Upstream LNG Technology
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Lecture – 86
Tutorial on piping in natural gas systems – II

Welcome, today we shall be learning some more applications of the various types of equations for the flow rate and the friction factor ok.

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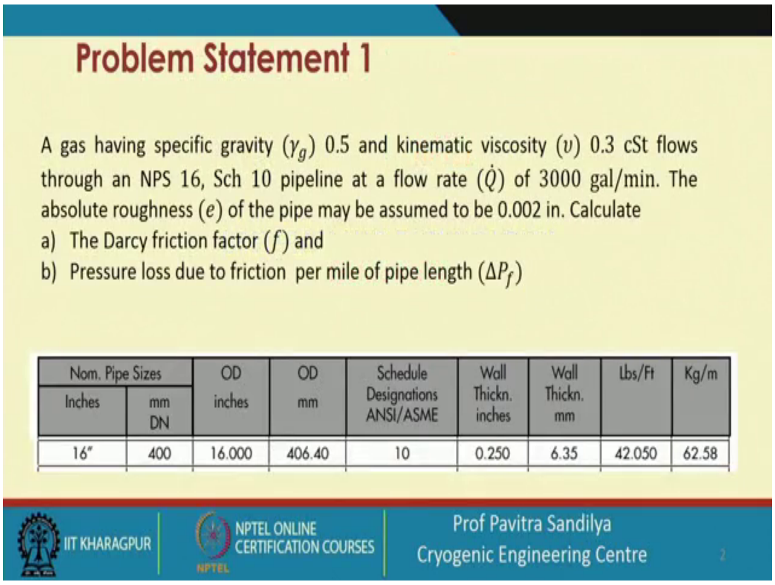

So, let us see that. First we go to an problem like we have a gas gravity given, the kinetic viscosity is given and now kinetic viscosity is what? It is the ratio of the dynamic viscosity and the density ok.

And this is given in terms of the; it is if you look at the um a unit of the kinetic viscosity that is in terms of SI unit that is meter square per second. In the CGS system it is centimeter square per second, another one is that centistokes. So, in case of the viscosity, we use the poise that is the gram per centimeter per second and in this case we use stokes ok. This is stoke the famous scientist from his name it came stokes.

So, this is given as the 0.3 centistokes that is 0.3 into 10 to the power minus 2 stokes. And this is the type of the pipeline given, this is the flow rate, this is the flow rate as in gallons per minute and this is the roughness has to be assumed to be 0.002 inches. So, we have to find out what; the Darcy friction factor and the pressure loss due to friction per mile of the pipe length.

Now, first you solve this we find one standard table, we find out the outer diameter and the wall thickness.

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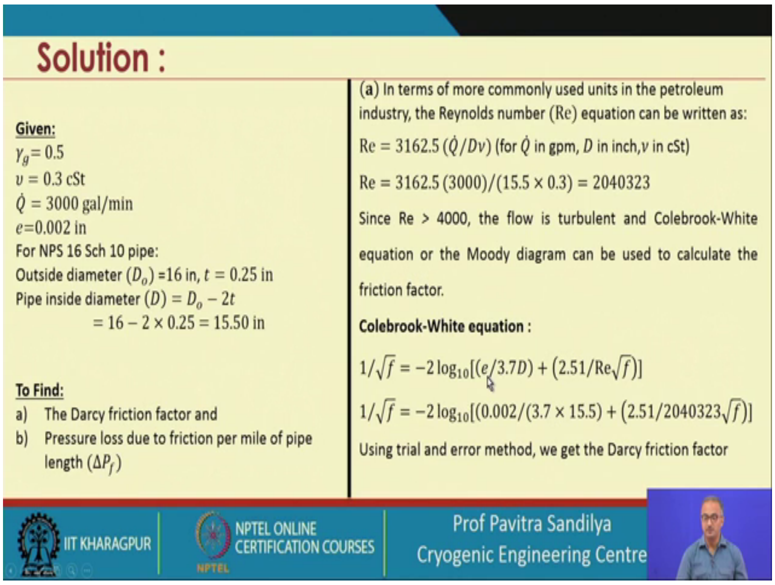

And these information first we put here all these gas gravity, the kinetic viscosity, the flow rate, the roughness factor and we find out the inside pipe line diameter ok. And then we have to find out the Darcy friction factor and the pressure loss.

So, what we do? First we find out the Reynolds number and this Reynolds number, this particular constant value is taken for the Q in is gpm, the D is in inches and nu is in centistokes; that means, whatever values we have been given those values are compatible with the particular expression for the Reynolds number.

So, we do not need to change much we simply put those values and get the value of the Reynolds number and we find that it is coming much much more than 4000 that is the flow is in is fully turbulent. And now it is fully turbulent we may either use a standard chart which I have shown you in the lecture and all we can use the some expressions like Colebrook-White equation to find out the friction factor ok.

Now, if you use the Colebrook-White equation again we find this is has to be solved iteratively using by some numerical method. So, we use this thing and we use some trial and error method, we plug in the values of the various information data given to us and we find the friction factor is appearing on the both the sides. Since, I explained to you how to do this trial and error. So, I am not repeating those things, but if I make those kind of substitution successively we can find out the friction factor coming to be this particular value.

So, that is how we are able to first answer the first part of the question. Now, we have to go to the second part of the question.

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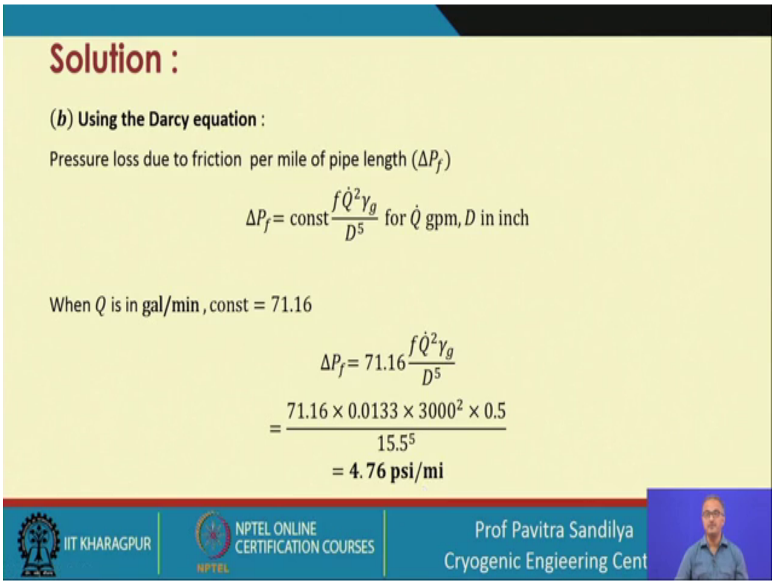

In the second part of the question we have given we have to find out this pressure loss due to friction per mile of the pipe line. Again in this particular expression if you are using gpm and this thing we are getting the constant value as 71.16. And now because we know the value of the frictional factor, we plug in the value of the other parameters. And we get that this is the value of the friction this the pressure drop per unit mile of the pipeline.

Now, this is the very simple way you can see that you can find out the pressure drop.

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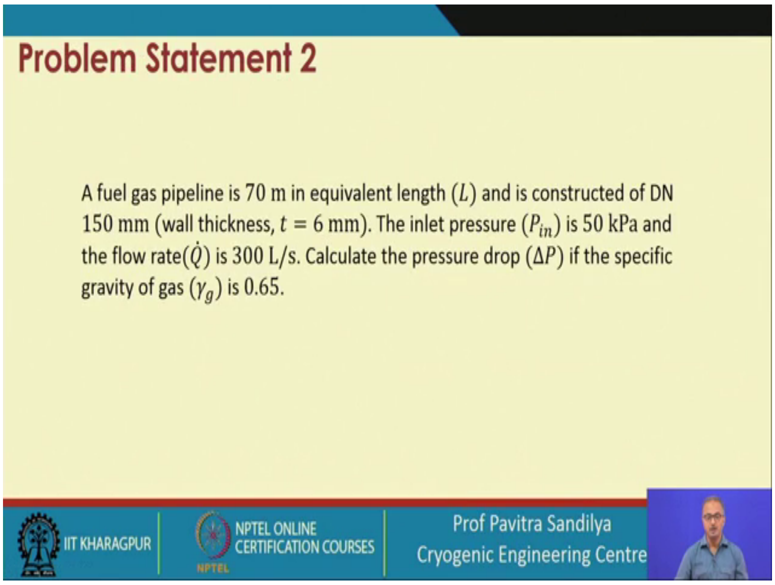

Now, we go to second problem, in this problem what we have? Is this we have this gas pipeline length it is flowing through a length of 70 meter; that means now we are dealing with SI units ok. And now it is given in terms of DN as I told you earlier this DN is signifies always in terms of millimeters NPS in terms of inches.

So, we are DN is 150 mm thickness is in this particular thickness and inlet pressure is 50 kilo Pascal. The flow rate is given to be 300 liters per second and a pressure drop has to be found out for a gas gravity of 0.65.

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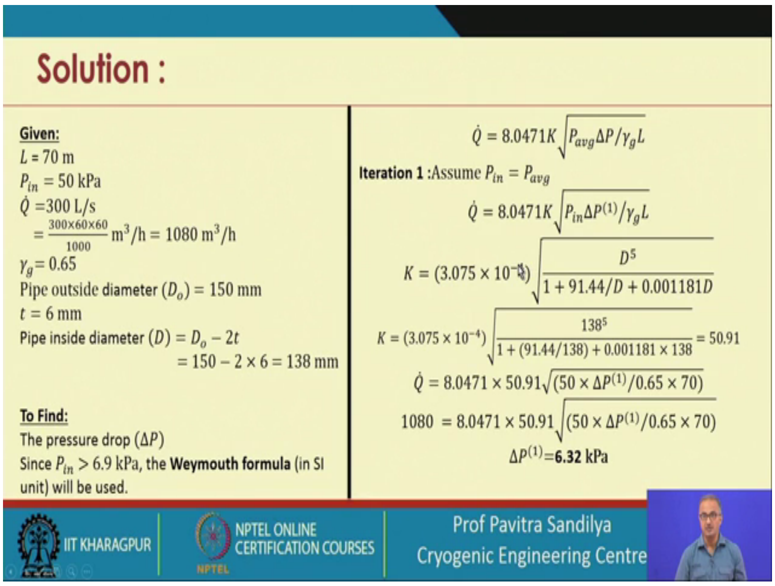

Now, what we do? First we put all the expressions here, now only thing is this because the volumetric flow rate has been given in terms of LPS that is liters per second. What we do? First we convert into cubic meter per hour because the equations we are going to use demands this particular unit ok.

And then we find out the inside diameter of the pipeline by subtracting the twice thickness from the outer diameter. And here we shall be using the Weymouth equation because the pressure is in is quite high. Now, this is the expression for the volumetric flow rate and we need the value of the delta P. And delta P is unknown to us we only know the inlet pressure. So, what we do? First as a first guess we take the P in to be the P average and again I would not be again going into detail of the solution.

So, we take this replace this P average by P in and we find out the first estimate of the delta P by plugging in the values of the volumetric flow rate. And everything and we find the K from this particular expression and we find the value of the K to be 50.91 and we plug in the values and we estimate the delta P 1 value to be 6.32. Now, once we get delta P 1 what we do we subtract it from P 1 to find out the P outlet. So, from P in we would subtract it to P outlet.

Now, with that P outlet again we calculate the P average. And again we find out the value of the delta P and that is how we keep on doing this particular this particular iterations.

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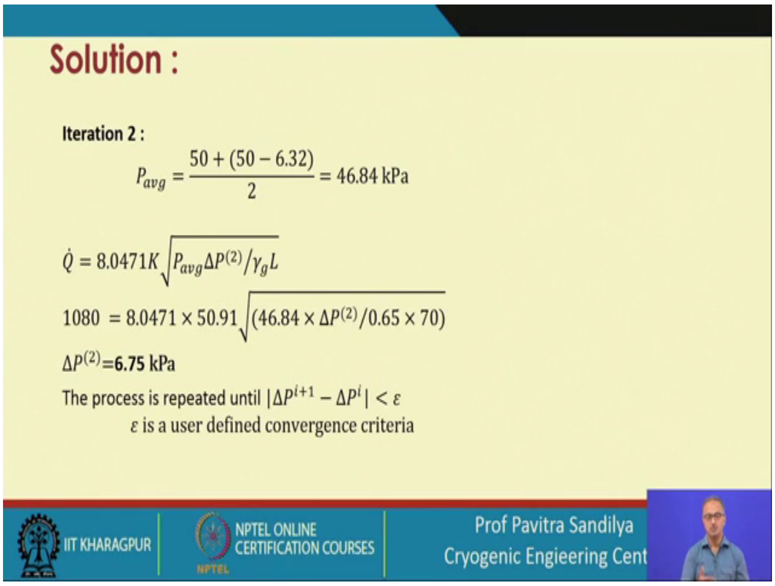

And we keep improving the value of this, but the value of the pressure drop. And we every time we check the pressure drops we are giving getting from the 2 successive iterations. And as long as this particular this absolute difference is within it is not coming below the user specified convergence criterion, we keep iterating it. And we will do this and we find out the value of the delta P pressure drop.

So, that is how we may vary means iterative manner and again I am telling you that you can use either a MATLAB a programming or you can do it manually. Or you can write your own code in any standard language like FORTRAN, you can use from C plus plus any of these languages also you can use to make this kind of calculations.

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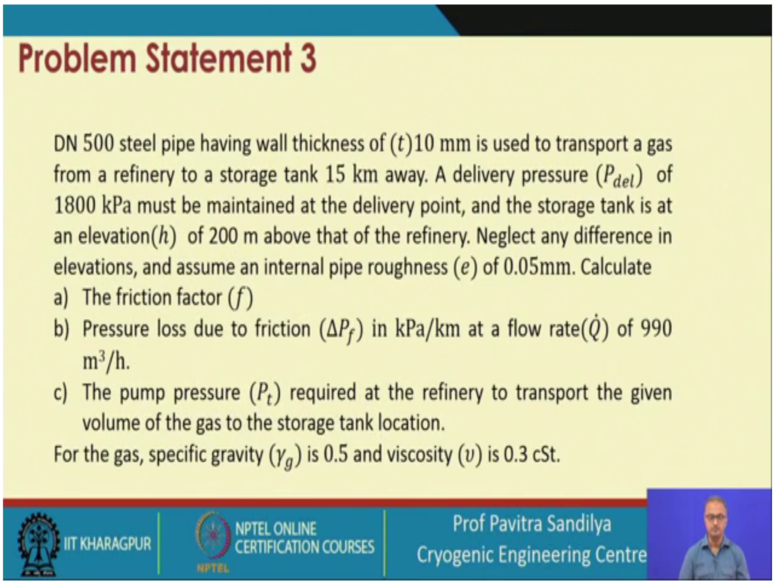

Now, we have another problem in which we are doing steel type of DN 500, thickness of this, and this is transporting a gas from a refinery to a storage tank that is 15 kilometer away ok.

So, the length the length of the pipeline is 15 kilometers. The delivery pressure has been given to be 1800 kilo Pascal and we have been given a elevation is about 200 meters. So, this is the elevation effect is also there, but these 2 the neglect the any difference in elevation, even if it is 200 we are neglecting. Thus, this difference in elevation and assume the internal pipe roughness to be 0.05.

And based on these information we have been asked to find out friction factor, the friction loss per kilometer of the pipe length at a flow rate of 990 cubic meter per hour. And we have to find the pump pressure required to transport this particular expression. And as I told you the pump pressure is taken to be to be to form we have to find the total pressure drop in the pipeline to decide the pump pressure. And these are the information that the gas diversity is 0.5 and viscosity is taken to be sent these centistokes that are kinetic viscosity.

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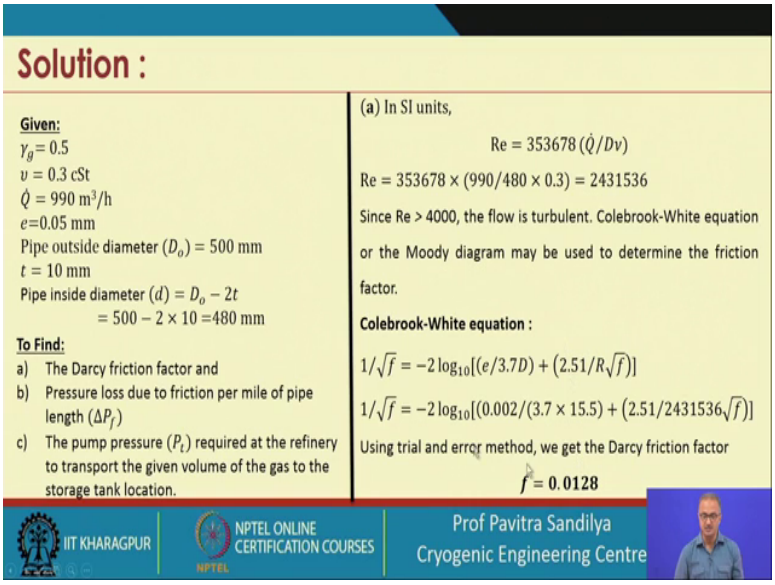

So, we first put in all the data given to us and then we find; what are the things we have to find out least them out separately and this will help you know to make the things very methodically. So, first in SI unit because all the expressions are given the units are in SI units. So, either SI unit expression or we find the Reynolds number to be this value and which is much higher than this value and. So, we get it and take it to be a fully turbulent Reynolds number.

And we use the Colebrook-White equation again we put all these values which I am not now repeating and by trial and error you find this is the value of the friction factor. So, this answers the first part of the question.

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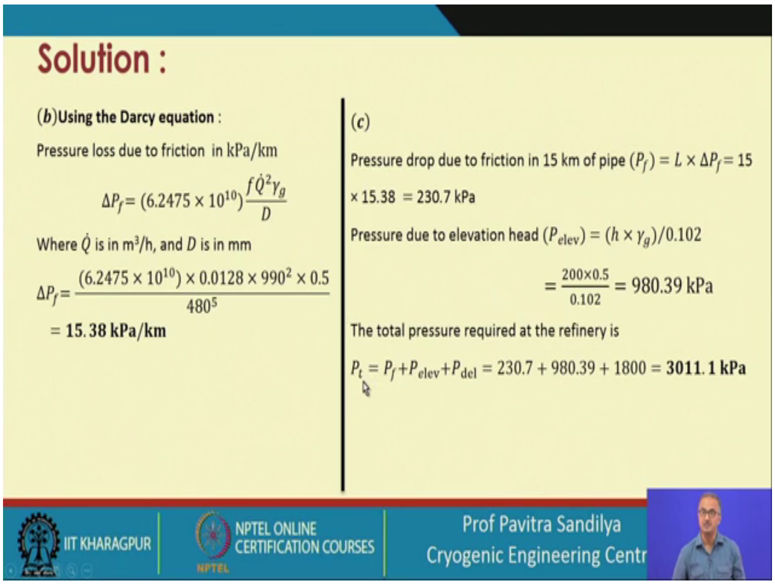

Now, once we know the friction factor what we do that to find out delta Pf? So, we use this expression for the delta Pf, friction the friction the pressure drop and we find out, we plug in the values, and we find out the value of the pressure drop per unit length of the pipeline is coming to this.

Now, the c part is how to find out what should be the pumping pressure ok. So, first for that first what we do? We find out the total pressure drop in the pipeline by multiplying the length of the pipeline with the pressure drop per unit length of the pipeline ok. And then we find the elevation effect is coming like this, this is the expression for the elevation effect; this is the pressure drop for the elevation. And the total pressure definer is now the due to the friction, the elevation and the outlet pressure that is the delivery pressure.

And we add these 3 pressures to get the pressure which has to be it is needed at the inlet of the pipeline.

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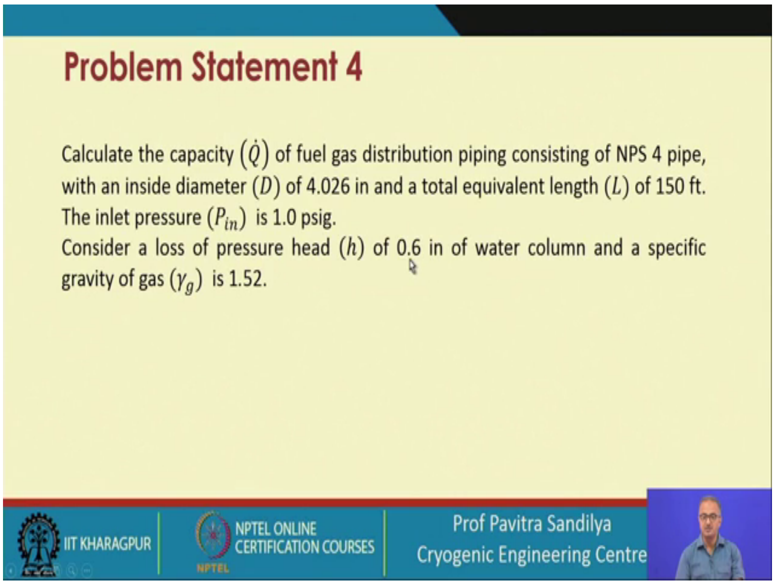

Now, we come to another problem, in this we have been given the capacity and the and the pipeline we are using, equivalent length is given like this and the inlet pressure is like this. So, we have been asked that consider a loss of pressure head by these 0.6 inches of water column and is gas gravity of 1.52.

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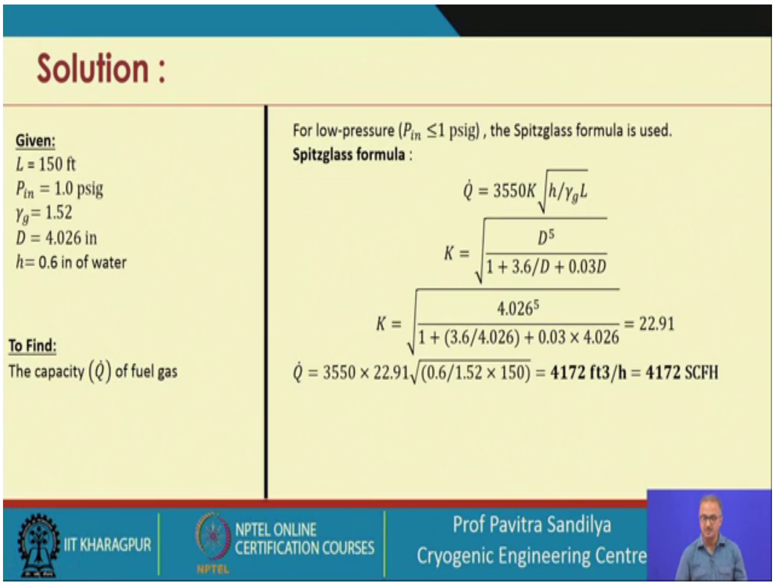

So, we put all these given information and we have to find out the capacity for what? Because, it is P is very small we are using the Spitzglass formula. So, we use a Spitzglass formula here and to find out the value of K we put this expression. Because we get the value of K and you plug in the values of everything here and we find out the a volumetric flow rate using this particular Spitzglass formula and this is coming in a standard cubic feet per hour ok.

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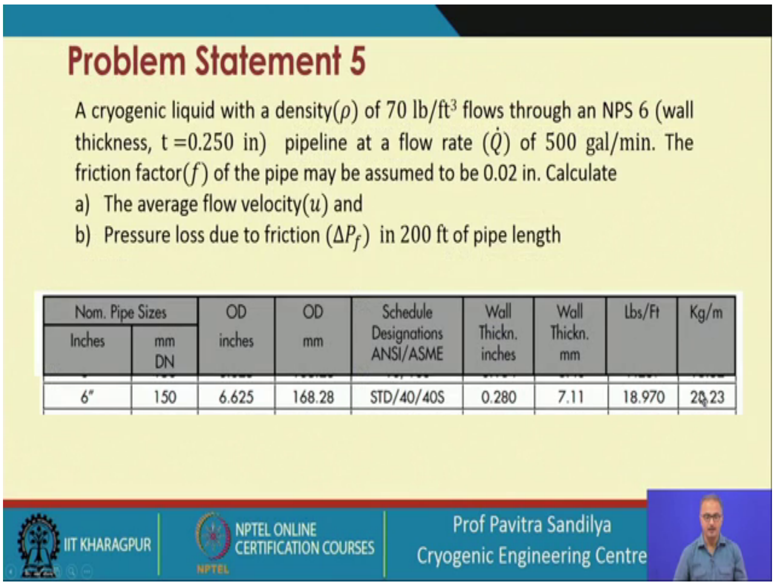

And that is next one we have a cryogenic liquid because we are we may having this LNG is cryogenic sometimes we have a liquid nitrogen also is there in the plant. So, we have the cryogenic liquid is there which has viscosity and density of this particular things flowing through this particular pipeline at a volumetric flow rate given like 500 gpm. So, assuming the friction factor to be 0.02, we have to find out this the average flow velocity and the pressure drop ok.

So, from this whatever the thing we again go for NPS 6 we find out a schedule number is 40. So, we find out the wall thickness and the outer diameter.

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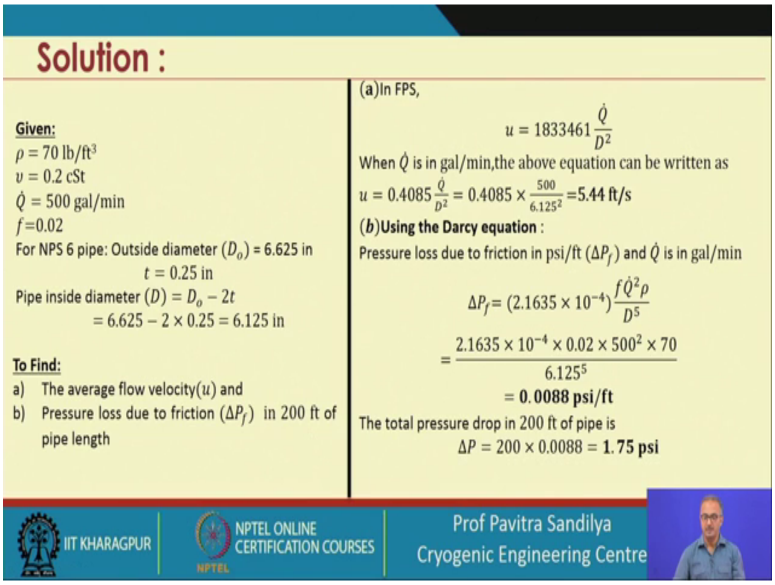

And we put all these expressions here, we find the inside diameter and we write other values given to us. And we find we have to find out the average flow velocity and the pressure loss ok. Now, in the fps systems we are using so, this is the velocity expression for the fps system and this is coming out to be 5.44 feet per second.

And now we are using Darcy's expression to find out the pressure drop. So, here we have the in the fps system this is the expression and we plug in the values and we can easily find out the pressure drop per unit length of the pipeline ok.

So, this is how we can find out, and the pressure drop. And now once we get this value we simply that we have to multiply this with the actual length of the pipe to get the total frictional pressure drop to the pipeline.

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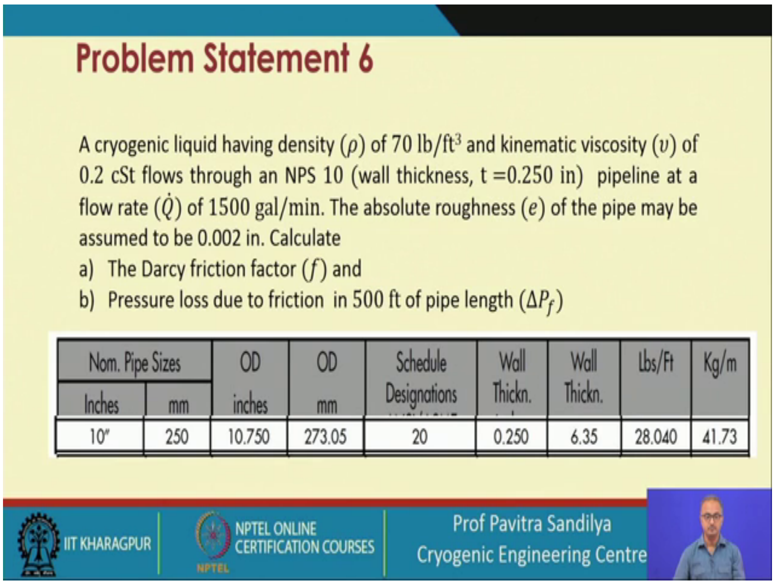

In this next one we have the same cryogenic liquid with some given value of density. The kinetic viscosity, the pipeline type, the flow rate, the roughness is given the 0.002 inches; we have to calculate the friction factor and the pressure loss ok.

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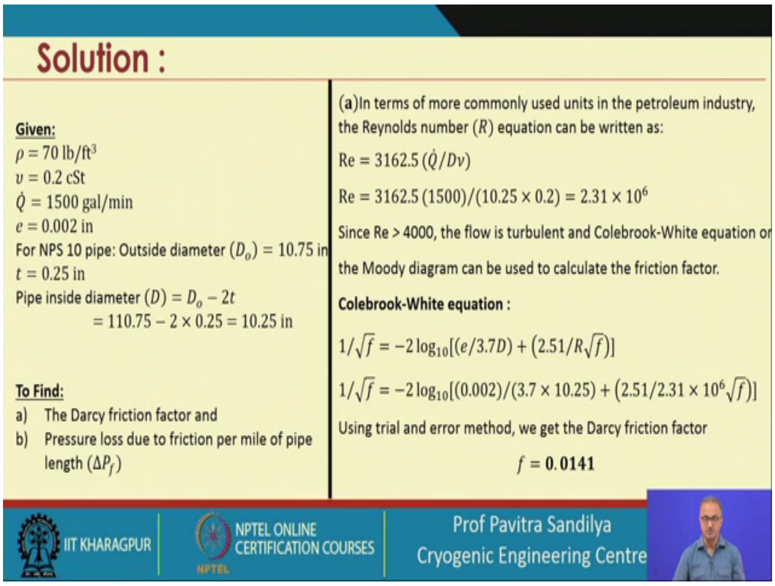

Now, here we put all the given information first. And this is what we need to find out and here we taken the expression for the Reynolds number like this and we find again it is coming in the turbulent regime.

So, we use this Colebrook-White equation and you plug in the values, we do some iterative calculation and we get the friction factor to be this particular value ok. So, this is a first part of the question.

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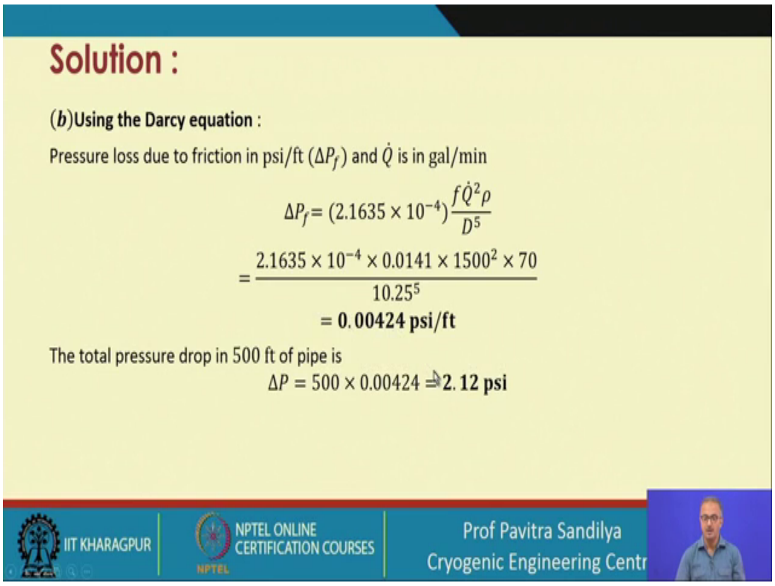

And second part of the question, we have to find out the pressure drop. So, we again go back to Darcy's equation, we plug in the values of all the data in this in required in this particular expression. And we get in terms of per unit length of the thing we get this delta Pf and to for the 500 feet pipeline, we multiply this with this value and we get the total pressure drop due to friction.

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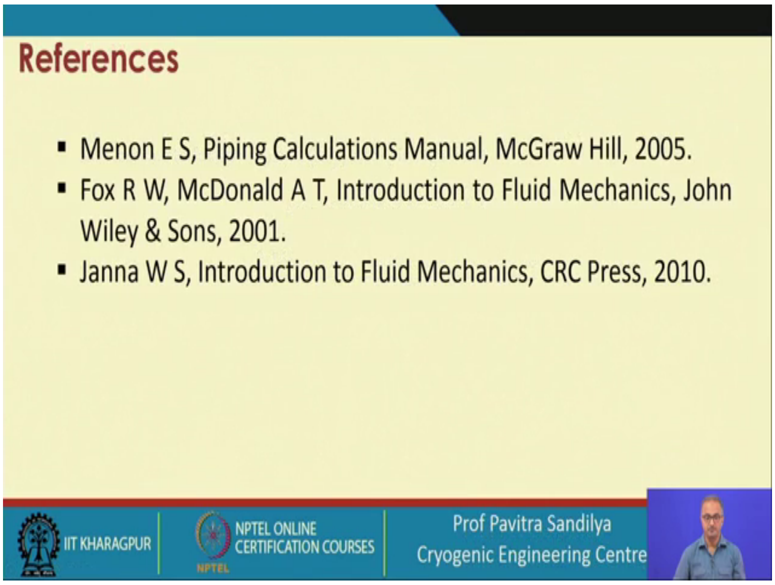

These are the books which you may refer to for further description of these calculations.

Thank you.