Oil Hydraulics and Pneumatics
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Part I: Numericals on Gear Pump, Tree Structure of Vane Pump
Lecture - 17
Vane Pumps

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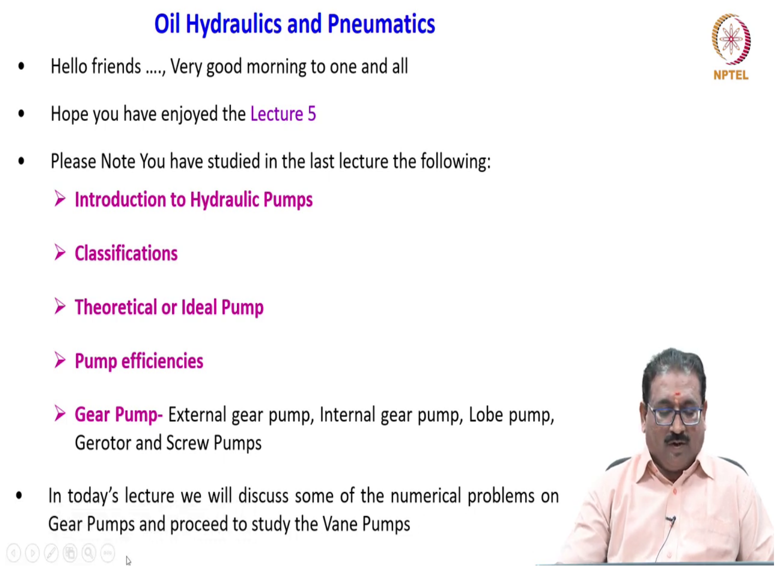

My name is Somashekhar, course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed the lecture 5. Please note, you have studied in the last lecture the following; Introduction to Hydraulic Pumps, Classifications, Theoretical or Ideal Pump characteristics, Pump efficiencies, Gear Pumps in which we have studied External gear pumps, Internal gear pumps, Lobe pump, Gerotor and a Screw pumps.

In today's lecture, we will discuss some of the simple numerical problems on gear pumps and further proceed to study in detail the Vane Pumps.

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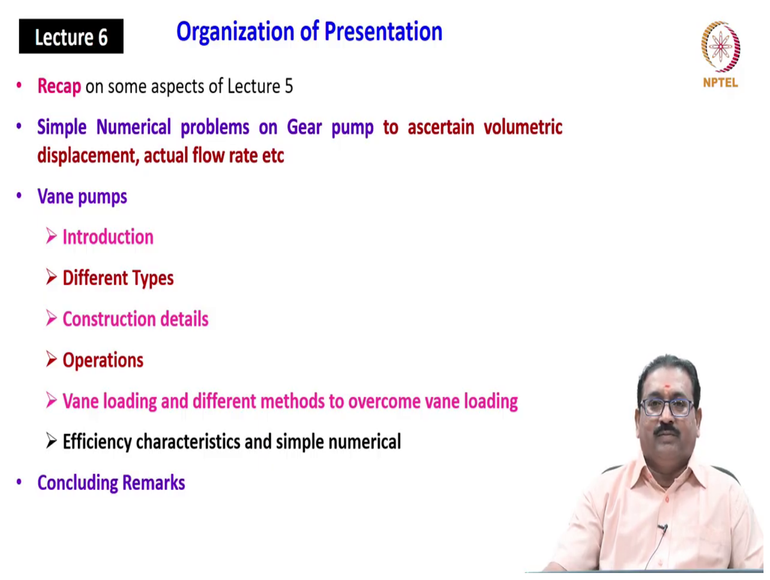

This is organization of presentation of lecture 6. Quickly, I will recap on the some aspects of lecture 5 which is needed for numerical calculations of the gear pump. Here we are discussing how to ascertain the volumetric displacement, actual flow rate with the geometrical parameters of the gear pumps move on to vane pumps.

Similar to gear pumps, we will discuss in detail about the vane pumps in which I will give you quickly the introduction, different types of vane pumps, constructional details, operations, vane loading and different methods to overcome the vane loading, efficiency characteristics similar to the gear pump, volumetric displacement, actual displacement; how to ascertain using the geometrical relationship of the vane pump components. Later, I will conclude on lecture 6.

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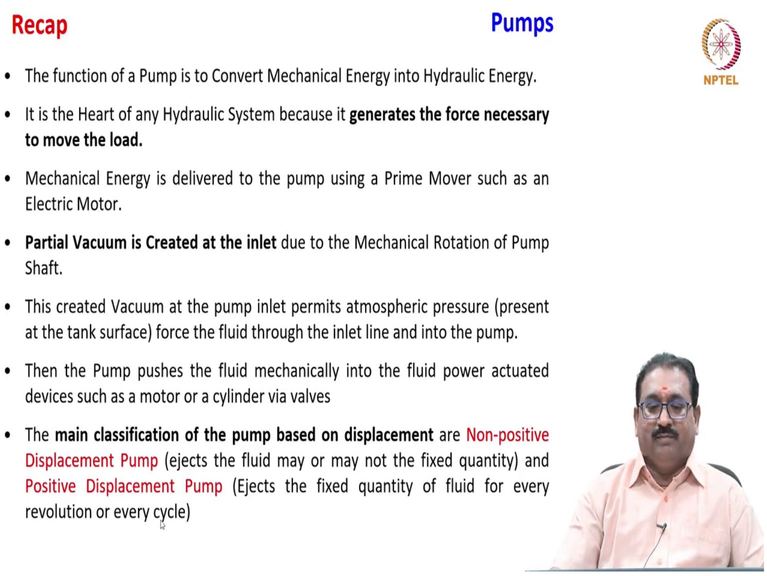

Quickly, we will see what you have studied in the last class. The function of pump is to convert the mechanical energy into hydraulic energy. The pumps are heart of any hydraulic system because it generates the force necessary to move the load. Mechanical energy is delivered to the pump using a prime mover such as an electric motor or a IC engine. The pumping theory is very important.

In all the pump, how the fluid will sucks and discharge the fluid, irrespective of the rotary pumps or a reciprocating pumps. Partial vacuum is created at the inlet due to the mechanical rotation of the pump shaft. This created a vacuum at the pump inlet permits the atmospheric pressure present at the top surface of the tank forces the fluid out of the tank into the inlet and then, to the outlet.

Once it is sucked, pump pushes the fluid mechanically into the fluid power actuated devices such as a motor or a cylinder through the valves. During the discharge, the volume decreases. The main classification of the pump based on displacement or non positive displacement pump, why it is called non positive displacement? It ejects the fluid may or may not be the fixed quantity for every revolution or every cycle. On the other hand, the positive displacement pump ejects the fixed quantity of fluid for every revolution every cycle.

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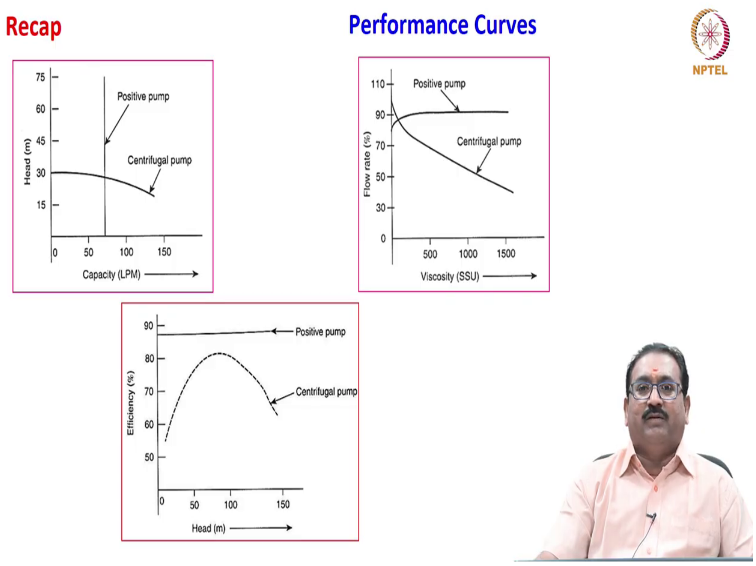

Later, we have seen the some of the characteristics about the positive displacement pump and non-positive displacement pump like a centrifugal pumps. The head versus capacity, you will see the positive displacement remains same; but centrifugal pump, it will goes on decreasing.

Similarly, the flow rate versus viscosity, positive displacement is not affected much, but centrifugal pump affected much as the viscosity increases. Similarly, we will see efficiency versus the head, positive displacement pump performs completely the assured things, but centrifugal pump increases and then, decreases.

What it will show us is non-positive displacement pump are also known as hydrodynamic pump, used for the flow transfer. Hydrostatic pump are used to generate the pressure with a small quantity of fluid. This is a main difference between the positive displacement pump and a non-positive displacement pump. Already, we noted that positive displacement pump plays a major role in the fluid power industry to generate the large pressures which intern the force and the velocity.

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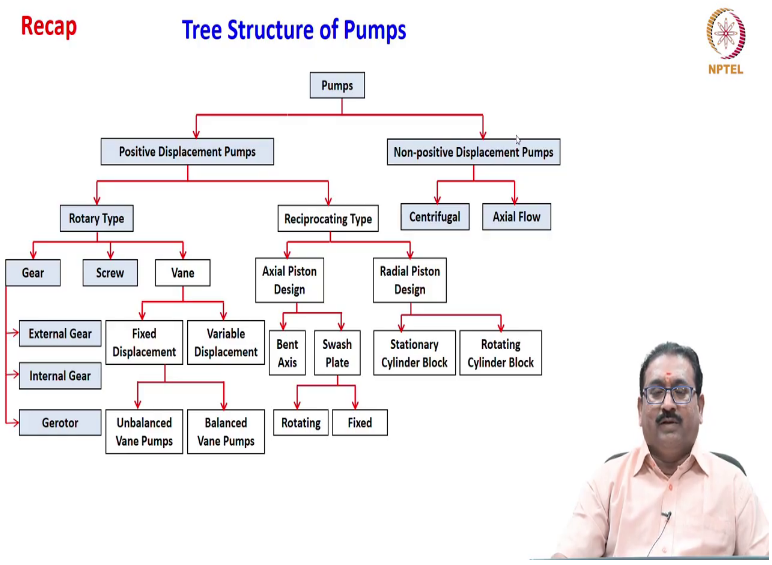

Also, we have seen the tree structure of the pump quickly. Pumps positive and non-positive, we discussed in the last class. Here, we concentrated more on rotary pumps in which gear pump, screw pump; external gear pump; internal gear pump; gerotor. In this category, it is a rotary action; but here along the axis, the fluid will be transported.

Non-positive displacement, there is a large clearance between the rotating parts and the housing centrifugal and axial flow pumps. This we are studied in depth in your fluid mechanics course; but our focus in the fluid power, all these pumps. In the last class, we discussed this; today's class, we will discuss the remaining.

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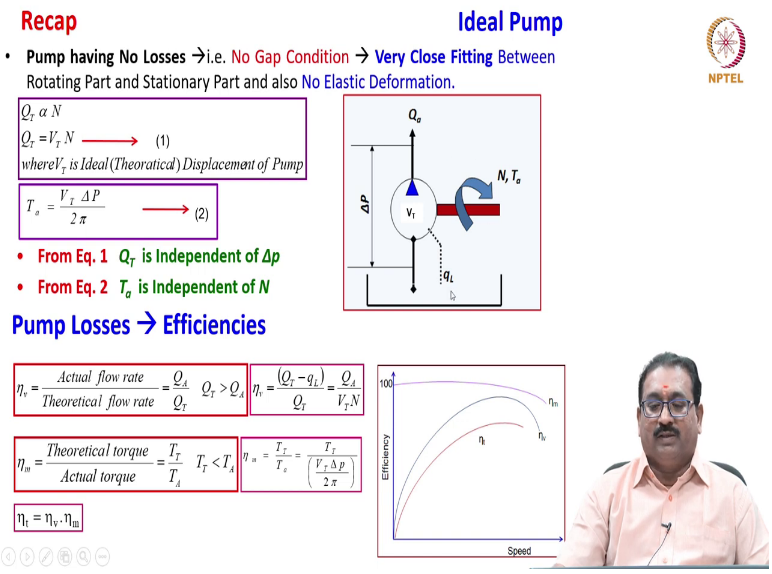

Also, we discussed the ideal pump. What is ideal pump? Pump having no losses. What is the meaning? No gap condition; meaning, very close fitting between the rotating part and the stationary parts and also, no elastic deformation. Please note friends, this is to arrive the some of the parameters; but actually all the pumps are having the clearances and elastic deformation is prone to be there in the all the pumps.

For the ideal pump the theoretical flow rate is directly proportional to the speed of the shaft. So, Q T equal to V T into N. What is the V T? V T is a ideal or theoretical displacement of the pump. In case of the rotary, it is a per revolution; in case of the piston type of pump, it is a per cycle.

Also, we know that the torque required to turn the shaft T a is equal to V T into delta P by 2 pi. From the equation 1, you will see here Q T equal to V T into N; meaning, Q T is independent of the delta P. Similarly, from the equation 2, T a is independent of the speed.

Also, we have seen the pumps available commercially all are having the losses. To study the performance of the all types of pumps, very important thing is we have to incorporate the pump losses like the leakages, rubbing action, mechanical losses, many things. That is why in the last class, we have listed the three important efficiencies to study the various types of pumps.

In which first one is a volumetric efficiency, which is a ratio of actual flow rate to the theoretical flow rate; Q A by Q T. Please note friends, Q T what you can call it is a ideal displacement which is greater than the Q A as because actual flow is less than the theoretical flow because of the leakage between the matting parts. Also, we have seen the mechanical efficiency which is a ratio of theoretical torque to the actual torque.

Here, also you will remember friends, theoretical torque is less than the actual torque because in theoretical torque calculation, we are not considering any friction and any mechanical losses. That is why actual torque is greater than the theoretical torque. Then, finally, what is very important?

Total efficiency is very important which is the volumetric efficiency and mechanical efficiency. Also, we have seen the characteristics curve, efficiency versus the speed. You will see here mechanical efficiency; the volumetric efficiency increases as the speed increases; it is a total efficiency.

Addition of these two, we will get the total efficiency. These are very very important while studying the different types of pumps. The today agenda is we have to discuss some of the simple numericals to ascertain these parameters. This is a sketch as I have told you. This is a pump, this is a shaft rotating at the theoretical torque with a certain speed; this is a delta P. What we are writing in all the equation delta P is this. q L is a leakage. This is a simple representation of the pump with some losses.

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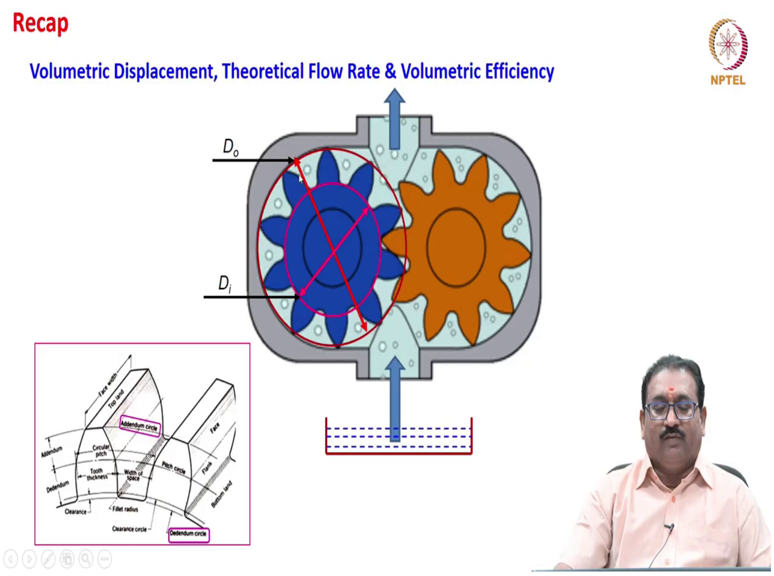

Now, we will see friends, already we have discussed in the last class, the gear pumps. The important thing what I have shown here it is a external gear pump; one is a driver, another is a driven which will sucks the fluid because of the again it is a here you will see where the gear will un mesh, volume increases immediately suction will create here. The tank is kept at the one bar. Due to the differential pressure, oil will be sucked here. That is why it is a suction; fair volume increases, un meshing takes place.

Once the fluid is catched, it is transmitted around the periphery in the pockets, you will see here pockets and when the gear again going to mesh, what happen here? Volume decreases, it positively agents. Now, in today's class, we will discuss a certain volumetric displacement, theoretical flow rate, volumetric efficiency based on the geometrical parameter of the things.

Very important things you will see here what I marked here is a D o, outer diameter of the gear and one more D i what I marked here, it is a inside diameter of the gear. These are the two important parameter along with the width of the gear.

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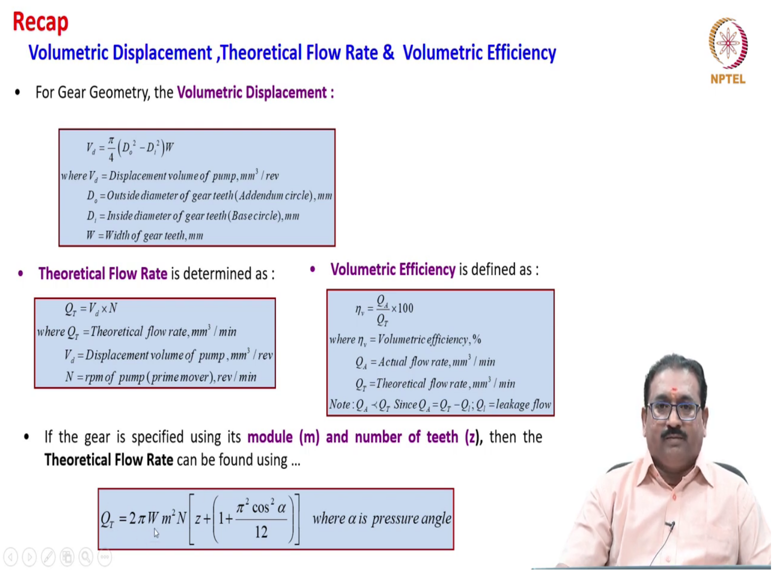

Let us we will see now friends how to ascertain this. Already, we have seen for the given gear geometry the volumetric displacement per revolution, how much oil it will discharge? This is a area multiplied by the width of the gear pi by 4 D o square minus D i square into W.

Then, theoretical flow rate is determined by V d into N; N is the speed of the rotation of the motor shaft. Please note friends, per revolution amount of fluid is fixed; even though you will rotate more, you do not think it is a variable displacement. But per revolution of the pump shaft, the fixed quantities ensured based on the geometry and all with.

Please note here, all the gear pumps are generally the fixed displacement in category. The flow rate can be varied by rotating the speed, but do not think the V d is changing. No, V d remains same. Also, we have seen the volumetric efficiency Q A by Q T. Q A includes the leakages.

That is why when you will buy the pump, characteristics curves are given. To determine the volumetric efficiency, what they will do? They will actually measures the output flow, leakage flow by running the pump at the different speeds.

Also note friends, if the gear is specified using the module and number of teeth, then the theoretical flow rate can be found out using the Q T equal to 2 pi width of the gear m square N into bracket z plus 1 plus pi square cos square alpha by 12. Here, alpha is the pressure angle.

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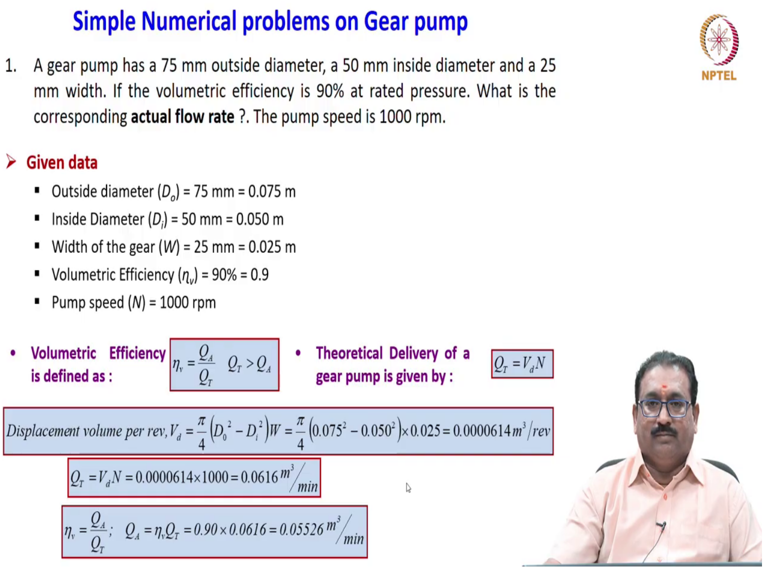

Now, let us we will see some simple numerical problems on the gear pump; how to ascertain these parameter using the geometrical parameters. A gear pump has a 75 mm outside diameter, a 50 mm inside diameter and a 25 mm width, if the volumetric efficiency is 90 percent at the rated pressure. What is the corresponding actual flow rate? The pump speed is given as 1000 rpm. So, quickly, I will list it out the given data outside diameter, inside diameter, width of the gear, volumetric efficiency, pump speed, these are the given parameter.

Please note friends here, you will convert all in the same unit. Unit is very important, while substituting in the formula. What we have to find out? We have to find out the actual flow rate. Actual flow rate, you have already seen from the volumetric efficiency Q A by Q T.

But also you know the Q T, theoretical delivery of the gear pump is determined V d into N. Then, what is this V d friends? Because they are given D o and D i, immediately you will calculate the displacement volume per revolution V d equal to pi by 4 D o square minus D i square into width of the gear.

Substitute all, you will get this N cube per revolution meter cube because I am substituting all in the same unit. Once you know V d, then what you will do? You will calculate directly the Q T, only I am multiplying with the speed. Once you know the Q T, what happens here you will see, automatically I will get the Q A. Q A equal to volumetric efficiency multiplied by the Q T, correct? I am getting the volumetric efficiency is how much it is? 0.05526 m cube per minute.

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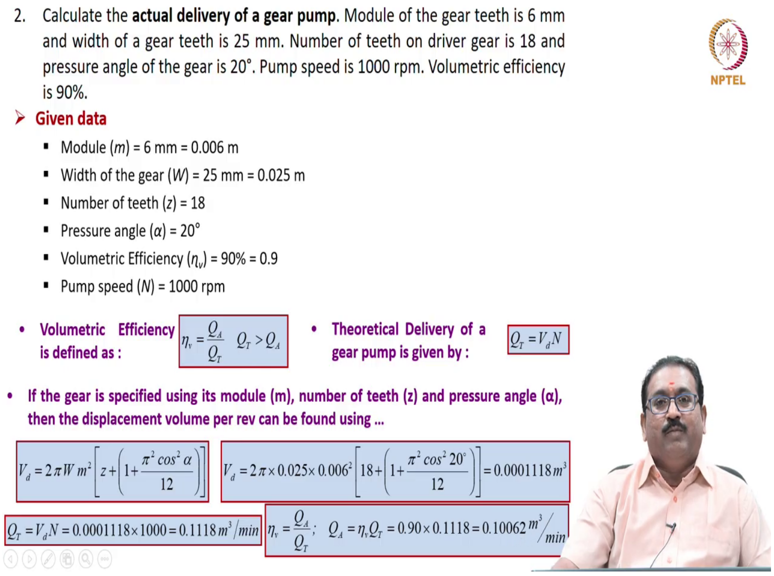

Move on to the next problem, calculate the actual delivery of the gear pump. Module of the gear is 6 mm and width of the gear is 25 mm. Number of teeth on the driver gear is 18 and pressure angle of the gear is 20 degree. The pump speed is 1000 rpm. Volumetric efficiency given is 90 percent. Then as usual, quickly list out the given data. Module is given now, width of the gear is given, number of teeth, pressure angle, volumetric efficiency is given, pump speed is also given in the given problem.

The what we have to do friends? Now, we have to do calculate the actual delivery of the gear pump. Actual delivery we have seen in the volumetric efficiency as usual, then we have to calculate the theoretical delivery of the gear pump which is given by V d into N. Now, you will please careful the V d, we have to calculate based on the given parameter. Here, the given parameters are module and the pressure angle and the number of teeth.

Now, we have to use this formula, substitute all the given parameter, we will get to the V d equal to this much m cube. Once we know the V d, quickly you will calculate the Q T by multiplying the speed of the shafts. You will get m cube per minute. Once, I know the Q T, then what we will do? Q A equal to volumetric efficiency into Q T. We will get 0.10062 m cube per minute.

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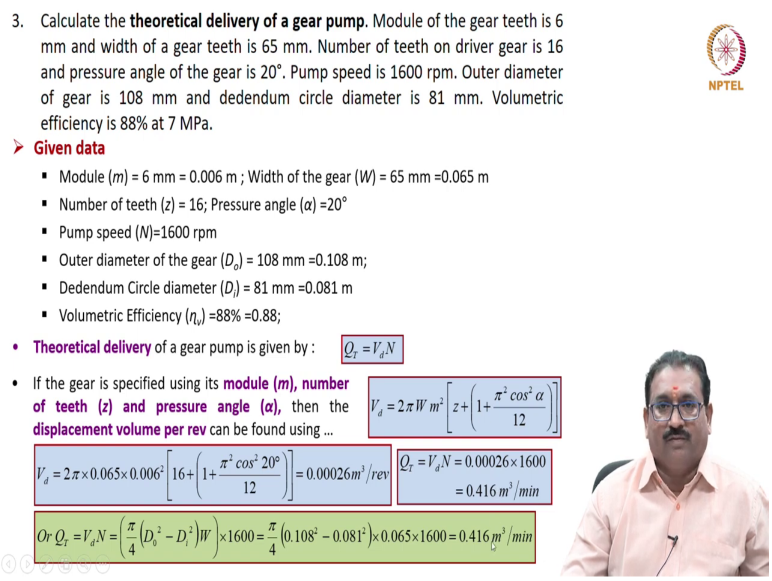

Let us we will see one more problem. Calculate the theoretical delivery of a gear pump. Module of the gear teeth is 6 mm and width of the gear is 65 mm. Number of teeth on driver gear is 16 and a pressure angle of the gear is 20 degree. The pump speed is 1600 rpm. Outer diameter of gear is 108 mm, dedendum circle diameter is 81 mm. Volumetric efficiency is 88 percent at 7 MPa.

As usual quickly, we will listed out the given data; module is given, width of the gear is given, number of teeth, pressure angle, pumps speed, outer diameter of the gear, sometimes they are giving addendum circle diameter. Addendum circle diameter is same as outside diameter of the gear.

Dedendum circle diameter is given, volumetric efficiency is given. What you have to do now? We have to calculate the theoretical delivery of the gear pump. Q T equal to V d into N. The

V d, you have to calculate. Module is given, number of teeth is given, pressure angle is given. Use this relation, you will get 0.00026 m cube per revolution. Then, Q T equal to V d into N speed.

Also, you will remember friends here; they are given outside diameter, dedendum circle diameter. So, another way is using the this formula pi by 4 D o square minus D i square into W. This is a V d multiplied by N is given the Q T. This is both will match each other.

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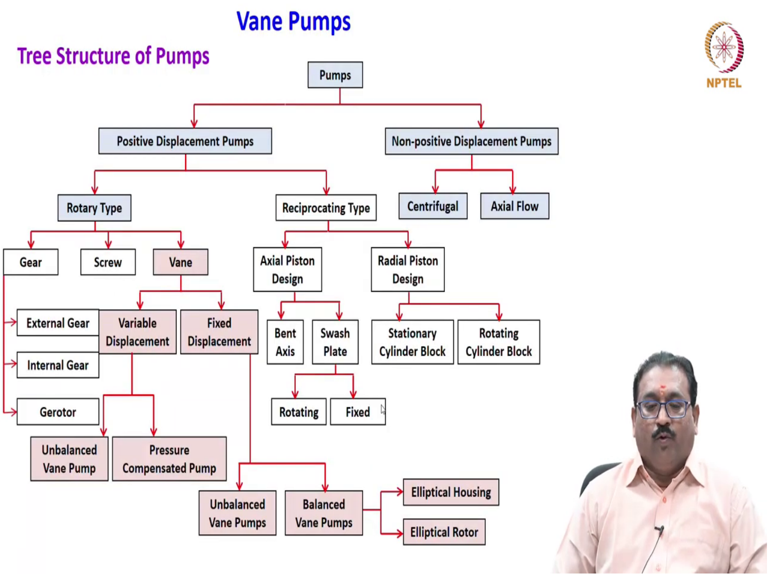

Now, we will move on to the vane pumps, here we are discussing the different invariants of the vane pumps. The vane pumps are classified into variable displacement and a fixed displacement. In variable displacement, we have unbalanced vane pump and a pressure compensated pump.

In a fixed displacement category, we have unbalanced vane pumps and a balanced vane pumps. In balanced vane pumps commercially, we will have a elliptical housing type balanced vane pump and elliptical rotor balanced vane pumps. Let us we will discuss these things in the next slides.