Oil Hydraulics and Pneumatics

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Part 2: Classifications of hydraulic motors, Governing equations, Motor performance-volumetric, mechanical and Overall efficiency
Lecture - 46
Hydraulic Motors

My name is Somashekhar, course faculty for this course.

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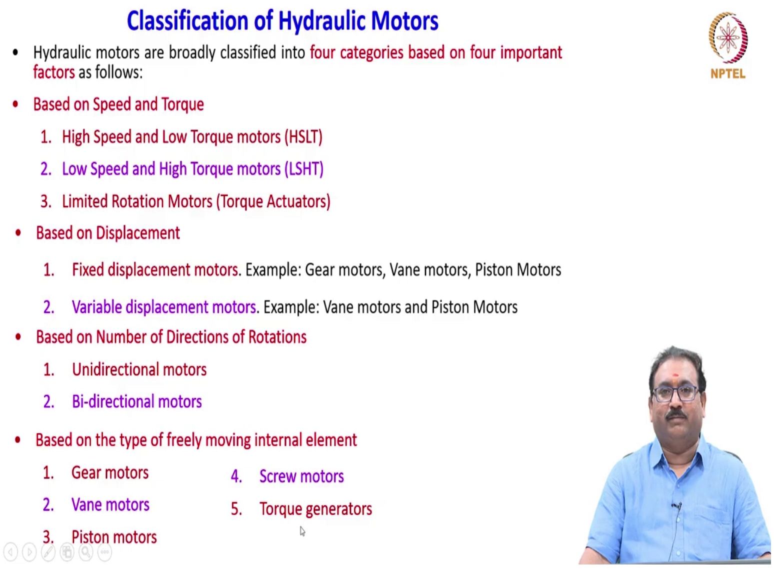

Now, we will see the Classification of Hydraulic Motors. Hydraulic motors are classified broadly into four categories based on four important factors as follows. First one based on Speed and Torque, here High Speed and Low Torque motors they are known as HSLT.

One more category Low Speed High Torque motors LSHT, Limited Rotation Motors or a Torque Actuators. Based on displacement: Fixed displacement motors - generally gear motors, vane motors and piston motors are available in the category of fixed displacement motors.

Variable Displacement motors - vane motors and piston motors based on number of directions of rotations, here unidirectional motors bi directional motors. Based on the type of freely moving internal element, based on which type of elements you are using the motors are classified as gear motors, vane motors, piston motors main moving elements in the hydraulic or a pneumatic motors. Apart from this we are having the screw motors, torque generators.

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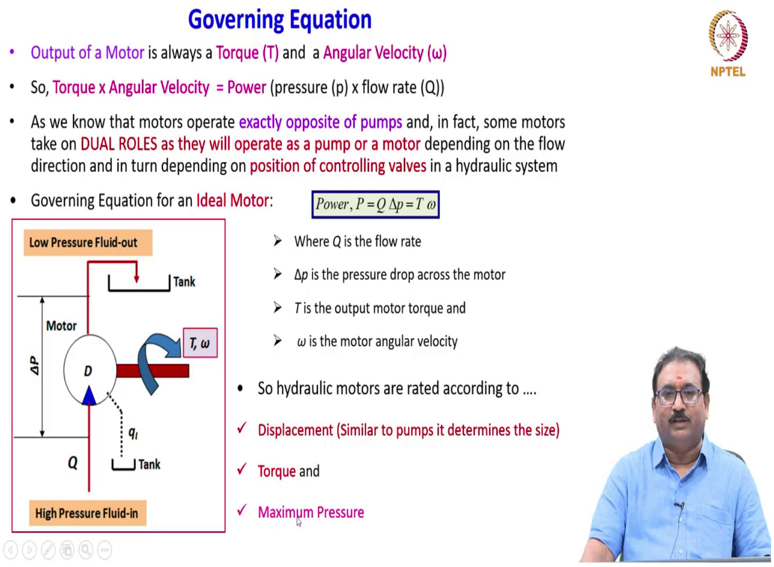

Before going to study in detail of all these types of motors we will see certain technical parameters by studying the governing equations. Output of motor is always a torque and angular velocity omega. So, torque into angular velocity is nothing but the power, here it includes the pressure and the flow.

As we know that motor operates exactly opposite of pumps, in fact some motors take on dual roles as they will operate as a pump or a motor depending on the flow directions and in turn depending on the position of controlling valves in a hydraulic system. Governing equation for an ideal motor is P power equal to Q into delta p this is equal to torque into angular velocity.

Here Q is the flow rate delta p is the pressure drop across the motor and T is the output motor torque and omega is the angular velocity. These things are represented simple diagram here; this is a hydraulic motor the input is a high pressure fluid coming through the pump and a valves here.

The output is after rotating the shaft to get the mechanical torque and angular velocity. The fluid will exit from the outlet which is a low pressure fluid out going to the tank, the delta p is important parameter across the actuator. So, hydraulic motors are rated according to displacement it is similar to pump, it determines the size of the actuator. Second parameter is a torque and maximum pressure, these are the important parameters used while rating the motors.

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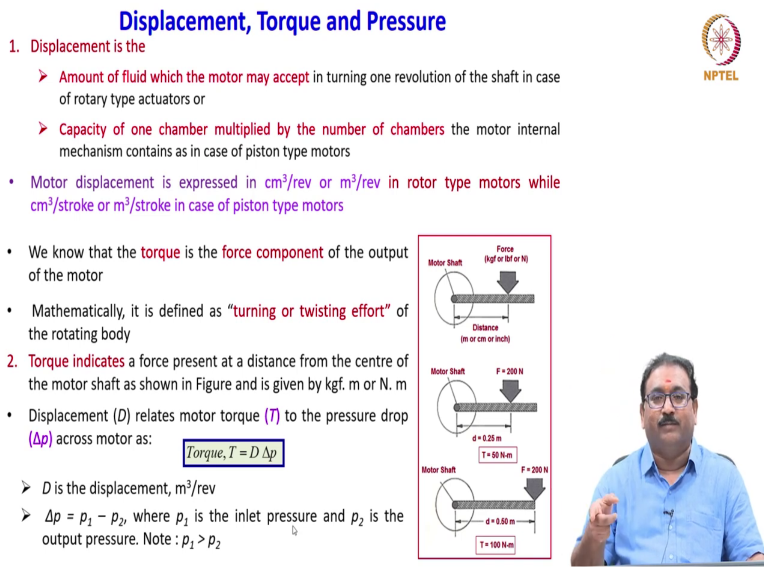

Then what is the displacement? There it is a displacement in case of pump, what it is? If it is a rotary actuator like a pump gear pump or a vane pump for one revolution how much fluid is displaced or if it is a linear actuator the one cycle section as well as discharge how much fluid will be expelled is the displacement.

But here slightly different friend what is this displacement? Displacement is the amount of fluid which motor may accept in turning one revolution of the shaft in case of rotary type of actuators or the capacity of one chamber multiplied by the number of chambers. The motor internal mechanism contains as in the case of piston type motors.

Motor displacement is expressed in centimetre cube per revolution or metre cube per revolution, in a rotor type motors while you will see here centimetre cube per stroke or a metre per stroke in case of the piston type motors. We know that the torque is the force component of the output of the motor.

Mathematically it is defined as the turning or twisting effort of the rotating body. See here; here the motor shaft what I have drawn here and force is acting at a distance. Correct here, the torque indicates a force present at a distance from the centre of the motor shaft and is given by the force multiplied by the distance, force maybe in kgf or a pounds or a Newton whatever it is and this distance is a metre centimetre or a inch.

Please take care for the units while calculating the torque or whatever it may be, the units are very important all should match. Here I have shown you here the force acting 200 Newton at a distance of 0.25 metre the torque generated is 50 Newton metre, here you will see the same force is acting at a distance of 0.5 that time the torque generated is 100 Newton metre meaning you will see the effect of distance.

Displacement D relates motor torque T to the pressure drop across the motor is given by torque equal to what? D into delta p, D is the displacement, delta p is a pressure drop across the motor, D is as I have told you m cube per revolution in case of the rotary actuator. But in case of the piston even though rotary actuator you have to take it at centimetre cube per stroke how much or meter cube per stroke.

Delta p is the p 1 minus p 2 please understand this p 1 is always the inlet pressure which is the highest and p 2 is the outlet pressure as because after rotating the shaft no energy in the fluid directly it will go to the tank, almost it is a 1 bar pressure it is that is why p 1 is always greater than the p 2.

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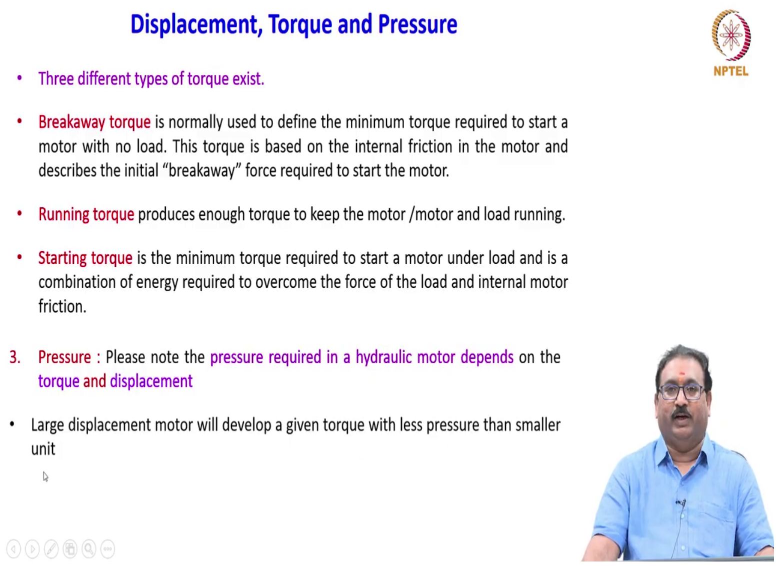

3 types of torque exist one is Breakaway torque is normally used to define the minimum torque required to start a motor with no load. This torque is based on the internal friction of the motor and describes the initial breakaway force required to start the motor. And second torque is a Running Torque produces enough torque to keep the motor or a motor and load running

Starting Torque is the minimum torque required to start a motor under a load and is a combination of energy required to overcome the force of the load and internal motor friction. Then one more important parameter is a third one is a pressure maximum pressure how much it will be act. Please note friends, the pressure required in a hydraulic motor depends on the torque and the displacement, large displacement motors will develop a given torque with a less pressure than a smaller unit.

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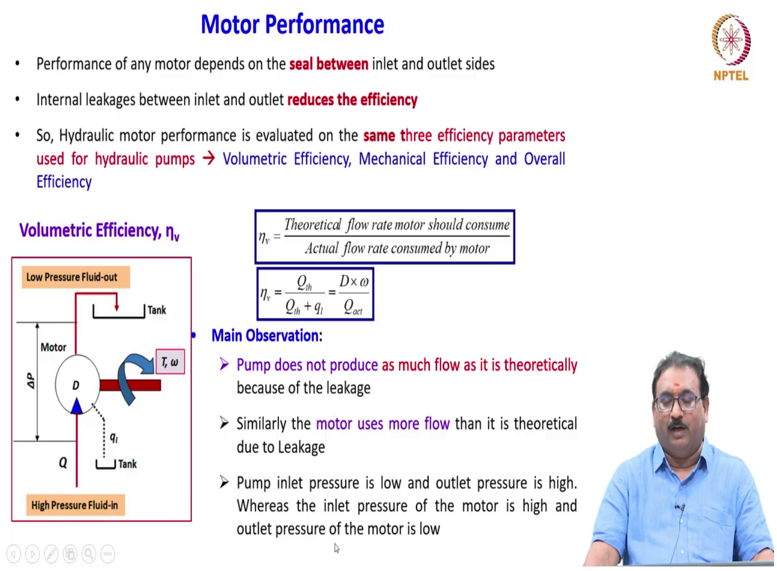

Now, we will see the Motor Performance, performance of any motor depends on the seal between the inlet and outlet sides. Internal leakage between the internal and outlet reduces the efficiency. So, hydraulic motor performance is evaluated on the same 3 efficiency parameters used for hydraulic pumps.

What are those? Volumetric efficiency, mechanical efficiency and overall efficiency. Volumetric efficiency - volumetric efficiency is the ratio theoretical flow rate motor should consume divided by the actual flow rate consumed by the motor; it is given by Q theoretical by Q theoretical plus leakage or Q theoretical is nothing but D into w divided by Q actual.

Here main observation friends here as compared to pumps, pump does not produce as much flow as it is theoretically because of the leakage. Similarly the motor uses the more flow than it is theoretically due to the leakage, pump inlet pressure is low outlet pressure is high; whereas, the inlet pressure of motor is high and the outlet pressure of motor is low.

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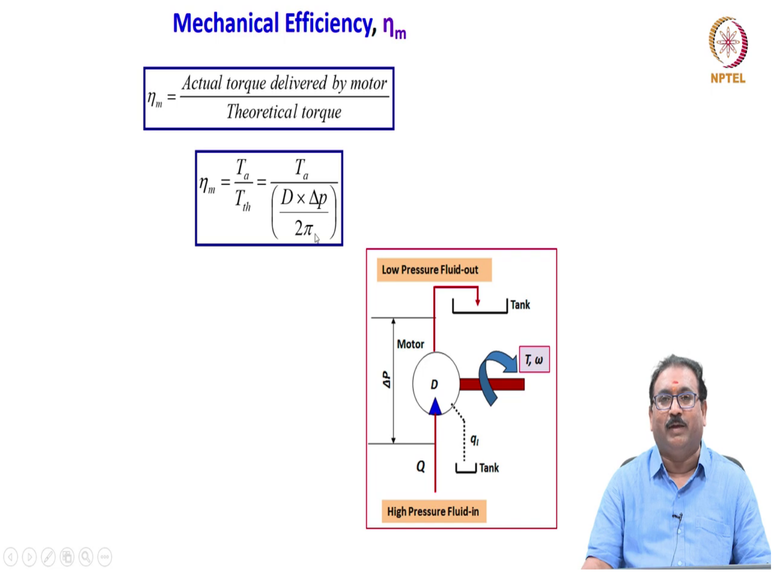

Now, we will see the mechanical efficiency which is coming from the shaft here. What is this mechanical efficiency is the ratio of actual torque delivered by the motor to the theoretical torque. Here T a by T h; T a by T h is D in to delta p divided by 2 pi.

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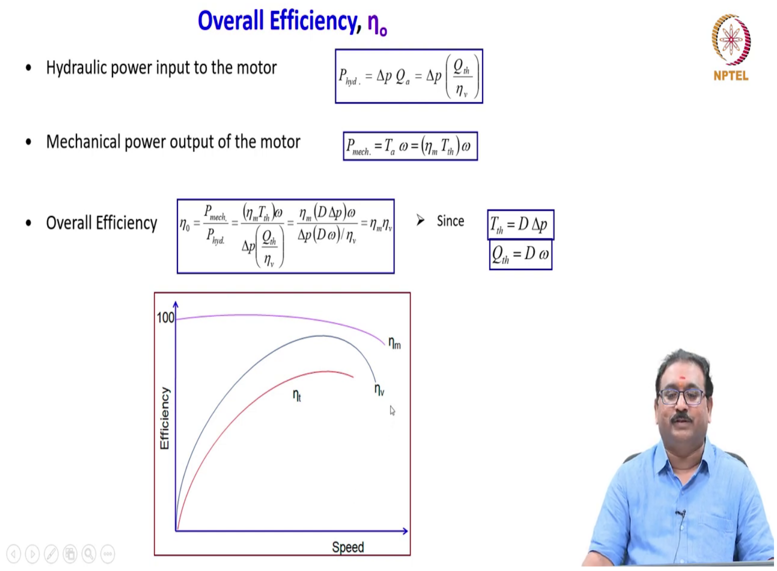

Similarly, the overall efficiency here we require to know the Hydraulic power input to the motor P hydraulic equal to delta p into Q a delta p into Q theoretical by the volumetric efficiency. Then Mechanical power output of the motor is Ta into omega this Ta actual torque is the mechanical efficiency multiplied by the theoretical torque into omega.

If we will take the calculate the overall efficiency which is the ratio of mechanical power to the hydraulic power. Substitute all the values mechanical power the what are the things are there substitute here, then what happen? Delta p delta p get cancels D D get cancels remaining things after also you will know it, these things I am substituting here. Finally, I will get what I am getting? Mechanical efficiency multiplied by the volumetric efficiency is the overall efficiency.

Now, we will see the efficiency versus the speed I have drawn the all three efficiencies this is the volumetric efficiency, this is the mechanical efficiency, this one is a total efficiency. These curves are you are similar to your hydraulic pumps.

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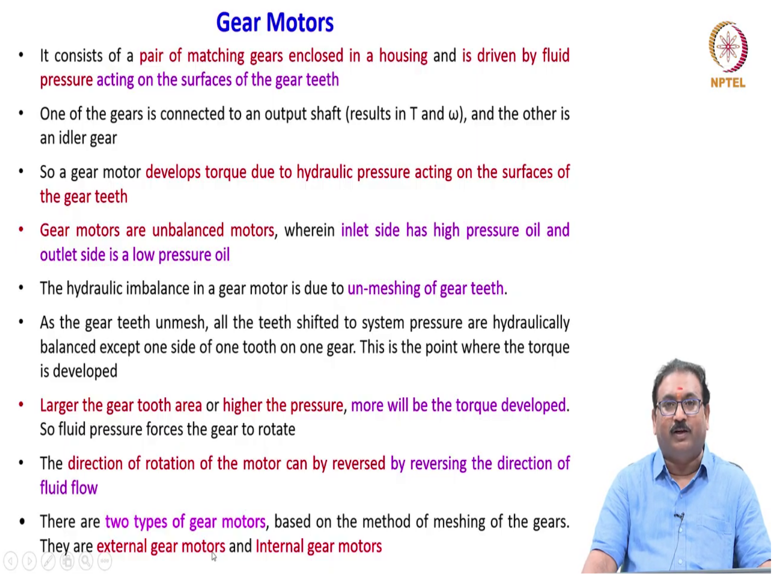

Now, quickly we will move on to the Gear Motors, it consists of a pair of matching gears enclosed in a housing and is driven by fluid pressure acting on the surfaces of the gear teeth. One of the gears is connected to the output shaft, where we want the torque and the angular velocity and the other is a an idle gear.

So, a gear motor develops a torque due to the hydraulic pressure acting on the surfaces of the gear teeth. Gear motors are unbalanced motors, wherein the inlet side has the high pressure oil and the outlet side is a low pressure oil. The hydraulic imbalance in a gear motor is due to un-meshing of gear teeth.

As the gear teeth unmesh, all the teeth shifts to system pressure are hydraulically balanced, except one side of one tooth on one gear. This is the point where the torque is developed. Larger the gear tooth area or a higher the pressure more will be the torque developed, so the fluid pressure forces the gear to rotate.

The direction of rotation of the motor can be reversed by reversing the direction of fluid flow. There are two types of gear motors based on the method of meshing of the gears, they are external gear motors and a internal gear motors; these are also similar to your external pumps and internal gear pumps.