Fluid Mechanics

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Lecture - 35
Applications of settling - II

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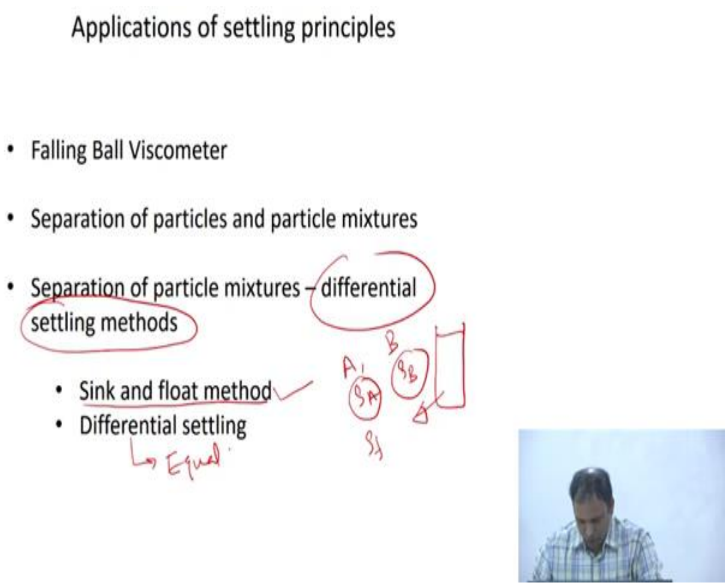

Now, there are techniques where you kind of exploit a concept called differential settling ok. And this concept of differential settling is typically used when you have mixture of particles of different sizes and different densities ok. So, now, in a method called sink and float method, what you do is somebody gives you a powder mixture and it has say particles of you know type A and type B. And say the density of the particle is rho A and density of the particle is rho B ok.

Now, what I can do is, I can put them in a column with a fluid. And if the density of the fluid that you are using ok, if it is in between the density of the two particle that you have in the mixture, what will happen is one of the particles would sink and the other would float right. So, that is why you know hence this name the sink and float method ok. So, in the sink and float method what you have is a mixture of particles of different densities and a use of fluid column whose density is in between the density of the two particle that you are considering, and then you basically separate it out ok, that is what is done in here ok.

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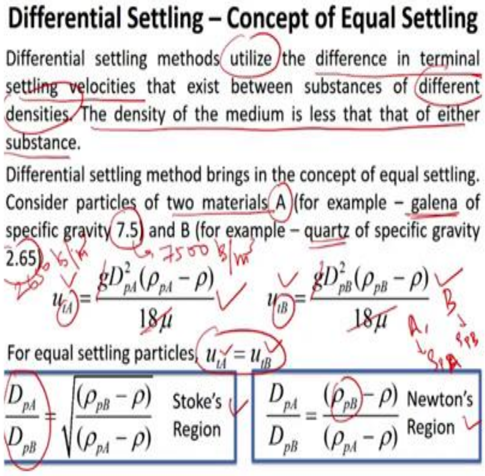

And there is a concept called equal settling that is what we are going to do in the ok. Now, so in the differential settling what you do is again you have a mixture of two particles ok, maybe again you know like say let me just ok. Again you have particles A and B ok, and the density of the particle you know as it is written here is rho of particle B, sorry particle A here ok and this is the rho of particle B right. Now, what is done in you know the equal settling concept is there you know you basically use the fact that there is a difference in the terminal settling velocities between the particles of different densities ok.

I am just going to. So, what you do is we know that you know this is a the settling velocity for Stoke's regime right and this is the settling velocity for again Stoke's regime, but again for the particles of type B here right, this is for type A, this is for type B. Now, if I say that the settling velocities of you know type A and type B are the same ok, what I do is I can get a ratio of the particle diameters right ok.

What I do is rho tA is equal to rho tB right, the density of the fluid is the same that gets cancelled right, sorry your viscosity the same, your g gets cancelled. So, basically because of the fact that this and this is the same, I can actually get an expression for the ratio of the diameters as the ratio of the density differences right that is for the Stoke's regime. And this is for the Newton's regime right. Any question? It is a simple fact you know what I have done is, I basically equated the settling velocities right.

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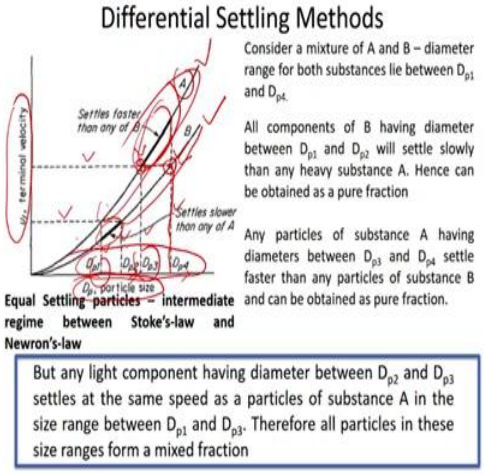

Now.

How this works you can kind of understand you know from a you know from a diagram ok, from a schematic. What you have here is this is the terminal velocity ok and this is the particle size ok. Now, on the y-axis sorry on the x-axis, you know there are these vertical lines right, these vertical lines here right. So, what you have is, you have a mixture of particles whose size varies from D p 1 to D p 4 ok. I have two particles of type A and type B and the size range of the particle in the mixture is the same that goes from D p 1 to D p 4 ok.

Now, there is an horizontal line that is drawn here ok. And this horizontal line and this horizontal line, it corresponds to the equal settling right, because you know I am just drawing a. So, this one the plot and that A is for the is how the terminal velocity, after type A particle varies as a function of size. This is a plot for how the terminal velocity varies as a function of particle size for B type of particle right.

Now, what can I say about the size range from D p 1 to D p 2 of B type of particle. Just by looking at this plot, what can I say about the settling velocities of the particle size range from D p 1 to D p 2 for type B particles? Can I say that the type B type of particle in the size range from D p 1 to D p 2 settle, you know the slowest right, because any particle of type B from D p 2 onwards settles faster right and all the particles of type A from D p 1 all the way up to D p 4 settle faster, therefore, the size range of B from D p 1 to D p 2 that it settles slower than any particle of A type plus all the particles of B going from D p 2 to D p 4 right. Everyone agrees with that?

So, therefore, I can actually what I can do is, I can I have a column ok, which is filled with a fluid. I introduce; I introduce all the particles you know at the surface of the you know the fluid column ok. And because I know that D p 1 to D p 2 of type B settles the look slowest ok, I can wait for the particles to settle for sufficiently long time. So, there you know all the particles of type B from D p 2 to D p 4 settle and all the particles of type A from D p 1 to D p 4 settle, therefore, what you have in the fluid would, be what do you have in the fluid that will be suspended would be only the particles of type B from D p 1 to D p 2 that is because they settle the slowest right, right.

So, what can I say about this size? So, now, this is the if I go vertically that is the maximum settling velocity of or that is the settling velocity of the largest size B type right, settling velocity of the largest size B type is this. If I move vertically sorry horizontally here, D p 3 D p 3 of type A, D p 3 of type way type A will have the same settling velocity as D p 4 of type B. Therefore, the size range from D p 3 to D p 4, the size range from D p 3 to D p 4 will settle the fastest right.

So, therefore, if I do experiments for a relatively short period of time ok, I again I have a column, I introduce the particles of the surface of the fluid ok, if I withdraw the fluid ok, so if I withdraw the particle from the sediment after an appropriate time, all the particles of type A from D p 3 to D p 4 would have settled to the bottom. And what you would have in the fluid would be all the particles of B from D p 1 to D p 4 and all the particles of A from D p 1 to D p 3 right, they will continue to remain in the fluid ok. So, therefore, what people do is people exploit this thing called differential settling, basically to separate out mixture of particles into different sizes ok.

And one thing I did not mention is that in this case the density of the medium should be less than the that of either of the substances right. In the case of sink and float method, the density of the fluid is in between the density of the two particles right, that is where that is why one would sink and the other one would float. In this case because you want both of the both the particle to settle and that will have happen only if the density of the fluid is less than the density of the two particle mixtures right.

What is that?

Any answer for this question. So, why are we not using sink and float method for this, why are we think about you know equal settling concept? Why should we look for the density which is smaller than the density of the two particles that I have in this system? Any thought?

That is one possible explanation. So, what are you saying is there you know in the sink and float method, I would have to use particles of a fluid whose density is in between the two particles right. However, if the density difference between the two particles itself is not too huge ok, then you know you may have difficulties or challenges in terms of you know finding out a fluid whose density is between the two ok.

But the more I think it is because of the practical difficulties ok, maybe there is an example here. So, say that you know I have a two particles, say A there is a something like the galena which is one of the ores of you know one of the material ok, whose specific gravity is 7.5 ok, that means, you know the density is 7500 kg per meter cube right. Let us look at quartz, it has a specific gravity of 2.65 ok, 2650 kg per meter cube is a density.

Now, you look at any fluid let us say water density is 1000 ok. Now, go back and take a look at you know the list of fluids and the density it will be very difficult to really have a density which is you know more than 2.65 ok. Of course, there are ways by which I can actually manipulate the density of the fluid. What people do is I have like say water I introduce salt ok. Depending upon the density of the salt that I am dissolving if I say you know like say I take NaCl right sodium chloride ok and I dissolve in water. What will happen to its density, it will go up right, you know if the density of the salt that I am putting in if it is larger than if it forms a homogeneous solution, the density will definitely go up ok. There are ways by which I can manipulate the density of the fluid.

But however for cases where the density of the particles are much larger than you know like say 1000 kg per meter cube right, so it will be difficult to really find a fluid whose density is in between the density of the two fluids ok. Therefore, people do exploit this differential settling where the density of the fluid that you are using is less than the density of the two particles of you are considering the mixture ok.

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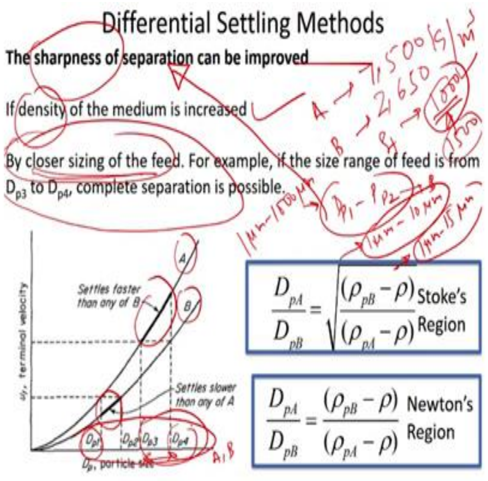

So, now, there is something called as a sharpness of separation ok. What I mean by that is how given a mixture of particles of different sizes and different you know densities, how cleanly can I separate out the particles into pure fractions ok. What I mean by that is in the previous example, say you know I have a particle size going from D p 1 to D p 4 ok.

Now, I take this mixture this has you know type A, type B, all the sizes from D p 1 to D p 4, if I am able to separate them into pure A and pure B ok, then my sharpness of separation is kind of one right. You know I am able to separate them into two pure fractions of different you know population of particle right.

Now, it turns out that you know the sharpness of separation can be improved if the density of the medium that I am using is increased ok. So, what I mean by that is in the previous example see you had a specific gravity 2 and 2.65 ok. If I use a fluid of you know say I am just going to mostly make it as that is your density of the particle A and particle B. If the density of the fluid that I am using is say 1000, then you will get a certain fraction like say maybe D p 1 to say D p 2 as a pure fraction.

Now, if I increase the density of the fluid ok, just to give numbers, let us say you are separating particles from 1 micrometer to say 10 micrometer of B into pure fraction ok, if I am using a density of that fluid which is 1000. If I make it 1500, it turns out that I can actually increase the size range ok, I can maybe go from 1 micrometer to say 15 micrometer ok, because I am able to get a larger size range into a pure fraction ok. It is a equivalent of saying you know I basically increase the there is a sharp, the sharpness of separation is actually increased ok.

So, one of the ways of you know increasing the sharpness of separation is by using a medium whose density is by increasing the density of the medium in which you know which you are using. The other way of doing this would be that you know if I have a way of choosing a size range which is closer ok, what I mean by that is let us take this example ok. I have explained that you know I have by considering the fact that you know D p 1 to D p 4 is a size range that exists between you know that is for the particle A and B, I talked about the fact that you know this settles the you know slowest and this settles the fastest right.

For simplicity, let us say that you know I only have size range from D p 3 to D p 4 ok. What I have done this, now I have done a closer spacing right, earlier I had sizing going from D p 1 to D p 4. Now, I have a mixture whose size range goes only from D p 3 to D p 4. If that is the case, I know that the size range D p 3 to D p 4 of A settles the fastest, that means, I can actually separate out all the particles of A into pure fraction. And the fact that you know thus again the same sizing D p 3 to D p 4 of B settles the slowest I can also separate that into you know pure fraction right.

So, therefore, there are two ways of increasing the sharpness of separation one is you use a fluid of a higher density or by increasing the density of the fluid. Or other one is if you consider closer sizing of the feed instead of taking a size range going from D p 1 to D p 4, you reduce the size range ok, either going from D p 2 to D p 4, or D p 3 to D p 4 if you do reduce that you know if you have a closer spacing in the size you know that again give you a another way of you know complete separation of the particle.

Ok.

Correct.

So, why would you say that or it will have some of A.

That you would have to work it out ok. Let me make another point which I did not make it. So, in this differential settling method ok, you can get a pure fraction of A and pure fraction of B ok and a mixture of A and B right that is what is a typical case. If you when

I talked about you know the sizing going from D p 1 to D p 4, we saw that you know D p 1 to D p 2 of B was coming as pure fraction and D p 3 to D p 4 of A was you know coming as pure fraction and in between it was a mixed fraction ok.

However, if you took this example of closer spacing D p 3 to D p 4 both A and B was coming as pure fraction right. Now, when you say that you know so the point that you want to make you know you are saying that, so it turns out that the when you use a density, so say there you know my size range is fixed ok, say that you know I have a size from 1 micrometer to 1000 micrometer that is the sizing that I am considering ok. So, both the pure fraction that you get of A or B are kind of slightly expanded if you use ok.

We are going to have a you know tutorial question, you know in the next class, wherein you are going to look at this example, where we will see that you know if you use a density like say 1000 kg per meter cube, you will look at you know what are the sizing that comes up your fraction ok. Now, if you work with the fluid of higher density, you will see that you know there is an expansion or the you get an expanded size range both in the A type as well as B type.

And of course, mix fraction anyway is going to be there for both the fractions, you know unless you know you are actually at a particular you know kind of a fraction where you know either you are working with a narrow size range or a part you know particle of a particular fluid of a particular density ok. You will see that maybe in the next class.

So, the mixed fraction, that means, the mixture of sizes are going to be there in both the cases whether you use a fluid of a particular density or a higher density, only thing that is going to be changing is the size range of the pure A and pure B that you are going to get you know by enhancing the density ok. Any more questions, anything that you want me to repeat a few things ok?

So, today's class we have kind of looked at applications of what we have learned right both in terms of you know exploiting this in terms of doing some fundamental measurements in terms of measuring viscosities by exploiting you know the settling principles. We also looked at some applications where the settling principles are used in diagnosis plus we also looked at a couple of examples where people use this motion of the fluid you know particle in a fluid concept or the settling principles to separate out particles you know if you have a mixture of particles of different sizes and different densities ok.

We talked about sink and float method and the differential settling method for separation of particles ok.

Maybe with that we will stop today. So, far we have when we looked at motion of particles in the fluid, we have always taken single particle right when you wrote this force balance, we took one particle and then we kind of identify the different forces, you know we need a force balance we got the working equation you know and then we got the expression for settling velocity right. But that is going to be the case if you are looking at like say falling ball viscometer as a method for measuring viscosity right.

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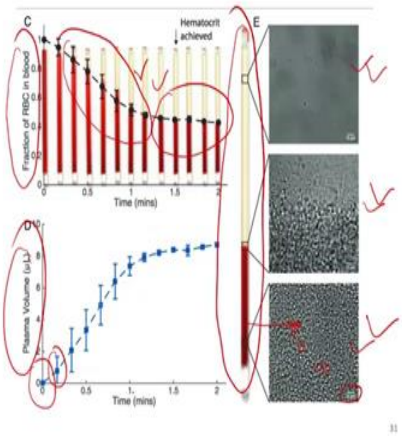

However, even if you go to this case right you know where you have a blood sample and you are really not dealing with one particle right. You know in this case you have a very thin capillary ok, you have a blood sample and you have large number of blood cells right. So, therefore, you want to talk about you know the collective behaviour now in the next class where in we are going to look at cases where you have more than one particles in a fluid you know and look at you know their settling behaviour in the next class ok. We will stop today and then we will meet up tomorrow here.

Thanks.