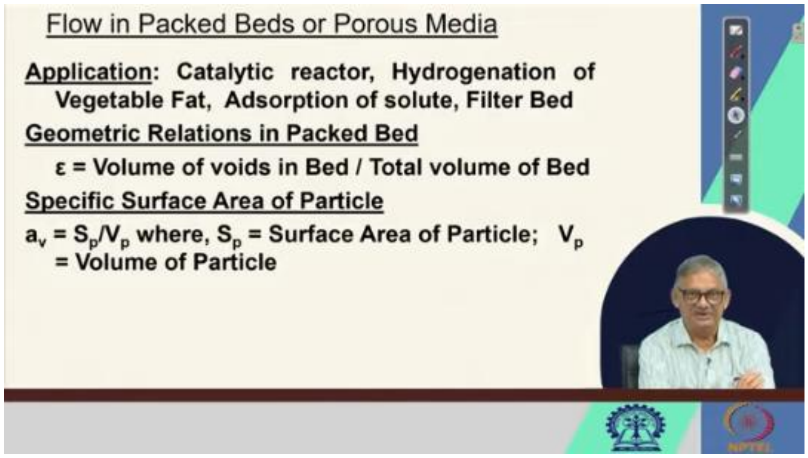
IMPACT OF FLOW OF FLUIDS IN FOOD PROCESSING AND PRESERVATION

Lecture36

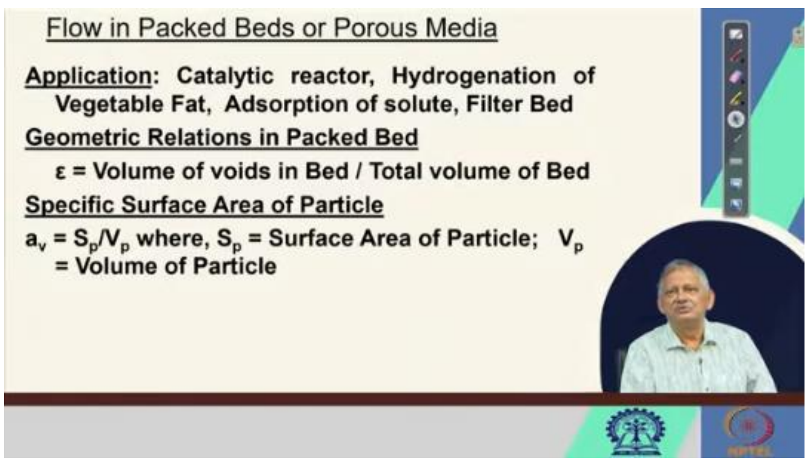
LECTURE 36 : FLOW THROUGH PACKED BED

Good afternoon my dear students and boys and girls and friends. From the incompressible fluid we have gone to compressible fluid. We have found out the relation between the pressure drop and all other parameters. Now, one applications of such is the flow in packed bed or porous media right.

So, flow in packed bed or porous media. This is so important that the flow characteristics, the flow regime, they are explicitly controlling the many many industries right. Let me tell as a preamble that flow in packed bed. What do you mean by that? Packed bed.



Okay, let me take this as an example. You see, you can fill up with this type of material into it, right? And it being flexible, so you can compress it, you can expand it accordingly, your packing will be there, right? So, that means depending on the packing density



your pack beds are different, right? So, for which we need to tell some definitions. We need to tell some definitions and that definitions apply for the cases of porous media. One thing which you come across very, very, that if you minutely look at, just now our rainy season was over. I do not know whether it is over or not, at least it has subsided.

Have you ever seen that any field and other plant where there were lot of water? And this water, it is not that all water got dried up because of sunlight or heat. Some water also went down into the mother earth. Right? How?

Those, what should I say, midty that is that that is the earthen part, they are porous and through those pores these water went down into the ground water level. where by ground water got recharged. Again whenever you are using you are pulling it through some different devices. This is also one example of packed bed right. So, there is immense of applications.

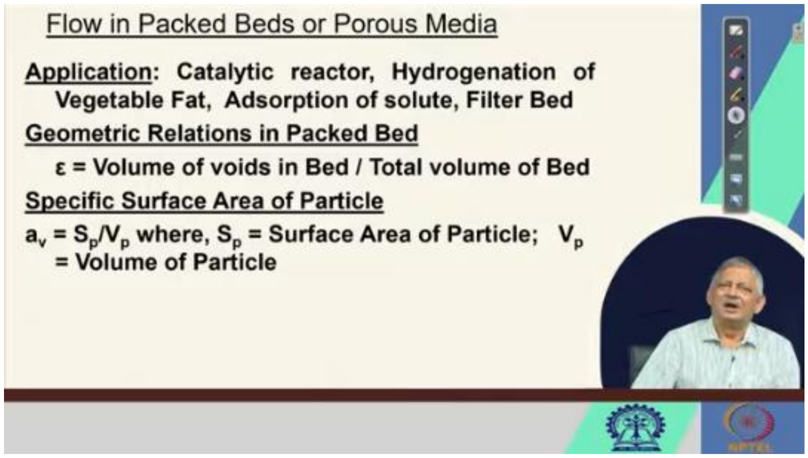
Only you have to look into properly that which one is filling up, which one is falling into which category right. So, we take that flow impact bed or porous media that is applicable to many many industries. So, we said that we will make some definitions, right. Like catalytic reactor, hydrogenation of vegetable fat, adsorption of solute, filter bed. with the development of science.

I do not know whether it is development or not because in the long run only its effect can be understood or felt. That the water purification system which you use at our houses, every house is now Really full of RO machines, right? Because of advertisement, because of many any other things, because of ease of operation, etc. All the houses are buying and keeping them.

I am not saying they are doing wrong, no. This is the go of the day. So, everybody is doing same thing. There also you have a packed bed or filter media, right? So, water is passing through that filter media and high molecular weight things are getting restricted and you are getting the cleaned water or whatever you can call.

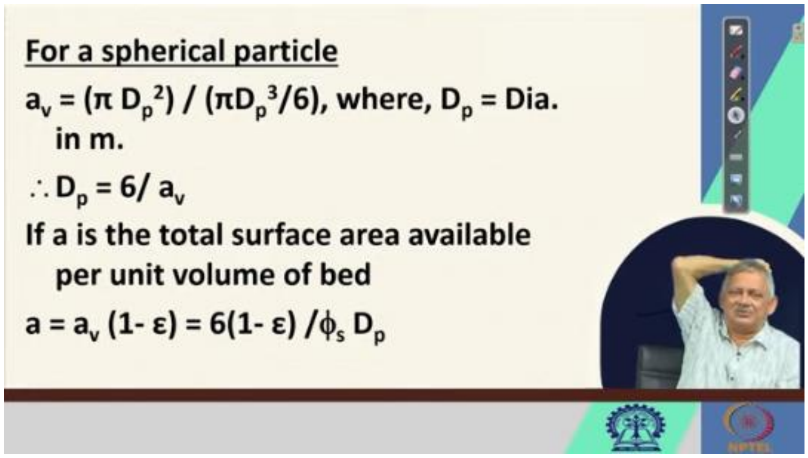
The thing is the why did I say that in the future you can only tell about it is that, that according to our science it is said that the water level should have micronutrients or constituents to the tune of 700, 800. Whereas after this purification, RO purification, you are getting the level towards 300, 350 ppm (parts per million) like that. So, that I do not know. That could be one of the reasons why our father, forefather, they used to be much more stout and strong than ourselves. Because in those time water was not like that, they used to take the simple ground water

pooled and consumed, right. Here now with the progress of urbanization, lot of I say both good and bad things are coming up. However, coming to the definition of applications, That these are the applications just coming in mind may there could be many many more that catalytic reactor, hydro generation of vegetable fat, adsorption of solute or filter media, this or filter bed these are the applications of the packed bed or porous media. Now, if you look at the application, if you look at the definitions as we said, first one is the geometric relations in packed bed, right.



In the very beginning, I had shown you a bag and I told you as many things you put, it becomes more and more filled up. right. That means the packing density has an effect that is what explicitly here we are saying. That epsilon a term as volume of beds in volume of voids rather that is void means where there is nothing. Volume of voids in the bed per total volume of the bed, right. Volume of the voids in bed over or divided by total volume of the bed that is the epsilon. So, void means again ok let me take this example though this is water though this is water you see some are not there right since it is water top is gas and bottom is water now just imagine that instead of water you are putting with some you are putting with some sand right and the bottle is filled up depending on the sizes of sand, depending on the compactness of the sand, your, this void volume that means, the volume where nothing is there would be different. So, that tells us about the new term called epsilon as the void volume over total volume of the bed right. This is one definition right epsilon or volume of voids in bed over total volume of bed. Now, another thing is specific surface area of particle right specific surface area of

So, that is called A_v, A subscript V and that is defined as S_p over V_p. What is S_p? S_p is the surface area of the particle S for surface area and obviously, V_p is the total volume of the particle. So, surface area over total volume that means, it is meter inverse one length parameter inverse area is meter square volume is meter cube. So, that means, area and volume after exchanging it remains one dimensional meter available, right. So, S_p over V_p is the specific surface area of particle A_v will be required in subsequently. For a spherical particle, a particle can be of any size, any type, anything. I hope if you go to the sea and in sea beach you will see that not only sand many other things are also available of different sizes, different shape, different things right.

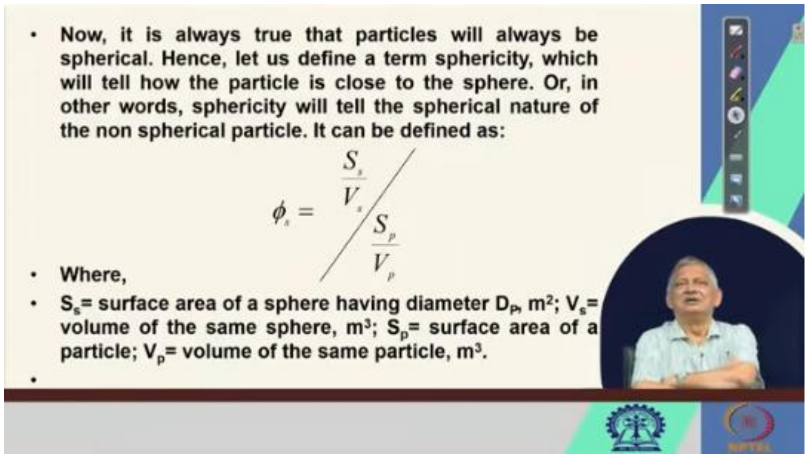


So, depending on whether it is spherical or not, if it is spherical then we can further define it as A_v is equal to pi D_p square that is the surface area over by over pi by 6 D_p cube that is the normal volume of a particle. pi by 6 D_p cube is the total volume and pi D_p square is the surface area which we are taking as the specific surface area definition. Obviously, D_p is the diameter in meter and D_p is 6 over A_v from this solution you see pi, pi goes out D_p square D_p cube, D_p remains there 6 in the denominator whereas, this A_V,

A_V goes rather 6 divided by A_V is the total surface area available per unit volume of bed. So, it is the total surface area available per unit volume of bed and that is A is equal to A_V into 1 minus epsilon you have seen what is the value of epsilon what is meant by that. So, A is A_V into 1 minus epsilon that is a solid part and that is equals to 1 minus 6 into 1 minus over phis D_p another new term has come up called phis right.

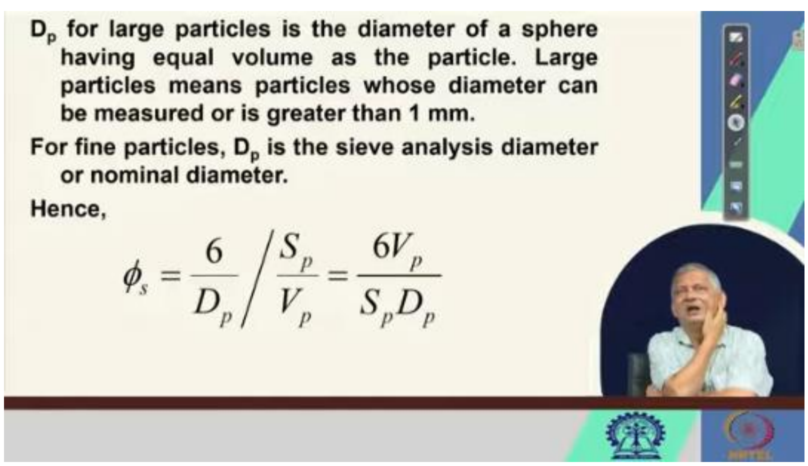
So, phis obviously, it corresponds to sphericity because we started with this spherical particle sphericity that means, how much close the particle is with respect to a sphere. right that also to be found out, right. So, what did we arrive at? We arrived at per volume rather it is said that phi s is the sphericity that is how close it is with respect to the sphere.

It also has a definition, definition is the sense the way it is said. It is always true that particles will always be spherical, hence let us define a term sphericity which will tell how the particles is close to the sphere. Or in other words, sphericity will tell the spherical nature of the non-spherical particle in course if it is if it is, it can be defined as phi S equal to S_P over V, S S over V_S divided by S_P over V_P, right.



So, that phi spherical or sphericity of the sphere of that particle can be defined as S_P over V_P or S_A over V_P divided by $S_P V_P$ ok. Now, what is what? S_A is the surface area of the sphere having diameter D_p, meter square, V_A or Vs is the volume of the same sphere in meter cube, then S_p is the surface area of a spherical particle and V_p is the volume of the semi particle that is in meter cube.

to make you understand again that what I say is that. SP is the surface area of a particle and V_P is the volume of the particle same particle right, but in many cases it may not be coming to the truth. For example, D_p for large particles is the diameter of sphere having equal volume as the particle Large particles means particles whose diameter can be measured or a greater than 1 millimeter that those are large particles. This I gave example when we were handling with grinding, we were handling with grinding right.

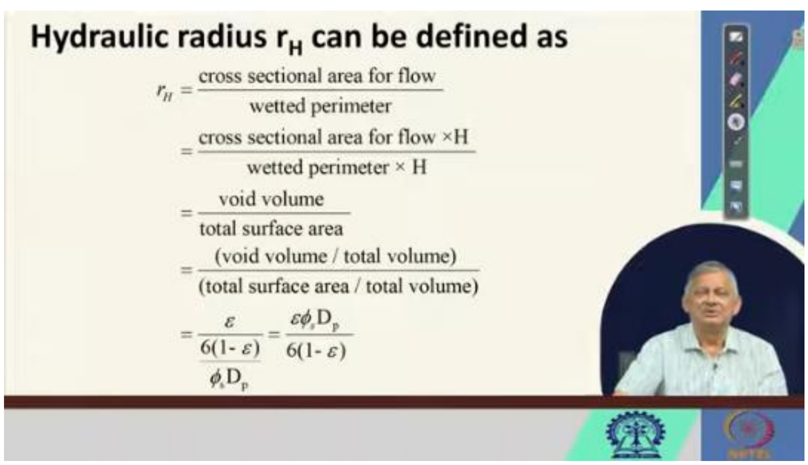


And, we said that this relation is available till 6 our day till 6 by D_p right. So, D_p for large particles is the diameter of a sphere. having equal volume as that of the particle. Large particles means particles whose diameter can be measured or is greater than 1 millimeter. For the particles D_p is the sieve analysis diameter or nominal diameter.

Therefore, we can say phis is equals to 6 over D_p over S_p over V_p or 6 V_p over Sp over Dp. So, phis, we are defining it to be a term which I have not here of course, phi s is equals to d 6 over D_p over S_p by V_p and this is equal to 6 V_p over S_p over D_p right. So, this is for fine particles, it could be very small as as as small as you can think of or it could be very big. But by definition it is 6 V_p that is V. What did we say?

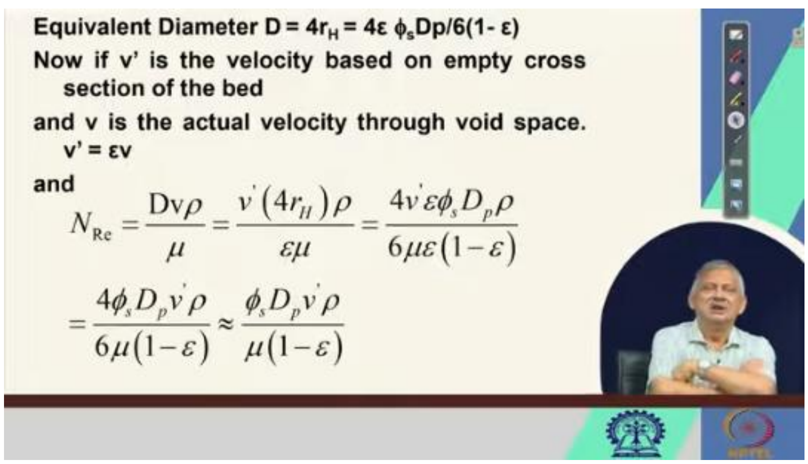
V is the specific volume. right. So, 6 over D_p over S_p over V_p that is with respect to us and 6 over D_p is the phi_s is equated to 6 V_p over S_p D_p right. S_p D_p we have already defined, V_p also we have defined.

Now, another very important thing which comes in is called hydraulic radius or R_h. Hydraulic radius or R_h that can be defined R_h, R_h is the cross sectional area for flow cross sectional area for flow area this is how it is flowing over weighted perimeter that means, if if we take that means, if we take R_h is equal to sectional area for flow over weighted perimeter. Now, sectional flow area if we multiply both by a term called H. or height, then it can be equated with cross sectional area for flow into H divided by weighted perimeter that is 1 or rather weighted perimeter right.



So, if we multiply both numerator and denominator with capital H, then CS, cross sectional area for flow into h over weighted perimeter into H. Therefore, it is equal to void volume, now the void things are coming. It is equally true that unless we have some information, then we cannot determine void volume. Rh in many ways we are defining a number one cross sectional area for flow by weighted perimeter, cross sectional for flow into H by cross sectional for weighted perimeter into H. We have multiplied both in numerator and denominator with H. Then you avoid volume over then void volume over total surface area, then dot rare volume or total general then void volume by total volume over total surface area divided by total volume is the relative hydraulic radius. So, hydraulic radius by word definition we say void volume by total local surface area and the void volume by total volume in the total surface area by total volume yes. So, it is epsilon (ε) by 6 into 1 minus epsilon by phi$_s$ (Φ) D_p.

or in arrangement it can be written phi$_s$ epsilon phi$_s$ D_p divided by 6 into 1 minus epsilon 6 into 1 minus epsilon right. So, R_h is in terms of epsilon that is void in terms of phi$_s$, that is the sphericity, in terms of D_p that is particle diameter, we have defined that to be R_h equals to 6 epsilon phi$_s$ into D_p over 6 into 1 minus epsilon. Now, another term this was hydraulic radius, another term which is very widely used very commonly used that is called equivalent diameter D is equal to 4 R_h that is equal to 4 epsilon phi$_s$ D_p over 6 into 1 minus epsilon.



So, equivalent diameter can be determined or can be defined as the 4 times hydraulic radius or 4 epsilon phi$_s$ Dp over 6 into 1 minus epsilon. if v is the velocity based on empty cross section. Now, empty cross section, what we mean? That again I am taking this help that now it is full of water, now if you consume all water then what is there? Nothing.

So, that is called empty, empty cross section is the velocity. When nothing is there the flow of the fluid is the having empty cross section velocity or we can tell it to be v prime (v'), ok. For us today's time is over and we will come to this in the next class and yeah accordingly we will proceed. Thank you.

Thank you all.