Upstream LNG Technology
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Lecture - 85
Tutorial on piping in natural gas systems – I

Welcome, after learning the theories about the friction factor calculation, the flow rate calculation in the piping's, in a natural gas systems, in this lecture we shall do some problems to apply those expressions which we have learnt.

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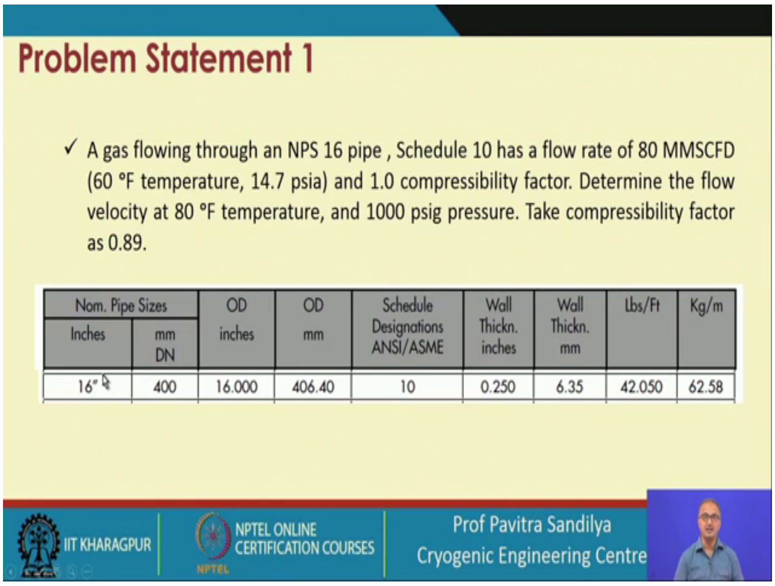

So, in this first problem is that in this case a gas is flowing through an NPS of 16 pipe and schedule 10 has a flow rate of 80 MM SCFD. Now, first I shall be explained the meaning of NPS, NPS is a nominal pipe schedule and standard.

So, this in this we have 16 we will find I will tell you how what is what does 16 mean and what is schedule number? As I told you it tells us about the thickness of the pipe line.

So, these are nominal diameters has been given and then we find that this is a standard flow rate that is the 80 million standard cubic feet per day. And this is the standard temperature pressure were given and the complicity factor is taken to be 1. So, we have to determine the flow rate at some other temperature that is 80 degree Fahrenheit and another pressure that is 1000 psig.

And then understand we are talking into a gate pressure we have to first convert it into the absolute pressure and at this temperature pressure the complicity factor is taken to be 0.89. Now, as I was telling you to understand the meaning of NPS and schedule number you will get in the literature standard charts given to us.

So, the standard chart for the nominal pipe sizes and you will find either they are given in terms of this inches, this 16 is inches or in terms of the DN in terms of millimetre. Now, this is nominal diameter the millimetre.

So, DN will be always in terms of millimetre and NPS will always in terms of inches and now we find that for a given nominal diameter the OD that is the outer diameter is specified.

Now, in this case it is happens to be 16 do not equate the nominal size to be the OD, nominal size is generally neither the OD nor the ID. So, it depends on the type of the pipeline for the generally for the higher side.

We find it goes towards the OD side and then we find that this is in inches is in this is in this millimetre and you can easily see that when DN is 400 it is coming 406.40 ok.

In terms of inches it happens to be same, but in terms of millimeter it is not the same though in millimetre terms 4 400 DN means 406.4MM of the OD. And now you look at a schedule number again we find that we have 10 schedule number.

And this is for this 10 schedule number we have in thickness is 0.25 inches or 6.35 millimetre. And these are the some of the diameters in this for feet, this is kg per meter, these are the other the mass of the pipe line.

So, this field is not considered, these are required when we are calculating a stress analysis. The how much stress will be given by the pipeline? Because, of the weight of the pipeline accordingly we have to design the support for the pipeline.

System so, then we will be requiring this particular value of the kg per meter per unit length of the pipeline how much will be the weight. Now, in this understand this is given for the stainless still, now this NSI for stainless still.

So, these are specific to a given material of construction of the pipeline. Now, after understanding this we shall be encountering this NPS and schedule number time and again.

So, later on I will not be going into the explanation of this NPS and a schedule number ok that is why I have just explained the things to you in this particular problem.

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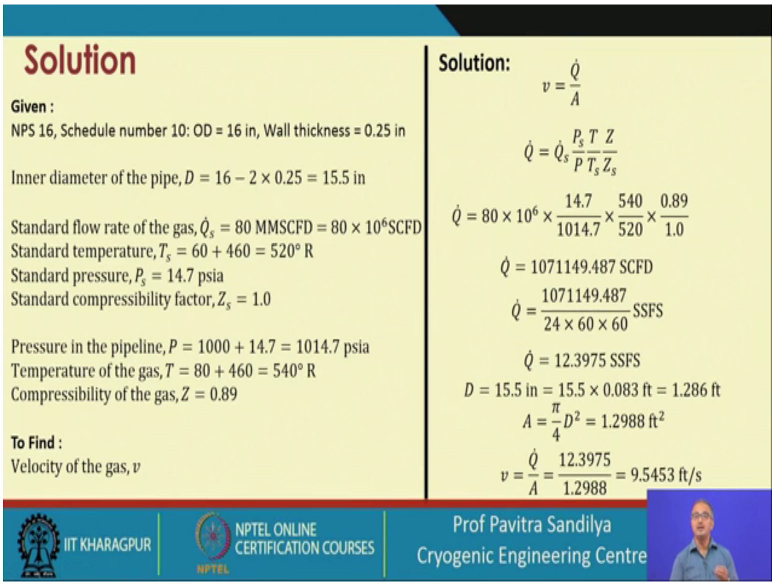

Now, first we brought down whatever are given to us. So, first we are writing the pipeline dimensions and from that we find out the inside diameter is given by the outer diameter minus twice the thickness of the pipeline. So, this is we are getting the inside diameter of the pipeline.

And now we have been given a standard cubic feet the flow rate of the gas. So, here we have that we are putting the now this million means 10 to the power 6.

The standard temperature again we first convert the Fahrenheit into Rankin. The standard pressure is this and as I told you the pipe line pressure has to be first converted from the gauge pressure to the absolute pressure by adding the ambient pressure.

And this is the temperature of the gas again we are adding 460 to convert from Fahrenheit to Rankin and this is the given value of the compressibility factor.

Now, with this information we have to find out the velocity of the gas. Now, this is the expression basic expression for the velocity that is the volumetric flow rate divided by the area of cross section.

And this particular expression we also found out earlier that we are representing the actual volumetric flow rate in terms of the standard volumetric flow rate. And we have the various temperature pressure and the dependency of the compressibility factor. So, here we have.

Now, we just plug in the values of the various these parameters over here and we will find out this is the actual volumetric flow rate at the given condition. You can easily see the difference between these 2 values, the standard value is 80 million and in this case if I it is about or 1 million.

For the given condition because the pressure has increased tremendously from 14.7 it has gone to 1014.7 that is quite a high amount of pressure. So, that is why you find the volumetric flow rate has come down.

So, here again we put this expression for the area of cross section in terms of feet square and this inches. So, we divide by 12 to get feet. So, after doing this we find this is the velocity of the particular thing. And one more thing you have to understand that it is given in terms of per day ok.

So, this per day has to be given in terms of per second ok. So, what we do? To convert day into second we simply put 24 into 60 into 60, 24 hour into 60 minute into 60 second. So, that is how we are converting the day into seconds. So, that is how we are getting the velocity in terms of second.

Now, please understand if you keep 2 per day it is not that we are we are wrong, one thing is this value of this velocity will be quite high. And generally we represent the velocity in terms of per second and not in terms of per day. But,, but the flow rate may be given in terms of that the capacity may be given in terms of per day.

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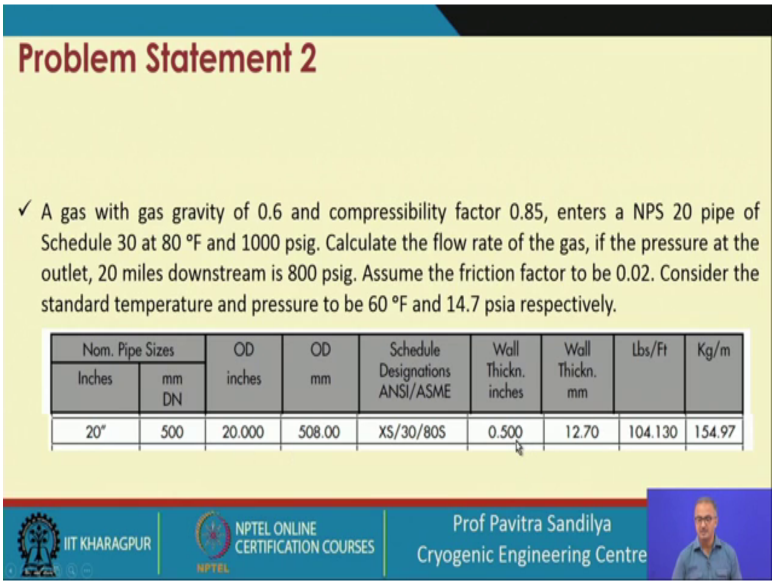

Now, we come to the second problem, in this case with the gas has a gas gravity you have 0.6 and the compressibility factor of 0.85. And it is entering a pipe line with NPS 20 and schedule of 30 and these are the pressure and temperature values.

We have to find out the flow rate of the gas for a pipe length of 20 miles and this is the outlet pressure given to be 800 psig. Understand this, we are not given the inlet pressure, we are given the outlet pressure. And the friction factor will be taken to be 0.02 and the standard pressure temperature are given like this.

Now, first thing is this, again we shall be referring to the standard table to find out the pipe and dimensions for 20 inch, 20 nominal diameter. We find that 20 inches is the outer diameter and for the schedule number of 30, we find this is 0.5 is the thickness of the pipe line.

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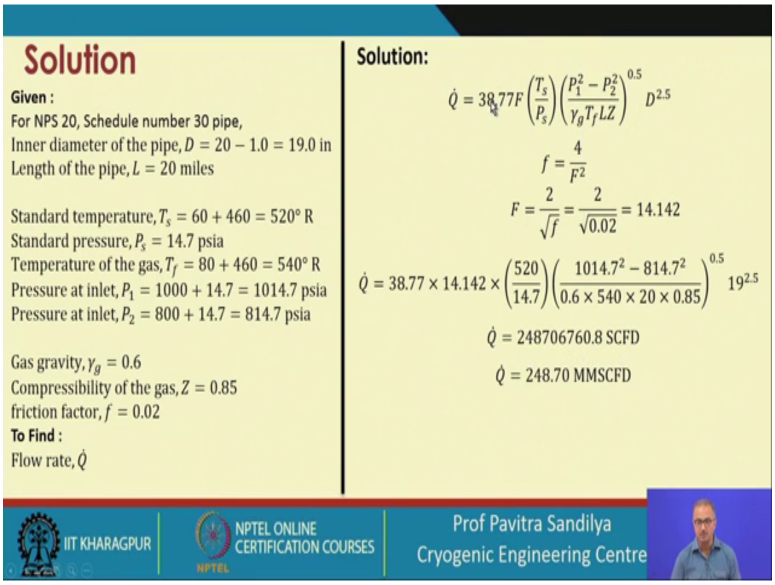

Now, with this expression what we do? Again we put down all these expressions and what we find that the inside diameter we will find out ok. This is a length of 20, we convert the temperature from Fahrenheit to Rankin.

We convert the gauge pressure to the absolute pressure and then we write other values which have been given in the particular problem. And now, we are ready to find out the volumetric flow rate.

Now, here we write this expression for the volumetric flow rate and we find this f the transmission factor we find like this. And this we know that in terms of friction factor and this is given.

And now we understand that this friction factor is the Darcy friction factor as I told you in the lecture. So, by default we shall be taking the Darcy friction factor.

So, here we have given a friction factor to be find the value of the F and we plug in the values of the various things the inlet pressure, the outlet pressure etcetera. And we find out this is the value of the Q in terms of the standard cubic feet per day.

We understand this in this particular expression we have to understand with these units, this particular value, this vary with the parameter it is this vocalized-noise] has been derived when the Q is in terms of the in cubic feet per day.

So, we plug in and we find this is. Now, this standard mean per day is also converted by if we divide by the 10 to the over 6, we will find out that we can find out the in terms of million standard cubic per day.

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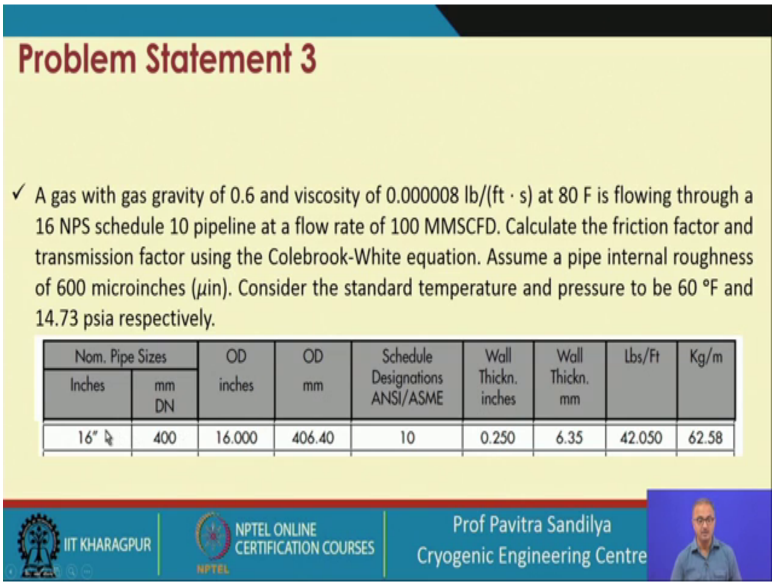

Next problem we take, in this case again we have given the gas gravity as 0.6. The viscosity is now given in terms of pound per feet per second at 80 degree Fahrenheit.

And we are given this particular pipeline that is 16 NPS and it schedule 10 and the flow rate is 100 cube million standard cubic feet per day. Friction factor and the transmission factor may be taken from the Colebrook fight equation. And the internal roughness may be taken to be 600 micro inches, the standard temperature pressure are given here.

Now, first again we refer to this standard table to find out the outer diameter and the thickness of the pipe line for the given a nominal diameter and the schedule.

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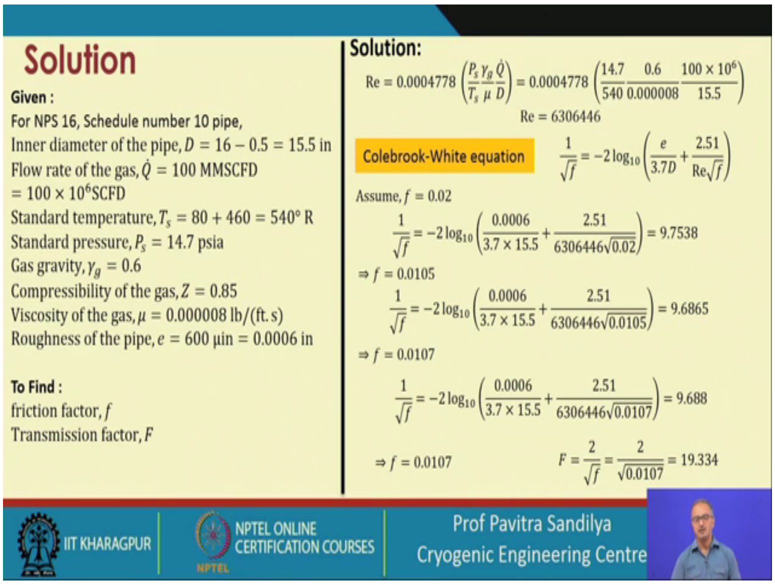

And next we proceed to write all the data which are available to us, needless to say that we are again putting this million into this standard cubic feet per day. Again converting the temperature from Fahrenheit to Rankin, the taking the standard absolute pressure these are the other extra information we are having.

Now, we have to find out the friction factor and the transmission factor. Now, this is the expression for the Reynolds number. Because, for friction factor we need the Reynolds number ok.

So, we are using this particular thing for Reynolds number and we find that we when we use a Colebrook expression this is the expression. We have a Colebrook expression and for this expression we find that this is I told you that is an implicit expression in friction factor.

So, we need to solve it iteratively using some numerical method. So, what we do? We first assume arbitrarily the friction factor to be 0.02. And now once we put the 0.02 value on the right hand side we can find the left hand side we can find that this is coming to 0.0 0105. That is, this 0.02 is not a very bad guess.

So, with this particular thing we can successfully substitute this value of the f to update the value of the friction factors. Again we take this value, we take this value over here on the right hand side. Again we modify this value and we find slowly and slowly we are converging.

And we will keep on doing this until we reach some user specified convergence criterion. We may say that we want to approach 5 percent, 10 percent, 1 percent. You can you can decide any of these convergence criterion to find your solution.

So, we find that it is not very different from 0.0105 and 0.0107 not much difference percentage also. So, we may again find out that we can keep doing this, we can keep iterating over it.

But, let us stop at this particular value and we find that if we take this as the friction factor. Then using this expression for the transmission factor we find it is coming to be this particular value.

So, that is how we are able to use the Colebrook white equation for finding the friction factor and the transmission factor.

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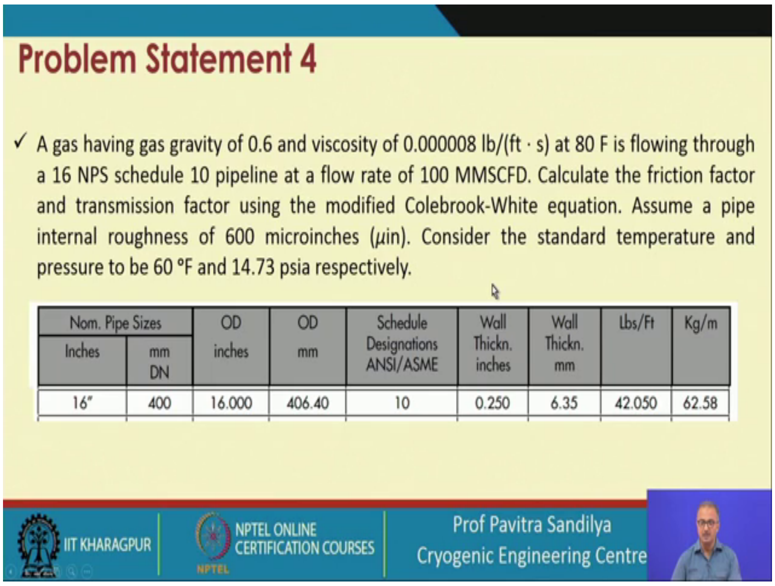

Now, we have another problem in which we have the gas gravity 0.6, viscosity has this value and it is flowing at this particular temperature. In this pipeline is given like this, schedule drew 10 and 16 NPS and the flow rate is given standard flow rate is given as 100 million standard cubic feet per day.

And again we have to given these development factors and we find these particular things.

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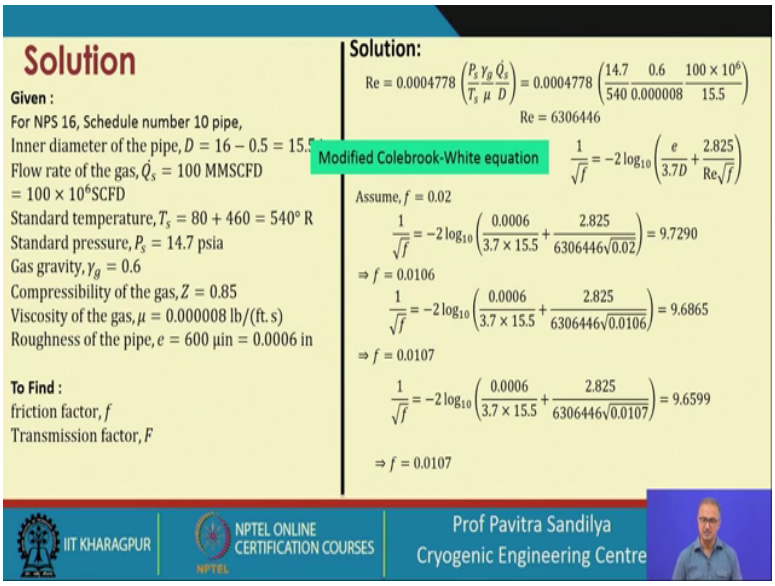

And we, now what we do that we use this modified Colebrook expression and again we I am not going detail into this because, I have done it already for the Colebrook. Now, just we are changing the to modified Colebrook. So, I am not repeating my this procedure.

So, here we find it again we adopt this iterative manner by. The substituting it successively and ultimately we reach a value of this 0.0107. So, what we find that in this case there is not much difference by the Colebrook expression and the modified Colebrook expression. So, you may use any of these 2 equations to find out the friction factor and the transmission factor.

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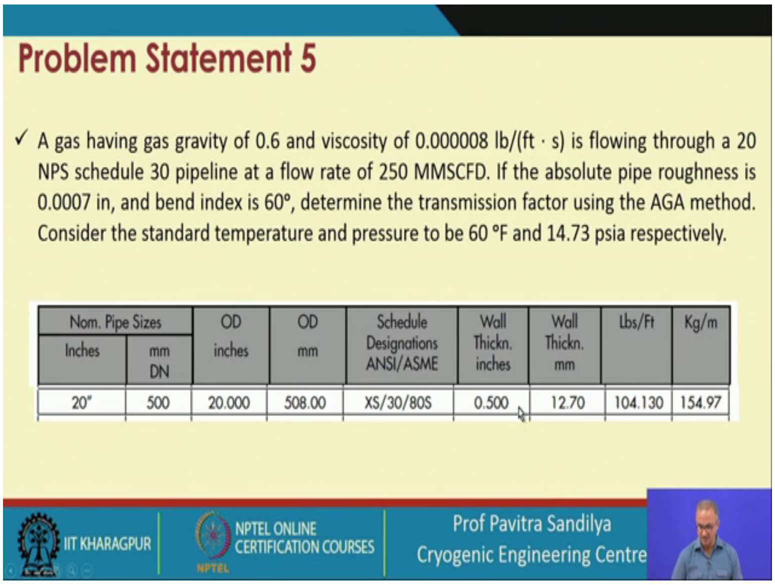

Nom. Pipe Sizes		OD	OD	Schedule Designations	Wall Thickn.	Wall Thickn.	Lbs/Ft	Kg/m
Inches	mm DN	inches	mm	ANSI/ASME	inches	mm		
20"	500	20.000	508.00	XS/30/80S	0.500	12.70	104.130	154.97

Now, we come to the next problem, in this case we have been given the gas gravity, the viscosity and the pipe schedule, the pipe, nominal pipe diameter. And this is the standard flow rate and this is the roughness factor has been given and now we are using bend index.

So, we shall see how to use this bend index and this standard temperature and pressure are given. So, we shall be using the AGA method that is the American Gas Association method. So, again corresponding to the given pipe line we find out the outer diameter and the thickness of the pipe line.

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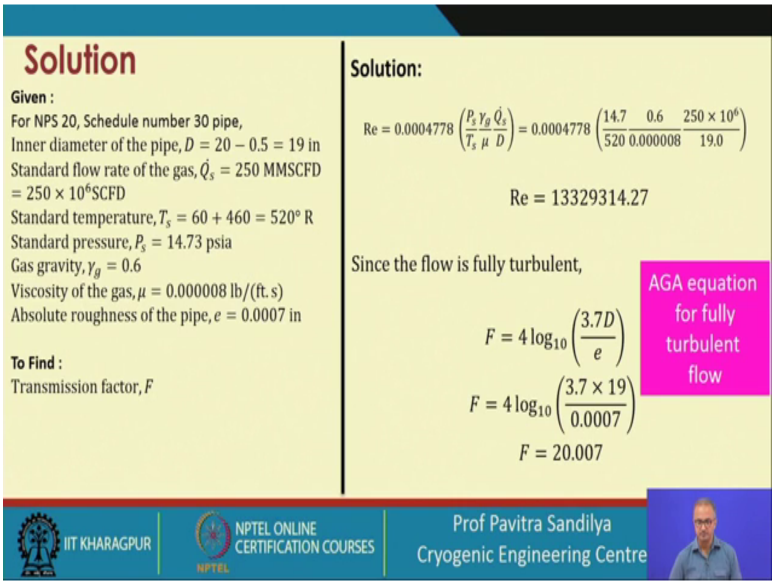

And here we first list out all the information given to us and we have to find out the transmission factor. So, we use this expression first we find out the Reynolds number and we use the AGA equation like this one and we find out the transmission factor to be this, for the fully turbulent flow.

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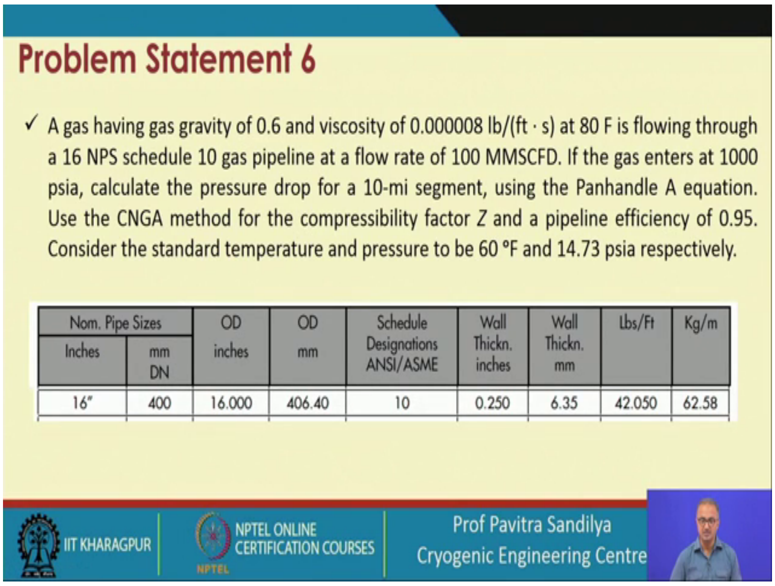

Now, we come to this particular n problem. Again we are given the gas gravity, viscosity, the temperature of the flow, the pipe type, the standard flow rate. The is the 10 mile is the length of the pipeline.

And we have to use the Panhandle A equation and we have been asked that CNGA equation, that is the California Natural Gas Association method to find out the compressibility factor and the pipeline efficiency is taken to be 0.95. And we are this standard temperature pressure.

So, again we go back to this particular table to find out the actual outer diameter and the thickness of the pipeline.

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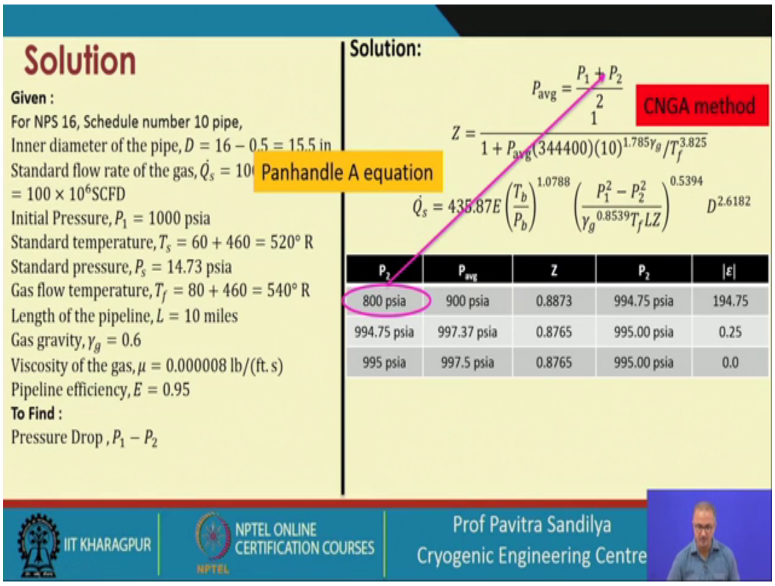

And we list out all the in given information to us and now we go to the find the value of the P average. Now because we are given the expression the value of the inlet pressure, but not the outlet pressure. What we do that first we go by some kind of the simple average by taking this value and we write the Panhandle equation here.

Now, after the panhandle equation what to do? Now, we have because we do not know the value of the P 2. We have to find a pressure drop for that we need the P 2 value and we do not know the P 2 value. What we need to do is this we have to find out by iteration method the value of P 2.

So, initially what we do? That we take the P 2 to be same some arbitrary P 2 value. And this is should be less than the P 1 that is it 1000 here and we take it to be 800 arbitrarily.

And now we take the average as this value. Now, this average value is taken for the time being, but you can also use that expression that 2 by 3 P 1 plus P 2 minus P 1 P 2 by P 1 plus P 2. So, that particular expression you should take. You should take and you can see that these are this is a P 2 value we are taking here.

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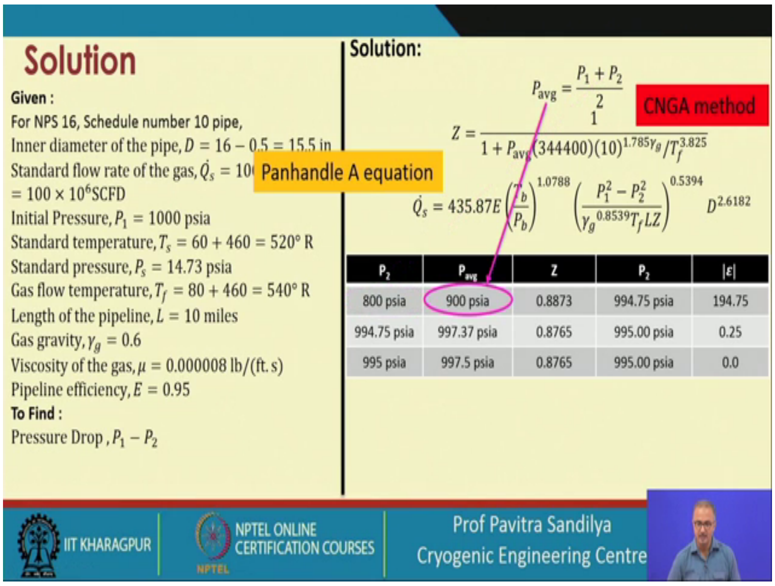

And this is a average value we have taken from here.

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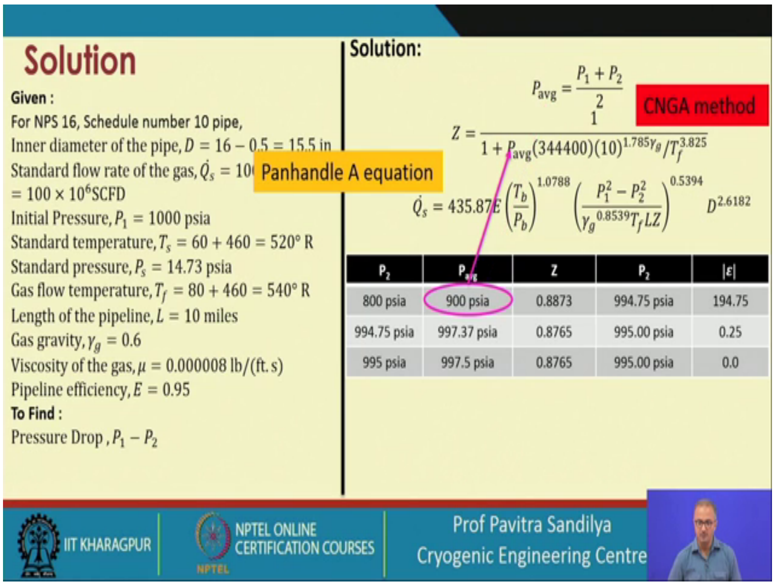

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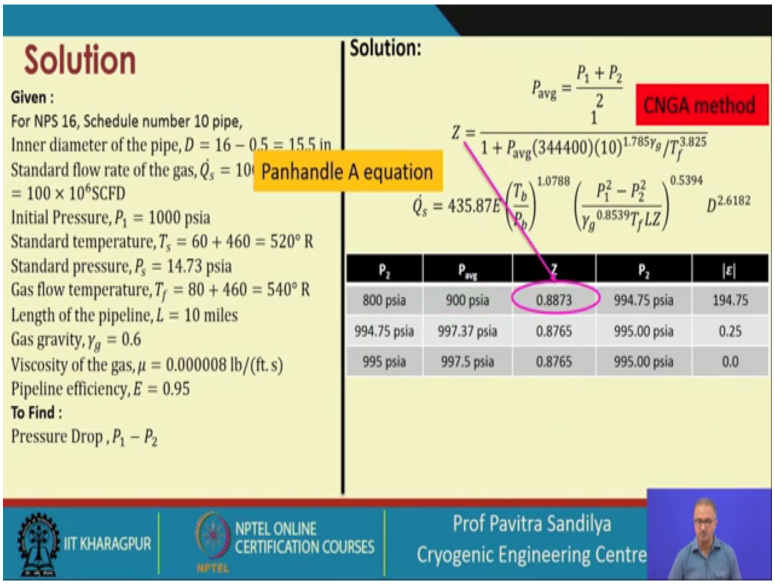

And now we are using this P average over here to get the value of Z.

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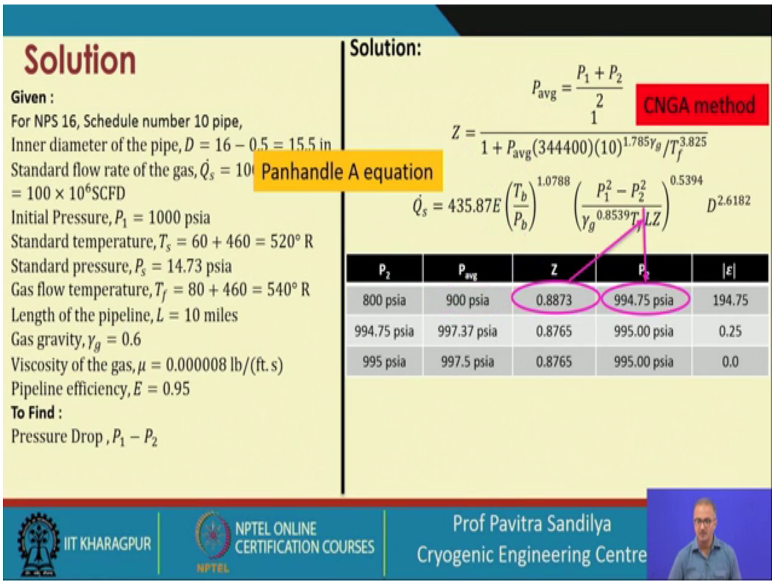

And then we find that from this we find the P 2 value. Now, we take the Z value over here we find this is a P 2 value we are finding by in the delta P.

Now, this first we are writing the absolute error. Now, with this modified P 2 value now what we do? Again we take this modified P 2 value again take the average P 2 value.

And this we repeat I repeat again we will find that we are getting and this particular expression for the P 2. And we find that as we do the iterations slowly and slowly this error is coming down.

And ultimately we find if you go up to this second place of decimal we find the error has come to 0. So that means, this pressure drop will be now calculated based on this P 2 value and we find that this pressure term is coming to 5 psia.

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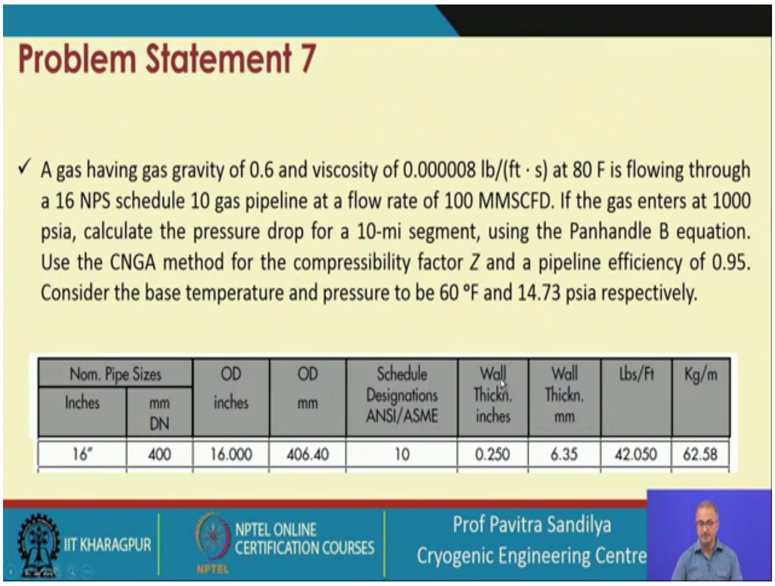

Now, we go to the next problem, in this we have the gas gravity given, viscosity given, the temperature, the pipe type, the flow rate, the length of the pipeline and we have been to do the same thing with now Panhandle B.

Now, again we have to use the CNGA method for the compressibility factor and the pipe line efficiency is same as earlier. And these are the standard temperature pressure. Again we go to this particular table to find out the outer diameter and the thickness of the pipe line.

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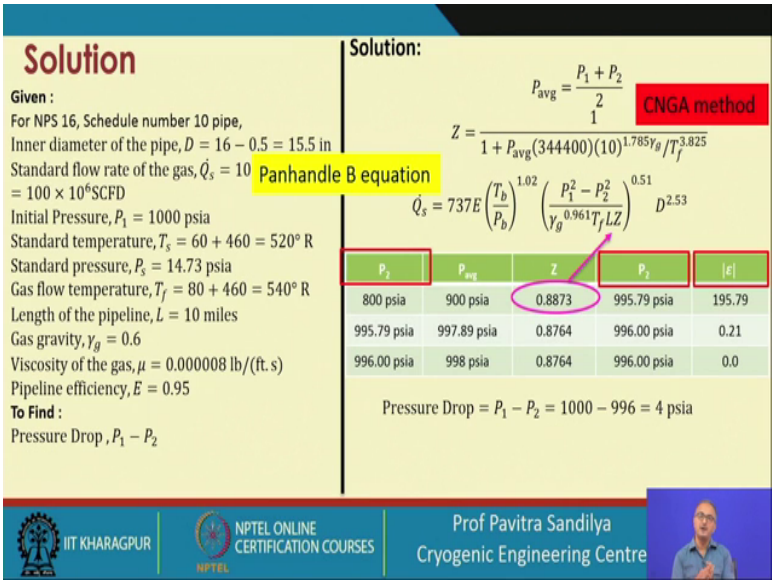

And now put all the expressions given to us now only change is this, we are going to use the Panhandle B equation. So, again this is a slight change in this equation, but we repeat the same procedure as we did for earlier. Again starting with 800 psij, we find out that how do we modify this value of the P 2.

And ultimately we reach a value of this particular 996. So, here we will find that Panhandle A was giving us 5 psia delta P, whereas, Panhandle B is giving us a 4. That is it is if you take these 2 values what we find that it is you know 20 percent difference in the values of the pressure drop.

So, this 20 percent difference whether this is acceptable or not that will be decided by the user, but we find that by using these 2 equations we are getting 2 different values

and if this is not acceptable then naturally because Panhandles B is a modified form of Panhandle A. So, we may go choose the Panhandle B equation to have a more accurate value of the pressure drop.

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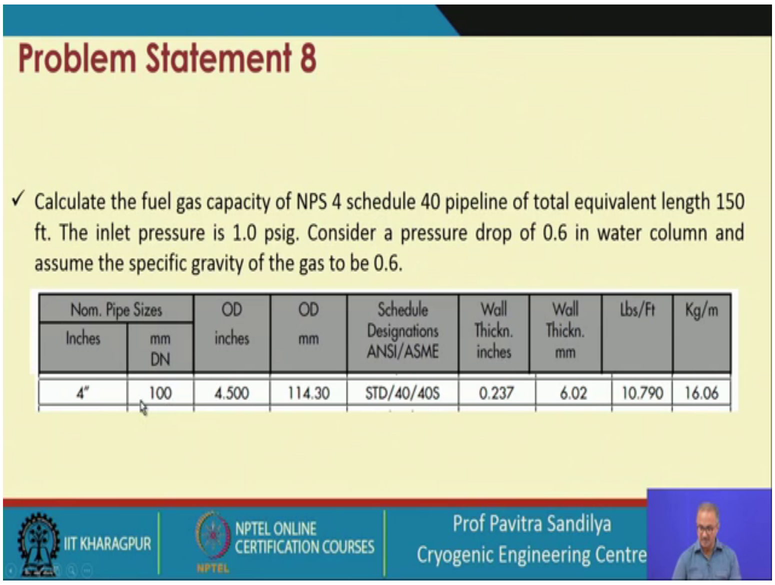

Now, here we take some fuel it may be natural gas some other LP something some fuel gas capacity. we have to find out and here for the this particular pipeline. Equivalent length has been given as 150 feet and this is the inlet pressure in terms of the gauge pressure and.

This is the pressure drop in terms of the inches of water column and this is the specific gas gravity. Again, we find out the outer diameter and the thickness of the particular pipeline for this given schedule number and the nominal diameter.

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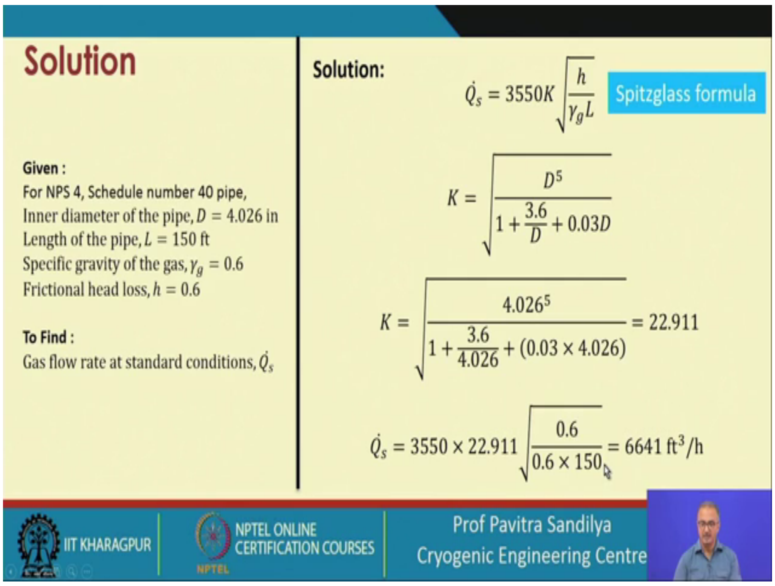

And now we find that we are using the speech gloss equation because, which is used for the higher pressures. So, what we do is this sorry the lower pressures we use the Spitzglass equation and higher pressures we use (Refer Time: 21:37) equation. So, we are using a Spitzglass equation and we are taking this particular expression and we are plugging in the values of the inside diameter of the pipeline. We get the value of the K, we plug in the value of the K, h has been given also and this L has been given.

So, we plugging the values, we find out this is the standard flow volumetric flow rate through the pipeline.

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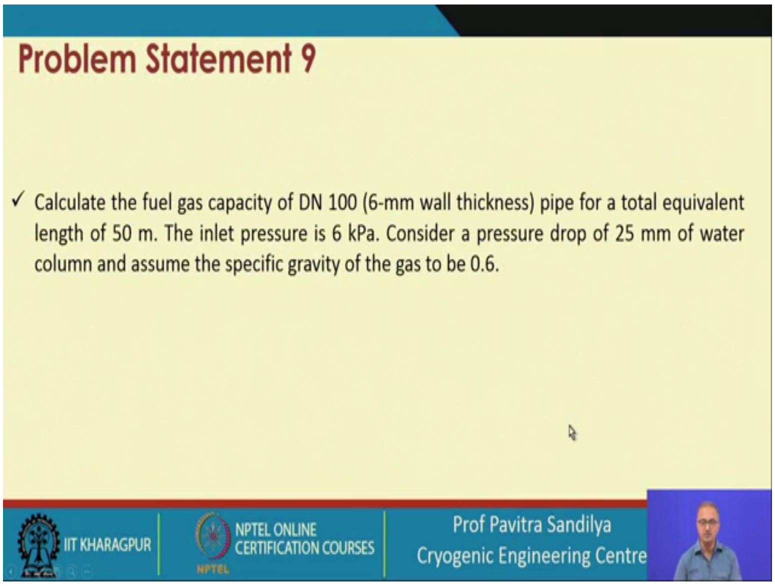

Now, we do the same calculation. Now, here we are using this 6 kilo Pascal in that pressure.

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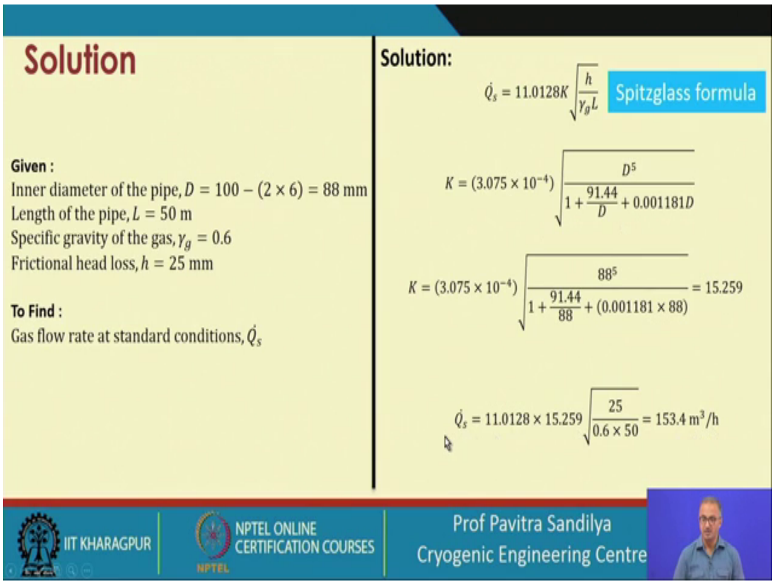

And we shall be using again we put down all the information given to us and we find that here we are simply changing the type of the unit. So, unit has been changed from inches to millimeters of water ok.

And with that we what we get that this is the in terms of the cubic meter per hour. We get the standard these are standard condition for standard flow rate by the same Spitzglass formula.

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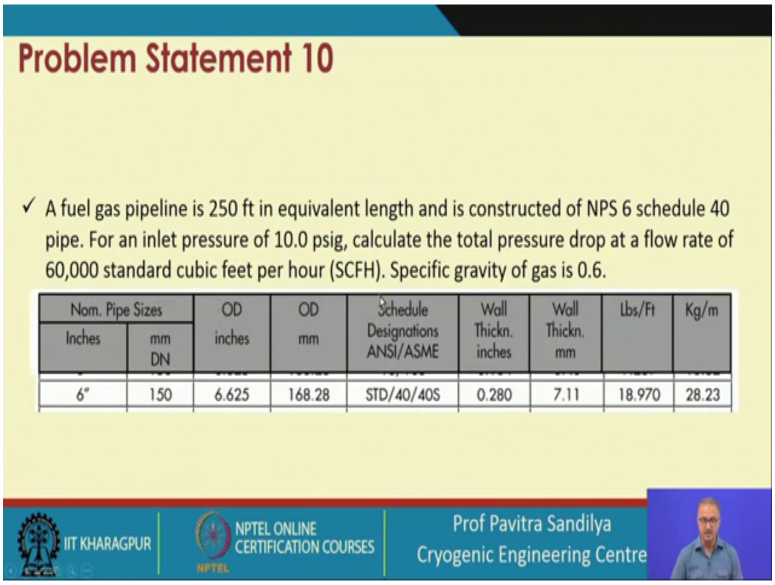

Next, we come to another thing that in this case the pipeline length has been given and this is the type of pipeline. This is the inlet pressure and in terms of gauge and we have to find out the total pressure drop at the flow rate of this. And a specific gravity is given to be 0.6.

Now, again we find out the pipeline OD and the thickness.

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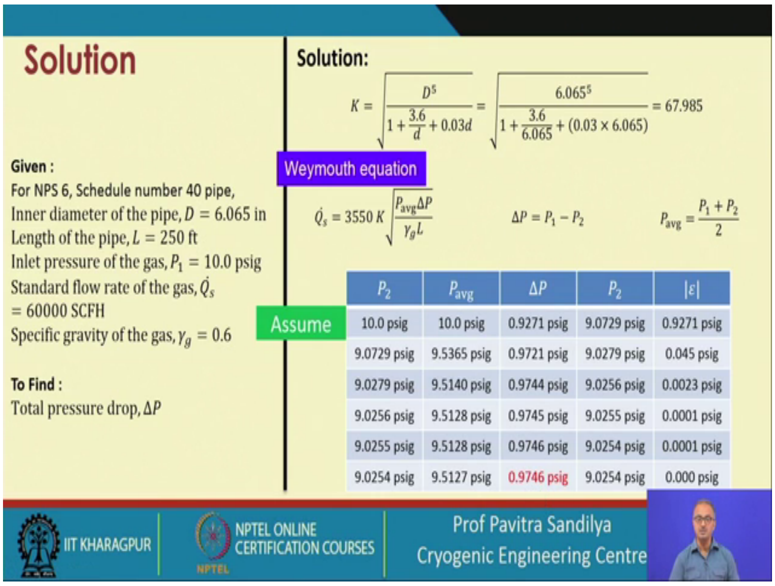

And we put all the information first and to we have to find out the pressure drop. Now we find that the inlet pressure has been given, but not the outlet pressure. So, now, first what we do? We find the value of the K and we use the Weymouth equation because, it is higher pressure.

So, we have to find out the value of this P 2. So, we if we take this P 2 now what we do is this to find out the value of P 2 initially we assume it to be 10 psig; that means, we are taking it to be the same as the inlet pressure. So, if it is take P 10.

That means there is no pressure drop we assume then we find the P average is 10 and we from that we find out the delta P value. And with this delta P value we can find out the from Weymouth equation we put the delta P value here. The P average here we find out the value.

Again we find out that the what kind of flow rate we are getting. Now, what we do rather than that we take the flow rate which is given to us.

We find the value of the K we take the P average value from this and we determine the value of delta P. And once we determine out delta P and then what we found? That delta P pone minus delta P is P 2.

So, we find the P 2 by subtracting delta P from P 1 ok. And now we use this P 2 to find out P average and this P average we take here. Again we know this value we know this value and again we determine the value of the delta P.

So, we find the delta is changing by using this Weymouth equation and for each delta P we are getting different values of the P 2 and ultimately we find that the error is also coming down and ultimately this coming to almost 0.

So, with this we take this P 2 to be 9 0.0 to 54 psig and the delta P is coming taken to be 0.97 4 6 psig. So, that is how by taking using iterative calculation we are able to find out the delta P what the pipeline.

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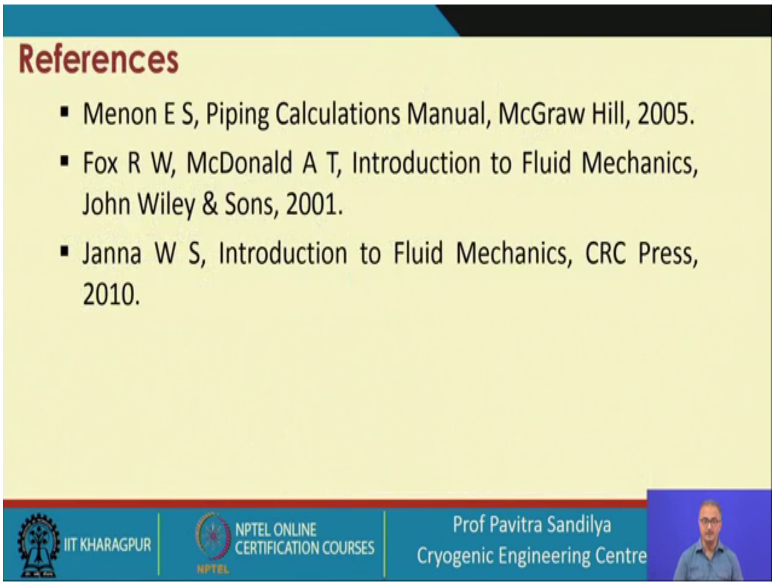

So, more can be found out from these books. And please understand that all these iterations you may either do it in the in the manually or you can use any kind of standard software like MATLAB to do these calculations. And we shall be providing you the sources of this data in separately during the assignments.

Thank you.