Fundamentals Of Particle And Fluid Solid Processing
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Lecture - 31
Filtration

Hello everyone welcome to the another class of Fundamentals of Particle and Fluid Solid Processing. Today we will start a new section a section called Filtration, we started in the previous section the removal of solid particles from fluid and on that we have seen the sedimentation; sedimentation of solid particles from a liquid element.

Now, this filtration is another way of separating this solid particles from fluid specially here we will be dealing with liquid filtration; that means, when the medium or the there is a suspension of solid particles in a liquid medium. So, but this similar kind of concept is also applicable for gas filtration as well, but the main focus in our this section will be on the liquid filtration.

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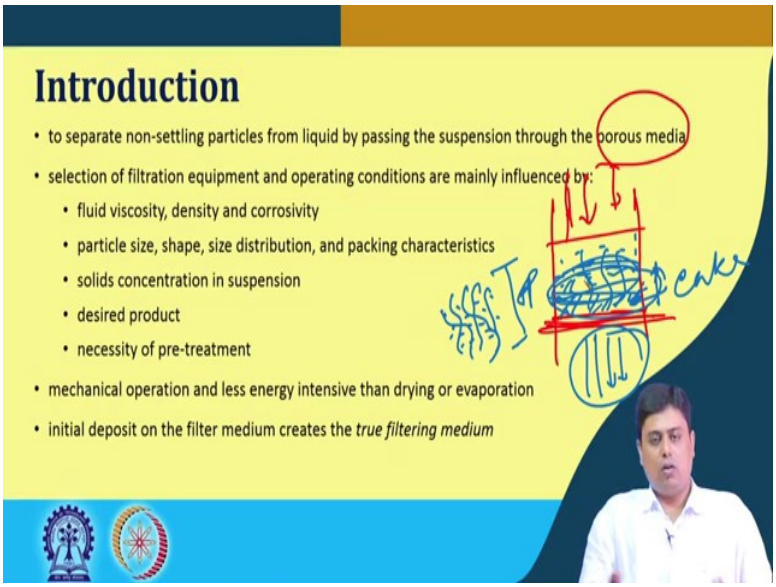

Now, filtration is basically a very household name we regularly encounter such phenomena. So, if we have to define this phenomena it is mechanical operation that tries to separate non specifically and particularly non-settling particles from liquid by passing the suspension through a porous media.

This porous media the reason that is mentioned here is the porous media because this filter media through which this suspension is flown. So, this filter media typically the pore sizes of the filter media sometimes in the order of the particle that is being separated or sometimes it is bigger.

Now, what happens this filter media works efficiently and effectively when there is a initial deposition of this solid particles happens on this filter media. So, usual or conventionally what we think that when there is deposition in heat exchange or some kind of other studies we consider those as fouling which is not good, but in filtration this initial deposits. In fact, when acts as an effective filter media this initial deposition helps this other particles to segregate clearly or separate clearly from the suspension.

So, the point is that if we have a clean surface of the filter medium initial deposits sits on those and it starts to grow, the thickness of those particles then starts to grow as the nigger size particles and other size particle different type of particles are then stick to that cake.

So, we call this thickness of this solid particles as the filter cake ok, this is one way of filter filtration process we will come to this in details but the point is that you can understand that as this thickness of this cake increases. Now, this cake is basically consist of fine particles which basically forms this porous media and that is why on the first place we mentioned this porous media of the flow of suspension through the porous media.

Now, usual filtration if this is our filtration filter media which is on a support say mechanical support it is lying on that and then there is some suspension poured in we have done this in the laboratory that taking a funnel on top of which on the top surface we have put a filter paper and then we have poured in the suspension. So, that the solutes or the solid particles gets stocked to that filter media and there is under flow which we collect as a clear liquid.

Now, there are few terminology that we will be using now is that the suspension we this whole liquid phase we sometimes call this as a filtrate ok. This is the solid particles this filtrate also sometimes call the effluent sludge this kind of names you would find in different textbook or different places.

Now, when it happens so; that means, on the top of this filter media if this is our filter media on top of this we will have a certain layer of solid particles which we call the cake and then we have this suspension. So, this is a typical process simplified schematic.

So, naturally now as we understand that as with time this cake thickness increases. So, which means if we run this operation at a constant pressure this outlet concentration or the outlet flow rate will decrease with time because the resistance inside this pore as the height increases it would increase for a constant pressure drop lesser amount of flow will happen through the tortuous path of this solid particles or the porous media.

Now, this thing we have seen in the earlier classes that if this is the porous media through the different tortuous path this fluid flow will happen we already have knew that or we already have known this what would be the pressure drop in such cases we have seen Darcy's law, we have seen argon equation, we have seen Kozeny-Carman equation. So, the similar concept basically will be applied here or you can apply here that basically this effective media is the cake medium which is of solid particles or the porous material, we call this as porous media. So, flow through porous media.

Now, naturally; so there are several applications now the applications you can divide it this in two fold. Now, since see one case you are having the solid particles at the top of the filter media and then you have the clear liquid. So, there can be two objectives one would look for this solid particles to separate from the fluid particle of the fluid or the suspension in that case the solids say are of more valuable product than the fluid.

In other case you can consider that the fluid is what I am looking is of certain purity which means we try to clear various solid particles from the fluid and in other case what was happening, we are separating this solid particles from the fluid because of solid particles where of more valuable to us.

So, the; that means, in one case the valuable product is solid in other case the valuable product is liquid. Examples; examples are like say water or say air filtration here the fluid media or the suspension media is what we are looking to clear or having some clarity on that some purity of that purity grade of water pure air such kind of scenario we want by removing the small particles solid particles that is there in those fluid media.

So, in that case water or air is what we are looking for is our desired product but in pharmaceutical industry or fine chemical industry the solid particles are what is of importance we try to separate or filter those from the bulk suspension.

So, which means when we try to find out that what would be our ideal filtration equipment or operating condition those are basically influenced by certain parameters those are this fluid viscosity, density and its corrosive nature with the filtration equipment solid parts. This is one of the vital parameter because in industrial scale several fluids can create corrosion, fouling etcetera with the fouling equipment.

The other important thing is the particle size, shape and the packing characteristics as well as its distribution. This size distribution is what; at first if we have the prior knowledge that helps us to propose that what would be the proper or the appropriate filtration equipment for that kind of suspension because this size shape this size distribution and the packing characteristics eventually dictates that how that cake characteristics will be.

The flow is effectively happening through that cake in cake filtration particularly and what is cake filtration we will come to that but mainly this solid particles basically either stick to the filtration media or the filter media or it goes inside the filter media and then it attaches there. So, that the tortuous paths basically gets clogged. Now, quite naturally; that means, the particle size shape distribution its packing characteristics are important in such phenomena.

The other vital component is the solid concentration in the suspension or in the feed, how much is the solid concentration that we are trying to filter it out, what is the desired product that I just discussed that which one is our valuable product which one you are looking to separate based on that there can be different types of illusion equipment ok. Because we can understand that if that cakes are forming continuously that cake or the solid particles eventually I mean is not of that much importance, the important portions becomes that whatever we are getting as a clear fluid.

Now, whether is there any necessity of pre-treatment of the suspension, if the pre-treatment is required then the consequent filtration equipment can also be changed for the optimized result. Pre-treatment means say the heating of the suspension a priory or adding some coagulant in that suspension to make the flocks.

So, basically this filtration process is a mechanical operation and it is less energy intensive than the other processes like drying or evaporation because there you need to supply the latent heat of the fluid which is mainly water in those cases, so it requires more energy. But in filtration it is purely the mechanical operation the mechanical energy that is required.

This initial deposit as I mentioned once it sits on the filter media it then actually creates the two true filtering medium or the effective filtering medium, the flow would happen through this cake and the filter medium; fine.

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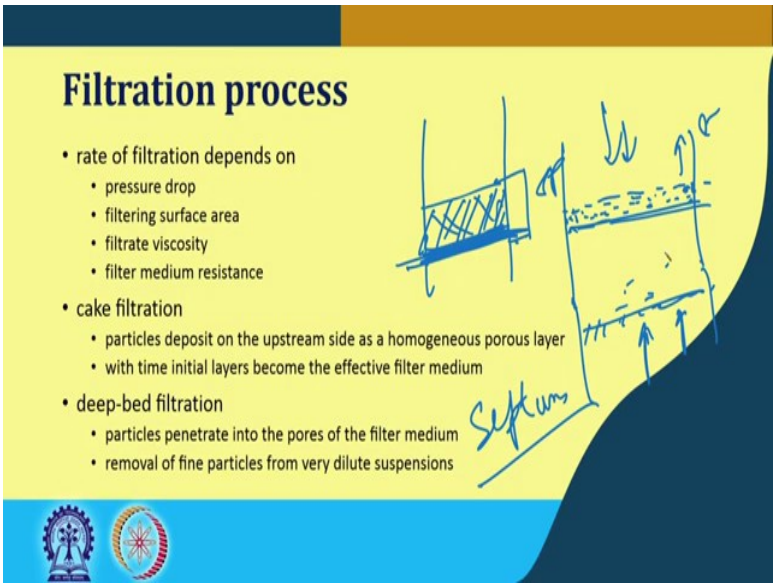

So, this now if you have understood that this cake or the initial deposit thickness on the filter media increases with time or if there is a higher concentration of suspension in fact, it would increase with the increase in flow rate. So, the rate of filtration the rate at which this process can be occurred depends on several factors and one of the primary factors is the pressure drop across the downstream or the down side of the filtration of the filter media to the feed entering portion or the suspension top area.

So, this effective pressure drop or the whole pressure drop that is required that actually dictates the rate of filtration or even if you can think of having if this is my filter and its support and if this is the cake. So, basically this pressure drop is what that is important in this or dictates this rate of filtration in this case.

It is also dependent the filtering surface area the available surface area for the filtration. Because see if this initial deposit thickness increases ok, for a constant pressure drop it would require much larger surface area or much larger widest space to have the same flow rate which means if that is not available, then the filtration rate goes down.

Then the other important parameters are filtered viscosity and the filter medium resistance because effectively what is the total resistance; the total resistance to the flow is the resistance in that porous media or the cake of certain thickness this portion and the resistance of this filter cloth or filter media whatever we take or membrane something else.

So, this two resistance basically this dark shaded one and this blue shaded one that I have mentioned this summation of this two resistances are the total resistance. So, which means the rate of filtration would also depend on this filter media resistance. Now, typically when this filtration process happens this process can be categorized broadly in two way and sometimes both are there in the in particular process.

So, the processes are or we call it as a cake filtration and the other one is the deep bed filtration. Now, what happens in cake filtrations that I have just mentioned earlier as well that it forms initial deposit and then that deposit on the upstream side increases with time. Now, this initial deposits when its sits on this filter media.

So, if this is my filter media and if this is the initial deposit say it has been deposited. Now, we assume typically this is the upstream side the flow is happening from this side to this side.

We assume that this is the homogenous porous layer which means the void is in this in this thickness is uniform. The resistance is in all the direction of this cake or this thickness of porous media is uniform and then this thickness builds up with time and with time this layer becomes the effective filter medium.

So, which means the resistance in the filtration in the such cases increases with time there is a rate of this filter medium the resistance. In deep-bed filtration what happens that particles penetrate into the pores of the filter media because filter media is having certain pore sizes which are usually larger than the particles that are being removed.

Now, as the particles penetrates it sits on the pores on those less accessible pores and then it basically clogs those pores and then what happens the pressure builds up, then effectively the resistance of this filter media also increases.

So, the point becomes now here you can easily understand that such kind of filtration that this deep bed filtrations would be of importance or would be of consideration if we try to have the

liquids or the filtrates of certain purity we do not bother about the solid particles that are been lost in the pores or being clogged in the pores which are difficult to remove.

Because those are inside those pores and sometimes becomes very difficult to clean those, but there we are having the pure liquid as the outcome and if that is of main importance then naturally this deep-bed filtration is of consideration and this happens in case of this water filtration, the drinking water filtration that we take the air filtration that we have.

In those cases this deep filtration is of immense importance and in cake filtration opposite to this you can understand now we can have this cake clearly that we can scrap out from the upper surface of this filter media and then that can be washed dried to recover the solid particles.

So, which means when the solids are valuable we can propose the cake filtration mechanism, in fact, it is the suggested medium of filtration but in case were we do not care about the solid particles we those are contaminants basically and we try to remove from the bulk fluid, then this deep bed filtrations is of significant importance.

Now, as you have now possibly understand understood that this cake filtration we have a layer of cake or a certain thickness of cake and in other case in deep-bed filtration the clogs or the pores or the filter pores of the filter gets clogged by the way sometimes we called this filter medium as septum s e p t u m. So, we the point is that we have to recover this filter media or this porous bed because sometimes those are of consideration if we do not care you can use it and throw it, but that becomes expensive in certain cases.

So, if you want to have a reusable filter media; that means, these particles or these pores have to be cleaned in case of deep-bed filtration and in case of cake filtration, the cakes have to be removed and from the top surface of the filter medium and that has to be again reutilized after certain period of time.

Now, quite naturally then this deep-bed filtration since it (Refer Time: 23:43) into the pores and it is difficult to remove those particles in certain cases and in fact, in both the filtration cases typically wash liquid is used to recover these filter media or the membrane that we use. What happens; we do a back flashing of this part of this medium; that means, initially we operated this to have our clear liquid once we have a clogged filter media we make the flow

upward with some washed liquid with a certain pressure drop or certain velocity and then with this back washing this pores gets cleaned.

Now, you can understand if these are these bed cake or say the filter media is of small particles or packed orientation, then this back washing followed by say fluidization can help in recovering this bed ok.

So, the point is that in these cases after the filtration done post filtration this back washing or the back flushing of the bed of the filter media is typically done to recover the filter medium and then again it is reutilized.

Regarding this pre filtration process before we started that, so as I during that time I mention that there is that initial deposits that eventually helps in filtration because that offers the very little resistance initially. In that case sometimes deliberately certain pre quote of the material is flown over this filtration medium to have desired pre quote that acts as the effective filtering medium.

Therefore; so these are these pre and the post processes that are typically done in this filtration process and it eventually helps either to have effective filtration or after this whole filtration process it helps us to recover the filter media. Now, if we consider say this cake if we go for the cake filtration ok; if we go for now cake filtration because see this is the course that we are talking about fundamentals of particle and fluid solid processing.

So, we consider the particles are of significant importance we are handling the particles solid particles and in that case logically this cake filtration is the process by which we recover the solids, in our case solids are of more valuable product ok.

So, which means we will stick to this cake filtration further in the next set of slides and the class. So, here we can recover the solid particles as this cake or the porous medium now you can understand if we consider this cake the flow through this cake or the resistance to this cake is eventually the concept of flow through porous media or flow through; flow through solid bed of particles for which we know the pressure drop expression we know how the flow characteristics or how the flow will happen.

I will conclude this lecture today with a one note is that if you understood this concept then you can understand that with time with the increasing resistance flow rate of the product decreases.

If you want to have a constant flow rate your pressure the has to be variable or pressure has to increase continuously why that is; when we will see in the next class the pressure drop relation once again we will revisit that we will understand that why this is happening and how this is happening ok. With this I would conclude today's talk and we will see you in the next day.

Thank you for your attention.