Mining Machinery
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Module - 07
Lecture - 36
Mine Pumps

Today, we are going to study another type of machines which are used in Mining Industry that is Mine Pumps. As you know whether it is your surface mining or underground mining, mine pumps are used and for dewatering, for different other technical jobs as well.

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So, this is; what is a pump? You know that it is a machine that imparts energy to the fluid to flow and rise to a higher level or boths; both the things can be done. Now, you know that in a mines, when you are having an open cast mine, we are having a the pit created and all this

rain water as well as some of the underground water, they get accumulated over here so that two machines to operate will have to keep that water removed.

And also, sometimes you do a hydraulic mining in which by this you make the minerals into form of a slurry and then, you take that slurry out. So, that is why sometimes you pump a mixture of solid and liquid and that solid liquid mixture can be of different types. Similarly, sometimes you transport the machines materials in a slurry form as for example, in Kudremukh mines, we had this iron ore then grinded to fines and from Kudremukh to Mangalore port, it was being transported through pipelines.

So, they are the huge applications of pumps. So, there are various pumps used in the mining industry and this class today, we will be introducing the construction operation of mine pumps and how you classify them.

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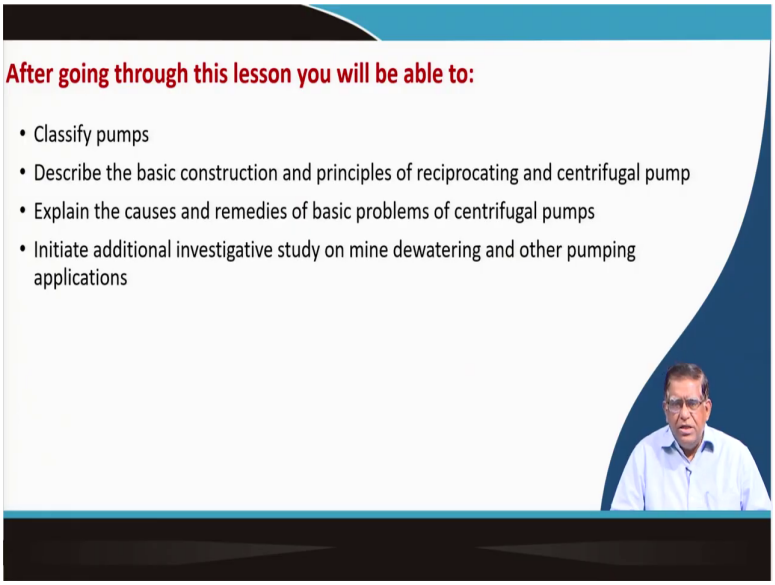

Our objective is to know the basic construction and operations and also, as a mining manager, you should be able to control that how the mine pump maintenance and their replacements and their selection for different jobs are done. So, for that reason a mining engineer must have a very clear understanding of how pump works.

And this lecture, should help you to take up some investigative study on pumps for dewatering and other pumping operations in mines. So, this will be an introductory class, where we will be learning about this pumps.

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Now, you as you show that the diagrams here, we have got different type of situations here. You can see that this surface mine dewatering that is we are taking from the water out of the open pit mines.

You can see in this figure that is your in an underground mine, after the mineral is taken out, the soil need to be filled up with backfilled material and many times slurries and then, sand mix or some different types of material even fly ash that are sent back to the mines to backfill it, that operation is also done by pumping.

Similarly, in the mineral processing plant while beneficiating, you are creating a lot of tailings and those are to be sent to the settling ponds. So, there also you can see that pumping operations are there. Other than that you can see in many of the mines and then transportation systems, there is a lot of dust suppression need to be done. So, for the dust suppression system also, there are pumps.

Other than that, there are pumps in different machines; for the drilling machines that is sometimes if in oil well drilling, you will be doing the drilling mud will have to be pumped. Similarly, that you will have to pump out the materials from the drill that blast holes, you need to; sometimes if you do the pumping with water, then other machines like your shearer or continuous miner, there also you have got pumps for.

There is a different type of pumps which are called your oil pumps like gear pump and van pump, we will be discussing those things separately.

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But you know that there are pumping operations are there in the mining industry. But this pumps in general is a very very important thing for human society. You may know about the history of this pumping which started in the that Egyptians in 2000 BC, they used to have this pump and which some of you might have still seen in some of the interior villages and rural areas that taking water from the well, there is also some sort of this the basic principle is also a pumping.

And then, there were you know that in before Christ about 200, Archimedes created that Archimedean screw pump for which lifting this water. Even now, there are such type of systems are there in some very small hydel projects that water is lifted and kept at over there and then, after getting that it is just you can create electricity some small rivulets, they create

a this and say a small dam and on that they take the water by a Archimedean screw pump. Still today, it is used in many places.

So, you can see the history of development of this pump, it started from this 14th century to 17th century, there were these a different pumps got developed. The first of the centrifugal pump, it came in 1475 and then, for oil gear pump, it came in 1593. So, there are different types of innovations and development in this. But you know that the water wheel, that is also a type of pump which has exactly used in 600 BC in the Egyptians.

Similarly, you can you may Greece people, they also used in 220 BC. At that time, they developed this piston pump, reciprocating pump or the positive displacement pumps were generated. So, that is our pumping as a knowledge to human body, human that knowledge, it was there for the centuries and recently, there had been lot of development in this pumping system.

As a result, we know now there are a large number of technologies are there. The latest exactly that in the last century that they are near 1950s and all, that came this submersible pump and with that submersible pump and then, magnetic drive pump they started being used in different industry in a different way. So, I hope you will be able to appreciate that such a technology such a knowledge which is there and we need to know about it.

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And as a result, if you see that in the modern time, the pumps are still going on different developments. As a result, you can have a large number of varieties of pump which are not exactly will be discussed in the class and I hope you will be making up your own study some time and nowadays, information's are available online from different websites, you just see that classification of pump.

And at least some of the things which are used our mining industry, you can find, it is like the sucker rod pump; you might have seen any oil filled diagrams that exactly you can see a big rod is moving up and down, that sucker rod pump is a very important things. Like that you may have this is in the agricultural sector, in the fishing sector, in our this mining sector, mineral processing sector, there are various different types of pumps.

But if you see that all these developed pumps can be broadly classified into two category that is dynamic pump and positive displacement pump. And under the dynamic pump there, we can this tell about the centrifugal pump which can be a vertical centrifugal pump or horizontal centrifugal pump and there a some varieties are there, which are called submersible pump or there is a fire hydrant systems were also some pumps are used.

Similarly, in the positive displacement pumps, we have got these diaphragm pumps, gear pump, peristaltic pumps, lobe pumps, piston pumps, many different types of pumps are there. So, you just have this in your mind that the pump can be classified on the basis of how the energy is imparted to that; how exactly it is placed, that is your where that the flow will be axially or it will be a mixed flow or whether it will be going as a peripheral site or this is exactly by giving as a single cylinder in a reciprocating pump.

Whether you are having a simplex or you are having a duplex pump or a triplex pump even where three cylinders will be working and then, these reciprocating pumps, whether they will be single acting or double acting depending on that you may classify.

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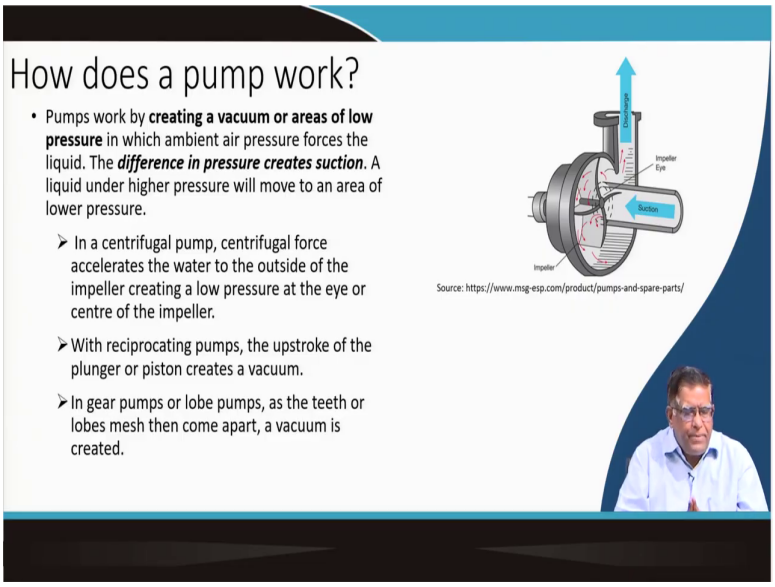

So, this part you make yourself a brief note on classification of pump. But coming to this exactly how a pump works, the basic principle you know that fluid flows from a higher level to lower level that is you have seen and this, what is the meaning of exactly this higher level and lower level? It is exactly the pressure differences. It is from a higher pressure; it goes to the lower pressure. So, that is why if there is no pressure, if you can create a vacuum, then whole thing will go over there.

So, this that is your creating a vacuum or areas of low pressure is the main thing in designing and developing a pump. Now, that is why the difference in pressure exactly creates the suction and in that the fluid starts moving and this one, you can see that in a centrifugal pump, what they do? They exactly a centrifugal force accelerates the water to outside of the impeller creating a low pressure at the eye or center of an impeller.

In a centrifugal pump, we will be discussing soon. There is a suction site and there is a discharge or delivery site. In the suction site, that is where exactly a shaft which is rotating one device called we call it as an impeller. Now, while this impeller will be rotating, it is here a negative or that is your a low pressures will be created and the water will be sucked from here and it will be pushed to and it will go.

Because when it will be going from a smaller area to bigger area, then this exactly the velocity will drop down and pressure will change. So, this exactly, the basic principle of your centrifugal pump. Now, there are these other things which are as a reciprocating pump or gear pump, they work in a differently.

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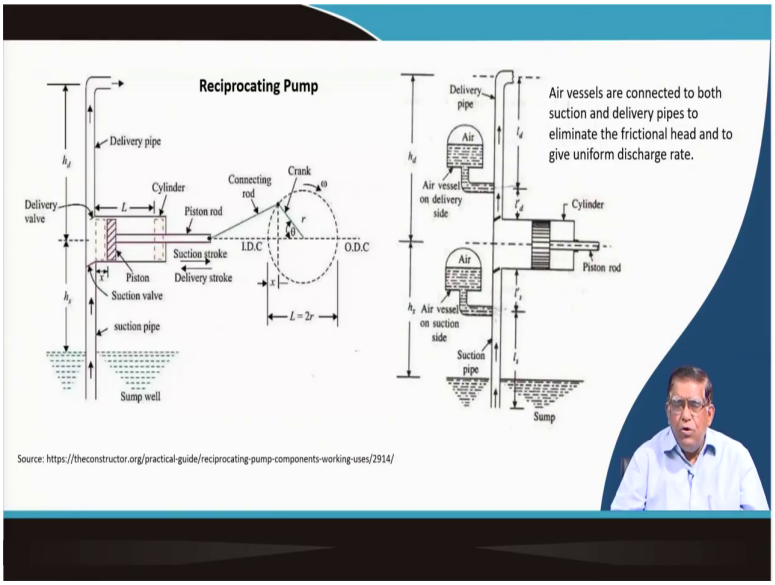

In a reciprocating pump, we are having exactly if you are having a sump and well, from there you are exactly taking the water through this reciprocating system to give a reciprocating

system, we have got a crank mechanism. When this crank, when it will be rotating with the speed of omega, this with an sweeping this one, this connecting rod it will be making a to and fro motion.

When it will make a to and fro motion, it will give that motion to a piston rod and then, there are two valves; as a suction valve and one delivery valve. Now, this when it will be going towards this directions, a low pressure will be created over here, so the water will be move coming over here.

When it is coming and when it make a move towards again this direction, then this valve get closed and then, this valve get open and that water which came inside this will be delivered over here. So, this is a basic principle of your suction pump; but there in between, where we are having this is your suction head and this is your delivery head or that exactly the pressure that will be coming into head.

Head is nothing but up to what you can lift the water. Now, there is a air vessel which is another addition to this so that there could be a uniform discharge is possible. So, the these are the basic principle of reciprocating pump which you might have studied in your class 12.

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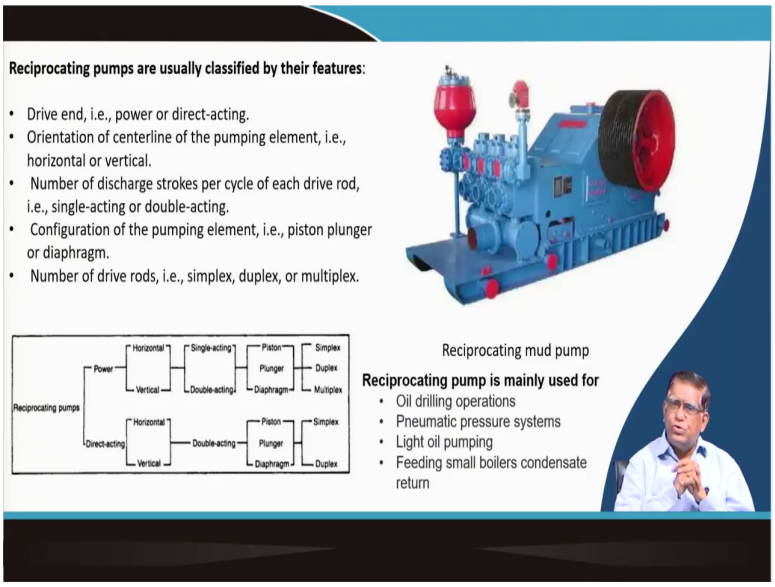

Now, these pumps are also can be reciprocating pumps are also of different type. Basically, they are based on how the power is imported; whether you are having the pump in a horizontal or it is in a vertical; whether it is a single acting or double acting? That means, in every stroke, it will be sucking or it will be doing only one sucking and then, one it is giving a discharging.

That is what exactly a single acting or that depending on the double acting, where you are having a continuously you are flowing it out. And then, the type of rod or that movement which is giving the reciprocating whether it is a piston plunger or diaphragm and depending on that, whether again we are having a simplex, duplex and multiplex type of pumps are there.

Similarly, that your mainly we have this drive end side, whether power is given directly or not, then orientations, number of discharge strokes, configuration of the pumping element and number of drive rods, depending on that this classifications are there. If you see a pump, particularly we use in the mining industry, that is particularly in the oil industry, we have got the reciprocating mud pump.

If you go to any drilling site, a oil-well drilling, there you know that the oil-well drilling, when you are making a drill hole up to 3000-5000 meter deep, there the drill cuttings are to be taken out by sending mud from the top into the hole and then, the mud comes back. So, for that, exactly the mud is given this flow.

The flowing of the mud to giving it pressure so that it goes bottom and then, from there it come back. It is done by that mud pump. So, this is one of the mud pump which is used is a triplex; triplex mud pump, it is used. It is a reciprocating pump which is for oil drilling operations. Also, there are in a pneumatic pressures and in light oil pumping and small boiler feeding also, some of this reciprocating pumps are used.

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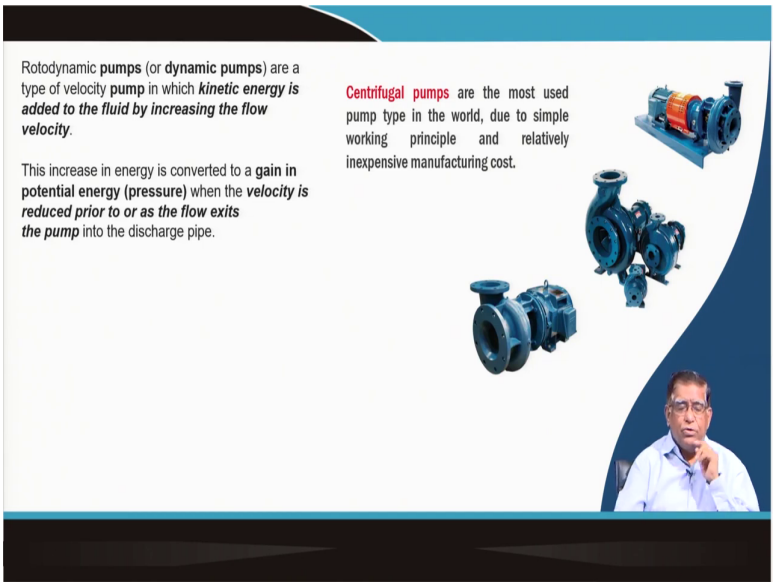

Now, this there is the mainly the rotodynamic or which is called your centrifugal. So, there are two things; one is your reciprocating and other is your dynamic or rotodynamic. So, this is the case you can see here, this type of diagram whenever you see, you can find out that there is a reciprocating pump.

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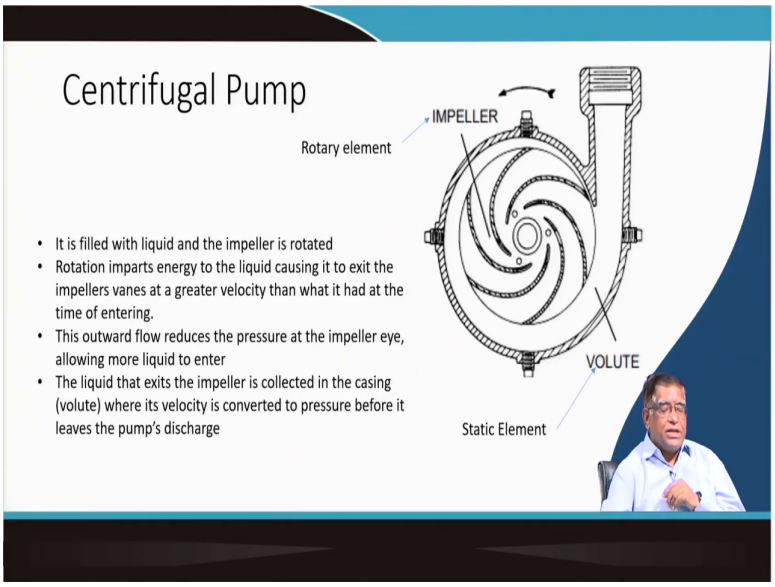

We will be knowing about that how this reciprocatings, the how this sorry that is a centrifugal pump work? Now, in a centrifugal pump, you have got this impeller and this is a given a shaft is there.

This shaft is connected to it is supported on bearing and then, it is through a gearbox or through directly, it will be driven by a motor or it can be many places, it will be either your chain drive or it is a bell drive or a gear related your main drive. By that that shaft is rotating and then, your this impeller will be rotating.

Now, these will be kept under a casing, this casing is called a volute casing. Now, the water entering over here and then, it will be following the path and it will go and it will get

discharged at this end. You can see here that is initially, this whole thing will be filled with water and then, impeller will be rotated.

The rotation will impart energy to the liquid causing it to exit the impellers vanes at a greater velocity than what it had at that time of entering. The velocity which was here and then velocity which is here, that is your whatever velocity it will be coming, it will its velocity will be gained over here.

Now, this outward flow reduces the pressure when your velocity is increased mean pressure is reduced and then, it will enter into the casing. The liquid exits the impeller and is collected in the casing and then, velocity is converted to pressure before it leaves to the pump discharge.

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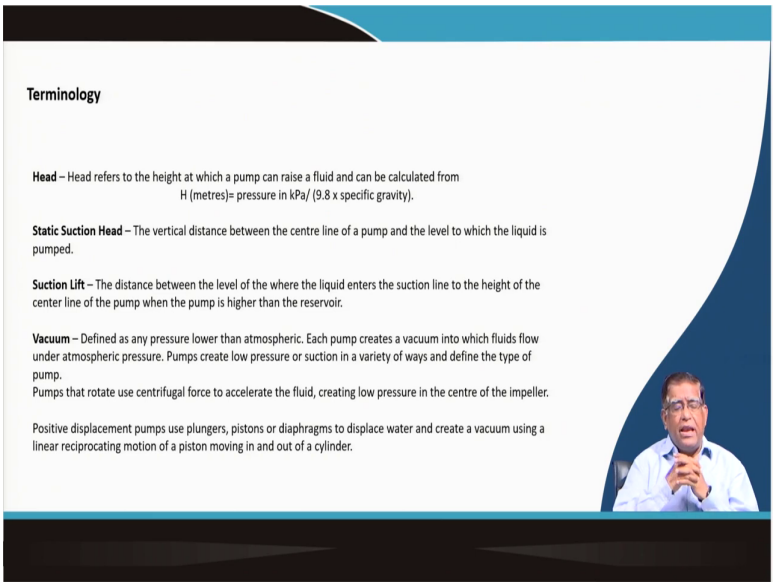

So, this is a basic system over here. So, in these pumping operations, you should know few terminology that what we say as a head. Head means, the height at which the pump can raise a fluid and can be calculated from the equation that pressure divided by 9.8 into that is acceleration due to gravity divided by specific gravity.

That is how we this determine the head when a pump will be pumping fluids of different density or different specific gravity. Now, static suction head, this is another important terminology. It is the vertical distance between the center line of the pump and the level to which the liquid is pumped.

So, from you have seen in the previous that is your suction head and the in the diagram of your centrifugal pump, we have shown over here in the other pump diagram, you have seen here; this is the suction head and this is your discharge head. So, what we get over here that is your suction lift that is the distance between the level, where the liquid enters the suction line and then, height of the center line of the pump, when the pump is higher than the reservoir.

So, that from how much exactly you are lifting. And then, the vacuum, it is defined as the any pressure lower than the atmospheric is a vacuum. Now, each pump creates a vacuum into which the fluids flow under the atmospheric pressure. Pump creates low pressure or suction in a variety of ways and that the way it is that suction is created, the vacuum is created that gives the particular type of pump.

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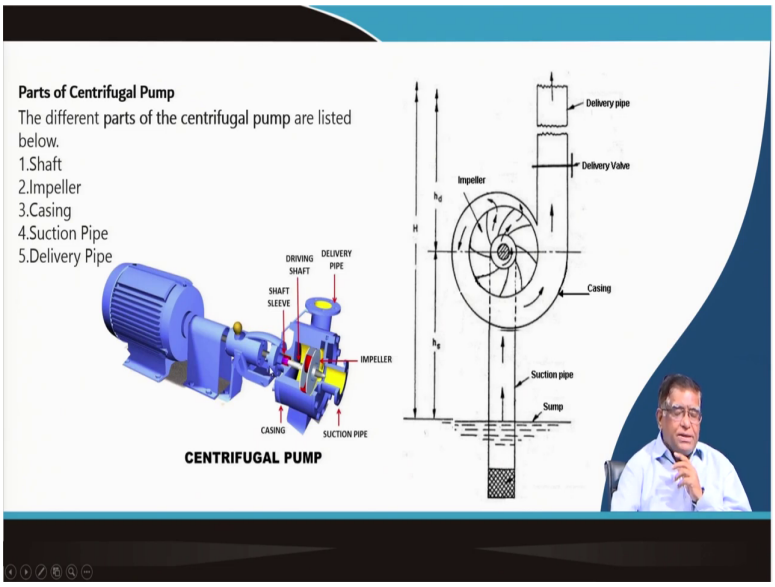

So, the positive displacement pump, we have said they use plunger, piston rods and things like that. So, if we think of a centrifugal pump, where exactly by rotations, we want to create the suction. So, how this is done? For that, it has got its different components. You can see here that is there is the that is water is there in a sump. Now, from there, we will have to raise up to a level.

Suppose, this is our impeller, so up to here, we will have to suction by a suction pipe and then, in the pump, there is an impeller and then there is volute casing is there, where we are having the drive motor connected to the shaft and then, it will be giving the delivery head will be there and then, there will be a delivery pipe from where the water wherever way you want to use you will be taking.

So, this in a centrifugal pump, these components as you can see there is a motor, this drive motor, we are having a shaft. Now, this shaft is supported on the bearing and then, there is a that is shaft sleeve through which it is coming over to the driving shaft for the impeller and then, there is a delivery pipe, you can see over here.

And then, this is a suction pipe through that this pipe suction which you are seeing, it is connected to over here and this portion is called the eye of the impeller and you can see now the impeller and casing which is there that as a volute casing.

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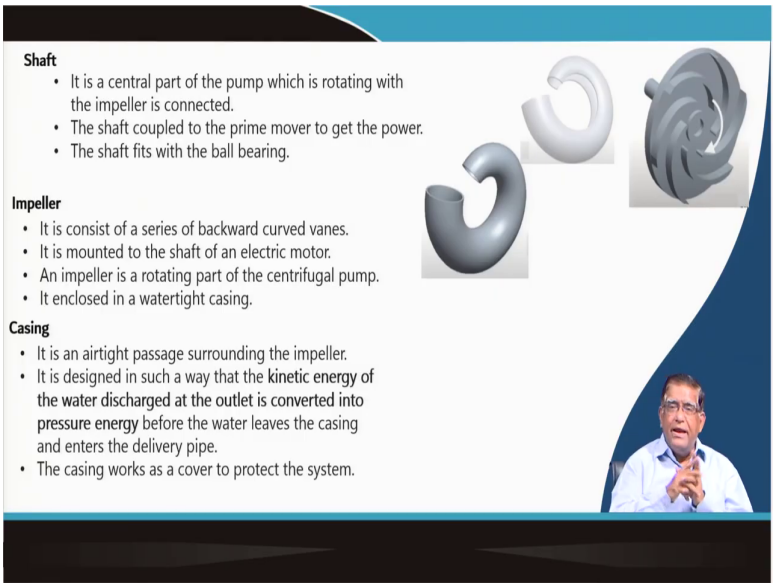

Now, that impeller you can see on this diagram. This is the impeller which rotates over here, there we are having this vanes which exactly guides the water, where it will be discharged.

And then, there is a volute casing, this impeller is kept inside a casing. So, these two are the main things and then, the shaft which is exactly the central part of the pump, we have shown in the diagram and we have you have now understood that this three main component that is shafts, impeller and casing.

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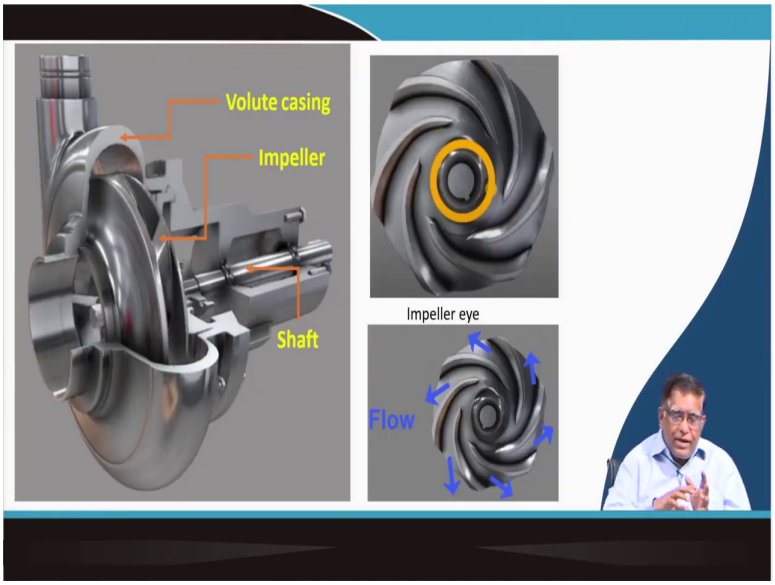

And that exactly in a real life how it will look like. That is you are having the shaft, this shaft is connecting it this impeller and this impeller is inside this casing. Now, this portion is called your the impeller eye so that the low pressure the vacuum is created at this point and the water, the fluid from the suction pipe will be coming over here and then, it will be delivered through this point. It is coming over here.

You can see here, now this you here is your part is less and then, it is going over here. So, here that velocity is high and then, it will be going and the pressures will be getting created

over here. So, this basic design that the mechanical engineering, they do and then, this exactly these were first the people imaginations that how they developed it about 500 years ago, you can think of this that this is the thing.

Then, of course, the subsequent developments are there, how you are exactly driving it, how you are giving the prime mover that makes the sense of it.

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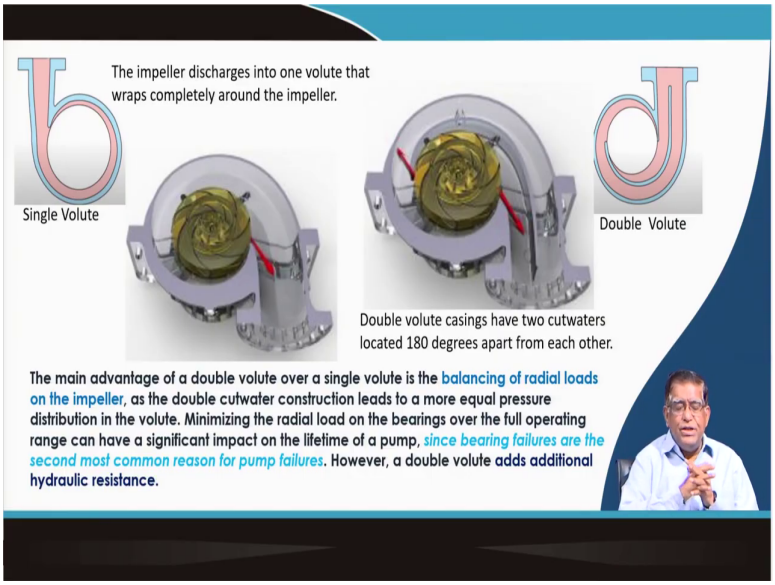

So, that casing which we say that volute casing in a pump, it can be of two types; one can be a single volute type as you can see here or it can be a double volute type. In a single volute, you can see here that is the water is taking a total turn and then only at one point, it is discharging to this point which is there at a little bit higher diameter.

You can see the volute casing, gradually the space increases. You can see here while drawing your volute casing, this snail like structures, here that is your width, here the diameter get increased. Now, this portion which is called your reversing, here exactly you go and then deliver the things. Now, in case of a double casing, you can see that this water from the impeller is discharged at two points which are 180 degree apart. You can see here and then, this will be going to out.

So, this they have got different that advantages. So, the main advantage of the double volute over the single volute is the balancing of the radial loads. Because when it is coming only over here and you know that in a pump basically on the shaft, it is a cantilever type of; at one end, we are having the load.

So, that is why on the bearing, there will be a different loads come so that in making it, a this is your double volute, it will be exactly having a balancing action or the radial loads on the impeller as well as on the shaft. So, this. Now, you can see that the minimizing the radial load on the bearing over the full operating range can have a significant effect on the life of the pump.

Mainly, the pump there that pump get damaged at the that their bearing or at the impeller; sometimes that impeller, there is one phenomena called cavitations lot of pitch formations over there. We will be discussing about that. Because how a at this point that your eye point on this impeller when the water gets sucks in, after that there is a if the that is your depending on the pressure conditions and that fluid conditions, there could be a bubble formations.

And that bubble when they collapse; then, on the impeller they will be doing a pitting actions, which is called the cavitations which can get create a problem. So, this mainly, the impeller and the bearing they get damaged in a centrifugal pump.

Now, so far as the bearing damage is concerned, it can be improved by balancing the loads. So, you know there is the constructions, the type of constructions, or the components of a pump that exactly affects their operating life.

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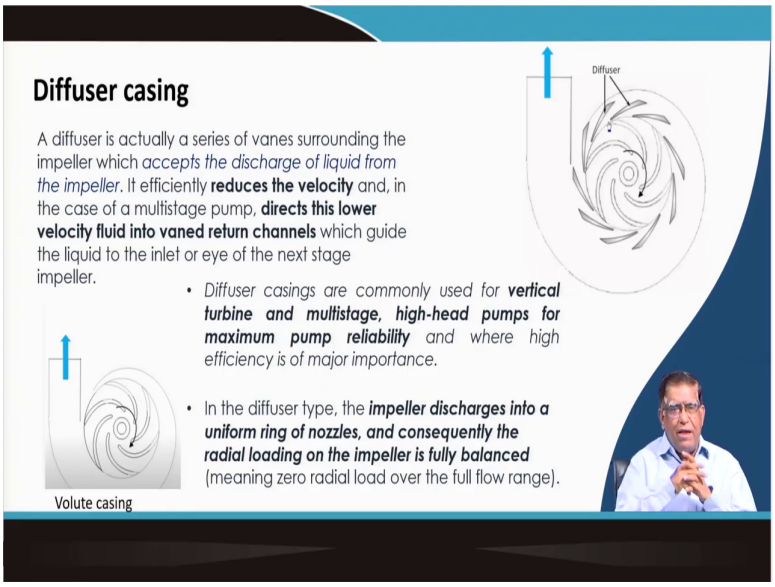

So, depending on what is the size, what type of load, you will be having that need to be seen. Now, there is also that casing which we have got a say single volute or double volute and then impeller. We have seen other than the impeller there is another things some diffuser casing.

In this casing, so you can see here in a volute casing, this is that only the impeller with a vane; but sometimes that we are having some static blades are there. So, this will be only adding into the flow, it will be deciding on that flow. So, this diffuser casing, it is actually a series of vanes surrounding the impeller which accept the discharge of liquid from the impeller.

It efficiently reduces the velocity and the case of a multistage pump directs the lower velocity fluid to a vaned return channels. So, you can this diffuser has got a big role in your multistage pump. So, basically the diffuser casings are used for vertical turbine and multistage high head

pumps for maximum pump reliability. So, this you now know that the casings are of three types then; single volute, double volute or with a diffuser.

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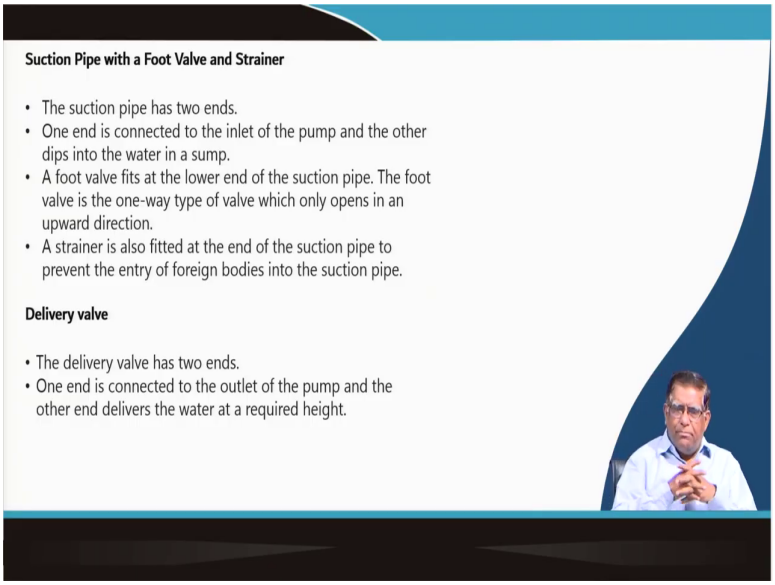

Now, the suction pipe or the foot valve and strainer that is also another part of this. Exactly the suction pipe below it, all the fluid will be sucked, at there we need to keep a strainer so that some grease and then the that particle, solid particles do not come into the pump because they may cause the damage to the pump.

And then, after that the last component is your delivery pipe that is from where from the immersive part of the volume casing, it is connected to the delivery and or the delivery pipe which takes the water to the delivery site ok.

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So, we summarily, we have got this volute casing, vortex casing and casing with a guided blades. What is the name of the guided blades? We have said there are we have got this diffusers casing, these are the main casing types.

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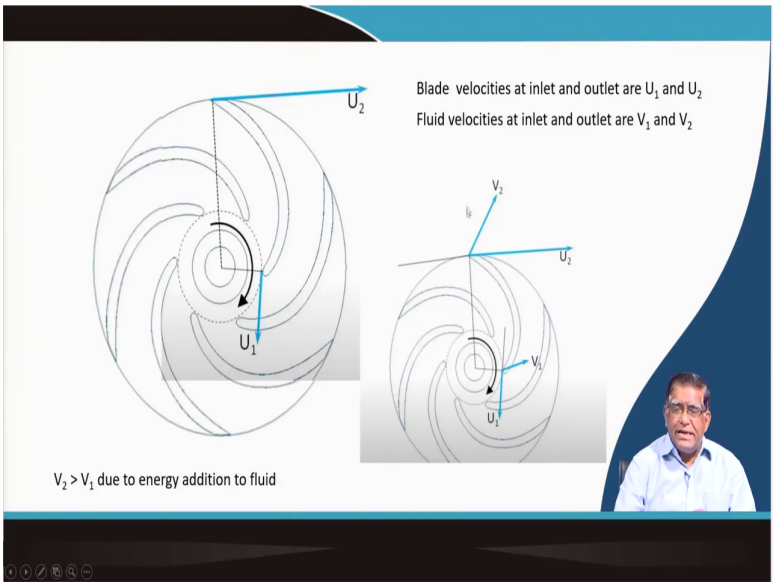

And then, you can see here basic principle that is your when your it is entering, this blade velocity is at inlet and then at the outlet. You can see that they are tangentially going, but that velocity is getting increased. So, that there are two things; one is the blade velocity and other is your fluid velocity.

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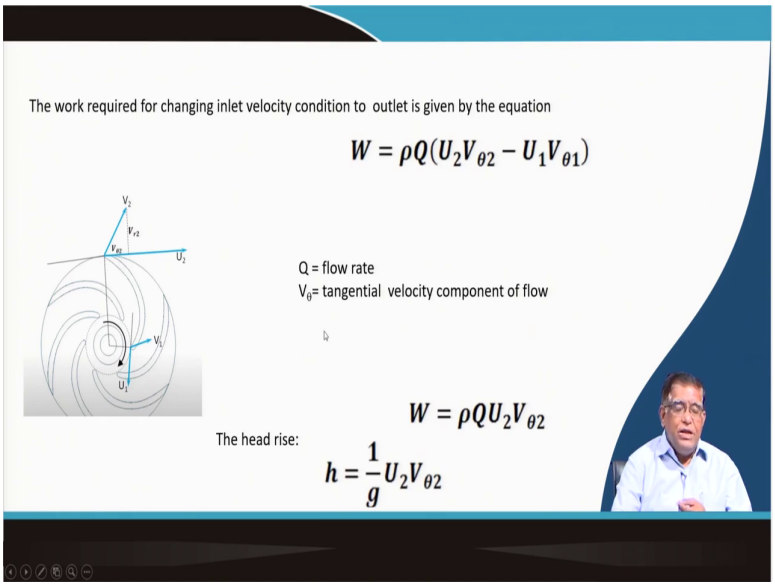

Now, that one thing is there that your this these two, they make this exactly the principle by which that our centrifugal pump will be working. Now, the two work required for changing the inlet velocity conditions to outlet, this is given by this. This is total work done. Now, for that, what we can see that the total head rise, what will be here because this V 1 will not be, it will be that entering at that time radially.

So, this angle will be 0. So, as a result, your this work will be coming equal to this much. So, therefore, the head rise can be calculated as that is your the product of the component of this which is there in this directions.

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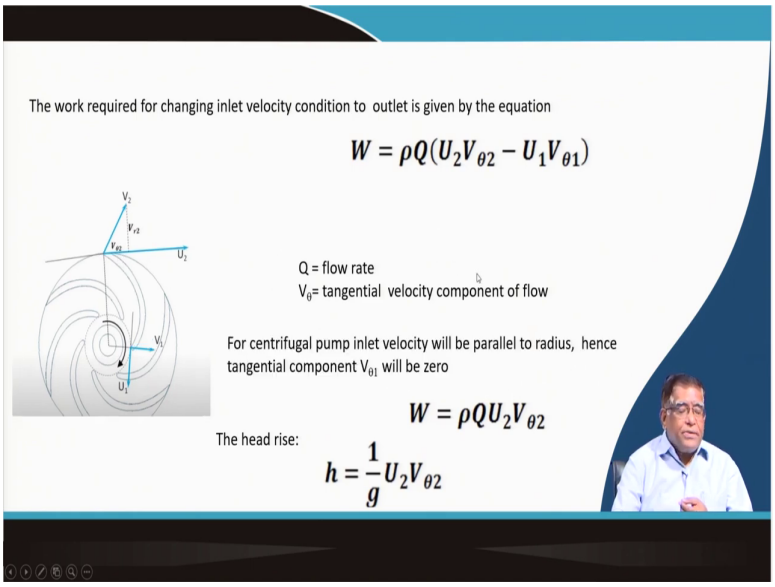

So, now, this shows here how you can exactly if your because this centrifugal pump, the inlet velocity is parallel to the radius. Hence, this tangential component V theta becomes 0.

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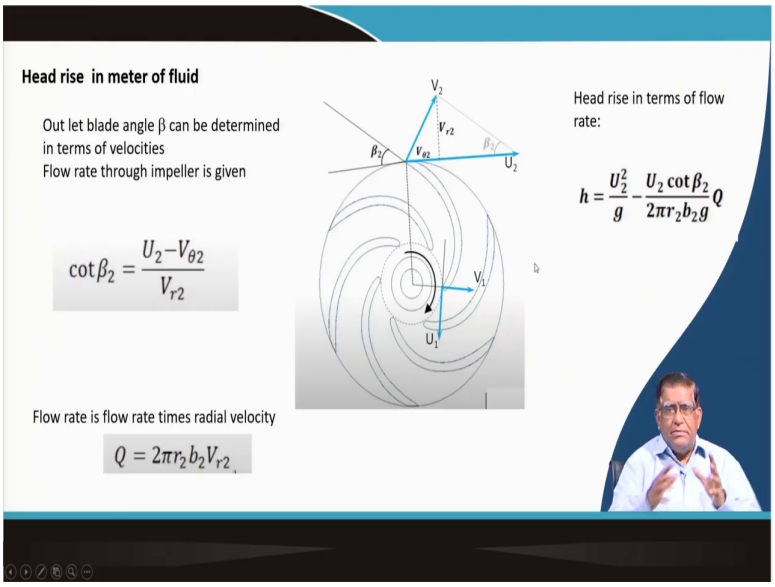

And then, you can calculate it out that in a meter of fluid, how much will be the outlet blade, if the outlet blade angle will this will determine that exactly what will be the flow rate coming. That means, a centrifugal pump depending on this blade angles and that your total work done on the fluid will be deciding, what will be the flow rate over there. So, while doing this that head rise in terms of that flow rate is calculated as given here.

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So, these theories of pump is very very essential to determine exactly how it will behave under different conditions. So, now, you have got this. The casings if it is the blades are curved that is your beta 2 is less than 90 degree and if that radial blades are set when your this beta 2 is 90 degree and then, forward curved blades that is the impeller of centrifugal pump can be of this three type; forward curve that is your radial curve and backward curve.

Now, in that that head, in case of your backward curve, it just goes down that is the quantity increases your head decreases; but in case of forward curve as the quantity increases, your head that is your head increases as the quantity increases. Now, this phenomena will be having an impact on the what will be the motor power required to drive the pump.

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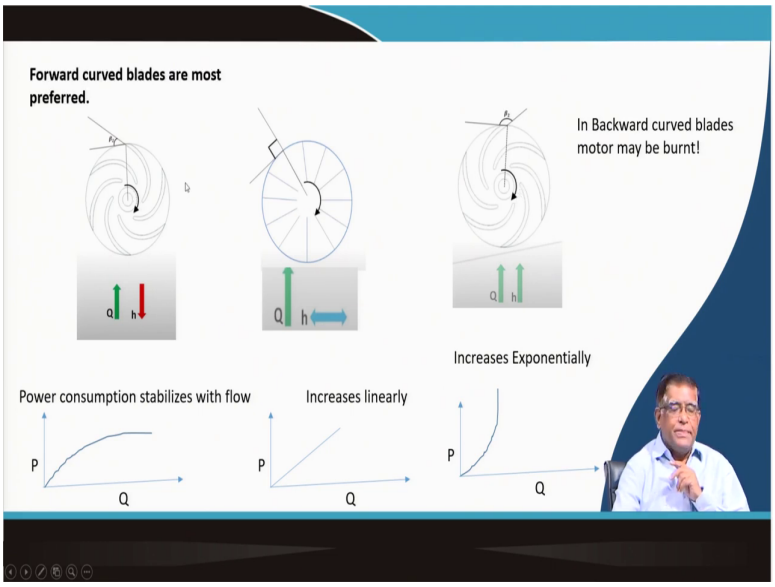

You can see here that motor power consumptions as because this in these ones as your flow is decreasing, that is why your total power consumptions it gets stabilized after some time and it reduces. But in case of your radial, there will be exactly power will be going on increasing and this case for your in this case, this will be increasing exponentially.

That is why, now, if we ask that which type of that is your, we will be selecting for a particular use. If this power increases like this with a increase of quantity, when we will be trying to get more quantity; that means, motor will get burnt. So, best way will be for the motor to give a better service for we will have to have this our backward curve.

So, this is the in backward curve blades, motor may be burnt; that is why we will not use this type of that is your blades. We will have to use this type of blades. So, this forward curved blades are the most preferred.

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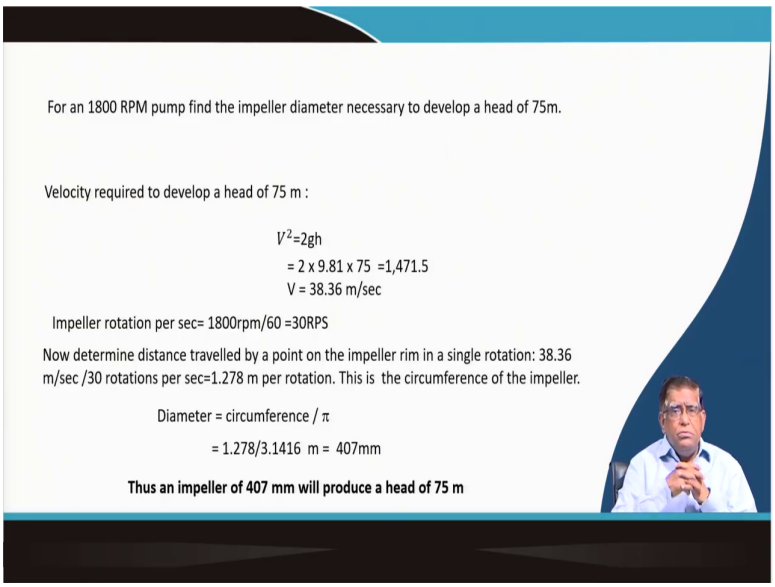

Now, if you see that exactly how you determine the heads. So, that is the velocity required for developing a head of 75 meter if we ask if that if your the what that your pump is moving at 1800 rpm, then what will be the that impeller diameter? How will you calculate it out? You know that this is velocity simple Newtonians our velocity calculation, your that initial velocity at that time 0.

So, your V square is 2gh. So, that is what is that velocity required to develop a height, you can find out; that is for height is 75 meter means velocity is this much. Now, impeller is

rotating at 1800 rpm means, 30 rotation per second. Now, if with how much distance one point that fluid will be going?

That will be the circumference of the impeller. So, from there, we can find out that is your this much meter, it is rotating; one point is rotating this much meter. If that is the circumference, then we can find out the diameter. This will be 407. So, that is why when you are selecting a pump, if you know that what type of that your motor that is your pump rpm is given.

From there, you can see if you know their diameter, you can find out how much you can lift that. Then you can find out for your required specification, that pump is giving proper or not.

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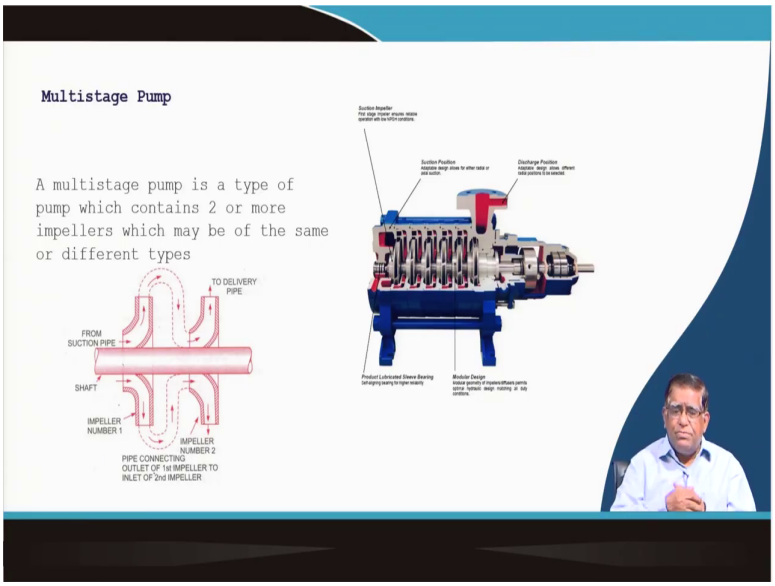

So, this is a very simple calculations by which by reading the specification of the pump designer, you can find out how to select and then, there is a different if you need now more head to be done at the high capacity to be given, one stage will not do.

There can be number of impellers and then, the first impeller giving it to the second, third and then ultimately, that head can be created and can be provided over there. This type of system is called your multi stage pump.

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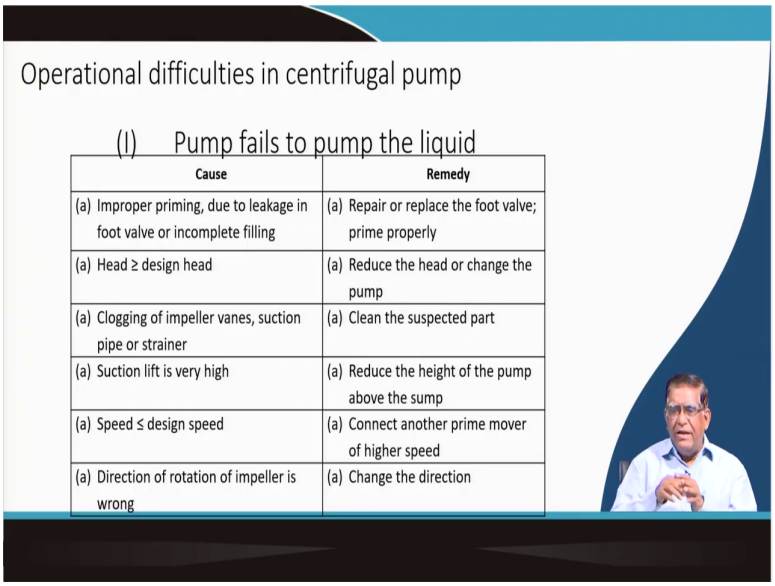

Now, this centrifugal pump, it has got a number of problems may be there that there are some causes and remedies, you need to study. Say what could be there? The pump fails to pump the liquid, no pumping is taking place that will be improper priming. Priming is that when I said at the beginning for that centrifugal pump to operate, there all that your that inside that

casings it will have to will have to keep water filled and then, only you do that is called your priming.

So, what you will have to do? That means, you cannot do the priming; that means, the valve can that it is not working. So, the foot valve that is your valve at the suction site could be a problem like that if you know the, that operational principle, you can find out the where is the fault. Now, head is more than the design head that is why you cannot get it there. So, you will have to reduce the head.

Then, clogging of the impeller vanes may be there a region, then you have to clean it. Suction lift is very high. Then, also it will not give the suctions that is you cannot suck it there. Then, if the speed is less than the design speed, then also it will not work. Direction of the rotation of the impeller if it is wrong, then it will not do.

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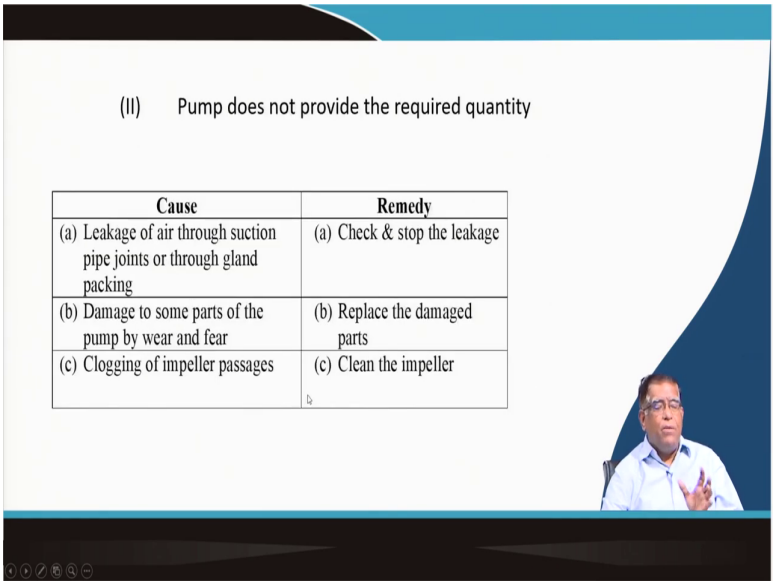

So, such type of problem will be there or that pump does not provide the required quantity. In that case, leakage may be there a case then damage to the some of the parts of the pump. So, you will have to do a investigations. The clogging of the impeller process, then also you will have to clean and do the operations.

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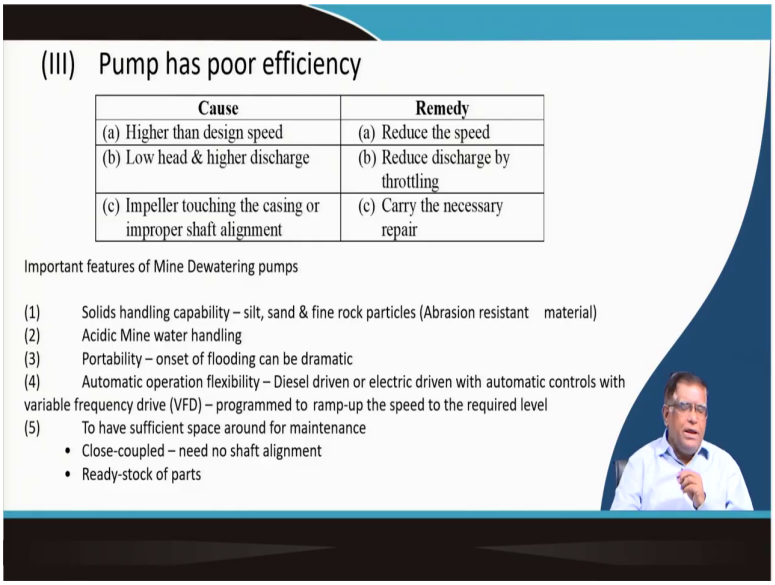

So, some problem may be of the efficiency; efficiency means, more power is getting consumed, then it is exactly whether you are running it with a proper design speed or not and then, your whether the head and things are designed accordingly or not. A detailed investigation can be carried out and you can get into that how that your pump can be running in a good thing.

So, in a nutshell, what your just this is an introduction that you will have to collect and study and see it is working and then, only you can do it over here.

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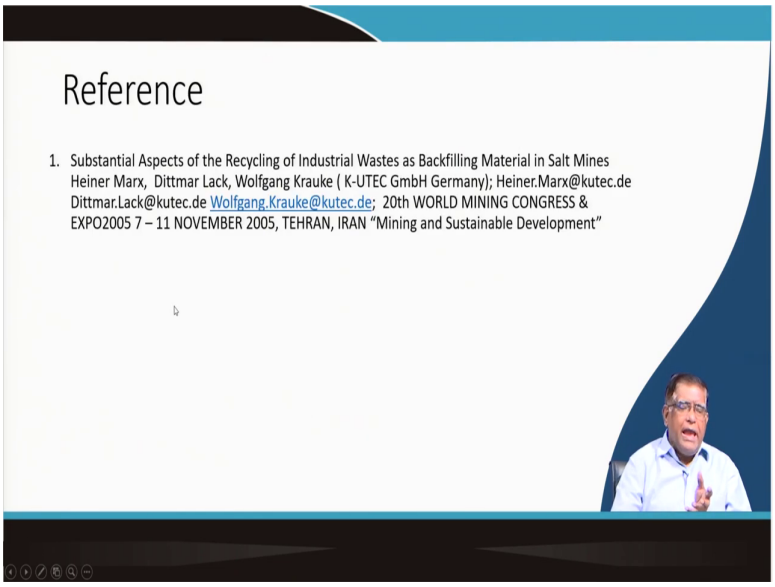

So, what I request you kindly go through the references and also, make a notes on how you will be doing an investigations of a pumping problem in different things. So, you need to study what are the various point of application of pumps in mining industry and what type of pumps are being used there and how to investigate the pumping troubles over there. So, this is an assignment, if you do, you will be able to learn on this.

Thank you very much.