Momentum Transfer in Process Engineering
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Module 11
Lecture No 55
Problem of Fluidized bed Condition Part 2

So we have done one problem on fluidised bed and perhaps at the end because of the time constraint we asked you that you please try and hopefully you have tried, there was a quadratic equation in terms of say A N Re square + B N Re – C that is equal to 0 by using that (())(0:50) formula you can find out the root of a quadratic equation and you can find out N Re from there and that – B with the coefficients – B + – B square – 4 A C by 2 A, using this formula can find out what is the value of that N Re, so that you have hopefully done, so let us now do another problem say let us do another problem yeah.

So this is like this, Air at 390 Kelvin flows through a packed bed of cylinders having a diameter of 0.0127 meters and length the same as diameter no this we have already done so hopefully this one.

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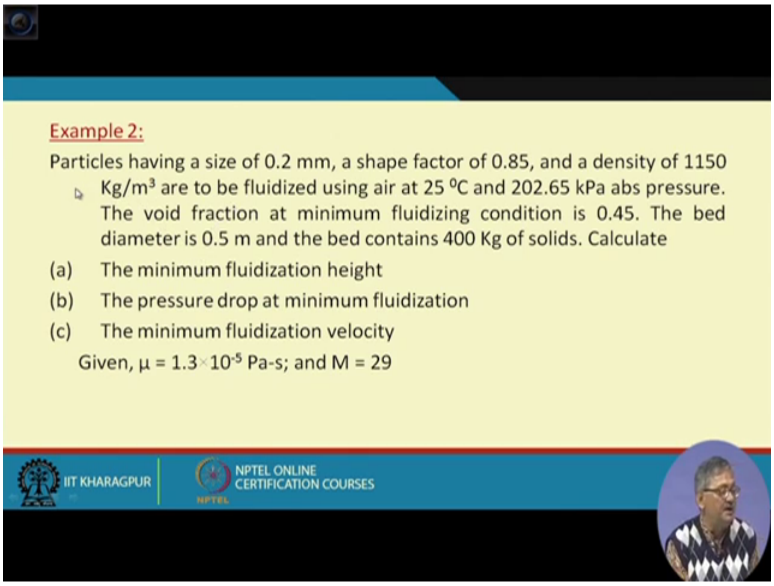

This is particles having a size of 0.2 millimetre, a shape factor of 0.85 and density of 1150 kg per meter cube are to be fluidised using air at 25 degree centigrade and 202.65 kilopascal absolute pressure. The void fraction at minimum fluidising condition is 0.45, the bed diameter is 0.5 meter and the bed contains 400 KG of solids. Calculate the minimum fluidisation height, the pressure drop at the minimum fluidisation, the minimum fluidisation velocity. Given, viscosity of the fluid is 1.3 10 to the – 5 Pascal seconds and molecular weight is 29.

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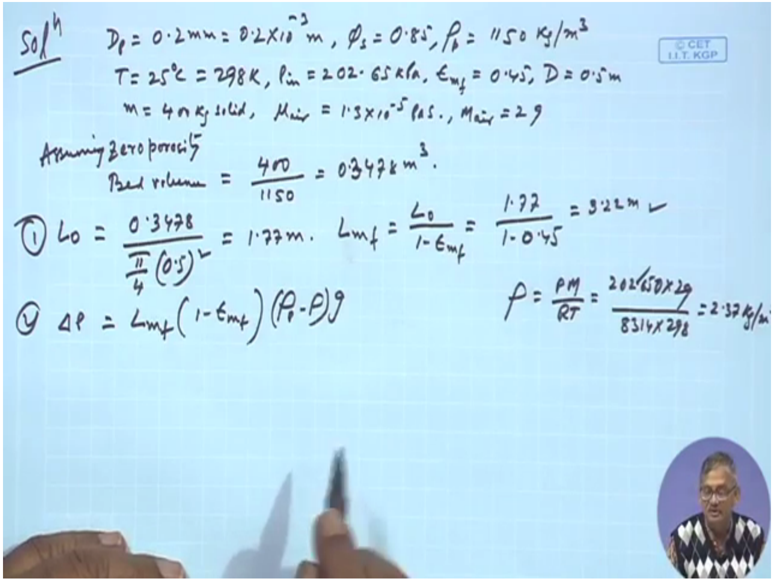

So I repeat the problem, particle having a size of 0.2 millimetre, a shape factor of 0.85 , so let us write D p the solution when we do, let us write this way that D p is 0.2 millimetre = 0.2 10 to the – 3 meter, shape factor that is Phi s 0.85, density Rho particle is 1150 KG per meter cube are to be fluidised using air at temperature, so T is 25 degree centigrade = 298 Kelvin and pressure inlet 202.65 kilopascal. The void fraction at minimum fluidising condition so Epsilon mf = 0.45, the bed diameter so D = 0.5 meter and it contains 400kg of solids, so m = 400kg solid. And given Mu air = 1.3 10 to the – 5 Pascal seconds and molecular weight of air = 29.

So as we have done earlier here also that assuming 0 porosity we can write that the bed volume that can be written = 400 kg by 1150 that is equal to 400 divided by 1150 = 0.3478 meter cube. So if L 0 is the length corresponding to no porosity then L 0 becomes equals to this volume 0.3478 divided by the cross-sectional area that is pie by 4 D square pie by 4 into it was 0.5 meters, so 0.5 square, so this becomes equal to 0.3478 divided by Pie into 4 divided by 0.5 square, 1.77 meter. So if it is so then L mf we can write equals to L 0 by 1 – Epsilon MF, so this is equal to 1.77 by 1 – 0.45. So we can write 1.77 divided by 1 – 0.45 so that is 0.55 = 3.218, so we roughly can write 3.22 meter.

So if L 0 is known, L mf is known then first one is done that one is the L mf 3.22. Second one is Delta P that we can write as Delta P is L mf into 1 – Epsilon mf into Rho p – Rho into g.

Now the question of Rho so we can write Rho = P M by R T and P is given as yeah inlet so 202.65Kpa or 650 pascal, remove that decimal into M is 29 by 8314 into 298. So this comes to be equal to 202650 into 29 into 29 divided by is equal to divided by 8314 into 298 = 2.37 kg per meter cube, so this hopefully you can see kg per meter cube okay.

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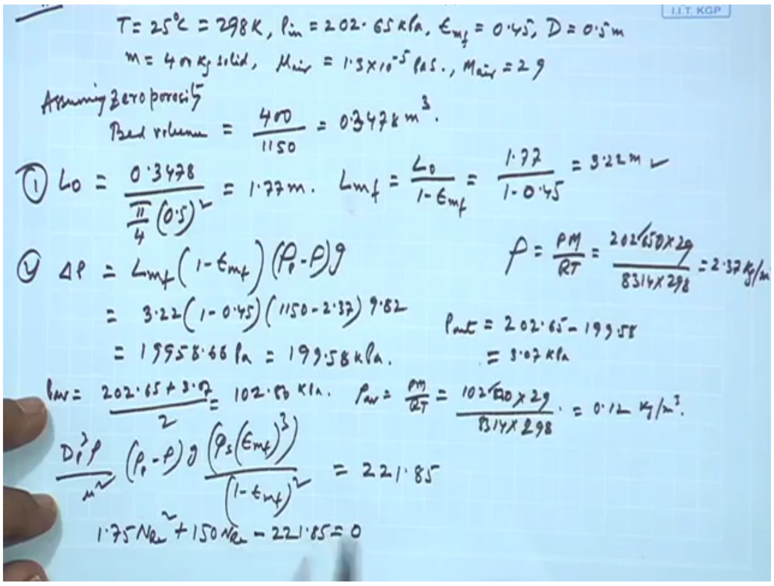

Now if Rho is so much, L mf we have found out 3.22 1 – 0.45 Rho p is 1150, Rho is 2.37 and g is 9.82, so this comes out to be 3.22 into 1 – 0.45 into 1150 – 2.37 into 9.82 = 19958.68 pascal, so we can say 199.58 kilopascal Delta p. So P out = 202.65 – 199.58 = 3.07 kilo pascal. So it appears to be a huge pressure drop 20062.2 yeah, it appears to be a huge pressure drop. So P out is there so you have got then average of P in and P out, P average = 202.65 + 3.07, did we do any mistake here?

199.58 kilopascal so this pascal 199.58 Delta P L mf 3.22 1 – 0.451 into 1150 2.37 9.82 so it is somewhere 1150 this is 0.6, we recheck this let us it is appearing a little absurd, 3.22 into 1 – 0.45 into 1150 – 2.37 into 9.82 = 19958 they have got Delta P 2.37 okay 202650 okay then we got 3.07kpa P 1 okay P average is 202 this by 2 = 3.07 into 101.325 this + oh 3.07 kilopascal sorry 3.07 kilopascal so 30700 3.07 kilopascal means or we can simply write 3.07 + 202.65 is equal to this divided by 2 = 102.86. I do not know this is appearing to be a little less kilopascal, so Rho average = P M by R T = 102.860 into M 29 divided by 8314 into T 298, so that becomes into 100 = 102860 into 29 = this divided by 8314 divided by 298, 0.12 okay 0.12 kg per meter cube, this is appearing to be low very low.

Okay, now we know that D p cube D p cube Rho by Mu square Rho p – Rho Rho p – Rho into g into Phi s Epsilon mf square or cube Phi s Epsilon mf cube divided by1 – Epsilon mf square. And this value if we take this should come to be 221.85 this value should come 221.85 then we can say that 1.75 N Re square + 150 N Re – 221.85 = 0.

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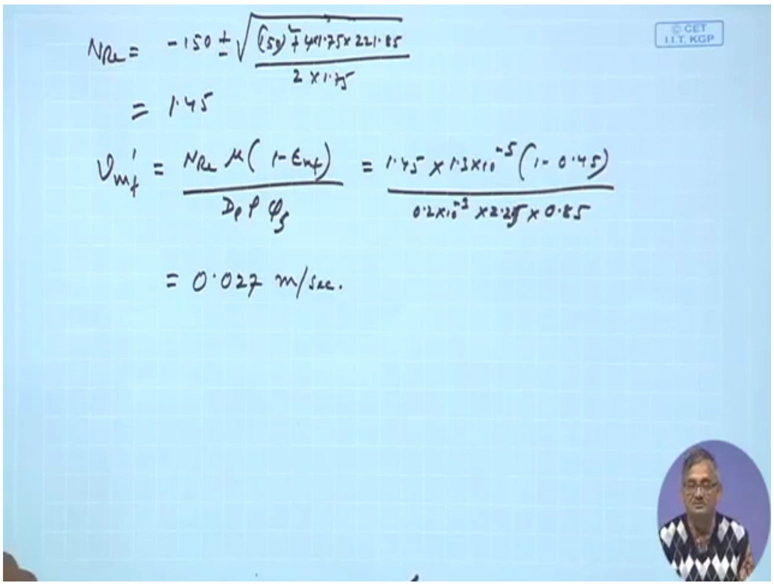

So from this equation we can find out the Rho as N Re = – B that is – 150 + – B square 150 square – – + 4 A 1.75 4 into 1.75 into C 221.85 by 4 A C by 2 A, 2 into 1.75 this becomes equal to okay 150 square + 4 into 1.75 into 221.85 is equal to so much square root of this is so much. So if we make it – then it becomes this – and this – into – whereas, if we take it plus then it is 1 – and 1 + then it becomes + that is meaningful so let us take it + so – 150 is equal to this divided by 2 into 1.75 is this is equal to 1.45, so N Re is 1.45.

Now from there if we see that V mf prime is equal to that N Re Mu 1 – Epsilon mf over D p Rho Phi s. So N Re is 1.45 into Mu is 1.3 10 to the power – 5 it was, 1 – 1.45 Epsilon mf, D p is 0.2 10 to the – 3 into Rho, Rho we got somewhere some wrong but it should be 2.27 around or 2.25 into Phi s given 0.85. So if we do this and see how much it is coming, it is 1.45 into 1.3 into 10 to the – 5 so much into 1 – 0.45 is equal to this divided by 0.2 divided by 10 to the – 3 divided by 2.25 divided by 0.85 = 0.027 meter per second. So we have found out that velocity, so velocity is coming to be 0.027 meter per second. Here we have shown that the quadratic equation which we got earlier here it was 1.75 N Re square + 150 N Re – 221.85 = 0.

So this on simply on finding out the root N R e we got so A X square + B X – C is got say + C + is here –, so that if we apply – B – B + – B square – 4 A C so that became + by 2 A, which came to be 1.45. Now from there V mf prime was N Re was Mu 1 – Epsilon mf by D p Rho Phi s, so from there we got this number and ultimately V mf = 0.027 meter per second. So this way we can find out and do the problems and you must to some practices so that this kind of minimum fluidisation velocity or what is the height of the bed under minimum fluidised condition or what is the pressure drop that is in majority cases that is required, so what is the pressure drop that you can find out from the different relations under fluidised bed condition.

Mind it that fluidisation is very helpful to increase the surface area for any extend of heat or mass or whatever that depends on what you are choosing as the what you are choosing as the unit operation okay, thank you.