If you try to understand that or try to draw that sketch you solve the 20% of the problems, another 20 I can say not the 20% maybe 50% of problems. Another 50% is that how to apply mass conservations equations, linear momentum equations and the Bernoulli's equations which it is not that difficult to apply it. So the basically the strategy is that you should try to understand these ones.

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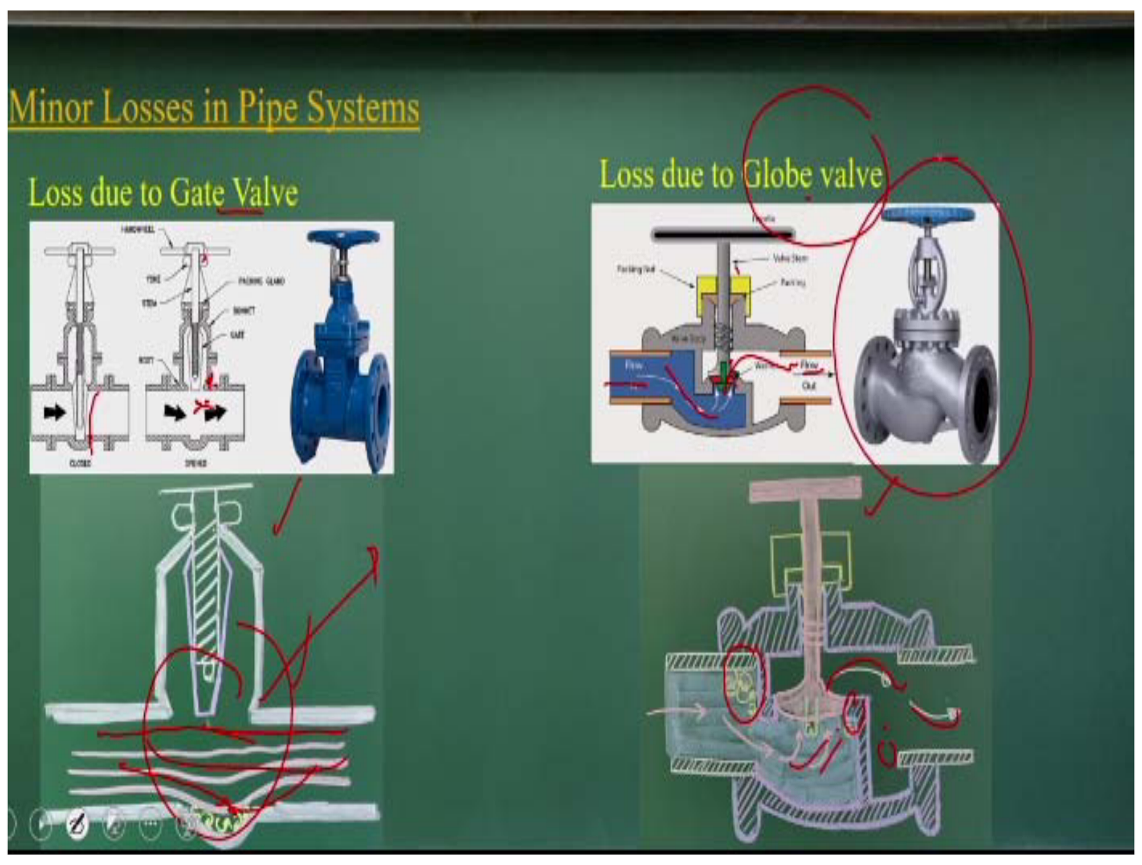

If you look it that most of the times also we have a valve to control the flow okay which is a gate valve okay, it is a gate type of systems. If you rotate it this valve closes the waters okay. And it can have a total open or half closed and all these conditions to regulate the flow to regulate the flow we have a these systems. Now if you look it if I am to draw the streamlines, how it happens it.

So streamlines will come like this okay. There could be the vortex formations. And if you try to understand it, that I have not this open or the totally close, if the half open your flow distributions you can understand it how the streamlines patterns will come, how the vortex formations will have. Either you open it or close it, but half close half open will make it us the flow process at these process difficult or the more energy will dissipate as compared to the other conditions.

Now if you look it similar way we have a the globe valve which is more control valve systems. The flow comes here, then rotate it and this valve it goes off and flow goes like this. So we can look it now in terms of vortex formations here, the vortex formations here, and once flow goes it also could have the vortex formations also here.

If you look it that way and just compare to valves one is globe valve and the gate valve this require for different type of discharge conditions.

So if you look at these conditions you can easily interpret it we will have a more energy losses for this case as compared to this ones. But we need sometimes this type of valve to control the flow systems.

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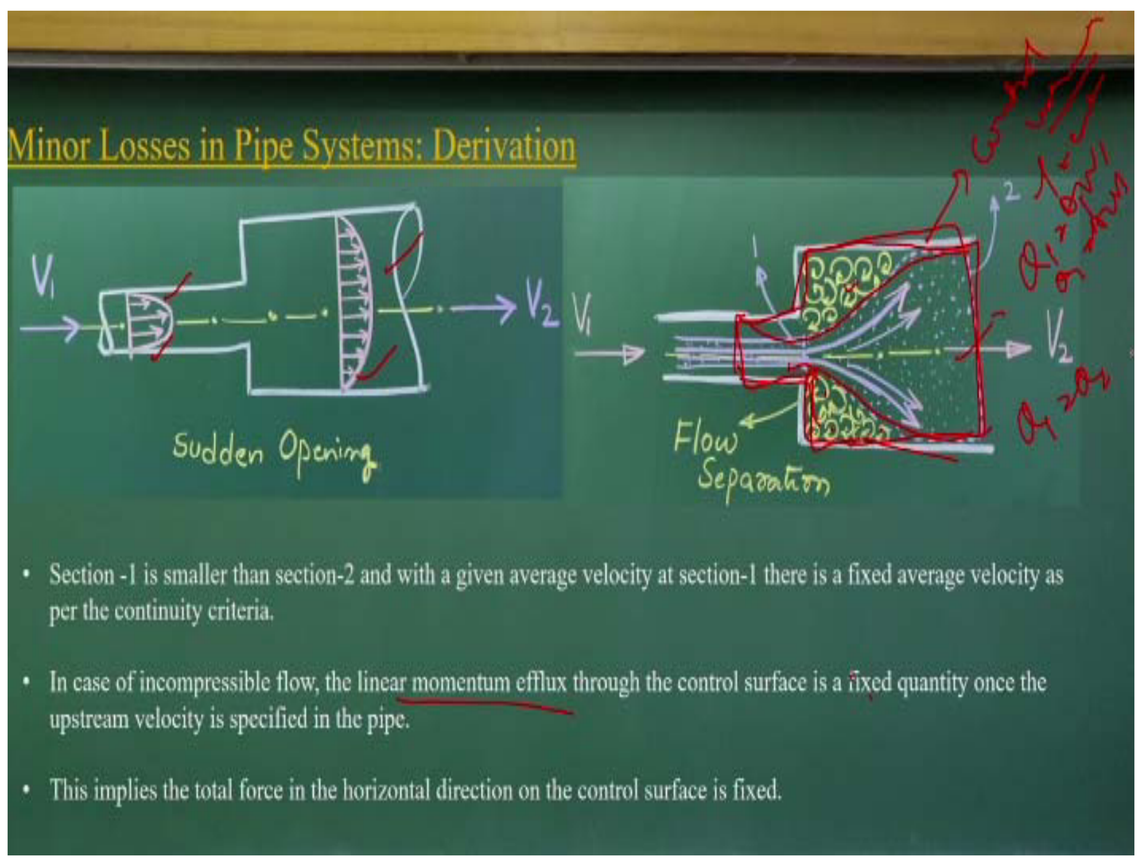

Let us come for derivations of energy losses and the pressure and velocity distributions of having a systems where two pipes we are enlarging it from the smaller diameter to bigger diameters. If you have that conditions and you can draw the velocity distributions. The velocity distribution it depends upon the type of the flow. If I have a laminar flow, the velocity distribution is different.

If I have a turbulent flow velocity distributions is different. That part we will discuss in the next class. So we will have a velocity distributions here depending upon the type of the flow. And then I try to understand it to draw the streamlines the flow separations point and the vortex formations. So I will consider the control volume as I said it earlier where I have a streamlines or this part.

Or I can consider the outer this one is my control volume part. I can consider it that or I can consider this is the control volume. The most of that we will use the linear momentum efflux that way we will apply it to compute it. So the basically what I am talking about here, this is what is our control volume. And we will apply mass conservations equations since this is a incompressible flow, density is a constant.

So mass conservations will be the A_1V_1 and Q_2 will be A_2V_2 and Q_1 will be the Q_2. The two locations will have the discharge is the same because of mass is constant.

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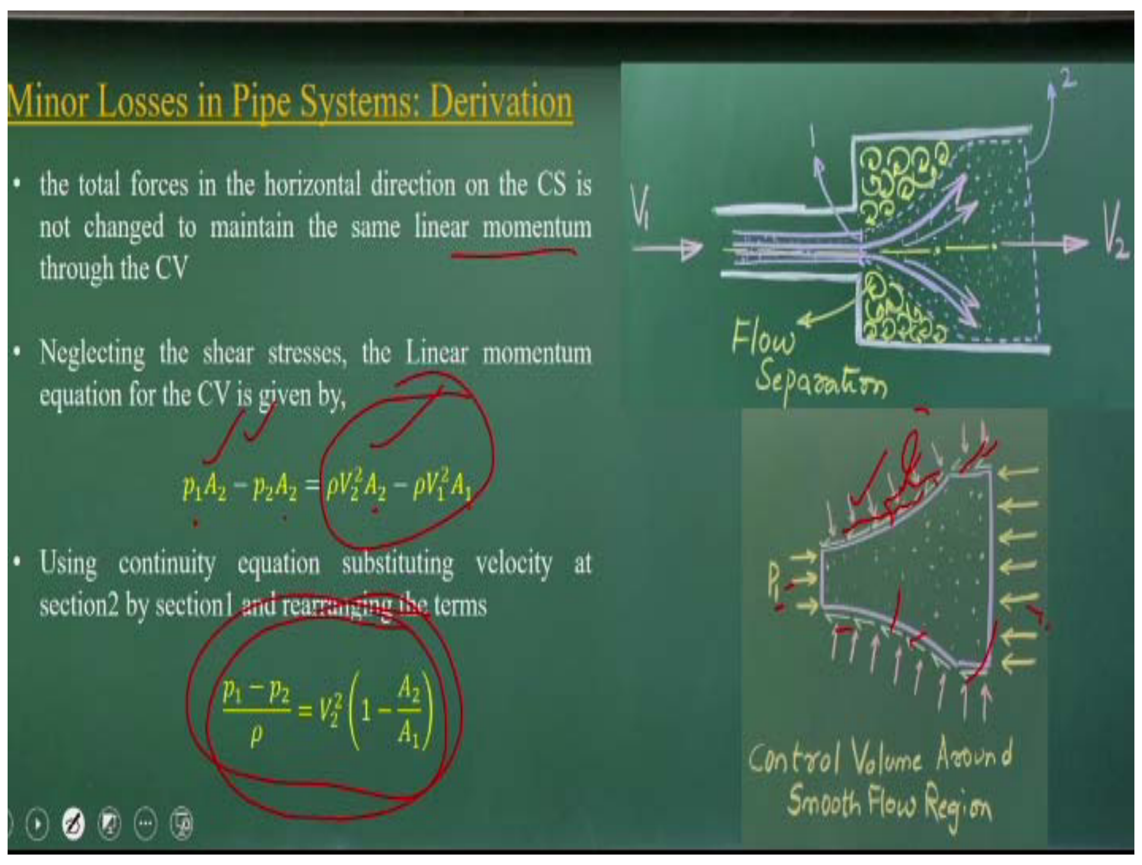

Now coming to this, I am just applying the linear momentum equations for these control volumes okay. So if you have this is the control volumes. So you may have the shear stress is acting on this okay, this the shear stress part, okay. But we are neglecting this part, we are neglecting the shear stress part. Just we are assuming the pressure different between these is equate with a momentum flux.

$$p_1A_2 - p_2A_2 = \rho V_2^2 A_2 - \rho V_1^2 A_1$$

This is what we have derived lot. So this is a rate of change of the momentum flux is equal to the, the pressure difference between the, the pressure force difference between this p_1 and p_2 and that what if you rearrange it you will get it this part okay. So it is very simple equations that we are using this. The linear momentum equations applying over these control volumes along this line and neglecting the shear stress components, okay. Because this is a very start reach okay.

That is because of shear stress whatever the force component will come it much smaller as compared to the pressure force and the momentum flux components. This is the momentum flux component what we are equating it V_2 and V_1 directions. If we that you get it this part. Okay, this is very simple just to rearrange the part and you will get it that.

$$\frac{p_1 - p_2}{\rho} = V_2^2\left(1 - \frac{A_2}{A_1}\right)$$

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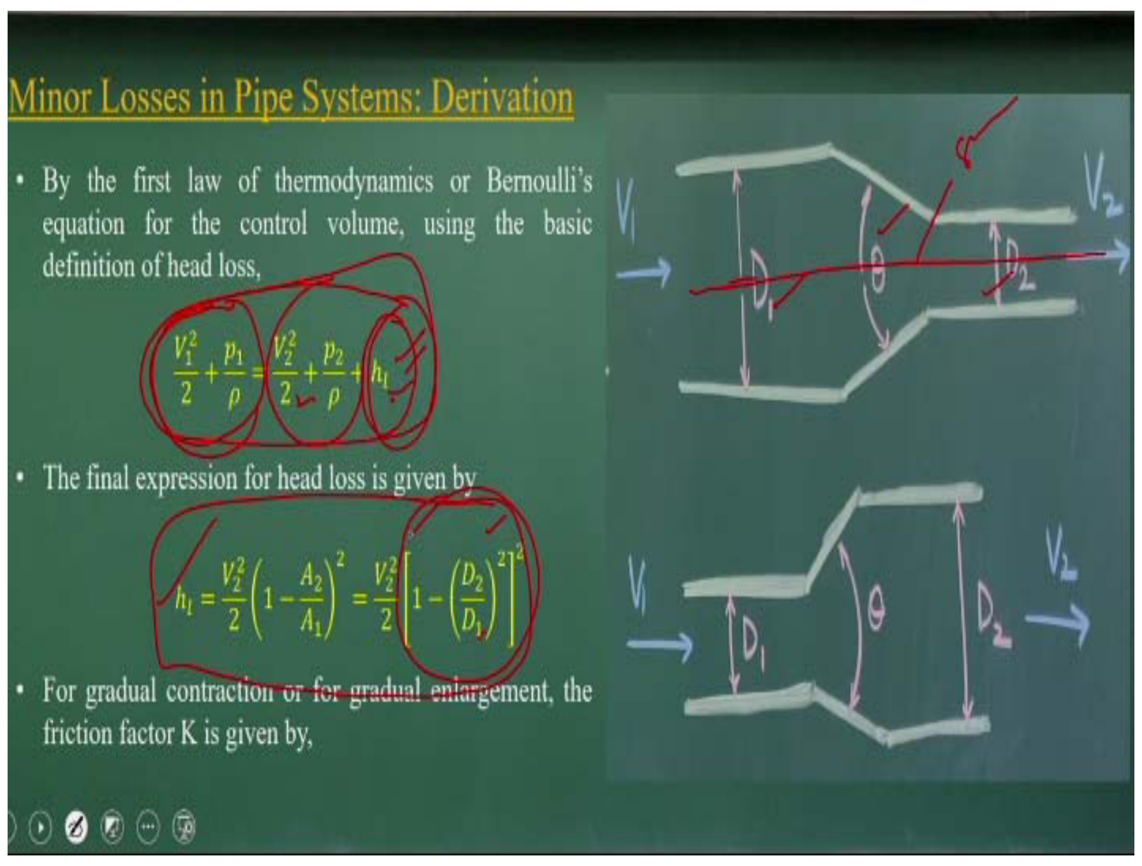

Now I will applying Bernoulli's equations along the straight line, okay I am just applying the Bernoulli's equation along the straight line. When you apply the Bernoulli's equations, this line is horizontal. This streamline is horizontal, so you do not have a z components. You have pressure head component and the velocity head component. That is what you equate,

$$\frac{V_1^2}{2} + \frac{p_1}{\rho} = \frac{V_2^2}{2} + \frac{p_2}{\rho} + h_l$$

So the flow is come from the one section to sections two where through the flow there is energy losses, that is what we quantify. So because of that we call it is a modified Bernoulli's equation which is nothing else. You are equating the energy, you know that how much of energy losses has happened. So you are just incorporating the energy losses at the sections two. That should be equal to the energy at the section one.

So that is very basic equations, but we are incorporating directly this energy losses, what we compute from major loss or the minor loss. If we substitute that, finally you get energy losses or the head losses in terms of the velocity.

$$h_l = \frac{V_2^2}{2}\left(1 - \frac{A_2}{A_1}\right)^2 = \frac{V_2^2}{2}\left[1 - \left(\frac{D_2}{D_1}\right)^2\right]^2$$

So the K varies with this parameters, which is very easy to quantify it, which is a functions of D 2 and the D 1.

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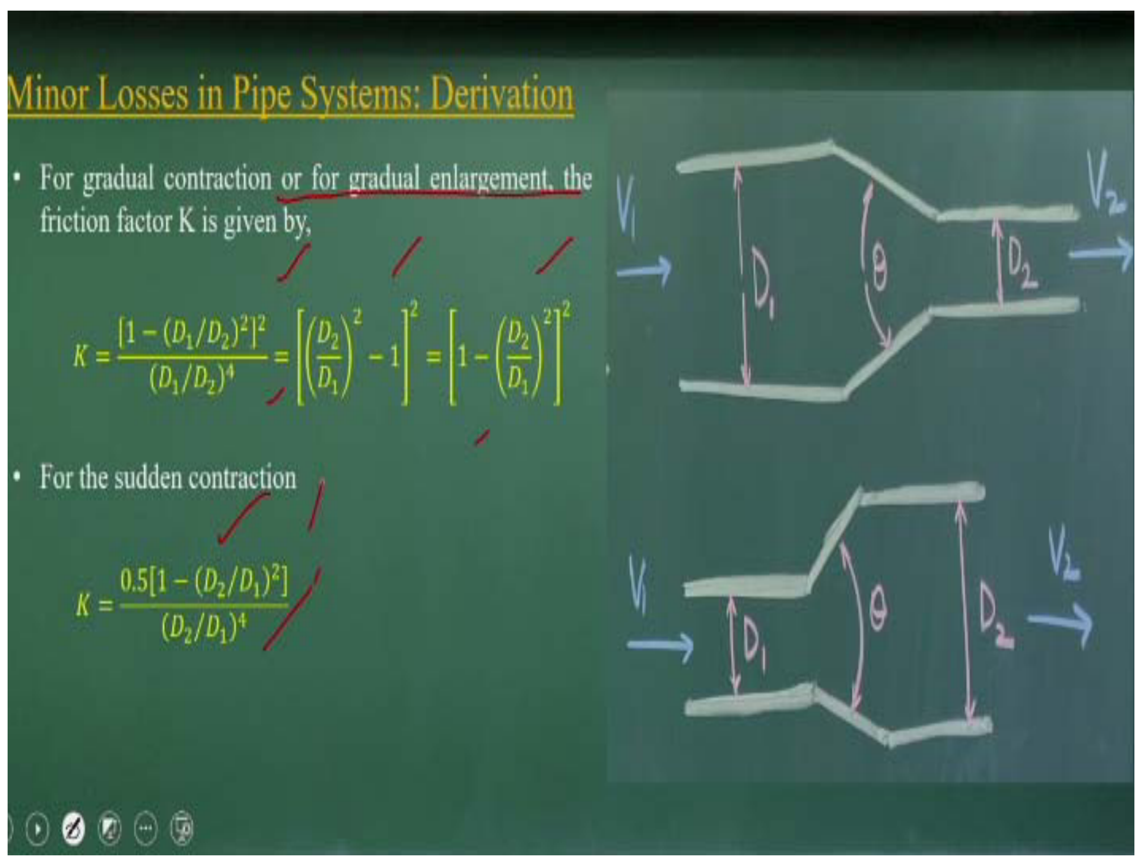

The same way if you have a gradually contractions happening it or gradual enlargement that you can compute this values, okay? And sudden contractions happening it you can have this type of calculations, we can get it with a simple applying this momentum equations.

For gradual contraction or for gradual enlargement, the friction factor K is given by,

$$K = \frac{[1-(D_1/D_2)^2]^2}{(D_1/D_2)^4} = \left[\left(\frac{D_2}{D_1}\right)^2 - 1\right]^2 = \left[1-\left(\frac{D_2}{D_1}\right)^2\right]^2$$

For the sudden contraction

$$K = \frac{0.5[1-(D_2/D_1)^2]}{(D_2/D_1)^4}$$

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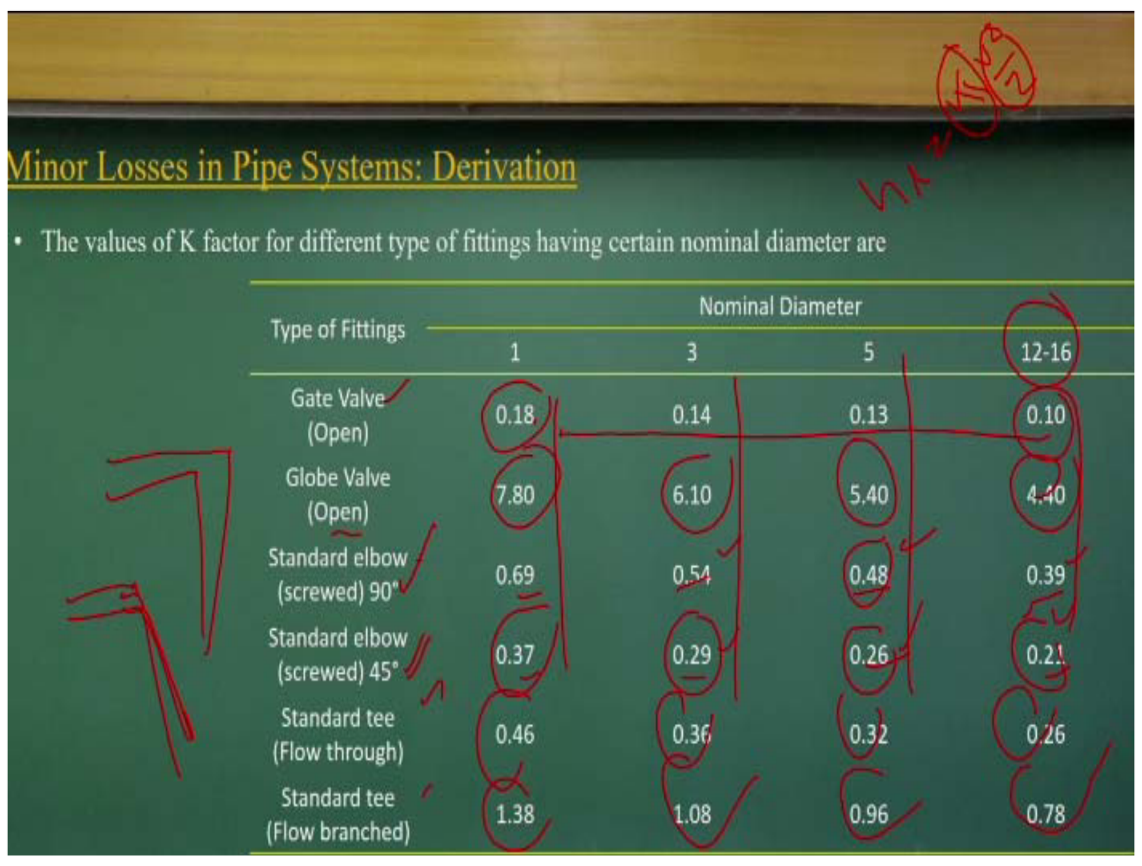

Now if you look at the tabular values what we have and here I am talking about the head loss is equal to

$$h_l = K\frac{V^2}{2}$$

So this K value. How does they value it. First is gate conditions which is 0.18 can varies up to 0.10 as the diameters increases. Same way, if you look it that, gate valve is 0.18, 7.80. So we can understand it, how much the globe valve and the gate valve the energy losses will be there.

Is much larger. But as you increase the diameters, it can be reduced it. Similar way, we can have 90 degree 45 degree, the elbow will have different quantity of energy losses. The 45 degree, we can understand it, it should have a less energy losses as compared to the this is 90 degree. So if you have a 45 degrees, you can draw the flow, the streamlines vortex zones you can understand it, the vortex zones will be the lesser as compared to the 90 degree. So this is less as compared to this one.

This is this to this one. So what I am highlighting is these are things you should understand from the tables. Do not look at the table you just data we should use it to other things. But these tables give a knowledge to us how the flow patterns are happenings. Similar way if you have a tee joint, you will have a different type of the energy losses is happening.

So these are the experimental data to get it this energy losses coefficient of K and if you know the velocities, you can compute it what is the minor loss or minus energy losses.

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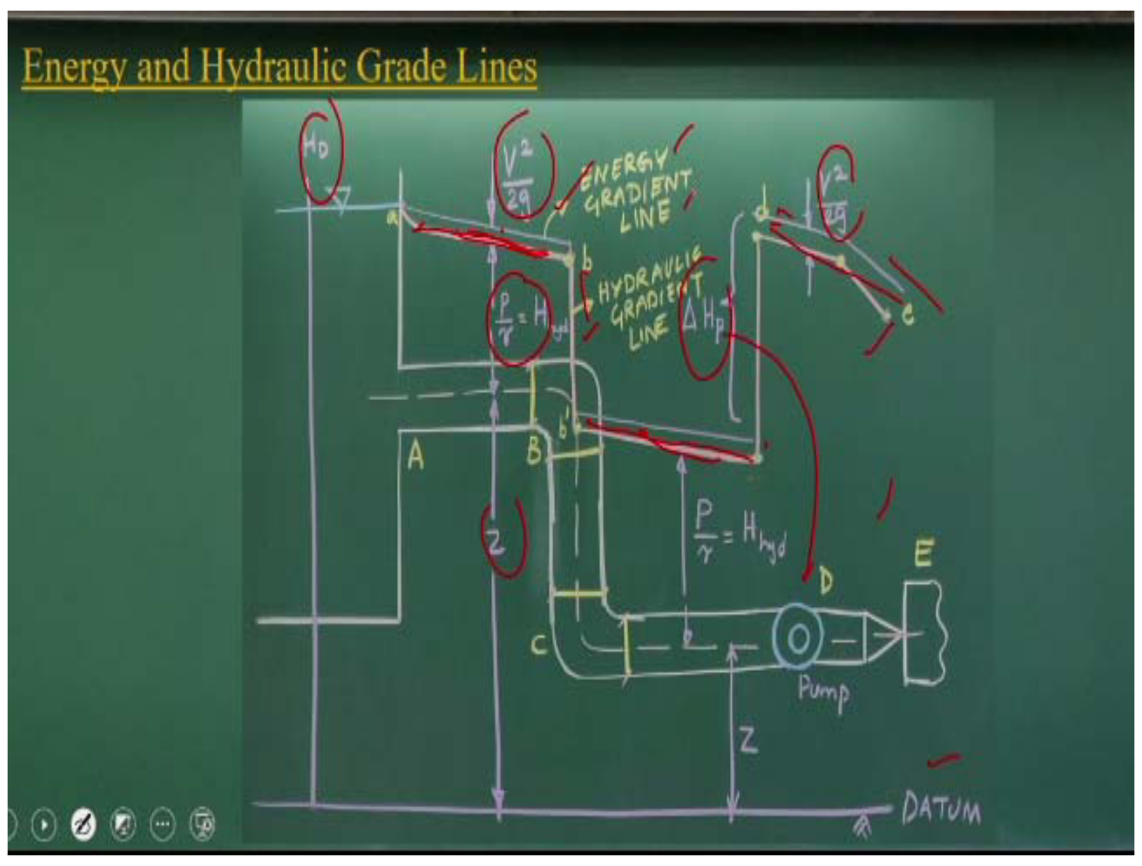

Again I am repeating it this energy gradient line and hydraulic gradient line what we discussed just after the Bernoulli's equations. Now let us I have the reservoir, okay. This is the datum. From the reservoirs I have the pipe systems okay and there is a pumping system. So you can draw hydraulic gradient line, also we can draw the energy gradient line.

The hydraulic gradient lines will have the z plus the pressure head, okay. Plus if you look at the velocity head we will get it the energy gradient lines. So now if you look it that as the pipe flows goes down you will have this drop of the potential head, that is what drop is there. Similar way if we look it that there is a pump systems which is increasing the energy.

This is the increase of energy because of the pumping systems and increase of the velocity, that is what will be making this energy gradient line. And if we can see there is a slope ,that is the major losses what is happens it, the frictional losses that will represent to us the slope components. The major losses will be there. So any pipe flow system you can sketch it tentatively what is the energy gradient line, what is the hydraulic gradient line.

This energy and hydraulic gradient line stock us that how the flow how the flow patterns are happening it with is how much of the velocity of the flow and what is the amount of energy is available at different points, okay. So we try to understand the sketching this energy gradient line and the hydraulic gradient lines.

That is what is important. As I said it earlier, today pipe designs and all the things are necessary, but there are lot of softwares are there, mathematical models are there you can compute this the design a pipe networks. But as a engineers always you should look into the hydraulic gradient line, energy gradient line. Then you try to interpret it, how much of velocity is there, how much of energy available for different conditions.

$$H_{hyd} = \frac{P}{\gamma}$$

So that interpretations we should do it and we should always try to sketch this energy gradient line, the hydraulic gradient lines and if we are good faster in how to draw the energy gradient line and the hydraulic gradient lines you could be a good designer, pipeline designers and all.

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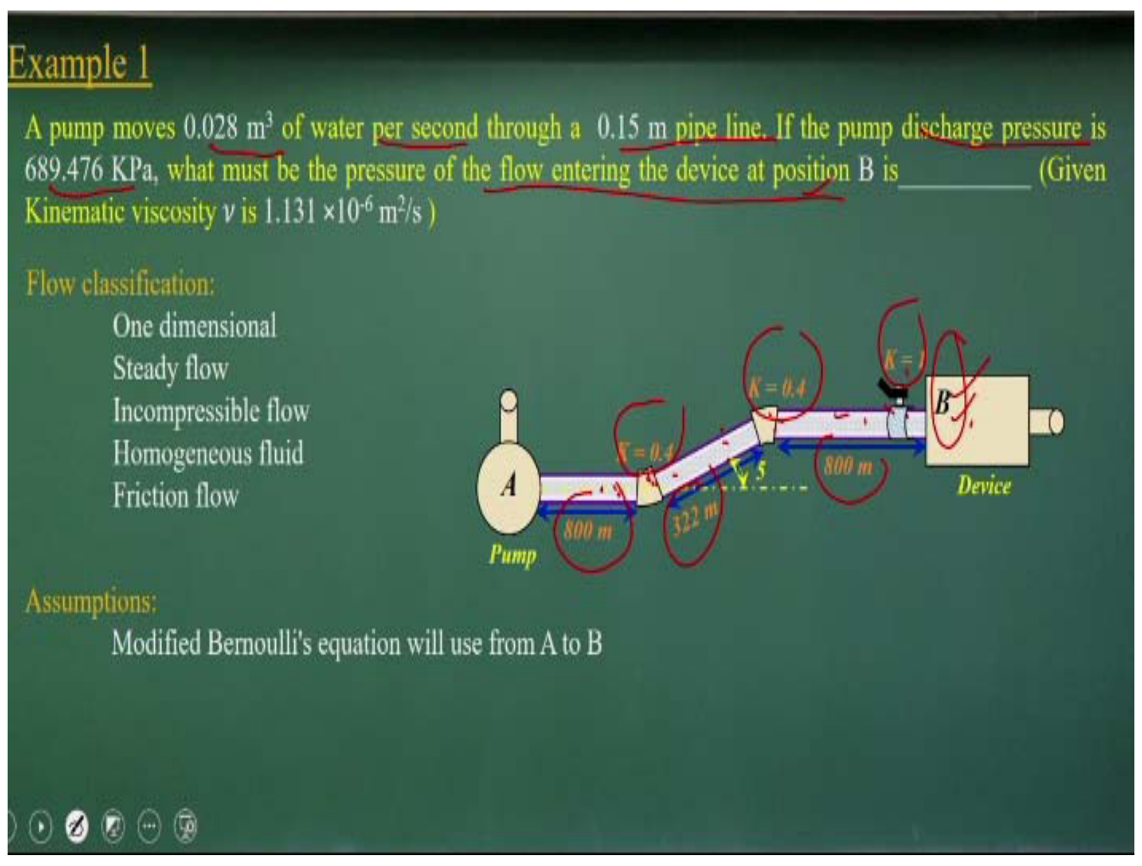

So now let us come to the questions okay, the examples what we have. Okay, so the first example is very simple is there is a pump okay and which moves this amount of the waters per second. That means, this is given to us, through a pipe diameter is given is a pump discharge pressure is this much okay kilo Pascals. What must be the pressure of the flow entering the device at the position B, okay.

That is need to be computed it that and there are pipe dimension of 800 meters 322 meters 800 meters is connected with a two junctions where you have the energy losses, the K factor is given to us with a valve also K factor is given to us. So we will apply the basically we will apply modified Bernoulli's equations and the energy loss equations or using the Moody's chart.

Based on these two we can find out if you know this pressure at this point you know this total energy available at this point, if you compute the energy losses through this pipe, this pipe because of frictions also the because of the junctions and because of the valve, if I know the total energy of losses on this, I know energy at this point, then I can compute energy at this point.

Once I know what is the available energy at these three point, then we can easily find out what could be the pressure. That is not a big deal, okay.

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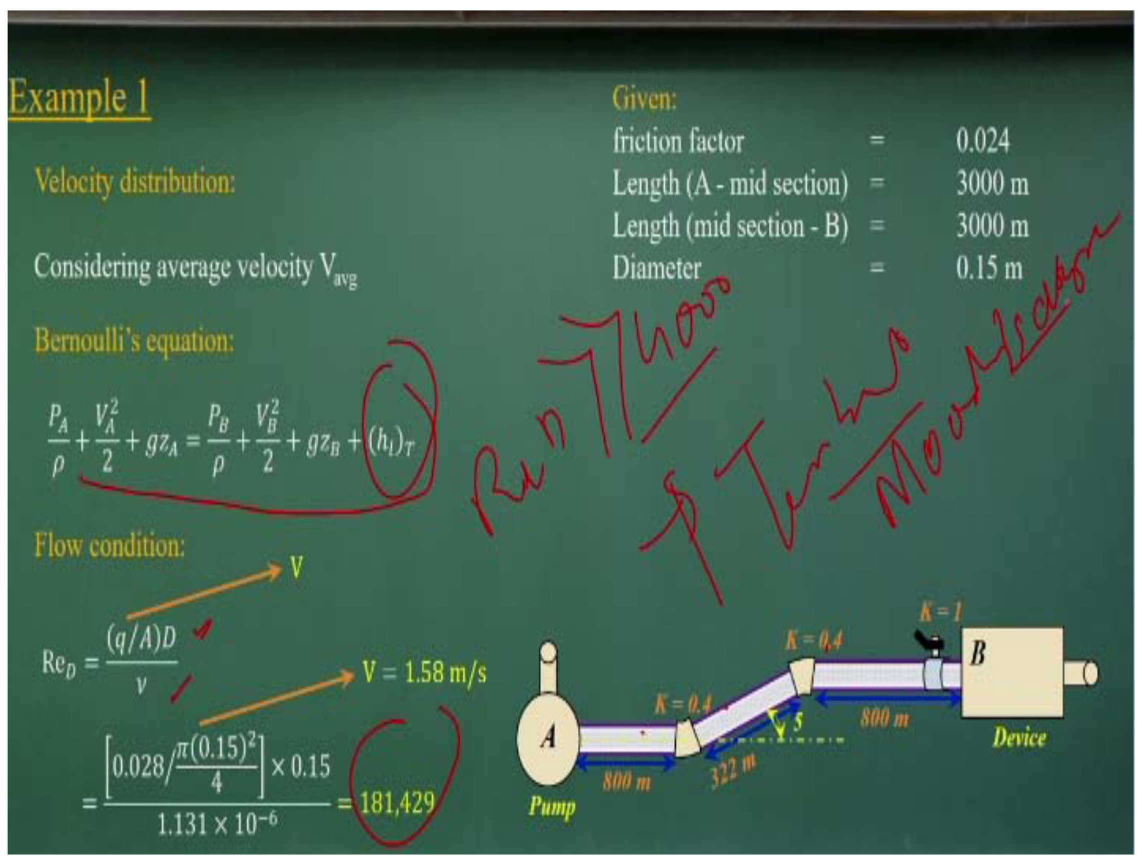

So first I say that we should have a modified Bernoulli's equations with the head loss components okay, modified Bernoulli's equations with the head loss components. First what you do it we should compute the flow Reynolds numbers okay. So here we are substituting with in terms of diameters and we are computing the flow Reynolds numbers which is coming out to be so large numbers okay.

Given:

friction factor = 0.024

Length (A - mid section) = 3000 m

Length (mid section - B) = 3000 m

Diameter = 0.15 m

$$\frac{P_A}{\rho} + \frac{V_A^2}{2} + gz_A = \frac{P_B}{\rho} + \frac{V_B^2}{2} + gz_B + (h_l)_T$$

Flow condition:

$$\mathrm{Re}_D = \frac{(q/A)D}{\nu}$$

$$= \frac{\left[0.028/\frac{\pi(0.15)^2}{4}\right] \times 0.15}{1.131 \times 10^{-6}} = 181{,}429$$

This Reynolds numbers is much larger than 4000. So the flow is turbulent. Okay, so you can multiply it what is happening the flow at this. This value is much larger, this flow is turbulent. So we can use Moody's diagram for solving the problems okay. So that is the, this is the Reynolds numbers and we are confirming it that the flow is turbulent. Also we are trying to we will use the Moody's diagram to computing that.

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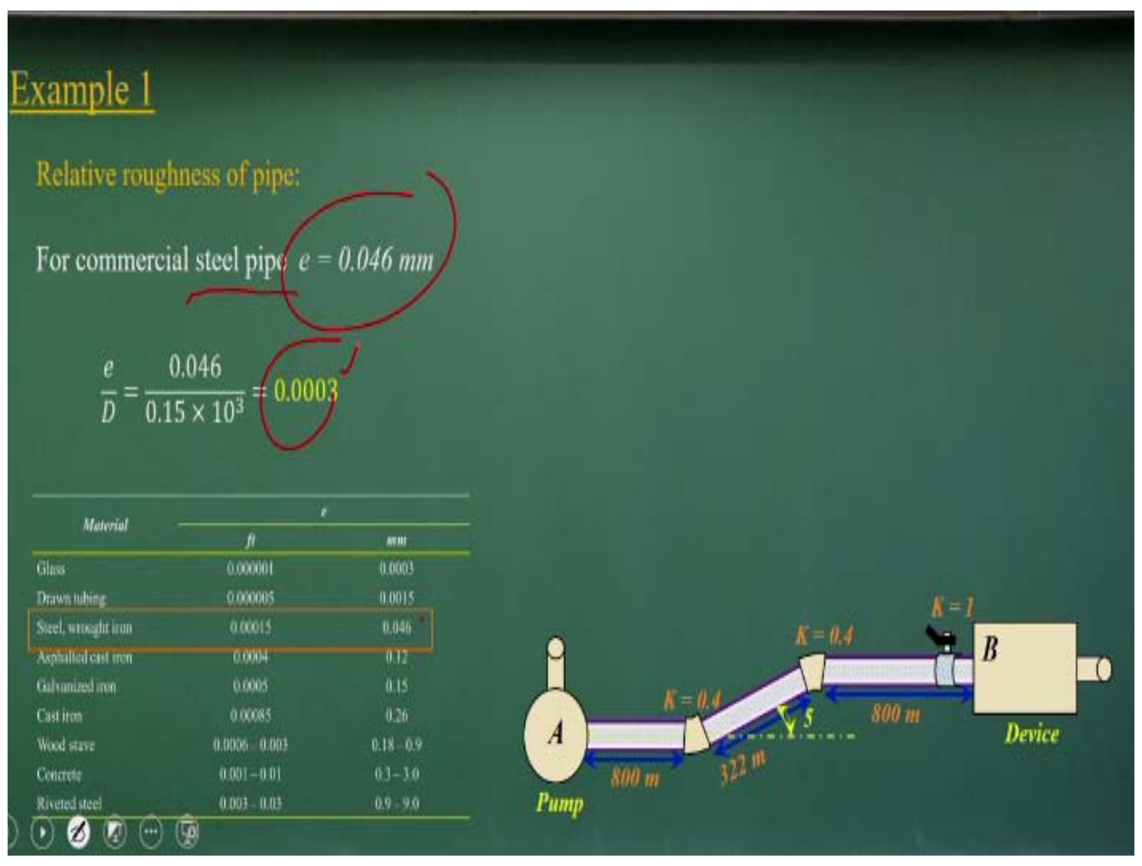

So this is a commercial steel pipe. So roughness value is given to here. The relative roughness value is know it. And once you know the relative roughness value, we are getting it this value and we are computing the relative roughness values.

For commercial steel pipe *e = 0.046 mm*

$$\frac{e}{D} = \frac{0.046}{0.15 \times 10^3} = 0.0003$$

If I know Reynolds numbers and the relative roughness value, I can compute it what will be the friction factors from Moody's chart. It is very easy.

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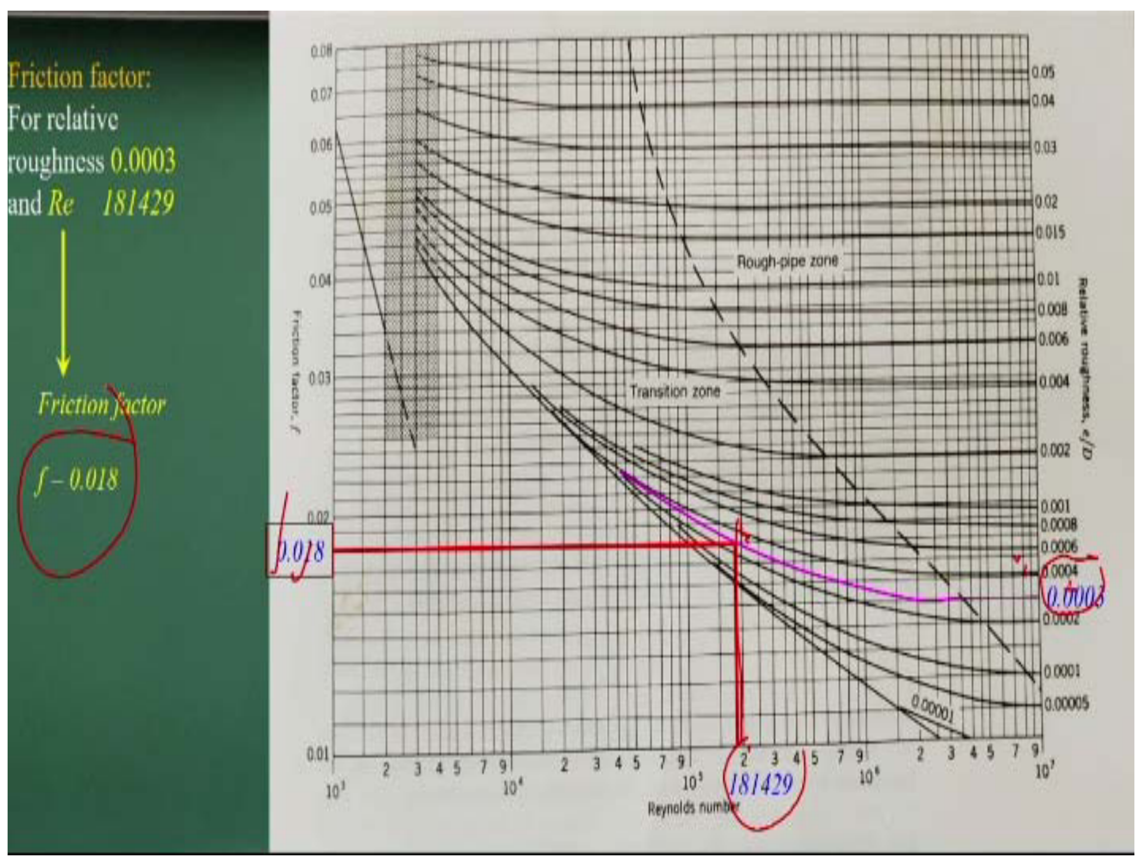

Identify this approximately which the curve will come there. You know, these Reynolds number, compute it that. Draw the lines with matching that then compute this friction factors, okay? It is very easy. Using this Moody's diagrams, you can first identify with respect to the relative which curve we should follow it. But if curve is not there exactly we can interpolate it that curve and know the Reynolds numbers, interpolate it this.

Then you get it the f factor which is the friction factors we are getting it. So once you know the friction factor then the problems I believe is quite easy okay.

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