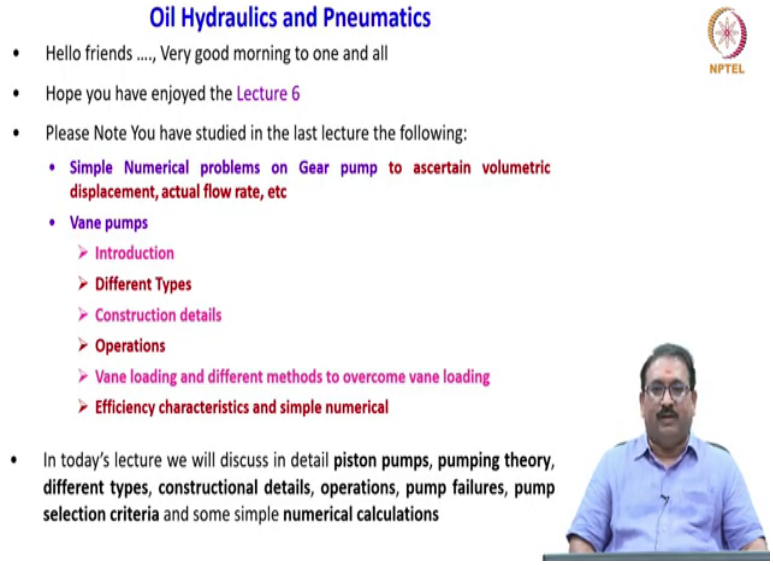
Oil Hydraulics and Pneumatics
Prof. Somashekhar S
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Part 1: Piston pump, Pumping theory, Constructional features and Operations of Hand Pump-Single acting, Twin single acting, Double acting, Two-stage
Lecture - 20
Piston Pumps

(Refer Slide Time: 00:27)

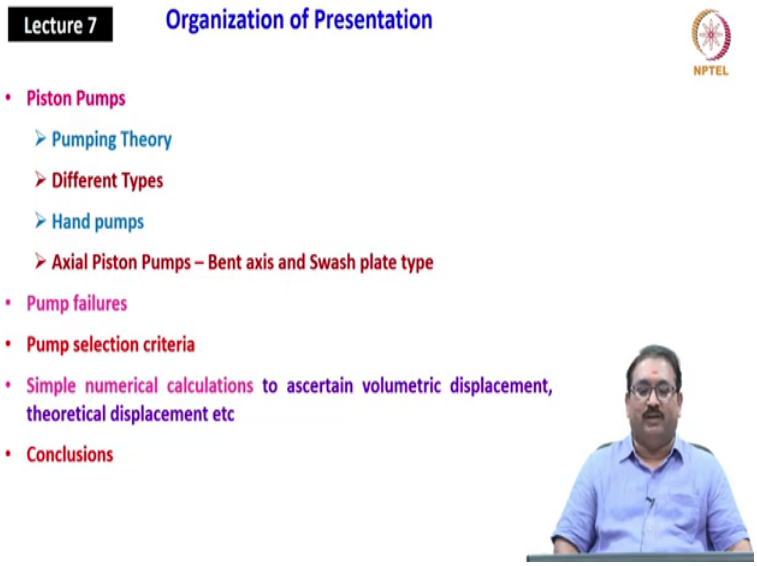


My name is Somashekhar, course faculty for this course. Hello friends, very good morning to one and all, hope you have enjoyed the lecture 6. Please note, you have studied in the last lecture the followings, simple numerical problems on gear pump, to ascertain the volumetric displacement, actual flow rate etcetera.

We started in the last class, the vane pumps in which we begined with introduction different types of vane pumps, constructional details, operations, vane loading and different methods to overcome the vane loading in a vane pistons.

Efficiency characteristics and a simple numerical calculations are studied in the last lecture. In today's lecture we will discuss in detail the piston pumps, quickly we will see the pumping theory, different types of piston pumps, constructional details, operating principles, pump failures, pump selection criteria and some simple numerical calculations to ascertain the volumetric displacement using the geometrical relationship of the pumping elements.

(Refer Slide Time: 02:15)

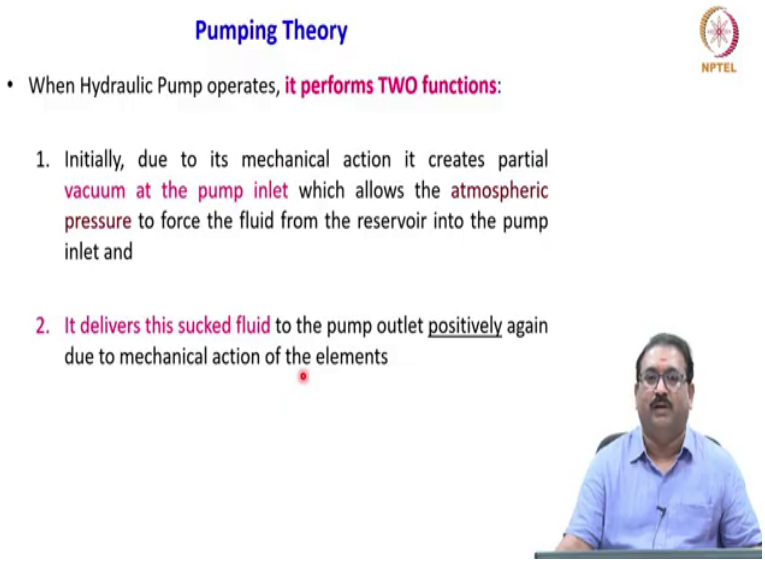


Friends, let us we will begin with lecture 7 with Organization of Presentation, as I have told you in the last slide the whole lecture is concentrating mainly on piston pumps, pumping theory, different types, hand pumps which are the basic of piston type pump category also

wide applications in industry. Then actually we move on to the widely used hydraulic pumps axial piston pumps, here we will discuss the different categories bent axis and a swash plate type and radial piston pumps.

We will also study today pump failures, pump selection criteria, simple numerical calculation to ascertain the volumetric displacement, theoretical displacement etcetera. Finally, we will end it with concluding remarks of the lecture 7.

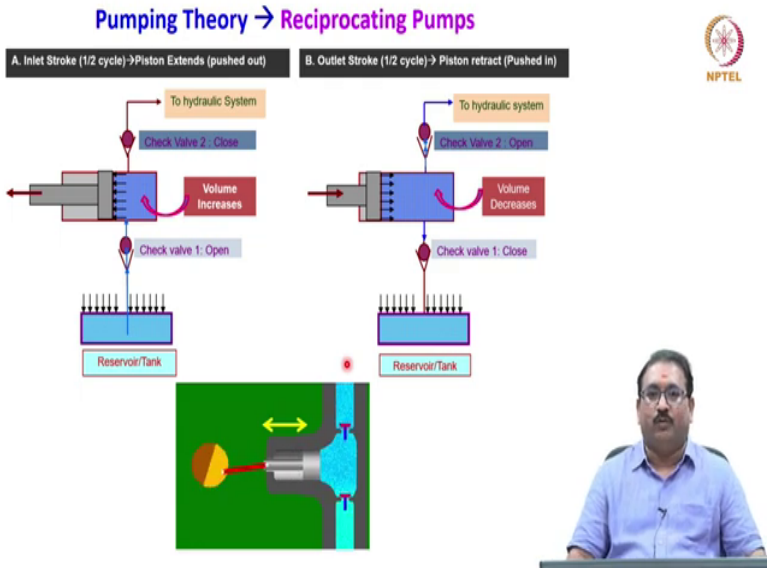
(Refer Slide Time: 03:39)



Already we have seen this pumping theory in the last lecture, already we know that when a hydraulic pump operates it performs two functions, what are those? Initially, due to the mechanical action it creates a partial vacuum at the pump inlet, which allows the atmospheric pressure to force the fluid from the reservoir into the pump inlet. This is called a suction and

it delivers this sucked fluid to the pump outlet positively again due to the mechanical action of the pumping elements.

(Refer Slide Time: 04:37)



So, quickly I will show you the pumping theory in the reciprocating pumps, as we know this is a piston pumps simple piston pumps. Here, the half cycle meaning when the piston is moved from left to right it will draws the fluid through the check valve 1, the path of least resistance is only this. Also please note friends when the piston moves out, what happens this volume increases. There is a close fitting between the piston diameter and the cylinder inside diameter, then air will not pass from this to this please note this.

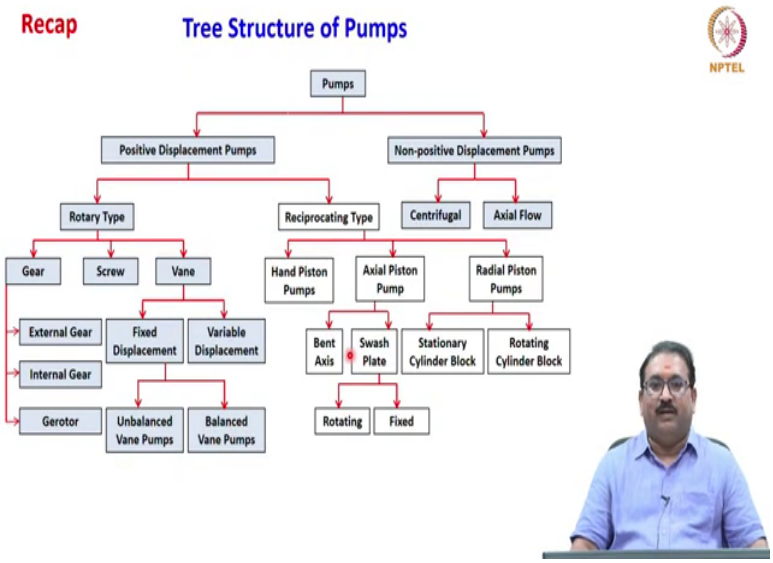
That is why piston pumps are very close tolerances between the matting element. If the air will pass from here to here vacuum will not create, the creation of vacuum is a prime importance in all the pumps. When the piston is drawn out what happens momentary vacuum

is created here also fluid will be drawn when the piston will draws out the volume increase, this is what you can call the half stroke half cycle it is. The complete stroke is another when the piston will move pushed in.

Then what happens? The fluid present here will pass through the outlet through the non return valve what you can call check valve 2, here oil will not move here because it is the only unidirectional valve it is NRV. Please note friends here when the push is piston is pushed in. What happens to here volume decreases this is a prime importance in the all pumping theory.

Volume increases always a suction will takes place when the volume decreases always a discharge takes place positively to the outlets, this is what you can call the pumping theory. Let us we will see here also when it will take out the fluid is pumped in, when piston is pushed in it will take out this is a one of the important theory what you have to remember.

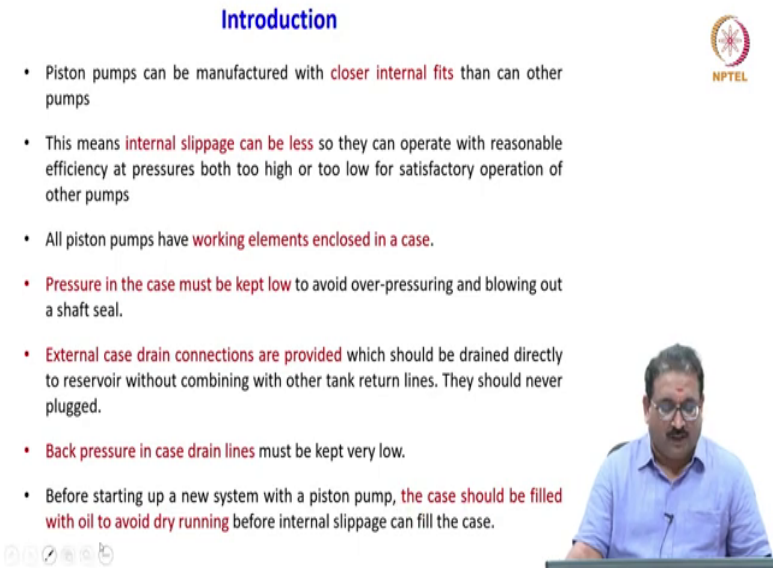
(Refer Slide Time: 06:59)



Then quickly I will show you the recap of tree structure of pumps. Whatever I filled here we already finished, now in the last stage we want to cover more on the reciprocating type, generally the piston type. They are classified into the hand piston pumps and axial piston pumps. In hand piston pumps also there are varieties are there we will discuss today, here axial piston pumps plays a dominant role in the fluid power industry.

Here, they are classified as bent axis pump swash plate type, in swash plate type rotating swash plate or a fixed plate. Radial piston pumps stationary cylinder block and a rotating cylinder block. If we will finish this it will ends the complete discussion on the hydraulic pumps.

(Refer Slide Time: 08:00)



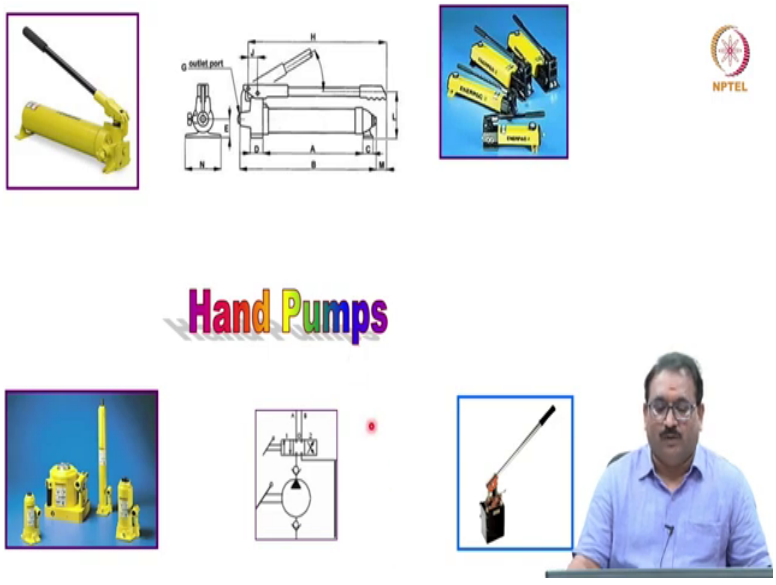
Let us we will begin today on this piston pumps, before going to study in detail I will give you general characteristics of the piston pumps in hydraulic industry. Piston pumps can be

manufactured with closer internal fits than can other pumps. This means internal slippage can be less, so they can operate with reasonable efficiency at a pressures both too high or too low for satisfactory operations of other pumps.

All piston pumps have working elements enclosed in a case, what we can call housing. Pressure in the case must be kept low to avoid over pressurizing and blowing out a shaft seals. External case drain connections are provided which should be drained directly to reservoir without combining with the other tank return lines.

They should never plugged. Back pressure in the case drain lines must be kept very low, before starting up a new system with a piston pump that case should be filled with oil to avoid a dry running before internal slippage can fill the case.

(Refer Slide Time: 09:45)

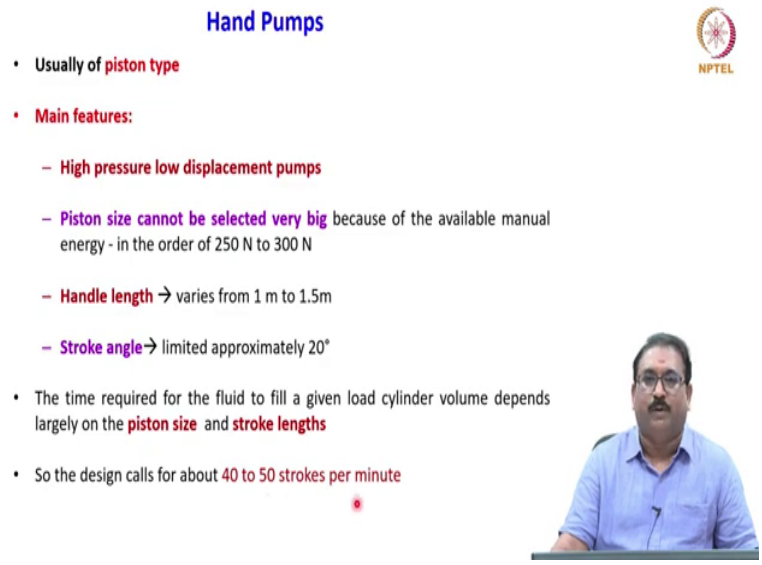


(Refer Slide Time: 09:56)

Now, let us will begin with the hand pumps. Already you come across this hand pumps in many places let us we will see now what are these hand pumps and it is applications very quickly. Hand pumps are manually operated pumps they use human power and a mechanical advantage to move fluids from one place to another place. They are widely used in every country in the world for a variety of industrial, marine, irrigation and leisure activities.

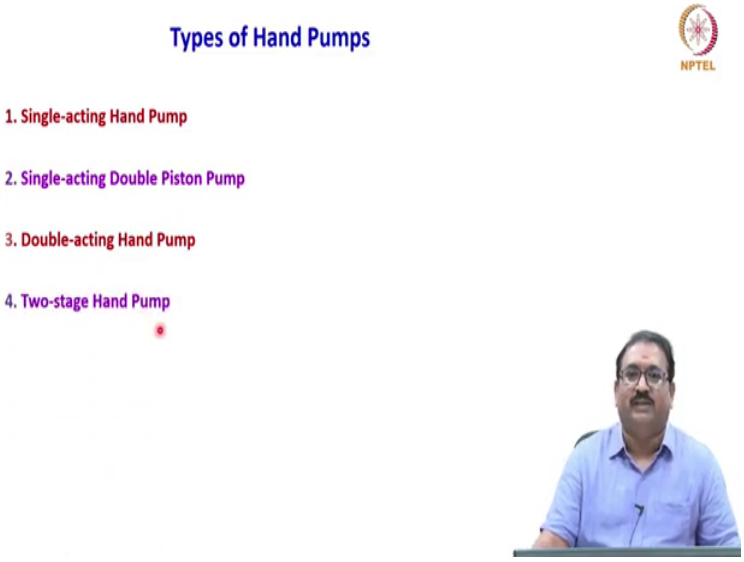
Typical applications includes; the hydraulic jacks which will lifts the large load with a very minimal force, workshop trolleys you see workshop trolleys, small bending presses, reserve pump in case of failure of motor driven pumps, clamping in workshop is usually done with the hand pumps. There are wide applications are there for the hand pumps; let us we will see one by one.

(Refer Slide Time: 11:09)



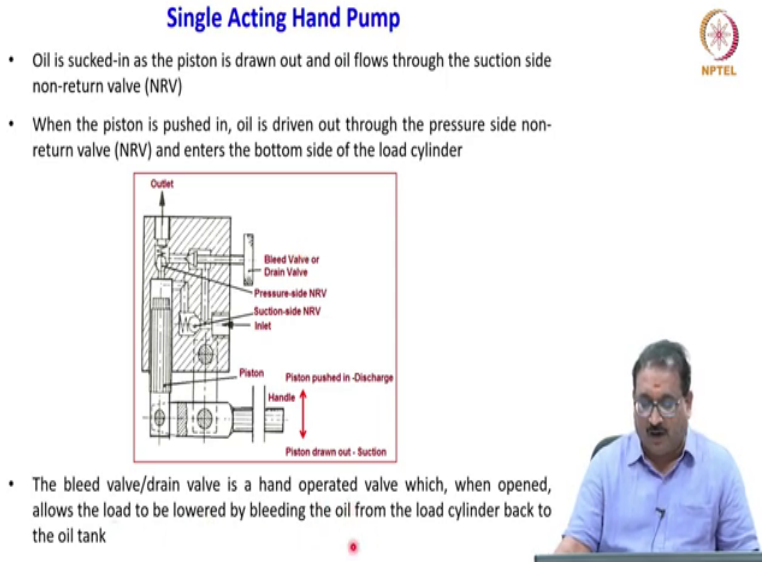
They are usually the piston type as I have told you main futures are high pressure low displacement pumps, piston size cannot be selected very big because of the available manual energy in the order of 250 Newton to 300 Newton. Handle length varies from 1 meter to 1.5 meter; stroke angle limited approximately 20 degree. The time required to fill the fluid the given cylinder volume depends largely on the piston size and a stroke length. So, the design calls for about 40 to 50 strokes per minute.

(Refer Slide Time: 12:07)



There are various categories of hand pumps are available commercially, single acting hand pump, single acting double piston pump, double acting hand pump and a two stage hand pump.

(Refer Slide Time: 12:25)

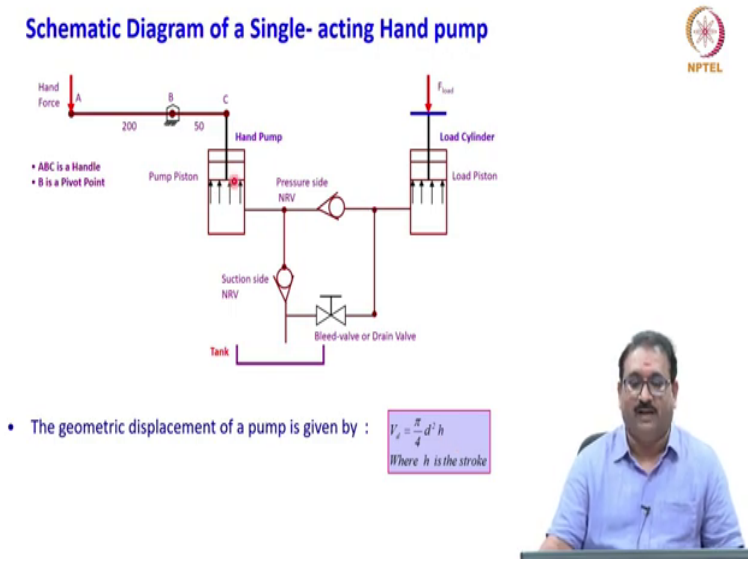


Let us quickly we will see with the schematic diagram of these. This is the single acting hand pump friends here you please see the figure here, this is a cylinder and this is a piston, this is a hand lever to move up and down this piston. The when the piston is drawn out fluid will sucked through the tank here through non return valve, when we will push up whatever the fluid you are drawn it is pushed to the outlet through the non return valve 2, what you can return here is a pressure side NRV.

To release the load here there is a manual arrangement bleed valve, if you open this bleed valve the flow will directly go to the tank ok. So, oil is sucked as the piston is drawn out and oil flows through the suction side through the non return valve suction side NRV. When the piston is pushed up oil is driven out through the pressure side NRV and enters the bottom side of the load cylinder.

Load cylinder I have not shown here, the outlet is going to the load cylinder to move up and down. The bleed valve or a drain valve is hand operated when opened allows the load to be lowered by bleeding the oil from the load cylinder back to the oil tank; it will not enter here directly it will go here to the tank.

(Refer Slide Time: 14:05)

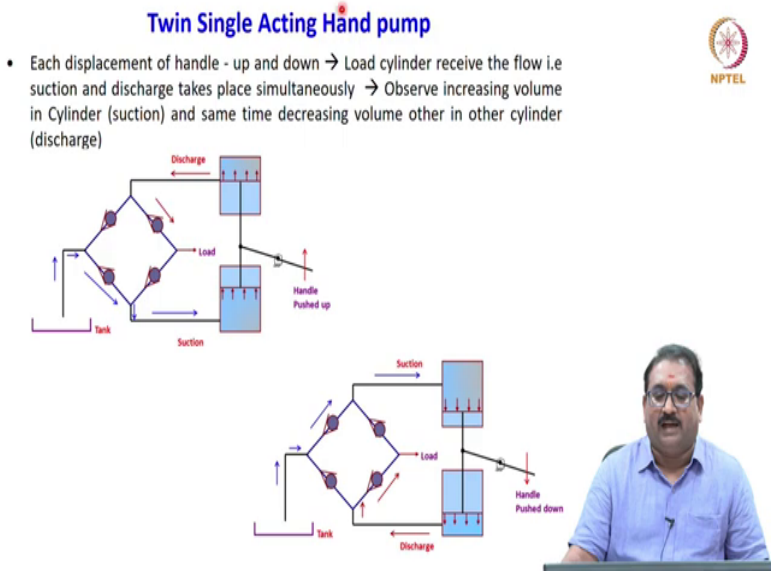


This is schematically shown in the line diagram here friends. Here I have shown load cylinder also you will see this is a hand pump actually, hand pump it is a lever B, if pivoted ABC is a hand handle B if pivoted point with the arm ratio 200 to 50. When you will move push down what happened piston will take an out, then what happened oil will be sucked from the tank to this fill this cylinder. It will not go here because path of least resistance is here only vacuum will create here.

Then when we will push down here piston then oil will go to the load cylinder to lift the load, to lower the load no arrangements, but here it is we will see here the bleed valve is there you will open the bleed valve then directly it will go to the tank. To lowering I am using the bleed valve or a drain valve in the single acting hand pumps.

So, the geometrical displacement from the pump is easily arrived as area pi by 4 d square into h; h is the stroke very very simple friends here. How much oil geometrical displacement based on the diameter of the piston here into stroke?

(Refer Slide Time: 15:34)



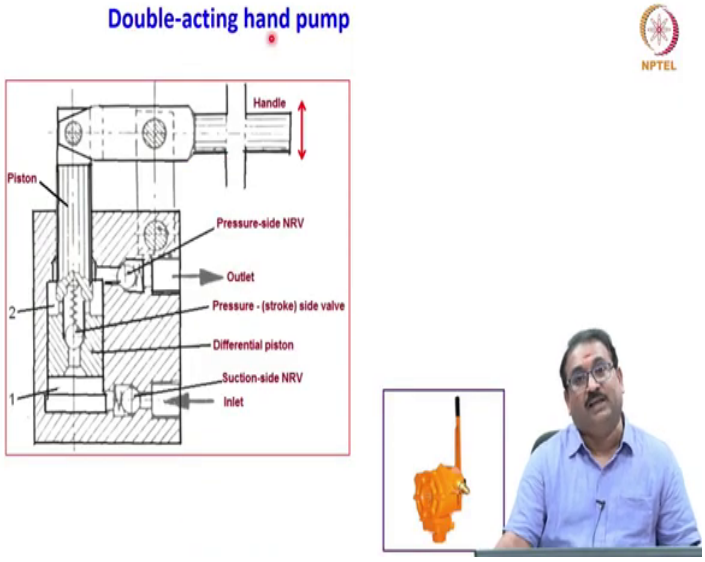
Now, we will see twin single acting hand pump, you will see the arrangements here friends two cylinders are there and this is connect rod is connected through handle pushed in and out.

Then you will see the arrangements are made through the non return valve for the discharge as well as the suction, how it operates we will see the twin single acting hand pump. Each displacement of handle this is a handle up and down motion, load cylinder here we will see the load cylinder receives the flow that is suction and discharge takes place simultaneously.

When you will move down both suction will take place as well as discharge is also takes place, when we will move up again suction will take place discharge will take place in the twin single acting hand pump. How it is will see now. You will see friends now I have shown here, when you will handle will move up what happens here the volume decreases, meaning whatever the fluid is there it will go to the load. Then what happens here when you will move up volume increases.

What happened it will sucks the fluid through this directions, similarly when you will push the handle down what happens here friends volume decreases here whatever the fluid is there it will go to the load, then here volume increases. When you will push down what happened oil will be sucked through this NRV. Please remember, for every up and down motion of the handle the fixed quantity of oil will be sucked and discharged based on the diameter of the piston used. This is a twin single acting hand pump.

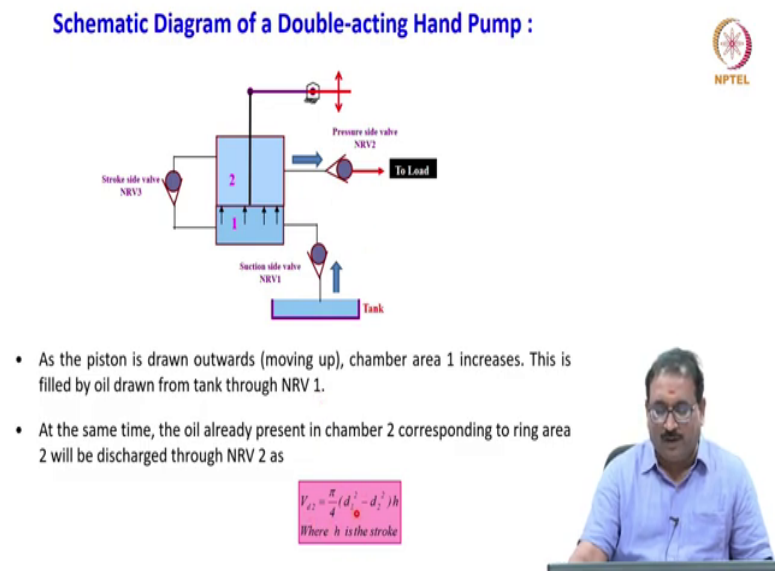
(Refer Slide Time: 17:36)



Now, we will move on to the double acting hand pump, double acting hand pump you will see here again arrangements are made here. Double acting hand pump here we are using the differential piston, here you will see the pressure side valve and it is a suction side valve and a tank is here this is a handle friends, handle this is a piston.

The up and down motion of this will make the fluid sucked in through the suction side NRV, then it will discharge through the pressure side NRV this is a outlet where loads it will reconnected to the load cylinder.

(Refer Slide Time: 18:20)

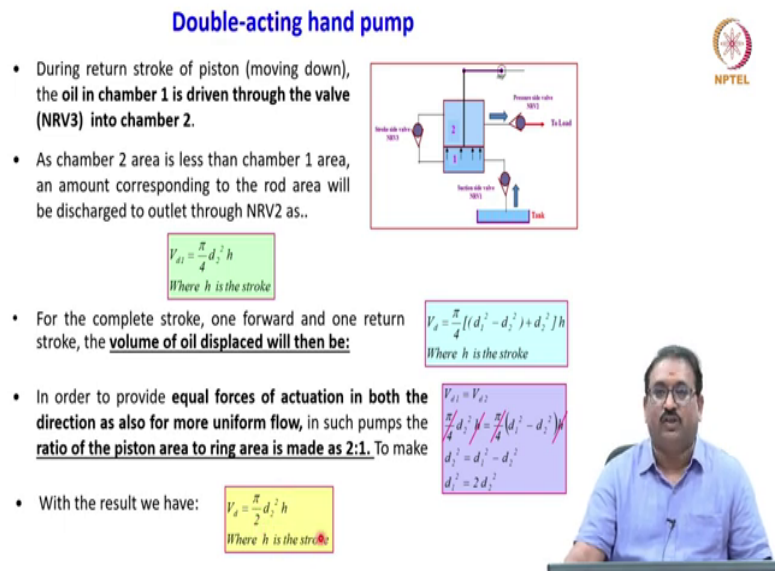


Now, I have drawn the simple schematic of this to understand better double acting hand pump, you will see friends here. What are the arrangements? When I will when the piston is moved up what happens you will see understand neatly, the fluid will be sucked through the suction side valve.

Then the fluid when it is moving up whatever the fluid is there it is going to the load, please understand this, because the oil will not go here also. Meaning; as the piston is drawn outward moving up what happened, chamber area 1 increases, this is filled by oil drawn from the tank through the NRV 1. At the same time the oil present here as I have told you in chamber 2 corresponding to the ring area meaning here it is a pi by 4 d p square minus d r square rod area.

It discharged through NRV 2 what you can call pressure side valve. Now how to find out the geometrical displacement here V d 2 what it is going pi by 4 d 1 square minus d 2 square into h stroke, this area the amount of oil will be discharged V d 2. What I can call, this is a double acting hand pump. This area is 1 is to 2 are based on the requirement how much fluid it has to discharged they will select the different area ratio of 1 and 2.

(Refer Slide Time: 19:56)



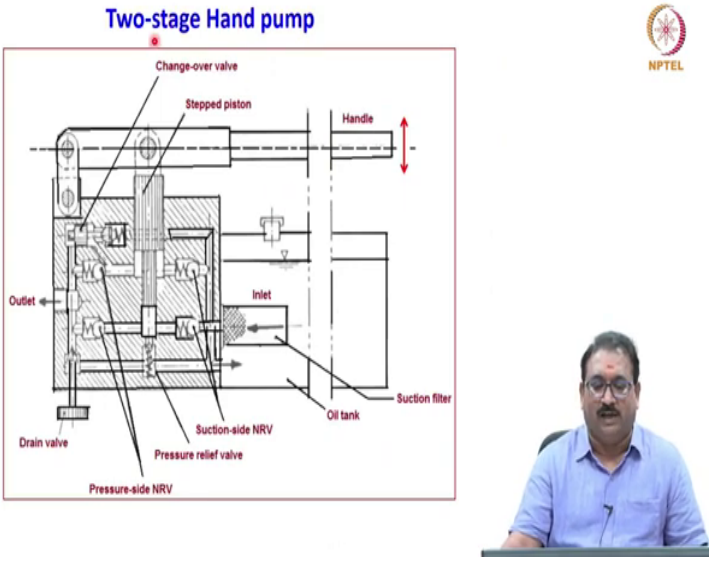
Now, during the return stroke of the piston meaning moving down, when you are moving down what happens the oil in chamber 1 is driven through the NRV 3. When you are moving down here what happened whatever the fluid is there here it is driven to the cylinder 2, through the NRV 3. As chamber 2 area is less than the chamber 1 area an amount corresponding to the rod area will be discharged to outlet through the NRV 2.

So, V d 1 during the downward stroke what is that pi by 4 d 2 square into h. For the complete stroke for a complete stroke means pushing down and pushing up, the one forward and one return stroke the volume of oil displaced will be V d equal to pi by 4 d 1 square minus d 2 square plus d 2 square into h. If we will simplify this look here in order to provide equal force of actuation in both the direction as also for more uniform flow.

In such pumps the ratio of piston area to ring area is made 2 is to 1. What is the meaning? Here to make V d 1 equal to V d 2 I am equating the V d 1 and V d 2 V d 1 already I know it pi by 4 d 2 square into h, when the piston is moved up when it is moving down pi by 4 d 1 square minus d 2 square into h.

After simplifying this d 1 square equal to 2 times d 2 square, meaning what with the result V d equal to pi by 2 d 2 square into h, where h is the stroke. Using the simple geometrical relations we are able to calculate the geometrical displacement of the pump.

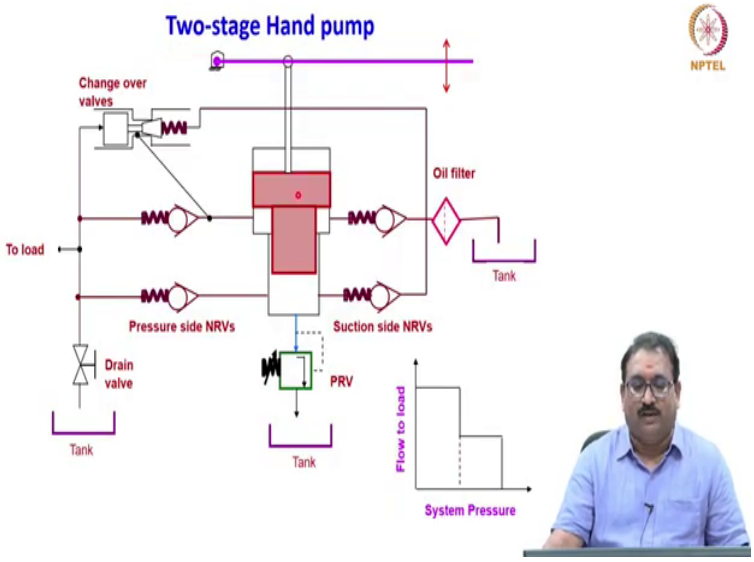
(Refer Slide Time: 22:19)



Now, we will see friends another category two stage hand pump it is, two stage hand pump it is you will see here, here it is a oil tank inlet and you will see this is handled top one is a handle moving up and down here you will see friends a stepped piston.

These are called a suction side NRVs these are called a pressure side NRVs. Again as usual the drain valve is there when it is reversing also the change your valve to do the sum functions.

(Refer Slide Time: 22:58)



Now, schematically again I have drawn here to understand better stapler piston here, same as usual when you will push down what happened it will move up, what happened fluid will be sucked to this side. Whatever the fluid is there it will go to the load, when you are reversing load you have to use drain valve directly it will go here. This is a very simple to understand the two stage hand pump.