Introduction to Fluid Machines, and Compressible Flow
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Lecture - 13
Introduction to Rotodynamic Pumps

Good morning, we welcome you to this session of fluid machines well. Today we will discuss the rotodynamic pumps, but before the discussion of rotodynamic pumps I feel that we should discuss the problems that I gave you earlier I think, because this is the opportunity when we can discuss about the problems on reaction machines. So, therefore, before starting this rotodynamic pumps I like to discuss about the problems that I gave you earlier for this for you to solve this, if you go look quickly to this problem.

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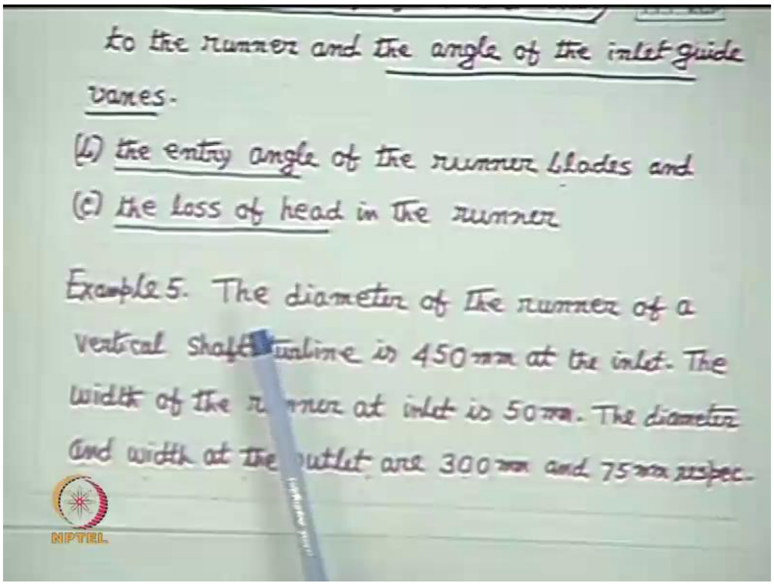

I just as we have hurried discussion on this problem, I hope that you have already taken it in your note the problem was like that the diameter of the runner of a vertical shaft turbine is four fifty millimeter at the inlet the width of the runner at inlet is fifty millimeter the diameter, and width at the outlet are 3 hundred millimeter, and seventy five millimeter respectively.

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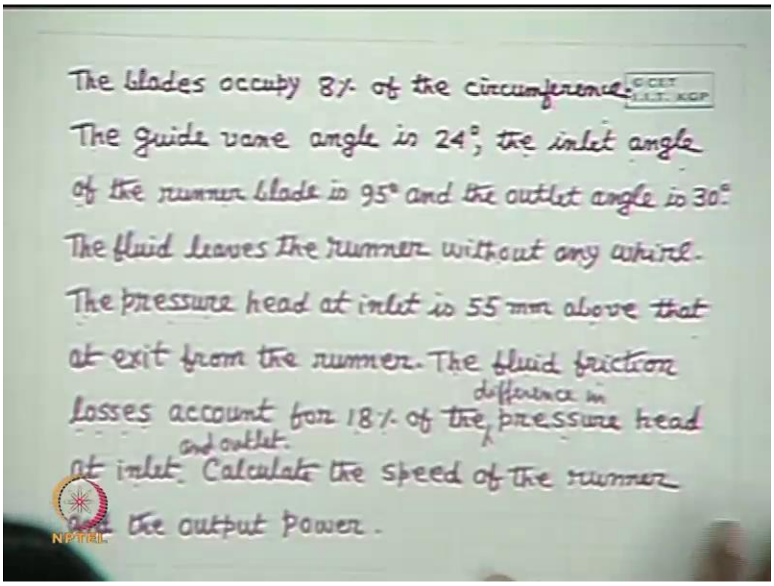

So, quickly we will be going through this problem the blades occupy eight percent of the circumference the guide vane angle is twenty four degree the inlet angle of the runner blade is ninety five degree, and the outlet angle is thirty degree the fluid leaves the runner without any whirl there is no any whirling component.

The pressure head at inlet is fifty five millimeter above that at exit from the runner the fluid friction loss account for eighteen percent of the pressure head at inlet actually there is a mistake this will be eighteen percent of the difference you write of the difference in pressure rate at inlet, and outlet it will be eighteen percent of the difference in pressure rate at inlet, and outlet calculate the speed of the runner, and the output power well. So, this problem if you solve just you see that how you can solve this problem.

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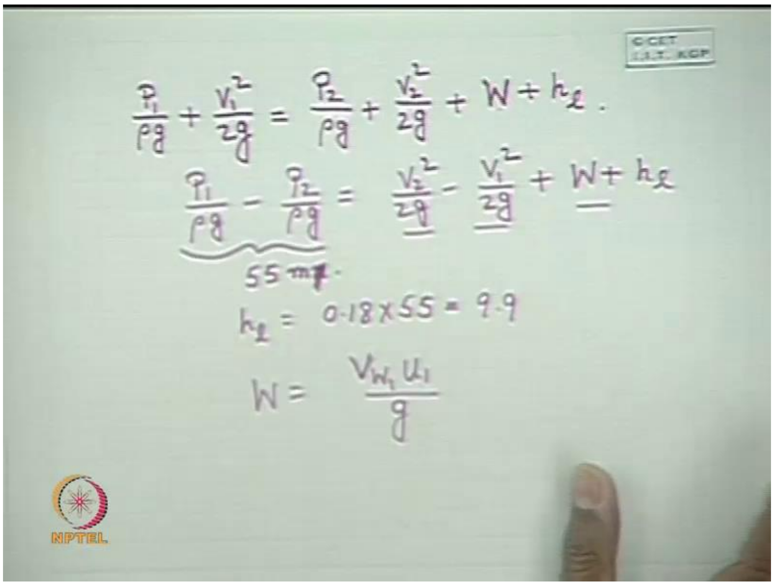

If I write the Bernoulli's equation at the inlet, and the outlet of the runner, then what we get it is the p 1 the suffix 1 stands for inlet v 1 square by 2 g; that means, the pressure head, and the velocity head is equal to p 2 by rho g; that means, simply an energy balance per unit weight bases v 2 square by 2 g plus the work head; that means, if I reproduce at this w w is the work head; that means, the work per unit weight plus the loss h l we consider the change in the potential head or the elevation between the inlet, and outlet of the runner to be negligible that mean this is the inlet pressure head inlet velocity head of the runner this is the outlet pressure head outlet velocity head of the runner work head plus the head loss.

Here we know from the problem that p 1 rho g minus p 2 by rho g, we can write in this fashion is equal to v 2 square by 2 g minus v 1 square by 2 g plus the work what is the value of this work head do you known this value of work head no we do not know we know only that w plus h l this h l we know. So, this is fifty five meter fifty five millimeter well I am sorry extremely this is not fifty five millimeter this is fifty five meter this cannot be. So, small the difference between the pressure is fifty five meter that is fifty five meter, I am sorry it is fifty five meter h l according to the problem is eighteen percent, 0.18 into 55. So, the problem is like this nine point now we do not know v 1 v 2 v 1, and w, but w we can express as w is equal to v w 1 u 1 by g where this is the tangential component of the velocity at inlet rotor speed, and g.

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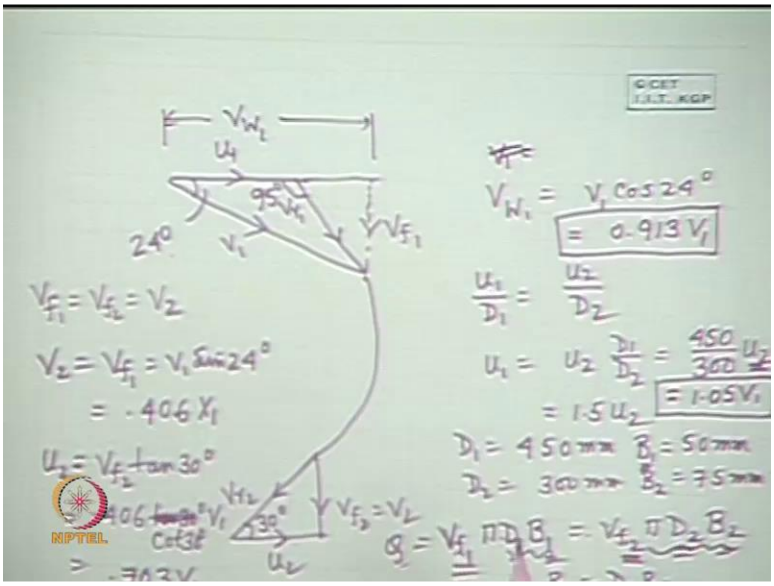

Now, how can we calculate this to do this we will have to find we will have to think in terms of the; that means, this is the rotor the usual velocity triangles well. So, this is your you 1, this is your v 1, this is your v r o. So, this is let this is the perpendicular. So, this is v f one.

So, according to the problem this angle is giving that is the (( )) angle twenty four degree you see, and this angle is given as ninety five degree, and here also similarly v r 2 well, and this will be u 2, and this will be v f which is equal to v 2 the absolute velocity is radial, and this angle is probably given beta 2 you see that beta 2 is also given thirty degree the outlet angle is thirty degree. Now here we see that in this expression v 1 v 2, and w if you express v w 1 u 1 by g I all the velocities can be expressed in single velocity we can find out that velocity from this equation, because we know h l we know p 1 by rho g minus p 2 by rho g.

So, know it becomes simply certain trigonometric manipulations that if you consider the inlet triangle inlet velocity triangle you see that v 1 is equal to what is v 1 v 1 is equal to v f 1 this is cos twenty four degree or v w 1 rather better we write the v w 1 we have to find out the v w 1 in the work head expression. So, everything better should be expressed in terms of v one. So, v w 1 is v 1 cos of twenty four degree let us thing that every all velocities should be expressed in terms of v 1 the inlet velocity. So, this comes out to be just I am giving you this already solved pint nine 1 three.

So, what is there, then u u 1 I have to find out what is u 1 u 1 by d 1 is u 2 by d 2 well. So, u 1 by d is u 2 by d 2 is; obviously, because the rotational speed is same. So, it is in the ratio of the diameter. So, u 1 becomes equal to u 2 d 1 by d 2 what is d 1, and d 2 d 1, and d 2 are given. So, therefore I can write that is equal to four fifty you see by 3 hundred four fifty millimeter is the inlet diameter, and 3 hundred millimeter is the outlet diameter it becomes 1.5 u 2.

Well, again now 1 thing that you see here in the problem d 1 is given four fifty millimeter what is b 1 that is the inlet at the width the inlet at the width is fifty millimeter let this be b 1 this fifty millimeter well similarly d 2 is given 3 hundred millimeter, and b 2 is given now here in this context I like to tell you 1 thing when b, and d d is the diameter at the inlet, and b is the width; that means, if the shaft if the turbine is in the horizontal proposition, then this b 1 is the vertical width; that means, pi d b is flow area; that means, pi d 1 b 1 is the flow area; that means, I we multiply it with v f 1 if will give you the flow rate q.

Now, this must be equal to v f 2 pi d 2 b 2 now where both d 2 b 2, and d 1 b 1 are given, then we will check whether v f 1 is equal to v t f 2 or not if they are different the areas that d 2 b 2, and d 1 b 1 that product of d 1 b 1 is different from d 2 b 2, then v f 1 v f 2 are not necessarily the same or a particular problem it is. So, we can accept this, but usually in all designs v f 1, and v f 2 are made same which I liked to tell that is any problem if you see that this four quantities are out o these four quantities 1 is not given, then we will make the equality.

That means rates will be same the steady condition, and we will make that v f 1 is equal to v f two. So, that automatically d 1 b 1 becomes d 2 b 2 in this problem the values are given such that this is this equality holds good; that means, from the continuity you make v f 1 by d 1 b 1 is equal to is equal to v f 2 pi d 2 b two; that means, the flow rates are equal, then at inlet, and outlet, then we get automatically v f 1 is equal to v f two. So, therefore, we can write that v f 1 et us write here v f 1 is equal to v f 2, and that is is equal to v 2 this is v two.

Now, from this outlet velocity triangle we see that v v 2 v 2 is what v 2 is in terms of v 2 v 2 is u 2 v 2 is v 1 in terms of v 1 let us see v 2 is v f 1 rather here, you see v 1 sin twenty four, then what is there v 1 sin twenty four is 0.406. So, therefore, we can find out u 2 from here u 2 is what tan that is v f 2 tan thirty, and v f 2 is 0.406 tan thirty 0 tan thirty, because tan cot thirty or tan sixty you are correct perpendicular by base. So, u 2 is based by perpendicular cot thirty tan sixty all the same cot thirty let me check with the calculations that well.

So, therefore, u 2 comes out to be point seven 0 3 v one. So, now, you see u 2 point seven 0 3 v 1 I I put here, then u 1 becomes equal to u 1 becomes equal to 1 point 0 five v one; that means, this if I put u 2 point seven 0 3 v 1 u two; that means, v 1 we get in terms e v w 1 we get in terms of v 1 u 1 we get in terms of v 1 well, then you see that in this expression we can write this v w 1 u 1 by g v w 1 is point nine 1 3 v 1, and u 1 is 1 point 0 five v 1 by g . So, v 2 what is v 2 v f 2 v 2 we see that v f 2 v 2 is 0.406 v 1 0.406 v 1.

V 2 is 0.406. So, therefore, this right hand side of this expression h l is known nine point nine that is eighteen percent of the difference in pressure head at inlet, and outlet. So, therefore, from this equation can find out the value of well when the value of v 1 is found out, then what we have to find out in this problem we have to find out the well we have to find out the what we have to find out calculate the speed of the runner, and the output power well the speed of the runner is very simple. Now when v 1 is found out u 1 is found out or u 2 any one of these, and speed of the runner is pi d n by sixty d 1 is e one. So, or pi d 2 n by sixty any 1 you make u 2. So, you can find out in the rotational speed in r p now to find out the power developed

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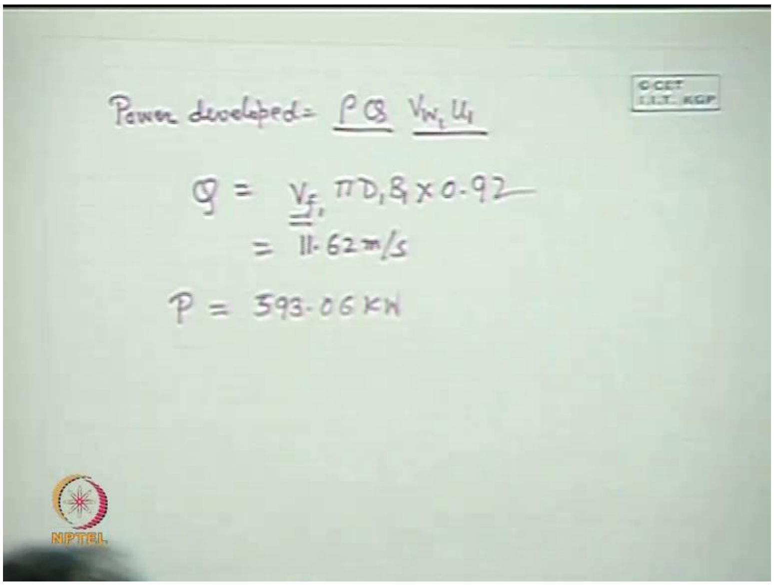

What you have to do you have to write the power developed what is power developed power developed we will have to find out rho q v w 1 u 1, because here the power developed by the runner is v w 1 u 1 into rho how to find out q q we have to find out all ready I have told now v f 1 pi d 1 into b one, but in the problem it has been given the blades occupy eight percent of this circumference; that means, the effective flow area will be point nine two.

So, you can find out the flow rate well. So, flow rate value will come if you eleven point six 2 meter per second, because all the velocities are known v f 1 also known when v 1 is known all the flow velocities are known. So, q is equal to eleven point six 2 meter per seconds, and power p become equal to five ninety 3 point 0 six kilo watt all right it is a simple problem. So, you see this problem again in you all. So, that you can understand well now I will come to the discussion on I have given you another problem on axial flow turbines please you see is a very simple problem solve it if you cannot I will discuss it in the next class if possible.

So, now I will come to the rotodynamic machines all right rotodynamics sorry rotodynamic pumps well let us find out well now I will discuss the rotodynamic pump please rotodynamic pump. So, you know the pump as we have discussed earlier is a machine where the mechanical energy is converted into the stored energy of the fluid, and you know the pump or compressors if you recall the classifications, then you will see that pump, and those machines which handle incompressible fluid or liquids; that means, in a pump the mechanical energy is converted to the stored energy of the in of the liquid.

Well, the rotodynamic machines again on the other hand are those machines which work on the principle of fluid dynamics; that means, there is a continuous motion of the fluid through the machines, and because of this motion relating to the machine a part of the machine as you know as rotor the energy transfer between the fluid, and the machine takes place. So, therefore, a rotodynamic pump is a machine where the fluid that is the liquid gains in its stored energy while flowing through a moving parts of the machine or while flowing through the rotor of the machine.

This is precisely a rotodynamic pump as similar to turbine the rotodynamic pump is also classified into different categories depending upon the direction of the 1 is the axial flow rotodynamic machines, where the flow is axial; that means, in a direction parallel to the axis of rotation understand; that means, the inlet, and outlet is at the same radial locations from the axis of rotation similarly the radial flow machines are there for pump that is radial flow pump, and as you know if it is a pump fluid gains the energy the radial flow machines will be radially outward flow this is, because the fluid will gain in centrifugal head that is the centrifugal energy per unit weight.

While in case of turbine it will be radially in void where the fluid loses its centrifugal head which got in terms of work obtained. So, it is outward radial flow turbine sorry pump. So, these outward radial flow pump is referred to as commonly as centrifugal the word centrifugal comes from the concept that the centrifugal head is impressed on the fluid or it is gained by the fluid. So, therefore, a radial flow rotodynamic pump is termed as centrifugal pump. So, basically we see that centrifugal pump is the converse of francis turbine, because francis turbine is a radially not flow machine where energy of the fluid is given to the rotor, and we get mechanical power.

Similarly, in a centrifugal pump it is a radially outward flow machines, where this situations are the fluid gains its energy from the mechanical energy imparted to the moving rotor. So, it is just the converse of francis turbine. So, before coming to the discussion of the shape of the rotor the blades the velocity triangle, and the work transfer we first concentrate on a general system a general pumping system what you mean by pumping or a general pumping system, and the net head developed by a pump there are certain terminologies static head net head developed this we will study through this study of a general pumping systems.

So, now let me tell you this thing clear the word pumping refer to hydraulic machines implies conveying of water from a lower head to higher head from a lower reservoir to upper reservoir you see that very common, and popular meaning of pumping, when we talked that when we tell that water is to be pumped or any liquid is to be pumped we simply means that it has to be taken from a lower reservoir to a higher reservoir; that means, from a place from a location to a location where the height is more this is the common implication of the word pumping as referred to hydraulic machines. Let us understand the general pumping system with this common implication of the word pumping.

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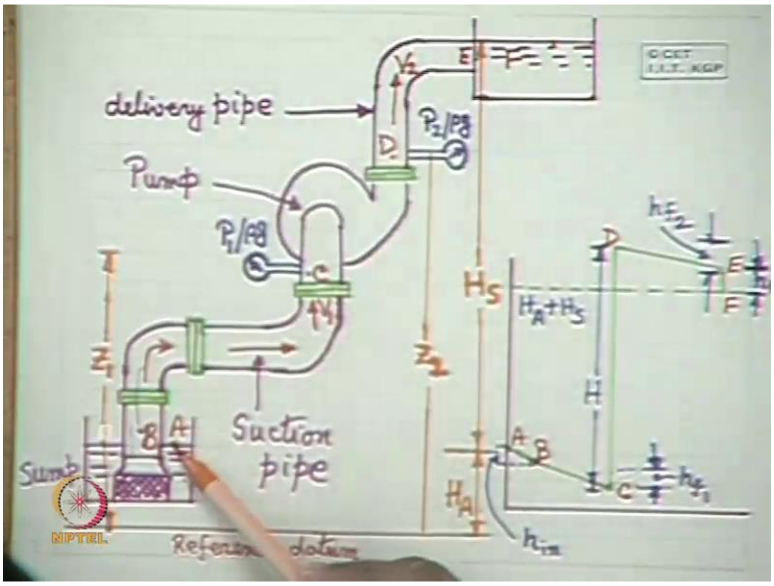

So, let us come to this diagram which will give you a clear understanding of the general pumping system let us consider just you see that this is a pump this is a centrifugal pump this may not be in a this may not necessarily be a centrifugal pump, but the figure is drawn that is a centrifugal pump with any pump is here now you see this is the lower reservoir where the liquid is there from where the liquid has to be taken to a upper reservoir here. So, this is the upper reservoir this is the lower reservoir there is a terminology that is kwon as sump s u m p lower reservoir is known as sump.

Now, this is a pipe which takes the water from the lower reservoir, and the water or liquid flows through these pipes, and goes to the pump. So, this pipe is referred to as suction pipe suction pipe why this is, because usually this quarter is kept at atmospheric pressure this is open to atmosphere. So, therefore, for the liquid to flow through this pipe the pressure in this pipe has to be lower than the atmosphere. So, that the fluid at rest at atmospheric pressure can flow through it. So, that is the reason for which this pipe is known as suction pipe where the liquid is shaft from the atmospheric pressure.

Now, after gaining energy liquid comes out from the pump, and flows through a pipe which is known as the delivery pipe, because this is the pipe through which the fluid is being delivered by the pump to the upper reservoir well usually these suction pipe diameter is little more than the delivery pipe in most cases it may be equal, but if there is a variation it has to be more than this that I will discuss afterwards, because of the cavitation problem known you see that at any point in the flow of the liquid through suction pipe pump, and delivery pipe the total comprises the pressured energy kinetic energy, and the potential energy.

Now, we take a reference datum here from where the elevations are or the potential heads are defined now let us see just a minute there is a mistake let us well this will be up to this now you see that what is the total energy of the fluid at the upper reservoir surface this is, because the fluid is at rest, and at atmospheric pressure. So, total energy of the fluid at the upper reservoir is h s plus h a, these are the terminologies at present without any name we just understand that h s is this height, and h is the height of this levels from the reference datum. So, h s plus h is the total energy at this point.

This point is h a why because at this point the pressure is atmospheric pressure. So, we consider the pressured energy to be 0 when the pressure is atmospheric pressure; that means, you calculate the pressured energy as p by rho g where p is the gauge pressure when the pressured energy is 0 kinetic energy is zero. So, total energy is h. So, difference in total energy of the liquid at upper reservoir, and the liquid at lower reservoir is h s this h s this is known as static head of the, this h s is known as static head h s is known as static head static head.

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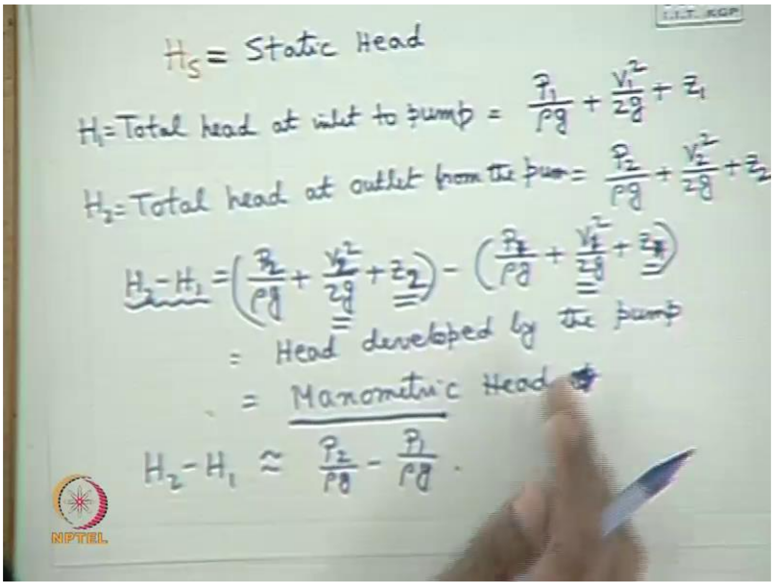

That means this is precisely the difference in the total energy of the liquid at the lower reservoir upper reservoir, and lower reservoir, and this is simply the difference in elevation head between the upper, and lower reservoir this is the terminology static here. Now we see the follow this diagram here, we see that how the energy changes now let us consider a point a where the fluid is at total energy h a it flows through this pump this is a typical strainer through which the liquid enters the suction pipe of the pump where the mechanical impurities are eliminated, and comes to a point b which is almost at the same elevation here.

So, the head or the total energy drops to a little which accounts to h in in is a suffix; that means, this is the loss at the inlet to the suction pipe, then while it flows through the suction pipe now this is the point c that is at the inlet to the pump there is a pressure gauge connection, and these the point at the outlet to the pump there is another pressure gauge connection which measures the pressure at the delivery, and pressures at the suction. So, at the inlet to the pump c is a point where you see there is a appreciable loss of it which is shown by h f 1 that is the head loss at in suction pipe, which counts for the frictional head loss while flowing through the suction pipe along with the head losses due to pipe banes. So, all major, and minor losses are taken into account these are the typical frame joints to make this pipe banes, which takes place in course of flow of the fluid from the inlet point b to the inlet to the pump c, then what happens well the fluid comes to the pump it gains energy this is the basic principle of the fluid machines where the energy is imparted to the fluid while it flows through the rotor, and stator of the pump, and in when it comes out of the pump machine it gains total energy or head is developed by the fluid with the basic principle of the pump.

So, there is an straight increase of the head to a point d now this line is h a plus h s; that means, in line implies the total energy of the fluid at this point now the point the friction in the delivery pipe; that means, when it comes to the exit point of the delivery pipe e the line slopes downward means to e where this d to e this loss this loss is h f 2 is denoted by h f two; that means, this is the frictional losses in the delivery pipe that is the frictional loss, and other losses of course, the looses due to bane in the delivery pipe, then what happens that the exit plane e their fluid is delivered to the upper reservoir which has got a flow velocity or the kinetic energy.

This entire kinetic energy is loss that is by 2 where e is the exit velocity; that means, the entire kinetic energy this physical implies that entire kinetic energy is converted into intermolecular energy. So, that fluid which was a velocity v at this exit plane is now coming to the; that means, these energies loss. So, therefore, this sis known as the exit inlet is converted in terms of intermolecular energy in the upper reservoir. So, in course of flow of the fluid through the suction pipe pump, and the delivery pipe I think you have understood this well, then I tell you certain terminologies.

You know that h s is the static head, now if we write the Bernoulli's equation between the point a, and the point c just you see first here between the point a, and the point c, then what we get before that let me explain some terminologies total head this is most important after that we will write the Bernoulli's equation total head at inlet to the pump total head at inlet to pump, and total head at outlet to total head at total head at outlet sorry pump at outlet from the pump what is total head inlet to the pump.

If we consider p is the pressure suffix 1 is the inlet to the pump the corresponding velocity that is the velocity of the fluid at the inlet to the pump; that means, the velocity of the fluid in the suction pipe plus z 1 let z 1 is the as I have z 1 is the elevation from a reference datum at the inlet similarly z 2 is that at the outlet, and p 1 by rho g, and p 2 by rho g at the pressure heads these are shown by the pressure gauges. So, therefore, total head at the outlet of the pump is p 2 by rho g well plus v 2 square by 2 g plus z. So, this is total head; that means, the total energy per unit weight this is the total energy per unit weight at the outlet.

So, difference of this is denoted by h. So, this h 2 minus h 1 is the head gained by the fluid that is p 1 by rho g plus v 1 square by 2 g plus z 1 minus p 2 by rho g well plus v 2 square by 2 g plus z one. So, this is oh it is opposite yes p 2 this is v 2 this is z 2 this is p 1 v 1 z 1, and this is known as head head developed head developed by the pump; that means, this is the head developed by the pump this is the head developed by the pump, and this is the head the developed by the pump which is gained by the fluid this is the change in the head I mean outlet to inlet.

This is known as conventionally manometric manometric head o the pump please ask me the question if any question you want to ask manometric head not or manometric head the work manometric head comes from the concept that I will tell you now. So, this is the head developed by the pump that is the outlet head of the pump minus the inlet heat that is head at the outlet minus head at the inlet, now usually t is found that the difference in delivery, and suction pipe diameters are. So, small that the difference between the velocity head that v 2 square by 2 g, and v 1 square by 2 g is made.

Similarly, you know very well it is very it is very much obvious that difference in elevations at the inlet to outlet is much small compared to change in other quantities. So, that h 2 minus h 1 that head developed can be simply written as p 2 by rho g minus p 1 by rho g. So, therefore, you see here that this differences in pressure head simply; that means, which is registered by any pressure measuring device is a well representation of the head developed by the pump or the manometric now the word manometric it comes that if you neglect the kinetic energies a change in kinetic energies.

Then the head developed is simply given by the difference in p geometric head; that means, p 1 by rho g plus 0, and even if we do not neglect the elevation head now this difference in p geometric head across the pump; that means, difference in p geometric head between point d, and c can be registered if there is a manometer attached to this point, because you know a manometer reads the difference in p geometric head the manometric deflection straight forward gives the difference in p geometric head not the pressure head only difference p geometric pressure; that means, the pressured plus the change in the elevation . So, therefore, this name is given that it is manometric head.

That means the head which is being registered by a manometer manometric head. So, if we neglect the change in the elevation also by p 2 rho g minus p 1 by rho g it is not usual to connect a manometer, because the difference in head is. So, high a manometric it will require a very high height the long height or very higher value of this height of the manometric tube. So, that the pressure gauges are attached to inlet, and outlet ends, and simply the difference of pressures are read, and the difference in pressure energies will representative of the head developed by the pump.

So, we know see that h s is known as the static head, and this h 2 minus h let this is h simply h h is the head developed by the pump now if we write the bernoulli's equation at the 2 points; that means, at inlet a, and at inlets at the inlet to the pump c; that means, at the sump that the liquid point liquid at the point, and a that means, the inlet to the suction pipe that is the liquid at sump, and the inlet to the pump c.

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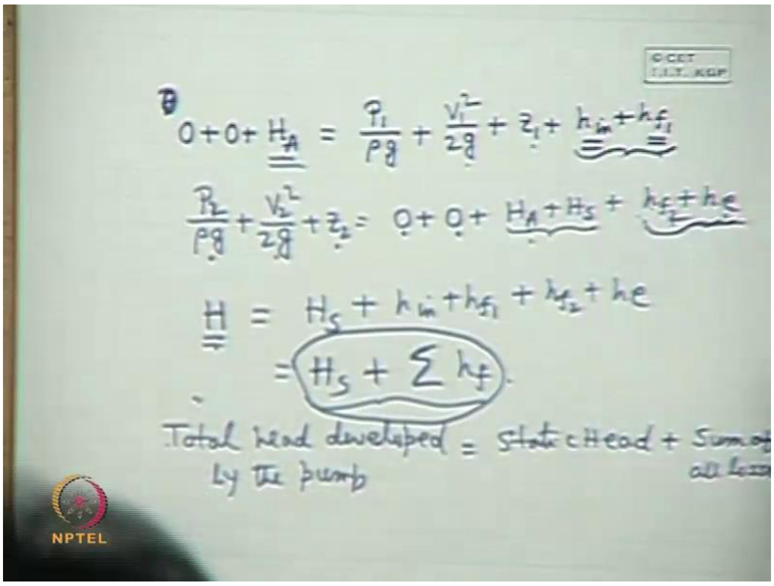

What we get we can write that this is sorry this at a pressure is 0 velocity is zero. So, only is h a you see that h a is its elevation when it comes to the inlet of the pump with our nomenclature suffix 1 is the refers to inlet p 1 by rho g V 1 square by 2 g plus, you see here z 1 that is the elevation at the inlet from the same reference datum. So, therefore, this is z 1 plus the losses h in as already we have denoted by this 2 terms this 2 terms constitutes the losses in the intake pipe at the intake of the pipe, and the total losses in the flow through the pipe. So, h in plus h f 1 is the total losses that takes place while the fluid flows from a point at the sump to the inlet to the turbine now if we inlet to the pump sorry sorry if we write the Bernoulli's equation between point d, and point f if we now write the Bernoulli's equation from point d to point f what we will get point d; that means, p 1 by rho g sorry p 2 by rho g plus v 2 square by rho g plus j 2.

If you recall the figure that z 2 is the elevation of the outlet end of the pump is, what is equal to there is no pressure free surface at the fluid at rest in the upper atmosphere upper reservoir no velocity plus h a plus h s plus the loss in the delivery pipe, which takes care of the frictional losses in the delivery pipe plus the losses in the pipe banes plus the exit loss this is the total loss that take place while the fluid flows from the outlet of the pump to the upper reservoir similarly this is the total loss that takes place when the fluid flows from the lower reservoir that is sump to the inlet to the pump.

Any query please ask me any query in this very simple Bernoulli's equation all right. Now if now if we substitute h a fro this equation to this equation, then we simply get this head developed if you just substitute this equation, and take this p 1 by rho g v 1 square by z 1 this. So, it is a very simple expression, we get h in plus h f 1 plus h f 2 plus h please tell me that whether we have got any difficulty up to this 1 I think there should not be any difficulty as far as algebraic steps are concerned, but from the conceptual point of view do you have any difficulty.

This is the energy equation that is the Bernoulli's equation between the 2 points this left hand side represents the liquid at the sump the lower. So, total energy per unit weight or head is the h a that is the elevation head this is the pressure head that inlet to the turbine velocity head at the inlet to the pump this is the elevation head this is the total loss all right similarly this equation represents the Bernoulli's equation between the 2 point that 1 is the delivery from the pump; that means, these are 2 points d, and if; that means, the point this corresponds to the point at the delivery end of the pump.

That means that the inlet to delivery pipe where this is the pressured energy per unit weight that is pressure head that is the velocity head, and that is the potential head similarly for liquid at the upper reservoir point f in your earlier diagram the pressured energy is 0 the kinetic energy is zero. So, the potential energy per unit weight datum head that is h a plus h s which is the total height of the upper reservoir from the same reference datum plus the total loss this we have already designated as these 2 losses h f 2 which takes care of the frictional losses in the delivery pipe along with the bane losses; that means, this takes care of all the losses that is incurred in course of flow in the delivery pipe plus the exit loss; that means, the exit kinetic energy which has t be lost, because the fluid has to come to rest at the upper reservoir all right.

So, if you see from these 2 equations that if you substitute h a from the above equation in terms of the pressure velocity, and z 1 the term at the inlet to be pumped, then we get a very important relation that this is this form of all the losses; that means, it is very clear, and from the simple concept 1 can tell that the head developed by a pump is equal to the static heat plus the sum of all the losses, and it is very simple, because if 1 sees this figure it says that if a fluid has to be pumped from this point; that means, from this lower reservoir sum to the upper reservoir the fluid has to gain this much amount of potential energy; that means, this much head the fluid will gain.

And at the same time a fluid has to be delivered at certain flow rate. So, to deliver the fluid at certain flow rate it has to come across through various fluid resistance the resistances in the flow path. So, that resistance in the flow path can be considered in terms of an equivalent head that is the head loss which has to be overcome to come for the fluid to come at the upper reservoir. So, therefore, this potential head at the static head that is the change or potential head between a, and m plus the head lost that is the resistance that is the resistance which has to be overcome by the fluid while flowing from this point a to a dash to be added.

And the sum of these 2 is acting as an resistance or the head that has to be developed by the pump. So, the total head developed by the pump total head we can write it is a very important formula total head developed total head developed by the pump total head developed by the pump is therefore, equal to static head. So, you have to immediately recall the terminologies, because the static head is the change of vertical height between the lower reservoir to the upper reservoir plus sum of all some of all losses you have to be very careful all losses you will have to take into account which take care which comes into the picture starting from the loss at the inlet to the suction pipe down to the loss at the exit of the delivery pipe.

So, this is the total head that a fluid has that the pump has to develop in pumping the fluid; that means, in conveying the fluid from the lower reservoir or the sump to the upper reservoir all right please any difficulty.

Student: Sir.

Any difficulty please.

Student: Sir.

Please yes from b to c.

Student: There are increase of.

The elevations of from v to c there is an increase in head due to elevation, but this 1 b to c even If there is an increase in head due to elevation the loss of h is much more than this increase in elevation. So, therefore, there is a loss in it you are correct when you write this equation you see that from b to c if I write this equation this is from a an a, and b mostly here you see that z 1 is there. So, you are very correct. So, in the equation it is taken care of. So, physically definitely when the fluid comes here fluid gains at the potential, but at the same time there is there are losses into fluid friction, and the pipe bend, and moreover the pressure here is much less than the pressure here.

Otherwise the fluid cannot flow though this, because the fluid flows from a point at the sum, because o pressure difference only, because there is no velocity you understand. So, fluid is at the lowest potential energy level at the sum all right. So, fluid pressure is atmosphere. So, therefore, here the fluid can flow or can enter into the suction pipe provided there is a pressure which is below than that of the atmospheric pressure. So, therefore, entirely in the suction pipe the pressure head is lower than the atmospheric pressure you were correct that total energy here is sum of the pressured energy which is lower than the point a or point plus the kinetic energy plus the potential energy potential energy, and kinetic energies.

These at the additive point as corresponding as compared to the point here, but the losses are much more. So, that the energy is less moreover you can argue from very simple physical concept that the energy here has to be lower than this otherwise the flow cannot be. So, in the direction of the flow energy has to decrease this is known as a commonly utilized phenomenological law; that means, the flux takes place with the negative gradient or negative potential gradient causes the flux. So, it has to. So, only here it is more this is, because the energy is added from outside.

So, when there is no energy added from outside the flux takes place with the negative gradient of the potential. So, I tell you all these things mathematically, but from simple common sense you can tell that the flow of energy takes place with the negative gradient. So, energy has to decrease in that direction of the flow, if there is no energy interactions from external source when the energy is added from outside that is why the point c is increased well time is up thank you today. So, hooks (( )) novel.