Fluid Mechanics

Prof. S. K. Som
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 26
Fluid Flow Applications Part - V

Good morning, I welcome you all to this session of fluid mechanics. In the last we started the discussion on flow meters and we, if we recall we discussed that there are three types of flow meters namely venturi meter, orifice meter and flow nozzles which work on the same basic principle. Flow meter means if you want to measure the flow rate of a fluid flowing through a fluid circuit.

Well to measure the flow rate this three flow meters venturi meter, orifice meter and flow nozzle, they work on the same basic principle that these meters provide a geometrical change to the flow of fluid usually a coaxial contraction to the path of the fluid flow. So, that the pressure drop is registered in the flow of fluid between two sections and at those two sections the pressure drop is measured by a pressure measuring instrument which is usually a manometer. Then by the straight forward application of Bernoulli's equation, we derive a equation in mathematical expression relating the flow rate and the pressure drop and flow rate is found out. So, let us discuss one by one these flow meters as the applications of fluid flow.

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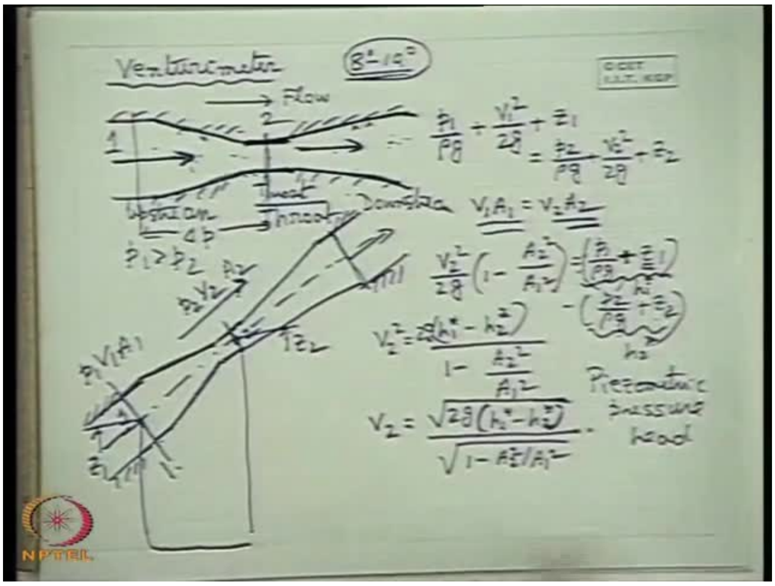

So, let us discuss first the venturi meter venturi meter venturi meter. This name of the venturi meter comes from the name of an Italian scientist Venturi. Venturi is the name of the scientist. So, a venturi meter looks like this, well it looks like this. If you draw a venturi meter it will look like this, it is like this.

That means a venturi meter consist of a convergent and a divergent. A convergent that means two conical part rather it is better to tell two conical part connected with a straight portion. Now, the characteristic feature is that one conical part is of shorter length that means this one is of shorter length, this one is of shorter length, this part whereas, another conical part is of higher length that means this cone angle is high whereas, this cone angle is low, of high length, higher length.

Usually this venturi meter is installed in the fluid flow path in this way that the flow direction is like this, this is the direction of flow. That means the shorter length part higher convergence angle is a convergent dart. Higher cone angle conical part it becomes a convergent dart that means when fluid flows these acts as a convergent data whereas the longer length part that is a conical part with a lower cone angle acts as a divergent dart. Why it is made? It is very important sometimes, it is asked in many interviews that if you are given a venturi meter two conical parts which way will you place. You will place in such a way that the fluid flow direction is such that it first goes through the shorter length that is the higher cone angle conical part and then lower cone angle conical part or the vice versa it is done like that.

This is because in this case when the flow takes place through a convergent data whether the angle of convergence is high or low, it is an accelerating flow. Why? The velocity increases, the area decreases in the direction of flow. Therefore, from the continuity the velocity increases that means this is an accelerating flow as a consequence of Bernoulli’s equation pressure decreases. Therefore, always pressure at the upstream is higher than the downstream which means the fluid is flowing in a, with a favorable pressure gradient that means the pressure force to any fluid element, this is always in the direction of the flow. In this case the separation loss as we discussed earlier does not take place that means the fluid particle near to the wall cannot flow back.

Whereas in the divergent dart when the fluid flow takes place you see from the continuity since the area increases what happens the velocity decreases and hence the pressure increases. Therefore, in the direction of flow there is an increase in pressure which means the fluid is flowing against a, against an adverse pressure gradient which means that in a fluid element the pressure forces is always in the direction opposite to the flow, but still the fluid flows because of the energy gradient.

So, in this case the fluid particles very near to the wall which looses their kinetic energy, which lose their kinetic energy because of the friction, fluid friction then cannot overcome these adverse pressure hill and they flow back with the favorable pressure forces. That means the pressure force is in this direction that is the separation loss we discussed yesterday.

So therefore, the separation loss is avoided or it is minimized if the angle of divergence in the divergent part of the flow is made very less. Usually in all design the divergence angle is made between 8 to 10 degrees. Therefore, you can make a very high convergence angle, but we cannot make a very high divergence angle whenever there is a divergent dart in a hydraulic circuit or a fluid circuit the angle of divergent should be limited to 8 to 10 degree, you understand 8 to 10 degree, so that the separation loss is minimized. This is the reason for which the upstream part corresponds to the rapid higher cone angle or a shorter length and the downstream part corresponds to a lower cone angle higher length.

Now, what happens throat is this, this section is known as throat throat T H R O A T throat, this is upstream, this is downstream section. This is throat T H R O A T throat. Throat is the minimum section, minimum section means sorry minimum area minimum cross section, minimum area section. Now, as the fluid flows through this in this direction the minimum maximum velocity occurs at the throat that is the minimum area part. This is a very short straight portion which connects these two conical part.

Similarly, the pressure here is the minimum velocity here is the maximum according to continuity pressure here is the minimum. So, if we measure the delta p between these two there is a pressure difference between these two section, let this section is 1, let throat section is 2, p 1 is greater than p 2. We measured the pressure difference and find out the flow rate. How to do it? Let us consider a practical installation. Now, let us consider this venturi meter is installed in a pipe line where the fluid is flowing, venturi meter as a instrument is installed with the flinch it is connected in the pipe line, this is a practical thing.

Now, let us consider the pipe is inclined in a vertical plane, in a general. Let us consider the most general case let this be the let this be the pipe. This is the pipe, let this be the pipe, let this be the pipe and this part is the venturi meter which is inclined to the which is sorry installed in the pipe. Pipe is inclined in a vertical plane. Therefore, this is the section 1 of the venturi meter upstream where the fluid flow is uniform then it comes to the convergent dart, this is the direction of the flow, then it attains a minimum velocity. This is the throat, let this be the axis and this is the downstream part.

So, venturi meter is installed within in the pipeline which is an inclined pipeline transporting water in this direction in a vertical plane. Now, what happens if this section is denoted as 1 and if this section is denoted as 2. Then we can write from the Bernoulli's equation between these two section let the pressure is p 1 velocity is V 1 the throat section let the pressure is p 2 and the velocity is V 2 and if we consider the z 2 as the elevation head and here z 1 as the elevation head from any reference datum then I can write the Bernoulli's equation p 1 by rho plus V 1 square by 2 rather p 1 by rho g we write in terms of the head plus z 1. Considering the in viscid fluid I can write p 2 by rho g plus V 2 square by 2 g plus z 2 without any loss that means considering the fluid to be in viscid Bernoulli's equation between this two point 1 and 2.

Then what we can write, now after this what we can write V 1 and V 2 may be connected through the continuity equation. Let us write that V 1 A 1 is equal to V 2 A 2. We can write the continuity equation where area is A 1 that is the area of the pipe which matches this base diameter of the venturi meter, the same area here A 1, but the throat area of the venturi meter is A 2. It is very simple V 1 A 1 is V 2 A 2, it is from the continuity under steady state the same flow rate passes through all sections, then if I just eliminate V 2 then what we will get V 2 is V 1 A 1 by A 2 that means we can write V V 2 is V V 1 is V 2 A 2 by A 1. Therefore, we can write V 2 square by 2, g V 2 square by 2 g we take here 1 minus what is V 1? A 2 square by A 1 square that is V 1 is equal to P 1 by rho g plus z 1, let this minus p 2 by rho g plus z 2.

Let us define this p 1 by plus z 1 as h 1 star and this is defined as h 2 star. So, we can write V 2 square is h 1 star minus h 2 star, this is h 1 star, this is h 2 star, 2 g of course, 2 g into 1 minus A 2 square by A 1 square, alright or we can write V 2 is equal to root over 2 g h 1 star minus h 2 star divided by root over 1 minus A 2 square by A 1 square. This is very simple. Now, this is very simple algebraic steps, but this h 1 star and h 2 star represents the pressure head plus the datum head at the inlet and this is the pressure head plus the datum head. This as a whole is known as piezometric pressure head.

Piezometric pressure we have already discussed what is piezometric pressure that takes care of both the pressure plus the corresponding equivalent pressure due to a static pressure due to the height of the liquid. That means in terms of head, it is the pressure head, pressure energy per unit weight plus the datum head that means due to the height of the liquid from any arbitrary datum.

So, combination of p 1 by rho g plus z 1 is the piezometric pressure head. So, we can write in terms of piezometric pressure head. Why we write in terms of this? There is a meaning to it, mathematically here it may not be very meaningful that why unnecessarily we are writing h 1 let us better recognize p 1 by rho g p 2 by rho g separately with z 1 z 2 the elevation at 1 and 2, no, it should be written in terms of this. This is because in fact what is done we attach a manometer between this two points to to register the pressure difference.

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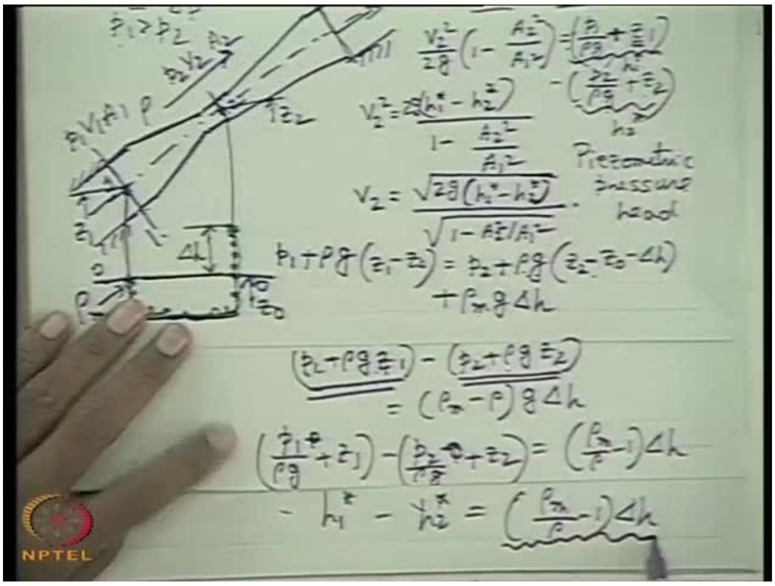

Now, let us consider any manometric liquid since p 1 is greater than p 2. Therefore, the manometric liquid will manometric liquid will take a position like that where this, this is the deflection delta h. Now, if I write the manometric equation and consider the manometer, manometric fluid density as rho m, consider the manometric fluid density as rho m, alright. Consider this as rho m then we can write the manometric equation considering here the pressure p 1 now we write again if we recall the hydrostatics that p 1 plus here the rho, rho is the density of the working fluid that the fluid flowing through the pipe and the venturi meter g into z 1.

Let we consider this level as the level 0 0 where or O 0 0 where we are finding out the pressure from both the sides and equating it and let the elevation is z 0, it is easy if we just define the elevations like that from a reference datum to find out the height. That means this height is z 1 minus z 0. So, this is the pressure from this side. What is the pressure from this side is equal to p 2 plus rho g z 2 minus z 0 minus delta h, z 2 minus the elevation head minus z 0 elevation head this one minus delta h minus delta h.

So, this is the pressure head due to this plus this one plus rho m g delta h. Well, if you now write it, it will be like this p 1 minus p 2 is equal to so rho g z 0 and rho g z 0 will be cancelled. So, rather not p 1 minus p 2, I am very sorry my entire objective is different. So, it will be p 1 plus rho g z 1, I am sorry. So, it will be now p 1 plus rho g z 1. So, rho g z 0 rho g z 0 cancels minus p 2 plus rho g z 2 is equal to this and here also rho g delta h that means rho m, this already we recognized earlier delta h that means p 1 plus rho g z 1 and p 2 plus rho g z 2 these are the piezometric pressures not the static pressure.

This is the static pressure or the pressure this is the piezometric pressure plus the equivalent pressure for the height z 1 z 2 measured from any arbitrary reference datum. So, if you divide it by rho g in terms of head that is p 1 by rho g sorry plus z 1 minus p 2 plus p 2 by rho g sorry p 2 plus rho g plus z 2 is equal to then rho m by rho minus 1 delta h which means that the difference in piezometric pressure head is nothing but rho m by rho minus delta h. So, now this rho m minus rho by delta h is ultimately replaced here h 1 star minus h 2 star, that means if we write, if you replace this, if you just recall this equation…

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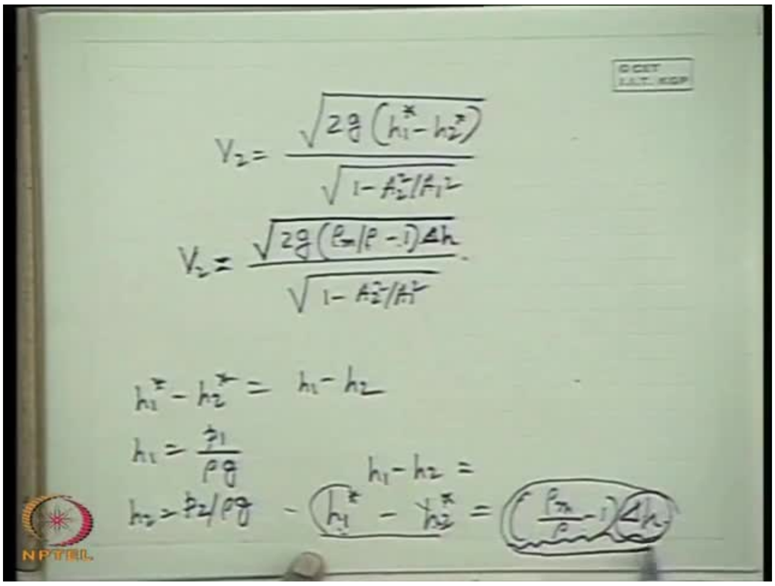

This becomes V 2 is equal to root over 2 g, again I am writing this h 1 star minus h 2 star by root over 1 minus A 2 square by A 1 square. We write V 2 is equal to root over 2 g h 1 star minus h 2 star is rho m by rho minus 1 into delta h and they are root over 1 minus A 2 star by A 2 star.

Now, thing is that when the venturi meter is horizontal that means this pipe is horizontal and venturi meter is horizontal, in that case what will happen h 1 star minus h 2 star is h 1 minus h 2 where h 1 is equal to p 1 by rho g and h 2 is equal to p 2 by rho g. That means z 1 z 2 is different and in that case delta h into rho m by rho minus 1 will give you the value of h 1 minus h 2 which means that if you write the equation for V 2 in terms of the deflection of the manometer then it is (( )) whether the venturi meter is inclined or horizontal.

This is a very important point, but if you write the equation in terms of p and z 1 then it is very important because whether z 1 z 2 will be cancelled or not it is very important, if you write here instead of h 1 star h 2 as p 1 by rho g plus z 1 p 2 by g because in that case h 1 star minus h 2 star is not always p 1 by rho g minus p 2 by rho g, if it is a horizontal h 1 star minus h 2 star is h 1 minus h 2 then p 1 by rho g minus p 2 by rho g.

Otherwise, it will be p 1 by rho g plus h 1 minus p 2 by rho g plus h 2, you have to be very careful whether it is inclined or horizontal, but if you straight forward write the V 2 formula in terms of the deflection of the mercury then it is immaterial because the manometric equation which we discussed earlier is such that if it is written in terms of the deflection of the manometric fluid then these equation represents the difference of piezometric pressure between the two points between which the manometer ends are connected.

So, whether there is the horizontal plane or is displaced vertically it does not matter. Ultimately these value gives the difference in the piezometric pressure that means difference in static pressure plus the equivalent pressure due to the elevation head. Therefore, it is immaterial whether the venturi meter is horizontal or not pipeline is horizontal or not if you use this equation, alright. Now, if I write these equation again.

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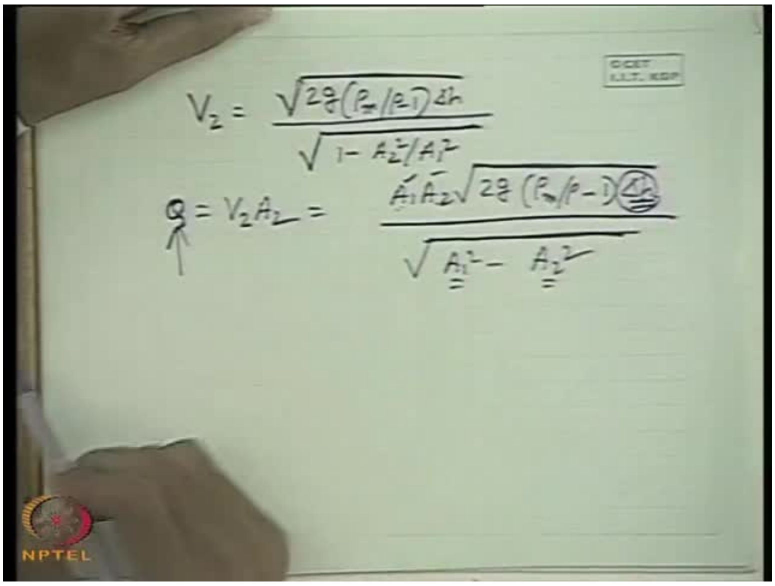

What we get? We get V 2 is equal to root over 2 g. So, this is a very very important conclusion, sometimes it is asked even in the interviews that will you be very careful if the venturi meter installation is not perfectly horizontal. The answer will be no because if I write the expression in terms of the mercury deflection in a manometer, if the mercury is the manometric fluid deflection of the manometric fluid it becomes the same equation.

So, now this is the value of the V 2 therefore, the Q will be flow rate will be V 2 into A 2 if you recall the A 2 is the area where the V 2 was found out, that means this is the throat area A 2 where the velocity is V 2 of flow rate is velocity into the area. So, that means A 1 A 2 if I simplify then root over 2 g into rho m by rho minus 1 into delta h divided by root over A 1 square minus A 2 square.

Now, see that I can find out the flow rate if I know the area of the venturi meter. That is venturi meter inlet and throat diameters are known because it is known from the geometry of the venturi meter and if I know the deflection of the manometer that means if a manometer is connected between two points. So, the measuring value is delta h which is put into these equation to find out the flow rate, but this equation will always overestimates the actual flow rate.

If one measures the actual flow rate for example, there is a opportunity, there is an opportunity to measuring the actual flow rate by collecting the fluid then you will find that by utilizing this equation with the measured values of delta h from the manometer deflection will always overestimate this flow rate. The reason is such that these equation has been developed considering the fluid to be in viscid.

So therefore, this pressure difference delta h manometer difference or the pressure difference is the pressure difference for the in viscid fluid, but the actual pressure difference which is registered in the manometer is more than that of an in viscid fluid. Now, try to understand this physically. Why there is a pressure difference for an in viscid fluid? This is because in of the difference in velocity. So, velocity difference because there is a difference in area. So, due to the change in area, there is the difference in velocity or change in momentum.

So, due to this change in momentum or change in velocity there is a change in pressure is a mutual conversion between pressure energy to kinetic energy or kinetic energy to pressure energy, whatever you call, but in that means for example, here the kinetic energy is increased. Therefore, the kinetic energy is decreased increased at the expense of pressure energy, pressure energy is decreased.

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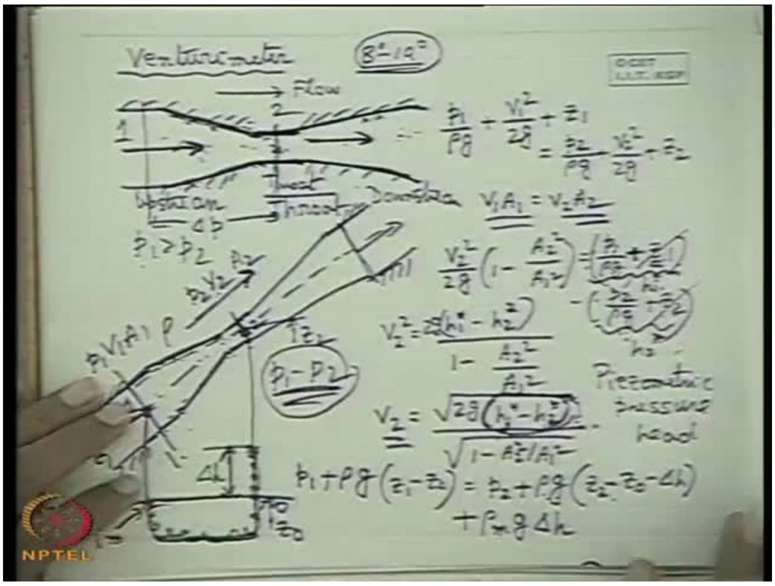

So therefore, the decrease in pressure energy that is p 1 minus p 2 will depend upon the increase in kinetic energy, but for real fluid over and above there will be an additional pressure drop because of the fluid friction. Friction between the fluid and the solid surface therefore, the pressure drop p 1 minus p 2 will be more. The p 2 will be still lower than p 1 not only because of increase in velocity, but also because of the fluid friction loss. Therefore, actual pressure drop in a real fluid in this situation is more than that what is estimated by a, by an in viscid fluid.

So therefore, delta h is more than actually what it could have been for the use of this formula. This formula is determined by considering the fluid to be in viscid. Therefore, Q is giving a higher value.

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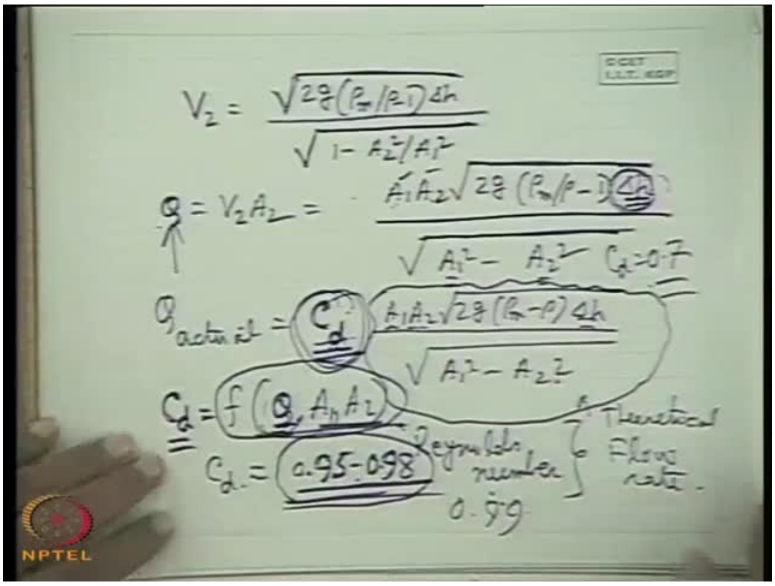

So, for that we write that Q actual, this is adjusted by multiplying this with a coefficient that is known as coefficient of discharge. So, coefficient of discharge is now very clear. So, this is known as that means if we calculate from this formula, the flow rate, this gives you a higher flow rate; this is sometimes known as theoretical flow rate. That means flow rate which is calculated by considering the fluid to be in viscid, but substituting the pressure drop from the real fluid measurement.

So therefore, this gives a higher flow rate. So, this is multiplied by a coefficient of discharge C d and this coefficient of discharge depends upon the flow rate depends upon the area A 1 and A 2 of the venturi meter, that means venturi meter geometry and flow rate, but this dependency is very very weak and at a higher flow rate usually C d becomes constant and it depends upon mainly the Reynolds number of flow which I will tell you afterwards, you do not know this thing, when you will start the viscous flow Reynolds number, you will see that there is a number known as Reynolds number, dimensionless number, characterizing the viscous flow depends upon mainly the Reynolds number.

But you must know at this stage that higher flow rate for all venturi meter and within all ranges of flow C d is virtually constant and lies between a value of 0.95 to 0.98 that means it is very very high. Usually it is made of brass the venturi meter and surface is so polished that the friction between fluid surface and the solid is so low so 0.95 to 0.98, this value of C d.

Now, the only job for measuring the fluid flow by a venturi meter is to calibrate the venturi meter. What is the calibration? Calibration means to know accurately the value of C d. How do you know the value of C d? I give you a venturi meter and tell you use the venturi meter, the venturi meter C d value is 0.99, you may doubt actual the venturi meter which I have given so rough surface and so badly designed it is value of C d is 0. 7 so there will be a tremendous discrepancy in the result if we use 0.9 as C d and 0.7. So, what you do?

You calibrate the venturi meter. What is meant by calibration? You find out the value of C d that means you find the flow rate by any other measuring device which is more accurate than the venturi meter which is usually a direct collection of flow in case of an hydraulic circuit, then you measure the flow rate and you find out the value of C d with known values of A 1 A 2 and delta h and you find out that in a range of flow rate where you measure your flow rate what is the value of C d and then you establish a relationship between C d and flow rate which is usually done for C d and Reynolds number, this relationship to establish is known as calibration of venturi meter, which is very important. That means to find out the exact or accurate value of C d to use the venturi meter to find the flow rate from this equation, alright.

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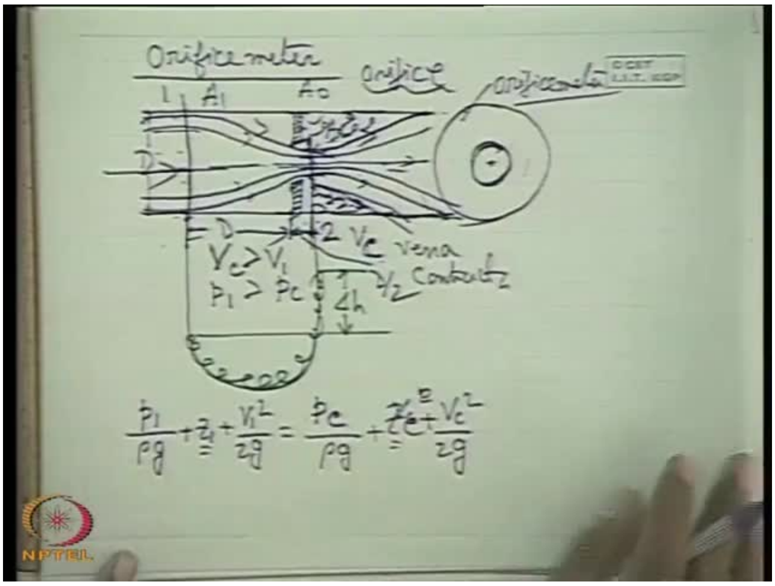

Now, let us see the next one is the orifice meter. Now, when the venturi meter is well understood orifice meter will not be a problem. Orifice meter is like this, a orifice meter is a orifice plate, that is a plate with a hole at concentric hole at the centre. Now, we consider a pipe, the orifice meter is like that. Let me draw a orifice meter with a, orifice meter is like this a little beveled side. So, this is an orifice meter. So, orifice meter if you see so this will be a circular plate. So, this orifice meter with a concentric hole.

So, this is simply a circular plate which have a thickness which is very thin and a sharp edged orifice with little beveling like this which is known as orifice meter, this is orifice meter. It is very simple in seeing you see a plate, a plate circular plate, a thin circular plate with a concentric hole within it, a sharp edged concentric hole which is known as orifice. So, this sharp edged hole is known as orifice. So, this is an orifice.

So, this is placed in a pipe. So, this gives when it is placed in the pipe where there is a flow and flow has to be measured what happens? This gives an obstruction to the flow. So, what happens is the fluid streamline behaves like this and there is a vena contracta as I have already told you so these are the streamlines. These are the streamlines. So, this is one streamline centre of so these are the streamlines.

So, what happens streamlines contracts because now there is an area contraction that means this placing this orifice meter by flinch we place the orifice meter between the pipeline connections to pipeline connection then what happens these provides a coaxial contraction to the path of the fluid then fluid streamlines of the fluid flow just contracts and then they form a vena contracta, that is the area minimum cross sectional area section which is very close to the orifice orifice plate that means flows downstream. So, this is the vena contracta vena contracta.

Now, what happens if we take a section here and if we take a section here, if this section is 1 and let this section is 2. Let us consider the area of the pipe is A 1, let us consider the area of the orifice in the orifice meter plate is A 0 A 0. Now, this area let us consider A C. A C is less than A 0 this is a vena contracta area. Now, you see that V 2 will be V 2 or V C, this section 2 V is V C. V C is greater than V 1 or less than V 1? V C is greater than V 1 because this is the maximum velocity with the minimum area and p 1 is greater than p C, p C is less than P 1. So, if we attach a manometer within this then the manometric fluid will behave like this.

So, you take this as the delta h. Here also now if you write the Bernoulli's equation between these two points you can write that p 1 by rho g again if there is an elevation head at 1 and 2 p 1 by rho g plus z 1 plus V 1 square by 2 g is equal to, if I write now one tapping is made at this upstream portion where the fluid is almost uniform fluid flow that means usually this is made 1 diameter upstream if D is the diameter of the pipe, 1 diameter upstream from the orifice plate and usually this is made, this should be made theoretically at the vena contracta section, but it is very difficult to realize the vena contracta section.

Usually it is made at D by 2 this tends downstream from the orifice plate. It should not be far away from the orifice plate, in that case a delta p, a high value of delta p is very difficult to be registered because fluid flow area is again expanding. Therefore, the pressure is again increasing, you understand.

So, this part is the A D portion as you know, when the expansion is taking place fluid is expanding, that is the diverging, streamlines are diverging there are the flow reversal zones. Therefore, you now recognize that this portion if we can attach the manometer at the vena contrata section we can get the maximum pressure drop. If we attach the manometer here we will get a pressure drop which is equivalent to frictional pressure drop because pressure drop pressure drop due to momentum change will not be able to capture.

Therefore, it should be at the vena contracta section. So, another connection, but it is difficult to realize where the vena contracta takes place. So, it is usually made at D by 2 distance downstream from the orifice plate. So, let this section is 2 so this two sections better I replace as C section because this is the contracted section p C by rho g plus V C square by 2 g rather z C z C if there is a elevation head difference z C plus V C square by 2 g considering the fluid to be in viscid. So, from this we can find out that V 1 minus V C again the same thing is there.

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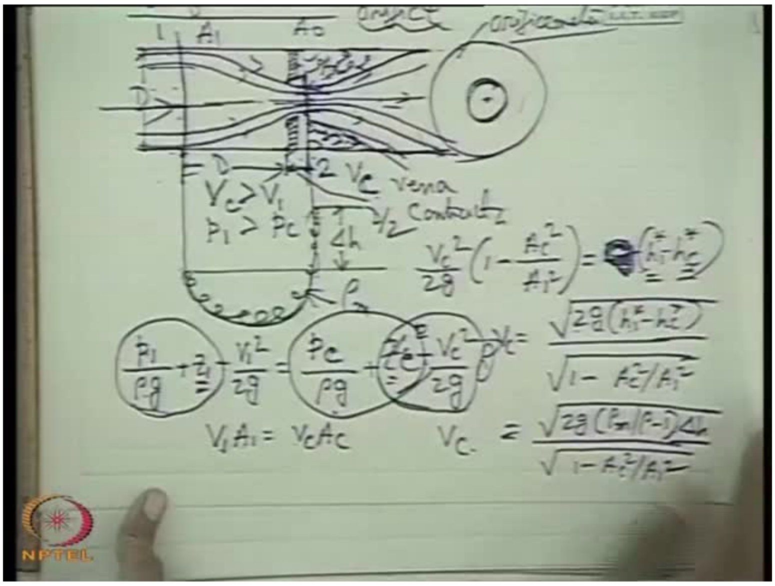

If you write V 1 A 1 is equal to V C A C. So, you just write in terms of V C then we can write it here that V C square by 2 g V 1 square by 2 g V C, V 1 is V 1 A 1 V C A C by A 1 that means V c square by 2 g similar way 1 minus V 1 is A C. A C square by A 1 square you follow it with the similar philosophy is equal to 2 g into p 1 rho g that means I write h 1 star minus h C star, what is this? This is the piezometric pressure head at the section 1, this is the piezometric pressure head at the section C.

So, that means V C is equal to root over sorry root over 2 g h 1 star minus h C star divided by root over 1 minus A C square by A 1 square, alright. Now, again h 1 star minus h C star from this manometer equation if rho m is the density of the manometric fluid will be equal to root over what is this 2 g h 1 star 2 g the same thing rho m by rho minus 1 into delta h that means in terms of the deflection of the manometric fluid in the manometer, this will measure the h 1 star minus h C star. If there is a, if this is horizontal so z 1 and z C equal so h 1 minus h 1 star minus h C star simply h 1 minus h C that means oh sorry, I am sorry, so, these two that means this is p 1 by rho g minus p C by rho g. It is as simple as that divided by root over 1 minus A C square by A 1 square.

Now, this is V C, alright. Now, one step further that again with the same logic here itself I multiply with a coefficient, why? Because if I substitute delta h from the practical measurements that measurement for a real fluid then this is more than what one can expect for an ideal fluid. Therefore, V C estimated is more, it is over estimated.

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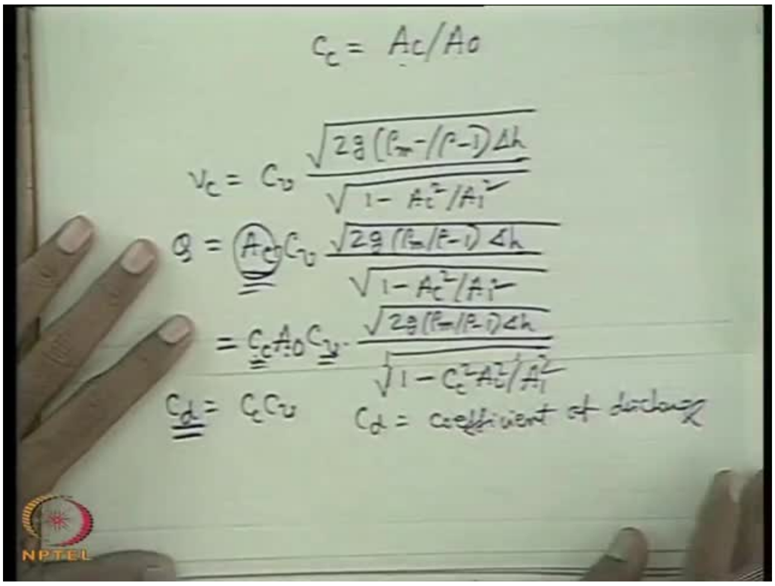

So, V C is corrected with a coefficient. So, this is known as coefficient of velocity that means C V into root over 2 g rho m by rho minus 1 into delta h root over 1 minus A C square by A 1 square.

So, this is the velocity, expression of the velocity. Now, if you find out Q? Q is equal to now this area. Now, you see V C is this area that is the A C that is the area of contraction that is Q is equal to A C into C V into root over 2 g rho m by rho minus 1 into delta h divided by root over 1 minus A C square by A 1 square, alright.

Now, A C we can replace as what is A C? C C into A 0 because we define the coefficient of contraction at A C by A 0 that means as you know earlier also we define a coefficient of contraction that is the ratio of the area at the vena contracta to the geometrical area of the orifice or the aperture. So, this is A C by A 0. So, this can be written as all now I express in terms of the geometrical area which we can measure, we cannot measure A C, but we know the orifice plate diameter that means diameter of the orifice in the orifice plate. So, C C A 0 times C V into root over 2 g rho m by rho minus 1 delta h into root over 1 minus A C is C C square A 0 square by A 1 square. So, this is the simple equation, alright.

Then C C into C V we replace as C d. So, we define C d as C C into C V. C d is the coefficient of discharge, C d is equal to coefficient of discharge, discharge. So, if I write this as C d then we can write this I can write now you see this.

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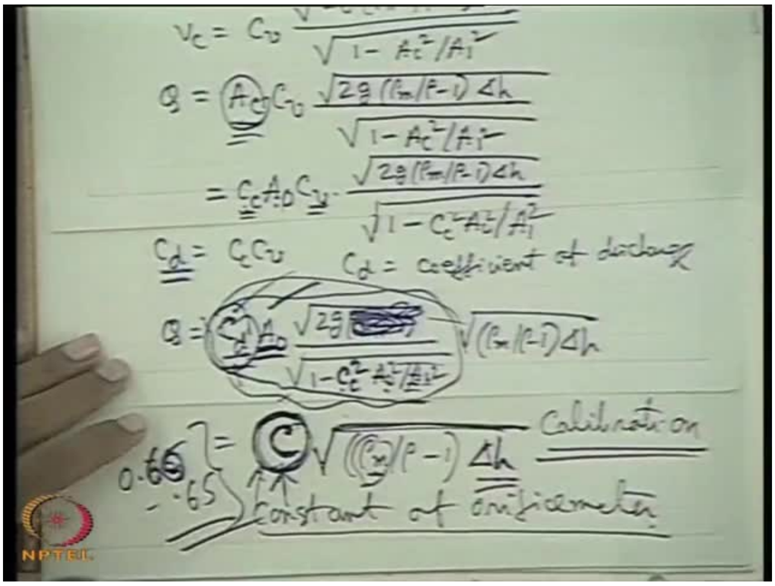

Q is equal to C d A 0 into root over 2 g rho m root over 2 g rho m by rho minus 1 divided by root over 1 minus C C square A 0 square by A 1 square rather this part I take out into root over rho m by rho minus 1 into delta h, alright. Now, this part is fixed for a orifice meter if I know it's value of C d, if I know the value of A 0 that is the orifice diameter of the orifice meter that the diameter of the central hole of the orifice meter 2 g 1 minus C C, if I know the value of C C for this orifice meter A 0 A 1 if we know, this can be written as a constant, all this thing times this one.

This one is varying depending upon the manometer that means depending upon the manometric fluid the rho m value will depend upon the manometric fluid used and the deflection of delta h that means this C is known as constant of the meter, constant of orifice meter which is a function of the geometry of the orifice meter. And its value C d C C which is again a function of A 0 A 1 and the flow rate. A 0 A 1 and the flow rate that means diameter of the orifice meter, diameter of the orifice of the orifice meter, hole that means diameter of the orifice in the orifice meter, diameter of this that means the area of the pipe in which the fluid is flowing and the values of C d C C.

So, this is a purely constant for a given orifice meter of a given pipe diameter and in a given range of flow usually at a higher range of flow it is independent of the flow rate so if I know the value of C that means the constant of the meter then I can find out. So, now in using an orifice meter the main or the pivotal job is to find out accurately the value of

C at different flow rate. So, that if I use orifice meter I can immediately find these value from my manometer, if I know the manometric fluid I can find out rho m, but when I will find out Q from here I must know the value.

If the orifice meter constant is given I do not bother with all these equations root over 2 g by root over 1 minus C C square I simply multiply it, but what I must know? I must know very accurately the value of C and to know very accurately the value of C is or to establish an accurate value of C within a range of flow is known as calibration of orifice meter. So, this is very important a calibration of orifice meter before it use.

So, usually the value of C for orifice meter, actually, it is value of C d for orifice meter varies between whether we can write the value of C considering this things A 0 A 1 usually in the range varies from 0.75 to sorry 0.65 0.60 sorry to 0.65, 0.60 to 0.65. This is the value of C d for the orifice meter. Alright, now we come to flow nozzle well.

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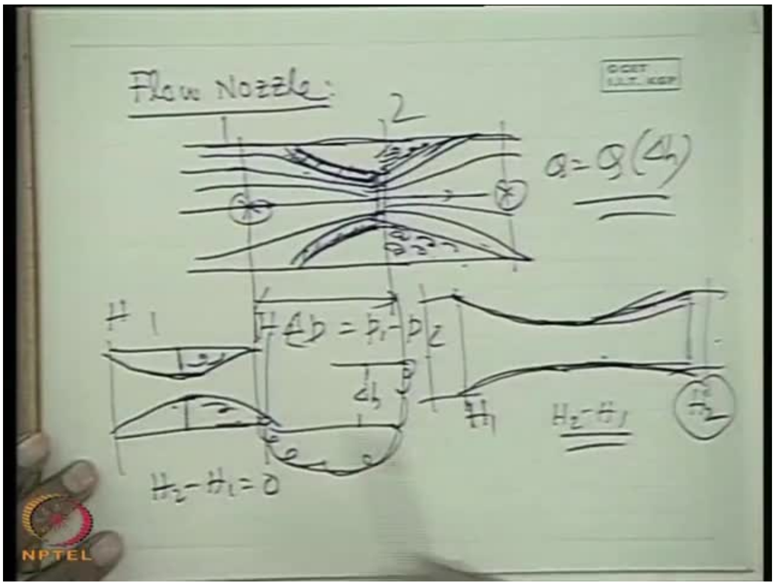

Now, we come to flow nozzle. Flow nozzle is a intermediate thing between these two. Now, flow nozzle is like that, it is like a nozzle that means in the pipeline you just provide a nozzle like this, you just provide a nozzle like this that means if you see the sectional view it will be like this. A nozzle, a nozzle is attached to the flow that means what happens it is unlike the orifice meter the, there is a converging part. So, streamlines are smoothly converging but what happens unlike the venturi meter also this part is not a diverging one so it cannot smoothly diverge.

So, streamlines goes like this. So, so streamline goes like this that means this is the streamline pattern and there will be eddy formations, more eddy formation, more losses will be there. So, this is a flow nozzle. So, if we make a connection just at the downstream of the nozzle and somewhere here in the upstream we get a pressure drop delta p. Let this section is 1, this section is 2. So, delta p is p 1 minus p 2, if this is registered by a manometer same thing delta h we can find out the flow as a function of delta h, same philosophy.

But here you see the flow nozzle the losses are more for the venturi meter, why? Because this part there is no, in this section there is no divergent part. So, fluid stream after converging smoothly along the surface they diverge like this. So, that the formation of eddies takes place due to separation losses.

Therefore, in this case the total energy loss in case of this that means if we have a total energy here, the total energy loss will be more, but this is counterweighed by its lower cost whereas, in case of a venturi meter, if you recollect in case of a venturi meter if you go like this, the energy loss from a upstream section to downstream section is very low because usually the separation loss is minimized. And this angle is very small. So, only frictional losses predominates and that too the surface is so polished so the friction loss is very small. Nevertheless, there will be losses, but H 2 is very less than, the difference between H 2 minus H 1 is very small.

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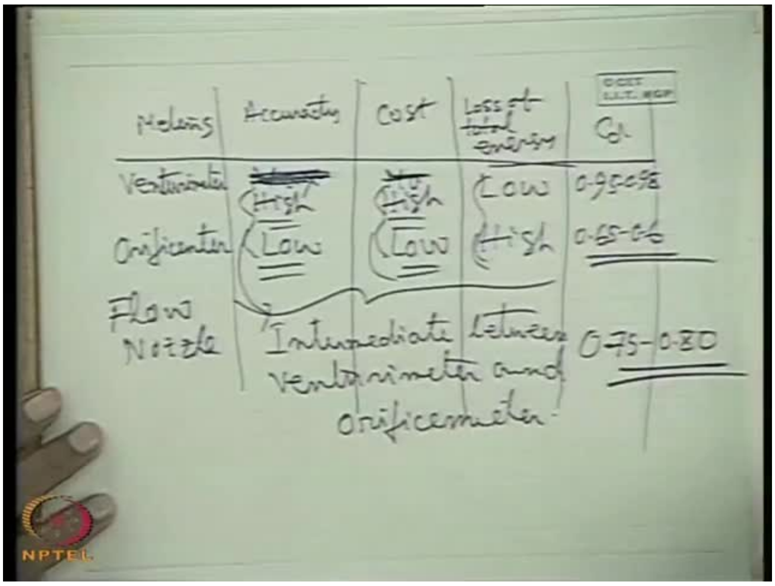

So, energy loss is very small. Wherever, whereas, in case of an orifice meter the energy loss is tremendous because it abruptly contracts and makes the vena contracta and then again it diverges. So, the energy loss that H 2 H 1 and H 2 is maximum in case of a orifice meter, but it is the cheapest. So, it is the costliest, it is the cheapest, energy loss is minimum, energy loss is maximum and this falls in between the two.

That means if we compare the instrument you see the meters, then you cause the accuracy and then you tell the cost, then you tell the loss of total energy, loss of total energy and then the value of C d. Then first you write the venturi meter. Venturi meter accuracy is maximum, cost is also not maximum you write high, cost is also high to make a venturi meter and the length is very high in the divergent part made of brass. So therefore, it is cost is very high, loss of energy is very low and C d value 0.95 to 0.98.

Similarly, orifice meter is other end, other extreme. Accuracy is very low, cost is also low. So, these two are compatible. So, loss of energy is very high and these value is 0.65 to 0.6 and flow nozzle or simply nozzle, flow nozzle this is intermediate between this two, intermediate between this two. That means I can write intermediate both all these three columns intermediate between intermediate between venturi meter and orifice meter and venturi meter and orifice meter I am sorry for handwriting is bad and the value of this also C d lies between 0.75 to 0.80, alright.

Thank you for today.

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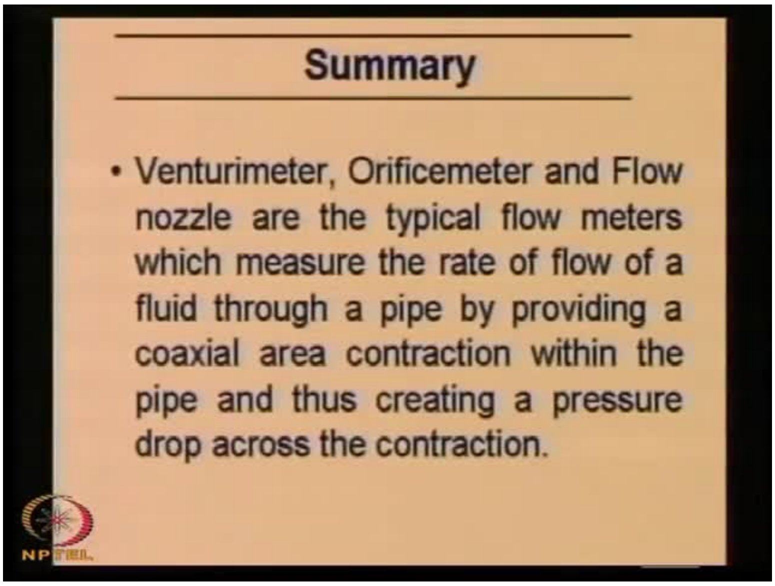

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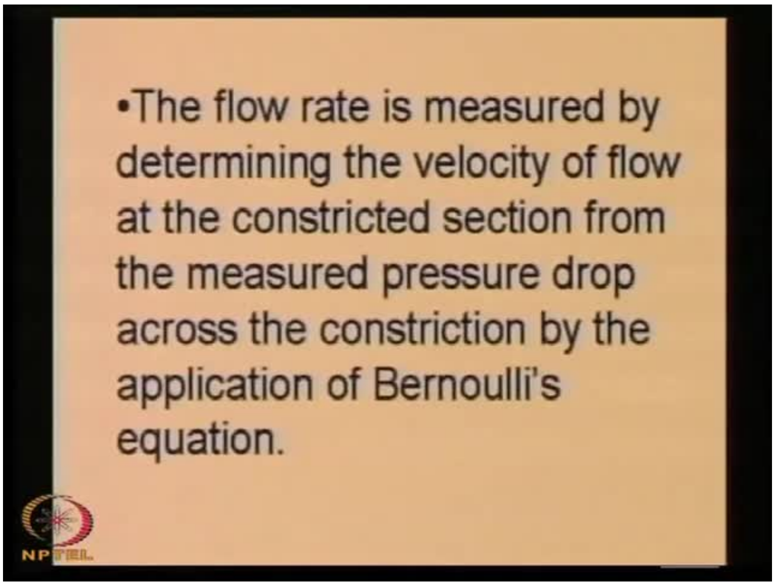

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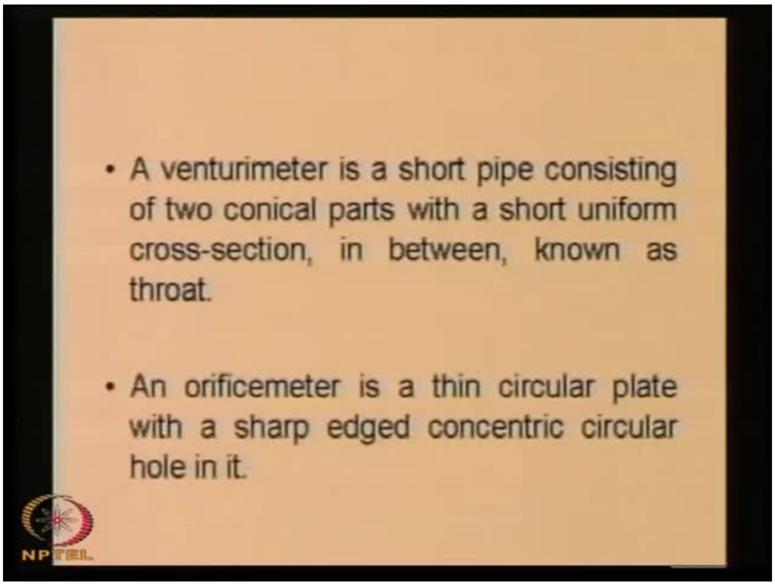

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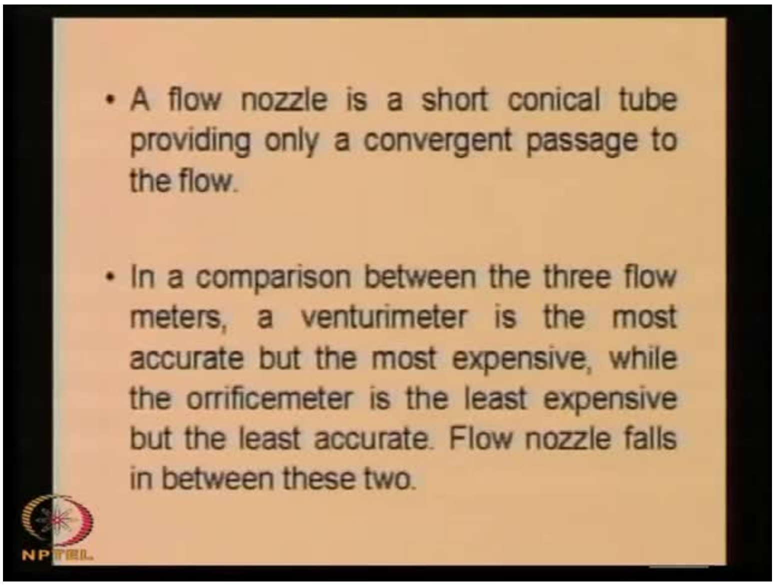

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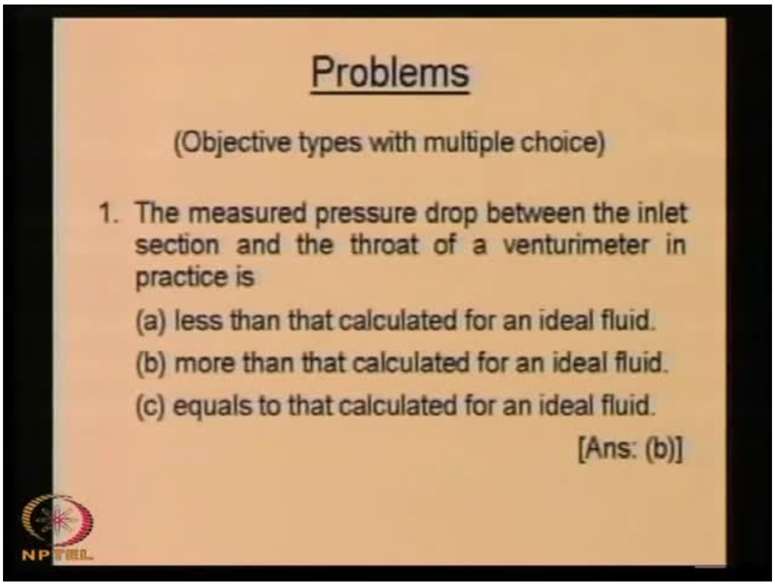

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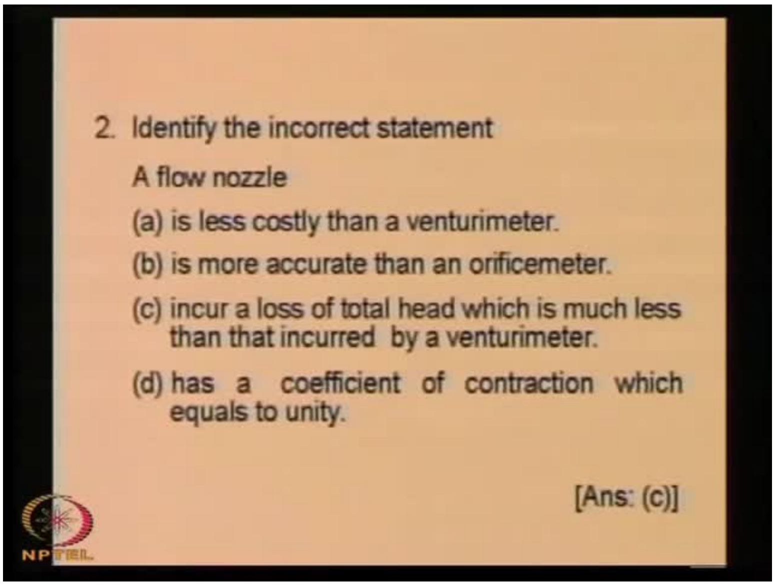

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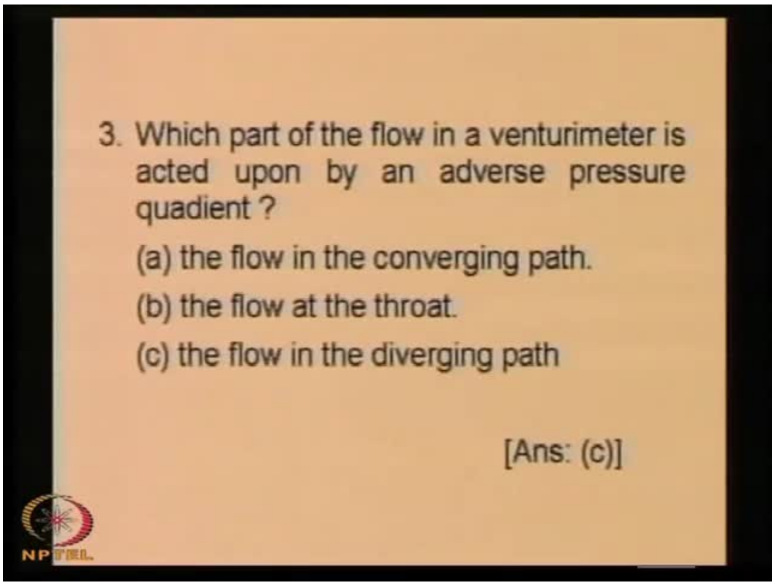

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