Irrigation and Drainage
Prof. Damodhara Rao Mailapalli
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur

Lecture – 33
Centrifugal Puwer: Power Requiement

So, this is the lecture number 33 on centrifugal pumps again. So, mostly as I just said in the previous lectures, we will be focusing more on Pump Power Requirement estimation.

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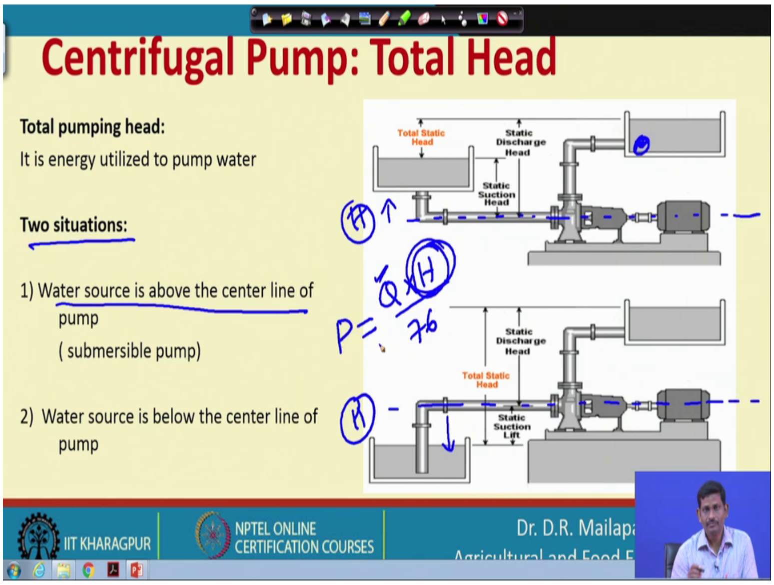

So, here there are the total pumping head is the total energy utilized by pump; in order to pump from I mean low head to high head ok. So, here there are two situations you can see, based on the location of the I mean water source. So, the if the water source is above the center line of the pump right and the water source is below the center line of the pump.

So, water source is above the central line of the pump for example, here if you see, so this is the center line of the pump ok; so the water source is above and in this case this is center line of the pump, the water source is below. In both cases we are going to see it what is the total head. So, our idea is if you remember the equation, the power which is equal to Q into H divided by 76. So, this will H is the head. So, here in both cases we are going to see what is the head. In this case what is the head and what is in this case what is the head ok. So, and the discharge anyway will be knowing, so knowing the discharge right.

And the problem is the head. So, head involves the real pipelines and then efficient head losses then other head losses. So, we are going to I mean the main task is to find out, what is the total head here in both cases.

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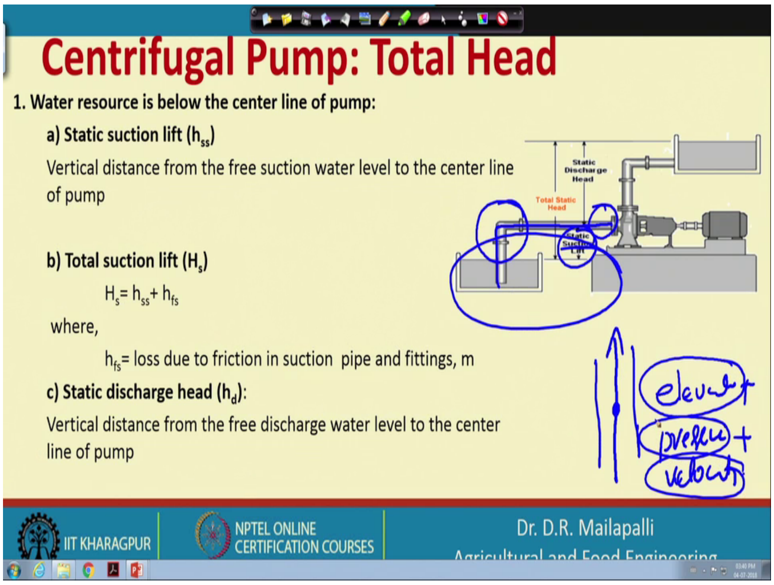

So, let us see the case number 1. So, that is the water source is below the center line of the pump here if you see center line of the pump below, then it has a static suction lift. So, since this is the pump center line it is below, so we use the term lift ok; if it is above we use the term head ok.

So, in this case, the static suction lift ok; so the vertical this is the vertical distance between from the free surface of water level to the center line of the pump. This we already in the previous lectures, we have defined this. So, this is if you see the static suction lift, so, this is from center line to the water surface. So, that is static suction lift and then total suction lift; so that will be suction static suction lift and then the friction head losses in that pipe ok. So, this is a total suction lift and static discharge head, so this is suction is done. So, we have the two pots here, one is the suction pot and then discharge pot.

So, in both cases, we going to estimate the head losses individually. So, as I said so here, so this is the suction case we have two parts; one is the suction lift and the friction head losses which are present in the the suction pipe. So, and also in addition to that, we have we have to consider the bends ok; which are present in that and also the velocity head ok. So, and then the so, here I mean if you see theoretically, so from moving one place to another place water in a pipe. So, there is a elevation head right plus pressure head, plus velocity head ok, from velocity head.

So, the elevation head of course, that is due to you know you know the pipes I mean the height and everything, the pressure heads that is due to the frictions and other things in the velocity heads. So, these three heads we need to consider here. So, total suction lift will be, suction lift plus and total static suction lift plus friction head. And then static discharge head, similarly, the static discharge head will be your the discharge head I mean static discharge head, plus the static discharge head. This is the vertical distance, so static discharge head is this is the pipe center line to the top surface of the delivery. So, this is the static discharge head ok.

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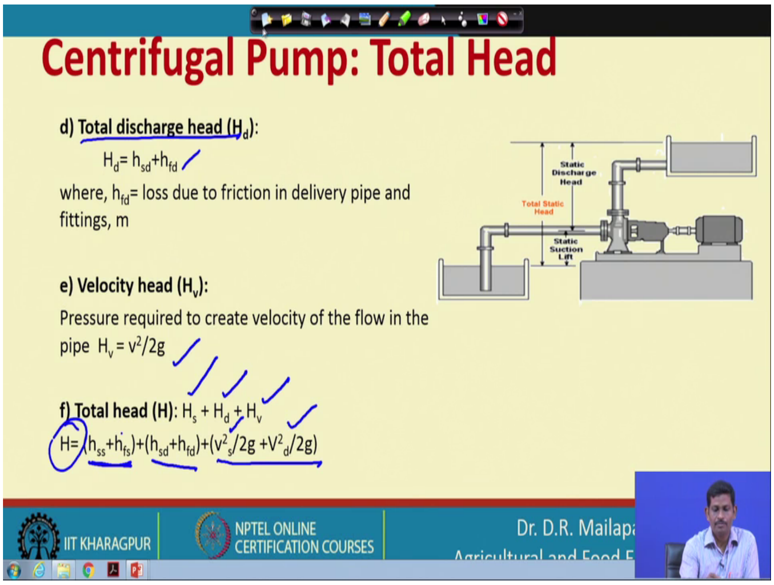

And then we are going to have the friction head loss in that and that will give the total discharge head. So, that is h sd and h fd. So, velocity head that is v square by 2 g you need to consider and the total head will be the suction right, discharge and velocity. So, this is a total suction head; total suction lift, total discharge head and the velocity head in both the suction, as well as discharge case v square by 2 g; so this is the total head, in case of water source which is below the center line of the pump. Now, similarly the water source which is above the center line of the pump if you see, so, in this case also, we consider the suction case and the discharge case both cases ok.

So, this in this case the static suction head because, this is above central line; so static suction head. So, that is the vertical distance between, the top of the surface and center line of the pump and then total suction head so that will be hs minus h fs. So, hs minus h fs this is friction head loss, but the negative because, this is we are not going to use any energy to pump because this is a due to gravity any way so gravity is helping us. So, it is a negative basically the head is negative here right. So, that is why, it is a negative head, but the difference of suction head minus friction head.

So, then static discharge head; so that is same as before because we are not changing anything here, so this will be same. So, one is the difference between static discharge, is the difference between these two. This is a discharge head and then adding the friction head loss here.

So then, the total discharge is the discharge head; static discharge head and the friction head loss and you have to use the velocity head. So, the total head in case of these this the so, water source above the center line of the pump is equal to, this is the static you know suction head, static discharge head I mean sorry total discharge head, total suction head and then suction. This is minus V square by 2 g and V square this is for discharge velocity head for discharge V square d by the 2 g because here the velocity if you see again this is coming down this is really helping, so, that gravity really helping us in pumping.

So, now the pump does not required to you know, use extra energy to pull this water because, it is anyway head ok. So, that is the reason velocity is negative here.

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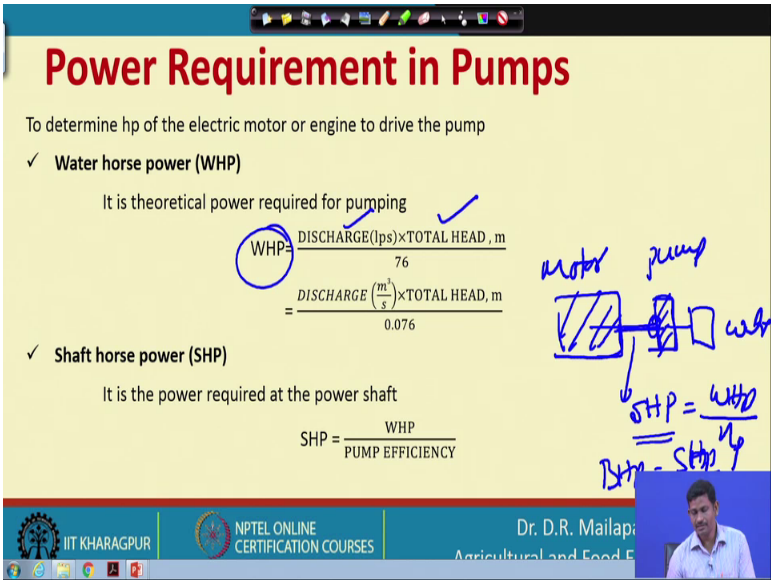

And with this, in both cases we found the total head. So, once we know the total head, sorry, so once we know the total head and discharge divided by 76 you get, this is a water horsepower. So, water horse power that means, in order to pump water from one place to another place, this much HP is required. And then, so that is a water then, after that in all this pump level right in the pump level; so this is the pump support this is the water right and here there is a motor, which really operates this pump right.

So, this is shaft right. So, if shaft is connected between the pump and motor. So, here this has, so because this is in a moving pots those are moving pots. So, here point this is called shaft horsepower which is equal to, water horsepower divided by pump efficiency; so how efficient is the pump. So, that will be shaft horsepower and then the next is the brake horsepower which is equal to shaft horse power divided by efficiency of the drive ok. So, that let us see that next if you see.

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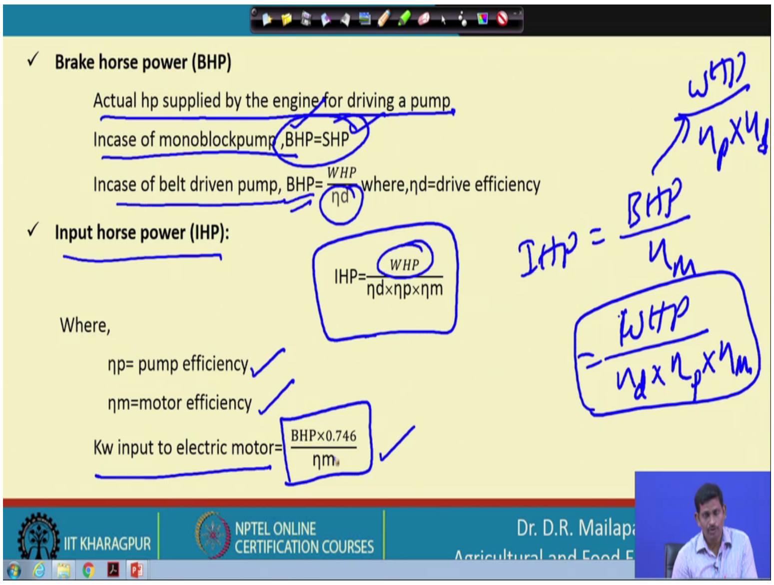

So, in case of monoblockpump; so BHP is equal to SHP. So, brake horsepower is actual hp supplied by engine for driving to a pump ok.

So, in case of BHP monoblock brake horsepower is equal to shaft horsepower. In case of belt drive, so we have to put the drive efficiency here WHP by you know drive efficiency you get BHP here ok. Then input horsepower, so this where the electric electrical energy I mean, there the motor really works. Water horse water horse power divided by I. So, generally IHP which is equal to BHP divided by efficiency of the motor ok. Since BHP is water horsepower divided by drive efficiency and then pump efficiency and then motor efficiency. So, that is, that is, what you get this equation from this equation.

So, BHP here is equal to WHP divided by pump efficiency and drive efficiency ok. So, np pump efficiency, motor efficiency and the kilowatt electrical motor that is BHP into 0.746 into motor efficiency. So, this equation will be used to find out the electrical motor I mean, power required to run the motor ok.

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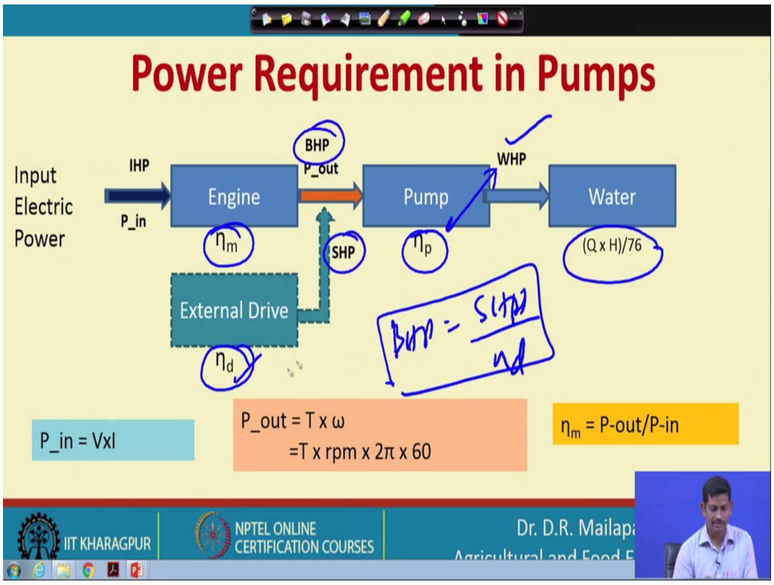

So this overall you this will give so, here we have water. So, water Q into H is 76 will give the water horse power. So, as since pump has an efficiency here, engine has an efficiency here, drive has an efficiency here, so, at this point shaft horsepower, so that will be equal to WHP divided by NP, so divided by NP; so shaft horsepower.

And then the BHP, so that will be is equal to SHP, in case of monoblock; otherwise BHP is equal to water horsepower divided by nd right, nd into np ok. Or BHP is equal to SHP divided by nd ok, in case of this.

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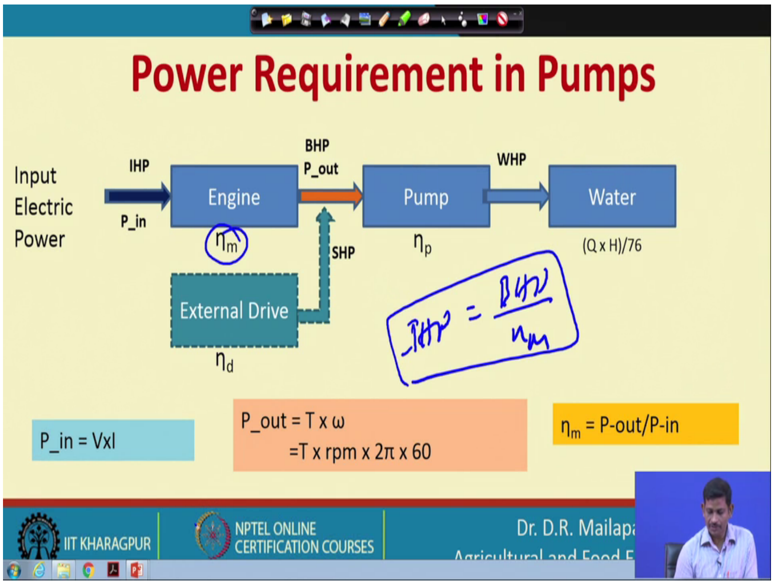

So, then putting engine efficiency, also motor efficiency, you get I mean IHP is equal to BHP divided by nm, so, that will give the engine efficiency. So, everything is here, so how to find out the motor efficiency?

So, here from if, you see the pump testing rig, basically the electrical energy which is supplied as voltage into current a that is P in and power out will be estimated using the a torque and angular velocity. So, that is T into rpm into 2 pi into 60. See there is which is a tau torque, torque meter is there and rpm is estimated I mean measured. So, knowing this T into wP out will be known; P out by p in is equal to motor efficiency. So, this way you can see how efficient is that.

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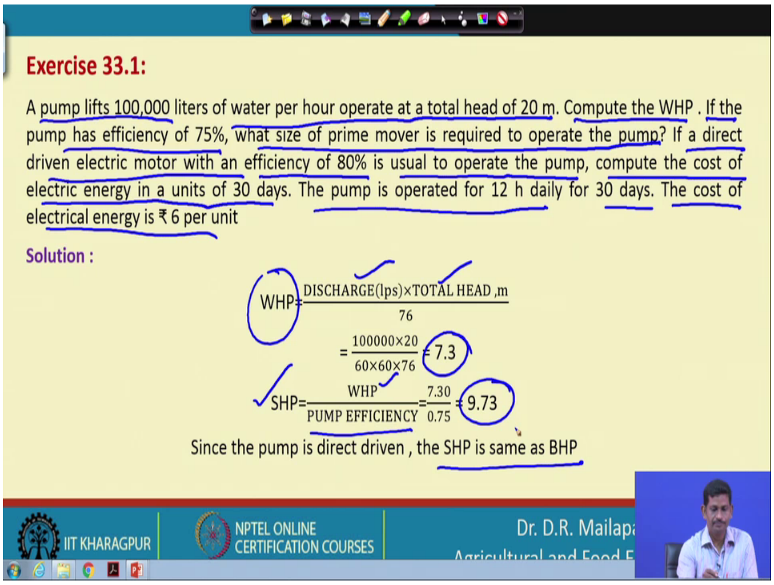

So, exercise here in this problem, in this problem, a pump lifts 1,00,000 liters of water per hour operate at a total head of 20 meter and compute the WHP water horsepower. So, if the pump has efficiency 75 percent what is the size of prime mover required to operate the pump? So, if a direct driven electrical motor with an efficiency 80 percent is usual to operate the pump, compute the cost of electrical energy a unit of 30 days, the pump is operated for 12 hours daily 30 days. So, the cost of electrical energy 6 rupees per unit.

So, we know w horsepower water horsepower, which is equal to discharge into head by 76 you get 7.3 and shaft horsepower W horsepower by pump efficiency you get SHP, that since the pump is direct driven monoblock, so this will be BHP.

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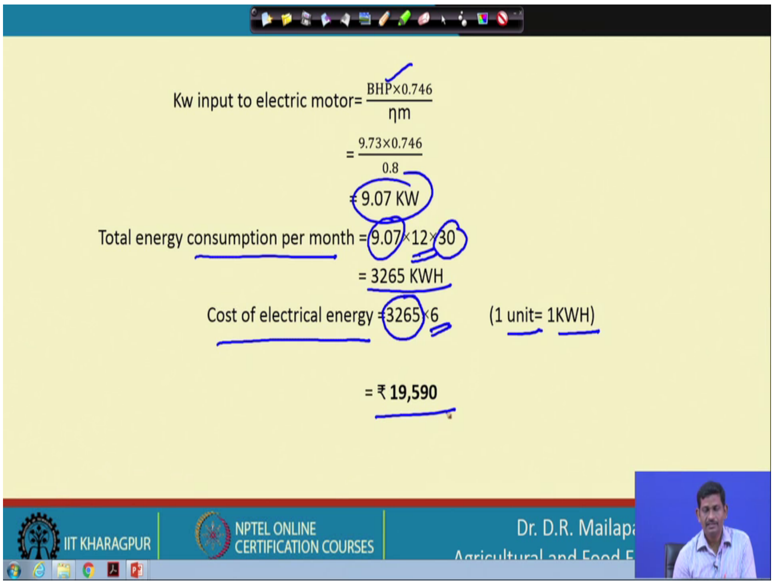

So, knowing the BHP, we can find out IHP right; so here if you see so this is BHP multiplied by 0.746 into motor efficiency. So, you get the kilowatts right. So, total energy consumption is the kilowatts into 12 hours a day and 30 days; the total these many kilowatt units and cost of electrical energy is kilowatt watt hours and 1 unit cost. So, 1 unit is equal to 1 kilowatt hour. So, total 19590 rupees is the electrical energy cost in rupees.

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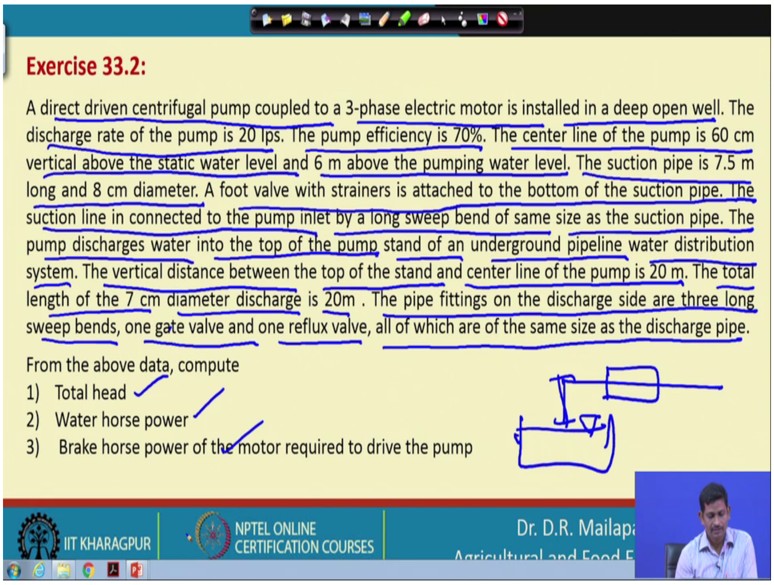

And this is a big example of course, it has a direct driven centrifugal pump coupled to a 3 phase electrical motor is installed in a deep well. The discharge rate of pump is 20 lps. The pump efficiency is 70 percent. The center line of the pump is 60 centimeter vertically above the static water level and 6 meter above the pumping water level ok. So, that means, this is the first case of this is the pump and you have the water source just below the pump center line.

Then the suction pipe is 7.5 meter; so this is suction pipe 7.5 meter long and 8 centimeter diameter. A foot valve is with strainer is attached in the bottom of the suction pipe. The suction line is connected to the pump inlet by long sweep bend same size of suction pipe. The pump discharges water into the top of the pump stand underground pipeline water distribution system.

The vertical distance between the top of the stand and the center line of the pump 20 meter. The total length of the 7 centimeter diameter discharge is 20 meter. The pipe fittings on the discharge side are 3 long sweep bends and 1 gate valve and 1 reflux valve all, of them are the same size at the discharge pipe ok. So, find out the total head Water Horsepower, WHP and Brake Horsepower right the BHP. So, these things needs to be worked out.

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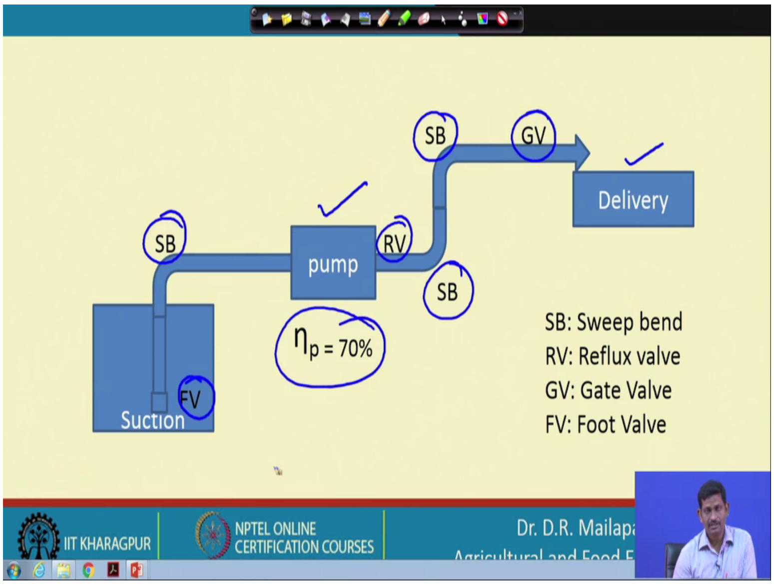

So, let us see here. So, the whole thing can be put in this manner; so this is the pump, so this is the suction line and at the end there is a foot valve ok.

So, here this is sweep bend, there is a sweep bend this is a gate valve reflex valve, there is another sweep bend here and this is the delivery and the pump has a 70 efficiency ok.

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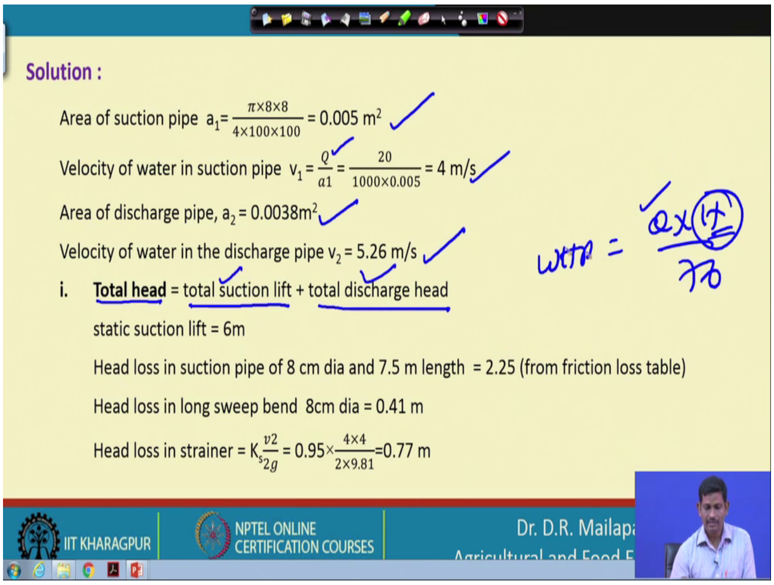

So, this way if you can schematic the whole thing then the calculations are like this. So, first area of suction pipe, since, diameter is given. So, you can find out area of suction pipe and velocity of suction pipe. So, knowing the discharge and velocity discharge and area you can find out the velocity. Similarly, for discharge pipe area and velocity. So, and first thing is the total head, the total head is equal to total suction lift and total discharge head ok. This is the total head. So, we find out total suction lift and find out total discharge head. So, once you know the total head and you will be able to find out the water horsepower which is equal to Q into H by 76. So, our interest, so q is known our interest is to find out h so, total head.

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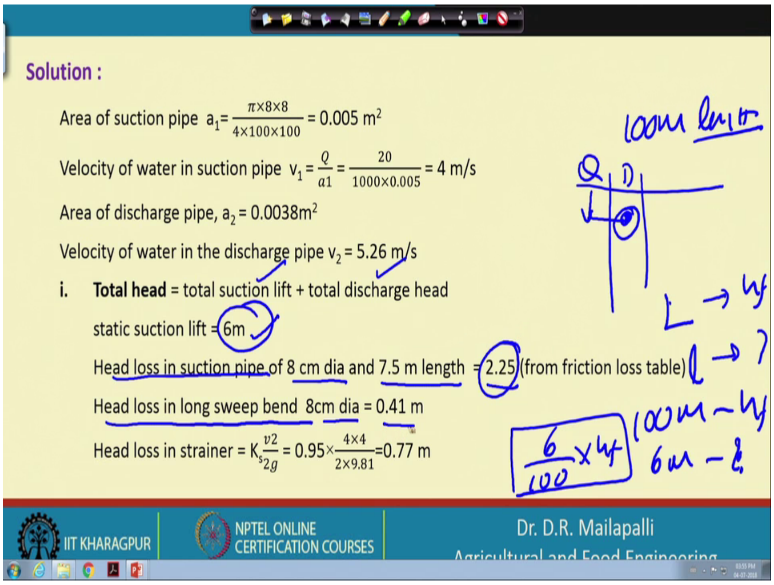

So, the total head as I said the 2 parts suction lift and discharge. Let us find out what is suction lift. So, it has again a static suction lift and friction heads, velocity heads ok. So, static suction lift 6 meter suction pipe line is given, so 6 meter. Head loss in the suction pipe 8 centimeter dia 7.5 meter length is 2.25. So, from friction loss table so, there is a table I said right. So, this is a Q for a particular Q and these are the diameter for a particular diameter you get the friction head loss for 100 meter length of the pipe ok.

So, for 100 meter length you got hf and for this length 6 meter length right; so what would be your hf? So, suppose this is 100 meter you get hf and for 6 meter what is this? Ok. So, that is 6 by 100 into hf. So, that will be 2.25 if, you look at that. And head loss in the long sweep bend 8 centimeter diameter that is 0.41.

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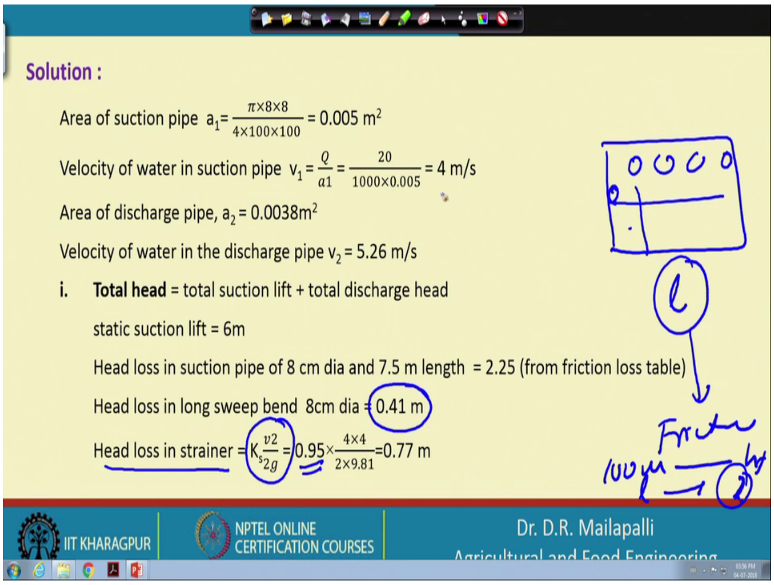

So, this is also similar to so, you have seen the you know the for different, for different bends you have seen for a particular discharge right; you get an equivalent length of the pipe and you go back to your fiction table. For 100 meter find out hf and for l find out the hf ok.

So, that is 0.41. Similarly, for head loss in this strainer, so there is an equation Ks into v square by 2 g. So, velocity is given I mean estimate we have estimated a velocity and then you get 0.77 meters for the strainer. So, strainer why for the suction we have strainer and the foot valve. So, similarly ok.

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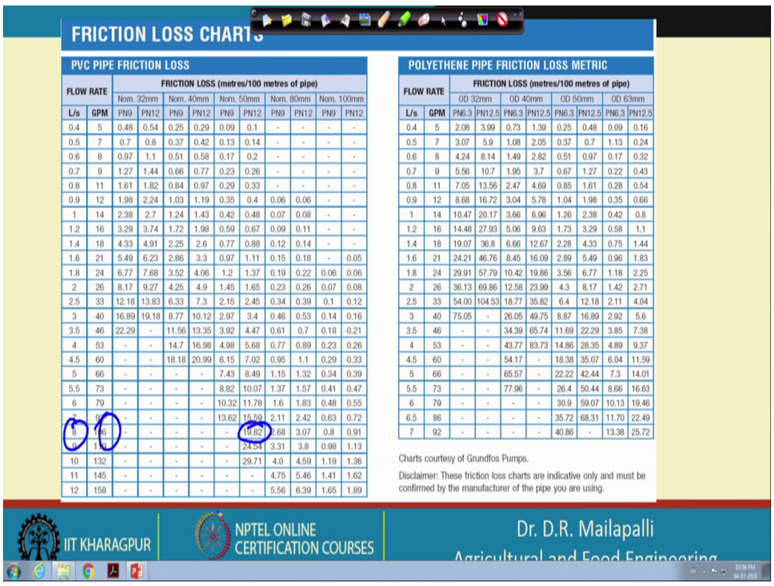

So, here there is a friction head loss table. So, knowing the you know, discharge here and the corresponding diameter, you can find out the friction head loss for you know 100 meter length and then you can reduce it to your length.

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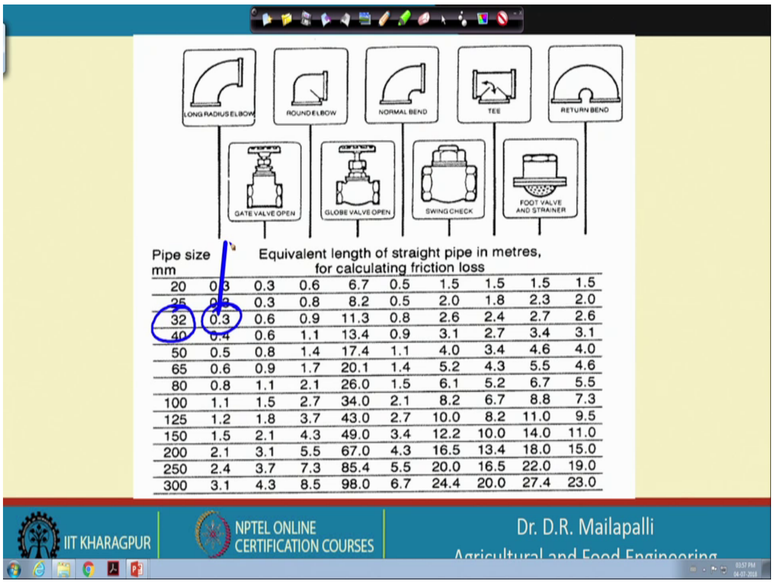

Similarly, for walls for long sweep bend for example; so, for a pipe size find out the this is equivalent pipe length and then go back to the friction table and find out the corresponding hf for this particular length.

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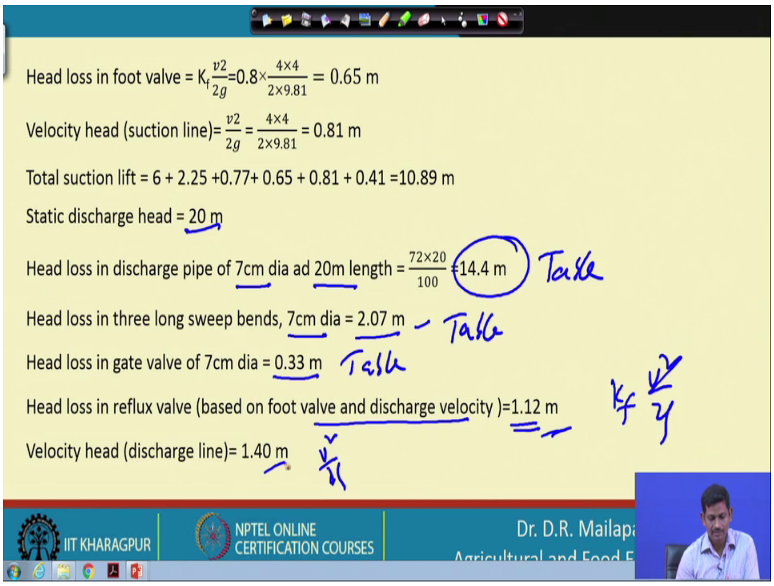

Ok. So, now, head loss head loss in the foot valve this is this much is the equation. Velocity head v square 2 g you get this. And total suction lift is static suction lift and then you get the friction head loss in the pipe and this is a bend. Sorry, this is a strainer and the foot valve ok, velocity head and then other bends. So, the total will be 10.89 meter is the static total static suction lift total suction lift this one.

Similarly, static discharge head 20 meter, this is the length of the pipe. And then head loss in pipe for 7 centimeter 20 meter length you get length 14.4 meter is the friction head loss. And head loss in the long sweep bends, so 7 centimeter you get 2.07 meter right. Head loss in the gate valve 0.33 meter, from the again this is from the table. So, this is from the table. This is also from the table and nomograph. This is also from the table right. Head loss in the reflex valve based on the foot valve if, we use the same foot valve equation like a kf into v square by 2 g you get this then velocity head discharge line that is again v square by 2 g , so that is 1.40 right.

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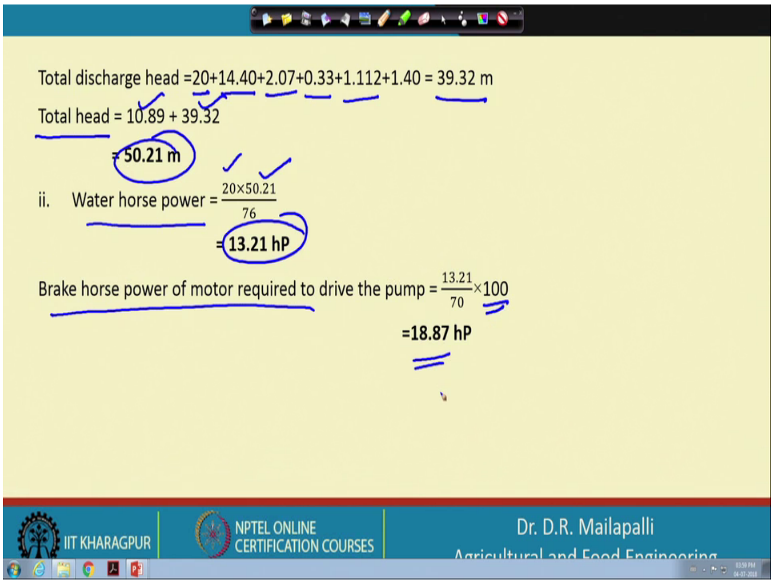

So, in case of discharge head the total will be this is the discharge, line length of discharge line and 14.40 is the friction in that line and 2.07 is the what is the called the bends and then this is this is what reflex valve and other bends ok. So, all together it will be 39.32. So, total head will be, this is the suction side and discharge side and total will be 50.21 meter and water horsepower is equal to, this is the head and discharge divided by 76 will be 13.21 hp and brake horse power of motor required will be 13.21 divided by 70 into 100, that will be 18.87 hp is the brake horse power.

Ok So, so this way in centrifugal pump, so we cover red in this lecture. If you install centrifugal pump in two cases the case number 1 when, the water source is below the center line of the pump, I mean you can estimate the total head loss right. So, the basically the head loss will have two parts. The part number one is the suction lift right. So, in this case if the suction lift and also discharge head ok. So, in case of water source, which is above the center line of the pump the suction head and discharge head ok. So, these two heads we need to consider for finding out the total head.

So, in each part either suction or discharge see if you can I mean divide. So, it has the basically, the elevation head, the pressure head and the friction head. So, these three heads sorry pressure head, friction head, velocity head. So, these heads will be considered ok. The first thing is the pipe line the length of the pipe. So, that will give elevation head and then the friction head loss either due to the pipe length so; that means the friction head loss and then the velocity. So, velocity due to the turbulence and other things, so, that will create velocity head ok.

So, these three heads then in addition to that if you have bends, you have to consider the friction head loss due to bends ok so, the similarly in case of discharge side. So, combining all heads together, will give the total head. So, low in the total head right, multiplying with the discharge divided by 76 will give the water horse power. So that means, the water to display it displace from suction to discharge head discharge level, you need to operate the pump at this particular hp right the power. So, then again the power will be different from end of the pump like starting of the pump to the motor level electrical motor level based on the efficiency of the devices ok.

Then based on that it is been like, you have water horsepower at the starting of the pump and then shaft horsepower, combining the pump efficiency then brake horsepower. So, that will be like you know, if we have monoblock pump. So, the shaft horsepower is equal to brake horsepower and then if you have external drive is used to operate the pump then, you have to consider the drive efficiency into calculation. So, then your brake horsepower is equal to shaft horsepower divided by your efficiency of the drive.

And then input horsepower, so that is equal to so, input horsepower is equal to brake horsepower divided by efficiency of the motor ok.

So, at the different stages the efficiencies are different. So, that the power is the different hps are different ok. So, we solve the two examples here; the first example, on the power requirement and second example also on a different cases, I mean finding out you knowing the total head. So, how to find out the total head for a particular case? So, case number 1, in this case like water source is above the center line. Similarly you can find out the case number 2 the water source which is above the center line that is case number 2 the total head ok. So, in the next class we will be focusing on cavitation in centrifugal pump generally it happens and then pump characteristic curves affinity loss and then there are other and pumps we need to discuss ok.

Thank you so much.