# Fluid Mechanics

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## Lecture - 25
## Fluid Flow Applications Part – IV

Good morning, I welcome you all to this session of Fluid mechanics. Well, today we will be discussing about the losses due to geometric changes, losses due to geometric changes. Well now before discussing this topic, you must start with this, at the outset we must say like this, that we have recognized that when there is a flow of a real fluid through a duct, then we know the flow takes place from a higher energy to a lower energy level. Energy gradient is the potential gradient for the fluid flow that means upstream the energy is more downstream the energy is less mechanical energy.

So, now in a situation where there is no additional mechanical energy into the fluid flow and no taking upper withdrawal of energy. Then mechanical energy decreases by virtue of certain energy conversion mechanism, where a part of the mechanical energy is being converted to other form of energy, which we call it as loss, when our attention is mainly focused on mechanical energy. This thing I am telling again and again in almost many classes, all classes and many other classes, because this is very important thing. Therefore, a fluid flows in those situations where there is no mechanical energy is added from outside to the flow or taken from the flow to the outside. Then mechanical energy decreases in the direction of flow, and this decrease in mechanical energy is known as energy loss.

So, one of the very important factors for this loss, how the loss takes place? Who is responsible for this loss? This is because of the fluid friction, that is, this is because of the friction between fluid layers. Finally, between the solid surface and the fluid layer, friction between the solid surface and fluid layer, which converts a part of the mechanical energy into intermolecular energy. So, the loss takes place because of the fluid friction, and this is the friction between the fluid and the solid surface, so this happens for all real fluid because all real fluid possess friction between fluid layers, which is the viscosity of the fluid and between fluid and the solid surface.

Now, there are certain instances, where even if we neglect this friction. For example, if very short duct is there, so that the friction mechanism is there, but the surface area area of contact because the frictional force depends upon the areas area of contact. The area of contact is such that the total frictional energy loss, energy loss in friction is very less or surface is very smooth or fluid having a very low viscosity whatever may be the thing, in those cases the frictional loss may be small.

But we have found out that there are other type of losses apart from the frictional losses that take place when the flow of a fluid, the path of the flow of a fluid is suddenly changed. This happens when the geometry of the duct through which the fluid is flowing is changed abruptly. For example, the fluid is flowing through a cross-sectional area of the duct the cross-sectional area is slightly increased or slightly reduced or there is a immediate change in the direction of the duct.

So, if there is a change in the geometry of the duct a sudden change, there is a sudden change in the path of the fluid flow. This causes a loss in energy that means a part of mechanical energy is lost and those losses are known as losses due to geometric changes. In this class we will study two of such important changes. Two two of such important cases of losses due to geometric changes, these are losses due to sudden enlargement; that means the cross-sectional area of the duct is suddenly enlarged or abruptly increased in the direction of the flow.

Another one is losses due to sudden contraction; that means when the fluid is flowing through a duct of cross-sectional area, the duct area is suddenly reduced. So, or contracted so losses due to sudden or abrupt enlargement and losses due to sudden or abrupt contraction of the duct cross-sectional area through, which the fluid is flowing. These are termed as losses due to geometric changes and also these are told as minor losses. The philosophy of minor losses is that in a long pipe, it has been found when in real situation the fluid flows through a long duct long pipe, sometimes the cross-sectional area of the pipe is suddenly increased or cross-sectional area of the pipe is suddenly decreased or the pipe is bend.

It has been found losses due to these geometric changes are usually small, compared to the total loss because of friction. Only in real situation it happens, so because the friction loss is much more because of the long length of the pipe compared to those losses due to geometric changes. This is the reason for which these losses are termed as minor losses whereas, the losses due to fluid friction between solid surface and the fluid is known as major losses.

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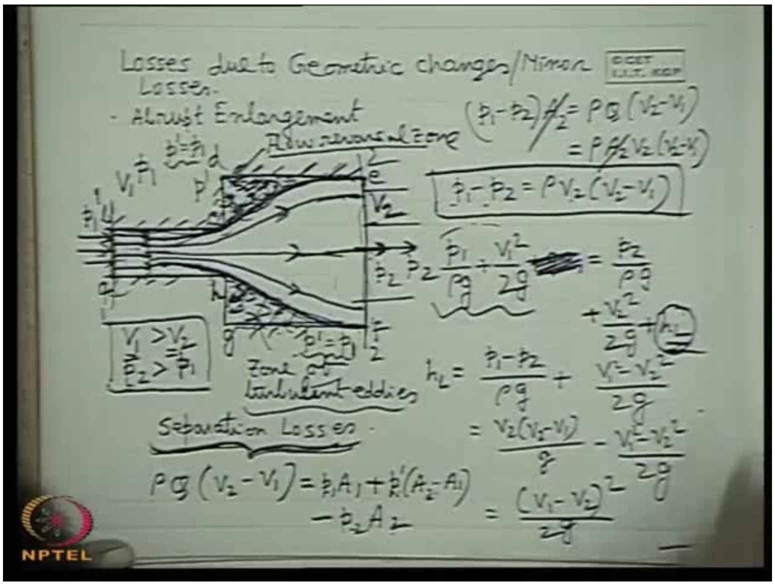


So let us now concentrate on losses due to geometric changes, losses due to geometric changes, geometric changes or these as known as minor losses. First we consider abrupt enlargement, abrupt enlargement, the losses due to abrupt enlargement. What is the problem? Let us physically understand the problem losses due to abrupt enlargement. Let us consider a duct like this and it is enlarged abruptly like this, it is abruptly enlarged like this.

Now, let the fluid flows in this direction, let the fluid flows with an initially uniform velocity, all right? Uniform velocity at this section, let this section is one at this section at this section the fluid flows with uniform velocity. Let this this is the section where fluid flows with uniform velocity V 1, let us consider V 1 through this duct. This is the duct now. The duct is suddenly enlarged to a higher area. So, what will happen the streamline, which is now fluid as in an uniform velocity for an ideal fluid or for a viscous fluid? Now here we consider a viscous fluid because these losses take place only for viscous fluid. That I will explain now, but initially we considered the fluid approaches here with a uniform velocity.

Now, therefore what happens? The fluid stream cannot take the abrupt change in the cross section like this because of their inertia, so the streamline gradually takes a shape like that and fills up this tube like this. So, this is a typical streamline, I am showing. This may be one streamline, this may be other streamline. So, these are the typical streamlines of the flow. Steady flow we consider, so it goes like this. Let this is, let we consider a section here at 2 and let us consider a section here at 1. So, fluid approaches with an uniform velocity V 1 with a pressure p 1.

After expansion in this enlarged section at some distance, downstream fluid attains a uniform velocity going out with V 2 and let the pressure is p 2. It is a long duct, closed duct. Now, this is the situation that streamline takes place it diverges like that. Now, very simple thing, first is that the cross-sectional area at one is less than 2. Therefore, according to continuity V 1 is higher than V 2 obviously because V 1 a 1 is V 2 a 2 because the same volume flow rate of fluid should pass, that what is coming in should go out under steady state. So, similarly p 2 is greater than p 1.

Since, the velocity here is lower pressure here is more. Therefore, the fluid is flowing from a lower pressure to a higher pressure, but I told you earlier emphatically that fluid flows from a higher energy to lower energy. Fluid may flow from a lower pressure to higher pressure, but the total energy at this section 1 1, is much more than the 2 2 or more than the 2 2. That difference is lost while during the flow. Now, this is the situation that fluid is flowing from a section one to a section two, where the velocity at section one is more than that at two and the pressure is at section one is less than that at two, all right?

Now, we consider that what happens when the fluid cross-sectional area, fluid flow cross-sectional area, that is the cross-sectional area of the stream tube diverges? So, when it is diverging, what happens it is found in practice that this areas in this corner, there is a flow reversal zone. That means the fluid particle goes on flowing in the back direction. This is the flow reversal zone. This zone is the, this zone is the flow reversal zone and this zone create a same zone turbulent eddies. That is why this is known as zone of turbulent eddies, so turbulent eddies.

So, if you just look from a practical point of view, as a practical man, you will see that here the fluid particles are going back. So, they just make a re circulatory flow type of thing that a fluid particles come back in this from downstream to upstream direction. Again flow like that are circulatory flow is taking place, which creates at urbulent eddies turbulent eddies. Eddies are small re-circulating flows. So, zone of turbulent eddies are formed. This is found in practice. So, what is this phenomena? This phenomena is known as separation loss, which is extremely important, in your advance fluid mechanics classes also you will learn, this is known as separation loss.

Sometimes we call it as boundary layer separation, but the word boundary layer, I am not bringing here at this in this context because this will lead more confusion. Only separation losses, this is boundary layer separation losses. Now, what is this in real fluid, what happens, when a fluid flows against an adverse pressure gradient. This is an adverse pressure gradient p 2 to p 1. Now, in p 2to p 1 when the fluid flows, the fluid is able to flow because energy gradient is not adverse. Energy here is higher than energy here, but what happens in fluid very near to the wall, for example, here very near to the wall has got almost 0 velocity.

As you know we have read it at the beginning, that it is because of the viscosity that fluid velocity at the wall becoming always becomes 0. So, the fluid particles near the wall looses their kinetic energy, velocity becomes very small and ultimately 0. That means we cannot expect though, there is a uniform velocity of approach to the fluid, but at any section the fluid velocity is not uniform. There is a variation of velocity. So, you can ask me sir, what is this velocity? I can tell this is the average velocity, we consider in case of a turbulent flow, it is more or less uniform. But, at the wall it suddenly changes to 0; that means at the wall velocity has to be 0, which is known as no slip condition. That you have already recognized for a viscous fluid, the no slip condition is that the relative velocity between the fluid and the solid is 0.

So, if the solid surface is at absolute rest, the fluid velocity will be absolutely. So, fluid will gradually change or suddenly change from a high velocity to a 0 velocity, which means the fluid particles very near to the wall will have very low velocity. That means they will lose the kinetic energy in surmounting the adverse pressure yield. So, for those fluid particles it will be difficult to go against an adverse pressure gradient. That means higher pressure to lower pressure, because they lose their kinetic energy because of friction fluid friction.

So, therefore particles fluid particles near the solid surface traces back. That means they take the course of a back flow in favor of pressure gradient. That means this pressure here is higher here is lower. So, they make a back flow. That is why the flow reversal takes place. This is known as separation loss and this back flow in this region near wall makes a small zone of little circulatory flows, which is the zone of turbulent eddies. They create turbulent eddies and because of this a part of the mechanical energy is being destroyed in form of intermolecular energy or is being converted in the form of intermolecular energy, which we call as the destruction of mechanical energy.

So, basically this is the phenomena separation loss of creating zone of turbulent eddies. While the streamline expands or streamline takes the flow of fluid takes place from a lower pressure to a higher pressure always this separation loss takes places for a real fluid. This is the reason for which the mechanical loss, the loss in mechanical energy takes place. Now, we find out the quantitative value of that. Now, let us find out let us do this thing. Let us take a control volume.

Let us take a ,b this is c at this corner da point here e, f, g, h. Let us take a control volume a, b, c, d, e, f, g, h. Simply by the use of momentum theorem to the control volume and the application of Bernoulli's equation with losses, you know that a Bernoulli's equation is also applicable for real fluids with losses, we can find out the magnitude of this losses. How? Let us apply the control momentum theorem to the control volume. Now, the pressure applied here is p 1 pressure applied in this surface e f is p 2. Now, it has been found out the pressure here the pressure here in this zone, where the eddies are formed is this is the pressure imparted on the fluid surface. On this surface of the fluid, this pressure is p dash. Let this pressure is p dash let this pressure is p dash, this has been found from experiment.

This is equal to the upstream pressure p dash. This cannot be proved here, this require a high level theory of viscous fluids but, it has been found from experiment this you know as an information as p 1. Now, if I write the momentum theorem, what is the momentum theorem? Net rate of momentum a flux that means mass, let Q is the volume flow rate through this duct, into the momentum a flux. That means net a flux that means rho Q into a flux minus in flux rho Q V 2 is the momentum a flux rho, Q V 1 is the momentum in flux. That means I take this direction as the direction in which I write the momentum equation. That must be equal to the net force acting in this control volume in this direction. What is that force p 1 into A 1 in this direction?

If I consider the area at section one is a 1 that means are of this duct, plus another force acting in this direction, which is this force into the area of this well this stream tube. That means this is p dash into this projected area in this plane to find out the net force in this direction is this p dash into, if we take this projected area. That means this, this is this point that means we take this body, you understand as the control volume. Therefore, the projected area of this part is A 2 minus A 1, very simple geometry and minus P 2 A 2 at this area e f. So, if you do this fluid mechanics is almost over.

So, now p dash is p 1, with this information, if you substitute here these information then p 1 A 1, p 1 A 1 cancels out. So, therefore only thing is that p 1 A 1 and p 1, so A 2 p 1 minus p 2. So, p 1 minus p 2 into A2 is equal to, this part I am writing in the left hand side p 1 A 1 minus. Sorry, this is canceled, so p 1 A 2 minus p 2a 2, p 1 minus p 2 A 2 is equal to rho q V 2 minus V 1 very simple.

Now, this can be written as Q can be written as, in terms of V 2 A 2 V 2, so V 2 minus V 1. So, this a two is cancelled, so we get p 1 minus p 2 is rho V 2 into V 2 minus V 1. So, this is the main equation which will be of great help to us to find out the energy loss. Now, I write the Bernoulli's equation between one and two. How to write p 1 by rho plus V 1 square by 2? Let us consider section one and section two at the same elevation level q, do not create any problem or if you think that you can write g z 1. It is of no problem, but better if you write g z 1, g z 1, then again a body force term will come.

Therefore, we better make it simplify because here the g z 1, g z 2, is not there. We have not taken, if it is in a inclined position vertical force. Then a component of weight will come here in the momentum theorem in the force net force acting on the control volume, that you can make it simple. So, here we are considering a simple case that in a same elevation head is equal to p 2 by rho plus V 2 square by 2. Let us consider in terms of the head per unit weight energy plus h l. That is the loss of head in due to this geometric change, that means if we consider the loss of head due to this geometric change, we take it at this right hand side.

That means total energy at the inlet is equal to total mechanical energy plus loss. I have told that Bernoulli's equation can be written for a real fluid where the losses are taking place with a loss term taking care of at the downstream section. That means this is the inlet energy which is higher than the outlet energy mechanical energy plus loss. That means h l is nothing but p 1minus p 2 by rho g plus V 1 square minus V 2 square by 2 g. So, if you substitute, then p 1 minus p 2 by rho g as V 2 into V 2 minus V 1 by g minus V 1 square. This is very simple, 2 g it becomes simply V 1 minus V 2 whole square by 2 g. So, therefore you see the the loss of head due to this abrupt enlargement is V 1 minus V 2 whole square by 2 g, all right? This can be written, this can be written as h L is equal to… Now, if we take this V 1 square as common, V 1 square by 2 g, then what will that, 1 minus V 2 B by, all right? V 1 whole square.

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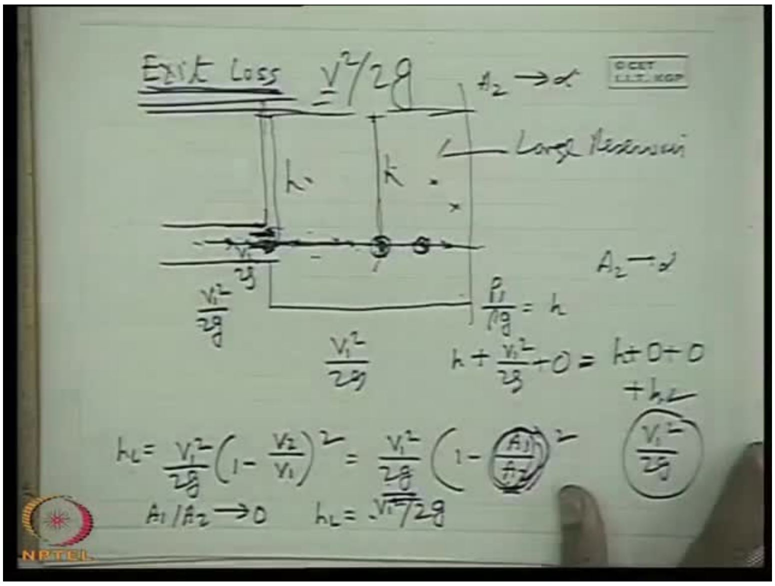


What is V 2 by V 1? This can be written as V 1 square by from continuity, what is V 2 by V 1A 1 by A 2 whole square. Now, consider a case when A 1 by A 2 tends to 0. Then, what is the loss V 1 square by 2 g. This is the case now, that when A 2 is very large compared to A 1. That means depending upon the value of A 1 by A 2, the loss will take with if A 1 by it is one there is no enlargement. Then what will happen if there is no enlargement. A 1 is A 2, then 1 minus 1 0 there is no loss, but if a 1 if a 2 tends to infinity that means for a given A 1 if A 2… A 2 is the downstream area is very very large, then the loss term h l becomes equal to V 1 square by 2 g.

This situation resembles this physical problem that a pipe discharging into a large reservoir, that a pipe discharging into a large. A 2 tends to infinity. So, until and unless the desired reservoir is large A 2 cannot be in A 1 by A 2 cannot be 0, so a 1 by a 2 zero means A 2 tends to infinity, that means the physical situation is that a large reservoir. In that case what happens the loss of head due to this flow is V 1 square by 2 g. This is very simple to understand physically, that the velocity head with which the fluid is discharge dis ultimately lost, because in this at this point in the large reservoir fluid is at rest. That means the velocity head is arrested in this large reservoir.

Another very important thing is that, if you now write the Bernoulli's equation at the same point, you will find the interesting thing. That what, if these two points, you write the Bernoulli's equation, you will find this pressure head. This energy pressure energy this height, datum energy. If you consider this as the reference, datum 0 kinetic energy 0 the 2 point same energy, but if you write the Bernoulli's equation at this point and the discharge plane, then you will see at this plane a extra V 1 square by 2 g is there. That means here if you write at just discharge plane, so same pressure let this be the height h.

So, p 1 by rho g is equal to h that means h plus V 1 square by 2 g. Let 0 is the datum head is equal to for anyone of these points where velocity is 0. So, you write the same pressure ,but 0 velocity 0 datum, so where is the equality? Equality is that loss. That means form this point to this point, there is loss this loss is V1 square by 2 g. So, this loss is V 1 square by 2 g. That means, physically it is velocity head is loss. That means this kinetic energy of the fluid is being converted in intermolecular energy. So, these points have got higher temperature than this point. So, that if you take care of the intermolecular energy the energy level will be same, otherwise the mechanical energy here is lower than this.

This is the loss and this loss is known as exit loss. That means, when there is an exit of a fluid stream with some velocity in a large reservoir or in atmosphere where the velocity is arrested. That means this kinetic energy is completely converted in intermolecular energy, so that the kinetic energy is lost. This loss is known as exit loss and it is magnitude is V square by 2 g where V is the velocity of discharge and this is a special case of for the loss due to abrupt enlargement.

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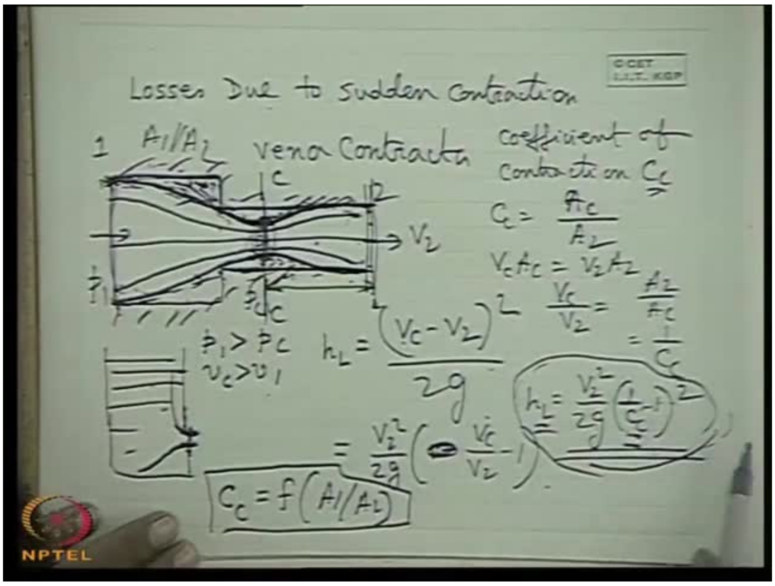


Now, I come to losses due to sudden contraction losses due to sudden contraction. Now, we can go quickly. Now, I consider a contraction. That means the fluid flowing through like this. That a fluid approaching in a duct whose area is ultimately suddenly reduced. Then the fluid let us this here this is 1, let us this is 2. So what happens, the fluid now here there is an interesting phenomena, here there is an interesting phenomena, this will be the nature of the streamlines. Streamline will adjust like this.

Now, in that case what happens in a real fluid? That if there is a contraction of area the streamline contracts to accommodate that area. There is a lateral force acting on the streamline because of this change in momentum by this duct, which makes this streamline narrowing down ultimately to an area, which is lower than the minimum geometrical area. That means if this is the section two that means this is the pipe 2 that cross sectional area of 2 pipe 2. That means a 2, so this cross sectional area that means stream tube narrows down narrows down to an area this cross-sectional minimum area, which is lower than the cross-sectional area of the this duct, that is reduced area duct.

So, this area is known as vena contracta. This is a Latin name vena contracta. That means this is the minimum area where if contracts. It happens so you can see in hydraulics laboratory. Also, it happens that, if a fluid is allowed to flow, that I will also discuss afterwards, that a fluid is there now. If it is allowed to pass through an orifice at the side of this, so fluid fluid particle will just fluid streamlines, will just you will see change in their path like that and they will narrow down to an area, which is lower than these orifice area. So, these area is known as vena contracta. It happens just after the orifice section at the downstream section, very close to the orifice section, that means the stream tube is narrowed down to an area minimum area, which is lower than this geometrical area .This is known as vena contracta, let this section is C C.

Now, here during this part of the flow of the fluid the fluid is flowing in an favorable pressure gradient. What is meant by favorable pressure gradient; that if this is p 1, this is p C, p 1 is always greater than p C, because v C is greater than v 1, because this cross-sectional area is less than this cross sectional area. So, fluid is converging and accelerating because the cross sectional area is reduced with velocity is increased because of continuity. So, since the fluid velocity is increased, so fluid pressure is reduced. That means p 1 is more than p C or p C is less than p 1.

So, there is no question of being a back flow because here the wall nears the wall. Even if the fluid particles losses their kinetic energy, but they will be forced to the main direction or direction of main or bulk flow because pressure is always acting towards them. Thereis a favorable pressure gradient, that pressure here is higher pressure here is lower. This happens in case of an adverse pressure gradient when the fluid particle loses its kinetic energy they will force back by the pressure forces but here, pressure forces takes place in the direction of the flow.

So therefore, in a converging flow or in an accelerating flow, where the velocity is increased, that stream tube cross-sectional area decreases. The question of flow separation does not come. All fluid particles flow in the direction of main flow. But what happens the situation when the fluid attains an area vena contracta, which is lower than the area of this pipe? That a 2, then what happens the fluid from the vena contracta? Again expands and fills the pipe area 2. Therefore, from C C to 2 it is again an expansionand the fluid particle here separates flow separation. Therefore, the energy losses that is taking part in these zones, not in this zone.

So, it is not because of the contraction, but because of the expansion, that is following the contraction and why this expansion takes place? This is because of the fact that the stream tube attains an area which is lower than the area of the geometric area of the tube. That is vena contracta, then it has to have an expansion or it has to expand to fill up the pipe 2. Therefore, it is the expansion from the vena contracta to the downstream section 2 2 for which the losses takes place.

Now, therefore it is again the losses due to expansion, but now here if I write the h l without anything if I recall the formula. It will be V c minus V 2 whole square by 2 g because it is same as the same thing that as if it has an abrupt enlargement from an area C C to 2 2. So it is the enlargement loss h l is V C minus V 2.So, this can be written as v 2 square by 2 g into 1 minus. What is that V 2 square by 2 g, sorry. This is V C by V 2 minus 1.

Now, a coefficient of contraction is defined coefficient of contraction is defined coefficient of contraction a coefficient of contraction C C is defined, which is the area ratio A C, the vena contracta divided by this part. That means how much it is reduced from the geometrical area of the pipe C C. So, from the continuity we can write V C into A C is equal to V 2 into A 2 because same flow rate should be accommodated through the tube. Therefore, V C by V 2 is A 2 by A C that means 1 by C C. So, one can write therefore, h L as V 2 square by 2 g, where V 2 is this final velocity in this small tube, into 1 by C C minus 1 whole square.

So, if the coefficient of contraction is given. Then, I can find out we can find out V 2 square by 2 gone by C C minus 1 is h l. But one very interesting thing here which appears in the mind of a reader that you see in this expression, nowhere the area A 1 is coming, because this contraction depends upon area A 1 by A 2. So, it is indirectly represent in terms of a contraction coefficient which is A C by A 2, but an intelligent student will find that this is an interlinking step. That means this A C is again related to a 1 and A 2. So, A 1 though is not coming explicitly in this equation, but A 1 is implicit in the C C, which mathematically can be explained that C C is a function of A 1 by A 2.

So, how to find out the value of C C? That means A C by A 2 that is a function of A 1 by A 2. So, depending upon this area and this area, so this area though not coming explicitly in this equation, it comes implicitly through the functional dependence of C C A 1 by A 2. So, this is 1 by C C minus 1 whole square. Now, in a special cases when this A 1 by A 2 is 1, that means there is no contraction A 1 by A 2 1 the value of C C is 1 that means h L is 0 . There is no question of loss so a same diameter.

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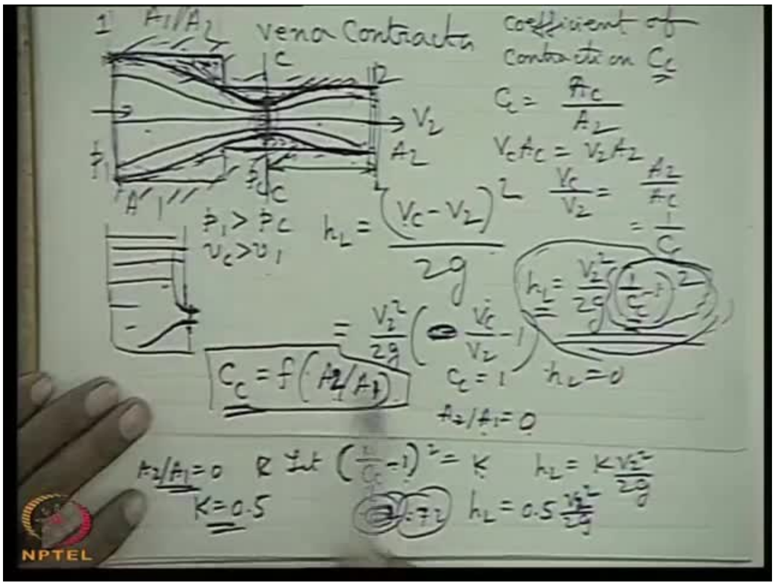


But you consider a situation, where this A 1 by A 2 the rather A 2 by A 1function of A 2 by A. It looks nice that A2 by A 1, which one is A 2? This one is A 2, this one is A 1 is again 0. That means A 2 by A 1 is 0, when A 2 by A 1 is 0, what is the physical situation. That means A 1 tends to be infinitely B rather than A 2. In that case it has been found that this 1 by C C minus 1 whole square that is K. Let let 1 by C C minus 1 whole square K that means h l is K V 2 square by 2 g.

So, when A 2 by A 1 equal 0, then k becomes 0.5. C C become 0.75 or something like that 0.72, so that 1 by C C minus 1 whole square becomes; oh sorry. Not C C 0.72 or it may be 0.72, I do not know the value exactly. That means 1 by C C minus 1 whole square. So, C C value becomes such, when A 2 by A 10, K becomes exactly 0.5. In that case h l equal to 0.5 V 2 square 2 g. That means I am exploring a very special case. When A 2 by A 1 0, which physically resembles that the fluid coming from a very large reservoir. A 1 is very large compared to A 2.

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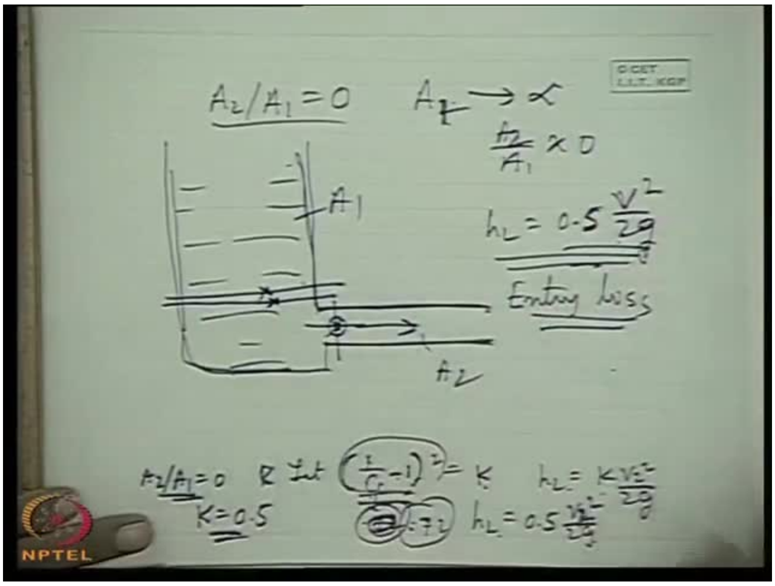


That means when A 2 by A 1 is 0 means A 2 A 1 tends to infinity. That means A 1 is very big compared to A 2. This resembles that the fluid coming from a big reservoir to a pipe. When the fluid coming from a big reservoir enter to a pipe, then it is nothing but a contraction loss. So, this big reservoir is A 1 and this pipe is A 2 where A 2 by A 1 is… Sorry, A 2 by A 1 is almost 0. In that case h L is 0.5 V square by 2 g, if V is the velocity in the pipe, uniform cross-sectional area. So, that means this is a special case for contraction that is 0.5 V square by 2 g, because this factor is this is K.

That means K becomes 0.5. So, this loss is known as Entry loss. That means if we have a section here just downstream to this and if we have a section here, so if we write the Bernoulli’s equation between this two sections are very close to here, you understand? So, if you write the Bernoulli’s equation between this two sections, here the entry loss has to be take care of which is 0.5 V square by 2 g. You have understood? So, this is a special case of losses due to contraction.

So, these are the losses due to geometric changes. Now, we will come to another topic, that is measurement of flow. Measurement of flow through, we will discuss in this classes measurement of flow through three devices, venturi meter measurement of flow by three devices; venturi meter, Orifice meter and flow nozzles. When the fluid flows through a closed duct, how to measure the flow rate, which is very practical information which is of very practical interest? There are several measuring devices, which measures the flow rate of fluid through a duct. One of such measurements, I tell you which comes very apparent that if the flow is a liquid and it is flowing through a hydraulic circuit. Where there is an open end that fluid enters enters through some point and then flowing through a pipe or a pipe network, there is an open end where the fluid is coming out.

So, most accurate and easiest method of measuring the flow rate is that collect the liquid flow, because liquid can be collected in a measuring bucket. You weigh the amount that is collected during interval of time and find out the average flow rate. This is one of the most direct and accurate method of flow measurement, but it is not always possible because the circuit is not open. So, you cannot collect the fluid or the fluid flowing is not a liquid that is a compressible fluid. So, there are several flow measuring instruments which can measure the flow rate of a fluid under steady condition through a fluid circuit. This is not within the scope of our syllabus to study in details, all the flow measuring devices, but we will be studying three flow measuring devices in this class. One is venturi meter another is orifice meter, another is flow nozzles.

So, this three flow meters in general work on the same basic principle. The basic principle is like that. When the fluid flows through a duct or through a circuit, this flow measuring device, when this is inserted in the circuit, they provide a co axial contraction or co axial. We can tell co axial contraction. That means the area is gradually changing that means they in general gives to a geometric change in to the flow field, so that the fluid path of the fluid flow is changed because of which there occurs a change in pressure in the fluid. Losses are there obviously and change in pressure is you say when the fluid is expanding, fluid is contracting because of the abrupt enlargement abrupt contraction, so pressure changes takes place.

So, this change of pressure is measured by a pressure measuring instrument, usually by a manometer. Then what is done by the straight forward application of Bernoulli’s equation. This pressure drop is equated with the velocity of flow and finally, with the flow rate. Therefore, by measured values, by substituting the measured value of this pressure drop in that equation, which is developed by the application of Bernoulli’s equation, we find out the flow rate. So, this is the basic principle, but in geometrical shape the venturi meter, orifice meter and flow nozzles are different though their basic principles are same. These we will be discussing in the next class as a flow measuring devices.

Thank you.

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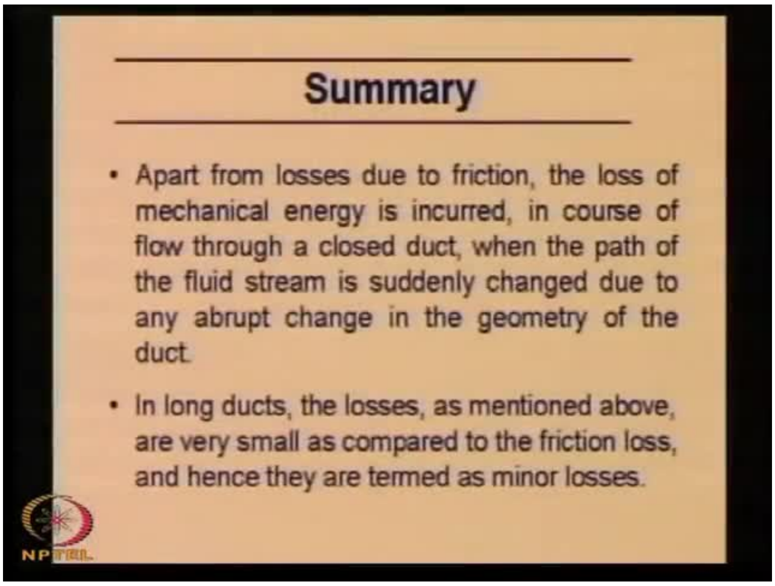


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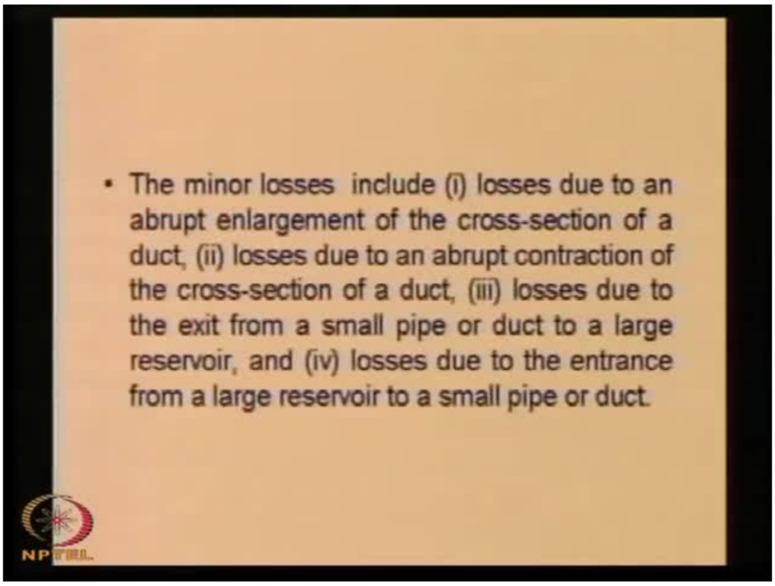

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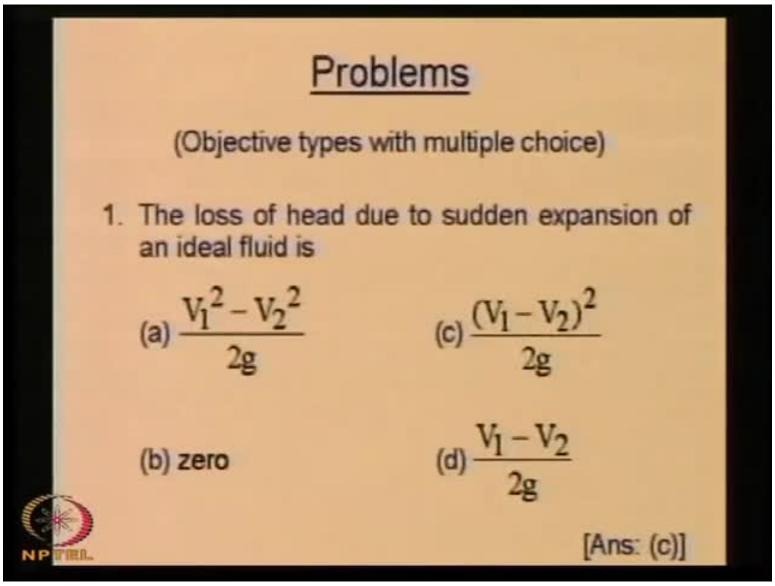


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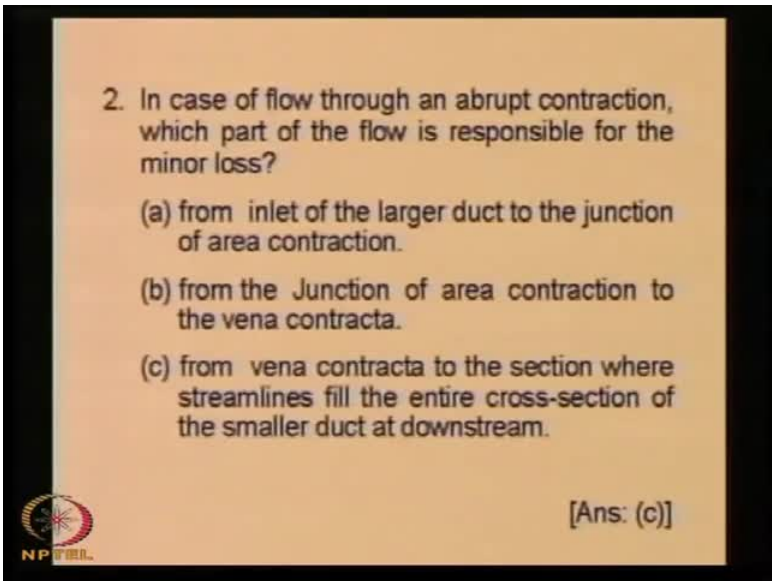

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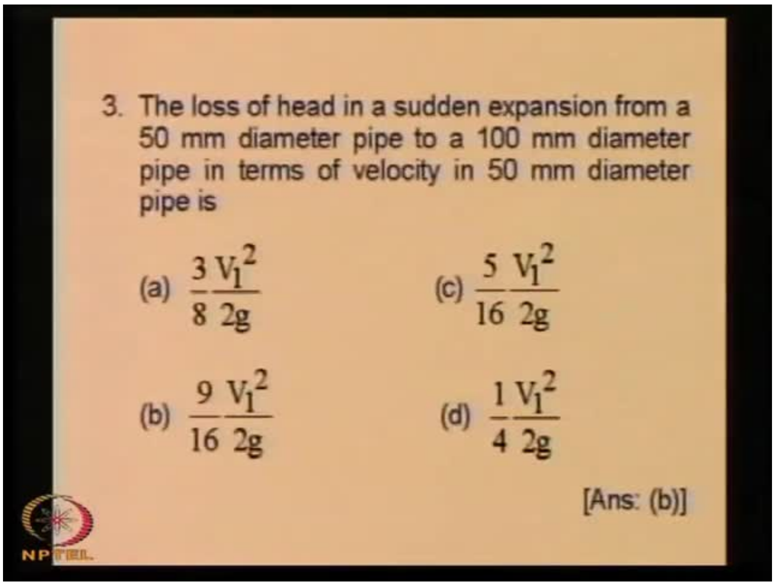


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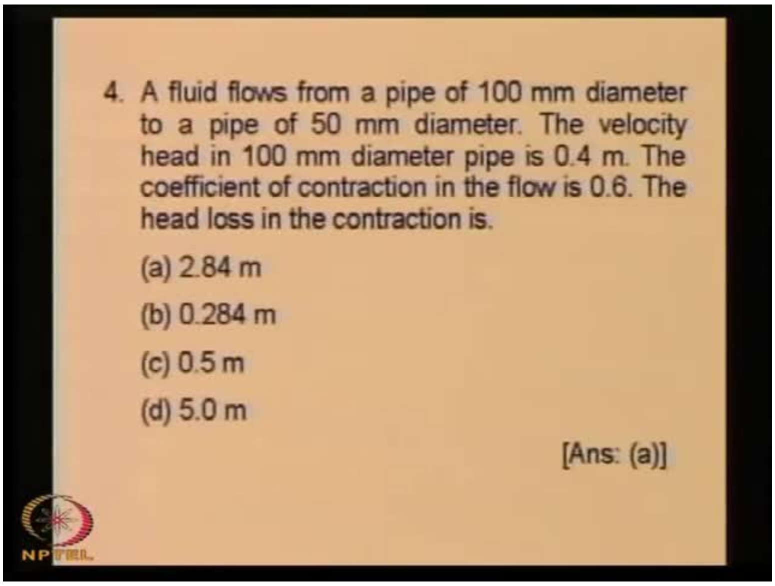

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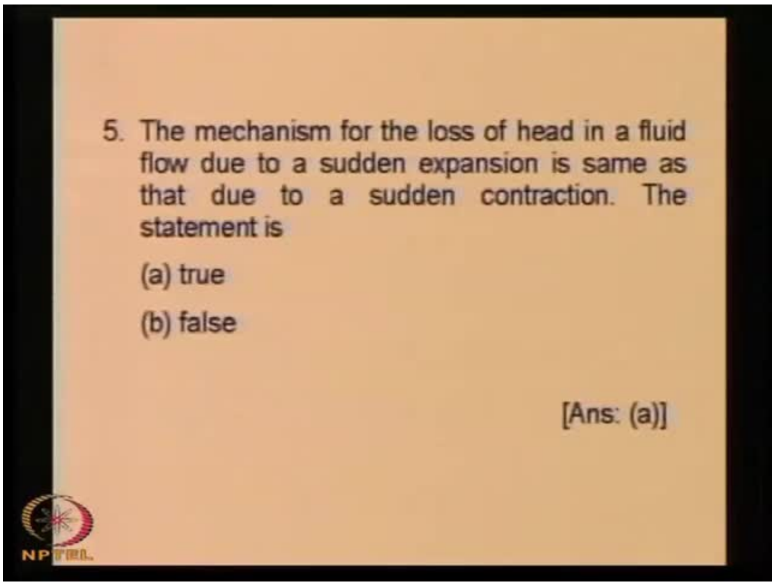


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