Fluid Mechanics

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Lecture - 38

Pipe flow systems

Welcome back to the video course of fluid mechanics. In the last lecturer, we were discussing about the pipe systems and losses related to the pipe. We have seen that the pipe losses can be classified into major losses, the losses due to the friction and also viscous effect of the fluids. We have seen as the major losses and we have seen one of the most commonly used equations, Darcy Weisbach equation and its derivation and then related to the pipe friction factor. We have seen the moody's diagram and other related equations and then we have discussed the minor losses. The minor losses are due to various pipe fittings or changes in a pipe say, like expansion, contraction and other kind of fittings.

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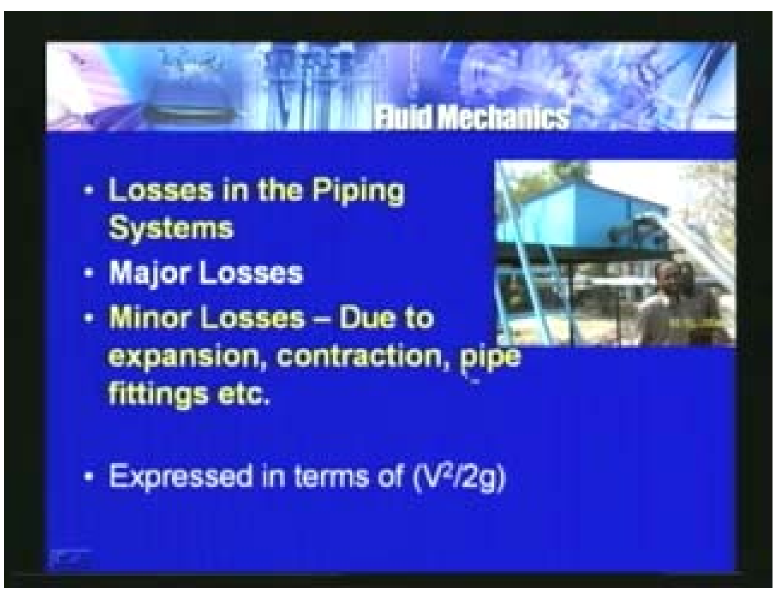

As we discussed, the losses can be major losses and minor losses. We have seen that the minor losses are concerned; we can put it in terms of v square by 2g, where v is the velocity of the pipe and so in terms of we can express k into v square by 2g, where k is the coefficients of constant with respect to various minor losses with respect to expansion, contraction, pipe fittings like junction, bens or t junction then walls etc. So these we have seen in the last lecture. Now, further we will discuss more about the various minor losses as far as pipe system circumstance.

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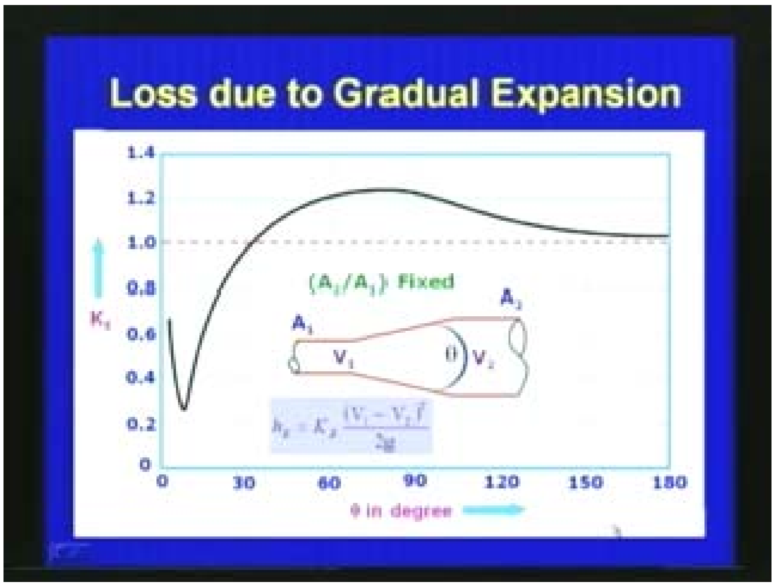

Here with respect to the loss due to the gradual expansion we have seen in earlier formula with respect to the expansion of pipe. When the pipe is expanding from some area friction section, A1 pipe diameter, d_1 to diameter d_2 and area friction A_2. Then we have seen the loss due to the expansion can be written as K_e into V_1 minus V_2 r square by 2g, where V_1 is the velocity at section 1 and V_2 is the velocity at section 2 and k is the loss coefficient with respect to various expansion types. With respect to various experiments as conducted, then with respect to this transmission, with respect to the expansion, this expansion angel is the angel theta. With respect to this theta we can find various loss coefficients. Here, we can see that it is ploted from starting from 0 to 180. Depending upon how much is the expansion, how much this angel then you can see that the lost coefficient is coefficient of pipe line is initially coming less, starting from point 7 it is going down and then further when the angel increases it is again increasing and then finally again it is becoming constant like this. This is obtained through a large number of experiments; this gives the loss coefficient k with respect to the angel theta. Like this for contraction also we can just do a number of experiments with respect to how much is the contraction or like as we have seen the expansion like this. So this is the expansion of the pipe with respect to the diameter change.

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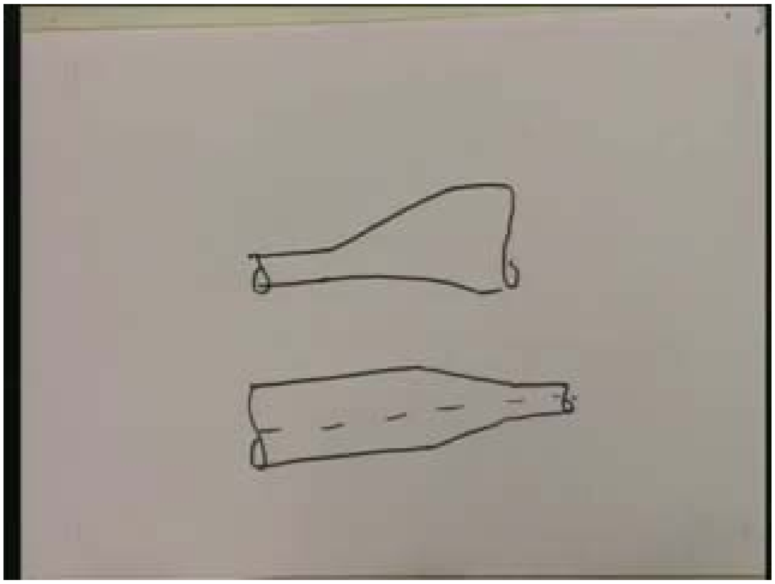

Similar way, corresponding to the contraction we have already seen an expression earlier, so with respect to the contraction of the pipe line we can also with respect to the angel of contraction, we can find out this loss coefficients K_e and then we can find out the loss for various angels. Then also we have seen this minor losses other then the expansion or contraction we can have various pipe fitting of pipe junction; also we have seen that when the flow enters from for example, from reservoir to a pipe, referable time to a pipe or when flow passes from the pipe to a tank or a reservoir so this is where there are enter and exit losses.

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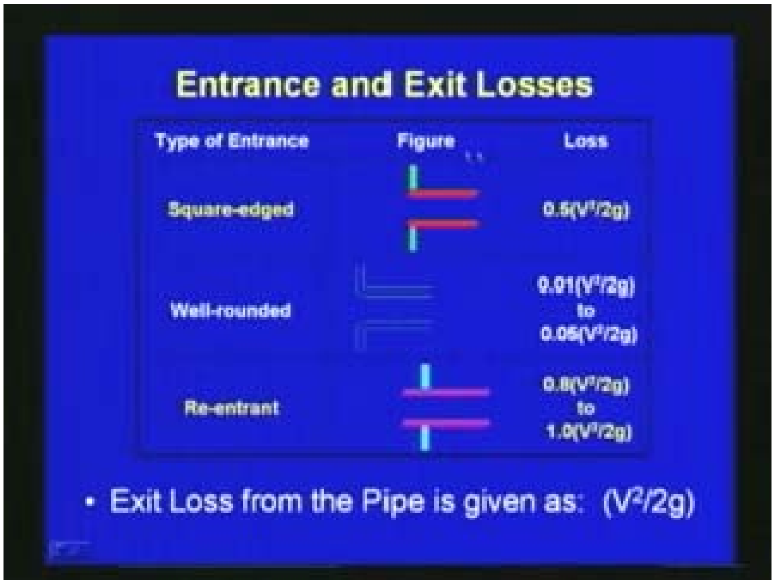

Here with respect to various parameter in this slide the type of entrance and then what kind of entrance if we see that and what are the brows coefficient, process with respect to loss coefficients here the losses are tabulated in the table, type of entrance is square edged like this. We can see that this is a square edges pipe entrance so generally the loss will be 0.5 times this v square by 2g, where v is the velocity team in the pipe flow; the pipe section here so 0.5 v square by 2g will be the loss with respect to the square adjust entrance like this and then we can see that if this square adjust entrance is just it is rounded or made by smooth entrance that we can see here, the losses will be reduced. So if it is well rounded like this we can see here instead of this corner edged this thing it is rounded. So the last coefficient will be reduced to 0.012 to 0.05 v square by 2g by depending upon the covered effectively a smooth we round it.

For well rounded entrance, the loss will be varying from 0.012 to 0.05 v square by 2g and then if the entrance is in such a way that there is re- entrance that means the pipe is extending to the other pipe or the tank or the reservoir like this re- entrance we can see that loss will be much higher. So it is generally varying from 0.8 v square by 2g to 1 v square by 2 g. Suppose this will be much higher than v square this thing and so like this so depending upon which way we give the entrance, which way the exit type space, the losses will be varying, the pipe loss will be varying and loss coefficient we can say obtained through experiments are the fluid test.

Generally where ever an expansion or where ever an entrance is there it is always better to have smooth transmission, smooth entrance, a smooth exit in such a way that the losses will be much less as shown in this figure for the well round case. So if all this exit and then entrance loss we can put in terms of v square by 2g as we discussed earlier and then some of the other important pipe components are like valves, gates for this also we can see that since these are also either some way controlling the flow and then there will be definitely effect of the pipe loss effect to be done.

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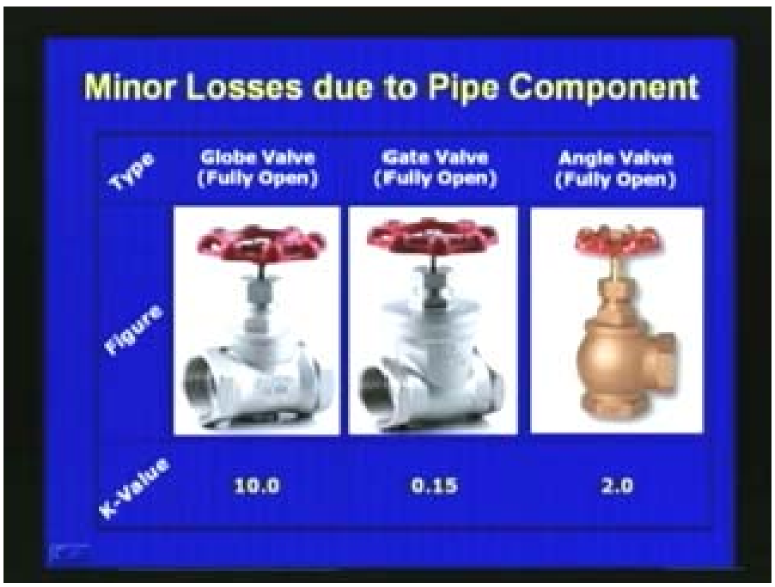

Here in this slide depending upon the pipe of the type of the valve, type of the gate, the loss coefficients k will be varying so the type of the gate r valve is put here and corresponding k value. As we discussed, the pipe loss is put in types of k v square by 2g, so this expression in to v square by 2g by k so k v square by 2g, so here when this is depending upon the valve gate or valve this k value is put here approx which also depending upon the material so this k value varying depending upon the material what kind of smoothing what kind of way the way consecution of the valve so this k will vary.

Some of this standard available values of k are written here, so can see that the valve is global, valve fully open globe valve there k valve will be above 10 as shown here and then if the gate valve is fully open, gate valve as soon in this figure then it is much less the loss will be much less it will be 0.15 with k value it 0.15 and then if it is angel valve, fully open like this an angel valve then the k value will be about 2.

So this value k depends upon the material, another type of consecution so generally the manufacture will specify this loss coefficients k with respect to the material and with respect to the type of manufacturer and other parameters based upon the test conducted in the laboratory and then if it is a swing check valve fully open then k value is about 2 then this is swing check valve as shown in this figure would be k value about 2 and if it standard tee junction like this.

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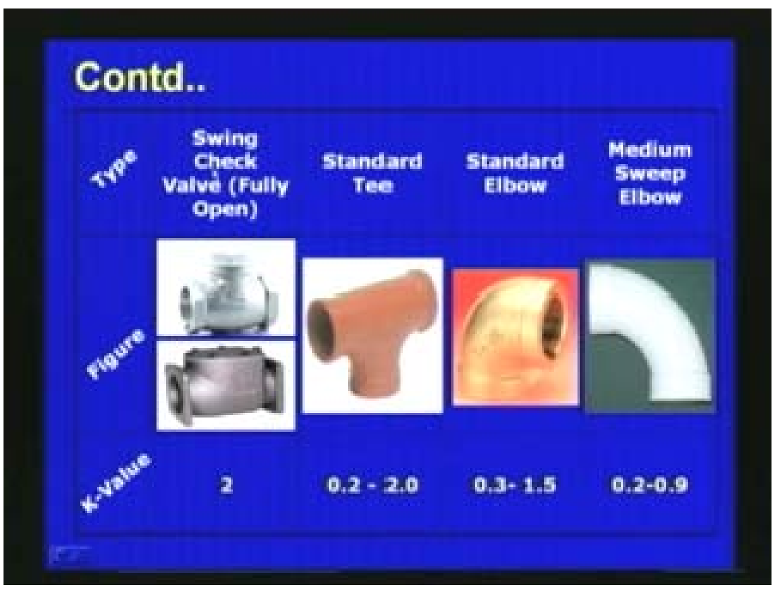

You can see that tee flow is going like this tee is dieting so the k value will be varying from 0.2 to 0.2 k value will be varying and if it is standard l board the k value will be varying from 0.3 to 1.5. So this is the standard board which is for diverting the flow. So it is 0.3 to 0.5 and if it is medium sweep elbow, that is, the flow much smoother and loss it will be much lesser, we can see that it will be 0.2 to 0.9 standard values will be varying

0.2 to 0.9 depending upon the pipe material and smoothness given. So medium sweep elbow k vary 0.2 to 0.9 and then if it is long sweep.

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Elbow valve like this long sweep elbow k value would be about 0.60 and if it is ninety degree bend like this we can see that for 90 degree turn of the pipe. If it will be using 90 degree bend, so here for 90 degree bend the k value would be about 1.2 and then if it is 180 degree bend you can see return bend like this k value would be about 1.5. So like this say for various valves where various junction t is over various gates depending upon the type of material, type of manufacturer according to the manufacturing wave manufacturing and how you give the connection between the main pipe to the valve with fittings this k value will be varying and most of the manufacturing will be specifying the k value for their products depending upon the material.

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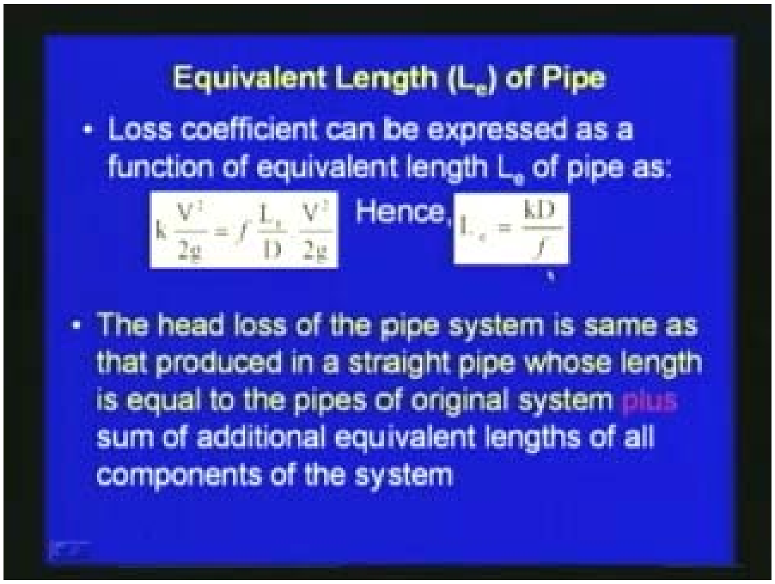

We can directly utilize with respect to which type of valve used or which type of gate or which type of bend we use for our pipe line, we can use this standard value available from the manufacturer and now we have already seen we are expressing the minor losses in terms of v square by 2g this is the average velocity.

Now another aspect with respect to this loss coefficients with which have discussed earlier it is equivalent length of pie, so the loss coefficients can be expressed as function of equivalent length l e of pipe as so we have seen this minor loss here is expressing term of k into v square by 2 g. The major loss we are using Darcy general we are using Darcy Weisbach equation so which is fl v square by 2g d. We can write this minor loss in terms of an equivalent length pipe length so that everything can be put in terms of the major friction losses. So that length is called the equivalent length, so to get that equivalent length we can equate that is minor loss again v square by 2g as f into l e by d into v square by 2g which Darcy's Weisbach equation f l e by d into v square by2g which is Darcy's Weisbach equation fl v square by 2g.

So this l e is the equivalent length corresponding to this last coefficient of minor loss k v square by 2 g. So finally with respect to this equation we will get the equivalent length as l e is equal to k into d by f, where k is the last coefficient, d is the diameter of the pipe and f is the friction factor.

For the given pipe system of the given system we can convert if there are number of bens, number gates, number of valves etc. So all this things we can convert in terms of the equivalent length and then finally we can solve in term of the major loss that is with respect to the Darcy's Weisbach equation. So the equivalent length is obtain l e is equal to k into d by f where k is the loss coefficient and d is the diameter of the pipe and f is the friction factor. So now the head loss of the pipe system is same as that produced by the straight pipe whose length is equal to the pipes of original system plus some of additional equivalent length of all components of the system. Once we calculate its equivalent length, calculation for various fitting, pipe fitting entrance losses and exit losses then we can write the total head loss; we can write in terms of the existing straight pipe which is already existing plus we can add some of additional equivalent length which we work from with respect to the various components of the pipe systems as described here.

Now with respect to various piping components we can also mention this value of k is given by the manufacturer depending upon the material and depending upon the components pipe components. So with respect to the piping components since it is le is equal to k d by f, where k is loss coefficient already known for the given fitting given components and f is also known as the friction factor then this l by d that means l e d will be k by f so for the given pipe fitting k will be the it will constant to be known and the friction fact to the also known, that we can have this kind of table so that directly from that table we can get this once the diameter is known we can get the coral length.

For example conventional globe value l e by d depending upon the material it can be 400 for y pattern globe value can be 160, fully open gate valve it can be 10, 50% open gate value can be 150, standard tee can be obtained 90 degree standard elbow it can be 30, 45 degree standard elbow is 16, return bend 50 like this k by f is given.

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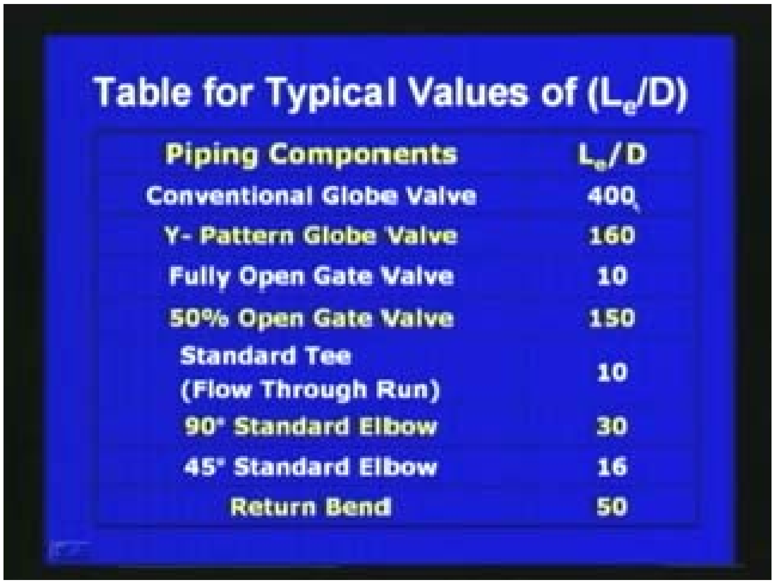

So that we get l e by d and the equivalent length by diameter, so once if you know the diameter with respect to the pipe fitting we can easily get the equivalent length of the pipe. Now just with respect to the tabular form we just discuss small example here.

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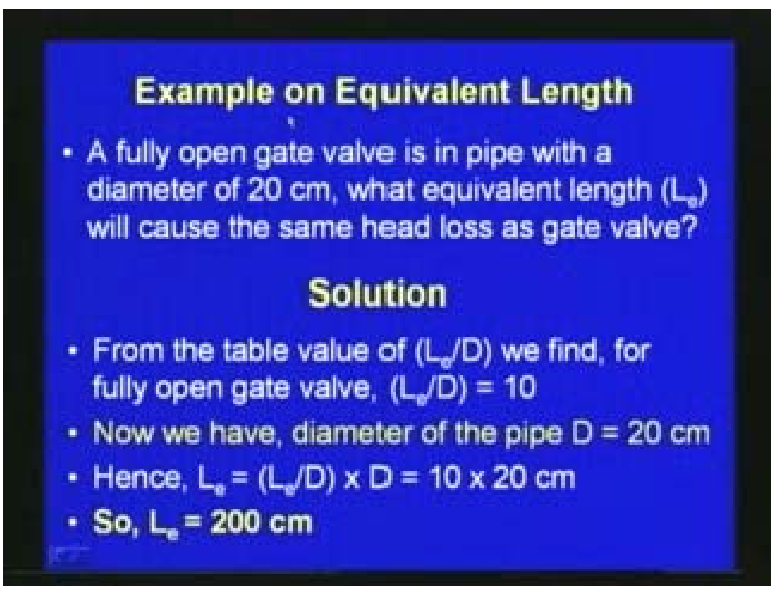

A fully open gate value is in pipe with a diameter 20 centimeter. What equivalent length l e will cause the same head loss as gate valve? So now the question here is same we have to fully open gate value in pipe with diameter 20 centimeter so we want to find out what to be equivalent length with respect to this gate value.

So that the same head loss as gate value from the table we can see that the l e by d so corresponding to see l e by d here, fully gate value is 10, so this 10 l e by d is equal to 10 so since here diameter is already give is 20 centimeter, so the equivalent length will be l e is equal to this l e by d already is given has 10 into d. So 10 into 20 centimeter, so that will give the equivalent length corresponding it will be 200 centimeter.

So equivalent to this fully open gate we will be having an equation and length of 200 centimeter of pipe for the where ever this fitting is done. So for the pipe system like this we can solve various examples, various problems where ever various fittings have there we can find out what kind of fitting and then l e by d values are known. So once the diameter is known we can calculate the equivalent length. Now other important aspects while we do these kinds of pipe design we can calculate the equivalents pipe.

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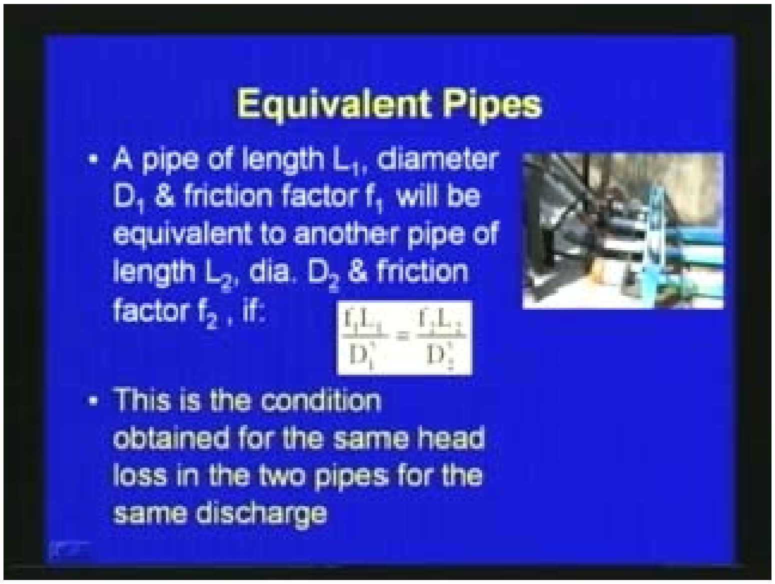

We can see that like in this photographic we will be using different kinds of diameter of pipes, for example here 1 diameter and here another 1 diameter here 1 and diameter here and so like that will be having number of types of pipes single system.

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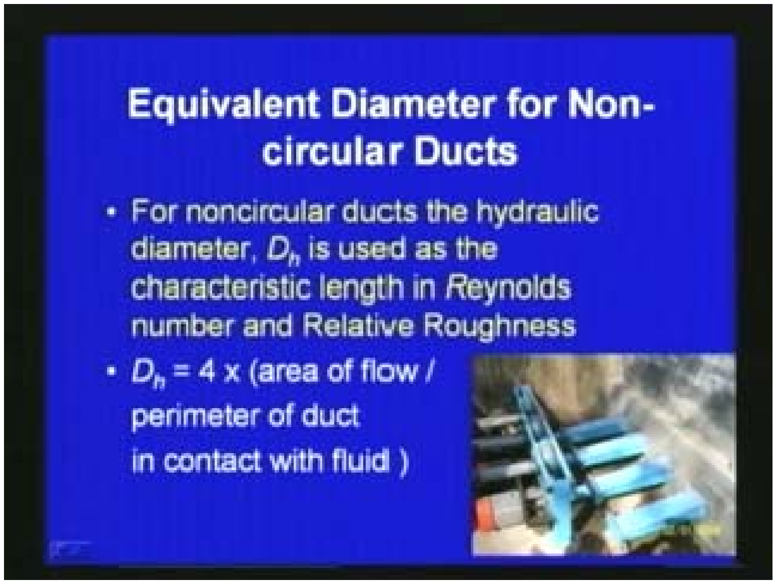

It will be easy if we can find out the equivalent pipes correspondingly, so this we can obtain for example pipe of length l_1 diameter d_1 and friction factor f_1 will be equivalent to another pipe of length l_2 diameter d_2 and friction factor f 2 if f_1 l_1 by d_1 to the power 5 is equal to f_2 by d_2 the power 5.

So this condition is obtained by for same head loss, the two pipes for the same discharge. If discharge the pausing is same then we can obtain, we can use this decry Weisbach equation and then discharge and if we since with the assumption if you the same head loss is there in 2 pipes between with 2 pipes width then you can Darcy Weisbach equation with respect to this two pipes and then we can write f_1, l_1 by d_1 to the power 5 is equal to f_2 l_2 d_2 to the power 5. From which we can find out whether the length as known and f_1 and f_2 known then what you do the d_2 in terms of d_1 are like that we can calculate the equivalent pipes correspondingly for the given system by using this equation and then also some dance for some kinds of problem we may be able to use the circular pipe the diameter we cannot specifically depend upon the field condition you cannot use the circular pipe. There we can how known circular ducts for example this one of the modeling work which will ducts reason ally from the charge full here the flow is come through a ducts like this so tapering ducts like this, you can see that these kinds of problem as we have to find equivalent diameter for the non-circular ducts. So for non-circular pipes the hydraulic diameter d h is used as the characteristic length for calculation of roughness number and relative roughness.

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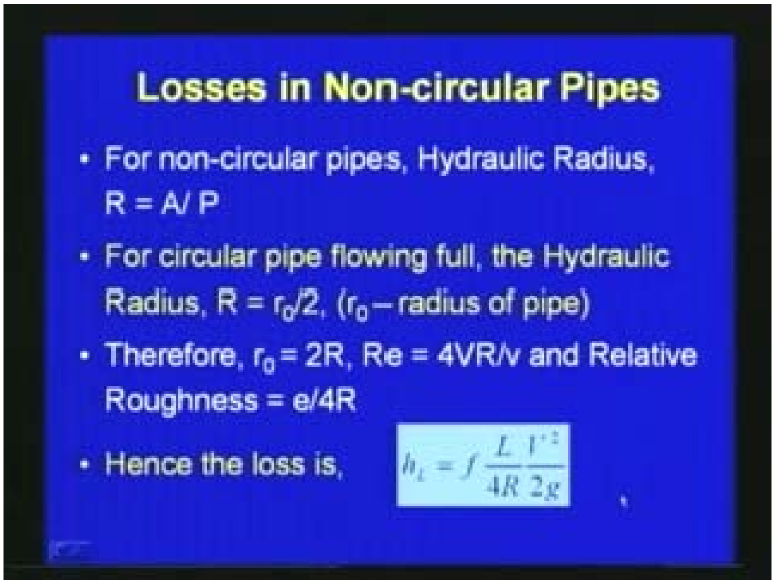

For the non- circular pipes which we use for the few problems we can calculate, we can find out the hydraulic diameter, equivalent hydraulic diameter d h and then we can solve for the Reynolds number or relative roughness and other parameters. Generally this d h which is the hydraulic diameter will be four times the flow by perimeter of duct in conduct with fluid. Here this a by p is hydraulic d is four times of hydraulic realize will be the hydraulic diameter for the given system so d h is equal to 4 into area of flow divide by perimeter the duct in contact. So you can use this equation to get the equivalent diameter for the non-circular duct and then for non-circular pipes we have to hydraulic radius is if r is equal to a by p.

For circular pipe flowing full correspondingly the hydraulic radius we can put as r e is equal to a by p which will is equal to d by 4 that is equal to r 0 by 2. Correspondingly you can see that if r 0 is the radius of pipe so r e is equal to r 0 by 2. Therefore r 0 is equal to two times the hydraulic radius. If we want to find out the Reynolds number, Reynolds number is the radius by new for the pipe where new is the kinematics disc city is the diameter of the pipe view is the velocity. Since r 0 is the radius is towards diameter is we can put equivalent diameters for r capital r is the hydraulic radius of the system.

The non-circular pipe so the Reynolds number the we can put in terms of for v are by mu and relative roughness will be e by d. So d is known for r so e by 4 r. Like this for given system for the given non-circular pipe system we can convert with respect to the hydraulic diameter by using from by hydraulic radius we can get the hydraulic diameter as describe here and then we can directly use in the calculation of the Reynolds number for the relative roughness for the given systems.

Then finally if you want to find out the head loss you can just substitute the Darcy Weisbach equation, we have seen the head loss equal to f l v square by 2g d so here d is now 4 times r where r is the hydraulic radius. So, h_l is equal to head loss which one is equal to f_l v square by 4r rho g. So it will be 8 f_l v square by 8 g r. Instead of d, it will be 4r, where r is the hydraulic radius for the non-circular systems.

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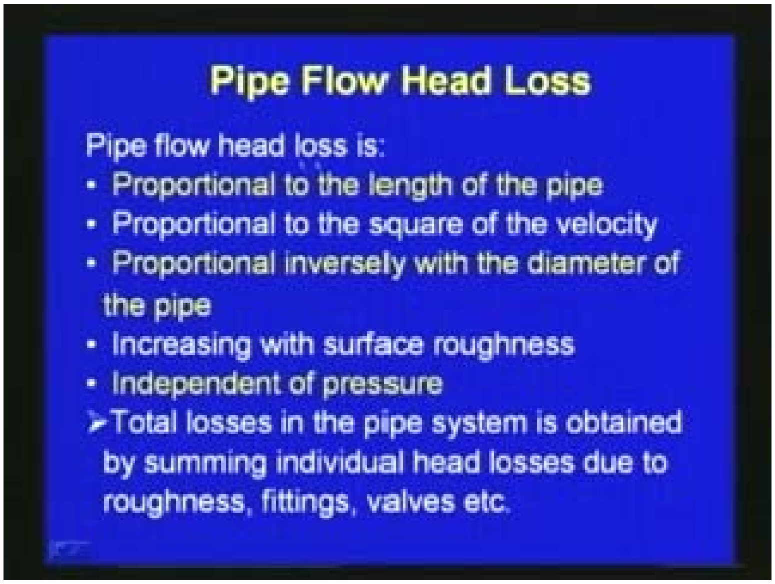

Like this for various shapes, various cross sections we can find out first we can find out the hydraulic radius and then we can find out hydraulic diameter and then that can be used for various calculations like Reynolds number relative roughness or the pipe loss. Finally, as far as the pipe losses are concerned as we discussed with respect to the Darcy

Weisbach equation the pipe flow head loss we can see that pipe flow head loss is proportional to the equation which we discussed here is f l v square by 2g d so h l the head loss equal to f l v square by 2g d. So this is the Darcy Weisbach equation so with respect to this we can see that the pipe flow head loss is proportional to the length of the pipe.

Since h f is equal to h l v square by 2g d. So it is pipe flow head loss is proportional to the length of the pipe then proportional to the square of the velocity and then we can see that this proportional to that proportional inverse with the diameter of the pipe, we can see that also this pipe flow head losses increasing with respect to the surface reference.

So if you use a more rough pipe then the head loss will be more but with respect to that relationship we can see that this pipe flow head losses independents of the pressure. It is mainly depend upon the velocity length then diameter and also the roughness it is independent of the pressure. The total loss in the pipe system is obtained by summing the individual head loss due to the roughness fittings while etc. so find out the total loss we will some of the friction losses and then losses give to be various fittings etc loss entrance loss, the expositional loss contraction loss etc.

So now we have seen, we started with as far as pipe flow system concerned started with pipe with calls with laminar turbulent and then we have seen the various relationships for this we have now discuss the losses five losses. Now while going for pipe design or then before for consecution when we go for design, we have to see that various kinds of problems, what kind of problem we are going to solve where we have to designed the dynamiter of the pipe or we have to find out how much the discharge passing through the pipe or we have to find out the friction factor for the head loss in the pipe.

So depending upon the analysis depending upon the problem which we do the approach also changes. Accordingly we can classify the general pipe flow problem into 3 categories, so here the categories is by what parameter is over a given and what be calculated.

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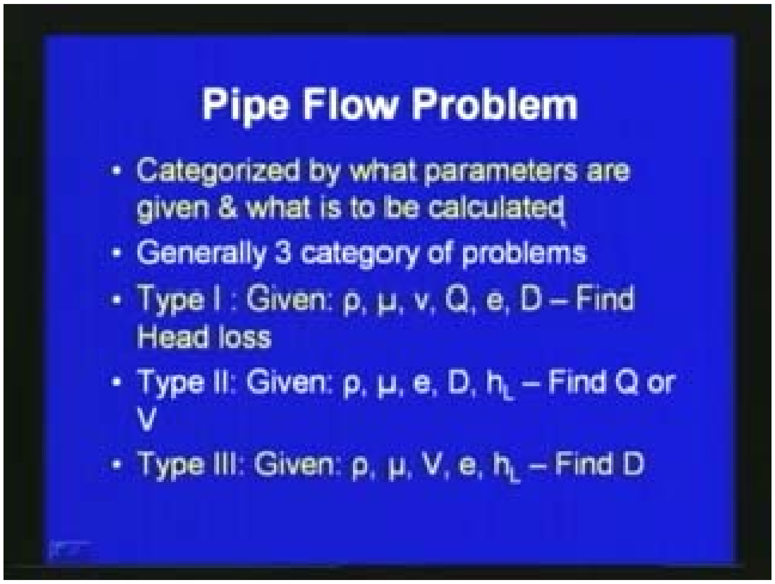

Some of the parameter will be given and we have to find out the remaining parameter so here generally we can categories into three categories type one type two and type three. So this category is according to what kind of data is already available what we have to find out. So accordingly the first categories type one generally the pipe flow the fluid parameter like density and dynamic coefficient of descosity and velocity will be given discharge will be given and also the pipe material like the roughness height and the diameter will given. We have to find out the head loss so this is the type of problem type 1 problem it is direct problem, since we have to calculate the head loss and the type 2 problem generally the fluid parameters like a density coefficients viscosity will be given and pipe parameters is the reference height and diameter given head loss will be given, we have to find out how much will be the flow type space of the velocity through the pipe at various sections.

We have to find out and then type 3 problems is all the fluid parameter is given like room and also the velocity, also the roughness is given and head loss is given so we have to find out we can design the pipe. So that we have to find out the diameter, so generally as far as generally design purpose will be 3 categories is problem type 1 type 2 and type 3.We will discuss in details for call to approach this defense types of problem so for type 1problem, question is to solve a type 1 turbulent pipe flow problem.

The following procedures we can utilize as the given parameters are as we discussed are flow properties, fluid properties and pipe geometry. The next step is by using this parameter will compute the inverse number and also we find out the e by d ratio reference side by diameter of the pipe ratio and then we can find out the friction factor by using the moody's chart over we can use some of the equation like Colebrook equation are the various other equations we discussed earlier over like swami join formula some more this equation you can utilize and then you can get the friction factor f and then once we get the friction factor.

We can directly use the Darcy Weisbach equation to compute the head loss hf here for the given system given problem so this is called type 1 problem.

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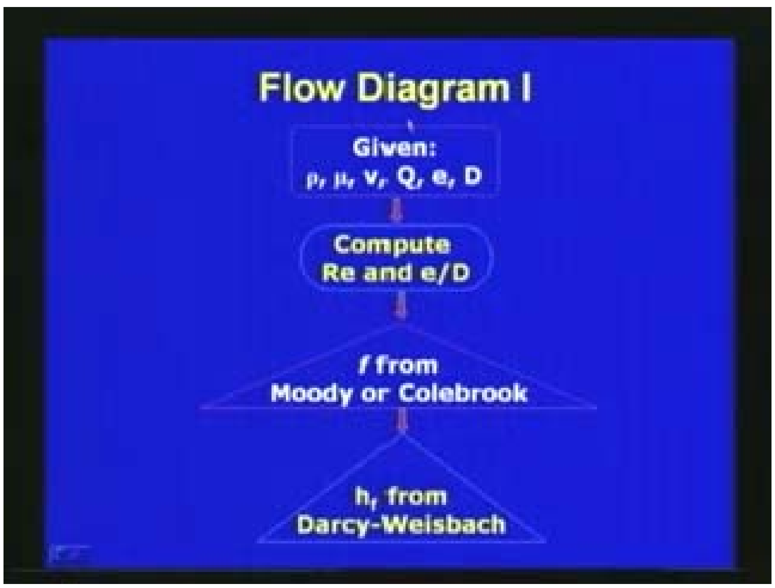

So this is figure diagram of flow chart here given rho mu v q e and d where rho is the density mu is dynamic coefficient v is the velocity q is the discharge and e is the reference hide d is the diameter. So you can calculate the Reynolds number and d by ration from the given data and then either we can use the moody's chart or the Colebrook equation to get the friction factor and then we can get the head loss where at least from the Darcy Weisbach equation, so this type of problem is the type 1 problem.

So now type 1 problem see can see to straight forward with respect to the given data, we can use some one the equation like a Colebrook equation and then we can primary use the Darcy Weisbach equation.

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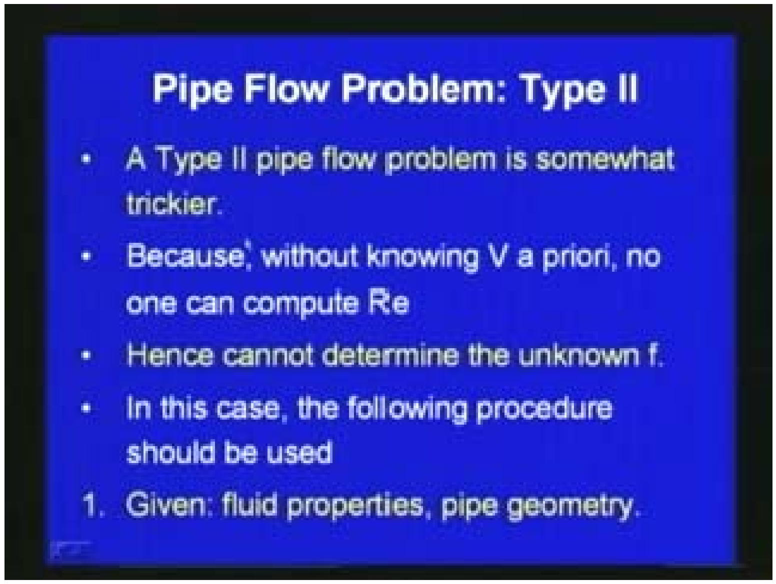

Next type of problem is pipe flow problem type 2 problems. So for type 2 the pipe flow problem it is more complex. Here since we do not know the velocity so we have to find out the discharge velocity so cannot compute the inverse number so we can directly get the friction factor f so the procedure generally for this kind of problem the procedure is as far as the given parameter are fluid properties and pipe geometry and then we can go for initial guess f from the high re portion of the known e by d curve on the moody's chart.

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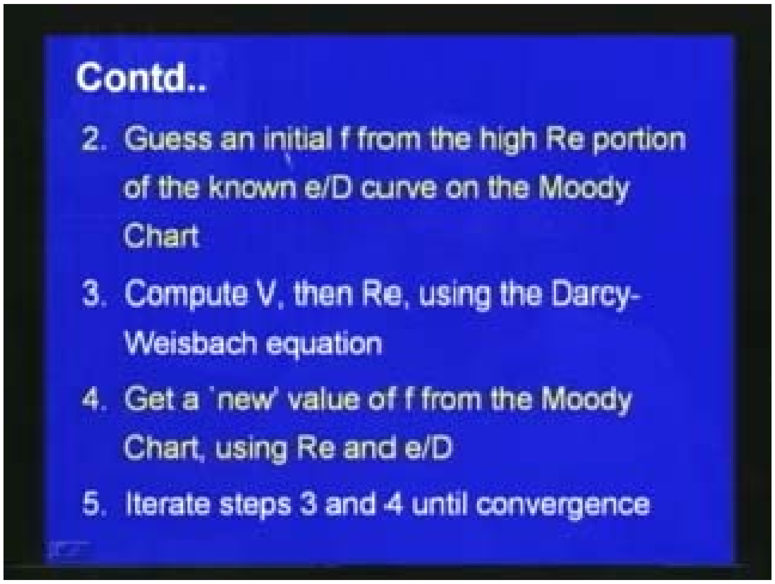

So you can use the moody's chart we can assume or we can guess the value of f and then using that value we can compute the v velocity then we can get Reynolds number using that we say use the Darcy Weisbach equation so from the new value of f from the moody chart we can using the we can earlier we assumed the friction factor f now using the obtained value of v and re and e by d we can get a new value of f from the moody chart and then we can check whether we are converging with respect to the discharge of the velocity which we the compute and then the we can iterate.

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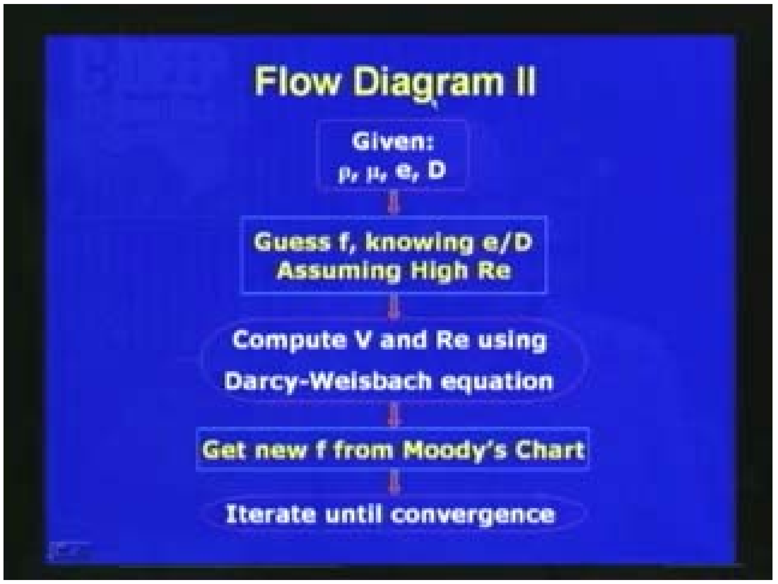

So this problem generally solved as iterate method so we iterate step three and four until convergence so this pipe to problem so it is represented in a flow chart like this given rho mu e and d and we will assume f and knowing e by d we calculate the get the Reynolds number and we will compute v the velocity and using r e, we can go to use the Darcy Weisbach equation we compute the v and then we will get using this parameter there is Reynolds number and this parameter here.

While working we get the new friction factor from the moody's chart and then we will come to track the problem until we get converge value over the discharge or the velocity which we are looking for in this type two problem. So this the flow chart flow diagram for the duct problem.

Now third one is type three so here we have to design or we have to find out the diameter of the pipe, so here for the diameter is not known converting directly we cannot get the Reynolds number or other parameter, so again here again we have to go for duct procedure since we do not know the diameter d a priori not only we cannot calculate Reynolds number but we do not e by d also.

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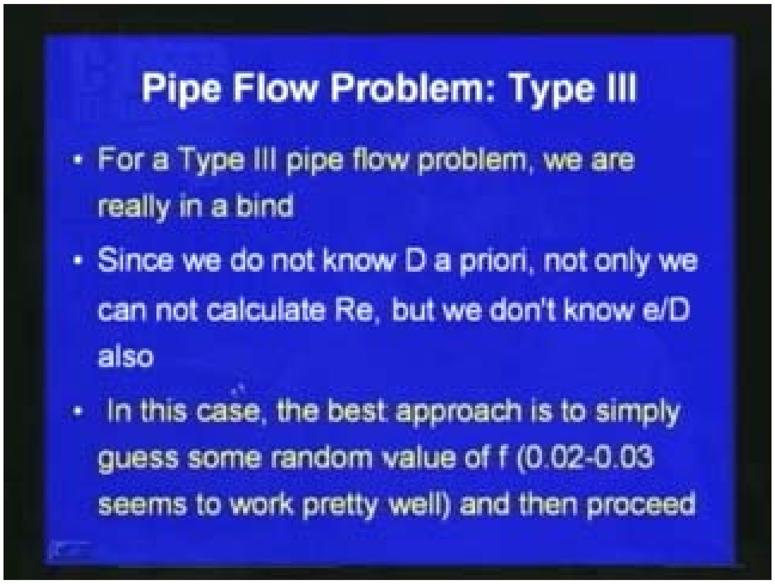

So hence the best approach is we will assume some value of f say for example 0.02 to 0.03 depending upon the material we can assume certain values and then we can proceed. Here the procedure is given ,fluid properties and flow properties we assume the value of f then compute d from Darcy Weisbach equation and then e by d and Reynolds number then find new value of f from the moody's chart and then will iterate between step 3 and 4 and will convergence.

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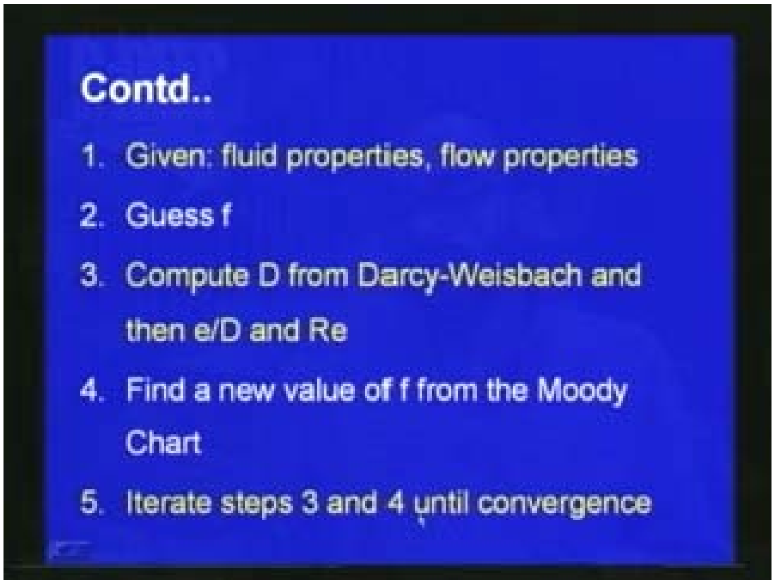

For the type 3 problem a flow chart given here, so given rho mu v and e, so that we will guess a value of f the friction factor and then compute d using Darcy Weisbach equation and then Reynolds number is known is e by d with respect to this we can use the go to moody's chart and find out the friction factor and then we can again it iterate until convergence.

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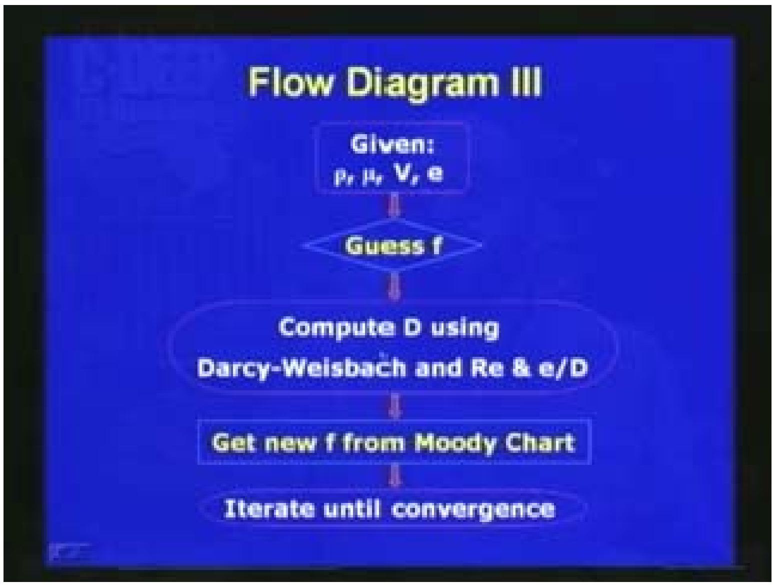

So this is the flow chart for the type 3 type of problem. So like this for the given system when we design pipe so we can first classify, we can just check what are the available data and then what is to be determined, accordingly we can classify whether it the problem type 1 type 2 type 3 that we can see which approach we have to utilize whether we have to duct procedure for the whether the solution is straight forward.

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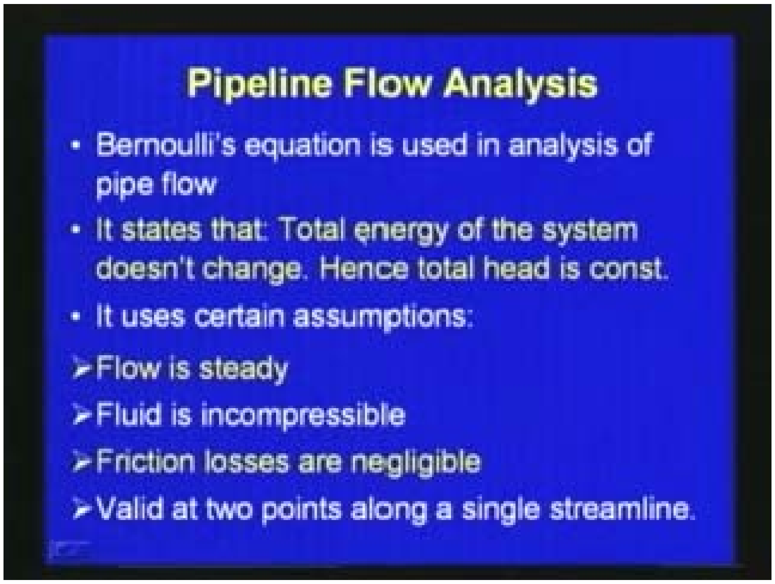

Generally, for pipe flow analysis we can use the Bernoulli's equation and as we discussed earlier the Bernoulli's equation states that total energy of the system does not change hence total head is constant.

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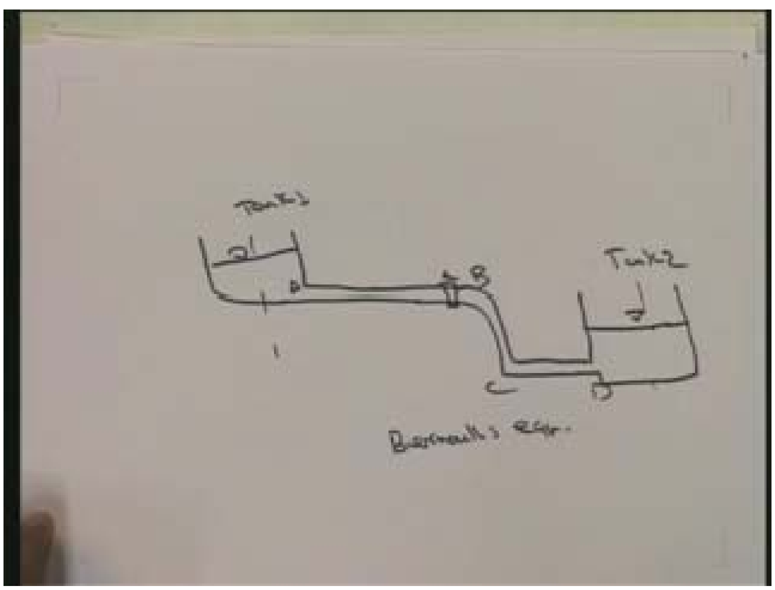

So based upon it when we design a pipe, for example here let us assume a pipe flow system starting from a tank and then it is going to another tank like this for such as system there is valve or a bench and exit lot entrance is like this. So here what generally we can use the Bernoulli's equation to show these kinds of problems.Between two sections assume that when we consider if this is a b c d and then between the tank 1 or server 1 and this is tank 2.

We can apply between two section the Bernoulli's equation and then the Bernoulli's equation states that the total energy of the system and does not change, hence total head is constant so since we will considering the pipe losses the duct friction losses are the minor losses are like at various pipe fittings are this will consider and then the iterate and the total energy of the system does in change between two section we can take it and then we can show the Bernoulli's equation to find out the various parameter. Here the Bernoulli's equation applied by using certain assumption the assumptions used here flow is steady, fluid is incompressible, fiction losses are nEGLigible, that means the same with respect to this we consider the friction losses are nEGLigible or valid at two points along a single stream line. So with respect to this here we consider to the assumptions we showed, we used the Bernoulli's equation and then showed the problem.

Two another important concept while doing this pipe flow design and analysis is the hydraulic and energy grade lines. This is the hydraulic and energy grade line, so knowledge of hydraulic grade and energy grade lines are important in analyzing complex flow problem.

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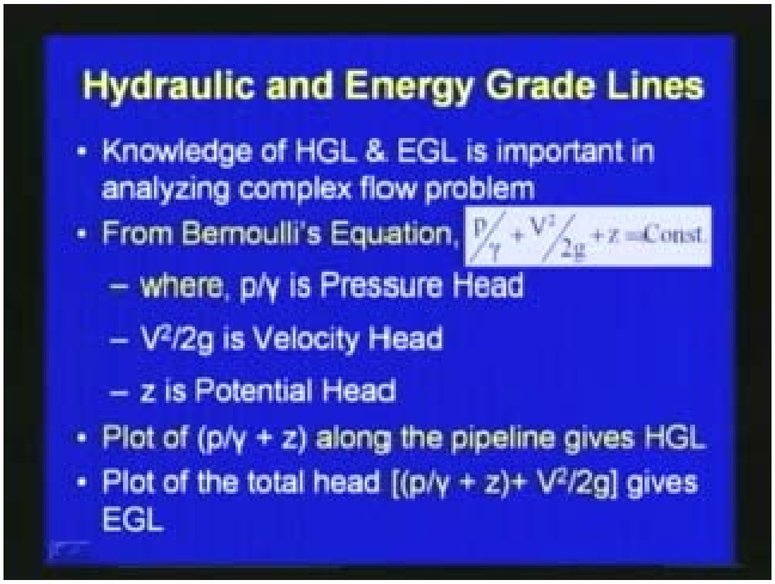

This an energetic grade n line means we know that say we using by Bernoulli's equation generally it is p by gamma the Bernoulli's equation gives p by gamma plus v square by 2g plus z is constant where p by gamma is the pressure head v square by 2g is velocity head and z is the potential head. So v is the average velocity p is the pressure, gamma is the expressive weight so g is the accelerating to have as per the Bernoulli's equation this is constant.

Now plot this p by g plus z along the pipe line gives the hydraulic radiant line, so if we block for this a pipe line system if we plot p by g plus z. We can plot for various system so this v square, this is the datum here and then we can plot p by g plus z. That gives the hydraulic grades n lines hgl p by g plus z gives the hydraulic grade n line and then the plot of p by g plus z plus v square by 2g this gives the energy radiant line. This two line we can plot with respect to the given pipe line system one is the p by comma plus z which gives the hydraulic grade line and we can also plot p by g plus z plus v square by 2g that gives the energy grade n line. Since from the Bernoulli's equations both hgl hydraulic radiant line and the energy hydraulic grade line and energy grade line we obtained from the Bernoulli's equations.

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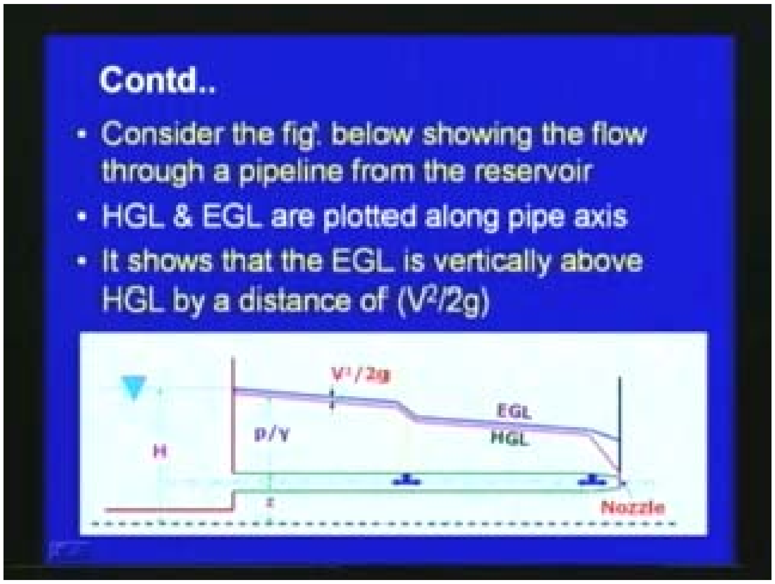

If you consider the figure here, this figure so there is a tank or reservoir higher then the pipe going like this and then it is nozzle here at the end of this pipe. If this is the datum then we can see that data available thrust will datum is h with respect to the reserved wire and then we can find out this p by g and then p g plus z. So this red line here that will be the hydraulic radian line and then if we add the v square by 2g which is the velocity here v square by 2g.

So p by g plus z plus p by g plus v square by 2g that gives the energy grade line with respect to the Bernoulli's equation which we have discuss here. So hgl and EGL we can plotted along the pipe axis like this and this shows here we can see that energy grade lines is vertically above hydraulic grade line above by a distance of v square by 2 g.

So the difference between the energy grade line EGL and hydraulic grade line is the velocity head v square by 2 g. so for this kinds of problem such a pipe line system like this we can plot the HGL hydraulic grade line over the energy grade line and then we can use this also to find out various norm the pressure p are we can use the either sometimes of velocity of depending upon the case.

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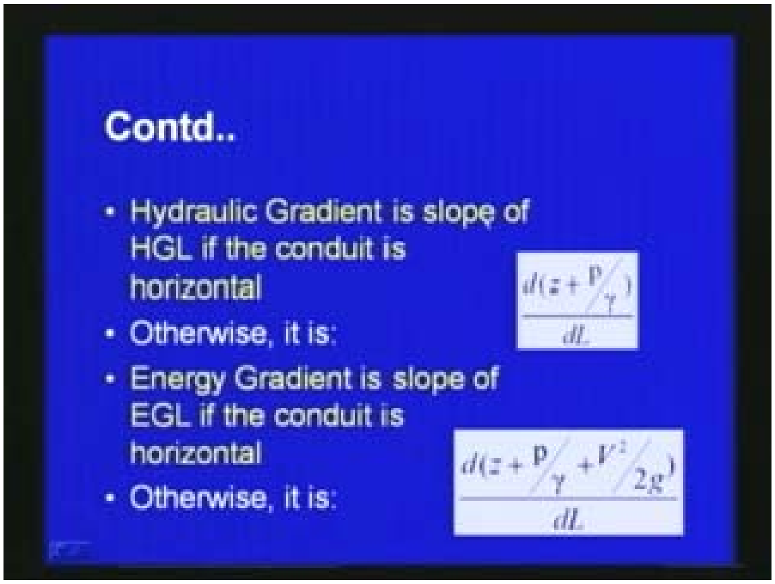

For various parameters now if the hydraulic grade lines are plot you can see that here this HGL hydraulic gradient is the slope of HGL if the conduit is horizontal. So you can see that pipe line is horizontal then it will be just the sloop of the hydraulic grade line, hydraulic gradient is slope of HGL but if not if it is the pipe line, if the conduit is horizontal then we can take the derivative certain d by d l of p by g plus z that will give the hydraulic radians if the pipe line is not horizontal. So if it horizontal it is just the slope of the HGL similarly the energy gradient is slope of EGL if the conduit is horizontal as we cans see here it is the slope of EGL and if not that means it is pipe line is not horizontal.

Then we can just take the d by dl of z plus p by g plus v square by 2g as atonics this equation, so depending upon whether the pipe line which we designed the process system which we designed is horizontal or if it is enclave so we can utilize the corresponding equation whether it is the directly this rope are the derivative with respect to z plus p by g for hydraulic gradient or the energy gradient is this we can say die d by dl of z plus p by g plus v square by 2g where d is datum head p by g is the pressure head and v square by 2g is the velocity here.

So just before going for the discussing various pipe flow systems discuss 1 simple example here so here the problem is say here we got a tank here and its from the central line so there is pipe line located at this here at this 2 meter about the datum the central line of the pipe and the pipe line length is 50 meter hitless here and then there is 10 meter here.

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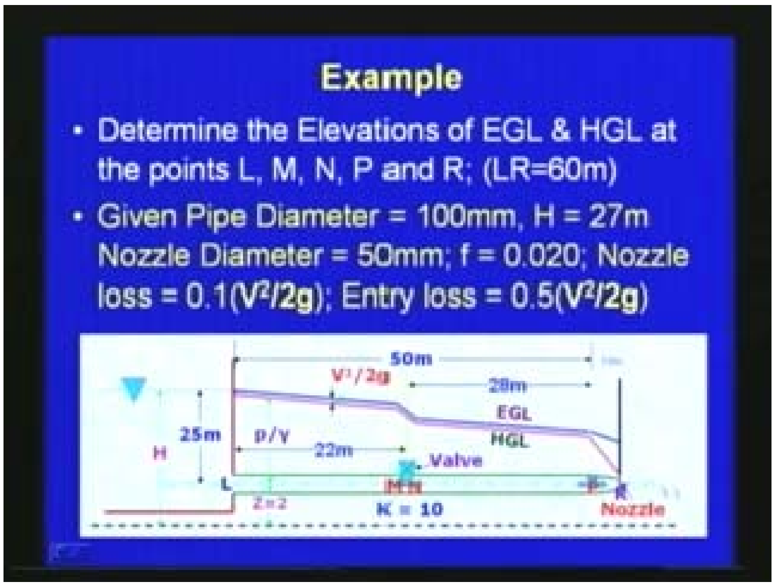

So, the total is 60 meter there is a no cell here, adjust 60 meter, so now the question is determining the elimination of the energy gradient line and hydraulic gradient line HGL at the point l here l m n p and r. Here, the total length is l 2 r is given as 60 meter from we have to find out the renovation of the EGL and hgl at point l m n p and r so the date given r the diameter of the pipe here this diameter is given as hundred and here the total h with respect to the reservoir the tank here is 2 meter plus 25 so 27 meter and notation diameter here is given as 50 millimeter and the friction factor for the pipe is given as pipe is given as 0.02 and nozzle loss here this with respect to the nozzle the exit loss.

So here the nozzle loss given is point 1 v square by 2g and the entry loss is here with respect to the entry loss is given as 0.5 v square by 2g ,so for this point l m n p at r l m n and n r we have to find out the elimination of EGL and HGL and also here in this system there is valve at this location at about 22 meter from the reservoir we have to evolve a control valve like this and this corresponding k value is given the last coefficient is given as 10.

Such system we have to find out the reversion of EGL and HGL, so as we discussed so here we will be using the Bernoulli's equation and which loading the head loss, so first we will consider the Bernoulli's equation is from exit from r to the reservoir, so here this is the exits point r to the reservoir consider the Bernoulli's equation so with respect to the reservoir h is the head and the p 1 by g is the pressure head and v l square by 2 g. So that is equal to v r square by 2g plus z plus d2 by g plus 0.5point is curve by2 g plus f l v square by 2g d plus k v square by 2g plus 0.1 v r square by 2 g.

Here, we are writing the Bernoulli's equation with respect to this location and then with respect to the outlet of the nozzle here you can see that with respect to this reservoir while tank is consent here the total head h plus we will be having the pressure p 1 by g actually it is atmosphere. So it will be 0 and then before this here at this just before the entrance of the pipe you can see that here the velocity here will be we will assume the velocity as 0.

This location is we can square by 2g and then if we take from here at the velocity at the nozzle if it is v r so v r square by 2g then we have to consider the various datum head z here datum head z and then we will be considering here this entry loss we have already seen this is 0.5 v square by 2g this entry loss then we will considering this for the pipe length here we can use the Darcy weisbach equation to head loss. So fl v square by 2g d and then we have this valve so that is give the k v square by 2g and then what is the loss here vertices the prospect nozzle 0.1 v square by 2 g, so here in this equation now the reservoir surface pressure we would assume that atmosphere pressure in that at p 1 by g would be 0 and v l since it is just before the entrance to the pipe. So v l here will be 0 so this equation would be only h that is, equal to 27 meter and then right-hand side we can see that here the pipe diameter is 100 meter if you write everything is term v which is the pipe develop velocity with the pipe.

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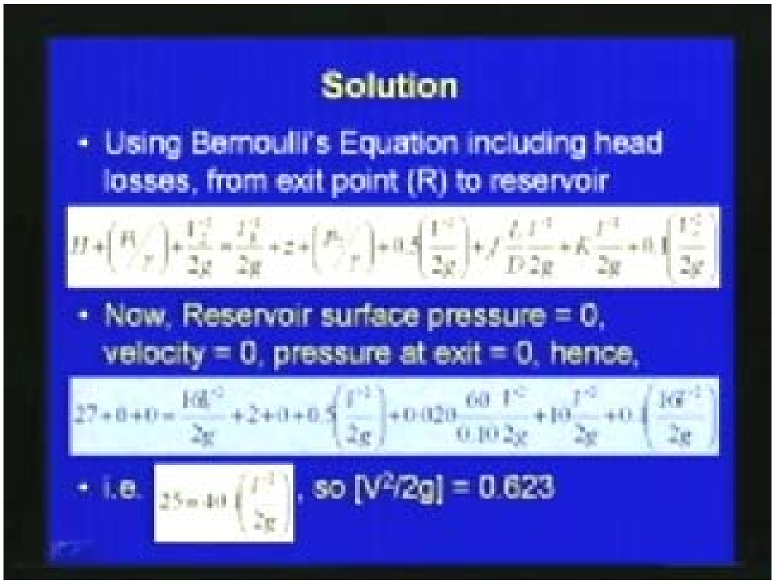

Since the diameter is 100 hmm and the nozzle is 50 mm we can see the diameter is half of the pipe diameter nozzle diameter, so we can see that reported in times of velocity it will be same with respect if use the continuity equation a 1 V1 is equal to a 2 v 2. So from that we can write this Reyes can be 2g; it can be written as 16 v square by 2g. so we are is win types of with respect to the exit point.

So we are writing with respect to the velocity of the pipe that is why 16 v square by 2g since the pipe diameter is 2 times the nozzle and diameter 50 m so16 v square by 2g and then z is 2 meter and then say here also at the exit we have seen the pressure as at most the pressure of V2 by g 0 and then 0.5 v square by 2g and then f is given 0.02. So fl v square by 2g d is 0.1 the pipe line meters 0.1 plus this k v square by 2g k is given as 10 so k v square by 2g plus 0.1 again this is given as the nozzle loss is 0.1 v square by 2g so now here with respect to the nozzle diameter it is 16 V_2 square by 2g is 0.1 by inter 16 by v square by 2 g.

So by solving this equation with respect to this nodes equation which is applied between the exit point at the reservoir we get 25 is equal to 40.1 v square by 2 g, so we get v square by 2g is equal to 0.623, so from this we get v square by 2g is equal to 0.623.

Now, we can apply the energy equation from reservoir to the point l, so here l is just entrance point here at this location, so we will apply irrespective to the reservoir and the entrance location l here if we apply the Bernoulli's equation from reservoir to l.

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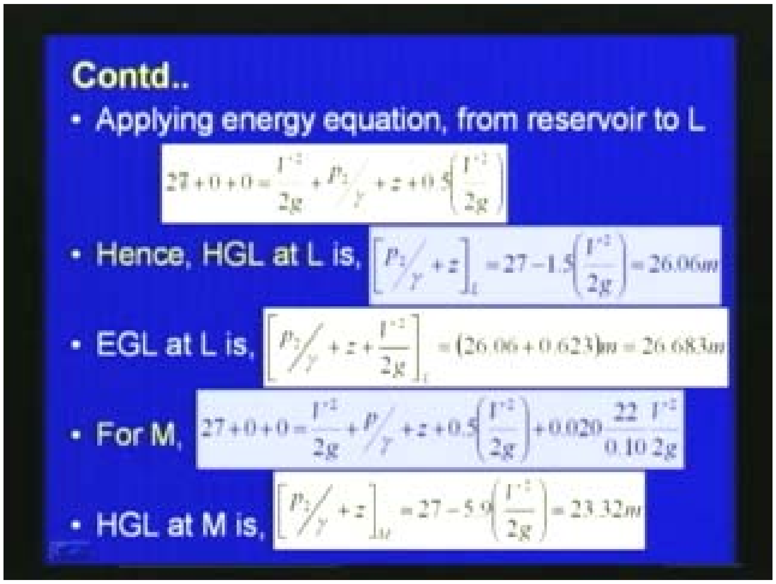

So very similar as in the previous case total head in the reservoir 27 and then at most reserves so here it is 0 p 1 by g 0 and here it is the velocity head is 0, the reservoir and then location illness concerned there will be the velocity head v square by 2g the p 2 is g is the pressure head and then said is the datum head and then we have this 0.5 this square by 2g as the entry loss.

So the equation plus 27 plus 0 plus 0 is equal to v square by 2g plus p 2 by g plus z plus 0.5 v square by 2 g, so now from this we can get the HGL at l that means have to give l line d we can take this p 2 by g plus z can be written as 27 minus. This 1.5 v square by 2g that is equal to 26.06 meter so this we get the hydraulic radian line at l HGL at l is equal to 26.06 meter, so now we also can get the EGL elimination of the EGL energy radian line so that will be v square by 2g plus p 2 by g plus z. So with respect to this the HGL high elimination we get add the v square by 2g which is 6.623 as we calculated so 26.06 plus 0.623 that is equal to 26.683 meter.

Now third point is calculating the elimination of fall and EGL with respect to this location. So we will now use the dharmolesh equation with respect point m so that is 27 plus which is the reservoir high head 27 plus 0 plus 0 is equal to v square by 2g plus p by g p 2 by g plus z plus 0.5 describe by 2g which is entry loss plus we are considering pipe length here.

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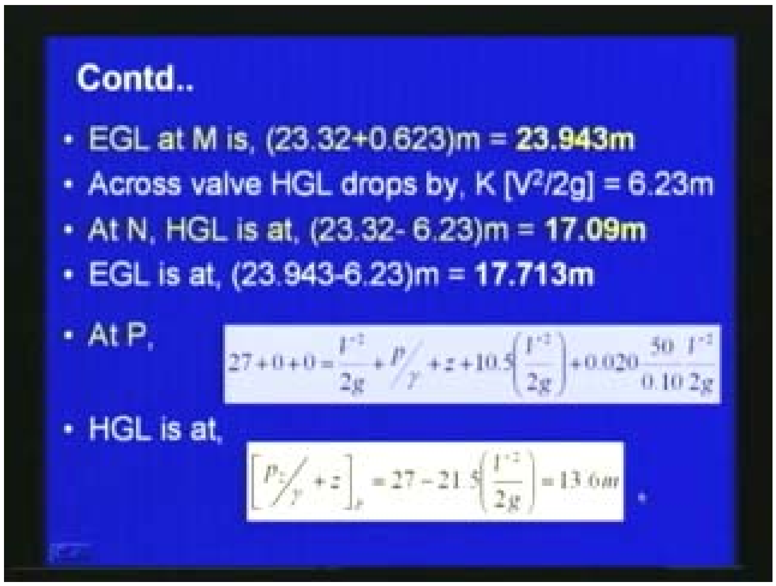

So fl v square by 2g d here this m is at 22 meter from here so we can write 0.02022 v square by 0.12 g as soon here so this is before the value so from this we will get a p 2 by g is z which is the HGL elevation as 27 minus 5.9 v square by 2g that is equal to 23.32 meter and similarly, analytic radian line if we have 6 3 v square by 2 g. We get 23.943 meter and then across the valve HGL drops by k v square by 2g so that is k is given as 10 so give as see that 6.23 meter so attained the hydraulic radiant line will be 23.32 minus 6.23 which is 17.09 and the EGL elevation will be 23.943 minus 6.23six point that is equal to 17.713 meter. Then the loss point at p this is p here at p we can see that again we apply the nodes equation so the reservoir 27 plus 0 plus 0 is equal to v square by 2g plus p g plus z plus 10.5 v square by 2g including the entry loss and then this valve loss plus 0.020 this fifty is total length v square by 0.12 g.

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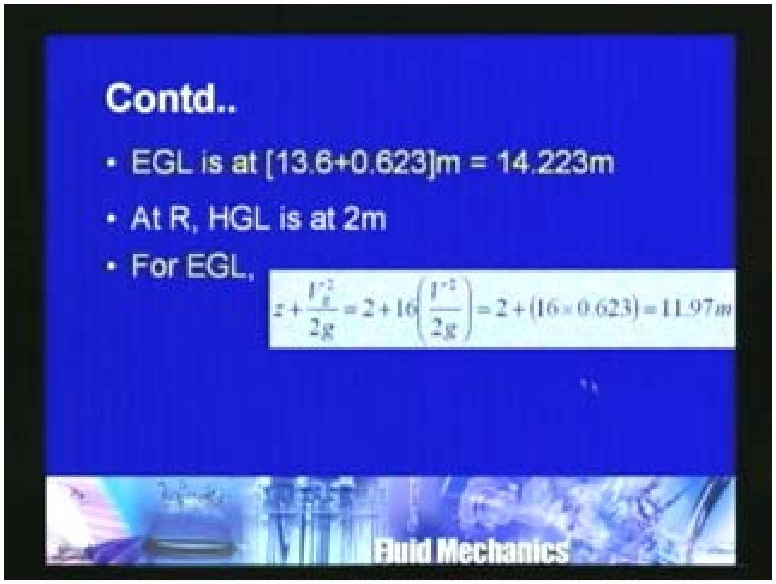

We can solve and get the elevation of the HGL as p 2 by g plus z as 27 minus 21.5 v square by 2g is equal to 13.6 meter and similarly EGL energy gradient line in add the velocity here 13.6 obtain from here plus 0.623 that will be 14.23 meter and at r that means the seat hgl is at 2 meter which is only z and then EGL is z plus v r square by 2 g. So, v r square by 2g 16 v square by 2g plus 2 so that would be 11.97 meter. This we can plot like this so here this red line shows the hgl and then blue line shows the EGL with respect this problem. Like this we can solve various problems for the given parameters. We can apply Bernoulli's equation and then various other losses also considered here and we can solve the problem.

The next lecture we will be discussing further about the pipe flow system like pipe in series and pipe in parallel.