Chemical Engineering.
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Lecture-51.
Non-ideal Flow and Residence Time Distribution (RTD) Basics Parts II.

Professor: So now let us take packet bed 1st I think you know when I have this U plane, what is the kind of contacting pattern we have? I mean the distribution?

Student: (())(0:26).

Professor: Is there plugged flow? Then what is happening that, sea, these questions when I ask you, utter phenomena is required, it is not that easy to answer my questions, even though they are simple stupid questions. Once you have common sense, then I think it is very easy. What is happening on each plane?

Student: (())(0:46).

Professor: Exactly, overall plugged flow, each, each plate is a CST, okay, you have tanks in series. Overall you may have that, okay, so what is happening at each and every plate, I think you know the liquid will be bubbling, the gas should be bubbling through the liquid and after some time it will overflow, if there is a gear, that means you know, what is that, down comers, yah. Otherwise they will simply go through the series themselves. Okay, yah but on the whole, the amount of liquid that is retained on the, on the sieve will have some residence time, that is that, also there is perfect mixing between, mixing means you know all the bubbles are creating good mixing in the liquid.

Okay, now we are talking about only liquid or gas, for liquid only we said that, you know tanks in series, what about gas, gas, what is overall flow? Gas is starting from the bottom, bubbling through liquid or the bottom plates, and then again going through next plate, again bubbling through, plate, again bubbling through. So if you take only residence times will be different but if you sum up all the, the bubble times when it is coming out, that is equivalent almost PFR, plugged flow.

How many things are there just imagine, that is why I was telling you, instead of talking stupid things on this teacher is bad, that teacher is good, that teacher is lousy, good you will not tell normally. Okay, good normally no one will tell. So bad things only we will project in hostels and all that. So instead of doing all that, why do not you sit down as groups and they start questioning, quizzing yourself. Okay, that, really, then only you will know the subject. You just sit down, you know, all of you may be in one hostel or maybe 2-3 hostel, in that hostel, in that hostel whoever are there chemical engineers, you come together and then say that at least, okay, today is Saturday, Saturday anywhere will take the class, Sunday, Sunday morning, said a and then try to question yourself.

Okay, now I know there are different pumps, how do you choose them? Right, and particularly, MS, Ph.D. scholars also, I am not only talking about M tech scholars. MS Ph.D., you always talk about your guides. That is true, they do not have any other work because they do not realise also brain is there and the brain if at all something is there, then I think that they will sit down and then try to criticise their own brain. Always you know other, okay, I should not say that here I think. Yah, other people look very beautiful for us, right, I think that is why other guides for you will look beautiful.

Swami may be thinking that some other guide is beautiful, this guide is not beautiful. Okay, so like that you know, that other guide student will thing that he is a lousy fellow, the other guide is excellent. That is all you think, you are not thinking about the subject, you are thinking about the guide where there is no use of thinking about guide. You do not learn anything from that, by discussing about him. So that is the reason why, I think you have to start that kind of thing, we say MIT is great, you know why? Because people will not talk about people, people will talk about subjects, that is why.

But in India, every institution is lousy we say because before anything we talk about people 1st. That is all, I think you know nothing else, we always talk about people. You can just imagine now, you can just see what you have talked to till now, did you talk any subject to your friend, any time? If at all you would have asked whether, okay, next semester subjects are coming, which one is easiest to pass? That is what you would have asked, not what teacher said and what you learn. Correct no? Yah, how do I get that 7.5, if it is MS Ph.D., correct no, 7.5 is the border for you, that is all.

Which courses if you take, you will easily get 7.5. No? Swami? Correct no, I am telling the truth also, yah, correct M tech people may be telling that without doing any work how do you get maximum marks. Because they do not have that border but maximum is 10 out of 10. If there is possible to take courses with some teachers where you get 10 out of 10, everyone will go to that, that is all. So this is what is happening unfortunately, that is why absolutely there is no learning, absolutely there is no learning. Anyway, same old story, okay.

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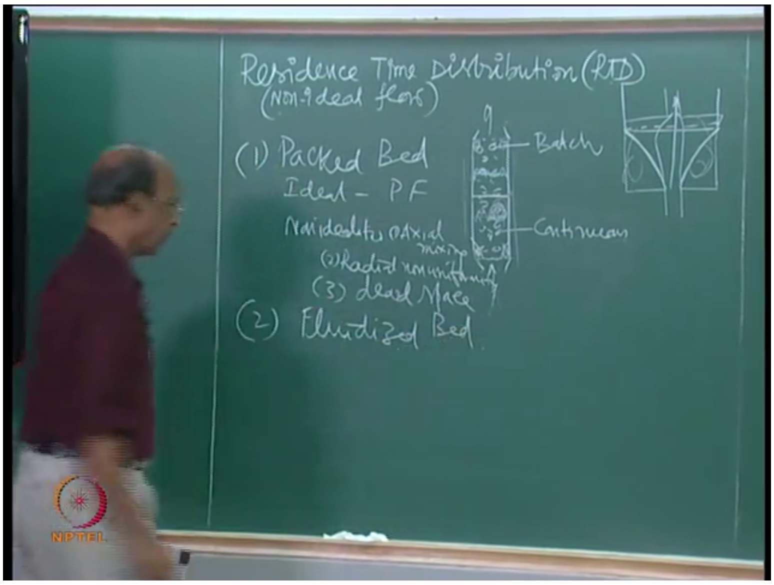

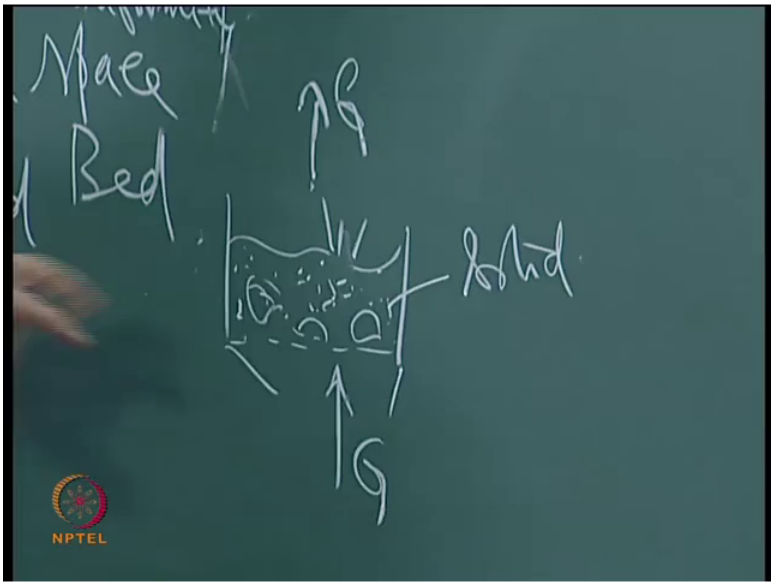

So now we will go to packet bed, we will take 1 or 2 columns and then just try to discuss, yah, in packet bed I know that we have this kind of bottom and top distributor, then you send gas maybe from the top or bottom. So these are the packings, this maybe catalyst, okay, that maybe catalyst. But ideally we expected that this maybe plugged flow because you can see the flat velocity profile and that is a requirement for our plugged flow. That means when you have flat velocity profile only, you will have each and every particle exactly spending same time.

But in reality, I think you know, this is only ideal case, when we imagine. In reality what kind of velocity profile you get in packet bed? Because all this information is required, all that is required. What kind of profile you get, actual profile in packet bed? I am sure none of you would have thought about that. Porwali any idea, what kind of profile a natural system you may get? Ideally we are assuming that it should be flat profile because my mathematics will be simple and, Rahul?

Student: Laminar.

Professor: Why laminar…?

Student: (())(6:39).

Professor: So you mean this kind of profile?

Student: Yes. Somewhat.

Professor: What will be turbulent with batch flow?

Student: Turbulent (())(6:52).

Professor: This one you are talking or something else? Yah, what is start-up? What else you draw you tell me. More, more you cannot.

Student: (())(7:12).

Professor: You know the actual profile in this will be like that. You know why? Now I gave the profile, at least you try to find out, find the reasons why should be like that. Particles are?

Student: Centre and… (())(7:41).

Professor: Near the wall. We have, you know the void will be slightly more than at the Centre. And that is worse when you have smaller and smaller diameter. If you take maybe 3 feet or maybe 1 meter or 1.5 metre, 2 metres, you may not see that kind of profile there. But in the normal columns you will see that. Right, so that is why we are now trying to flatten this and say that ideally we will have flat velocity profile. Right, that is one, that is, even that is ideal case but the true profile will be something again like this, fluctuation.

So that location will be our non-ideality, so the ideal profile for packet bed is, ideal is, ideal is PF, now tell me, non-ideality, because we have to identify needs and we call, okay, yah. 1st of all solid batch and the fluid which is going in, PF if it is ideal. Because I have liquid and, sorry, I think I have to write, what, 2 phase as, but instead of writing this, this is batch, this is continuous I will write.

In continuous if it is ideal plugged flow, then you have PF, right, okay, good, so this is the one. And now non-ideality, what are non-idealities we can expect here?

Student: (())(9:25).

Professor: I will be very fast if I write on my own without discussing.

Student: Channelling.

Professor: Where is channelling in packet bed? Because normally what is the height of the packet bed, L by D of the packet bed? D the diameter, L is the length, L by D, what will be L by D of normal packet beds? Manikattan maybe knowing in the industry.

Student: 20. 10.

Professor: So definitely more, okay, more than maybe 20, maybe 30, right. But you know when you have that kind of long columns, do you expect channels? I am just questioning, I am saying whether she is right or wrong,.

Student: Towards the sides. Near the entrance.

Professor: Yah, near the entrance. So the 1st one, 1 non-ideality is axial mixing, that you will agree. Axial mixing is one, right, why? Because we do not expect, we expect only flat velocity profile were generally you will have the particle moving back and forth because of the packing and also because of the turbulence. Okay, turbulence, please imagine, the turbulence is like this only, even in the normal turbulence does not mean that you know you have perfect mixing. That you have to separate it out, Merit, yah, right. So when you talk about turbulence, we are not talking about perfect mixing, we are talking about over the turbulence when you have the velocity profile, that will be shown only like this.

If there are slightly more turbulence, then you may have a little bit like that. Okay. But even then that is always under axial mixing. And what about the radial mixing? Is it perfect? Non-ideal packet bed? What do we expect in radial mixing? Radial mixing should be perfect, axial mixing must be 0, then you will get plugged flow, right. And the radial mixing also should be infinity but do you have infinite radial mix. That means infinite, it means that across that you will have same concentration and temperature but actually what it should be?

Because all packet beds, all chemical reactions, whether they are endothermic or exothermic, then you have to put a jacket outside, or some kind of heating or cooling mechanism inside the, inside generally we do not put in packet bed but that is also possible, we can also put that. Right, so imagine that I have the outside jacket, then it is exothermic reaction, you just have to imagine, then I have a coolant here. What will be the temperature profile inside? At any cross-section if I look, because heat transfer this taking place in this direction, exothermic heat inside the reactor, uniformly generating because of this profile.

But heat is removed and where do you have less temperature, where do you have more temperature?

Student: (())(12:27).

Professor: Yah, more temperature you will have near the, at the centre, less temperature there. That means there is a gradient in temperature, right. So particularly when I have gas phase reaction, do you have concentration gradient now?

Student: Yes.

Professor: How does that affect? CA equal to any point TA by RT. So when T is changing, concentration also changes, when concentration changes along the length, how can you assume that you plugged flow? Because plugged flow definition is across the cross-section you should have a perfect mixing. Perfect mixing means concentration must be uniform, that is why in fact the greatest problem with packet bed is not axial mixing, radial mixing. Radial nonuniformities will be there. What we expect is ideally there should be uniformity of concentration in the radial direction but that will not be there in most of the packet bed reactors.

Axial mixing actually is not a problem, okay. So that is why radial nonuniformity, radial nonuniformity, okay, so that is also a kind of non-ideality for us. Okay, then what are the other things? This is… Dead zone, where do you expect dead zones?

Student: Near the walls.

Professor: Near the walls we assume velocity equal to 0 but you cannot say that is dead zone.

Student: (())(14:05).

Professor: Yah, you see, when actually I put this kind of corn, if I do not, you have that kind of cone, if I have only flat, anyway, that is the distributor plate, otherwise it cannot enter. So here we expect some kind of dead zone. Similarly even here you may expect some kind of dead zones. So dead zones also, if you very badly designed, this is what is happening. Right, okay, that means very badly designed means I have a packet bed something like this, okay and then entry notch.

Also height, I do know L by D must be 50, 60 or 100, so then I put L by D equal to 1, I tried 1, so that means it will be very very lousy. Correct no, L by D, this D and L, both are same, so this will be something like this and again you are putting, this is one of the lousiest designs of the packet bed. Then what Sushmita is telling also we will compare, channelling. Because by the time it goes like this, and then again it has to come like this. So all these things are waste, dead, this is channelling. Why it is channelling? Because it is supposed to spread throughout and then come but instead of that, straightaway this coming because you have this much dead zone, this much dead zone.

In fact that is the reason why you put the same shape here, correct no. The same shape is here because this is how, if you are able to design this kind of packet bed, so then packing from here, then you will have the velocity entry at exactly plugged flow entry. I do not know in transport phenomena when you are assuming, you assume flat velocity profile entry into any equipment, otherwise that variation itself is a periodic one, that is an assumption. That is why next time when you are taking, this time next time you have, yah, next time when you are taking, please be observant for these assumptions.

Each assumption has a tremendous meaning to simplify the mathematics. Okay, yah, good. So, yah this is radial and also dead space and is packing is not properly put, then if, as you have some kind of more wide edges, there you may have even recirculation. That means it is a circulating and then going back and then again maybe going back, you know like turbulence okay, you know like eddies. But recirculation generally we do not expect but that is also a possibility. Okay, good. So this is the one, now, this is for, because solid is batch, we are happy, we are only talking about continuous phase and in general continuous, ideal should be plugged flow, liquid should be moving in the form, gas, can be moving, maybe moving in the form of plugged flow.

But if you do not have plugged flow, then what are the other non-idealities that are coming into picture. Non-idealities are radial mixing, which is not very serious but the radial mixing is much more serious, you are mathematically also solving that, it is slightly complicated than axial mixing. Then you have dead space, but dead space and all that can be easily, you know there are some things which you can tackle on your own, you can avoid dead space provided you design like this. So you do not have to worry about that space. But axial mixing and radial mixing you cannot already, definitely there will be some kind of axial mixing.

And radial mixing, definitely you also have because temperature gradient. Because of the temperature, you have to remove the heat but if you have adiabatic system, you may not have. If you have adiabatic packet bed, that the reason why for SO2 reaction and all that, you know SO2, they use adiabatic packet bed. Even though it is exothermic reaction. But where do you cool, 1 bed, heat exchanger, another bed, heat exchanger, another bed, heat exchanger, there the packet bed will be almost ideal plugged flow, if you make it again sufficient L by D.

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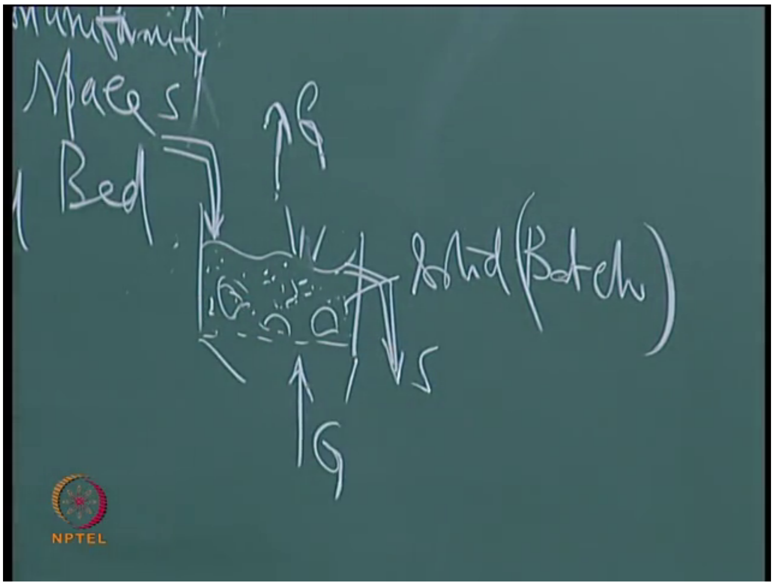

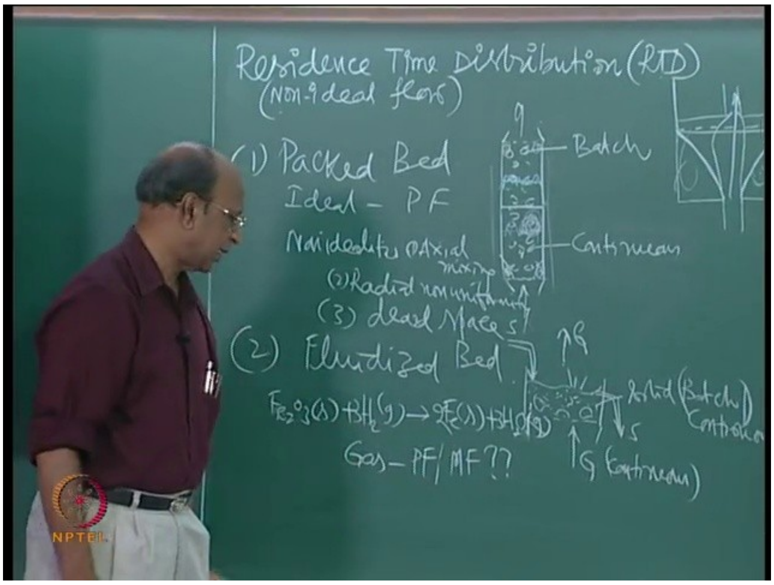

So for everything again there is beautiful explanation, provided you what to think and then do it. Okay, so this is 1, the 2^{nd} one let us take as fluidised bed right. Fluidised bed is normally shown like this, okay. You also have what is called bubbles in the fluidised bed, these are the solids and this is gas. Most of the time a fluidised bed is also used for reactor, catalytic reactors. So the solid will be catalyst, right, yah when solid is catalyst, I can put that as in batch condition may be batch, okay. Or it may be continuous also, that means I am taking continuously and then solid continuously entering, solid continuously leaving, right.

And this example of solid continuous solid coming out can be also all, this overreaction, for example iron ore if you want to convert to iron, okay, what is the reaction? Iron ore to iron? What is iron ore?

Student: Reduction reaction.

Professor: Fe2O3

Student: Or Fe2O4.

Professor: Okay, Fe2O3 let us take. Fe2O3 solid, plus what is the gas used? Carbon monoxide or or? No other? CO2. Hydrogen, yah. Hydrogen gas, yah what do you get? A Fe solid plus H2O gas, my God, I am losing time here. Okay, good, now how do you balance? This is 2, this is 3, okay, correct? 3 H2O, yah, O I have written smaller.

Student: (())(20:49).

Professor: Here 3 H_2O. This is the one. So now solid can be continuous and solid can be continuously coming out. Right, and the gas is entering, fluidising, and also reacting with the solid and that goes out, here H_2O may come out in the form of vapour, right.

So what are the ideal conditions here? Now, I have solid continuous, now again slash continuous or gas continuous, gas always continuous. So like this you know for every time, every time you have to now analyse, okay, you taken equipment, many phases entering, whether they are continuous, whether they are batch and once you know they are continuous, then now you have to discuss whether they are plugged flow or mixed flow. Now tell me gas how it moves? Is not plugged flow, ideally? 1st is ideal, ideally is in plugged flow or is it in mixed flow?

Student: Mixed flow.

Professor: Okay, so now gas, okay, PF ideal, why do you say PF ideal, gas ideal PF?

Student: (())(22:11).

Professor: It is velocity profile (())(22:14) Because I think the gas is mostly going in the form bubbles.

Student: Velocity of the gas is very high. Velocity by which the gas is flowing through the column is very high.

Professor: Yah, so I think you know there is a lot of question, it can be either plugged flow or mixed flow, this is the question. Okay. Next course only we will clear this. When, under what conditions abysmally slow and under what conditions it is plugged flow. It is plugged flow when you are maintaining the bed only just at the point of minimal fluidization velocity, okay. Alia you have heard of fluidised bed? Yah, right, yah fluidization is an operation where all the particles are kept in suspension by, by the drag force of the fluid.

It can be liquid or it can be gas, in environment engineering mostly we use liquid and in catalytic reactions and noncatalytic reactions mostly we use gas. Okay. So and also that minimum fluidization velocity is the velocity that is minimum required to lift the entire particle and then just keep in suspension. Above minimum fluidization velocity, when you go, then these bubbles will form. If you are able to exactly maintain at the minimum fluidization velocity, then you may assume plugged flow. And you can never maintain exactly at the anima fluidization velocity, that is also there.

Why? You need some kind of contact between gas and solids, that is the reason why you are using fluidised bed and when you are using just only minimum fluidization velocity, that content is not guaranteed. That is why we go 1.5 times minimum fluidization velocity, 2 times and in the industry 40 times minimum fluidization velocity. All this we can discuss in the next, chemical, chemical and catalytic reaction engineering. But anyway, so that is why I said PF or MF, both are question marks, under what conditions, we do not know, right. This is for gas, we have to find out, in fact if it is very simple plugged flow or mixed flow, there is no thrill in fluidised bed at all.

Like exothermic reactions we also have a lot of thrill in the fluidised bed. Fluidised bed exothermic reactions are much more thrilling because one thrilling is exothermic reaction, another thrilling is fluidised bed itself. Okay, good. That is the one. So if I take solids, solids are in batch and continuous. It can be in back but I think let us make continuous as for this reaction, noncatalytic reaction because continuously it feeds, continuously it comes out. So how the solid moves? Is it in plugged flow or is it in mixed flow ideally?

Student: Mixed flow. Mixed flow. It can be both.

Professor: It can be both. Why, how can it be both? Normally what are the dimensions of fluidised bed? What are the dimensions of fluidised bed? L by D wise? It will be diameter 1 inch and then Height will be 100 inches?

Student: (())(25:22).

Professor: Yah?

Student: Diameter will be very high. L by D ratio will be less.

Professor: Yah, L by D will be around 1 or maximum it can also go to 2 or 3, okay. Why beyond that you cannot go I can tell you in the next semester because there is what is called slugging and all that that comes. Because particles will move in the part of slugs, not as real fluidization, all these troubles are there. So generally, L by D, 1 to 2 is the best design and less than 1 will be again shallow bed, shallow bed, less than 1. That means you take 1 inch diameter, not 1 inch, 1 foot diameter and only 6 inches height, okay. Yah, 1 foot diameter and 6 inches height. So that will be called shallow bed.

So we are wasting a lot of things in the bed, so that is why we do not want to use that kind of thing, L by D normally 1 to 2. So when I have normally 1 by, L by D equal to1 to 2, what kind of flow I expect for the solids? See this is why when we are discussing this, I do not know whether other teachers are telling you like this or, I think every teacher must be telling the same way, otherwise how can you explain? You cannot explain. So when it is actually, when I ask you know what is really happening, all the solids are moving, you have to imagine a lot, you have to imagine how the gas is flowing through that.

And how gas is flowing through solids, whether it is pulling, pushing the solids away or it is lifting solids away, what happened to the lifted solids, whether they are again falling, all that imagination should go into your mind. Then only you can answer, okay. Yah, now you tell me. Mixed flow, why mixed flow?

Student: Sir, I think there is perfect mixing, there will be better mixing, there will be no (()) (27:14).

Professor: Yah, mixed flow is right because this gas will try to take the solids up and some merit has to get separated and after that what will happen? Yah, for solids there is no more drag, you know, so that is why the solids will simply fall. When they are falling, they go to bottom, they just sink in. So again, some of those solids again picked up, so when you look at that, then you will have almost perfect mixing for solids because most of that, that means that solid can be either here or here or here or here, anywhere in the column. That is what is the definition of perfect mixing.

And if I also take the temperature of the solids, okay our concentration of the solids, throughout, that means if you take reaction, uniformly and the same size particles, then throughout the bed I will have the same conversion at a given time. Okay. Otherwise, yah…

Student: (())(28:13).

Professor: Because still here only you have the bed.

Student: (())(28:20).

Professor: No, I think you are talking about pneumatic but we are talking about fluid injection.

Student: (())(28:25).

Professor: Yah?

Student: Solid is continuous.

Professor: Solid is continuous only we are discussing. Solid only is continuously falling here, I think you know, you introduce your and then take out here. Right and what he is telling is, if I take very small bed, small diameter and lot of solids there and then like slug, what you mean by slug? All the particles are just lifted up and there also after some time it will break because some of the solids will go and touch the walls and what is the velocity near the walls? Zero, then what should happen to the particles? They have to fall down. Right, when you go to pneumatic conveying, that means the velocity is much much higher than the turbulent velocity of the solids, so even those few solids which are near the wall, they will be also taken away by the gas.

That is why that kind of high velocities. But even then, in a, in a pipe very have the boundaries, pipe will have definitely boundaries, even perfect pneumatic conveying you will never get. Why? Again near the wall, velocity is 0. So, some of the few solids, 1 or 2 particles which are near the wall may slide down. Even if you go beyond pneumatic conveying, all these things are you know nice way of telling, like in breeze when you have lot of breeze, there are no boundaries there. So if you have very fine solids, all those fine solids will be taken away. You should have seen no, recent cyclone, what has happened. What all dust has come and fallen on us, there is no boundary.

If there is a boundary, our boundary is administrative block for example, just imagine. So those particles which hit the administrative block and on the surface of administrative block, there will not be that kind of velocities, particles would have slide. Same, your body also acts as a boundary, particles will come and, yah, it will be thrown your body and face. But once it starts here, again velocity near the, you know skin is, that is 0, so some particles will fall down. If it is fine dust, at that will stick, okay, then you have to go and wash your face, otherwise people will not recognise you who you are.

So that is why, even truly pneumatic conveying also some particle will be sliding down, okay, good. So that is why here we have, for solids, perfect mixing, mixed flow. Now what are the non-idealities that will come here? Okay, the non-idealities, I think you know, we started heterogeneous system, homogeneous systems we have discussed sometimes I think in the beginning itself, what other non-idealities that make? Like if I have a CS TR, single phase liquid for example, okay, what other non-idealities you may expect, where do you get that zones, yah, near the corners.

That is again we try to put bowl like thing, right, yah, then any other… Where are recirculations?

Student: Near the end.

Professor: Yah, if stirrer is very badly designed, recirculation will be near the stirrer. That means the fluid which is touching the propeller, you know that blade and that maybe recycling that itself, all the time, that will not mixed with the other components. Yah, one more, bypassing. By wrongly putting the inlet and outlet, it may bypass, you know bypassing is an inherent quality for mixing, but natural bypass is different, this is artificial bypass by putting wrongly the input and output things. That means if I have, yah, so if this is the pipe or if this is the tank, this is the tank, bottom is closed and this is entering here. Logically at least I should put in the opposite direction, logically, okay. So by innovation, okay, I will put my inlet here, also outlet here, like Y, like Y, why I do not know.

Okay, like this, right. So that means it enters and comes out, it will not go down. That is the reason why the best design for CS TR, the mixed flow is bottom, top, okay. So you will not have bypass. Bottom inlet, top outlet, why cannot you do the reverse? I can also do know, here inlet, here outlet, yah but you know the maintenance of level is not easy. I told you know after sometime everything becomes common sense, after sometime. But you have to reach that level, you have to use 1st sense, then it becomes common sense. Okay, yah, that is the reason okay, so that is why you can expect their bypass if you are wrongly putting inlet and outlet pipe, okay, so that is what.

We call that as bypassing, no, where is that non-idealities I am writing? I have not written non-idealities, okay. So for mixed flow, for plugged flow when I have plugged flow for gas, the same non-idealities what we mentioned here will come. Anywhere plugged flow, you will definitely have axial mixing, you will definitely have radial nonuniformity, okay, and then by wrongly designing the column you may have dead space recirculations. That is what what you have to learn, that means on the plugged flow condition, what are the non-idealities. See, sorry to say this one, I cannot say under plugged flow conditions what are the non-idealities.

The moment you say plugged flow, it is ideal, okay, you may be imagining as ideal plugged flow but what are the non-idealities possible under those conditions. The 1st one is I axial mixing, the 2nd one is radial nonuniformity. But because I think there will be mixing but it will not be affected things. The 3rd one will be, yah, the dead zones, dead zones are in your hands, you made it with your hand by wrongly designing the pipe, you know by putting the, without putting the cone, right. So that cone will allow you to develop the velocity profile, then it becomes flat, then it enters.

If you are not allowing that, then you have dead zones. And some kind of channelling will be there, what he said is right, channelling will be there, if the L by D is very small, okay, L by D or packet but is very small and one quarter when you have more solids, another corner you have less solids, correct no, because you have not properly adjusted the solid in packet bed. So under those conditions, channelling also will be there.

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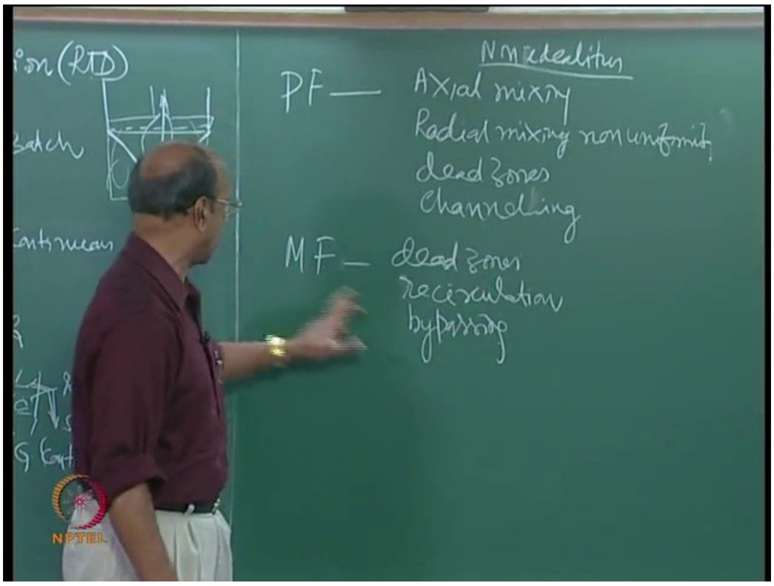

Right, so whenever you have plugged flow, general, okay, plugged flow, axial mixing as non-ideality, radial, radial mixing nonuniformity, that means it is supposed to be uniform across the cross-section it will not be there. Then dead zones, okay, actually the dead zones are man-made or woman made, okay. Nowadays, you cannot say only man-made, person made, okay. Yah, so that is why I, dead zones you can actually stop dead zones by designing nice, right. And some kind of channeling, channeling double N or single N? Okay, single L, so this is channeling, these are the general things, non-idealities that come into picture if I have, non-idealities.

Okay, so when I have mixed flow, mixed flow we may have dead zones, recirculations, okay and bypassing. Okay, bypassing or short-circuiting also we say but bypassing, you know generally the thumb rule is that for packet bed channeling is used and for mixed flow bypassing is used. So the difference is, in channeling at least the fluid will spend some amount of time but bypassing is almost instantaneous, it may not spend even 1 second or 2 seconds or maybe 2 seconds it may spend. It mean, again in comparison with your mean residence time.

Mean residence time if you have 10 minutes, if you have, the channeling maybe having 1 minute and whereas bypassing will have only one second or 5 seconds, that is the meaning of channeling and dead space. So now, as I told you, I promise you that you bring any kind of reactor to me which is there on this planet, okay, any kind of reactor. Like yesterday you said trickle beds, yesterday you said moving beds, of course fluidised bed, all these beds can be imagined in terms of only 2, mixed flow and plugged flow. Any reactor you bring, but you have to look at this thing like for example trickle bed, in trickle bed you have solids in the batch condition.

Then we have gas moving from the top, liquid also moving from the top, right. How this movement is taking place in trickle bed, we are fortunate because you know the solids are in batch condition, we do not have to worry, the other 2 phases you have to worry. Liquid will enter and also gas will enter, depending on gas velocity and liquid velocity one will take the other, like you know, behind you in OAT, if he is a very strong guy, he will push you, he will take you, you do not have to… Only thing is he will not lift and take you but he will be pushing you and then you will enter. But if there is a small kid and you are heavier than that small kid, you will push that guy.

So similarly in trickle bed also that happen. Depending on which phase has more energy, more velocity, then that will push the other one. So normally what you expect for both is, plugged flow or mixed flow?

Student: Plugged flow.

Professor: And also trickle bed diameter is small compared to length. That is why the shape also you should get immediately in your mind, shape also, shape of the reactor also immediately in your mind you have to imagine. Otherwise you cannot answer these questions, right. Simply not telling, trickle bed, without knowing because somewhere you would have heard of trickle bed, you come here, trickle bed and says trickle bed. Unless you have that feeling, I told you know, finally nothing will work without feeling I say. Even your love will not work without feeling.

You have to say that love with so much feeling, so for that you have to take training from Kamala Hassan or someone. But I think you know, really, because that guy is a great actor, so I think he should get Oscar sometime. So he will show what is that real feeling is, okay. So if you want to say those words, go and take training and then you can say that. Otherwise limply, I love you, does not mean anything, okay. Same thing with subject, when I like CRT, when I love CRT means that feeling should be there, otherwise there is no, you do not really enjoy that. Simply you are saying some words, like trickle bed, you do not know.

Okay, then fluidised bed, we do know whether there is solid OR gas or anything, okay, so that kind of feeling will not help you at all, you should have the real feeling. And to develop the real feeling, you have to totally immerse in that feeling. Okay, Neetu, Neetu, Simi, Simi, Neetu, yah, okay, yah. So that is the what is the problem, now I think I will leave you.