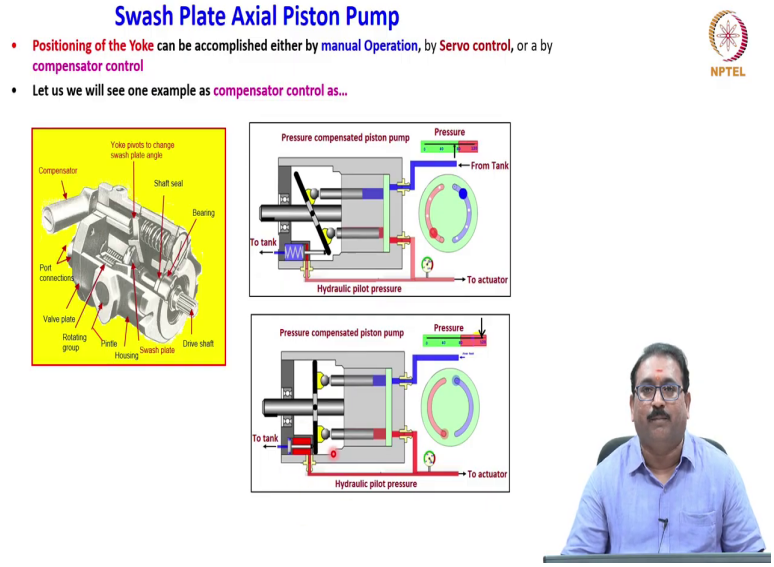

Meaning; the positioning of the yoke can be accomplished either by manual or a servo control or a compensator control. Let us we will see one example compensator control as, because you are discussed this compensator vane pump in the what we will call the vane pump you are discussed.

Similar arrangements here friends, what is that you will see here what I have shown the cut section model of the axial piston pump pressure compensated, compensator, which is here you will see is an yoke arrangement yoke pivots to change the swash plate based on the external pressure ok.

You will see arrangements here, what I did here pressure compensated piston pump, this is a swash plate, this can be moved up and down whatever you want. What I will do here, I will set the required pressure required pressure assumed to be I have setting here a 75 bar that time the outlet is receiving the complete flow, because I will get the, I will set the, 75 means what?

It is for the required angle maximum angle when the that time I am setting here, you will see the this is a compensator spring. Please remember here, from the actuator I am monitoring the pressure meaning, this is a hydraulic pilot pressure when pressure starts increasing beyond the 75 bar.

You will see here 120 bar, when it will reach this is what happens compressing, then what happen this swash plate is coming to the middle position then what happens here, we will see friends, the pistons are on the same line, that time no flow. This is an arrangement made between the compensator spring and the monitoring the outlet pressure and moving this swash plate through the this arrangement, hydraulic arrangement pilot signals.

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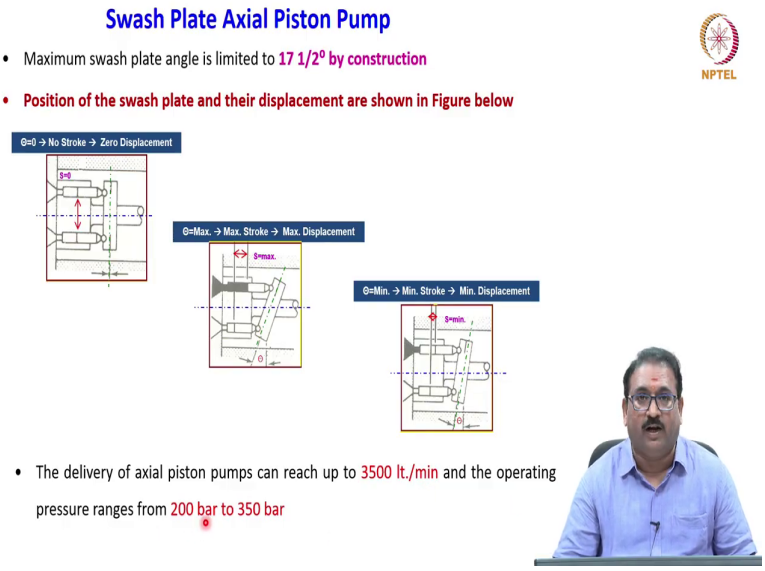

Then maximum swash plate angle is limited to 17, 1 by 2 degree by construction. The position of the swash plate and their displacements are shown here, you will see here. Now, swash plate is this, this is a piston stroke is 0 as, because swash plate is like this. Here, we will see maximum theta maximum theta, maximum stroke, maximum displacement, then you will inclined any direction you will see. Theta is very small compared to this, that is a minimum displacement.

Meaning; what I am doing here, I am moving the swash plate to get the required flow rate. Always there is an angle theta, otherwise there is no flow 0 displacement. The delivery of the axial piston pumps can reach up to 3500 liters per minute and the operating pressure ranges from 200 bar to 350 bar.

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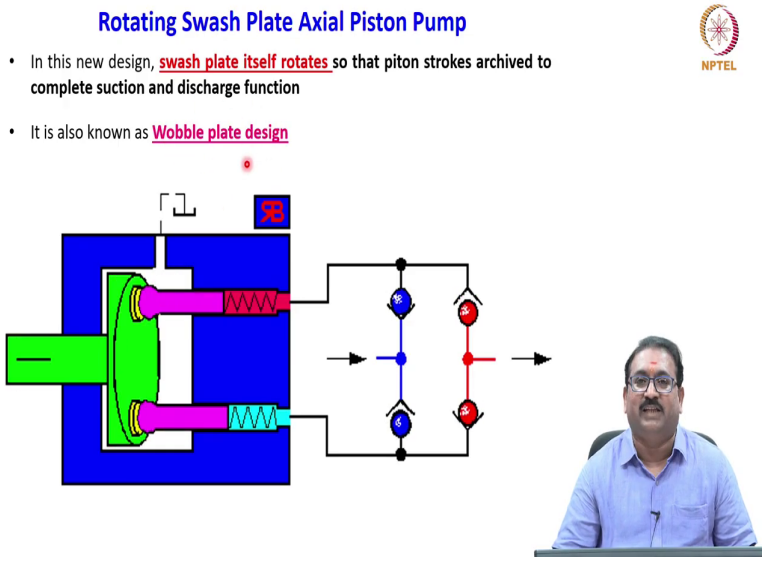

Now, we will see friends some figures, I am showing you here. In this design the swash plate itself. You will see swash plate itself rotates. Now, swash plate itself it is a rotates to make the strokes of the pistons then what happens suction and discharge will takes place. This is what we will call the rotating swash plate axial piston pumps, the piston stroke achieved by rotating the swash plate itself. Similarly, one more design, it is also known as please note, wobble plate design it is.

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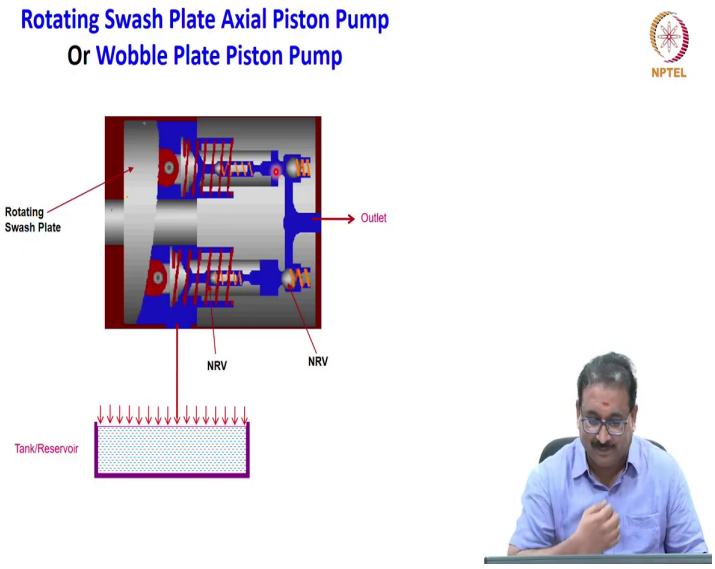

You will see one more wobble plate design using the springs. The rotating swash plate axial piston pump are also known as wobble plate. Now, the swash plate itself it is moving in and out then what happens; the suction of fluid will takes place and discharge will takes place simultaneously. The same effect, but here, swash plate is not fixed; it is rotating to get the required strokes, meaning; to move the piston in and out of the port plates.