Momentum Transfer in Process Engineering
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Module 11
Lecture No 54
Problem of Fluidized bed Condition Part 1

So we have done that minimum fluidisation velocity and what is the expression to find out the Delta p or pressure drop from the minimum fluidised condition if using Ergun's equation, this we have done.

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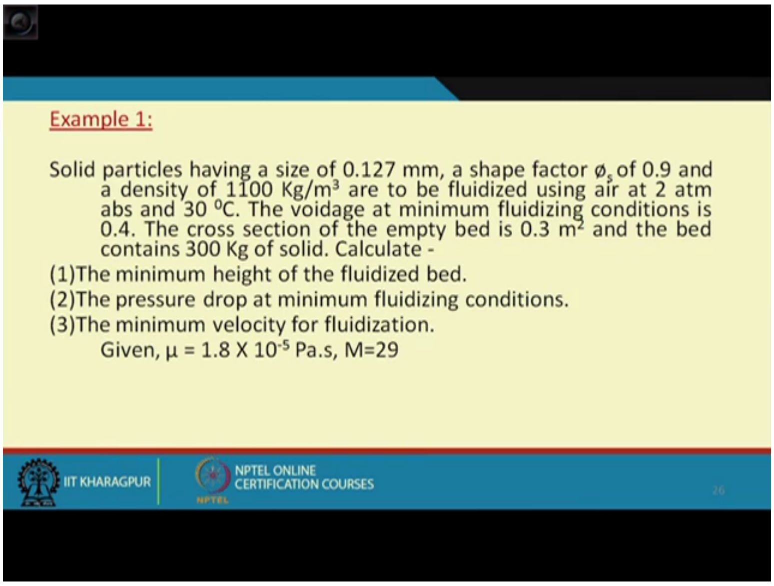

Now it is some problem for that, number 1 say a problem is like this, a solid particle having a size of 0.127 millimetre, a shape factor of Phi s of 0.9 and density of 1100 kg per meter cube are to be fluidised using air at 2 atmosphere absolute and 30 degree centigrade. The voidage at minimum fluidisation condition is 0.4. The cross-section of the empty bed is 0.3 meter square and the bed contains 300kg of solid. Calculate; number 1 the minimum height of the fluidised bed, number 2 the pressure drop at minimum fluidising conditions, number 3 the maximum velocity for fluidisation given viscosity of the fluid is 1.8 10 to the – 5 pascal seconds and molecular weight of the medium is 29 that is the fluid having molecular weight of 29 kg per kg mole.

So if we if we reread if read once again it looks like this the problem, a solid particle having a size of 0.127 millimetre, shape factor of Phi s of 0.9, density of 1100kg per meter cube are to be fluidised using air at 2 atmosphere absolute and 30 degree centigrade. The voidage at minimum fluidisation condition is 0.4. The cross-section of the empty bed is 0.3 meter square and the bed contains 300kg of solid. Calculate; number 1 the minimum height of the fluidised bed, number 2 the pressure drop at minimum fluidising conditions, number 3 the maximum velocity for fluidisation given viscosity of the fluid is 1.8 10 to the – 5 pascal seconds, molecular weight 29 kg per kg mole.

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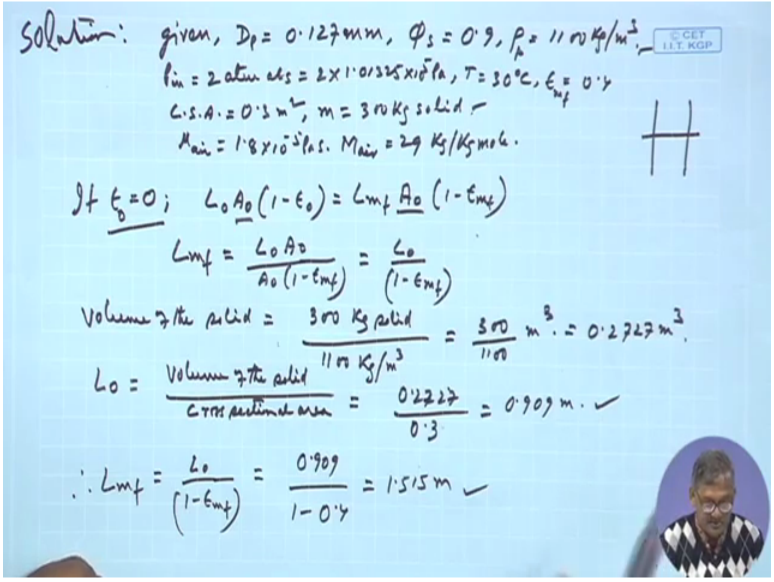

So if we solve it , it looks like this that given from the condition given are particle having size or D p = 0.127 millimetre, shape better Phi s = 0.9, density Rho = Rho particles = 1100kg per meter cube, pressure P 1 or inlet = 2 atmosphere, absolute = 2 into 1.01325 10 to the power 5 pascal, then temperature T = 30 degree centigrade then Epsilon = Epsilon mf = 0.4, cross-sectional area = 0.3 meter square and bed contains 300kg of solid that is w or m whatever we call, m = 300 kg solid. Apart from that we are also given Mu of the air that is fluid = 1.8 10 to the power – 5 pascal seconds and molecular weight of air = 29kg per kg mole, this is what we have been given.

Now, for solving it let us take this way that if Epsilon would have been 0 that is there is no void, earlier also we had done the same thing that we can use a mass, density, area of the bed to obtain the height of the bed in complete packed bed condition. So if Epsilon would have been 0 then we can write L 0 A 0 into 1 – Epsilon 0, this is equal to L mf A 0 into 1 – Epsilon mf because we said uniform cross-section earlier also that there is no change in the cross-sectional area because as long as this is fixed, our sectional area also remains same. So if that be true, we can say that L mf = L 0 A 0 by A 0 into 1 – Epsilon mf if Epsilon 0 is 0, we had taken Epsilon 0 as 0. So if that be true then we can write this is nothing but L 0 by 1 – Epsilon mf.

Now volume of the solid this is equal to we have been given that mass is300 kg of solid by the density Rho of the solid which is given 1100 kg per meter cube. So this means 300 by 1100 meter cube. And yes let us look into how much it comes 300, 1100, let us take that calculator 0.2727 meter cube. So if volume of this is so much then L 0 that will be equal to volume of the solid divided by cross-sectional area, so this is equal to volume has become 0.2727 divided by 1100 sorry divided by cross-sectional area, cross-sectional area has been given 0.3 so this we can that 0.2727 if we take this way 0.2727 divided by 0.3 = 0.909.

So 0.909 meter is L 0 therefore, L mf this now becomes equal to L 0 by 1 – Epsilon mf and 1 – Epsilon mf L 0 is 0.909, 1 – Epsilon mf is given 0.4 = 0.909 divided by 1 – 0.4 that is 0.6 so 1.515 so minimum fluidised bed height, height of the bed under minimum fluidised bed condition minimum fluidisation condition is 1.515 meter whereas, the bed has packed only solid is 0.909. So as we have been asked, this is the first one which we can say, we have been asked that what is the minimum height of the fluidised bed, minimum height of the fluidised bed that has become, then it is the pressure drop at minimum fluidising condition, so let us go and see what is the pressure drop.

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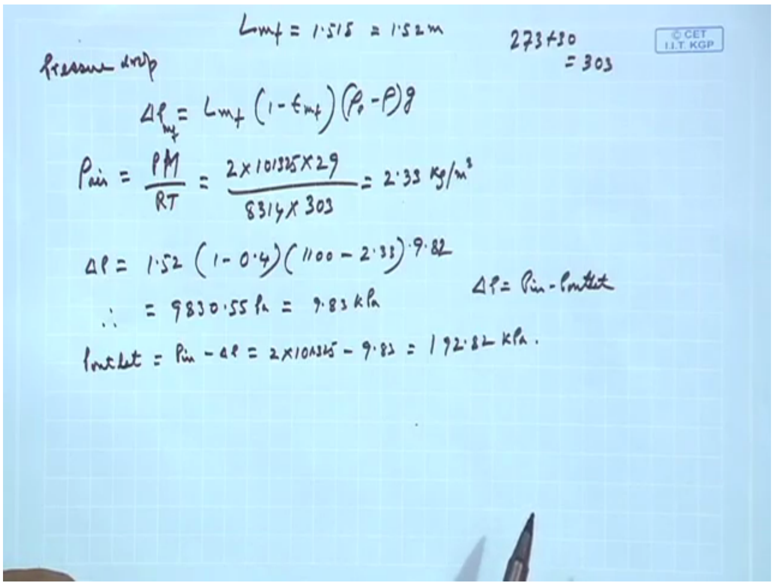

So pressure drop so 1.515 was L mf was 1.515, so roughly you can take 1.52 meter. So now pressure drop under fluidised condition this Delta P mf can be written as L mf into 1 – Epsilon mf into Rho p – Rho into g, now we have been given if you remember in the previous sheet we had seen Rho p was given but Rho of air is not given, so since temperature is given we can say Rho of air that is equal to P M by R T, so P is 2 into 101325 into M given 29 divided by 8314 into 30 degree centigrade means 273 + 30 that means 303, so 303 this becomes equals to let us look into this 2 into 101325 into 29 is equal to this divided by 8314 divided by 303 = 2.3328 so we can say roughly 2.33kg per meter cube.

So once we know Rho, then we can write that Delta p = L mf was 1.52 into 1 – Epsilon mf was 0.4 and Rho p was 1100 – 2.33 into 9.81 or 82 in many cases we use. Therefore, this becomes equal to let us see how much, 1.52 into 1 – 0.4 is equal to this into 1100 – 2.33 into 9.82= 9830.55 pascal, so this means this is equal to 9.83 kilo pascal 9.83 kilopascal is Delta p therefore, P inlet is so much, what is the P outlet? P outlet is Delta P, Delta P = P inlet – P outlet so P outlet is P inlet – Delta P, so P outlet is P inlet – Delta P, P inlet is 2 into 0.01325 or 101325 okay and this we can write 101.325 if we say kilopascal – 9.83 = 2 into 101.325 = this – 9.83 = 192.82 kilopascal, so we have found out what is the pressure drop and what is the minimum fluidisation height.

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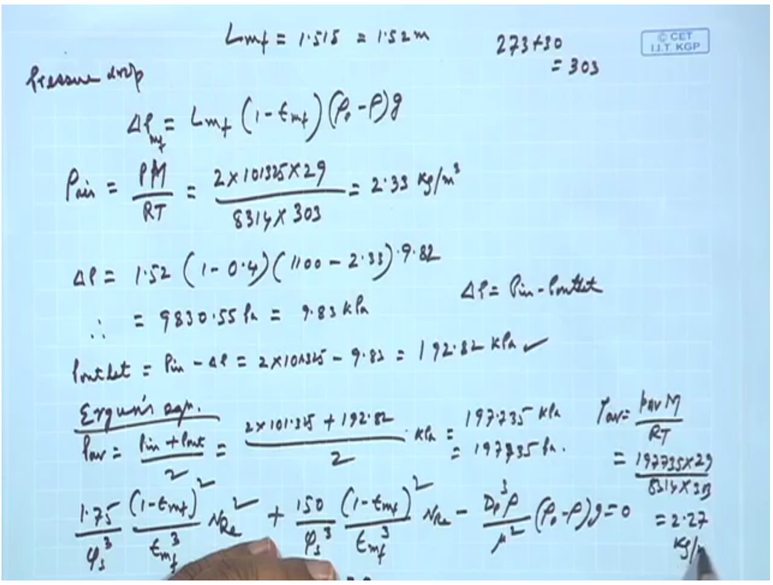

Third one is what we need to find out the velocity, so for that velocity we can use that Ergun's equation modified or new form of Ergun's equation as we have done earlier. We can write from here that now since we know P 2 Delta P was 9.82 kilopascal and P 2 is 200 12 point so much pascal, Delta P is 9.82 kilopascal so P 1 was P inlet was 2 into 101.325 okay – 9.83 so it is P in – P out okay so P out is P in – Delta P. P in is this – that 192.82 so how come it is, yeah 2 into how come it is Delta P in – P out that is P out is P in – Delta P yes it is okay.

Now for that what we need? Average P, P average = P in + P out divided by 2 = P in was 2 into 101.325 + 192.82 over 2 so much kilo pascal so let us see how much it is, 192.82 + 2 into 101.325 so this is to this divided by 2, 197.735 so much kilo pascal = 197735 pascal that is P average. So we use that modified Ergun's equation then we can write that 1.75 by Phi s cube into 1 – Epsilon mf square by Epsilon mf cube N Re square we said it is a quadratic equation + 150 divided by Phi s cube into 1 – Epsilon mf square over Epsilon mf cube N Re – D p cube Rho by Mu square into Rho p – Rho into g this is equal to 0. So we can say A N Re square + B N Re + or – C = 0, then come what is A and what is B.

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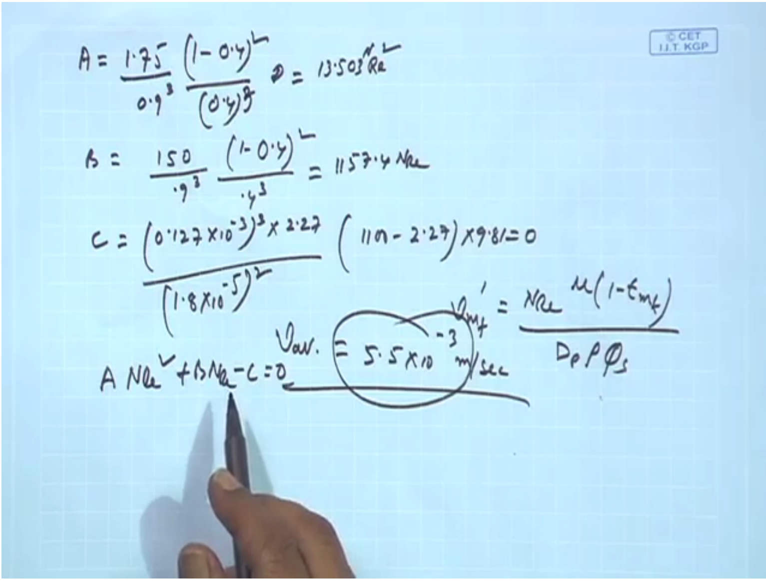

So A becomes equals to 1.75, Phi s given was if I see properly Phi s 0.9, Phi s given was 0.9 then 1 – Epsilon was 0.4 square divided by 0.4 square and this is what and this is equal to let us see how much it is, 1.75 divided by 0.9 cube into 1 – 0.4 square divided by 0.4 cube not square, Phi s cube Epsilon mf cube so that is 0.4 cube = 13.503 N Re square. B is 150 divided by Phi s 0.9 cube into 1 – Epsilon mf is 0.4 square divided by 0.4 cube so much energy and this is equal to 150 divided by 0.9 cube is equal to so much into 1 – 0.4 square = so much divided by 0.4 cube = 1157.4 N Re.

And C = D p particle size was given 0.127 millimetre particle size given was 0.127 millimetre. So 0.127 millimetre into 10 to the power – 3 whole cube Rho, Rho in this case it was we found to be equal to Rho average last we got average Rho is P average, so when we got P average we can also write Rho average = P average into M by R T = P average is 197735 into 29 by 8314 into 303 so Rho average came out to be 197735 into 29 into 29 divided by 8314 divided by 303, 2.27 kg per meter cube.

So from there we got that yes C is this so that was into Rho 2.27 divided by Mu, Mu given was Mu given 1.8 10 to the power – 5 Mu square into Rho P – Rho 1100 - 2.27 into 9.81 = 0, so what we get? We get a quadratic and from there we get the value of V and V will come somewhere V average from that N Re if we define N Re to be like this V mf prime is N Re into Mu 1 – Epsilon mf by D p into Rho into Phi s, so from there by calculation we get 5.5 10 to the power – 3 meter per second from where this value.

So if you try because we are not having any more time, time constraint is there, so if you try hopefully you will get somewhere this value 5.5 10 to the – 3 meter per second velocity using because from here this becomes N Re square A + B N Re – C = 0. So our quadratic equation by solving it we get N Re value and from that N Re value we can get the value of V using this relation okay thank you.