Indian Institute of Science

Design of Photovoltaic Systems

Prof. L. Umanand
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

NPTEL Online Certification Course

(Refer Slide Time: 00:17)

Let me now describe to you the octave script file that we will use to obtain the friction pattern using the Colebrook white formula. So here on the screen I have ask a script file Colebrook.m it is an m file to be run in octave, you could with probably slight modification for compatibility also run on matlab.

I even tried running it on matlab, I will provide this as a resource you can experiment with it and then try to see if you run in matlab and octave. So I am writing a function file function output F which is a friction factor, I am calling the function name as Colebrook, I will use the same file name Colebrook.m.

And I am providing two inputs R, Reynolds number, ed. Ed is the other input which is the Rockne's ratio, ed is actually e/d ε/d that we have used in the Colebrook equation. Okay, after the comments then let us come here, there is a number of input arguments check and now let us do the main program. So the main program is actually distributed into a if loop, so there is one if condition where the flow is checked.

So the Reynolds number should be positive, and R less than 2000. So between 0 and 2000 we have seen that the flow is laminar and the equation used is F=64/Reynolds number. So this will give the friction factor if the flow is laminar. Else if the value of the Reynolds number of greater than 4000 and we say that the flow is turbulent. So we will use the Colebrook equation.

So I am using this identities $A = \varepsilon/d/3.7$ this is what we used in our iterative relationship. B is 2.51/Reynolds number, now XK the initial value of the XK I am going to set it as $1/\sqrt{0.1}$ as discussed earlier and will use a variable Δ and set it has xk later within the loop I am going to use Δ te difference between the pervious present and the pervious now let us enter a while loop while this Δ the difference between the present estimate and the previous estimate is greater than 0.0001 small value because the to find the roots the iterative equation should converge and as it converges and goes to a value less than 0.0001 let it come out of the loop.

So while Δ is greater than so much or form all these operations so xkk is what I am using for xk+ 1 which is = the Colebrook equation iterative equation which we derived then Δ xk+1 –xk is basically Δ x and I am setting xk to the new value new estimate wherever that xk+1 estimate is so that loop can continue and once Δ is come lesser than this value then comes out of the end y and the friction factor is $1/xk^2$.

This is the friction factor so for turbulent flow we apply this Colebrook iterative relationship else meaning what happens if the Reynolds number is between 2000 and 4000 so it will come into the else condition so here it is actually a transition between laminar to turbulent, turbulent to laminar so there is no valid defined relationship what I have done is f laminar is 64 /R and F turbulent is I have repeated this equation set here evaluated at wherever the value of Reynolds number that we have passed into the function.

And I am taking the max value max value for friction factor will give you the worst case HF worst case friction loss component so that we are safe and we are doing design so it will be a conservative value so I am computing the F using the laminar equation computing the F using the turbulent equation using Colebrook formula and then taking the maximum value among these two to take as the conservative value of the friction factor for the transition region.

So this is the function that we will be using for finding the friction factor now for example let us go into octave and then call this whole group function so how will you call it, so let us say I want to know the friction factor coal group and let me give the Reynolds number and see we have to give the Reynolds number and e ed e / d, so let us Reynolds number of 5000.

And let us say e/d roughness ratio of 0.001 so this will give you a friction factor of 0.038495 same thing if you are used PVC for the pipes we have to use PVC for the pipes the roughness ratio would be 0 and for the same Reynolds number of 5000 you will get a friction factor 0.037 slightly lower, so the Colebrook function can be used how to find the friction factor for any given value of the Reynolds number.

We can also use this Colebrook function to make our own moody chart through we may not use the moody chart for design we will directly use this Colebrook function to give the friction factor for a given Reynolds number and ε by d roughness ratio it will give you inside some inside and understanding to develop our own moody chart not only for only exercise purpose but also to cross check with the moody chart there in the literature and to validate that Colebrook function is correct.

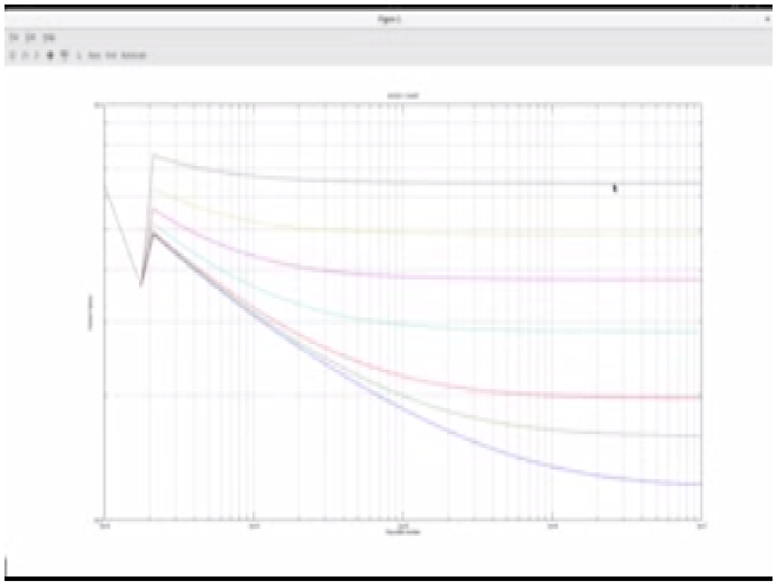
(Refer Slide Time: 08:10)

So I have here prepared of very small script file and octave find that calculates and plots the mood chart for friction factor estimation based the Colebrook white formula, so I will do the x axis and defining in the Reynolds number and sweeping the x axis with Reynolds number value from 10^1 to 10^7 and using logs space logarithmically spaced points from 10^3 to 10^7 that is the Reynolds number if factor now and the roughness factor I will just given few select points, points that I.

In the literature there was a certain roughness ratios that were used so I have used the same roughness ratio values so that I can compare the graphs I get from this moody chart with the moody chart of the literature and then I use one for loop for incrementing the roughness ratio another for loop for incrementing the Reynolds number vector and after that within an innermost loop you call the Colebrook with the value of Reynolds number updated every time for a given roughness ratio and then you will get an output where f is a vector, vector matrix you will have one row for every value of roughness ratio and the plot.

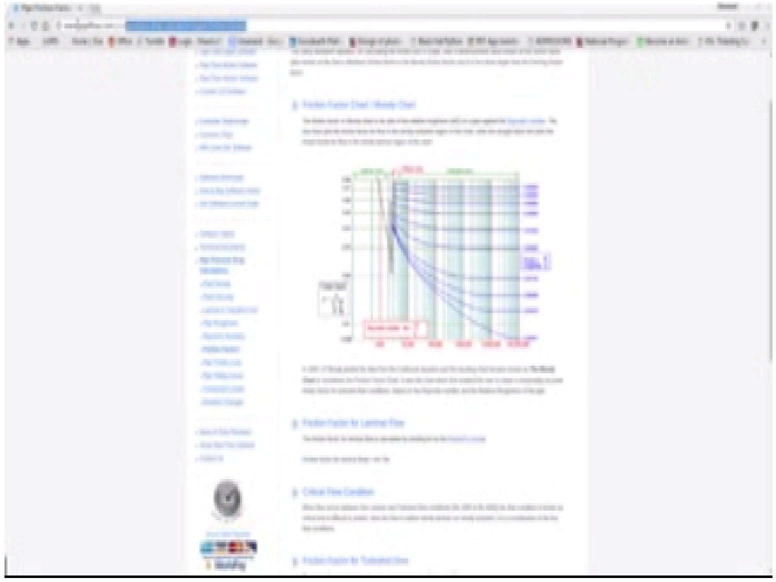
So plotting is lob lock normally you would have seen in the moody chart which I discussed earlier both the x axis and the y axis are logarithmically scale so it is a lob lock graph if Reynolds number on the x axis verses the friction factor on the y axis you will get a family of curves based on the roughness ratio as a variable, as a parameter. So this is the script that you will use for obtaining the moody chart, we can executed and then just see so let me type in moody chart so you will see that the moody chart.

(Refer Slide Time: 10:51)



Is something like this and this is the moody chart that I also showed to you and discussed with you this y axis is a friction factor x axis is the Reynolds number starting from 1000 to 10^7 Reynolds friction factor is from point 0.1 to 0.1 now you have this family of Carouser the parameter is the roughness ratio this is at 0.0001 this is 0.04 like that.

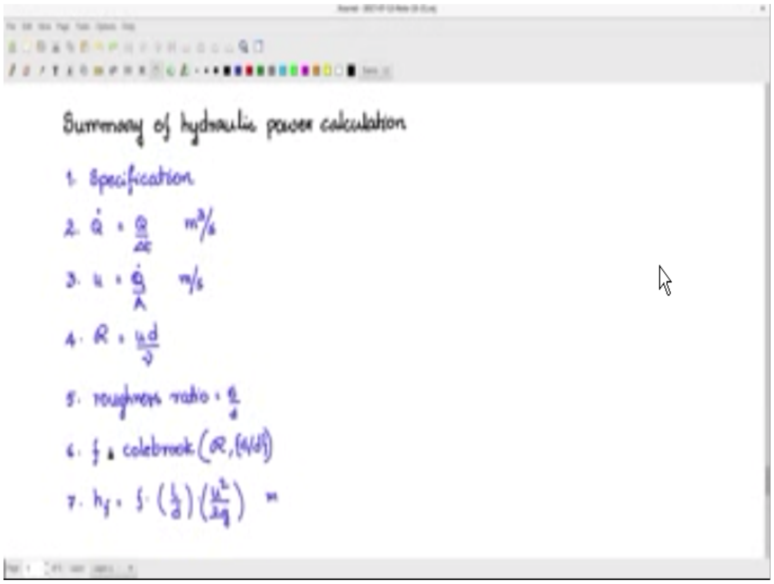
(Refer Slide Time: 11:38)



I went to Google and then went to this particular side here to look at the moody chart see that there is a moody chart given here and for similar values of roughness ratios which I have chosen in the octave script. You can actually compare it with the moody chart that we have generated using octave script both are similar in fact the values are also exactly the same for the various roughness index so this actually verifies using this laminar portion this is the laminar portion a single line going in there and the turbulent portion starts from here.

This is the turbulent portion and the if you cross check for each of the roughness index the values will turn out to be the same as given in the literature so our cold brooks iterative algorithm is actually verified validated by this and you can now use that for the design of your pumping system.

(Refer Slide Time: 13:01)

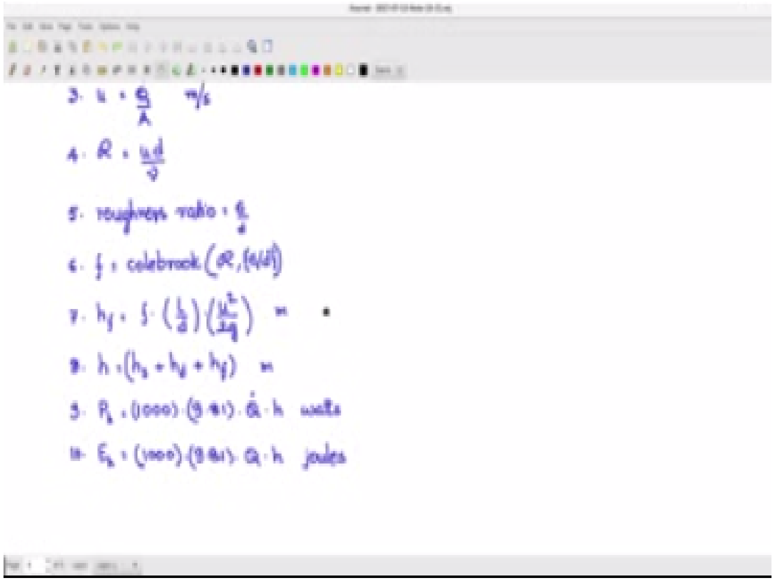


We have talked about many parameters and many variables during our discussion on hydraulic power let us summarize now on calculation of the hydraulic power and hydraulic energy so let us summarized the steps first specification we need to specify the parameters let me come back to this later after I list on all the steps and see what are those parameters at we need to specify next we calculated Q. or dq/dt which is Q that discharge volume by discharge time these two are design given by the user requirement in meter cube per second.

Then we calculate the velocity of the fluid knowing the discharge time at the discharge volume and the pipe dimension especially the cross section area Q./A will give you meter per second the speed of the fluid within the pipe fourth calculate the renounce number given by ud/μ that is the kinematic recoursity fifth calculate the roughness ratio which is given by ∈/ the internal diameter of the pipe ∈here is the height of the surface.

So this express this in mm and this also in mm sixth find out the friction factor we have seen the Colebrook white formula we will use that function or the moody's chart and then use renounce number and the roughness ratio to obtain the friction factor seven use the friction factor to calculate the head equivalent of the friction loss so f x l/d x u^2/2g this is expressed in meters, u is the value which is fluid velocity, g is the gravity, d is the internal diameter of the pipe. L is the total length of the pipe, f is the friction factor as form from 0.6. Let me move this above like this, now 0.8.

(Refer Slide Time: 15:51)



What is the total dynamic head h? Total dynamic head is suction head + discharged head + hf the friction lost component of the head as calculated here by the formula. Then you calculate the hydraulic hour, what is the power requirement and this we have found out to be ρq.gh ρ is 1000kg/m g is 9.81 x Q. x h x + max and =energy hydraulic energy 1000 x 9.81 x Q x h j. so here Q. expressed in m^3 /sec, so this is the entire steps is that 10 point step for finding out.

The power and the energy for any hydraulic water pumping calculation now what is the specification let us have a look at what are the parameters that you need to specify so first you need to specify the discharge volume how much amount of water do you want to lift up to the over at tank in a day or in a one hour these things you need to specify discharge volume in meter cube Δt is the discharge time in seconds d is the diameter inner diameter of the pipe in meter A is calculated as $\pi/4\ d^2$ is the cross section area of the pipe orthogonal and normal to the direction to the flow.

And this is in meter square L is the total length of the pipe both vertical and horizontal so the fiction law need total length of the pipe in meters the symmetric viscosity we saw that for what it is $0.5.10^{-6}$ meter square per second it is height of the surface bumps expressed in mm HS is the succession head in meters HD is the discharge head in meters so all these points all these parameters have to be specifies so you specify them automatically every equation will follow you can intact put this up in a script file in a octave or mat lab and then use this as a design file for calculating the hydraulic power and hydraulic energy requirement for a given water pumping the application.