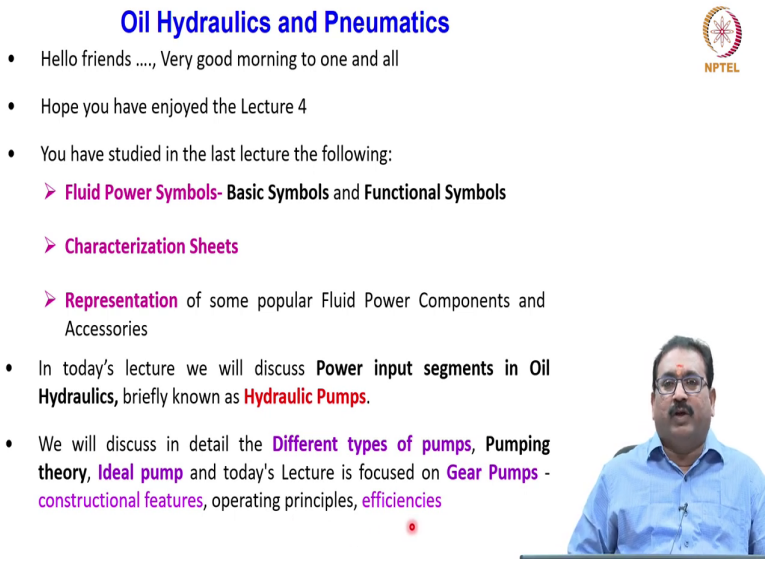
Oil Hydraulics and Pneumatics
Prof. Somashekhar S
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Part 01: Introduction to Hydraulic pumps, Facts and Figures, Classification
Lecture - 13
Hydraulic Pumps

(Refer Slide Time: 00:23)



My name is Somashekar, course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed lecture 4. You have studied in the last lecture the following contents, fluid power symbols which consists of basic symbols and a functional symbols, characterization sheets, 7 characterization sheets we discussed, and representation of some popular fluid power components and accessories in the last class.

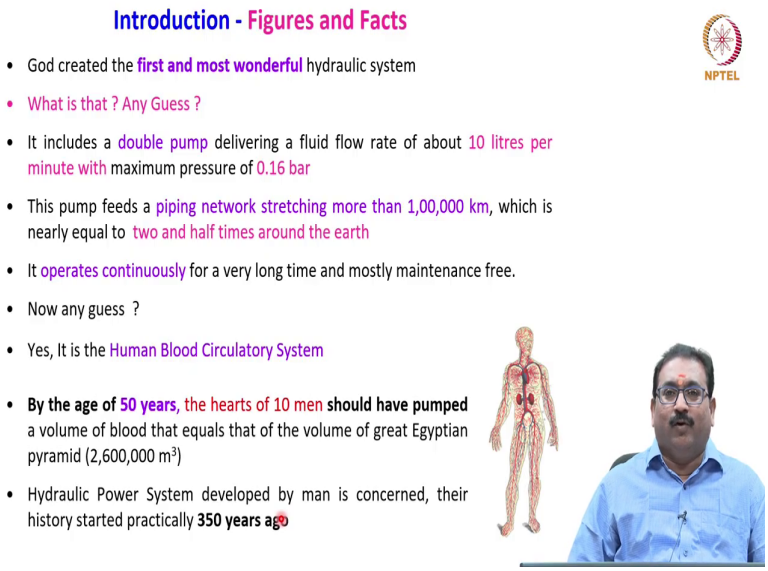
Basically, the energy conversion, energy utilizing, control elements and some accessories and actuation methods; how to represent it using the fluid power symbols in the last class which are accepted universally around the world. The hydraulic circuit created in India, it is acceptable in US, Germany and any other country because all the hydraulic circuits are represented using the fluid power symbols as we discussed in the previous lecture 4.

In today's lecture, we will discuss the power input segments in oil hydraulics briefly known as hydraulic pumps. It is a very big chapter. I am divided this chapter into 3 segments main, in today's lecture we will discuss the different types of pumps, pumping theory, ideal pump, what are the characteristics. Today's lecture focused more on the gear pumps in which we will discuss the constructional feature operating principles and efficiencies how to calculate.

(Refer Slide Time: 02:35)

Let us we will see the organization of presentation of lecture 5 which is as follows. We will begin with hydraulic pumps today, introduction, detailed classifications, pumping theory, characteristics of ideal pump are also known as a theoretical pump. As I have told you today we will discuss mainly on gear pumps, low pumps, screw pumps which includes the constructional features, operating principles, efficiency characteristics. And later I will conclude for the lecture 5, what we discussed in the today's class.

(Refer Slide Time: 03:33)



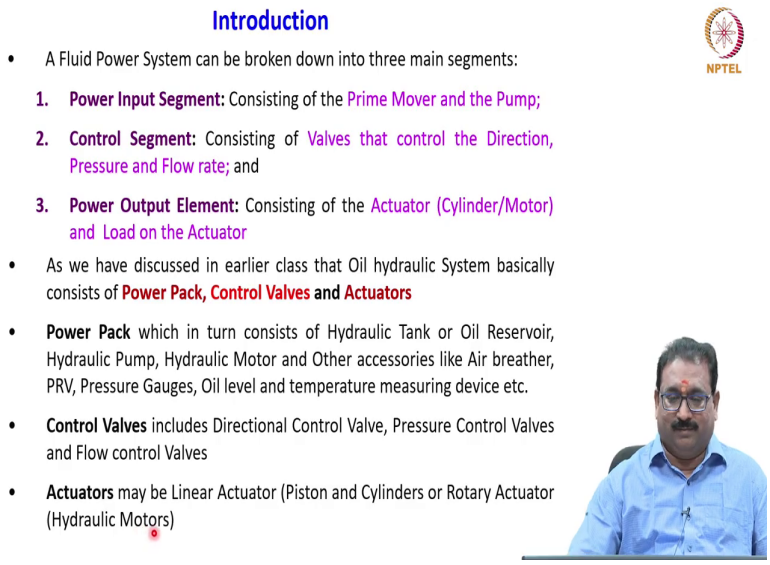
Begin with introduction I will give you some figures and facts which are essential to know the fluid power engineers. God created the first and most power wonderful hydraulic system, what is that? Any guess from the student side. You need some clues; I will give you some clues.

It includes a double pump delivering a fluid flow rate of about 10 litres per minute with a maximum pressure of 0.16 bar. This pump feeds a piping network stretching more than 1 lakh kilo metre which is nearly equal to 2 and half times around the earth. Please note it operates continuously for a very long time and mostly the maintenance free.

Now, any guess? See friends, god created this hydraulic system when the human beings are born on the earth, then what is that? Any guess. Yes, it is a human blood circulatory system. By the age of 50 years the hearts of the 10 man should have pumped a volume of blood that equals that of the volume of a great Egyptian pyramid.

Hydraulic power system developed by a man is concerned their history started practically 350 years ago. Now, we are focusing on current day fluid power system that is what you can call a man made fluid power system to generate the large amount of force and required speed.

(Refer Slide Time: 05:52)



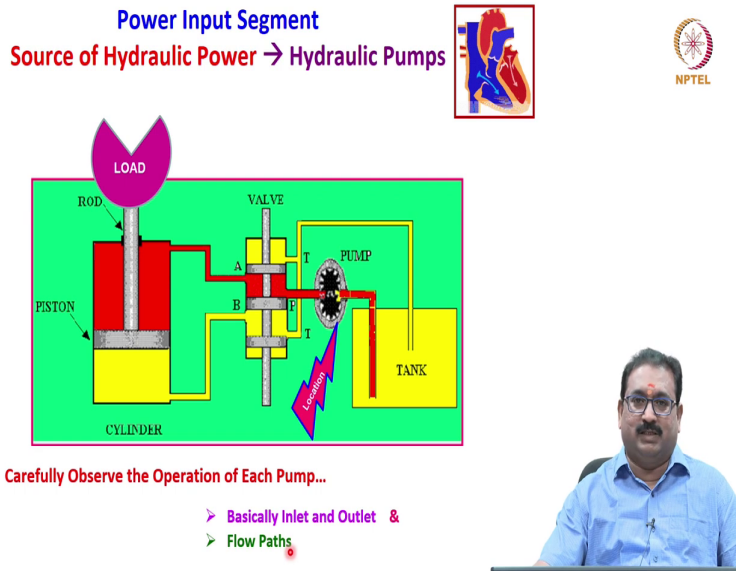
Let us we will see a fluid power system can be broken down into 3 main segments, please note friends. The first one is power input segment which basically consists of prime mover and the pump. And second one is a control segment consisting of valves that control the direction pressure and flow rate, and they are known as directional control valves, pressure control valves, and flow control valves. And third important segment is power output segment consist of the an actuator either a cylinder or hydraulic motors and the load on the actuator.

You will take any fluid power system either it is a oil hydraulic or pneumatics, it consists these are the main elements. Also we discussed in the earlier class, oil hydraulic system basically consists of a power pack, control valves, and actuators. Power pack which in turn consists of hydraulic tank also known as oil reservoir, hydraulic pump, electric motor and

other accessories like air breather, pressure relief valve, pressure gauges, oil level and temperature measuring devices.

Similarly, this control valves includes direction control valve, pressure control valves, and a flow control valves. And finally, actuator maybe the linear actuator piston and cylinders or a rotary actuator also known as hydraulic motors.

(Refer Slide Time: 08:14)

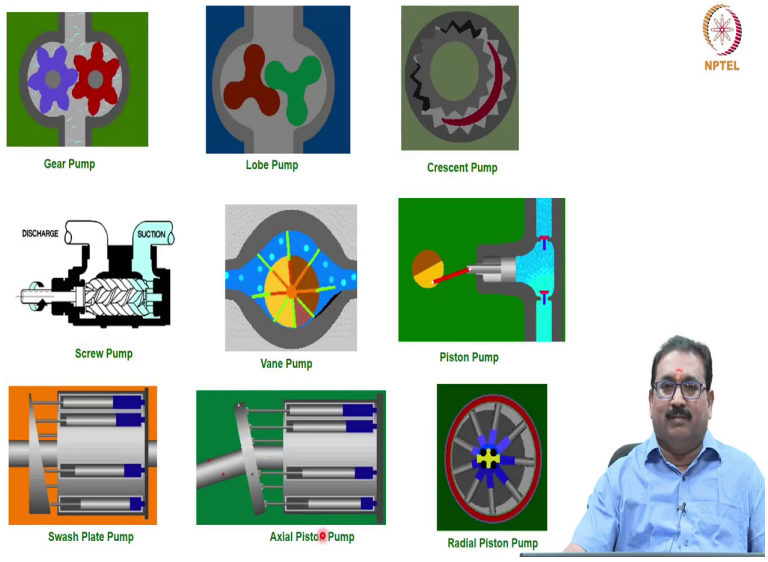


Power input segment what you can call a source of hydraulic power is a hydraulic pumps. Just see friends here, this already you are seen the some schematic diagram here which consist of basic elements, oil reservoir or a tank, a pump, valves, actuator with a load.

Now, please understand the location of the pump here. Exactly above the tank is a hydraulic pump drive through the prime mover what you can call electric motor or a IC engine. Now,

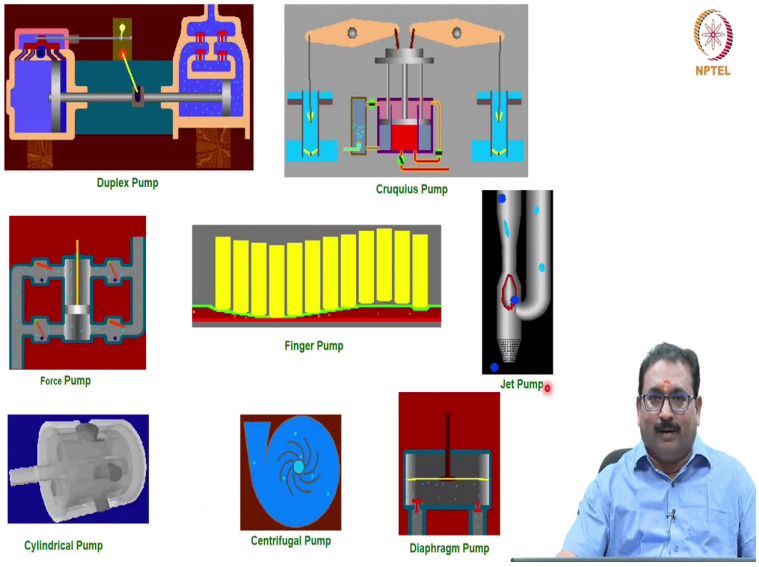
we are begin here in this part. Carefully observe the operation of each pump. I will show you in the next slide. Please concentrate mainly on the inlet, outlet, and a flow paths. Quickly you will see friends I will show you some of the hydro pumps which are frequently used.

(Refer Slide Time: 09:29)



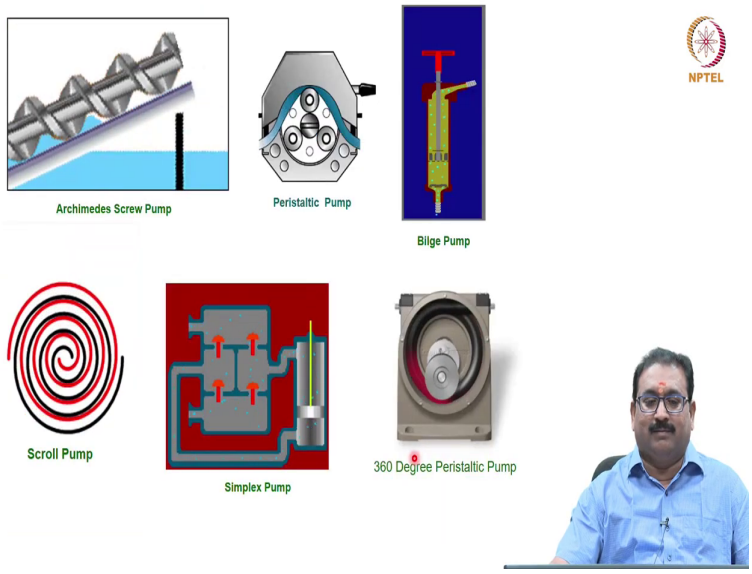
Just see how the fluid will enter, how the fluid will escape from the pump; how it enters, how it delivers. See the elements, different types of elements are there. See here how the fluid will enter, how the fluid will leave. Similarly, you will see how the fluid will enter, how will go. Here also, how the fluid will enter, then how it will deliver. Like this you will see here the friends.

(Refer Slide Time: 10:01)



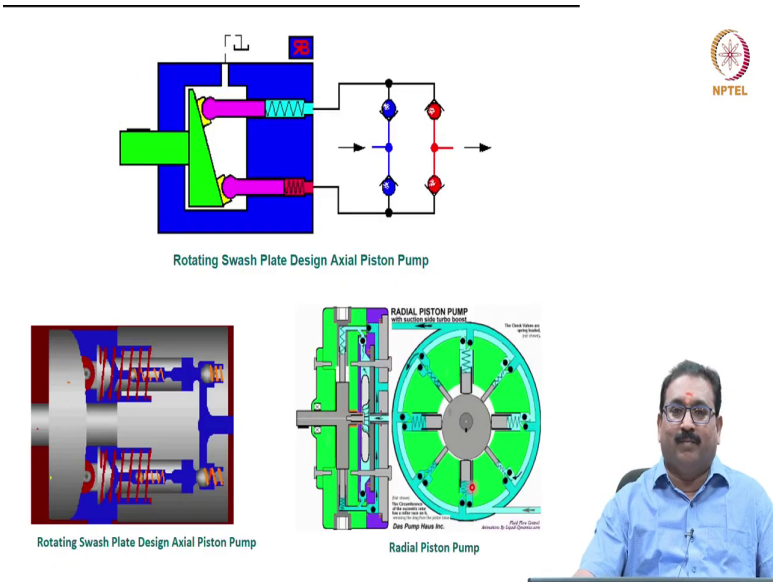
Also, you will see some of the pumps, duplex pump, force pump, finger pump, jet pump and many more, many more pumps. Please observe the inlet, outlet, and a mating elements.

(Refer Slide Time: 10:23)



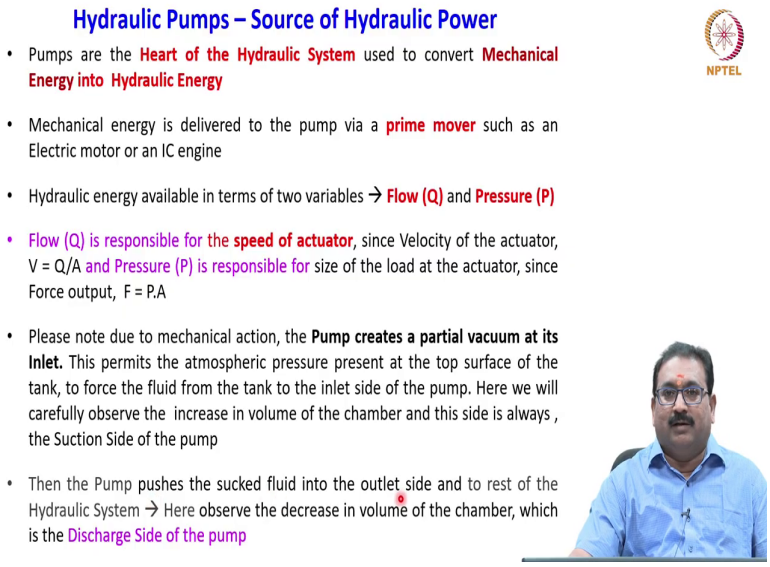
You see the Archimedes screw pump, peristaltic pump, bilge pump, scroll pump, simplex pump and many more.

(Refer Slide Time: 10:41)



You see the mating elements how they will rotate, how the fluid will be sucked, and how it will be delivered to the system

(Refer Slide Time: 10:56)



So, there are various types of pumps are there to suit the customers requirement. Then, what is required in the fluid power system? Please note friends pumps are the heart of the hydraulic system used to convert the mechanical energy into hydraulic energy. Mechanical energy is delivered to the pump via the prime mover such as an electric motor or an IC engine.

Hydraulic energy available in terms of two important variables what you can call it as a flow Q and a pressure P. Already, you know in the earlier class flow is responsible for the speed of an actuator as because the velocity of the actuator V equal to Q by A, A is a constant parameter. If you will use the hydraulic cylinder, pi by 4 dp square piston diameter, Q only variable then the velocity of the actuator largely depends on the Q.

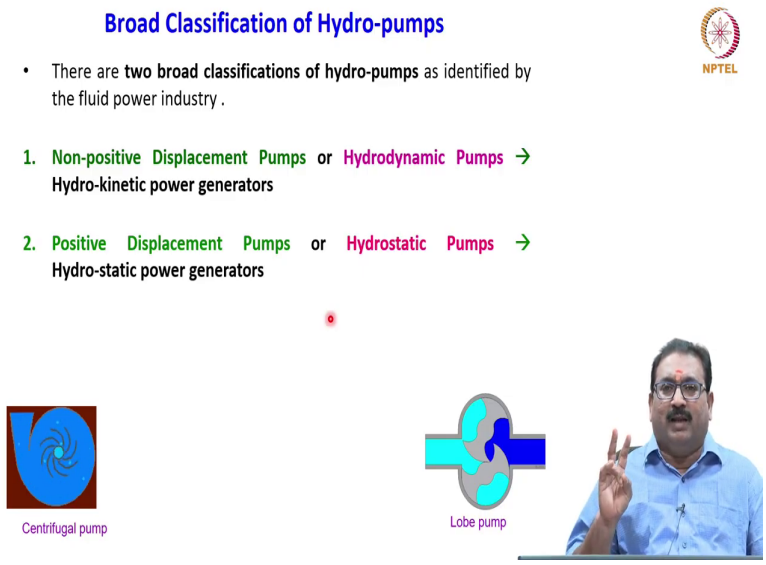
Similarly, pressure P is responsible for the size of the load on the actuator as because force output F equal to P into A, again A is constant here only variable parameter is P. Now, what

we are doing we are getting the two important parameter pressure and flow through the pump. How it is we will see.

Please note friends, due to the mechanical action the pump creates a partial vacuum at its inlet. This permits the atmospheric pressure present at the top surface of the tank, to force the fluid from the tank to the inlet side of the tank pump. Here we will carefully observe the increase in volume of the chamber and this side is always a suction side of the pump. I will explain you these concepts with figure in the latter slides. Then, the pump pushes the sucked fluid into the outlet side of the pump and to rest of the hydraulic system.

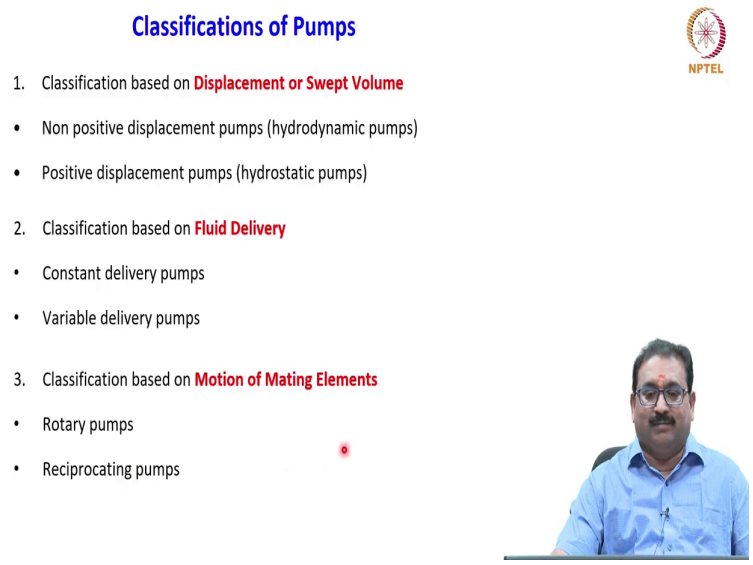
Please note here the decreasing volume of the chamber which is the discharge side of the pump. Always you will remember friends increasing volume and decreasing volume are very very important in the suction side and the discharge side. I will explain to you when we are discussing the pumping theory.

(Refer Slide Time: 14:12)



Now, quickly we will see the broad classification of hydro pumps. There are two broad classification of hydro pumps as identified by the fluid power industry. First one is a non-positive displacement pumps or a hydrodynamic pumps, they are hydrokinetic power generators, hydrokinetic power generators. And another one is a positive displacement pumps or hydrostatic pumps; here you will see they are known as hydro static power generators. These are the two main classifications of pumps.

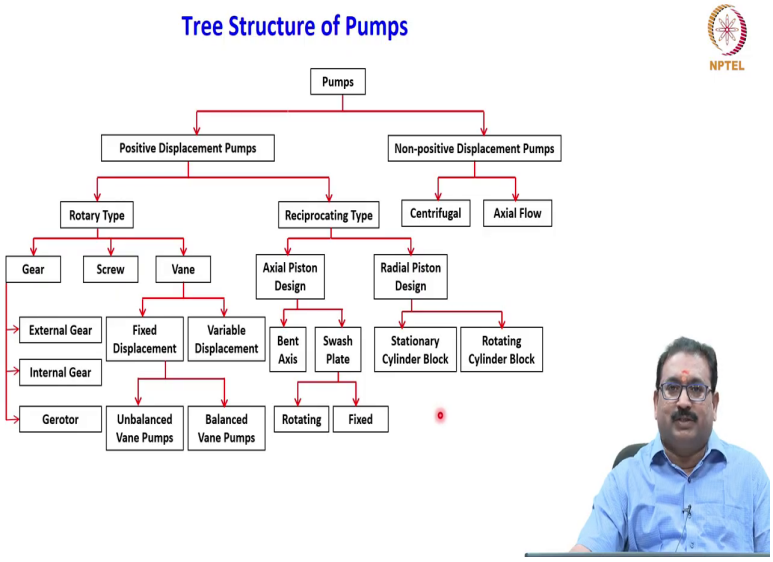
(Refer Slide Time: 14:59)



Now, we will focused on different types of classifications of the pumps as follows. One is based on the displacement or a swept volume. What is this? For one cycle or one rotation how much fluid your getting at the outlet it is known as a displacement or a swept volume. I will explain to you to you in the next slide what it is.

Based on this displacement volume or a swept volume, the pumps are classified as non-positive displacement pumps also known as hydrodynamic pumps, positive displacement pumps also known as hydrostatic pumps. Second classification is based on the fluid delivery, how it is my fluid delivery at the outlet here constant delivery pumps and another one is variable delivery pumps. Third classification is based on the motion of the mating elements during the fluid transfer from the inlet to the outlet, rotary pumps and reciprocating pumps.

(Refer Slide Time: 16:24)



If you will see the tree structure of the pumps under each category what you are seen in the previous slide they are divided into various types. Let us we will see the tree structure of the pumps how it is.

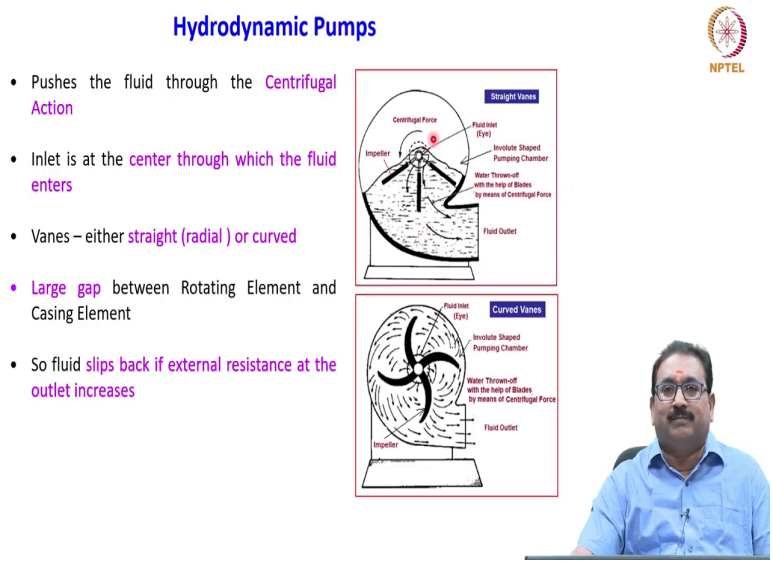
As we knows the pumps are classified based on the displacement as a positive displacement pumps and a non-positive displacement pumps. In a positive displacement pumps, rotary type and reciprocating type based on the motion. In non-positive displacement pump, centrifugal pump and a axial flow pumps are more popular. In rotary pumps, based on the element used they are classified as a gear pumps, screw pumps and a vane pumps. But under the category of reciprocating type you are getting the axial piston design and a radial piston design.

Now, we will see the based on the meshing how it will takes place. They are again classified as external gear pump, internal gear pump, and a gerotor. In vane pump, they are classified as

fixed displacement design and a variable displacement design. In the fixed displacement design, we are have unbalanced vane pumps and balanced vane pumps.

In axial piston design, we have bent axis type and a swash plate type. In swash plate type, whether it is a rotating or a fixed again the classification of pumps you are getting here. If you will see the radial piston design based on the cylinder block, either it is a stationary or it is a rotating. The pumps are classified in the different categories. There is very large classification of pumps are there. We will discuss these things in the pumps chapter.

(Refer Slide Time: 19:02)

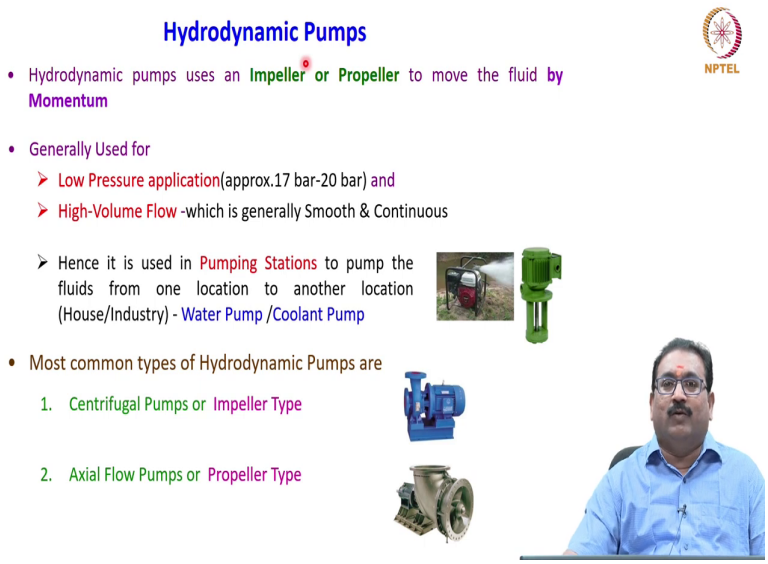


Let us we will begin hydrodynamic pumps. You have already studied this hydrodynamic pumps in the fluid mechanics. Already we know that what are these hydrodynamic pumps. They will push the fluid through the centrifugal action. Inlet is at the center through which the fluid enters.

Vanes you will see, this is a body, you know what I will call a involute shaped pumping chamber it is and here it is what we will call a impeller, straight impeller, curved impeller, both are both designs are available. Fluid will enter from the center what we will you can call eye, and it will throw out due to the centrifugal action of the rotating impeller. Fluid will throw out to the exit side.

Please note here in the two figure frames, straight impeller, straight vanes, or a curved vanes, in both the cases you will see friends there is a large gap between the housing and the rotating impellers, large gap is there. Please understand this.

(Refer Slide Time: 20:35)



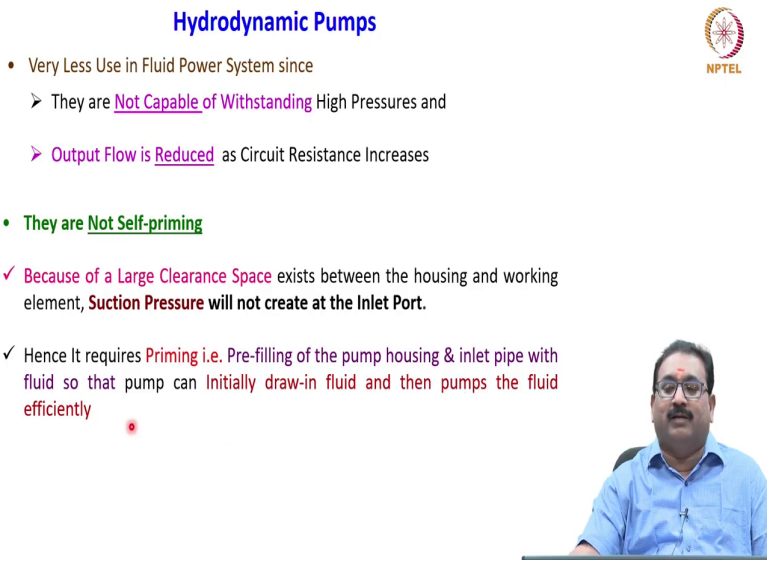
So, when you close the outlet the fluid will slips back. That is a one of the important thing what you have to note in the hydrodynamic pump. Always there is a large gap between the rotating element and the casing. When the outlet resistance increases fluid simply recirculate

inside it is slips back. As I have already told you, hydrodynamic pumps uses impeller or a propeller to move the fluid by momentum.

Please note here these types of pumps generally used for low pressure application, maximum you are getting here 17 bar to 20 bar, but high volume flow rate is ensured which is generally smooth and a continuous flow you are getting at the outlet. Hence, the hydrodynamic pumps are basically used in pumping stations to pump the fluids from one location to another location as we have seen in the house and industry, water pump and a coolant pump.

Most common types of hydrodynamic pumps what we have discussed in the fluid mechanics, centrifugal pumps or a impeller type, axial flow pumps or a propeller type. These types of pumps are very little use in the fluid power system as because we want the large pressure. Flow rate is not so important. But in hydrodynamic flow is very important pressure is not so important. We will focus more on the hydrostatic pumps or a positive displacement pumps in the fluid power system.

(Refer Slide Time: 22:41)



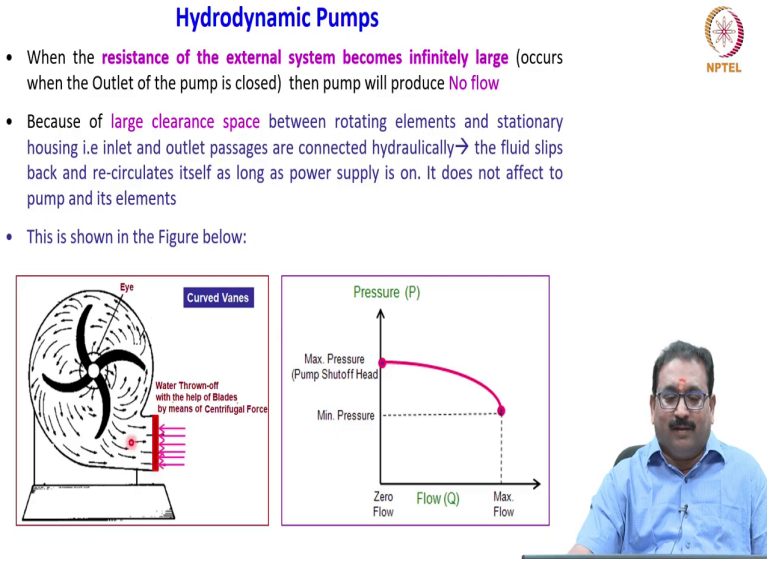
Let us we will see some of the features of the hydrodynamic pumps. As I have told you a very less use in fluid power system as because they are not capable of withstanding the high pressures and output flow is reduced as circuit resistance increases.

Also they are not self-priming, because of large clearance space between the housing and the working element suction pressure will not create at the inlet port. That is why they are not self-priming. If the pump you will not use for hydrodynamic pumps for a long period, then pump will not sucks the fluid and delivers it requires a priming.

What we will do? We will open the inlet and we will pour the liquid. It is a one of the drawback in the hydrodynamic pumps. They are not self-priming. Hence, it requires a

priming. Priming means what? Prefilling of the fluid in the pump housing and inlet pipe, so that a pump can initially draw in fluid and then pumps the fluid efficiently.

(Refer Slide Time: 24:04)



As I have told you when the resistance of the external system becomes infinitely large. Meaning what? When you will get when the outlet of the pump is closed due to some reason in hydrodynamic pump, then what happens to the pump? The pump will not produce any flow then airflow will go it will recirculate inside churning actions.

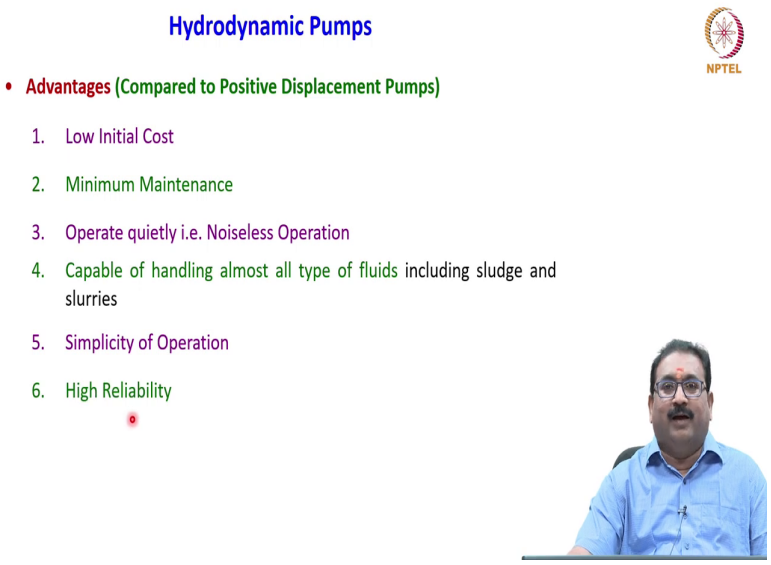
Because of the large clearance space between the rotating elements and a stationary housing, the inlet and outlet passages are connected hydraulically they are connected. The fluid slips back, and recirculate itself as long as power is on it does not affect the pump and its elements. This is shown in the figure below.

You will see here friends this is a hydrodynamic pump. When I will close the outlet what happens? The fluid will not go out. Then, what happens? Due to the large clearance between the impeller and the housing the fluid will recirculates. Once you leave it, it will go. Meaning here I will show you here the pressure versus flow characteristics when there is no closing at the outlet, you will get the maximum flow with a minimum pressure what it is designed.

When the flow resistance increases if we will close it, what happen? The flow goes on reducing. At one stage you will not get any flow. Meaning what? What is meaning here? At this pressure maximum pressure pump shutoff head, meaning it will recirculate inside. It will not affects to any element here. But this is not the case in the hydrostatic pumps. Please understand this friends. This curve is very important.

When you will close this what happen? At one instant you will not get any flow, 0 flow you will get with required pressure, how it is designed. But when you will close, open this what happen? You will get the maximum flow with the minimum pressure what it is designed.

(Refer Slide Time: 26:41)



Then, you will see some of the advantages of this pump over the positive displacement pumps. Low initial cost, minimum maintenance, operate quietly because noiseless operation. It is capable of handling all types of fluids including sludges, slurries, etcetera; simplicity of operation, high reliability.