Introduction to Fluid Machines, and Compressible Flow
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Lecture - 12
Governing of Reaction Turbine

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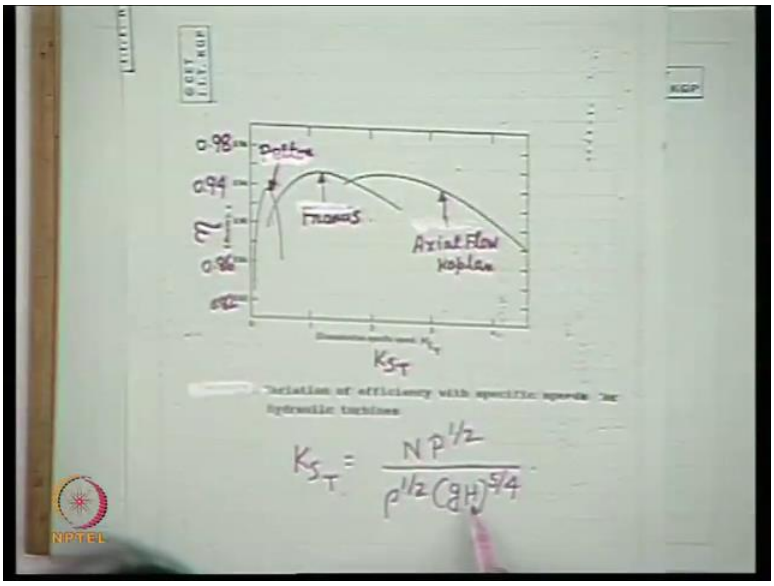

It is the percent of full load, and the efficiency is the ordinate as you see this card refers to the I think you can see now this is the this is the propeller turbine, this is the Francis turbine this is the coup line turbine. Now here off course you may have the question the propeller turbine, and coup line turbine is different usually in practice we refer to a turbine whose a entry is merely radial, and tangential, but exit is purely to that of a coup line turbine we refer to that as a coup line turbine this one for coup line turbine, and refer to a propeller turbine when the entire floor in the turbine is, and this type of turbine have got blades which are similar in nature to the propeller of a ship, and there are less in number usually four to six the number of these are popular term this is purely axial term.

So, see form this card this give you an idea that how the efficiency varies you see the built in turbine give you most very high efficient with though wider range of load. So, therefore, turbine in this respect you can tell as a flexible with respect high efficiency this is not sure in case of Francis turbine or propeller turbine attends almost maximum efficiency of, and then a change in load makes the decrease of efficiency there is a job in efficiency either side; however, the coup line turbine is compromise between these two that it is almost like built in turbine in efficiency, and does not fall in this side the; that means, beyond the load you see that is really evaporate high efficiency now after that I will show you another cart this is the propeller turbine propeller this is the this is the propeller one these one is the this is the coup line turbine, and this one is the transistor.

Now after that I will show you another very interesting plot is this plot between the efficiency, and the dimensional dimension less specifics these are the efficiency values this is I think 0.82, and the 86.90 0.94 0.98 0.82 this is the this is the typical plot 0.86 this is 0.86 this is 0.98 this is 0.94; obviously, this is the 0.90. So, you see this Francis this a couple now you have to recall this specific speed dimension is for a turbine is n p to the power half regarded rho to the power half row is there in g is there in dimension g Four.

So, we are seen that this specific speed earlier that is a dimentionized parameter, and it indicate the similarity conditions; that means, you can say that it is similarity parameter also, and at machine of a particular homologue series has different characteristics card as for as a relation of specific speed with the efficiency. So, this corresponds to all turbines follow this card all Francis turbine follow this card all floor turbines for the here we see that the efficiency of the turbine is high is arrange of nine four ninety four percent when the fixed speed is low which mean that tilten turbines are efficient only at low specific; that means, at a high this already we discussed earlier.

So, this gives typical range of this specific speed this is one dimension this two this is three this is for the next is the Francis; that means, Francis turbine operates a relatively lower turbine see if you operates Francis turbine at a high at you what will happen in the these range Felton turbine you give an efficiency below ninety five percent it is not twice it is not a vice decision to choose a Francis turbine in this specific speed, because Felton turbine will be given higher efficiency. So, axial flow turbine the other end is efficiency too much to lower specific speed; that means, higher, but the higher specific speed or at a lower rate axial flow coup line turbine given gives really high efficiency as compare to the Francis one, and built a, so these we are discussed earlier, but in this regard immediately we can see every state forward application of this through a problem this state forward application of this concept.

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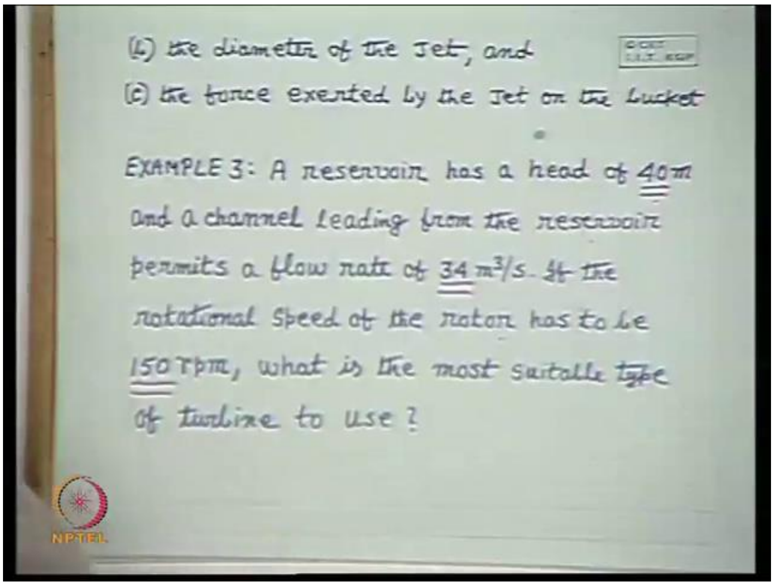

And this field art through a problem like this note this problems at a very state forward, and simple application of the problem, which give you clear concept in the design of the type of turbines hydolic turbines for a particular opposition which I told you earlier, but now this give you a clear example a reserved has a raid of forty meter, and the channel leading from the reserver permits a flow rate of 34 meter per second while; that means, a head is available that I have this much amount of it available that is the total energy of that wait for unit to a, and the permutable flow rate; that means, available flow rate is thirty four meter to… Now if the rotational speed of the rotor has to be 150 r p; that means, rotational speed of the rotor is fixed 150 r p what is the most suitable type of turbine here; that means, you have the applying conditions like this forty meter flow rate thirty four meter cube per second, and the rotational speed of the roter is 150 r p this three of the operating conditions which are usually specify by the turbine very simple a practical example that we have here; that means, you have to just calculate this specific speed.

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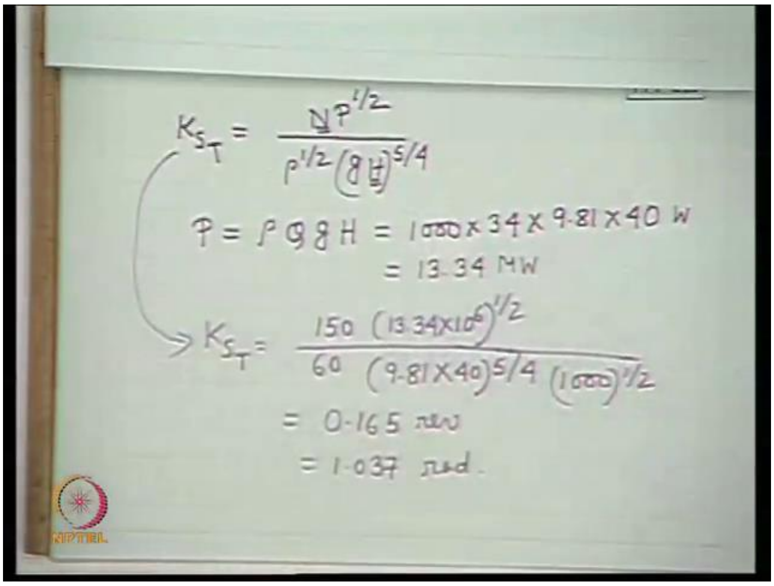

Let us calculate if non dimensional of dimensional now whether we will calculate the dimensional non dimensional depends upon the readymade figures readymade au what is called that table is available look to you to that whether you have the values of the dimensionalize or dimensional specific speed. So, this is the problem. So, now, what we do we have to calculate this specific speed; that means, n p to the power half rho to the power half g h to the power half. So, eight is given forty meter in the problem is see rotational speed is givens you calculate the power what is power is density flow g H. So, power developed 0 to 08.

So, this can be equal to haws in density kg per meter q thirty four meter q per second is q g is 9.81 into meter per seconds. So, therefore, we get the power developed from the available head as this one which is in what. So, this comes to the 13 point if you calculate it with g four. Now if you calculate this specific speed dimensionally, then what we do n is 150 r p m better put it in r p s, then thirteen point three four into ten to the power 6 in terms of what its nothing only this algebraically Illusions into the calculations g into 8 what equal to the power 5. Now if we calculate it will come as 0.16, and sorry to the power1000 to the power if you calculate it I am giving you the answer it will come or in terms of revaluation it is very simple thing that is straight forward application; that means, if you find out the case t with the value, and then you see from our earlier figure 1.037 radiant it is giving in terms of radiant case still in radiant. So, which will now will if we have this chart in our hand which one will select we will select

Francis very good. So, answer is that Francis turbine, so Francis. So, for this operation who will choose a Francis turbine, because it wrong circuit may higher efficiency very good now I will come to the governing of turbines well governing of turbines now governing of now governing of reaction turbines as I have told you earlier the governing of turbines means to change the flow to the turbine accordingly with the change in the turbine when the load increases we have increase the liquid flow to the turbine similarly when the load is decrease we have to decrease the flow or so that this speed of the roter frequency of the electrical output this is done in a reaction turbine by changing the position get position a changing the positions of the mares. So, that the flow rate to the turbine is by changing the gate opens.

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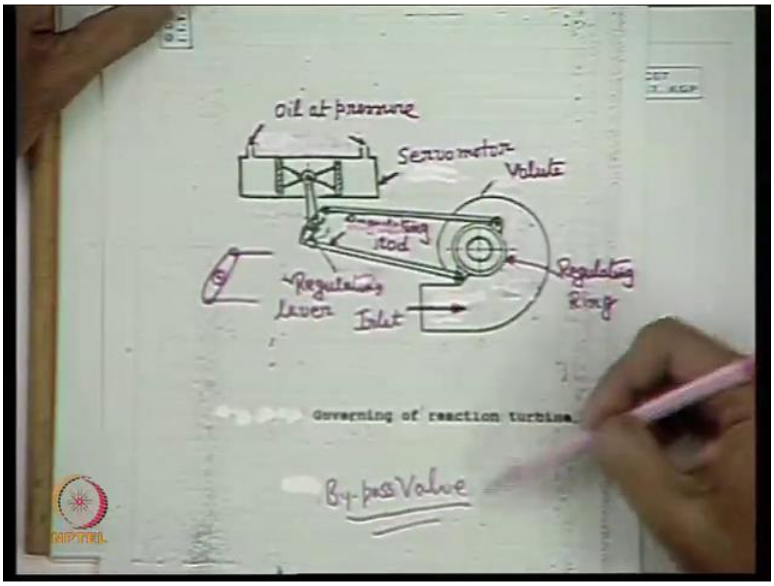

How it is do you? Now I already told you earlier I already told you earlier that the gates on the fixed veins of the turbine are pivoted. So, that this can be rotating this can be moved now this is see this is the volume casing this is valve this is the valve casing up the turbine this is in led; that means, the liquid flows through this now this is the turbine weaked gate this is the roter of the turbine. So, this weaked gates are veins which are not strongthey are connected through levers to a regulating ring this circular portion this isregulating. Ring this regulating ring is connected to this regulating rode this two sides these are the regulating roads these are the connecting pins. So, this regulating roads are connected to the regulating rings are one is the other ends connect to a regulating lever this is a regulating lever which is keep to a sharp by the typical this type of this is, this is the sharp. We are the regulating roads are going like this, and this is keep to a sharp which is turn by a servo motor this is the servo motor this is the servo motor piston which is activated by the pressurize the pressurize pressure of the oil which comes to the servo motor when actual the piston is actually construal by; that means, that since the pressure, and if that proportion heat controls the notion of this.

Servo motor piston which ultimately activate or trance this sharp to which this is lever is speed, and ultimately through this regulating rode, and through the lever mechanism which is ultimately connected to the a weaked gates or the static gains of the roter; that means, automatically when the low changes the oil pressure changes, and ultimately through this mechanism the position of the gate is changed. So, that the gate openings hurry, and accordingly the flow liquid flow intents that the liquid flow rate entering to the turbine changes this is the mechanism by which the governing of reaction turbine is made apart from that there is another, another bypass valve or valve bypass or really valve bypass valve that is been used in this circuit to this along with this phenomena along with this sorry along with this mechanism to discharge or bypass some amount of water in different line.

That means, it is not allowed to go to the turbine this is known as double this is known as double; that means, simultaneously the flow rate is control to this mechanism by alerting the position of the of the weaked gates along with the bypassing or changing the direction of flow or converting or bypassing certain amount of flowing other directions not allowing them to enter to the turbine this is known as double regulation. So, depends upon the amount to which the change in the flow rate has to be made; that means, when the load changes when the. So, this is all about the governing of reaction turbines. Now we will solve certain important problems, because now we have almost completed the reaction turbines. So, therefore, at the end we like to go through certain important problems.

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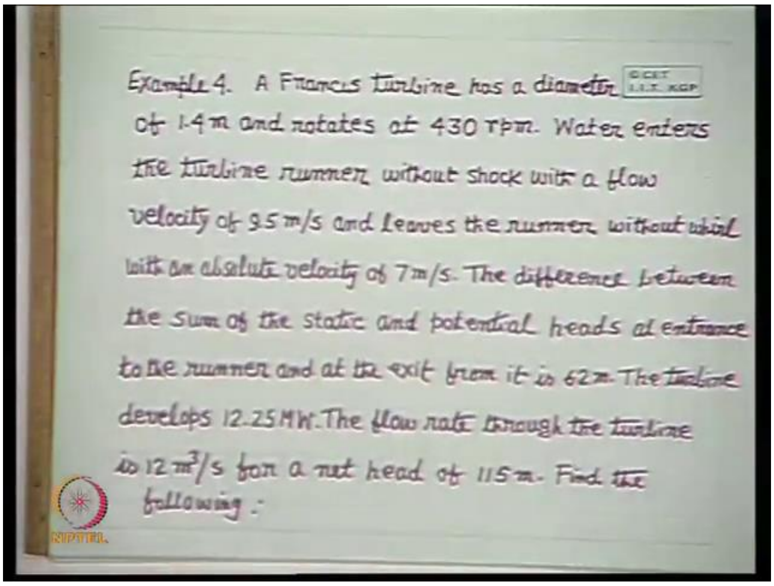

So, that explains yes just of minute au take this diagram otherwise it will be difficult for you for me to understand others efficiency verses k s t diagram yes, please tell it does not matter it may be hydraulic efficiency going the picture is there we will up to take care of the if the hydraulic efficiency is more means also it is usually yes, very good in the problem is solving efficiency. We had not assume that is a trend it is nothing coming quantitatively correct what we are finding out a trend that whether you will use which type of turbine here we are use the power developed you are considered the hydraulic or overall efficiency to; that means, this is the power developed. So, if we use this power developed you will be getting it at case to…

Now any turbine if we choosed these may be reduced, because power develop may be reduced you may add you may make a multiplication of a tow that will not change this order of cased; that means, we are in connected to find out the ranges of the specific speed were we stayed that this range Francis is; that means, you have not coming to a range whether specific speed is in the range of point one of point. So, definitely this not the power developed this is the power. So, exact power can developly multiplied by efficient. So, at the beginning in the power. So, therefore, it take this they are made the reduction you cannot deeply with point nine some approximate value we can till you their range; that means, that specific speed will be in the range of one we can write in the range of one there Francis turbine is the most suitable that. So, you are assumed the abstain for theoretical point of view you should write here; that means, this provided assume to work very good correct now next problem next state is that we should go through certain very important problems which will give a clear idea the Francis turbines which already, and turbine look into this problem a Francis turbine has a diameter of one point four meter is this is the diameter of Francis turbine one point four meter one point four meter is the diameter, and rotates at 430 r p; that means, the revolutionary speed the rotational speed is what there enters the turbine one or with the flow velocity of 9.5 meter per second this is the flow velocity, and lives the runner without very; that means, without any this is usually done in the design of all runner split that they do not have any willing velocity if in a problem for your examination purpose does not mention that without very that you can assume that the outlet is without, and you can draw the velocity triangle we can absolute velocity of seven meter per second.

So, this is the absolute velocity of the water at the dist that difference between the norm of the static, and potential heads the difference between the sum of static, and potential heads at entrance to the runner, and at the exits from it is 63 meter; that means, it is difference of static, and potential understand static, and potential q by rho g plus g that is the difference between the static, and potential if this some of this two quantities between the entrance, and exit is 62 meter the turbine develops 12.25 meter this is the power developed the flow rate to the turbine is 12 meter q per second. So, flow rate is 12 meter q per second for a mate head of 115 meter net head is 115 meter problem is the wrong one this is turbine problem this one is data sometimes it is very long, but you will have to understand this things what are the data rotational speed the flow velocity without discharge 7 meter per second is the absolute velocity of the discharge difference between the heads accept the velocity head the difference between stating, and potential head is 62 meter the net head 115 meter. So, this is the net head as fine the follow what are the followings that we had to find out the absolute velocity of water.

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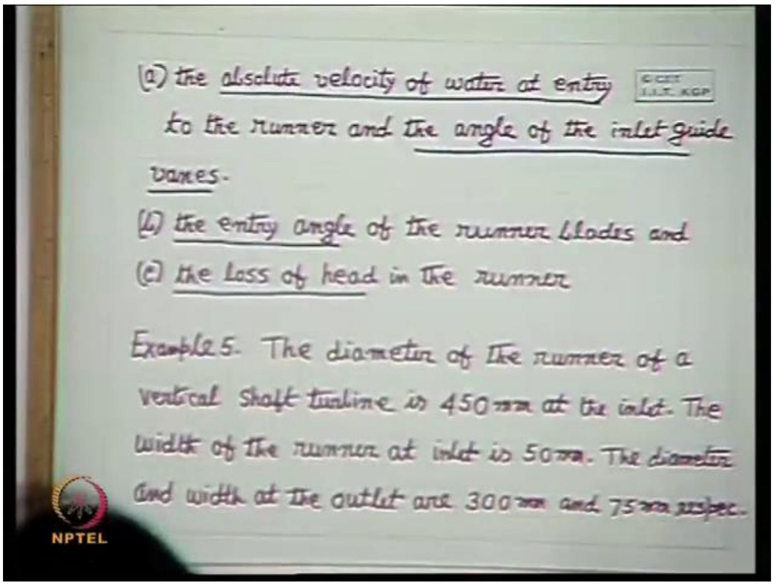

These are the things that will have to find out absolute velocity of water into to the runner, and angle of the inlet absolute velocity of the water at end to the runner, and the angle of the inlet he entry angle of the runner blades the entry angle of the runner blades, and the loss of head is let us solve Again I am telling any difficult to is the completed yes again I repeat the Francis turbine has a diameter of a 1.4 meter, and rotates that 430 r p m what are enters the turbine runner without flow velocity of 9.5 meter per second, and leads the runner without very with an absolute velocity of 7 meter per second the difference between the some of this static, and potential heads at entrance to the runner, and I have the exit from the turbine develops 12 to 5 the flow rates through the turbine is 12 meter per q per second for a net head of 115 meter fine the follow what are the followings the absolute velocity of water at entry to the runner, and the angle of the inlaid the entry angle of the runner are blades, and the. So, let us find out that how we can solve the problem let us think of the velocity triangle.

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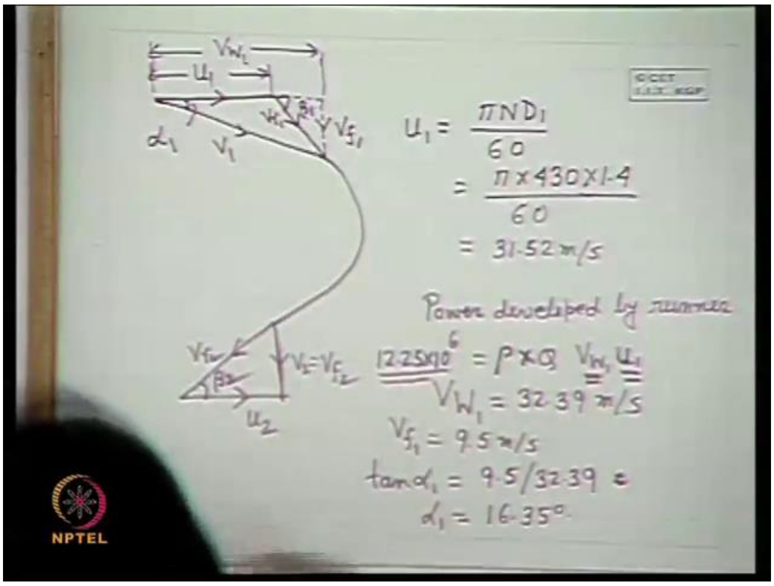

That means if you consider the runner blade like this if you remember this the runner blade. So, so please see the, this is your you are in let this is b r 1 and… So, this is will be b f one that is the flow velocity of the. So, therefore, this is the one you one is this, so this is we done immediately will have to think in terms of the velocity trend the outlet velocity you will be like this triangle, and this will be now without will it is already mentioned in the problem. So, therefore, v 2, and v at 2, and this is the u two which will be lower than the one in a in a franc is turbine that you will flow as you know, and this is your react tool.

So, therefore, these angle is the angle of the blade at the outlet this is the angle of the blade at the inlet beta one, and this is the guide when n guide when always specified as the angle of the guide; that means, the angle at which the fluid leave to the or this is the angle of the absolute velocity of the fluid approaching the runner, and all the angles are referred when ever angle we do not tell we what direction, because it is always referred to the direction with the direction of the velocity; that means, the tendent to the roter at the point in the tangential direction. If these to the velocity triangle now we what are the quantities are we know that we know you u one what is u one is by are you calculated n t 1 by 60. So, it is given in the problem is it given in the problem 430 r p m. So, 5 into 430 divided by 60 you are n is the r p m, and what is the diameter of the runner as a diameter of 1.4 meter na here, there is a problem that is why I like to point out the problem in particular in this diameter of the runner is given you will have to considers the this diameter of the…

Because it is not very explicit in his mathematical language the diameter is the diameter is the, because the flow takes place we varying diameter radial formations were both the outlet you can, but here it is very difficult to know inlet diameter or the outlet diameter. So, it is a convention that the diameter of the radial turbine outlet diameter in case of radial formations diameter is the outlet diameter. So, which is very important to you find out what is the value of. So, then what will we do d w 2 is 0. So, what you will find out power giving to the runner by the water this power giving; that means, the power available or power developed you can write by runner.

What is the power developed by runner it is rho into q into you know from the all of turbine equation d w one. So, u one we know we know v w one how do you know v w one v w one v do not know, but know the power developed that is 12.25 tend to the power 6, and we have 32.3 v w 1 we get, because we know that the turbine develops 12.25 mega watt. So, power developed by the turbine is the rho q v are also mechanical efficiency take to the hundred percent, because this power developed is a the final power developed, and this v w on you 1 is the power developed by the runner. So, we considered the mechanical. The mechanical efficiency we can considered this to be one, and we can find out.

So, now it is easy to find out the alpha one. So, we know the v w one. So, we can find out the alpha one, because we know the flow velocity at the inlet is 9.5 meter per seconds; that means, to f 1 is equal to 9.95 per second. So, we can calculate time alpha 1 is 9.5 divided by 3, and this comes to be not tunnel from alpha one comes to the 16.3 now find out tend that beta 2 for beta 1 we try will have to find out tell me which will have to find out the at the runner, and the angle to the runner; that means, this beta 1 that we will have to find out beta 1 how to find out beta 1 if I write ten beta 1 is b f 1 by very good v w 1 by know b f one you know v w 1 you know in 1 v w 1 know since you know this alpha 1. So, v w 1 is v 1 cause alpha. So, this will give you a value of beta 1 is equal to 84.77 alright. So, next is the loss to the runner you have to find out now we see that total head now head lose to the runner.

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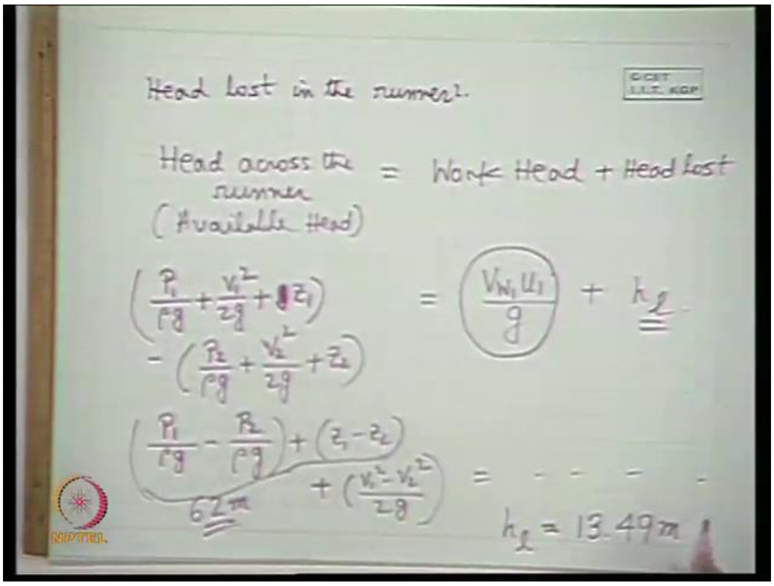

How to find out head lose in the runner this is the last thing that would have what are the thing we are found out absolute velocity of water at entry the angle of the inlet guidelines can that entry angle of the runner blades the loss head in the run. So, the loss of head in the runner how can you find out loss of head can be found out looking like that head across the runner across the runner; that means, available here these terminology to understand very clearly available here across the runner is equal to means that is the produced by the; that means the plus the now head across the runner available head is the difference of head between inlet, and outlet; that means, if I give this suffix one as inlet.

And suffix two at the outlet the runner that means available is this is the inlet head which comprises the that is the pressure a the velocity here, and the potential minus well p two by plus v two sorry very good, and what is this v w one this case there is no this is eight l. So, these things are clear we have been given that this head available what is the value due to the runner? So, we can find out this thing from a different way that we know this p 1 by minus p 2 by plus j one minus j rather we can take p one by plus v one square minus is equal to their item now this is even as 62 62 meter well this is given as 62 meter. So, this part we can calculate from our velocity triangle we can we can already calculated v one have you not v are not calculated v one is so far. So, v 1 we have calculated. So, we know the value of v 1.

We can calculate the v 2 also how we can calculate the v 2 v f 1 is equal to v 2 v f 1is equal to v f 2 is equal to. So, if we know both v 1, and v 2 from the velocity triangle is the trigonometric reactions, then I can find out the net head across the runner well this thing is already calculated this thing is already. So, we can find out. So, ultimately if you calculate alright this we have already calculated au earlier 32.39 this is 32.39 what is that into 31.52 divided by 91 this is v w 1 this is. So, plus so this way we can solve this problem next we come to another problem.

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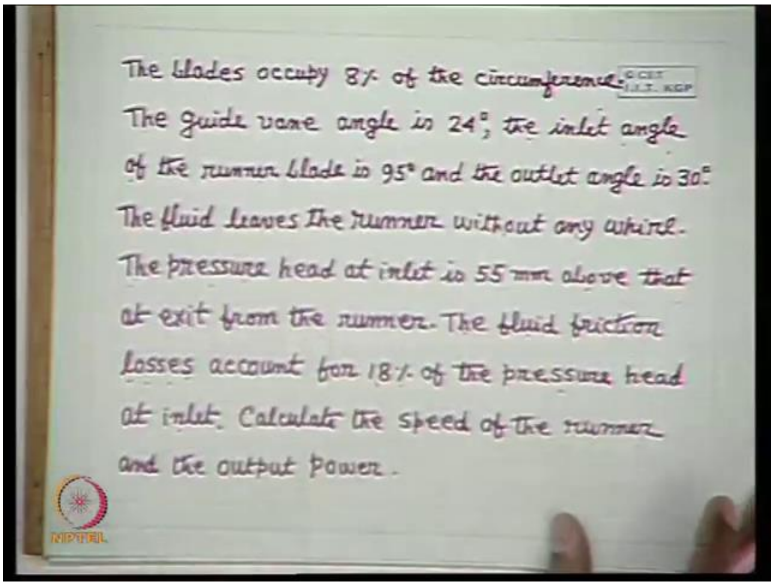

This is another interesting problem this you can take it Francis turbine quick you write this problem au time is up, you this problem the diameter of the runner the diameter of the runner the diameter of the runner the diameter of the runner of a vertical short turbine to the diameter of the runner of a vertical short turbine simply write this problem is 450 millimeter is 450 millimeter at the inlet the diameter of a runner of a vertical short turbine is 450 millimeter inlet the of the runner at inlet the of the runner at inlet is 50 millimeter is 50 millimeter the diameter 50 millimeter the diameter, and at the outlet are the diameter, and at the outlet are 300 millimeter are three hundred millimeter, and said 85 millimeter respectively 3300 millimeter; that means, the diameter, and at the outlet are 300 millimeter, and 75 millimeter respectively than diameter well the plates occupy next is that the plates occupy 8 percent of the circumference which give you the idea out the flow area.

So, flow area is not the entire circumference times dually the blade occupy eight percent of the circumference stop the guide when angle is 24 degree which is alpha one that is the angle of the absolute velocity of the interest to the 24 degree the inlet angle of the runner blade varies 95 degree well the inlet angle of the runner blade is 95 degree, and the outlet angle is thirty degree, and the out let angle is 30 degree the fluid leaves the runner the fluid leaves the runner without any will a fluid leaves the runner without any the pressure headed inlet is fit to 5 millimeter above that at easy a pressure head at inlet is 55 millimeter about that at exit, and the runner the fluid friction the fluid friction loses the fluid friction loses account for 18 percent of the pressure head at inlet au fluid friction loses account for 18 percent of the pressure head calculate the of the runner, and the output power calculate thus p w runner, and the output power well calculate thus p w runner, and the output power.

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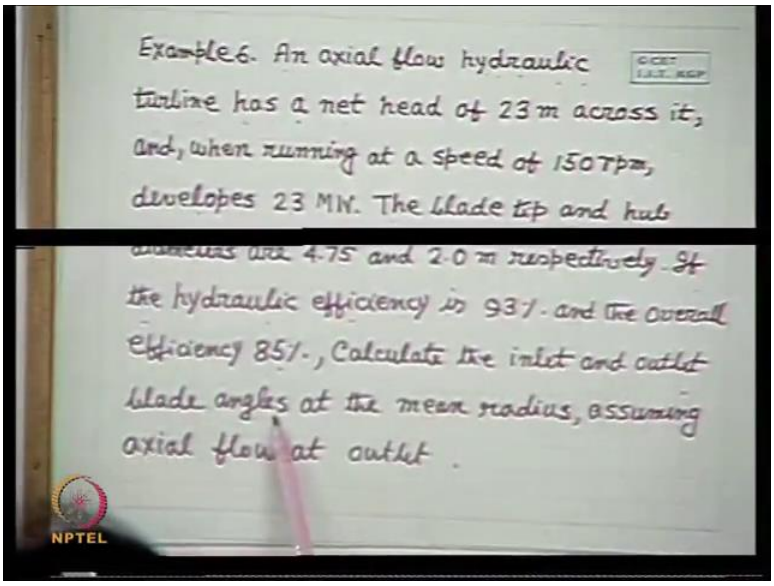

You write another problem for this a last one flow hydraulic machine quick, and, because time is short an flow hydraulic turbine has a net head obtain into three meter across it axial flow hydraulic turbine is a make rid of into three meter across it. And running of this speed of 150 r p m developed into three mega watt that is the power developed that is the across the turbine, and speed of 150 r p m that blade one half diameters which is very important the blade t n half diameters are four point seven five into 2.0 meter respectively; that means, the half diameters that determines the flow area, because you are flow is axial flow turbines the blade q, and half diameters 4.752.0 meter but inlet, and outlet is through the entire height of the blades to entire diameter; that means, it is a real if the hydraulic efficiencies 93 percent, and the overall efficiency 85 percent calculate the inlet, and outlet blade angles at the mean readier assuming axial flow at outlet assuming axial flow at outlet entire flow to the turbine is axial assuming axial flow at output alright. So, you please try this problem next class if you have any difficulty solving the problems you can discuss before starting the new topic palms proto dynamic palms. So, next class I will discuss the proto dynamic palms, but I will given this two problems is one problem I have solved other two problems which I given pleased try to your house. So, if you have any difficulties next class we will discuss about this, and then we will start the new topic rule proto dynamic palm.

Thank you.