Oil Hydraulics and Pneumatics
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Part 02: Positive Displacement pump and pumping theory
Lecture - 14
Hydraulic Pumps

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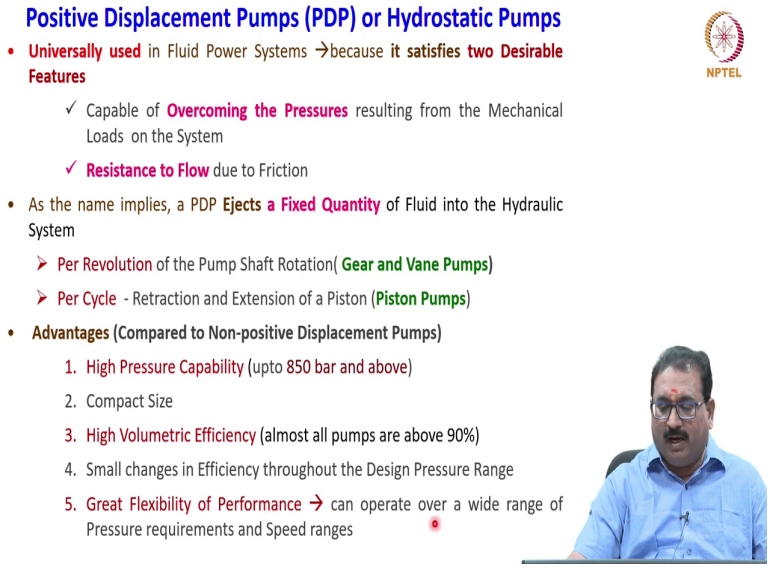

My name is Somashekar, course faculty for this course. Please understand friends, the Hydrodynamic Pumps are known as a non-positive displacement pump. What is this? For every revolution of the pump you may or may not get the fixed quantity that is why it is called as non-positive displacement pumps the quantity of output not guaranteed. As resistance increases flow decreases as we are seen in the previous.

Now, will see the Positive Displacement pumps or hydrostatic pumps. They are universally used in fluid power systems because it satisfies two desirable features. What are those? Capable of overcoming the pressures resulting from the mechanical loads on the system. Second one is resistance to flow due to friction.

As the name implies, a positive displacement pump exacts a fixed quantity of fluid into the hydraulic system. For the per revolution of the pump shaft rotation in case of gear pump and vane pump. As already we know that gear pump and vane pump rotary pumps. That is why I am telling you for per revolution of the pump shaft affects the quantity of fluid is ejected positively.

If you are seeing the piston pumps what you can call a reciprocating pump that time per cycle, meaning what it is? Retraction and extension of the pump will ensure the fixed quantity.

When we will retract it will suck the fluid when you will extend meaning suction and discharge will ensures the fixed quantity of fluids in case of the piston pumps. We will discuss these things with figure in the further slides. But, you will remember friends, positive displacement pumps are those pump in which the per revolution or a per cycle fixed quantity of oil is ensured at the outlet.

So, advantages compared to non positive displacement pumps are high pressure capability meaning upto 850 bar and above is also possible based on the design. Compact size; high volumetric efficiency, almost all pumps are above 90 percent. Piston pumps may go up to 96 to 98 percent. Small changes in efficiency throughout the design pressure range. This is only due to the leakage some losses. Great flexibility of performance can operate over a wide range of pressure requirements and a speed range.

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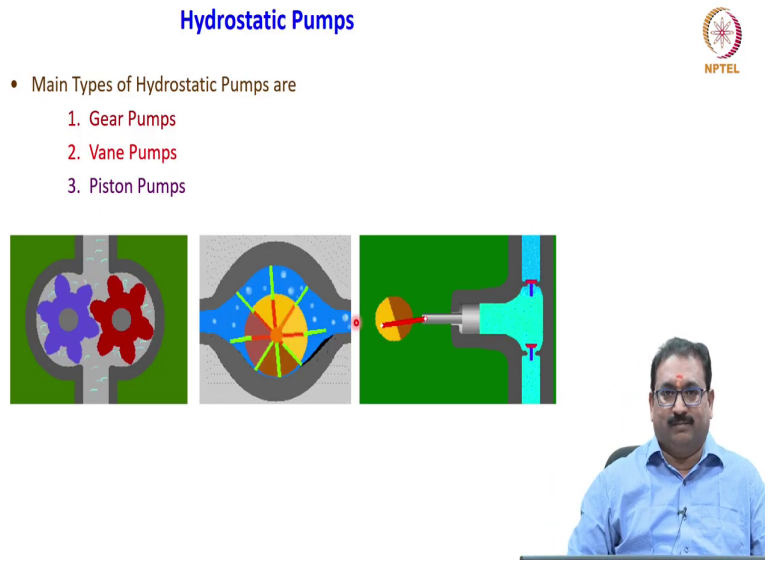

Now, we will see friends these are most popular pumps are hydrostatics. They are gear pumps, they are the gear pumps I will tell you what are constructional features; then vane pumps; piston pumps. In all the pumps you have to understand neatly friends some rotating elements are there, stationary housing is there, in all the cases you will see.

Also note, inlet is there outlet is there; inlet is there, outlet is there. Irrespective of the gear pump, vane pump, piston pump. Rotating elements are enclosed in the housing, inlet is there, outlet is there; inlet we are connecting to the tank, outlet is connecting to the walls and what you can call actuators.

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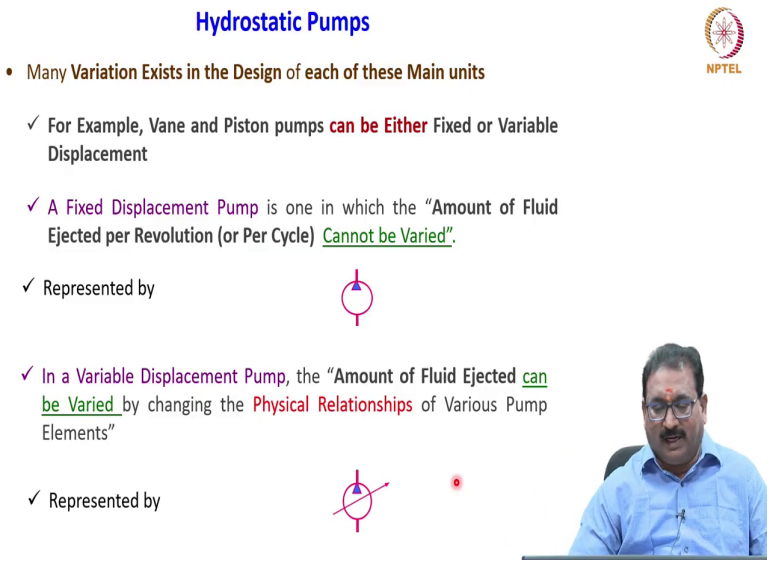

Let us now concentrate more on the hydrostatic pumps not the hydrodynamic pumps. Hydrodynamic pumps you already studied in the fluid mechanics as I have told you previously. Many variations exist in the design of each of these main units, gear vane or piston. For example, the vane and piston pumps can either fixed displacement or a variable displacement; a fixed displacement pump is one in which the amount of fluid ejected per revolution or per cycle cannot be varied.

When you are buying if you will be the fixed displacement pump, over it is. The designer, manufacturer can fix the relative motion between the one element to another element, fixed it is. You cannot change, cannot varied that is a flow cannot be varied. They are represented as we have discussed in the symbols circle, triangle field, inlet, outlet. Please note the direction of the triangle field how it is; field is hydraulic.

In a variable displacement pump, the amount of fluid ejected can be varied by changing the physical relationships of the various pump elements. Already we know they presented how it is one arrow mark over the same what we are seen; circle with triangle field, inlet, outlet and a put the arrow; meaning it is the displacement per revolution or a per cycle can varied based on the requirement. They are quite expensive as compared to the fixed displacement pumps.

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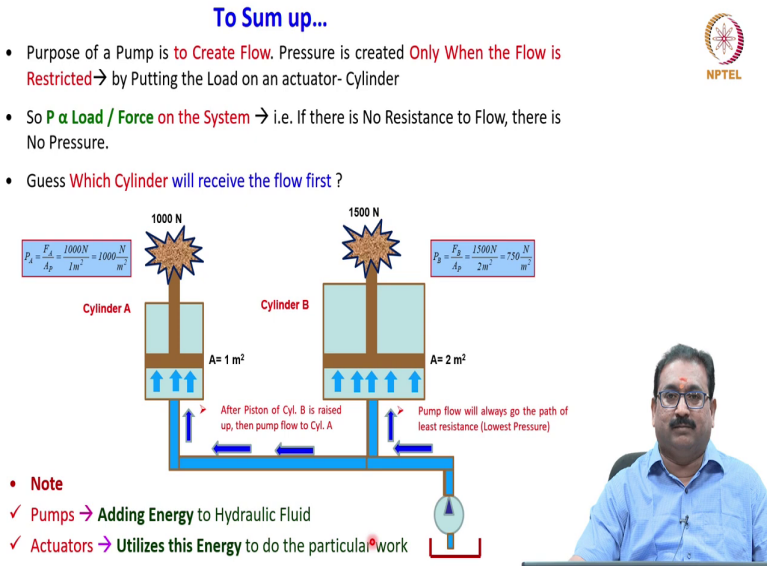

To sum up on the pumps, purpose of pump is to create a flow, note down please friends. Pressure is created only when the flow is restricted. How? By putting the load and the actuator either the cylinder or a motor, if no load only pump will ejects the flow. That is why they are known as flow generator, not the pressure generators.

P is proportional to load that is force on the system. If there is no resistance to flow there is no pressure. Now, I will show you simple sketch. You know already the resistance to flow is a

pressure. Understand neatly in mind otherwise pump will produce only the flow. It will sucks the fluid and it will ejects the fluid that is a duty of pump, it is not a pressure generator, understand.

Pressure is created based on the load on the actuator. Now, we will see here friends I have shown two cylinders with load 1500 Newton and 1000 Newton and also the given the area of the piston can you please tell me which cylinder, cylinder A or cylinder B receives the flow first from the outlet? How to do it friends?

We must know first what is a pressure at A. Pressure at A is equal to F A by A P. F A means this is a load 1000 Newton divided by area of piston here 1 meter square, this is a 1000 Newton meter square. Similarly, you will calculate here P B the pressure at this; what is F B by A P? 1500 Newton by 2 meter square, this is 750 Newton per meter square.

Then where which one will receive now, can you please tell me? Yes, because pump flow will always go to the path of least resistance lowest pressure, then only it will move after the cylinder B is raised up, then the pump flow to the cylinder A. This is very simple calculation will give you the glitch fair the flow will moves always the flow will moves the path of least resistance.

Also note friends pumps are adding the energy to the hydraulic fluids. On the other hand, actuator utilizes this energy to do the particular work.

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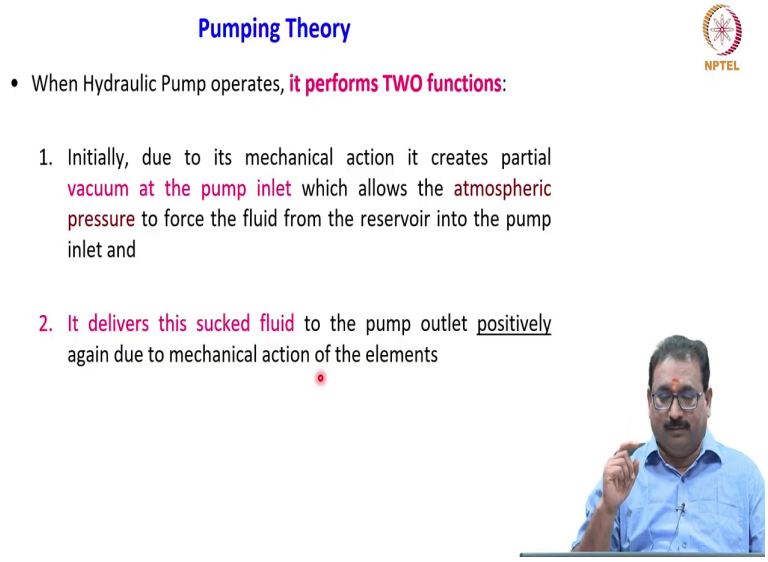

Now, let us will see the pumping theory what is this pumping theory? When the pump is connected to the hydraulic tank, how the fluid will suck and how it will transport to the rest of the hydraulic system. The, what is a theory behind it? When a pump operates it performs two function. What is first one?

Initially, due to the mechanical action what is this I will tell you, but understand this initially due to the mechanical action it creates a partial vacuum at the inlet. This is a must which allows the atmospheric pressure to force the fluid from the reservoir into the pump inlets.

And, then what happens? It delivers this sucked fluid to the pump outlet positively again due to the mechanical action of the elements. This creating the vacuum always happen at the inlet,

then due to the differential pressure the tank is always kept at the atmospheric pressure. That is why air breathers are there on the tank surface always air is acting.

Due to this differential pressure meaning the pressure created at the inlet partial vacuum and the tank pressure one bar it will sucks the fluid. Once it will catch fluid will transport the very very important thing is there is a close clearance between the rotating or a reciprocating element with the housing. That is a very very important thing in the hydrostatic pumps.

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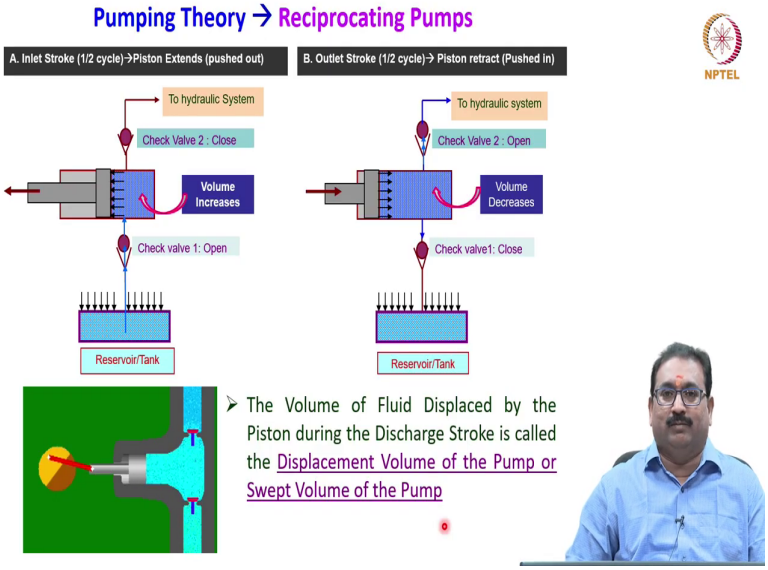

Let us will see in case of reciprocating pumps, what is the pumping theory. Very simple friends here as shown in this sketch you will see here the inlet stroke, meaning it is half cycle. What is this half cycle, I will tell you. The piston extends this extends in this figure it piston extends meaning it is pushed out, piston is pushed out it will sucks whatever you call or it moved from the right side to left side.

Then what happens, you will see here friends. When the piston is drawn out this volume goes on increasing that is why it is called increasing volume is always a suction side. It will sucks the fluid, then when the piston is pushed in what happened to volume? Volume decreases that time fluid will be e discharged out of the pump outlets.

Now, we will see this friends the half cycle means when the piston moves from your right side to left side volume increases half cycle, the fluid is sucked in. When will pushed inside the cylinder the volume decreases, it will discharge the fluid another half cycle. Then understand neatly; here I have shown you the two check valve check valve one opens when the piston is drawn out that time the tanks are kept at the atmospheric pressure, then it will sucks the fluid because it will creates the partial vacuum.

Please understand friends there is a very little gap between the piston and the cylinder. If there is a large gap then air will pass from here to here, then vacuum will not create, then it is not called as a hydrostatic pump. The very very important thing is there is a very very minimal clearance between the piston and the cylinder. Then when it will sucks at the at a moment the vacuum create here, then fluid will be sucked because it is one bar and it is the vacuum fluid will sucks check valve 1 opens.

Path of least resistance only here it will not open, when will pushed out fluid will not enter through this it will closes then fluid enters only to the hydraulic system through the check valve 2, it will opens. You will see here friends what I have shown you here you will see here and the other cycle when you pushed in the fluid will move here not through this it will closed. You will see the animation also.

When it will moved out the fluid will suck then it will push in this will close this will close these are the NRV 1 and NRV 2 the very very simple. Please understand when the piston is drawn out the volume increases meaning section is taking place, when you will pushed in volume decreases meaning discharge is taking place. The increasing volume and decreasing volume or very very important in the hydrostatic pumps, which will determines the suction and discharge of fluid.

Similarly, we will see now friends this increasing volume and decreasing volume in case of the rotary pumps. Before going that the volume of fluid displaced by the position during the discharge stroke is called the displacement volume of the pump or it is also known as swept volume of the pump. One cycle when it will take it out sucks when you will pushing discharge this is one cycle it is the how much quantity is fixed that is what we will call the displacement volume or a swept volume.

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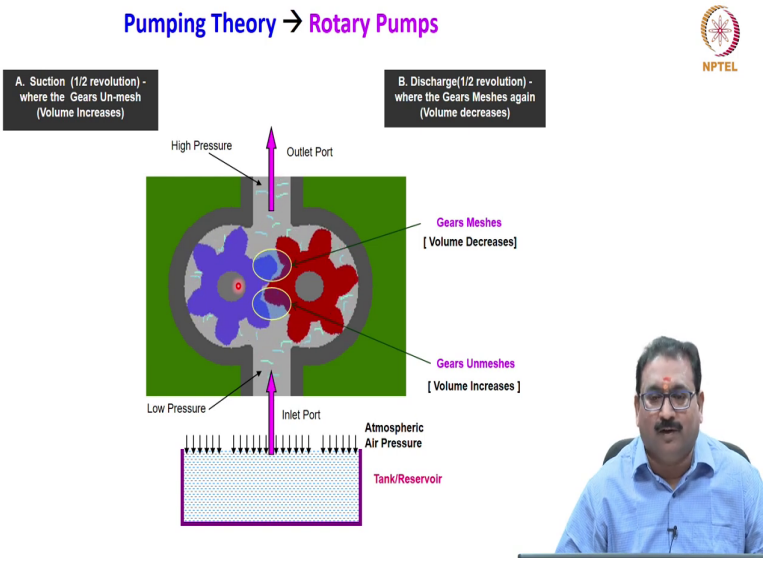

Let us will see now this pumping theory, what is a pumping theory? The increasing volume and a decreasing volume you have to observe between the elements and the housing. You will see here friends the two gears are enclosed in the housing; one is connected to the, your electric motor driver another one is a driven gear, correct? Very simple it is what I have shown.

Please observe here friends, I have marked hear you will see the gears are unmeshing. You will hold your hand you will move here look here you see the area here when you will move here area increases. Carefully you will observe when unmeshing takes place the area increases. This is always a suction sides, meaning when it will starts rotating momentarily the unmeshing takes place that will creates the vacuum.

Then due to the differential pressure one bar at the tank and vacuum at this, the fluid will suck in. It will sucks due to delta P fluid will be sucked in. Then fluid will be transport see how it is transporting along the periphery meaning the pockets formed between the gear tooth and the housing and the wear plates, top and bottom plates.

Very important thing what you have to see the gear unmeshes when it will starts that time volume increases slowly you will observe here volume increases. When going to re mesh what happen the volume decreases, meaning what happen it will force the fluid out, but you may ask the some amount of fluid will come to the tank again that is what you can call the leakage.

That is why volumetric displacement is playing a major role. What is this I will tell you in the next slide. Please here understands here friends the one cycle means as I have told you suction takes place half revolution, where the gear teeth unmesh here volume increases like one then another moving. The discharge is another half revolution where the gear teeth meshes again; meaning it will forced out the fluid from the outlet.

Again you will see friends the one rotation means one complete rotation half rotation sucking another half rotation discharge. This is what you can call the pumping theory observed in the rotary pumps in previous slide you have seen the reciprocating pump one complete cycle means half cycle it will sucks the fluid another half cycle it will push the fluid out.

Similarly, here the half the rotation fluid will be sucked another of revolution it will discharge the fluid out of the tank. This is very very important in the hydrostatic pumps.