Fluid and Particle Mechanics
Prof. Sumesh P. Thampi
Department of Chemical Engineering
Indian Institute of Technology, Madras

Lecture - 64
Pressure Drop in Pipes Which Connected at Junction

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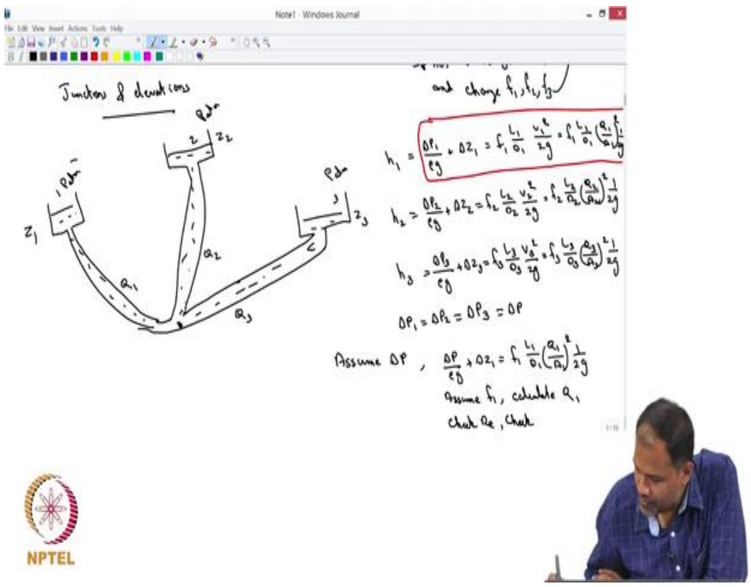

Let me give a new example; can you know which has got junctions and elevations. So, you have let us say some reservoir from which a pipe is coming. Let us call this reservoir 1, this is another one, and then there is another one ok. So, this reservoir 1, this as reservoir 2, that is reservoir 3, and all of them are filled with some fluid ok. Let us say this is at an elevation is z 1, this is at an elevation is z 2, and this is at an elevation is z 3.

Now, you, so the what is going to happen is that the fluid from the highest reservoir or the highest two reservoir is going to flow into the third reservoir. You do not know what it is, and let us say your interest is to calculate what is the flow rate through each of these pipes ok. So, let us assume that Q 1, Q 2, Q 3 are the flow rates, but you do not know what is Q 1, Q 2, Q 3, you do not know what is the pressure drop except that you just know that it is all you know at different elevations. So, here we will have P atmospheric here we will have P atmospheric here we will have P atmospheric.

So, the flow rate Q 1 is determined by the atmospheric pressure or the and then this hydrostatic head. So, it is really is z 1 that determines what is the flow rate through Q 1, and that would generate a pressure difference between the top of the reservoir and this point at the junction. Similarly, there will be a pressure drop across your second pipe, there will be a pressure drop across your third pipe.

So, you can write down general equations. You can say that your h 1 which is the pressure drop across the first pipe is given by delta p 1 by rho g that is a pressure drop plus you know delta is z 1, so that is essentially so that is the definition of our head loss ok. So, so far we have not been taking you know z into consideration, because we never worried about elevation changes, and that is equal to f into l 1 by D 1 into v 1 square by 2 g ok. Where v 1 we do not know, but we know it in terms of Q 1. So, let us write it as f 1 into L 1 by D 1 into Q 1 by A 1 whole square and then there is A 1 by 2 g ok.

Similarly, h 2 is equal to delta p 2 by rho g plus delta z 2 that is equal to f 2 into L 2 by D 2 into v 2 square by 2 g or that is equal to f 2 into L 2 by D 2 into Q 2 by A 2 whole square into 1 by 2 g. Similarly, h 3 equal to delta p 3 by rho g plus delta is z 3 equal to f 3 into L 3 by D 3 into v 3 square by 2 g that is f 3 into L 3 by D 3 into Q 3 by A 3 whole square into 1 by 2 g ok.

$$h_i = \frac{\Delta P_i}{\rho g} + \Delta z_i = \frac{f_i L_i}{D_i}\frac{v_i^2}{2g} = \frac{f_i L_i}{D_i}\left(\frac{Q_i}{A_i}\right)^2 \frac{1}{2g} \; ; i = 1,2,3$$

Now, what we know is that h 1, h 2, h 3 should be different, because the z 1 is z 2, z 3 are different, but delta p 1, delta p 2, delta p 3 should be same. Because on one side, it is all exposed to atmosphere and delta p 1 is what the pressure difference between the top of this reservoir and this junction. Similarly, delta p 2 will be the pressure difference between the top of the reservoir, and this junction in which three pipes join and then so it is delta p 3.

So, we would know delta p 1 is equal to delta p 2 is equal to delta p 3, so that is one thing that we know and therefore, what you can do is you can start again you need an iterative procedure let us say assume delta p. So, let us call it equal to delta p assume delta p. So, if you know delta p, then what you can do is that let us take the first equation which is that.

So, let us write it down if you assume delta p, then delta p by rho g plus delta is z 1 is equal to f 1 into L 1 by D 1 into Q 1 by A 1 whole square into 1 by 2 g. So, you assume f 1, calculate Q 1, check Reynolds number, check Re gives assumed f 1 that is this f 1 if not continue till you get a f 1 Q 1 consistency ok.

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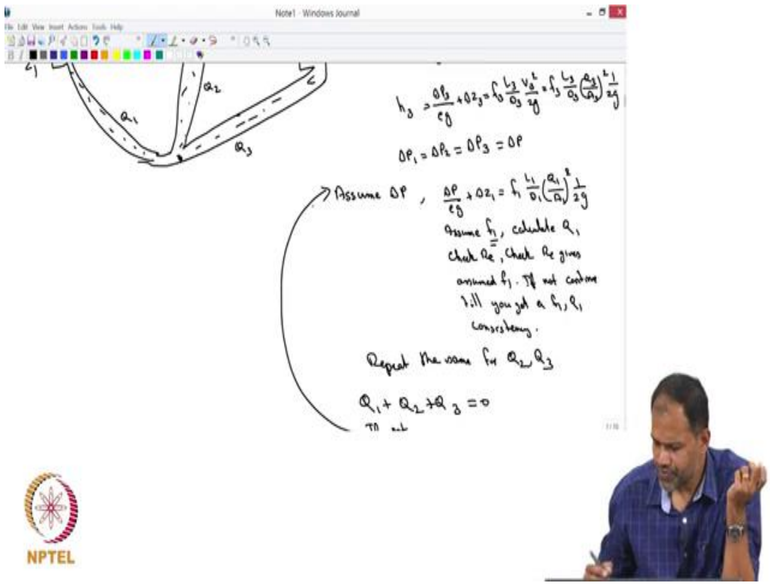

So, then you can do that and repeat, the same for Q 2 and Q 3. And once you get Q 1, Q 2, Q 3, then you know that Q 1 plus Q 2 plus Q 3 should be equal to 0. If not, then you have to go and change your assume delta p, and the process to be continued. So, what am I trying to say I am trying to say that you can for example, assume delta p, you know the equation for each pipe, so you can solve for what is velocity in each pipe. But when you try to do that you would not know what is the friction factor, so you have to assume a value friction factor find out the velocity in each pipe ok, and you have to do that in an iterative manner, so that you get an f 1 v 1 or f 1 and Q 1 combination that satisfies the assumed delta p.

And then you can do the same thing for second pipe, you can do the same thing for third pipe that means you have gotten the flow rate for first second and third pipe. But you also know that you are actually looking at a junction and there cannot be a net flow, so Q 1 plus Q 2 plus Q 3 should be equal to 0. So, you can check that condition and if that condition is violated, that means, this delta p that you have assumed the one which you started with is actually the wrong one, and you need to change that value. And then continue this procedure still till you find that Q 1 plus Q 2 plus Q 3 equal to 0.

So, this for example one way of solving the set of equations. As I mentioned earlier you can come up with any procedure, so that this condition is satisfied. So, the point in note is that as far as the junction is concerned, there is no net flow through that or whatever is coming into that junction the flow it should be such that that fluid flow should go out or in incoming flow should be equal to outgoing flow. As long as you impose that condition and your solution satisfies that that is going to be your solution.

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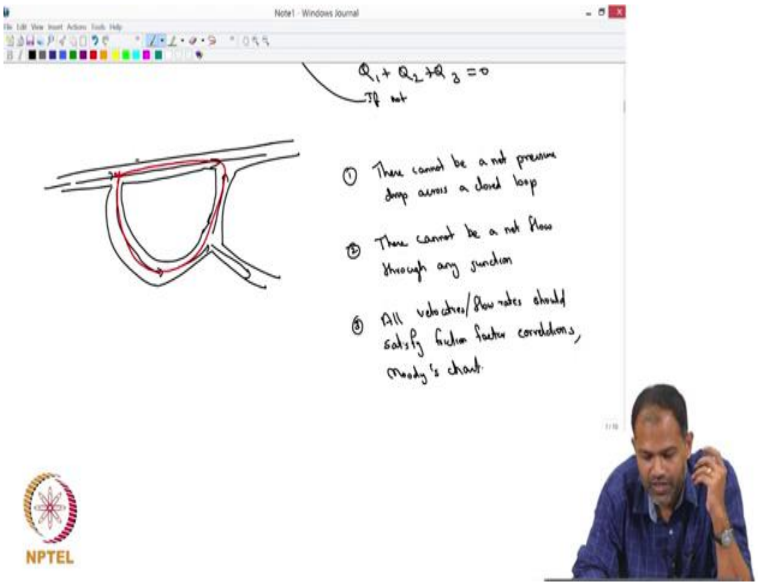

So, in general whenever you have a system it is you know you let us say you have a pipe, it might be complicated one, this is something like this cames. So, there is a fluid that is going to go like that, there is a bifurcation, and then it goes, it goes that way, it goes this way and so a complicated system. What you can do is that given this that, if I take any loop let us say a loop that you start from there, and finish that loop. And if I am coming back at that point then you can insist that there cannot be a pressure drop across a closed loop, because I am starting from the same point and ending at the same point.

So, you can has insist that there cannot be a net pressure drop across a closed loop. Second thing that you can say is that there cannot be net flow through any junction. So, these are the two constraints that you should impose. And if you are trying to impose that constraint and then you are going to get all values for velocity, you are going to get Reynolds number for each pipe and then you can insist that all you know friction, all velocities, all velocities that you calculate or flow rates that you calculates should satisfy friction factor correlations Moody's chart.

So, as long as you write down you know set of correlations that satisfy these three constraints, then you basically will have a system that needs to be solved ok. And most of the times you would end up the solution being in an iterative form because you will have more than one unknowns, and the equations may not be straightforward to do it. And remember when I have done all these calculations, I have assumed all minor losses to be 0, but the minor losses should be accounted for because we know that some it can be it can play a major role.

So, then it will really depend upon the system that you are looking at. So, so for example, when you write down the total head loss, you should write down the total head loss due to the length of the pipe as well as that due to the minor losses like bends and valves and so on in the system.

So, it becomes a very system specific configuration. But what we have done is really looked at what are the constraints that you should impose ok. So, the constraints would be one is coming from the mass conservation which is about how a flow gets divided or added up. The second is about coming from the force balance, which is about your pressure loss or how does the pressure drop whether they get added or equally divided and so on.

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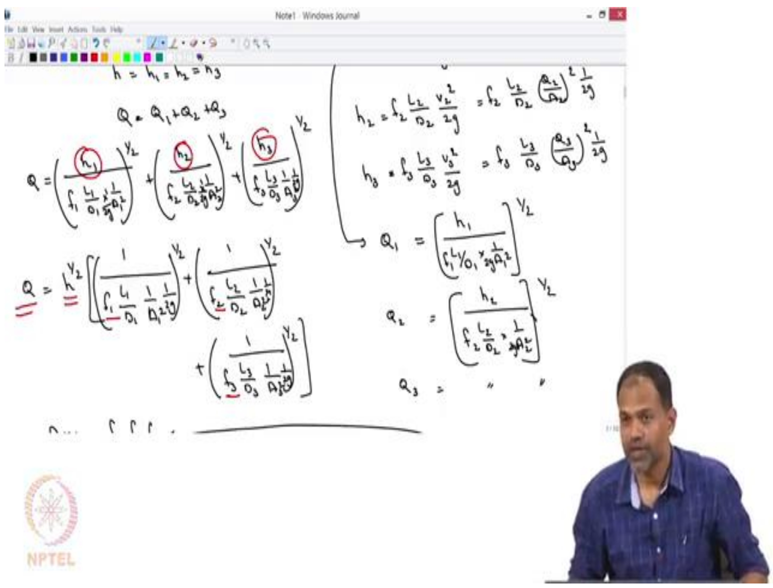

So, these are the two rules that you should remember. I just realized that while I wrote the first problem, I have not taken a one by 2 g into consideration. So, here when I replace v 1 with Q 1 by A 1 there is a factor of 1 by 2 g is a factor of 1 by 2 g is a factor of 1 by 2 g which would appear in expressions for Q 1, Q 2 and in Q 3. And when you have substituted that would again come, so that is 1 by 2 g, 1 by 2 g, 1 by 2 g, 1 by 2 g, 1 by 2 g and 1 by 2 g, it is just coming as a factor ok.