Momentum Transfer in Process Engineering
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Module 11
Lecture No 53
Fluidized bed flow

So we have seen that what is the minimum fluidised velocity or the condition at which the particles start moving corresponding to that velocity which is the minimum fluidisation velocity and the height is the minimum fluidisation velocity condition height and velocity is already said and of course before the fluidisation starts, the packing was compact, now when the fluidisation has started packing will be little if it was closed pack, now it will be little loose packed and that that void corresponding to that is called minimum fluidisation void, void under minimum fluidisation condition. So let us now find out what is the height, what is the velocity all this let us now find out okay.

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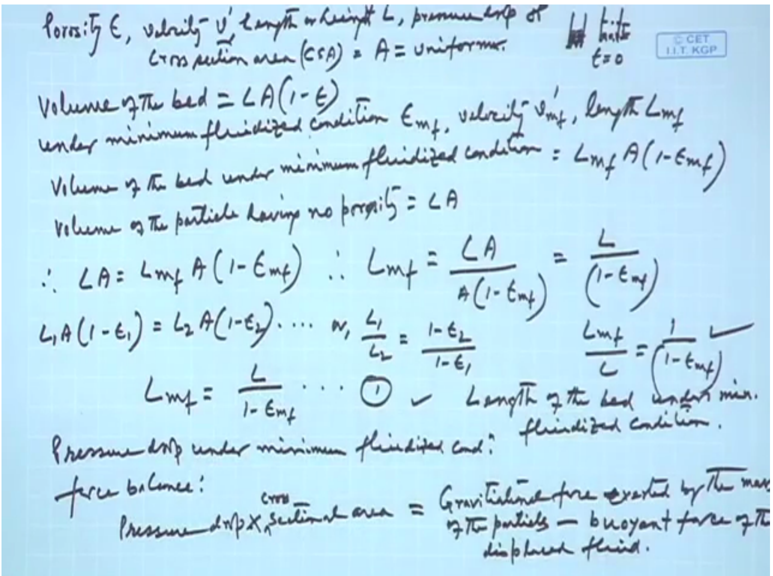

So let us see that what it is it, it is that we can determine this length and height of this. Now I will say that before onset of fluidisation if the porosity is Epsilon, velocity is V prime and the length is length or height whatever we call, this corresponding to the this we said and here we had particles were like this so this was the height or L whatever we call. Normally in most of the books it is said L, can also use nomenclature as H it does not matter as long as defined. Length or height that L and Epsilon V prime and pressure drop Delta P, so this is before onset of fluidisation.

Now the cross-sectional area of this is CSA is equal to A and which is uniform. And we can say the volume of the bed we can say that volume of the bed that is equal to L into A into 1 – Epsilon, if Epsilon is void the remaining solid is 1 – Epsilon so area is uniform so A, L is the height so volume is that L A into 1 – Epsilon. Now this under minimum fluidised condition this under minimum fluidised condition if we say corresponding to Epsilon it is Epsilon mf, velocity is V mf prime, length is L mf, area remains same area of the particle. In that case we can say that the volume of the bed under minimum fluidised condition, this can be said equals to L mf into A into 1 – Epsilon mf.

Now if we assume that there is no porosity, so here we have that containers and the particles are like that it is highly compact, no porosity Epsilon is 0 then it becomes the full solid particle. In that case we can say the volume of the particle then you can say that volume of the particle having no porosity that should be equals to L into A, A is the cross-sectional area and L is the bed height so that is the volume of the particles which is containing in that container. So then we can say that this L into A volume of the particle that must be equals to L mf times A times 1 – Epsilon mf because same particle is there, this is the height under fluidised condition, particle sectional area remains same.

Epsilon mf got changed, earlier here it was 0 and now it is new Epsilon mf, so the particles remaining is 1 – Epsilon mf into A into mf that is equal to L A. Therefore, we can write L mf that must be equal to L times A over A times 1 – Epsilon mf, so this we can say is nothing but L over 1 – Epsilon mf. So we can easily then that L 1 A 1 – Epsilon 1 must be equal to L 2 A 1 – Epsilon 2 etc etc dot dot dot. That means we can say that L 1 over L 2 = 1 – Epsilon 2 by 1 – Epsilon 1, same is true here that is L mf over L = 1 over 1 – Epsilon mf, here it was no Epsilon no void so there is 1 by this.

So this he can say what is the minimum height when we have got minimum fluidisation or we have got fluidisation that height corresponding to the bed height is the minimum fluidised bed height, or height of the bed under minimum fluidisation condition height of the bed under minimum fluidisation condition that is L mf. So L mf we can find out if we know the L that is original height of the particles when there is no void and in that condition we have seen that the relation between the void as on the fluidised condition and the initial length or height of the bed that is written as L mf over L mf over L = 1 over 1 – Epsilon mf, where Epsilon mf is the void under minimum fluidised condition. So what we can write is that L mf is L over 1 – Epsilon mf say we note it to be 1.

Next comes this is the length of the bed under minimum fluidised condition, so we can write length of the bed under minimum fluidised condition L mf. So next comes what is the pressure under fluidised condition, so pressure drop under minimum fluidised condition what is that. Now in that case we have to do the force obtained from the pressure drop times sectional area must be equal to the gravitational force as we have said extended by the mass of the particles that – the Buoyancy force of the displaced fluid.

So if we say that if we do the force balance by doing force balance we can write that the pressure drop times sectional area it is a cross-sectional area okay, let us also write cross-sectional area, this must be equals to the ohh gravitational force exerted by the mass of the particles by the mass of the particles by the mass of the particles. And we can also say this – the Buoyancy force of the displaced fluid.

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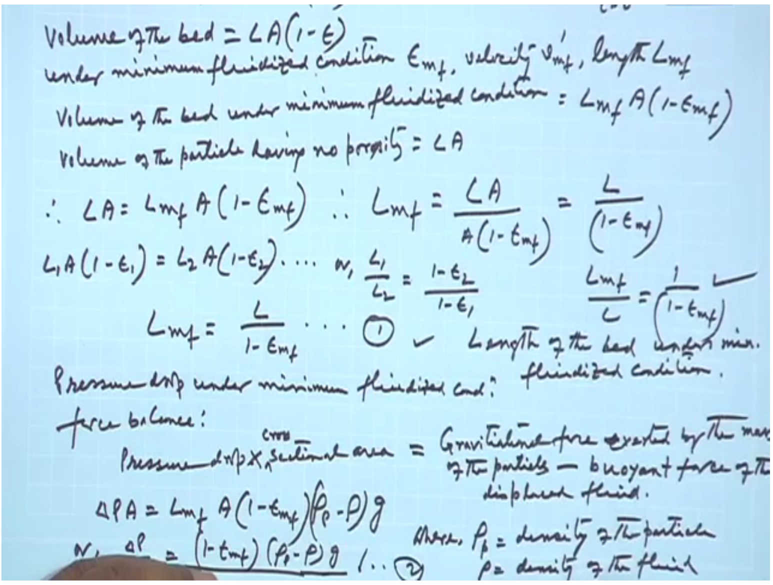

So this if we write mathematically we can write Delta P A that is equal to L mf A into 1 – Epsilon mf times Rho times P – Rho into g, where Rho P = density of the particle and Rho = density of the gas or fluid. So we got that Delta P A = L mf A into 1 – Epsilon mf into Rho P – Rho into g, this is equal to we can write that Delta P over L mf this is equal to 1 – Epsilon mf by or 1 – Epsilon mf into Rho P – Rho this into g Delta P by L mf is A A goes out uniform cross-sectional area, so Delta P by L mf = 1 – Epsilon mf into Rho P – Rho into g, so this we say to be equation 2.

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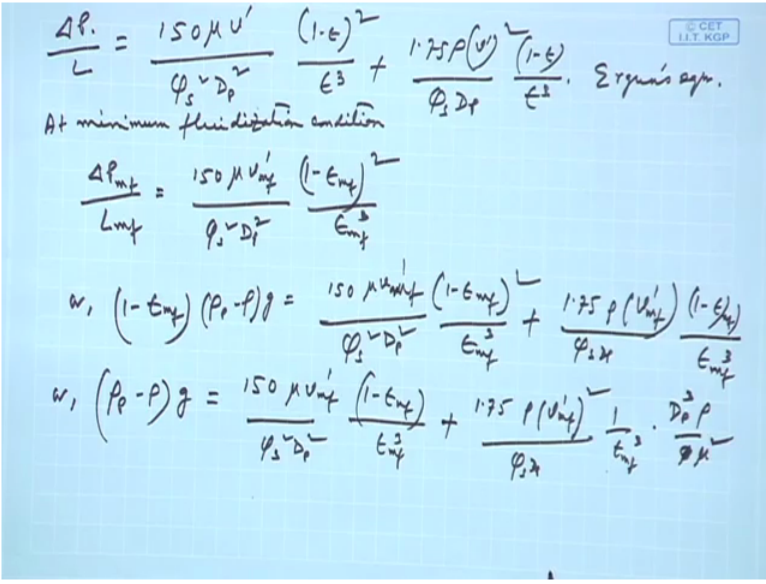

Now we can write Ergun’s equation as Delta P by L that is equal to 150 Mu V prime over Phi s square D p square into 1 – Epsilon whole square over Epsilon cube + 1.75 Rho V prime square over Phi s D p into 1 – Epsilon over Epsilon cube this is the Ergun’s equation. So if this is the Ergun’s equation so at minimum fluidisation condition we can say that minimum fluidisation condition we can say that this Ergun’s equation we can rewrite as Delta P mf also at minimum fluidised condition over L mf, this is equal to 150 Mu V prime mf divided by Phi s square into D p square because particle size will not change because we said uniform cross-sectional area into 1 – Epsilon mf whole square by Epsilon mf cube.

So this we can rearrange as 1 – Epsilon mf times Rho P – Rho into g this must be equal to 150 Rho sorry V mf prime over Phi s square into D p square whole into 1 – Epsilon mf square over Epsilon mf cube just rewriting that, this + 1.75 Rho V mf prime over Phi s D p into 1 – Epsilon over Epsilon mf cube, so 1.75 into Rho V mf prime by Phi s D p into 1 – Epsilon mf over Epsilon mf cube, so this is the Ergun’s equation as required by you, in this case we have said that so 1 – Epsilon mf Rho P – Rho into g this is that Ergun’s equation okay fine.

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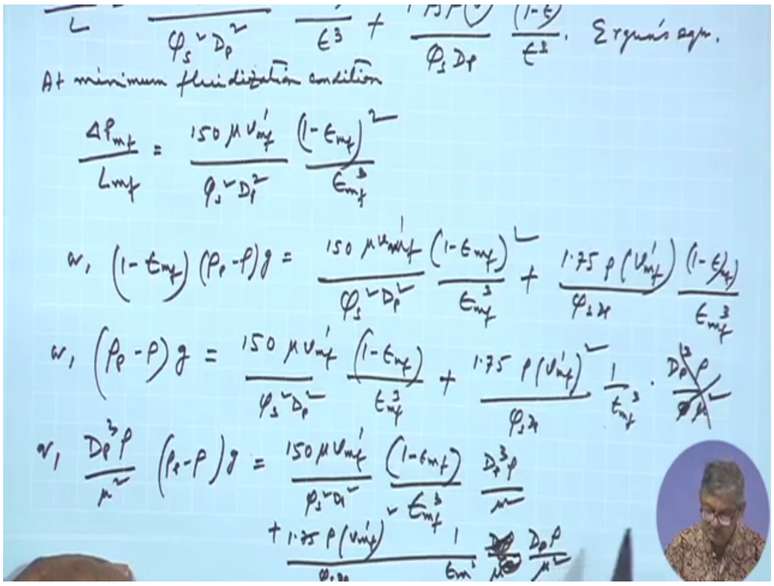

So if this is true then we can also write Rho P – Rho into g this is equal to 150 Mu V mf prime over Phi s square D p square into 1 – Epsilon mf over Epsilon mf cube + 1.75 into Rho V mf prime square by Phi s D p into 1 by Epsilon cube times D p D p cube Rho by Mu square so this is what was D p Rho by Mu square D p cube Rho by not Epsilon mf okay this is true but D p cube Rho Rho P – Rho into g = 150 Rho V prime mf by Phi s square D p square 1 – Epsilon mf by Epsilon mf cube + 1.75 Rho V mf prime square by Phi s D p multiplied by 1 by Epsilon mf cube multiplied by 1 by Epsilon cube so this is no more required.

So now we can rewrite our D p cube multiplied all along Mu square Rho P – Rho into g this is equals to 150 Mu V mf prime divided by Phi s square D p square into 1 – Epsilon mf 150 Mu V mf prime Phi s square D p square 1 – Epsilon mf by Epsilon mf cube, we multiply both the sides with this D p cube Rho by Mu square + 1.75 Rho V mf prime square divided by Phi s D p + 1 by Epsilon mf cube into D p D p Rho by Mu square.

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If this is the Ergun's rearranged condition, we can further rewrite that D p cube Rho by Mu square into Rho P – Rho into g this is equal to 150 by Phi s cube into 1 – Epsilon mf whole square by Epsilon mf cube into Phi s D p V mf prime into Rho, this divided by Phi cube is where, (())(27:38) there, so Mu 1 – Epsilon mf this + 1.75 over Phi s cube into 1 – Epsilon mf square over Epsilon mf cube into Phi s D p V prime mf, so Phi s D p V prime mf into Rho divided by Mu into 1 – Epsilon mf. So this on rearrangement we can write 1.75 by Phi s square into 1 – Epsilon mf square over Epsilon mf cube N Re square + 150 by Phi s cube into 1 – Epsilon mf square divided by Epsilon this 150 by Phi s cube 1 – Epsilon mf by Epsilon mf cube N Re.

This – D p cube Rho by Mu square into Rho P – Rho into g this is equal to 0. So we have found out that the relation using Ergun's equation with N Re is a quadratic equation N Re square N Re and the (())(30:45) so B square – 4 A C + – 4 A C + C square so this we can V square – 4 A B + A square this we can use + – B that finding out fluidise solution and get the correct value okay thank you.