Upstream LNG Technology
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Lecture – 64
Pumps in natural gas systems – I

Welcome as we have learnt earlier how to move the gases in the natural gas processing. Here also we are now going to look into how the liquids are going to be moved in the system. And as we know that in any kind of plant both gases and liquids are there at various points and various locations and they have to be moved over long distances in the plant. So, it is very much important for us to know have to have some basic idea about how to move the liquid and how to do some analysis to know the performance and some kind of design of the fluid moving machineries.

So, in this particular lecture shall be looking into the various types of pumps which are used in the natural gas systems. And in this we shall been learning about the classification of the pumps, the positive displacement pumps, the kinetic pumps, the selection of the pumps and the performance of the pumps.

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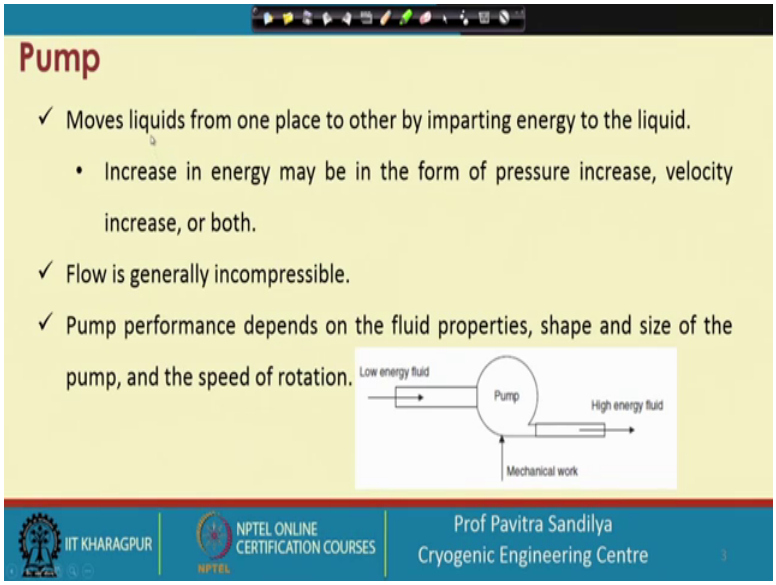

So, first let us see the that water pumps now pumps are some liquid moving machinery from and they what they do that they move the liquid from one place to the other by imparting some kind of energy to the liquid. Now here we find that the energy which is

imparted to the liquid it may come out as a in the form of the pressure increase that is pressure energy; velocity increase that is the increase in the kinetic energy or both that means, both pressure energy has as well as kinetic energy may get increased.

And then generally because we are talking of the liquids so the flow is generally taken as incompressible; unlike in case of compressors where we are using gases there the flow is taken as sometimes as compressible. Now the performance of this pumps depend on the type of fluid we are handling the shape and size of the pump and the rotational speed if there is any kind of rotation. So, here we in this schematic diagram we can see that we are getting some low energy fluid which is going through the pump and we are putting some mechanical work into the pump and that is how we are able to increase the energy of the outgoing fluid.

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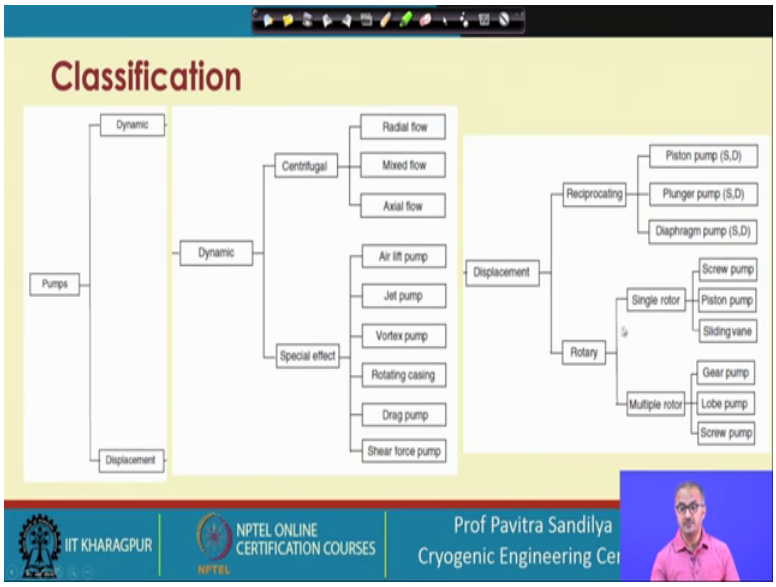

Now there are various classifications of the pump the broadly they are classified into two groups. One is the dynamic another is the displacement. And again this dynamic and displacement are further classified now we the dynamic can be classified into centrifugal pump then the special effects pumps.

So, we can see radial mixed flow, axial flow, and their special effect pump like air lift pump, jet pump, vertex pump, rotating casing drag pump, shear force pump, and many things are also getting you know innovated and invented in the with more than more depending on the kind of applications we have.

And similarity we have many classifications for the displacement type of pumps in this we have reciprocating and rotary and reciprocating again we have piston type plunger type diaphragm type. And a rotary we have single rotor multiple router and here also we have screw pump, piston pump, and sliding pump; and in this we have multiple rotor we have gear pump, lobe pump, screw pump.

Now, definitely this particular course is not about pumps in a separate courses and books ever written on the pump what we shall be learning in this that what are the very commonly used pumps in the natural gas industries and some; even that is not exhaustive, but some commonly common one and how to access them choose them select them with those things we shall be looking into this particular lecture.

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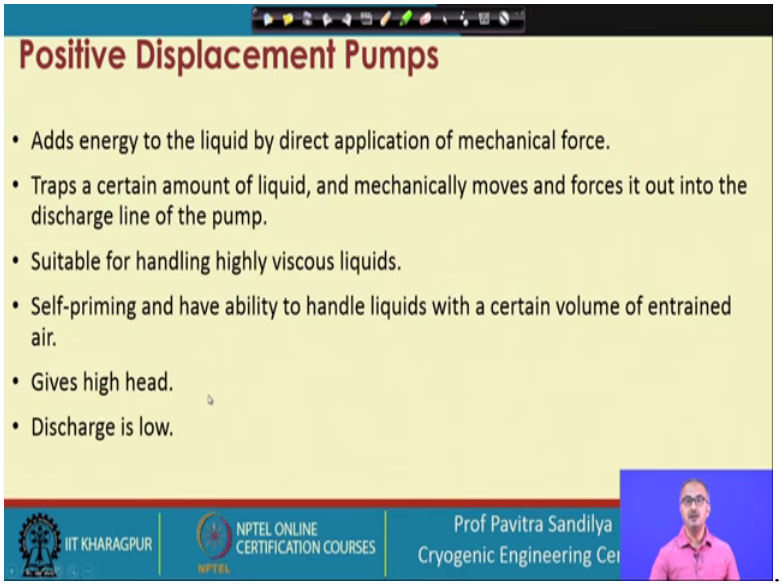

So, first we come to the positive displacement type of pumps and in this what we see the positive displacement meant; we are displacing the particular liquid positively by giving some mechanical force. So, here we have some it act energy to the liquid by direct application of the mechanical force.

And what happen when that into do this kind of pump traps a certain amount of liquid and mechanically moves and forces it out into the discharge line of the pump. And you can say this operation is something like the way we are using the syringes to for injection. So, we are first sucking in the liquid and then pushing the piston in the syringe

to push of the liquid. So, this is similar manner you can imagine that this kinds of pumps are working.

Only thing is this they differ where the way this mechanical energy is important to the liquid that is how we are getting different types of the positive displacement pumps. And they are suitable to handle highly viscous liquid and their self priming and have ability to handle liquids with a certain volume of entrained air. And priming you know that priming is done so that we can drive out the entrained air otherwise what happens the liquid cannot get sucked in, because the liquid pressure has to be more than the pressure inside the pump.

And if the and we know that a force proper for example, for water we need about 10 meter of water height to get one atmosphere pressure. So, if there is some kind of air trapped inside the pump and it is at atmospheric pressure, then we need that large hydrostatic head of the water column to make the water go into the pump. So, there we need some kind of priming. So, that the trapped air can do not should not stay inside the pump.

So, in this particular type of pump reciprocating pump there is no problem with this because whatever trapped air is there. Whenever we are using any kind of mechanical force that by the force we are able to drive out the trapped gas trapped here and that is how it is a self priming kind. And this kind of pump give very high head and low, but low discharge.

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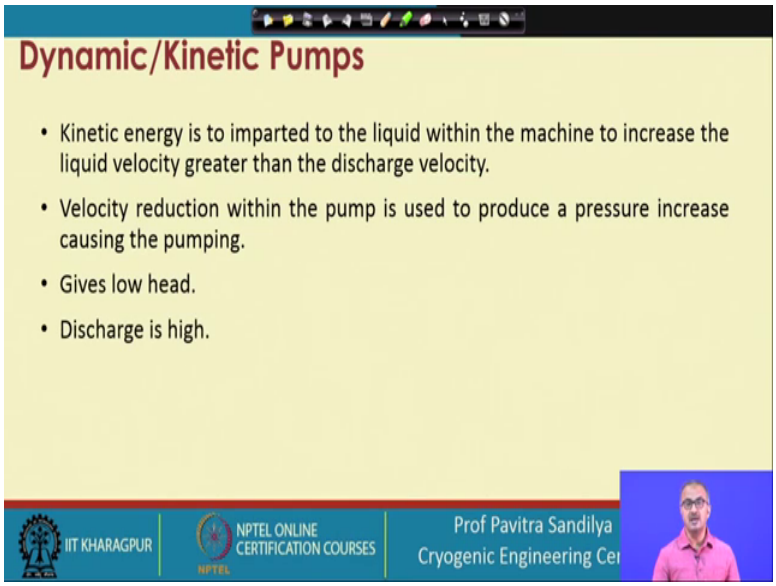

And then we have the dynamic or kinetic pumps; as a name suggests that kinetic means we are important some kind of kinetic energy or in that is coming in terms of the velocity. So, in this kinetic energy is imparted to the liquid within the machine and by doing. So, what we are doing we are increasing the liquid velocity that is that is more than the discharge velocity. Now why we are doing this more now why because by again we are reducing that velocity imparted to the liquid and when we are decreasing the velocity of the liquid we are able to recover the pressure which was lost during this increase in the velocity. That is we are basically going by a energy balance.

And we can say that we are using some kind of Bernoulli equation that energy balance. That energy balance we are using to first increase the velocity of the fluid more than the discharge velocity again reducing the velocity to recover the pressure. So, that we can generate some pressure in the outgoing liquid this kind of pump if this is gives low head, but high discharge.

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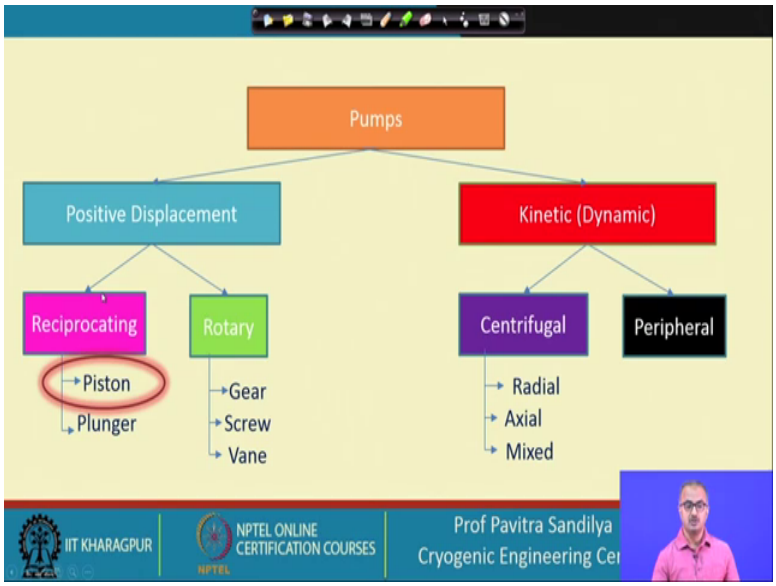

So, now what we shall doing? We shall be selectively not all of them, but selectively we shall look into the working of these pumps. So, first let us look at the piston pump.

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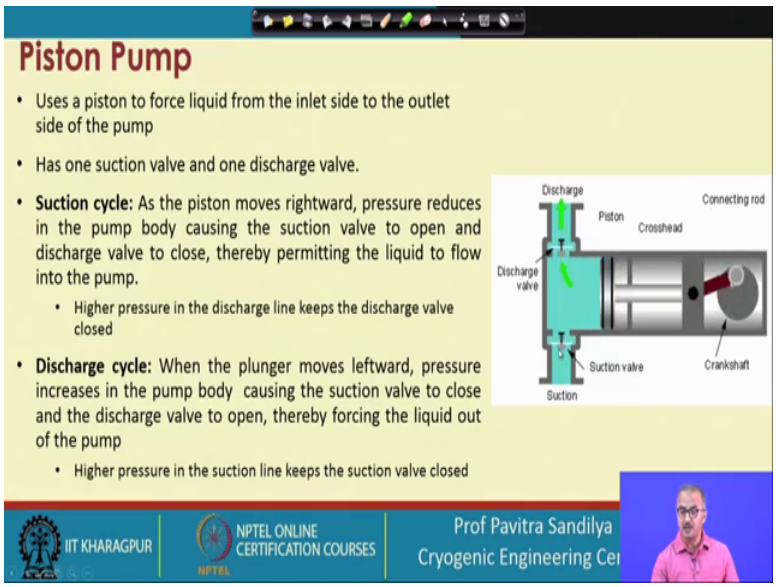

And as the name suggests that it has a piston which will be moving to and fro two drive the liquid out and such in the liquid some same as the kind of syringe we find for our injection. So, here we have a piston to force a liquid from the inlet side to the outlet of side of the pump. And here we find how it is working that this is here we find this is suction side and this is the discharge side and we have a discharge valve here and a

suction valve here. And here we have with a load the crankshaft the rod is connect in the crankshaft with the piston and the piston is undergoing this to and fro motion.

So, what happen suction cycle the pistons move rightward and the pressure reduces in the pump body and causing this suction valve to open opens. So, when it going to other side you can see whether it is going to the right hand side this valve is opening and was this valve is opening liquid is getting sucked in; and when this is sucking in this valve is remaining closed so no liquid can go out during these suction cycles. So, this is the suction cycle and high pressure in the discharge line keeps the discharge valve closed ok.

So, that is how it is only sucking and then here discharge cycle; that means that when it is going on the left hand side the liquid this valve is again opening and this valve is closing. So, that this liquid is able to move out from the discharge or delivery line. So, this is how this kind of piston pump works.

Only in this case we find that there will be a time gap between the suction cycle and discharge cycle due to which the flow which is obtained from this kind of an arrangement will be intermittent; sometimes it will be there and sometimes it will not be there, but generally we want a constant flow rate.

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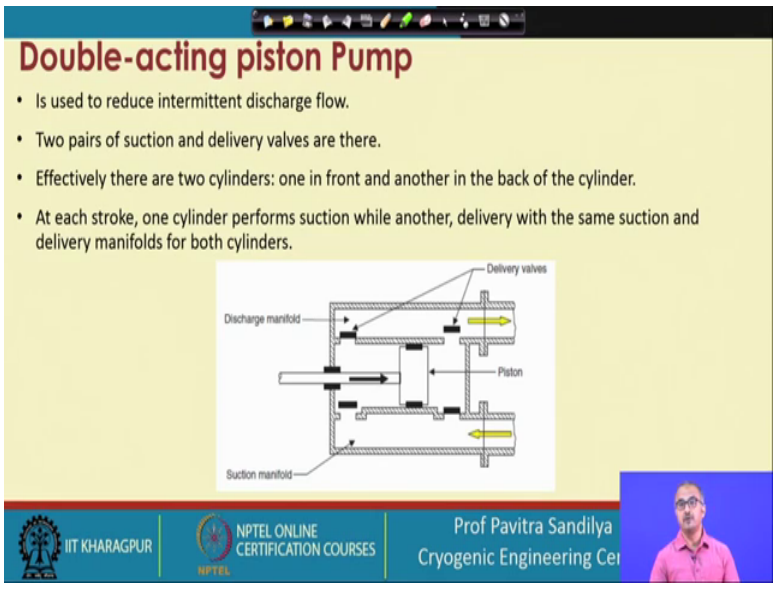

And so for that what we do we go for a double acting pump and it is to reduce the intermittency in the discharge flow and we have now two pairs of suction and delivery valves.

Now, you can see this is one suction line this is another suction line, this is one delivery valve and this another delivery valve. And we can see that these are pressed one in the front of this a piston. So, once it is in the front section and another set of this suction and delivery valves on the behind the backward of the piston. So, what happens one of the pairs will be acting at a time. So, we find that when this piston is going to the right hand side these discharge valve is open and at that moment. So, the liquid is flowing out of the discharge valve in the manifold. At the same time this suction valve is open behind the piston, so that the liquid is coming through this section. And once what happens once it delivered now this piston will move back, when it moves back what happens this suction valve closes, this discharge valve open while this closes and this opens.

Now, what happens is the liquid will now start coming in through this section and will be delivered out from this section ok. So, that is how we are finding the same manifold either this or this valve is active is sucking in the liquid and in the same manifold either this valve or this valve is active in delivering the particular liquid. And that is how what we are finding in this manifold we are always having the liquid present at all time. So, that we are able to reduce is not eliminate because the amount which is going out through this valves maybe differing, because the space available behind the pistons and above in front of the pistons are slightly different, but overall we shall be finding we are able to reduce the intermittency of the liquid flow rate quite well by using this double acting pump. So, this is what goes staging of the pump.

So, that is how this double acting works. And then we go to the gear pump.

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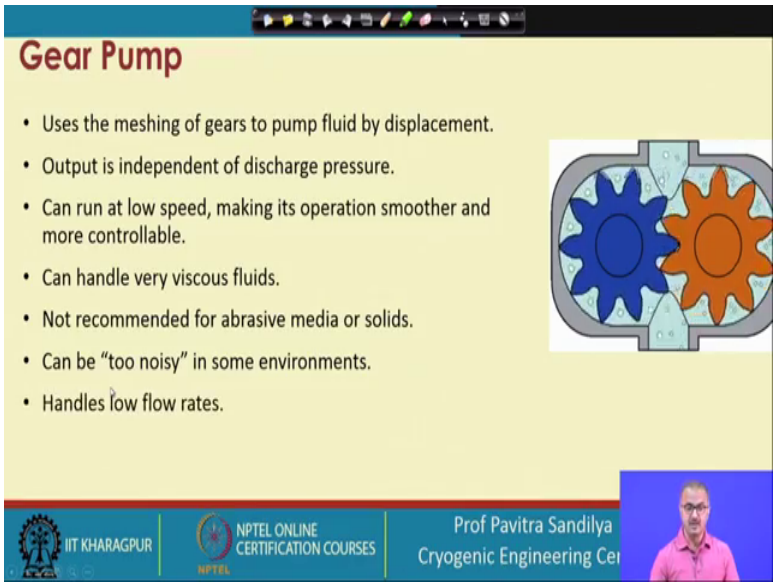

As the name suggests that we have two gears and here what we find the liquid is coming through this side and because this gears are moving and this liquid is taken from these two sides that is the casing in which the gears are pressed and we find that the liquid is going either from this side or this side. And then there it is getting compressed then this it is going through this and this is this compression is increasing the pressure in the liquid and then it is passing out from the delivery line.

So, this is the way this gear pump is able to pump or the liquid and the output of the gear pump is independent of the discharge pressure and it can work at a low speed. And it can be work at a low speed it means that we can have gets smoother operation and we can make it more controllable. It can handle very viscous fluids, but it is not recommended for abrasive media of solids because in that case what will happen the wall of this casing will get damaged. So, that is why it is not recommended for abrasive media and also the gear teeth the teeth of the gear they can also get damaged by any kind of abrasive material. But because of this rotational thing and this gear meshing up here there could be lot of noises in the environment and you can handle low flow rates.

And then you come to another type of pump that is the vane pump.

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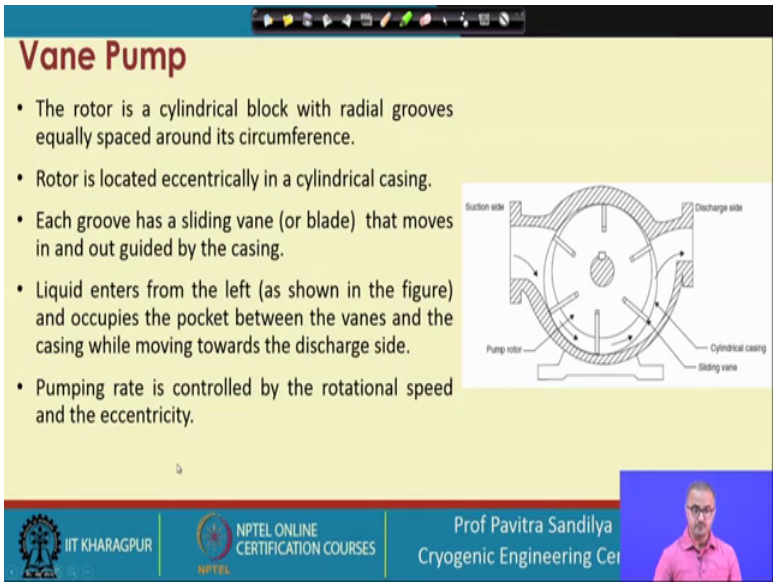

In this case you can see that what are the vanes here we have the vanes and first thing is this with this is rotor part the pump rotor we can see and in the pump rotor we have many groups in the rotor. So, these groups are generally equispaced along the circumference of the rotor. And the in each of the grooves we have some what we call sliding vane or blades.

So, sliding means these vanes can go inside and outside of this each of the grooves and how these are go inside outside this is a guided by the casing. And this rotor is pressed eccentrically with the stated that the outer casing; why because if I we do that what was happen all the vanes will not be inside together neither is a outside together.

So, that we can get some of the vane should be inside and some will be outside. And why: because when the vanes are inside suppose this eccentric what happens these vanes which are away from the casing will be opening up they will be coming out of this things. So, they will make way for the liquid to move inside the pump.

But though the vanes which are on this side they will get pushed in and they will moving in. So, no liquid can pass through this side. So, liquid will pass only through this side. So, what will happen? This vanes are active they are going out and they are letting the liquid passing, the other vanes are not able to make the liquid pass because they getting there is no hardening clearance between the vanes and the casing. So, liquid is moving up and this going out from the discharge side.

So, this is how this vane pumps are working. And the pumping rate is controlled by the rotational speed and the eccentricity it means; how the axis of the rotor is displaced from the axis of the casing this axis are not matching they are away from each other. So, that is how we are getting the eccentricity. .

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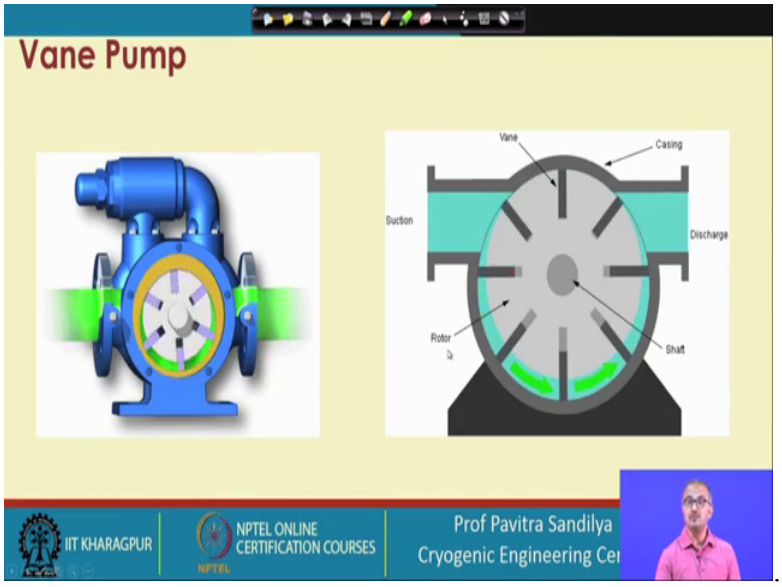

Now, this is here we find that how this rotor pumps are working we can see that how this vanes are working. If you look this figure the vanes are coming out and as soon as they go inside they are moving inside. Similarly we find in this thing also the vanes are out and as soon as they go to the other side they are coming inside and the liquid is flowing only through this side. So, it is no liquid is flowing from this side. So, that is how we are able to get the pumping action in this kind of vane pumps.

Next we go to the screw pump.

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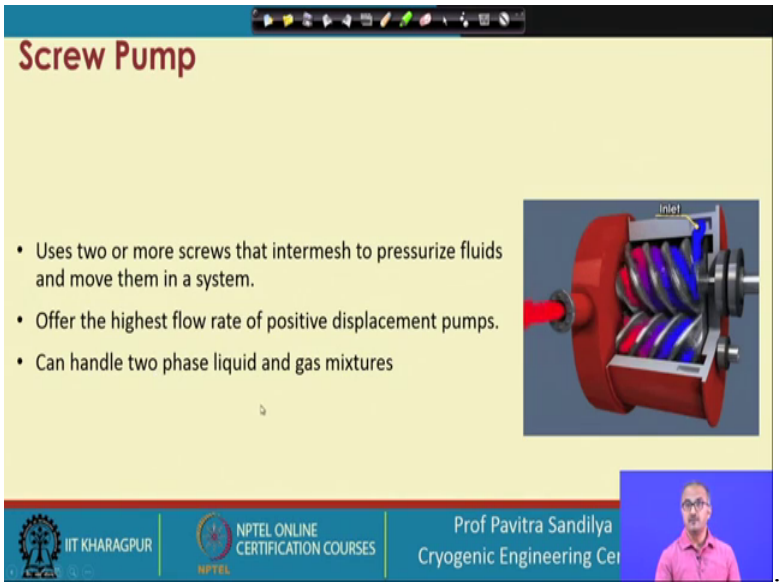

The name suggest that we are using some kind of screw and you can see these are the screws here, and here from here the inlet is coming here and this screws are there through a pair of screws through which the liquid is flowing. And then we are finding that this because of this reduced spacing between the screws this liquid is getting pressurized and ultimately it is coming out from this delivery line.

So, it` is using two or more screwed that intermeshed to pressurize the liquid and them when they and move out of the system. And offer the highest flow rate of among the all the positive displacement pumps. So, because of the intermeshing of the screws we are able to generate the high pressure and it can handle two phase vapour liquid mixtures.

Next we come to the kinetic pumps and under this we come to the centrifugal pumps. We shall be looking in general again we find under the centrifugal pump we have various other pumps like radial pump, axial pump, mixed pump.

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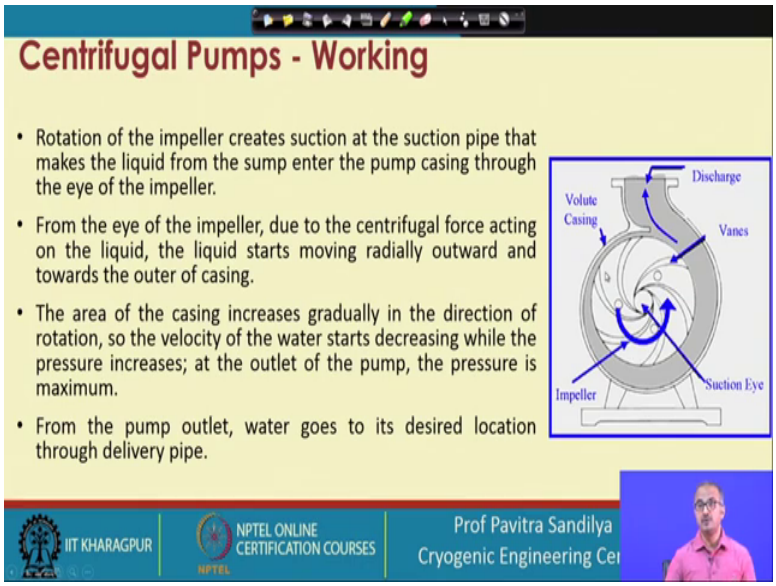

So, we shall be looking into the centrifugal the normal centrifugal pump that is basically the radial centrifugal pump. And here we have the working of the radial pumps that here first we see that what we have we have a suction i and this is the impeller. Through the suction i the liquid entered and as it goes on the impeller and this impeller is rotating and due to the rotating motion of this impeller the liquid sucked in. And once this liquid comes on the impeller it across the centrifugal acceleration and as it moves away from the centre what happens we know that omega square r the r is increasing. So, this acceleration is increasing and when it goes at the tip of the impeller the liquid is attaining the highest flow rate.

And once it comes to the thing it is if this impeller what happens it comes to what we call the volute casing with comes volute casing and this volute casing as you can see it has an increasing area of cross section. And was the area of cross section increases what happens the flow rate reduces and the when the flow rate reduces what happens the pressure starts decreasing what happens the pressure starts decreasing this is the energy balance.

So, Bernoulli's equation you can use though what will happen that the velocity reduces pressure increases and at the discharge line we will be able to recover much of pressure and it will be quiet high; it is higher than the inlet pressure. So, that is how we are able to get the pumping action for the centrifugal pumps.

And once this pressure is there so the liquid can be moved up at any other location up.

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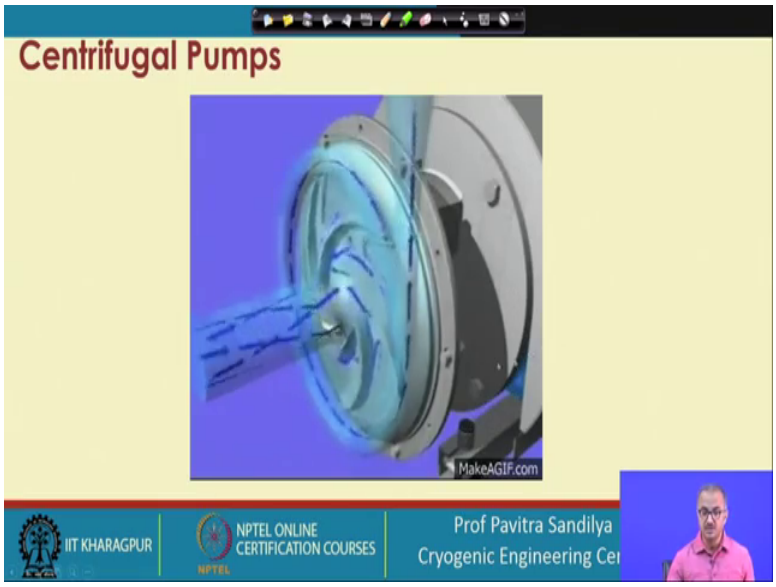

So, here we see the how the things are working. That the from the i the liquid is coming out coming in and then it is going on the impeller and this as it goes to impeller goes it impeller tip then it goes in the volute casing and the volute casing as you can see the area of cross section is increasing, it consist kind of diffuser sections. And then the pressure is increasing due to decrease in the kinetic energy and ultimately we are getting a high pressure liquid.

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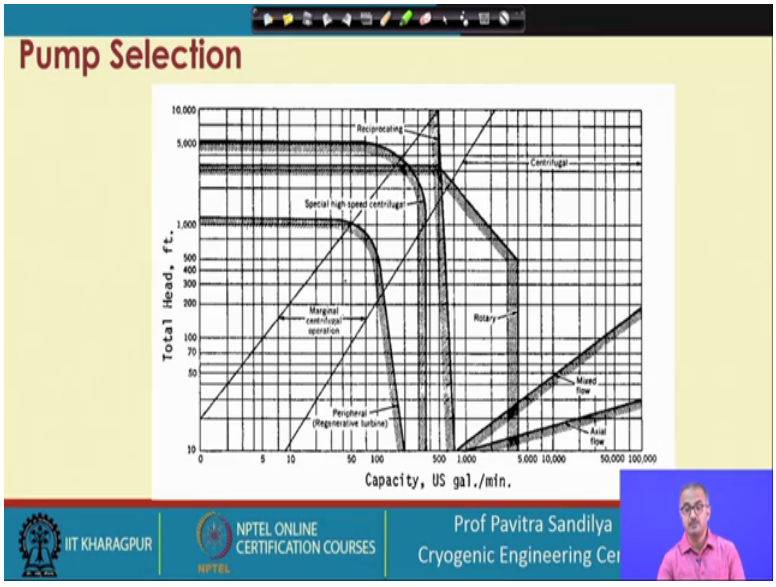

Now before we end with a going to the way that we select the pump. So, here generally we have the head versus the capacity. What happens we have to look into aspects when select the pump that head means that how much pressure drop it can encounter and we may have two put the pump the liquid from bottom plane to the top plane. So, how much head we can generate from a given pump and at what capacity. So, we want sometimes both high capacity and high head and sometimes we want low capacity high air or sometimes may we makes have some other combinations.

So, here we find that various types of pumps have been given and this kind of graph we can use to have a first guideline to choose the kind of pump we need for a particular application. So, we if you know the head required and the capacity required we can find out which kind of pumps would be used. And you can see there is various other pumps are given your axial flow, mixed flow, rotary flow, then centrifugal reciprocating, then high speed centrifugal then there other pumps peripheral; so the radius.

So, this is one of the representative guidelines the similarly depend the manufacturers will give us the different types of this kind of charts from which we shall be able to select the appropriate pump for a given application.

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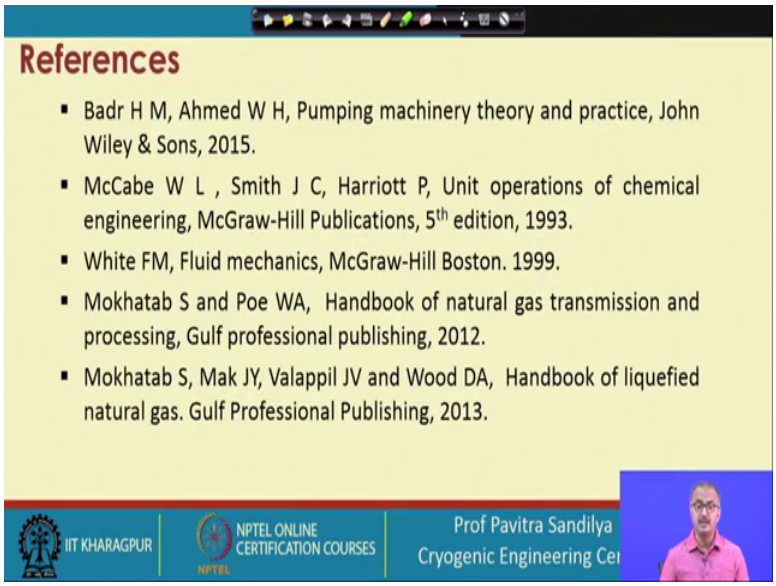

And these are some of the books which you can refer to for more detailing and explanation about the pumps.

Thank you.