Upstream LNG Technology
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Lecture - 67
Tutorial on Pumps –I

Welcome, we have learnt something about the pumps and the various ways of analyzing their performances for the skill up. So, we shall be now taking up a few problems in the setup tutorials to see how to apply our principles for the various types of effects from the pumps.

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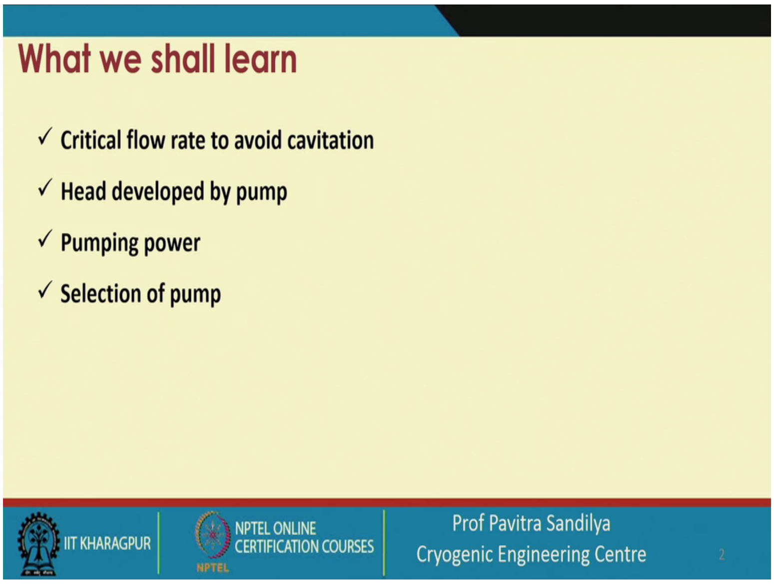

So, in this particular tutorial, in this lecture, what we shall learn about? We shall do some tutorial on the critical flow rate to avoid cavitation. Then how to estimate the head developed by a pump and how to estimate the pumping power and how to select a pump?

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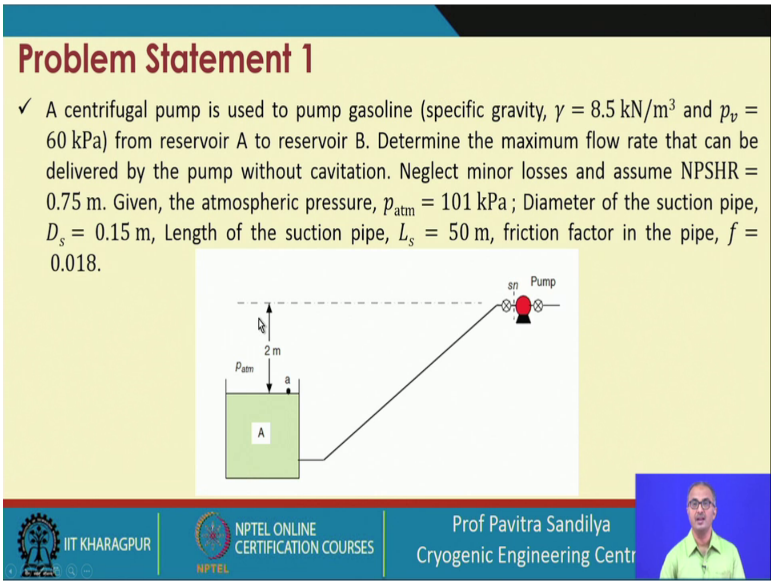

Let us come to the first problem, in this it is stated that there is a centrifugal pump which is used to pump gasoline and the specific gravity factor is given like this 8.5 kilo Newton per cubic meter. And this is the vapor pressure of the gas, this is and this is pumped from reservoir A to reservoir some reservoir B. And here is the pump with us so, the reservoir B is not shown here, we are just concerned on the suction side. So, we have to determine the maximum flow rate that can be delivered by the pump without cavitation because we know that cavitation occurs only in a suction side and not in delivery side generally.

So, we are looking only in the suction side and we have to determine the maximum flow rate which can be used without cavitation. And we can neglect the minor losses and it is given that the available NPS required NPSH is 0.75 meter and we have to figure out. Then what is the available NPSH, ok? So, the required NPSH and this is given by the manufacturer of the pump.

And this is the atmospheric pressure and diameter of the pump. May this pipeline is given as 0.5 meter, this s stand for suction side and the length of the pipe line is given as the 50 meter.

So, this particular pipeline can be assumed to be 50 meter and with a 0.15 meter that is 15 centimeter diameter and the friction factor may be taken as these particular this value. So, with these information, we have to find out the maximum flow rate which can be used without cavitation.

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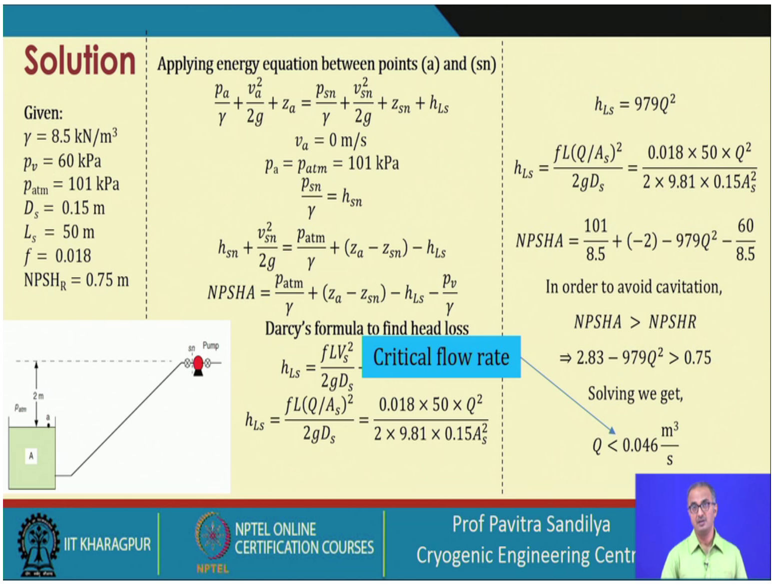

So, firstly, what we do we put all the data, the information given to us and here be the particular thing. And here we see this particular liquid level about 2 meter below the pump level.

Now, in this any of this pump problems what we have to do? We have to apply the energy balance or the first law of thermodynamics. So, in this energy what we take? We take pressure, energy, the kinetic energy, potential energy and some losses in the pipeline. So, these losses may be minor losses or maybe major losses. So, here we take the v a to be 0 because this cross section is quite big. So, the rate of fall of the liquid level maybe neglected and then this p a, this is whatever pressure is on this is the atmospheric pressure which is given. And here, we put the p sn by gamma as the h sn that is the pressure head at the suction side this s n is the suction of this pump.

And now, we with these we put modify this equation, this particular equation. And we finally, get the NPSHA as this. So, this is available NPSHA, which we have to find out and we know that if available NPSHA is more than the required NPSHA then there will not be any cavitation.

So, to find this NPSHA we have to find out the value because we know all the values we need to know of this h L S and this h L S depends on the flow rate. So, whatever the flow rate that will decide the values of NPSHA and that is how we can decide that what is the maximum flow rate that can be allowed.

So, we write these thing as this is the major friction loss and this is the minor friction loss. So, this as per the problem, this will be neglected. And in this, we have the friction factor the velocity through the pipeline D s and L s. And what we generally do that we plug in all the values here in terms of the A s, ok.

And we find because this is and this Q is not known to us, this we have to find out and A s can be found out from the D s value. Now, after plugging in the value of the this A s is nothing, but the pi by 4 D a square, ok. Plugging the value we get this relationship between the head loss and the flow rate this Q is the volumetric flow rate. So, here we put all these things and find that NPSHA, if you put this value here we find NPSHA coming in terms of the volumetric flow rate.

Now, in order to avoid cavitation this available NPSH should be more than the required NPSH. And if you put this particular expressions here, we find that Q should be less than this; that means, the maximum permissible flow rate of the gas will be liquid will be 0.046 cubic meter per second. We should not cross this if we cross this then we will be landing up with the problem of cavitation. So, this is the critical flow rate for the system.

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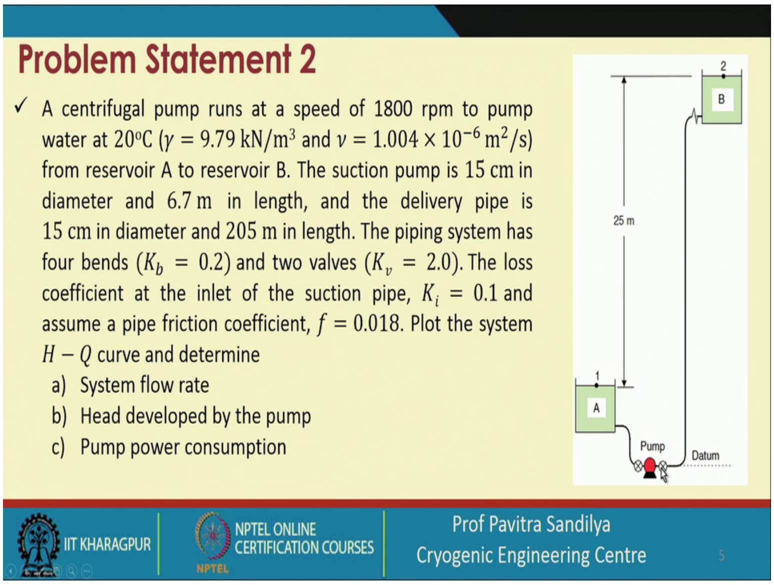

Next, we come to the centrifugal pump, another problem in which a centrifugal pump is running at a speed of 1800 rpm and it is pumping water at 20 degree centigrade, the gamma is given here, gamma is what the product of the density. And the gravitational acceleration and this is the velocity and here you can see that it is pumped from reservoir

A to reservoir B. And the difference in elevation is about 25 meter and here the datum is given for the horizontal pump, ok. And the suction pump is about 15 centimeter in diameter and 6.7 centimeter in length and delivery pipe is 15 centimeter diameter. These are length and the piping system has 4 bends, 2 valves. So, all these bends and valves asset of this fittings will be causing some kind of pressure drop to the system.

And when the pressure drop is there the suction head will also change, ok. And; that means, the NPSH will change and the loss coefficient in the suction pipe is given to be this 0.1. And the pipe friction coefficient can be assumed to be this value and we have to plot the H q curve for this particular system and we also to determine the system flow rate the head developed by the pump and the pumping power.

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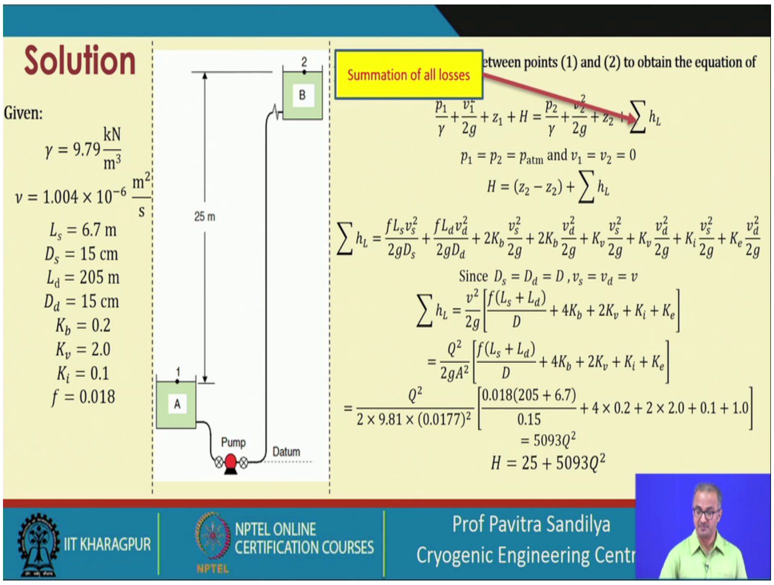

Now, let us put all the data which have been given to us. First here and we again consider this particular figure and as I said earlier that let us apply the energy balance equation to generate the H verses Q. So, we write this in a Bernoulli equation, here as I described earlier. And here again we find that because both these two points, this point 1 and point 2 which are the surface of the liquids in the two tanks and both these are exposed to the atmosphere. So, both of them are experiencing atmospheric pressure. So, that is the P 1 equal to P 2 equal to P atmospheric where we are also assuming the rate of change of this fall of the liquid level; in these two tanks to be very very small. So, that is why we are taking the velocity of fall to be 0 and with this what we find that this is the expression for the head developed.

Now, for this loss of the head in the pipelines and fittings, we find that for all the bends and valves and whatever we have given in the problem we write these expressions. And these K these, these expressions, you can see these expressions are written for the suction side and delivery side for the various types of fittings and these are for the pipelines. And in this case, we have been given that the delivery side and the suction side diameters are the same. And we take it to be and the delivery side and the suction side diameters are same and the flow rate also same.

So, we the velocities will also be the same. So, we take them to be V the V s equal to V d equal to V the way sequel to be due to and then when you plug in these things, we simplify this expression for the head loss like this.

And when we put this V in terms of the Q by a volumetric flow rate divided by the cross sectional area. So, we get this expression and then we plug in all the values which are given in this particular problem. And we finds, we can easily find out the relationship between the head loss. And this thing and we then we put this value over to this expression and what we get we get this value of the head related by the thing and this H q when we plot this has this gives us the system plot and we will enter that this is the system curve.

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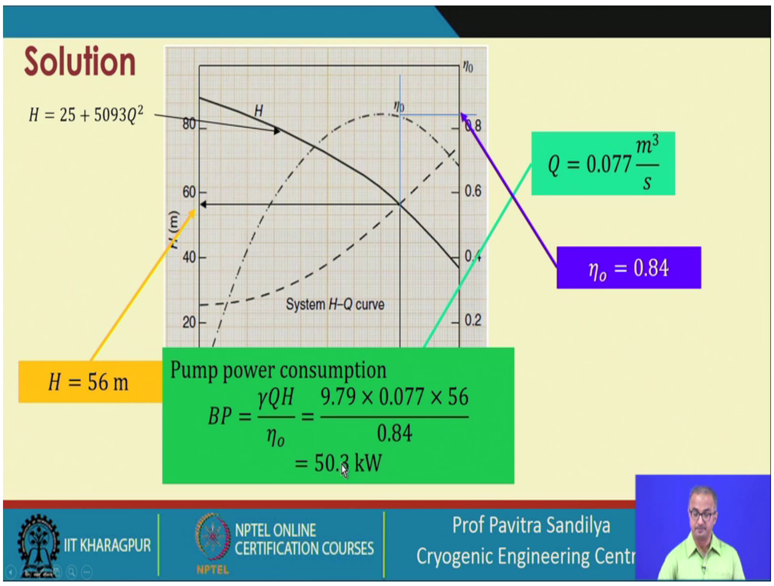

Now, what we do? We this H, this is we writing H by Q and this two dashed curves are supply this curve is efficiency curve this is the H verses Q given by the manufacturer and this is the one we have generated this particular big, big dash lines is the we have generated.

As we learnt earlier that wherever our system curve is intersects the H Q curve given by the manufacturer, this intersection point is defined this is taken to the operating point. So, what we do that here this is the; this head H verses Q, which we are there and here we are fine this is the particular value of the cube we read at the intersection. So, the dash lines are given by the manufacturer and the solid line is generated by us. So, this is how we are able to find out the operating point of the particular this particular pump. And here, we find at the operating point the head developed will be 56 meter and; that means, the, the pump can raise the liquid up to 56 meter.

And if I want to find out the efficiency of the pump, then we can just simply extend this vertical line up to the overall efficiency curve this is given by the manufacturer and read out from this particular axis the value of the efficiency. And we find that it is slightly more than 80 percent that is it is about 84 percent; that means, we can say this pump will be working at 84 percent efficiency with this flow rate and producing this particular head and the power consumption can be found from this particular formula which I showed you in the theory. And this is we plug in the values and we get this is the power requirement by the pump.

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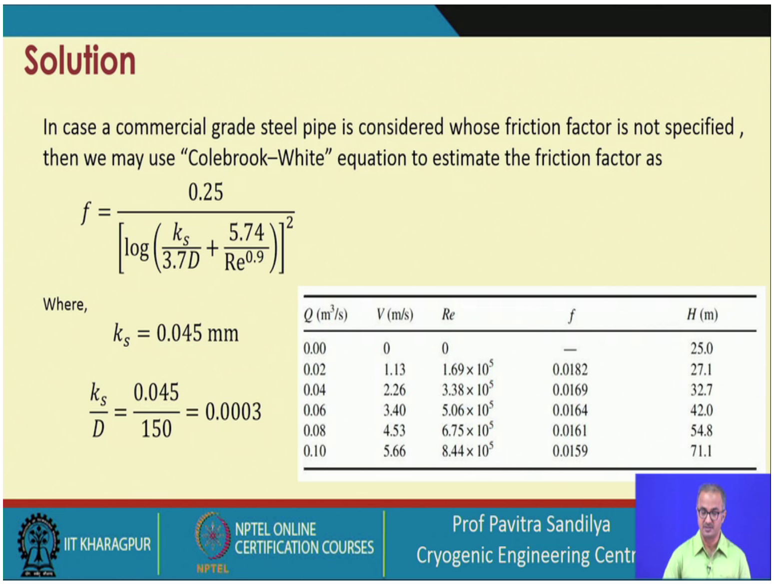

Well now, what we do that when we talk of some commercial pipe then friction factor is not generally specified in that case, what do we do? Then we have to choose some appropriate correlation to estimate the friction factor and one of these correlations is the Colebrook white equation. This is the equation expression here and in this case this case is the roughness factor which will also specified in the literature for a given pipeline.

So, this is taken to be point 045 millimeter and we plug in the value over here and we get the Reynold's number, we can find out that we can find out that for different values of Q that we determine the Reynold's number. We get different values of the velocities and we can find with the all the; this corresponding to any Q, we can find the value of friction factor. And similarly, we can from our system curve, we can find out the various values of the heads.

So, what we essentially find in this table is this, as we change the flow rate and we find the head generated changes. And seconds thing what we find that in this case as the as the flow rate is increasing what we find the head generated is also increasing. So, this is the, but the significance of this particular table and this particular set of calculations.

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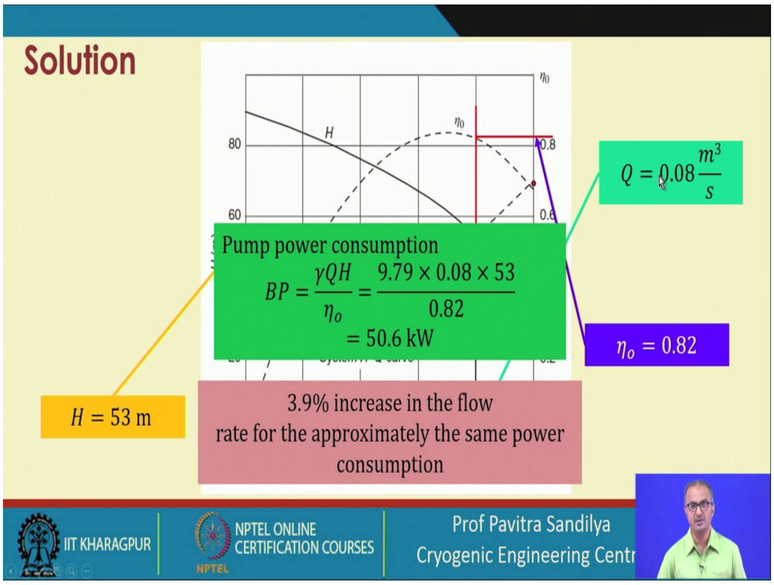

Now, we want to know that under this new condition, if we are not given the friction factor how the pump will behave? Now, we have generated the H Q curve from this thing and these are the supplied by the manufacturer. Again you look at the point of intersection and what we find in this case, it is coming to 0.08; that means, there is a slight increase in the flow rate in the pump. And correspondingly, we find that the, but the this head has decreased from 56 meter to 53 meter.

And it has increased from, from 077 cubic meter per second to 0.08 cubic meter per second. And what we also find that there is some loss of efficiency, it was earlier 84 percent. Now it has come down to slightly by 82 percent. And the pumping power is also come down it was earlier 53 kilowatt. Now, it has come to about 51 kilowatt. So, there what we find there is a 3.9 percent increase in the flow rate for approximately the same power consumption. So, the power consumption does not change much, but the flow rate has shown a slight increase.

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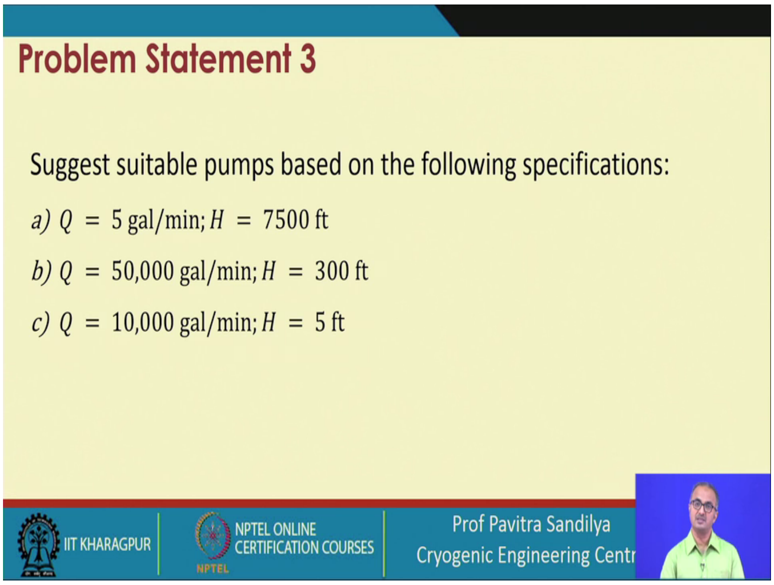

Now, we come to another problem in this problem it is quite straight forward application of the data supplied by the manufacturer it is related to the selection of the pumps.

So, here we are given in this particular problem various combinations of the flow rate. And the head produced by the pump and we have to suggest which pump we should use under this given conditions.

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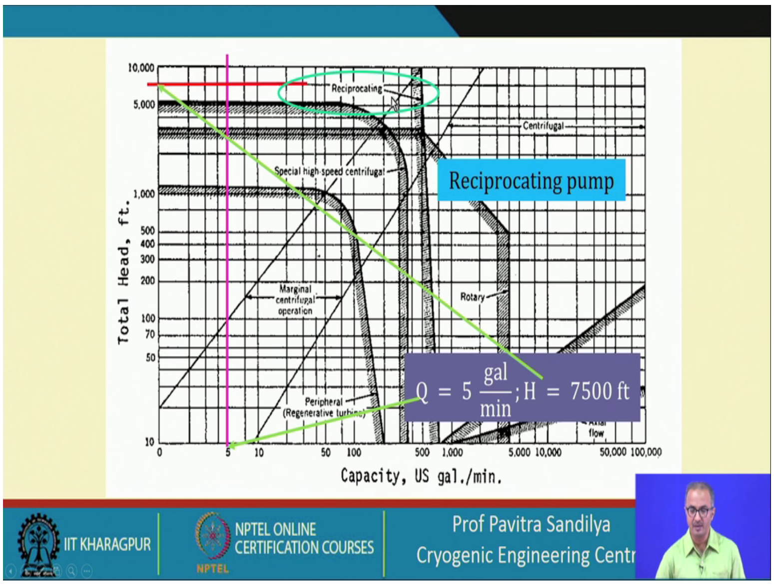

So, here what we shall do that we shall basically considering this particular chart which gives us the selection of criteria for the various pumps. And it is plotted with respect to the total head and the capacity and we shall we what we shall do? We will take one by one all these things. So, first we shall talk about the 5 gal per minute and the head is 7500 feet.

So, on this X axis, we shall be locating the flow rate as 5 and on the Y axis, we shall be locating the head and wherever these two lines intersect this one this line. And this line intersect, we shall see that which that we will see that this intersection point falls in this in this zone. So, in this zone, what we say that we are going to use a reciprocating pump. So, next we shall go to second part.

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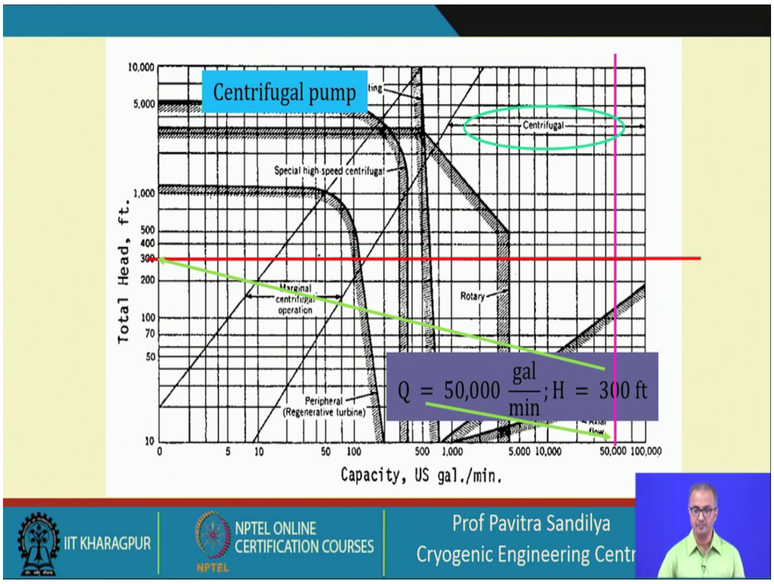

In this case, the flow rate is given 50000 gallon per meter and H is 300. Now, first we will look at 50000 that is here and 300 feet on the Y axis it is here and wherever this tool lies intersect this is the point this is the centrifugal pump. So, in for this particular combination, we shall be recommending centrifugal pump.

And what we clearly see is there that a reciprocating pump the head is quite high the flow rate is low, but for centrifugal pump the head has come down, but the flow rate has increased. And that is what we also learnt in our theory; that means, we are whenever we want high head at low flow rate we can go for reciprocating. When we want high flow rate high capacity, but low head we go for centrifugal.

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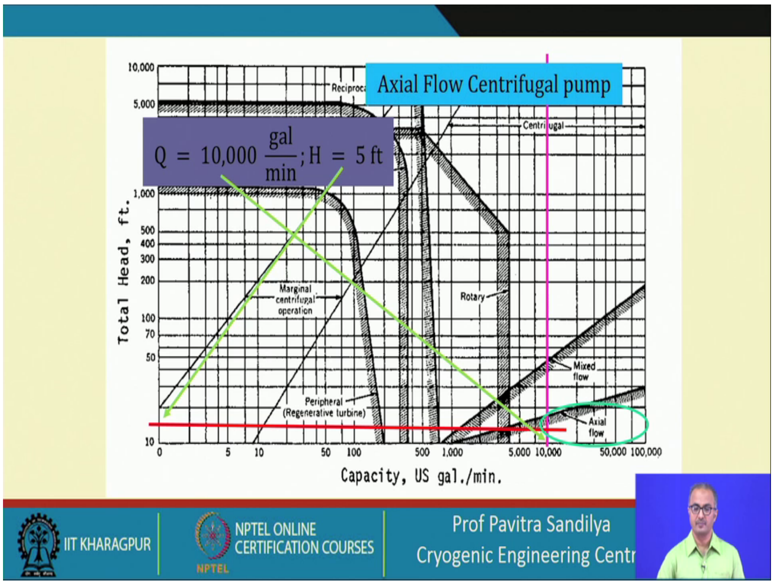

Then next we come to the third one in this case Q is given as 10000 and H is given as 5 feet. So, again this locates this 10000 on this axis. And this thing and we find that wherever they are intersecting this is the axial flow. So, in this particular case we shall be recommending axial flow. So, we find that the head is very low, but the capacity is quite high. So, in this case the axial flow pump is recommended.

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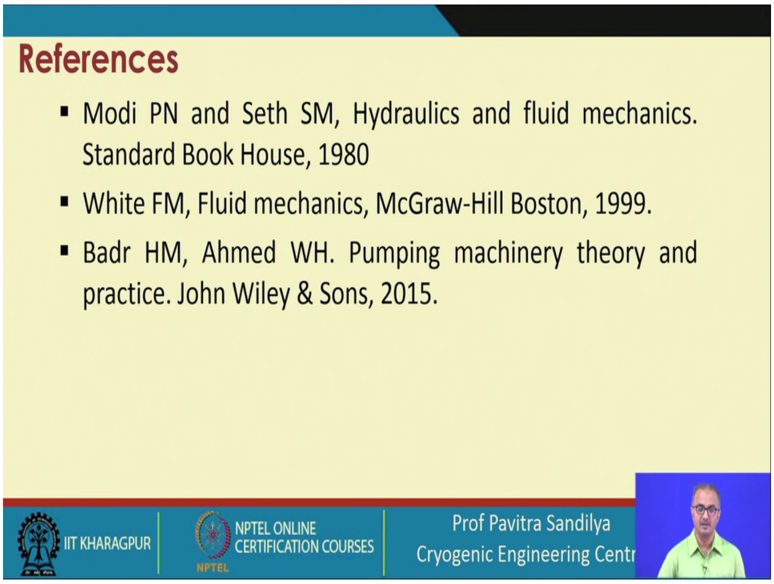

Now, these are the few of the books from which you can know detail about these particular theories.

Thank you.