Oil Hydraulics and Pneumatics

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Part 3: Variable Displacement Pressure Compensated Vane Pump, Balance Vane Pump, Kinematic Inversion of Vane pump and Numerical

Lecture - 19
Vane Pumps

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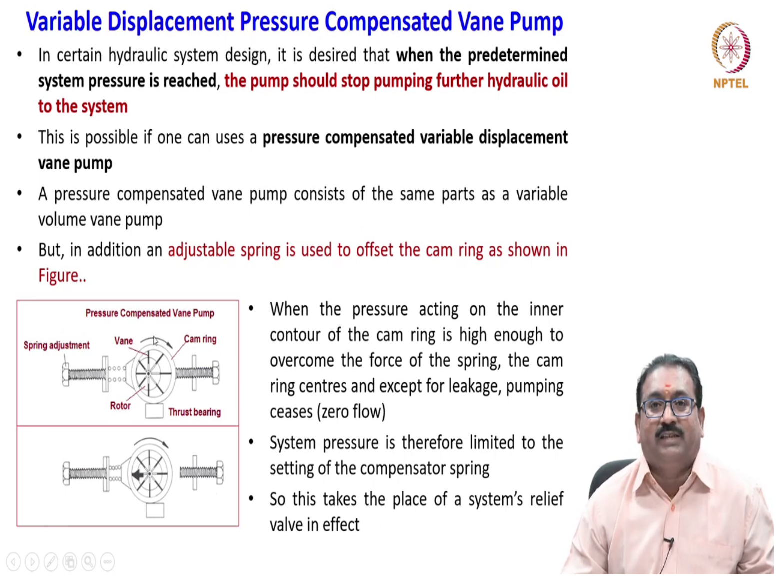

My name is Somashekhar, course faculty for this course. Now, we will see in a certain hydraulic system design it is desired that, when the predetermined system pressure is reached the pump should stop pumping further hydraulic oil to the system. This is possible if one can use a pressure compensated variable displacement pump. A pressure compensated Vane Pump consists of the same parts as the variable volume vane pump we discussed.

But in addition it has an adjustable spring, which is used to offset the cam ring as shown in the figure here. You will see friends here in the pressure compensated vane pump we have the one stiff spring, which can shifts the cam ring to the desired position. Then what happens here friend? When the system pressure acts on the inner counter of the cam ring is high enough to work on the force whatever you are setting here spring.

The cam will re-centres and accept the leakage pumping ceases meaning it is a zero flow. System pressure is therefore, limited to the setting of the compensator spring. Then what is an arrangement friends here? In the variable displacement pressure compensated vane pump all parts are same slotted rotor cam ring vanes.

But shifting of the cam ring is done through the very stiff spring compensator spring whatever the pressure you will set it here. For example, I am setting here 100 bar, then what happened? The on other side the discharge pressure is acting if the discharge pressure is exceeding the setting pressure here, it will push the cam ring to the centre.

When it is centre oil will re-circulates this is the basic mechanism in the pressure compensated vane pump. When we are using the pressure compensated pump no need to have the pressure relief valves because it will do as same function.

Otherwise every pump in fluid power system is equipped with the pressure relief valve. When you are using the pressure compensated no need to worry because automatic adjustment of the way your cam ring is done through the system pressure itself.

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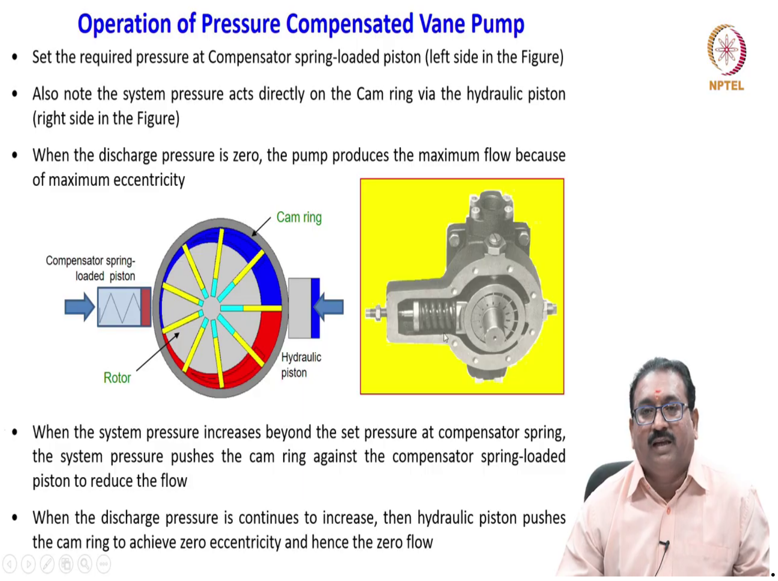

How it is? I will tell you here. You will see here friends set to the required pressure at the compensator spring loaded piston. Also note the system pressure acts directly on the cam ring via the hydraulic piston on the other sides, meaning discharge pressure is acting here. When the discharge pressure is zero beginning you know the pump produces the maximum flow because the maximum eccentricity I am providing by pushing the cam ring using this spring.

When the system pressure meaning the discharge pressure increases beyond a set pressure at the compensator spring the system pressure pushes the cam ring against the compensator spring loaded piston to reduce a flow. When the discharge pressure is continues to increase further, then the hydraulic piston here pushes the cam ring to achieve the zero eccentricity and hence the zero flow.

You will see mechanism here. So, this is a stiff spring which is used to push the cam ring. And another side your delivery pressure or a system pressure is acting. If this pressure is goes on increasing it is tried to push the cam ring against the compensator spring.

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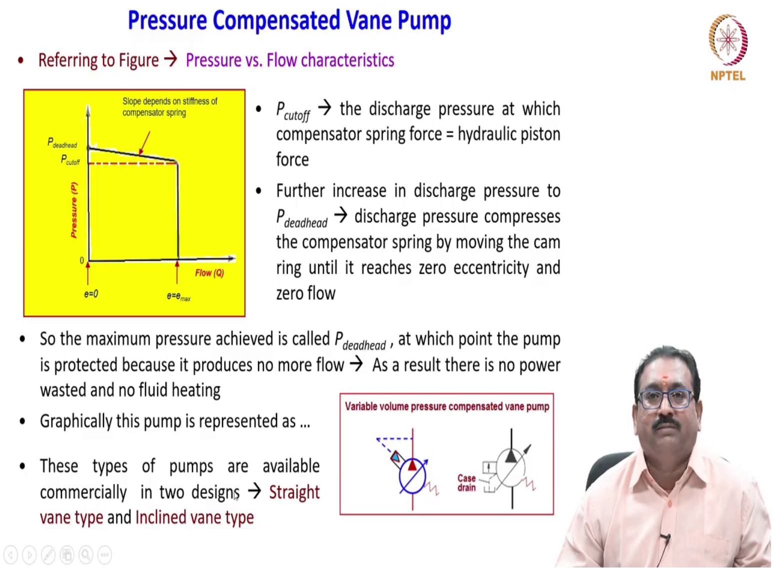

You will see here, now I have drawn the pressure compensated vane pump the pressure versus the flow when maximum eccentricity you will get the maximum flow. If pressure is increasing you will see if the pressure is increasing meaning, when the P cut off when will, what is this p cut off? The discharge pressure at which the compensator spring force is equal to hydraulic piston force.

This is the P cut off, if further increase in the system pressure or a discharge pressure meaning where P deadhead pressure is reached, then zero eccentricity pump will not produce any flow see here, pump will not produce any flow zero eccentricity zero flow. So, the maximum pressure achieved is called a P deadhead at which point the pump is protected because it produces no flow.

As a result there is no power wasted and no fluid heating. Graphically this pressure compensated vane pumps are represented like this as I have told you the symbol. Then outlet of the pump pressure is always getting the feedback against the compensator spring. If both will match us force given by the compensator spring the force given by this system pressure matches, we will call P cut off.

If further increasing this, what happen? Zero flow you will get this is also represented in another way. You will always you will see friends when the cam ring is coincides with the rotor axis, but no flow, correct? But leakage flow is there that is what you can call it as a case drain it is going to the tank. These types of pumps are available commercially in two design.

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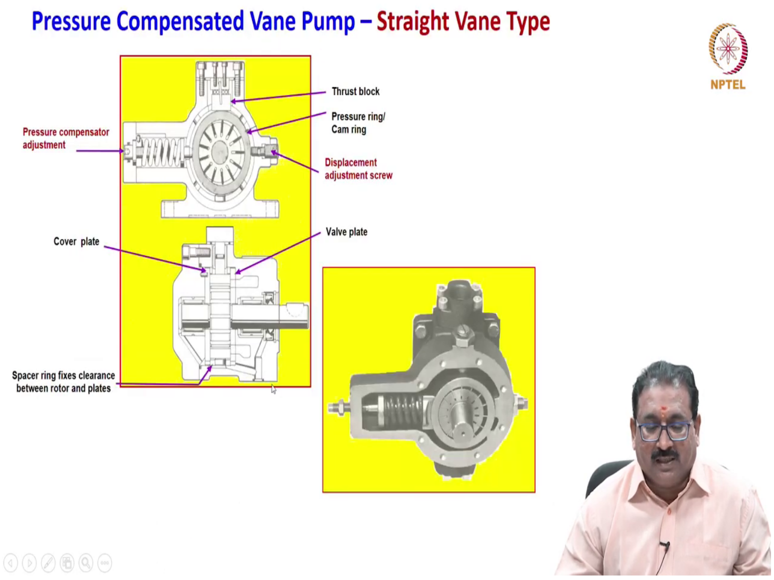

Straight vanes and inclined vanes you see the sketches here.

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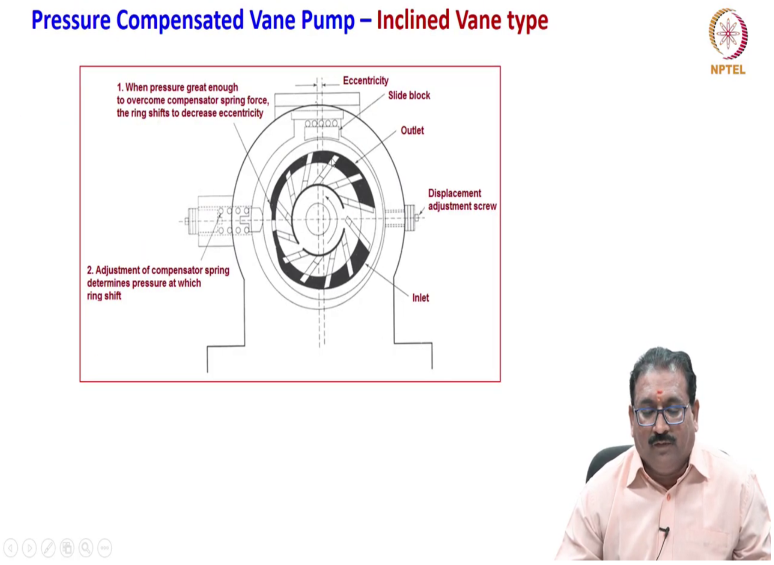

This is the straight vane vanes are straight see here straight vanes or the vanes are angular vanes you know they inclined at certain angle. Both designs are available in the pressure compensated vane pumps.

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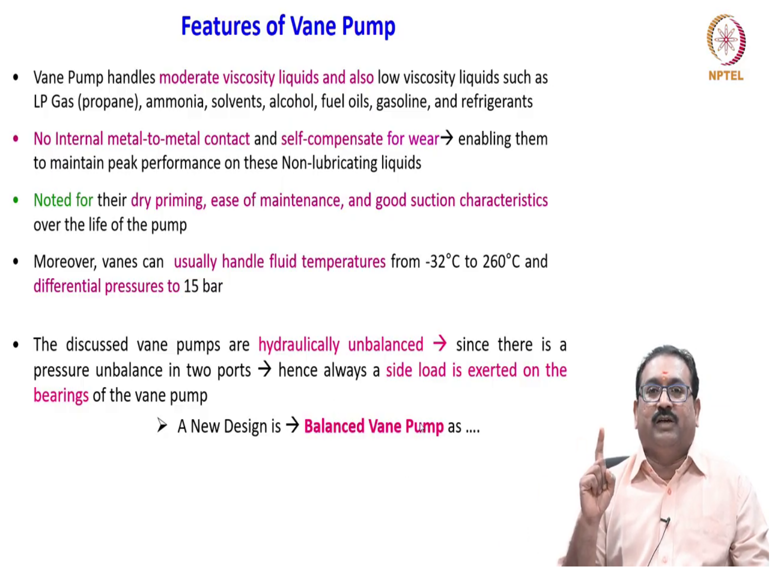

Very quickly I will give you some of the features of vane pump. Vane pumps handles moderate viscosity liquids and also low viscosity liquids such as LP gas, ammonia, solvents, alcohol, fuel oils, gasoline and refrigerants.

No internal metal to metal contact and self compensate for wear enable them to maintain a peak performance on these non lubricating liquids. Vane pumps are noted for their dry priming, ease of maintenance and a good suction characteristics over the life of the pump. Moreover the vane pumps are usually handle fluid temperatures from minus 32 degree centigrade to 2 7 260 degree centigrade and differential pressure to 15 bar.

The discussed vane pumps are hydraulically unbalanced, what is this friends? As we have seen in all the cases the outlet pressure is higher than the inlet pressure. Meaning this discharge pressure is acting on the vanes as well as on the router bearings.

So, always there is a side load is exerted on the bearings of the vane pump because of the unequal pressure outlet measure is very higher than the inlet pressure, that is why it is called as hydraulically unbalanced. What to do friends now? A new designs are available, what you can call a balanced vane pump? Here a hydraulic pressure balance is achieved during the operations.

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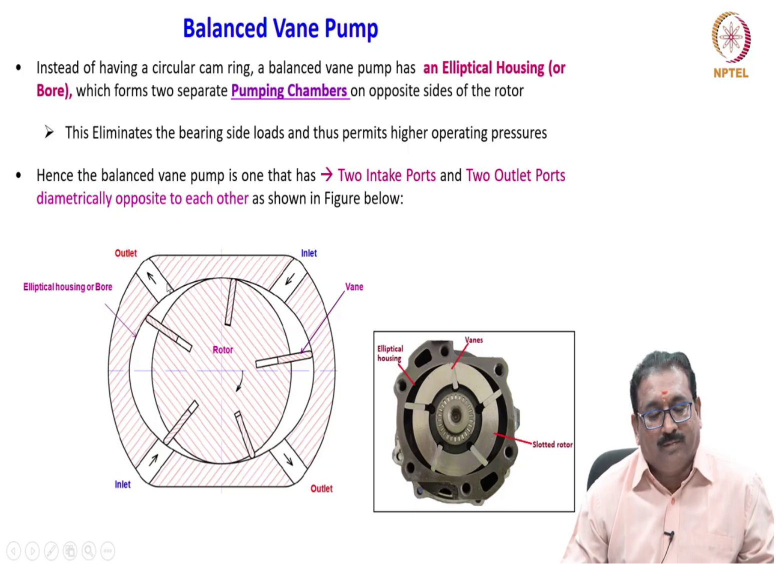

You will see now the balanced vane pump is shown here, what is the changes friends here? You will see here. what are the things rotary is there then you will see here the elliptical housing or a bore is in elliptical shape, but rotor you will see also you will see the elliptical housing bore and a rotor axis are coincided no eccentricity here.

So, here instead of having the circular cam ring a balanced vane pump has an elliptical housing or a bore, which forms two separate pumping chambers on opposite sides of the rotor. This eliminates the bearing side loads and thus permits a higher operating pressures.

Hence the balanced vane pump is one that has two intake ports and a two outlet ports diametrically opposite to each other as shown in the figure here. Two inlet ports and a two outlet ports due to this designs, but you will see the opposite ports are pressure balanced.

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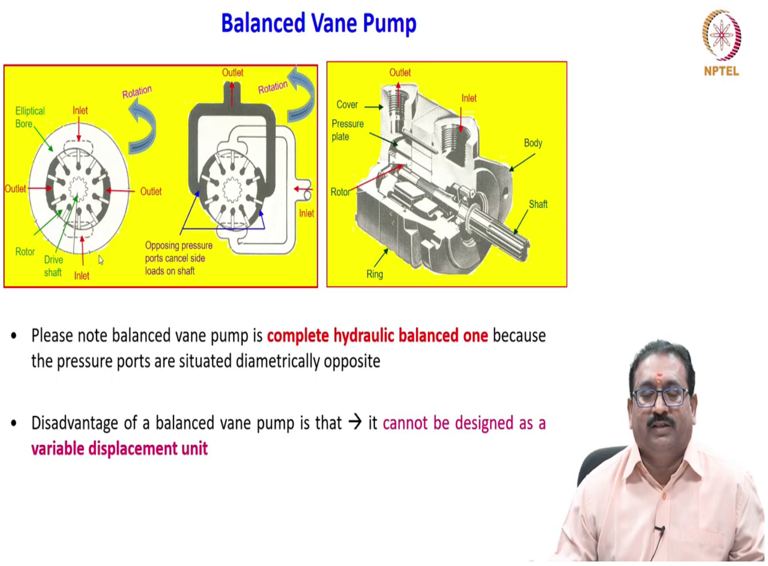

Also you will see actual practice the inlets are taken and outlets are taken connected to the respective ports. Please note, balanced vane pump is completely hydraulic balanced one because the pressure ports are situated diametrically opposites, you will see diametrically opposites.

Disadvantages of the balanced vane pump is that, what is that? It cannot be designed as a variable displacement because the bore diameter is fixed during the design stage itself, then only rotor is circular itself you cannot vary this.

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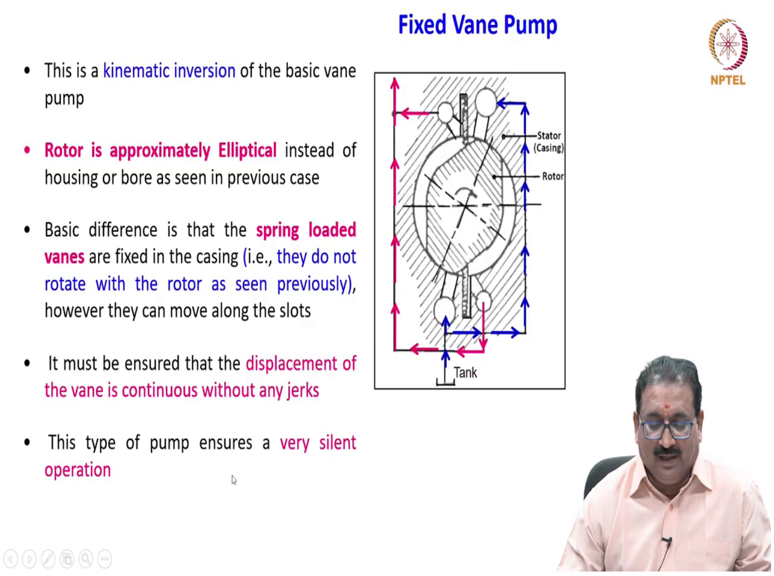

Similar to that you will see here friends the rotor shape you will see now, see the rotor shape and see the casing or a housing you will see circular housing, but rotor you will see the shape.

This is a kinematic inversion of the basic vane pump rotor is approximately elliptical instead of housing or a bore as seen in the previous case. Basic difference is that spring loaded vanes are fixed in the casing, you see spring loaded vanes all are spring loaded vanes. They do not rotate with the rotor as seen previously. However, they can move along the slots. You see here when it will based on the shape of the rotor the vanes will come in and out.

This will may creates similar to previous, again the suction and the discharge. The oil will suck here it will go then during the other half revolution oil will come here it will go here the whatever the oil is go present here it will go here, again it is a two inlets and two outlets. It must be ensured that the displacement of the vane is continuous without any jerk this type of pump ensures a very silent operation.

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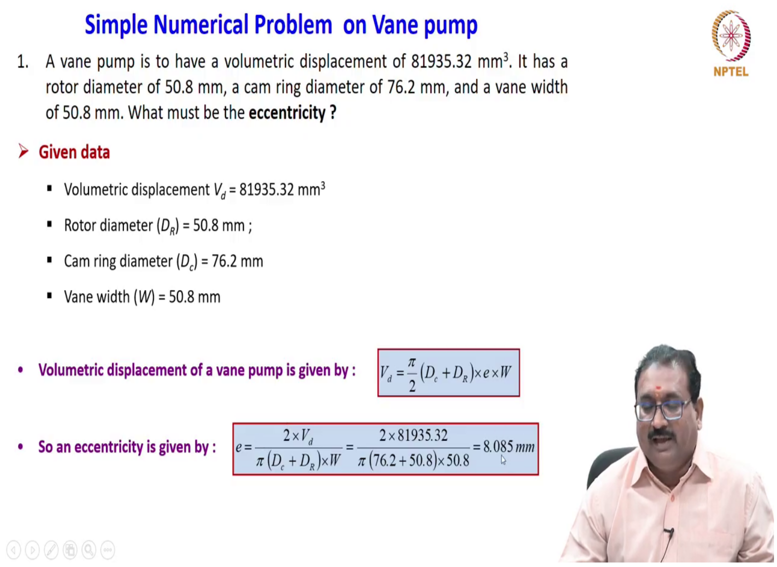

Quickly we will see some of the numerical problem on vane pump. A vane pump is to have a volumetric displacement of this much m cube. It has a rotor diameter of 50.8 mm, a cam ring diameter of 76.2 mm and a vane width of 50.8 mm, what must be the eccentricity?

Now, you will see friends the volumetric displacement is given. Now, you have to find out the eccentricity, using the same geometrical relations the given datas are volumetric displacement is given, rotor diameter is given cam ring diameter is given, vane width is given. Then volumetric displacement of the vane pump is given by V d equal to pi by 2 D c minus D r into e into W. Substitute all the values you will get the eccentricities 8.085 mm.

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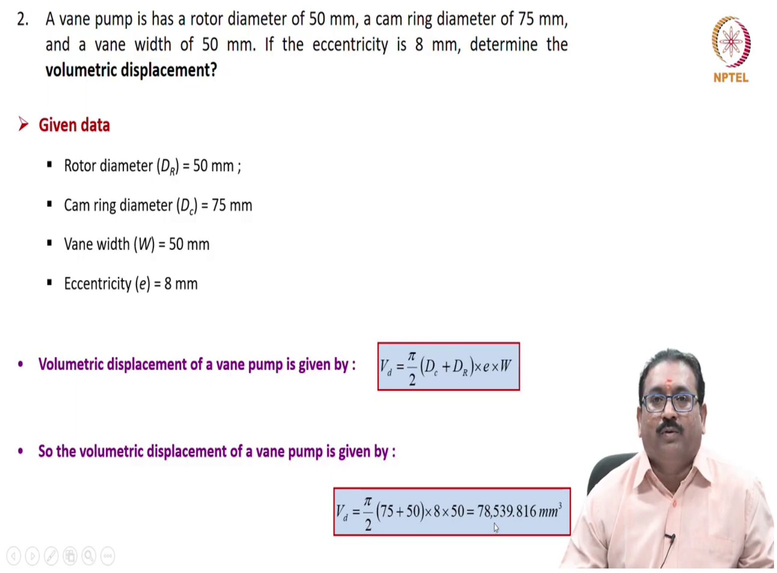

Similarly, we will see one more problem a vane pump has a rotor diameter of 50 mm, a cam ring diameter of 75 mm and a vane width of 50 mm. If the eccentricities 8 mm determine the volumetric displacement.

Compared to previous there are now we have to do calculate the volumetric displacement same the given datas are rotor diameter, cam ring, vane width and eccentricity. Then we will use the same formula volumetric displacement based on the geometry pi by 2 D c minus D r into e W. Substitute all the values you will get the this much m cube of oil will be discharged.

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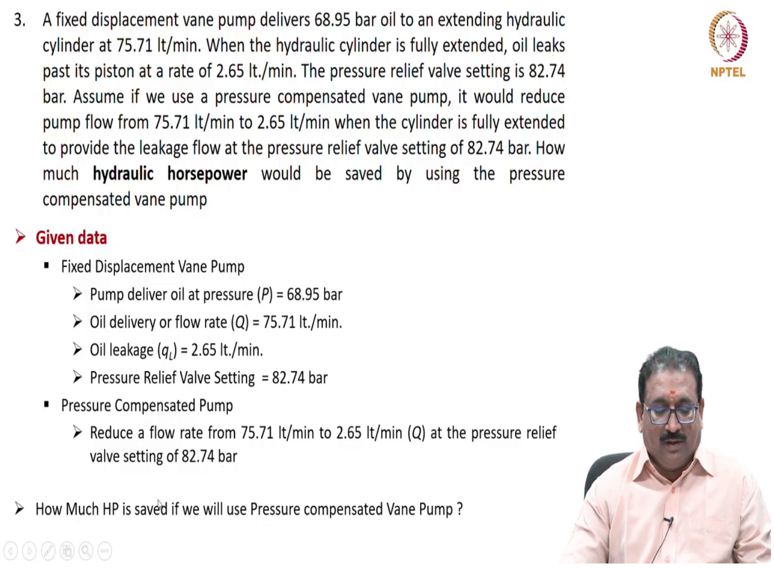

Very quickly we will see one more a fixed displacement vane pump delivers 68.95 bar oil to an extending hydraulic cylinder at 75.71 litres per minute. When the hydraulic cylinder is fully extended oil leaks past its pistol at a rate of 2.65 litres per minute, the pressure relief valve setting is 82.74 bar.

Now, you will assume, if we use the pressure compensated vane pump it would reduce the pump flow from 75.71 litres per minute to 2.65 litres per minute. meaning it is a maximum flow to leakage flow it will reduce automatically if you will use a pressure compensated pump, then what you have to do now friends?

Now, how much is the hydraulic horsepower would be saved by using the pressure compensated vane pump? To do this you calculate the hydraulic horsepower in the fixed displacement. Similarly, we will calculate the hydraulic horsepower in the pressure compensated pump then you will take the difference, how to do we will see. The given datas are for the fixed displacement pump they are given the delivery pressure, flow rate, oil leakage and a pressure relief wall setting.

In the pressure compensated pump, they are given very important; it reduces the flow rate from 75.71 litres per minute to 2.65 litres per minute at the pressure relief wall setting 82.74 bar. How much horsepower you saved if you use a pressure compensated pump?

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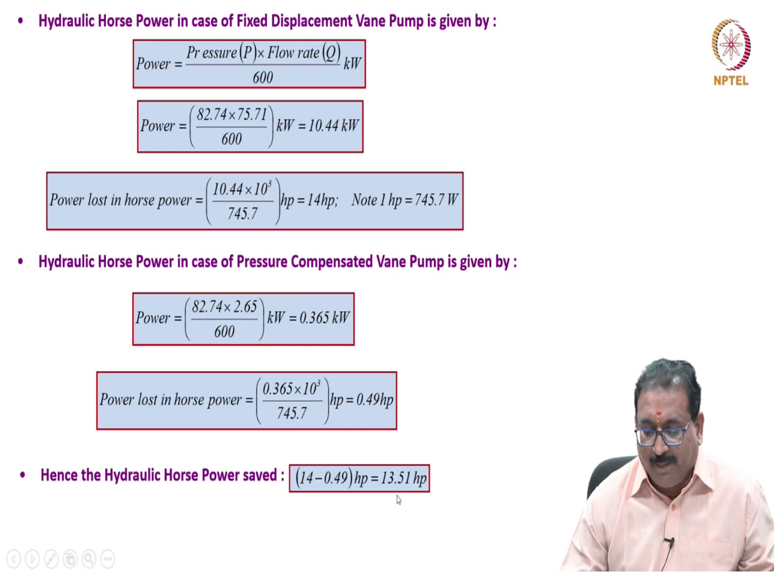

For this how to start hydraulic horsepower we know that in the fixed displacement pump power equal to pressure into flow rate divided by 600 to get kilo Watts. Then I will substitute all the values given, I am getting here 10.44 kilo Watts. The power lost in the horsepower noting that 1 hp equal to 745.7 Watt I will get fourteen hp here.

Similarly, hydraulic horsepower in case of the pressure compensated pump same it is pressure into 2.65 divided by 600 you will get 0.365 kilo Watts. Then power lost in the horsepower similarly I am dividing using 745.7 I will get 0.49 hp here. I am getting see difference you will see here 14 hp and where it is 0.49 hp large difference.

So, hence the hydraulic horsepower saved when you are using the pressure compensated pump is 14 minus 0.49, which will gives us the 13.51 hp ok.

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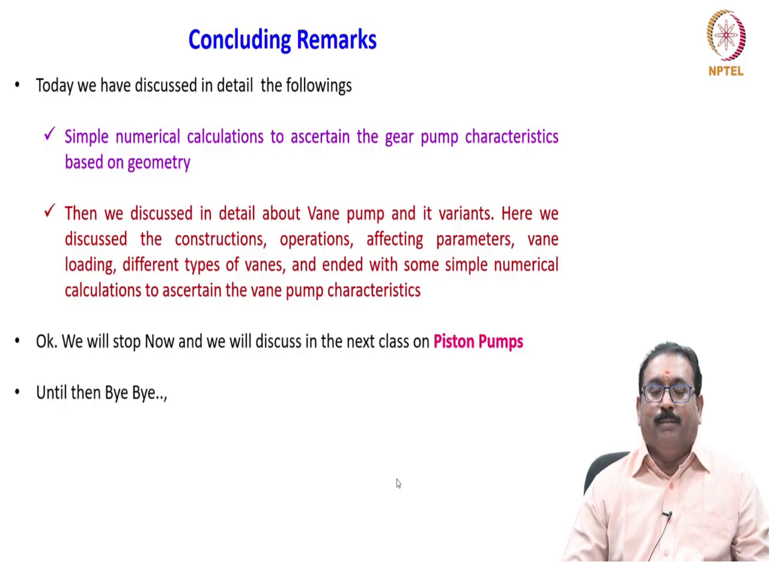

Friends we will conclude today's lecture. We have studied the followings simple numerical calculation to ascertain the gear pump characteristics based on the geometrical parameters.

Then we discussed in detail the vane pump and its variants, here we discussed the constructions, operations, affecting parameters, vane loading, different types of vanes and ended with some simple numerical calculation to ascertain the pump characteristics ok. We will stop now and we will discuss in the next class the piston pumps until then bye.

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

Thank you.