Fluid Mechanics

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Lecture – 39

Pipe Flow Systems

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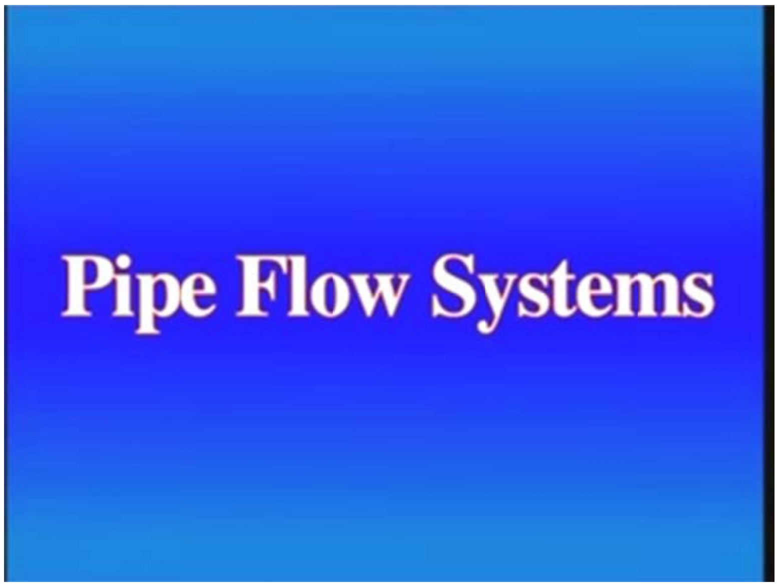

Welcome back to the video course on fluid mechanics. In the last lecture, we have discussed various concepts of pipe flow system design. We have seen typically three varieties of problems: first problem is type 1 problem where, already the fluid properties like density, viscosity, velocity or discharge and the pipe properties like the diameter and the roughness height. These values are given and we have to find out the head loss.

We have seen that we can directly solve this problem by using this Darcy Weisbach equation and related equations for type 1 problems. And then we have seen the type 2 problems. In this the full properties like fluid density, dynamic viscosity nu are given and also the Head loss is given from one section to another and also the pipe diameter and the roughness height is given, we have to find out the discharge or velocity passing through the pipe flow systems. That is type 2 problem. Here, we see by using various equations we have to go through and iterate a procedure to find out Q or v. Since, without velocity we cannot calculate the Reynolds's number, we will assume some friction value f and then calculate the Reynolds's number and then we see that through an iterative procedure will be solving this type 2 problems.

In the type 3 problems, it is given that fluid properties like the fluid density, coefficient dynamic viscosity is given; velocity is given; the roughness height and the head loss is given. We have to design the pipe or we have to find out the diameter. Here also, we will assume certain values of f flow and the friction factor and then we find out the diameter of the pipe through an iterate procedure as we discussed in the last lecture. We go to some other systems of pipes like various pipes in series, piping parallel systems and say with the brazen piping system.

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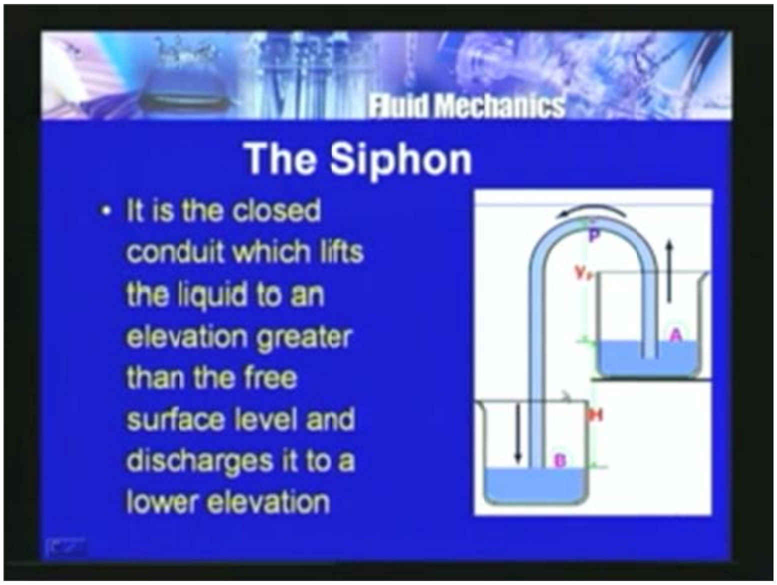

Before that one more aspect we have to discuss here is the siphon. Siphon is also one of the bottom system used to transfer many of the fluids from one location to another or different kinds of systems. A typical siphon is shown in this slide. Here we can see that what we are doing is, if there are two reservoirs one is at an upper elevation and other one at lower elevation. From upper elevation to transfer the fluid or water through a raised location we use the siphon. Siphon is a closed conduit which lifts the liquid to an elevation greater than the free surface level and discharges it to lower elevation. Siphon is acting like this. Here, we have got higher elevator reservoir A and we have got a lower elevator reservoir B. But gravity flow is not possible. Since, there is a raised portion here. Through the raised portion we provide a pipe line but you can see that here the highest point in the pipe line is much above the reservoir A, but we are transferring the liquid or the water or fluid from A to B and B is set at a lower position. It is a closed conduct which lifts the liquid to an elevation greater than the free surface level and discharge to a lower elevation as we have seen.

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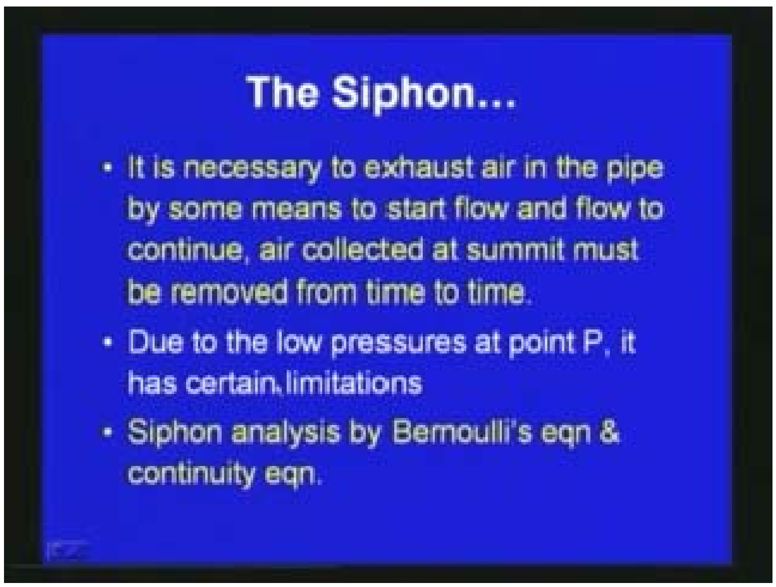

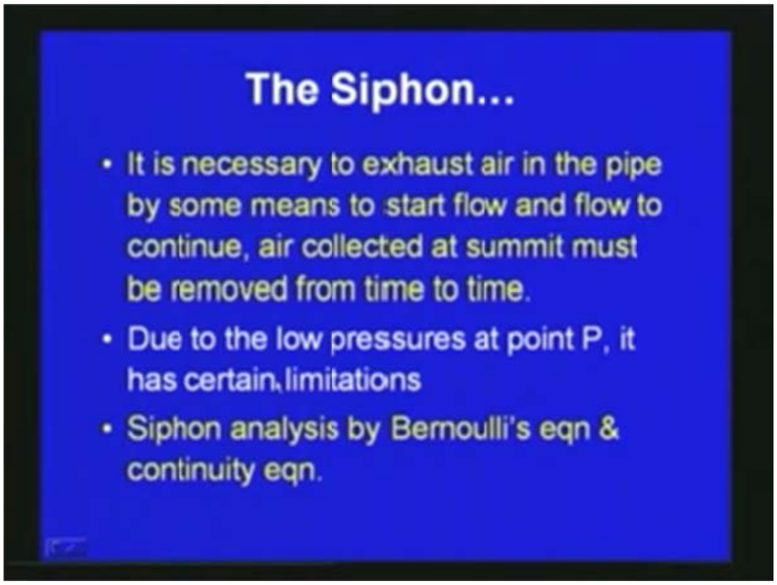

Here to operate the siphon system, it is necessary to exhaust air in the pipe by some means to start the flow and to continue the flow, air collected at summit must be removed from time to time. To get a continuous flow or even to start a flow we have to remove the air collected inside the pipe for various reasons.. You can see that there will be a low pressure at the raised position and due to the low pressure at point P we can see that in this continuous flow there can be some interruptions with respect to the flow and this low pressure has some limitation as for as the siphon is concerned.

The siphon analysis we can do through the Bernoulli's equation and Continuity equation symbol analysis. Since here what you have to find out is the either the pressure at the elevated clock location or we have to find out how much liquid has to be transferred over. We have to find out the head losses in the process. Different kinds of problem which we discussed with respect to the pipe flow systems are applicable here also. We can use the Bernoulli's equation and then we can also use the Continuity equation together to get the various parameters with respect to the siphon.

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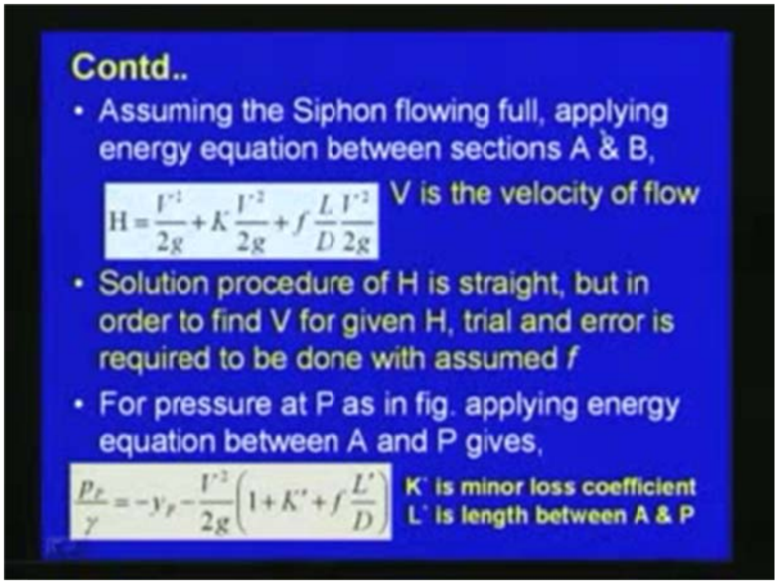

(Refer Slide Time: 06:58) As we discussed here, with respect to this siphon here, assuming the siphon is flowing full we can apply the Energy equation between section A and B, i.e., between the reservoir A and B between these locations if you apply the energy equation we can write H is equal to V square by 2 g plus K V square by 2 g plus f L V square by 2 g D where V is the velocity of flow, f is the friction factor, L is the length of the siphon, D is the diameter is the siphon, g is the acieration D 2 and gravity and K is the coefficient with respect to the minor losses; this gives the energy equation. The solution procedure for H is straight forward, but in order to find the velocity V for the given H we may have to go to trial and error. So, division with assumed value of the friction factor f. You want to find out the pressure at P as shown in figure. [Refer Slide Time: 08:05] Here, at this raised location here we want to find out the pressure very much lower here are some times which may be negative pressure also.

Here to find out pressure at P as in the figure we can apply the Energy equation between A and P that will give $P_{P.}$ As the Energy equation between A and P gives P_P by gamma is equal to minus y_A minus V square by 2g into 1 plus K dash plus f L dash by D where K dash is the minor loss coefficient and L dash is the length between A and P.

Here [Refer Slide Time: 08:38] you can see that this y_p this is from B to A. This is H here and y_p is the vertical distance from A water level location to the top point P. If you want to find out the pressure at P you can utilize this equation P_P by gamma is equal to minus y_P minus V square by 2 g into 1 plus K dash plus f L dash by D where K dash is the minor loss for coefficient for the system and m dash as the length between A and P.

Like this as far as siphon is concerned, we can solve the given system. Whether, we want to find out the H that means, the head loss or whether we want to find out the velocity or we want to find out any other parameter depending upon the different types of problems we discussed earlier we can find out the type of the problem and then we can go for direct solution by using by Bernoulli’s equation and the Continuity equation or we can go for a trial and error solution as we discussed in the earlier lecture. Here, as we have seen this siphon is one of the important piping systems used in so many places we use the siphon action over the siphon to transfer liquid from one reservoir to another reservoir where ever, whenever there is an elevated portion between the two reservoirs we can use this siphon action or we can use the principle and the siphon. This is about the siphon.

Now, we will discuss the multiple pipe flow system. So far the problems which we discussed are related to a single pipe system, when it is connected to a reservoir. Now we will discuss in detail about the multiple piping systems. Mostly, we can see that if you discuss about the water supply system or when we deal with the various other piping systems either gas transfer or any other liquid transfer system most of the times we will be dealing with multiple pipes. For long distances we cannot use a single pipe to transfer liquid from one place to another, so we will be using a number of pipes. For that we have to deal with the multiple piping systems and also many times at many locations we have to deal with divided flow.

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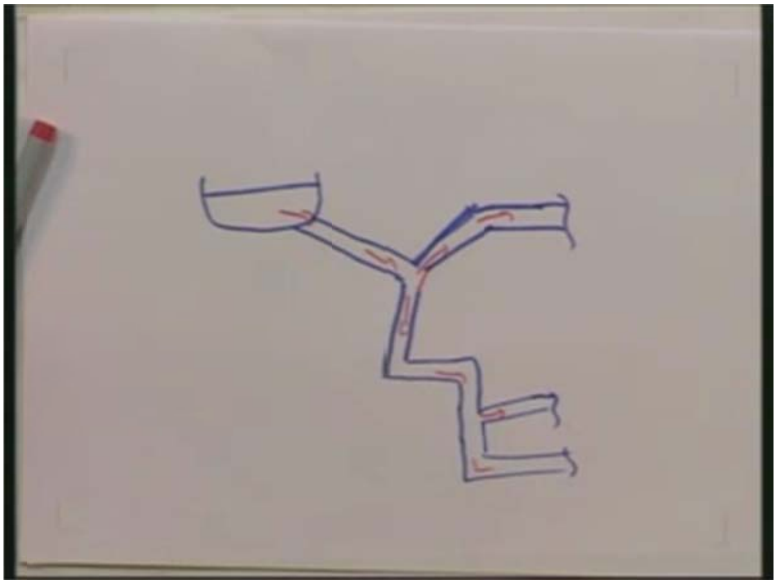

The flow will be coming from one location, you can see that, if this is a reservoir here and this is the pipe from, say for example, just like in the case of water supply piping system we can see that depending upon the problem the flow will be dividing between one system to another and then again there will be various branching like this. In all this system you can see that we may have to deal with multiple piping systems with divided flow you can see that the flow is starting from this location it is flowing like this but here you can see it is flowing like this, flowing like this: so the flow is divided between the piping systems.

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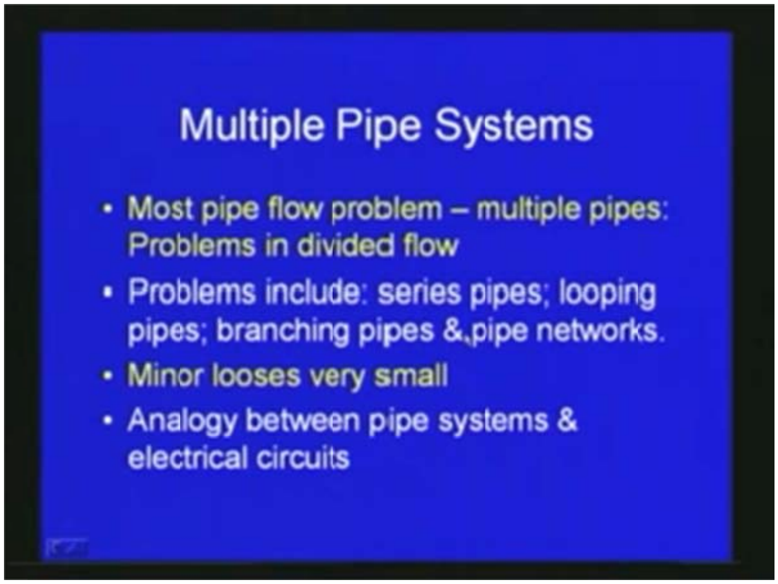

The kind of problems in multiple pipe systems include the pipes in cds (12:35) then looping pipes, branching pipes, and pipe networks. Typical problems in this multiple pipe system include: the first case is the piping series, [Refer Slide Time: 12:53] when we are connecting say for example, a reservoir to another reservoir we may depend upon the kinds of pipes which may be of larger diameter or smaller diameter. Like this it may be in a piping series. Here you can see that this is the typical case whenever the flow is through piping series. Here the different pipes are connected serially. That is why we say that pipe flow is series, pipe connection in series. Sometimes we will be having, depending upon the problem we may have, pipes .in parallel system. For example we can have a piping system like this with respect to various systems. We can have different kinds of piping series. This is called piping parallel.

This is another: first one is piping series; next is piping parallel system and then as we have seen earlier here we can see branched piping systems. So we can see [Refer slide Time: 14:14] that branching from one pipe to another of it is Branched pipe system.

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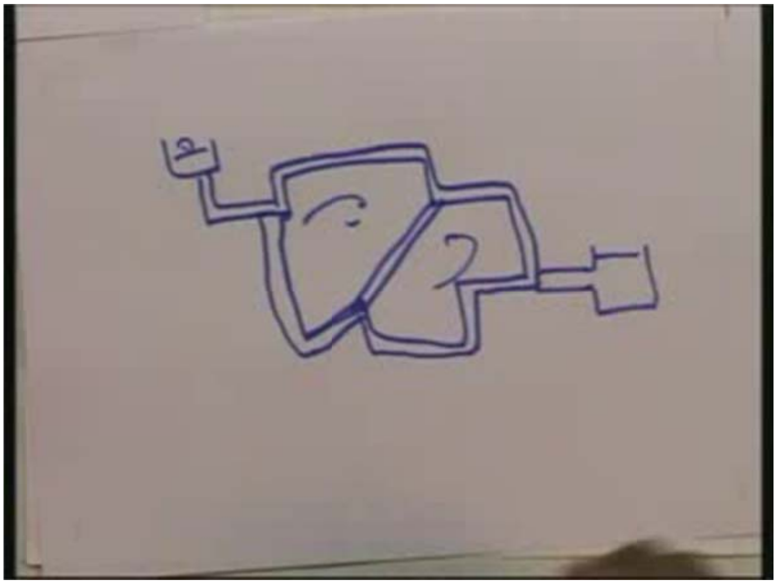

We can also have pipe networks. Depends on the problem say for example, most of the water supply system which we provide to cities has a network of piping systems going like this. It will be depending upon the problem it may come and joins with the same system. This is starting from… this is a piping system where you can see that it will be coming back to the system. This is called a networking of piping. So we can see that if this is a reservoir and here we got another system reservoir or other location. We can see here there will be loop here, one loop, another loop, so, this is network system. Depending upon the problem we will be having with multiple pipe system we may have series pipes, looping pipes, branching pipes or pipe network. We will be discussing each of these cases separately in detail. Most of this multiple piping system compare to the major losses that means, the friction losses which we calculate using Darcy Weisbach equation. Compared to these major losses minor loss will be very small. Depending upon the problem say for some problems you may neglect the minor losses but that also can be included in the calculation for better prediction.

When we deal with the pipe flow systems [Refer Slide Time: 15:58] the analogy between the pipe systems and electrical circuits is also helpful in some of the calculations.

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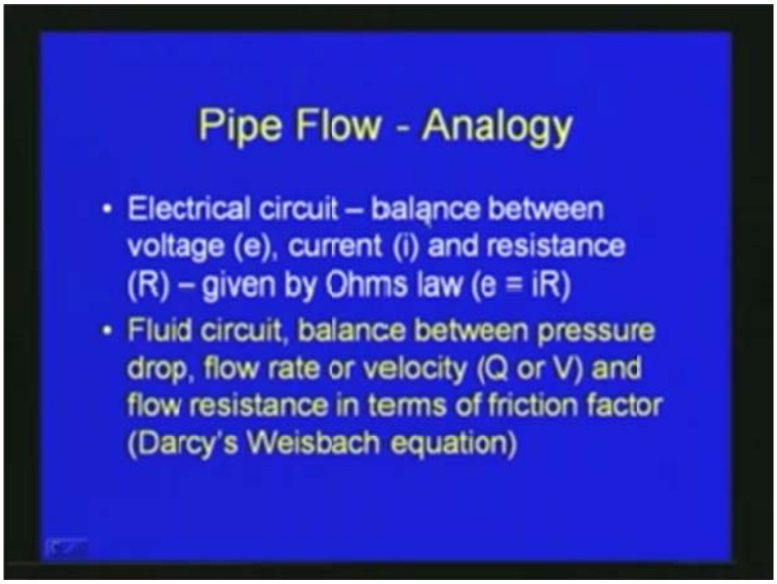

We can have an analogy between the pipe flow system and the electrical circuit. The pipe flow analogy with respect to the electrical circuit.. In the electrical circuit we can see that it is balance between the voltage e current i and resistance R given by ohms law e is equal to iR. You can see that here this is for the electrical network or electrical circuit similar way for fluid circuit just like in the network pipe network or the pipe flow systems we can see that there is a balance between the pressure drop flow rate or velocity and flow resistance in terms of the friction factor as we have seen the Darcy Weisbach equation.

We can have one to one correspondence with respect to the electrical circuit say for example, if we can just consider the ohms law there with respect to that we can very similar way with an analogy between the fluid circuit we can compare with the pressure drop with respect the voltage the flow or velocity with respect to current and then we can the resistance the in electrical circuit we can compare with respect to the flow resistance in terms of the friction factor and then we can compare with the Darcy Weisbach equation which we seen earlier with respect to the electrical corresponding for electrical circuit system. Like that we can have an analogy and then we can use this analogy for the solution of the pipe flow system.