Course on Momentum Transfer in Process Engineering
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Lecture 37
Module 8
Problem on Pneumatic conveying Part-1

We had done this conveying, right? Pneumatic conveying and now this pneumatic conveying we will do a problem because a problem solution and this problem will be earlier we had said that may this for particularly compressible fluid things are complicated and your expressions are bigger so it may or may not be possible to do in a one shot, so there it may be require some trial and error or things like that. So maybe this problem we will handle and there it may be required, right?

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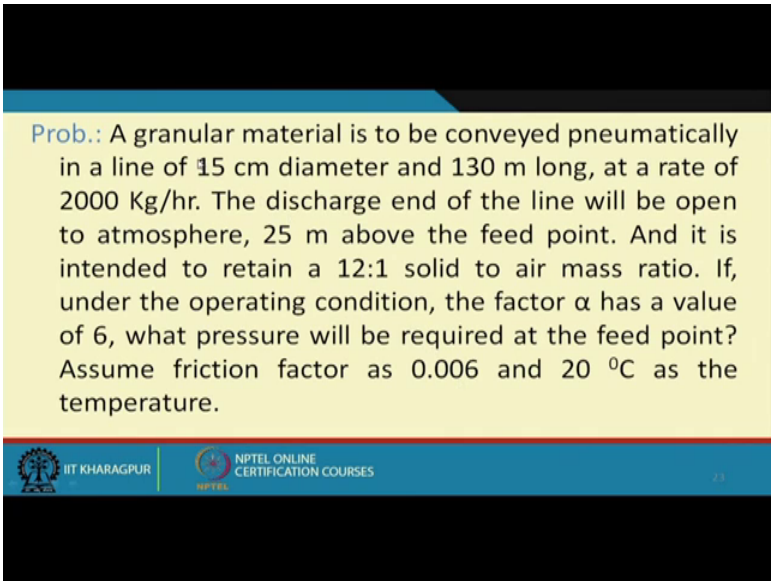

So let us go to that I think this is on 23, yes. So the problem says like this, A granular material is to be conveyed pneumatically in a line of 15 cm diameter and 130 meter long at a rate of 2000 kg per hour. The discharge end of the line will be open to atmosphere, 25 meter above the feed point. And it is intended to retain a 12:1 solid to air mass ratio. If, under the operating condition the factor alpha, you remember we had said that this alpha we had taken as factor multiplied with the all losses frictional losses everything and we said this alpha maybe given or may not be given sometimes you may find out, sometimes it might have been given.

So in this typical problem alpha has to be found out. So the factor alpha has a value of 6 this is given, what pressure will be required at the feed point? Assume friction factor as 0.006 and temperature to be 20 degree centigrade, right? So I repeat, A granular material is to be conveyed pneumatically in a line of 15 cm diameter and 130 meter long at a rate of 2000 kg per hour. The discharge end of the line will be open to atmosphere, 25 meter above the feed point. And it is intended to retain a 12:1 solid to air mass ratio. If, under the operating condition the factor alpha has a value of 6, what pressure will be required at the feed point? Assume friction factor as 0.006 and 20 degree centigrade as the temperature, right?

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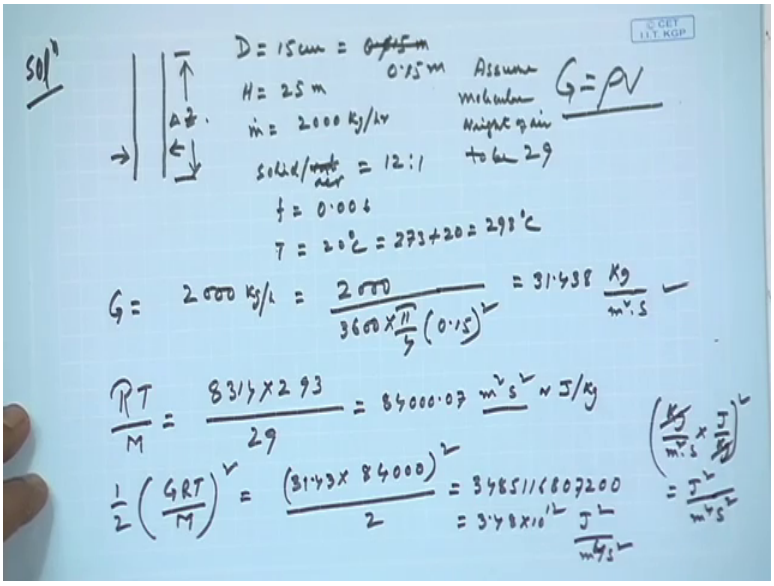

Now let us look into the solution of this problem from the given problem it is coming that the diameter of this is D is equals to 15 centimeter is equals to 0.015 meter, right? Height of this is z or delta z whatever we call that is given 25 meter, so height is equals to 25 meter, right? And the rate of the mass flow rate m dot is equals to 2000 kg per hour, right? And this solid to air ratio this is 12:1, then friction factor is 0.006 and temperature is equals to 20 degree centigrade that means 273 plus 20 is equals to 293 degree centigrade, right?

So if that be true m dot is given so mass flow rate is given, we can write G, right? G as 2000 kg per hour, right? That can be written as 2000 divided by area that is kg per hour so we can write 3600 as kg per second into area pi by 4 D square D is 0.015 not 15 centimeter 15 centimeter then it is 0.15 not 0.015, so it is 0.15 meter that should be clear, right? 15 centimeter is 0.15 meter this

is square, right? And this comes to equal to let us look into that calculator, okay so 2000 divided by 3600 divided by pi by 4, okay is equal to this divided by 0.15 square is equals to 31.438, right?

So so much kg per meter square per second, right? This is the mass velocity. So that we said earlier that mass velocity rho v G is equals to rho v so that we got 31.438 this thing, right? Okay. Now, RT by M this is equals to R is 8314 into this is 293 molecular weight of air is not given so assume molecular weight of air to be 29, so by 29 this comes to equal to 8314 into 293 is equal to this divided by 29 is equals to 84000.06 or 0.07, so so much joules per kg or meter square second square so is or this is joules per kg this meter square second square joules per kg this conversion we had done in one of the earlier problems if you remember and we showed how this is convertible in terms of unit that we had done, right? We are not re-doing here, okay.

Now if this is true that 84000 of so much now some other are required GRT over M square is equals to this G is 31.438 or say 43 into R 8 RT by M, so RT by M is 84000 let us ignore the other one, right? So this square divided by 2, so this becomes equal to let us look into how much it becomes, so it is 31.43 into 84000 this square that is square divided by 2, so that comes equals to 3485116807200, so 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 is equals to 3.48 into 10 to the power 12, right? So that is what 3.48 10 to the power 12 so much joules square per meter square per second square.

So this will be meter to the power 4, right? Joules square because this GRT that was joule per kg, right? This is kg G is kg per meter square per second into RT by M that was joules per kg so this square this is equal to this kg kg goes out this joules remains so becomes joules square per meter to the power 4 second square, right? So that is what it is coming, okay.

Now, let us look into the third one that is what next, next is we have been given the pressure, right? We have been given the pressure, one inlet pressure is given what outlet pressure we have to find out that is what exactly we have been given that and length also in this case we total height was so much, so if there would have been like this, so total length was 130 meter, right? And pressure was given alpha was given is equals to 6 and pressure will be at I can remember (())(14:41) conveyed pneumatically in a line at a rate of so much and the discharge end of the

line will be open to atmosphere and what we have to find out what pressure will be required to the feed point, okay.

So this discharge end is atmospheric pressure, so it is 1 atmosphere and here the pressure p inlet how much has to be found out, right?

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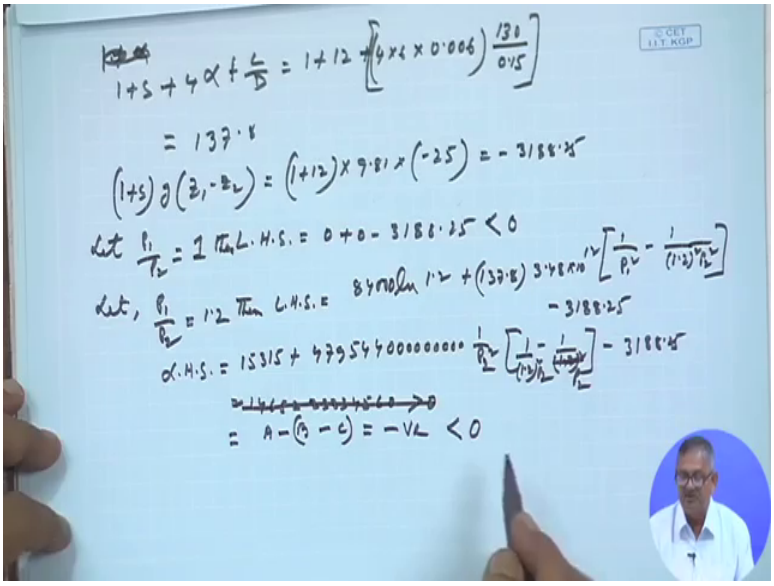

If that be true, then let us then find out what is the value of 1 plus alpha 1 plus s, so it was 1 plus s plus 4 alpha f L by D, what is the value of this? This is 1 plus s is given 12:1 so 12 plus 4 alpha is 6, L is alpha L is given as L by D, okay. So L is given as this 4 into alpha into f, f is given 0.006, right? Into L is given 130 meter by D is given 0.15, right? This we can write like this, right? 4 alpha f so this.

So this is equals to 1 plus 12 that is 13 already, so let us look into how much what is that again we have taken out, so 4 into 6 into 0.006 into 130 divided by 0.15, right? So much plus 12 plus 1 is equal to 137.8, right? 137.8, right? 137.8. So this if we take other value is 1 plus s into g into z1 minus z2 that was equals to 1 plus 12 is g is 9.81, right? Into 9.18 into z2 minus z1 that is given or this is z1 minus z2 so against the gravity so 25 meter it was given so into 25, right? This becomes equal to how much? 1 plus 12 is equal to this into 9.81 81 sorry so 9.81 into 25 plus minus is equals to minus 3188.25, right?

So that is what we got 1 plus s. Now let p1 by p2 that is equals to 1, right? Then, we get left hand side the equations we had given earlier in the previous class is 0 plus 0 minus 3188.25, right? So if it is 1, then this becomes 0, 0 into 0 plus 0 minus 3188.25 so this is less than 0, right? This is less than 0, so let another p1 over p2 so this to be 1.2, right? Then, left hand side of the equation this becomes equals to how much?

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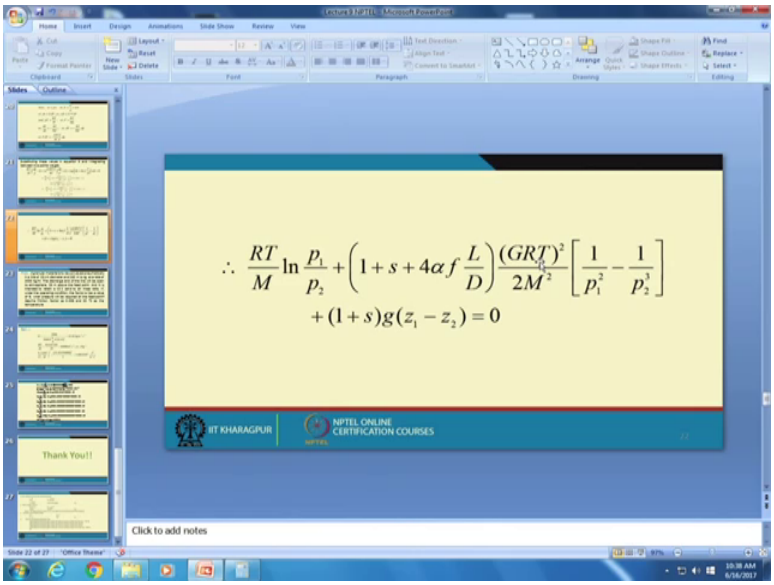

If we go back to I hope the equation we need to write somewhere, right? So we had equation let us write here this is RT by M ln of p1 over p2 plus 1 plus s plus 4 alpha f L by D, right? Into GRT square divided by 2 M square, right? This times 1 minus 1 by P whole square minus 1 by p2 square, right? This plus 1 plus s into g into z1 minus z2 this is equals to 0. So this is the equation this was the equation which we have to do.

So RT by M ln p1 by p2 plus 1 plus s 4 alpha f L by D into GRT square by 2 M square, right? Into 1 by p1 square minus 1 by p2 square plus 1 plus s g z1 minus z2 that is equals to 0, right? So in the first case, we said left hand side is equals to p1 by p2 that is ln 1 so 0 and this p1 is equals to p2 so this goes off, right? So this was also 0 and we had the third term this one this we found out minus 3188.25 so it was this it is less than 0, right?

Now, if we assume p1 by p2 is 1.2, then what we get? We have RT by M is 8400 so RT by M is 8400 ln of 1.2 plus 1 plus s plus 4 alpha f L by D, so this we got here is minus 3, right? 1 plus s plus 4 alpha f L by D, no no this is 137.8, right? So 137.8, right? Into GRT by M square, so by 2

GRT by M square this whole thing we got 3.48 into 10 to the power 12, right? So this is 10 to the power 12 and this becomes 1 by p1 square minus 1 by p2 square. So we have taken p1 is equals to 1.2 p2, right? So 1 by p1 square minus 1 by 1.2 square p2 square, right?

So if that be true, then we get minus 3188.25 that was the last term, right? So if we take p1 square out, then we can write left hand side is equals to 8400 ln of 1.2 so 8400 ln of 1.2, 1.2 ln is this into 84000, right? So it was like that which came 84000 from here, right? So this becomes equals to 15315, 15315 plus 137.8 into 3.48 10 to the power 12, right? So 3.48 into 10 to the power 12 is equals to this into 137.8 137.8, right? Is equals to so much if we take this is equals to 4795440, 1, 2, 3, 4, 5, 6, 7, 8, 9, 2, 3, 4, 5, 6, 7, 8, 9, right? Into if we take 1 by p1 square common, then it becomes 1 minus 1 by 0.2 square, right? Minus 3188.25, right?

So 1 minus 1 by 1.2 square is how much? 1.2 square inverse of that is this plus minus this plus 1 is equals to 0.3 so 0.30 into that 479544 into 10 to the power 9, right? So much plus 15315 is equals to this, right? Minus 3188 we have written right 3188, yes 3188.25 is equal to some value is equals to it has come 1465273334560, right? Which is greater than 0, right? So if this is like that, this means this has come like that and our values are like that which is greater than 0 if we take that this has become 1 minus 1 by 1.2 square p1 is 1.2 p2, right? This was done p1 is 1.2 p2, so that should have been p1 is 1.2 p2, right?

So we should have written here 1.2 square p2 and this is p2 and then this should come out and our this value should have been 1.2 square inverse of that minus 1, so this is equals to minus 0.03, right? So that means the whole term so irrespective of the values, so this is a value of A and this becomes value of say negative B minus a value of negative C, A is less than B plus C so it is a negative some value, right? Which means it is also less than 0, right?

So we have taken two trials, one is p1 by p2 is 1, second is p1 by p2 is 1.2 and in both the cases we saw that the expression left hand side whatever we had that is less than 0, that means we can have p1 by p2 higher than 1.2, okay. We will do in the next class, time is not there, thank you.