Dairy and Food Process & Products Technology
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Lecture - 47
Milk Centrifugation

Now, we have done in pasteurization, homogenization, now we will come to cream separation right in this 47th class of Dairy and Food Process and Products Technology we come to this Milk Centrifugation. That is, by centrifugal force application of the centrifugal force, you are separating fat right. This principle is utilized for cream separation, all cream separators. These are age old process. Now, nothing has come up after that in place of this. So, that better thing can be done, but till now that the same old one is being going on and still the centrifugal separators are the best for separation of cream from the milk right.

So, to what extent you can that depends on how the performance of course is there, but generally this is the best one as of now.

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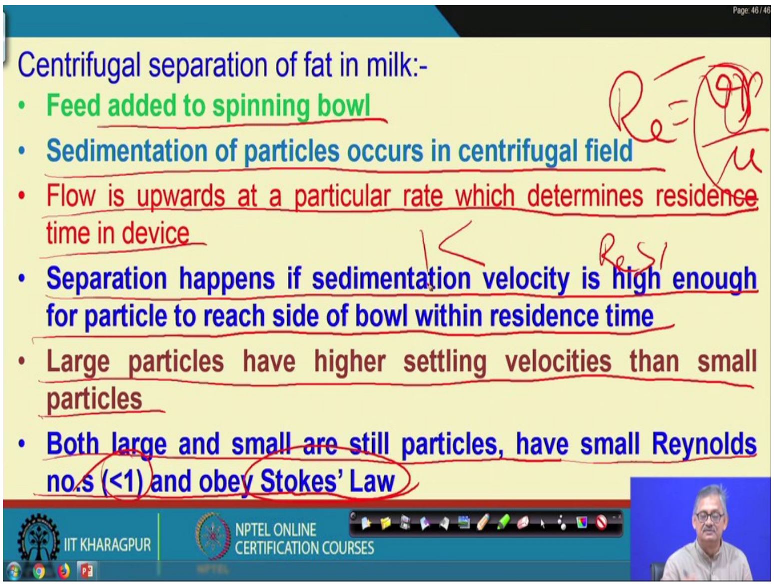

So, we come to that centrifugal separation and the centrifugal separation of milk fat, from milk that feed added to spinning ball the process is like that, feed is added to a spinning bowl, then sedimentation of particles occurs in the centrifugal field, then flow is upwards at a particular rate, which determines residence time in the device, then separation happens if sedimentation velocity is high enough for particle to reach side of bowl within the residence time.

Then large particles have higher settling velocities, then the small particles and that have small Reynolds numbers less than 1 and obey the 'Stokes law' because to obey the Stokes law the Reynolds number has to be less than 1.

So, whether it is large or small both still undergo the Stokes law and by that method get separated because, the Reynolds number according to that is less than less than 1, unless Reynolds number (Re) is less than 1 that Stokes law cannot be applied. So, that this $\frac{dv\rho}{\mu}$. Reynolds number is $\frac{dv\rho}{\mu}$ that remains because, d is not so high such that 'Re' becomes greater than 1 'Re' remains always less than 1 right. So, Stokes law can be applied.

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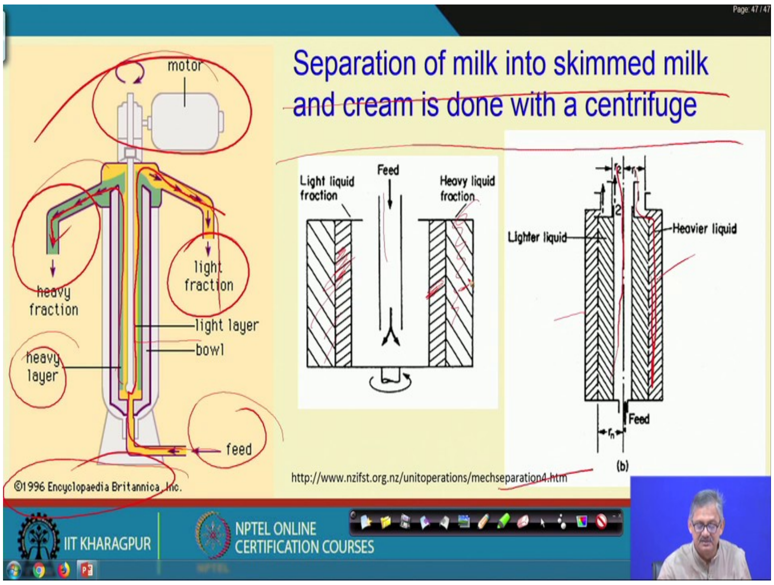

So, with this process if you look at the schematic presentation, that you have a motor, which is flowing the milk, or in this case milk for separation of cream right. So, light fraction is coming out and the heavy a fraction is coming out right and, this is the heavy layer. And this is the light layer that is why with 2 color's, we have shown it right. This is the feed which is going through this. So, this is the inner one lighter one is going on and this is the heavier one outer one that is coming out right.

So, this is from old one Britannica that one photograph. Now, separation of milk this skimmed milk and cream is done with the help of centrifugation and, and the schematic again diagram, we can use from this we have taken that this is the centrifugal separator right. So, heavier one that is coming out like this and the lighter one that is coming out like that right. So, light liquid fraction is this and, this is a feed and heavy liquid fraction is this. So, light one is this and heavy one is this, or rather light one is this and heavy one is this right; so how it is getting separated.

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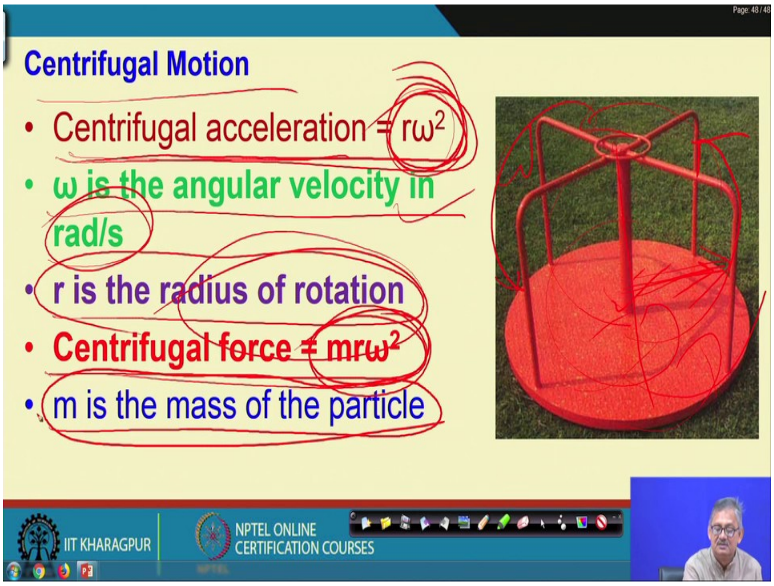

Then we come how the same principle works, I hope in every park you have seen such kind of merry go round right, every park you have seen such kind of merry go round, just to give you idea, this I have shown that dos merry go round, they are you have seen that this is rotating like that right somebody is making this rotation. So, as the rotation is becoming heavier, or the revolutions are becoming more, then the when you this brings back you into your childhood that, when you are doing this, you are feeling that he will be thrown out right you will be thrown out like that right.

So, that was the same principal is also working. So, this you have done during your childhood and, this true in every park children park it is there right. So, this is the typical example of a centrifugal motion, or centrifugal force acting right, on this principle only the screen separation also takes place right. So, there the centrifugal motion is like this, centrifugal acceleration that works at $r\omega^2$ is if ω is the angular velocity and, if r is the radius, then the

Centrifugal acceleration= $r\omega^2$,

ω is the angular velocity in radian per second and, r is the radius of rotation right. So, this is the r is the radius of rotation. So, this is the centre and this is the r where r is this and ω is the angular velocity by which it is moving right.

So, centrifugal force that becomes then, this is the centrifugal acceleration r ω square,

Centrifugal force= $mr\omega^2$

Where m is the mass of the particle. If m is the mass of the particle ω is the velocity of the angular velocity of the particle and, r is the radius of rotation, then $mr\omega^2$ is the centrifugal force acting on the particle right.

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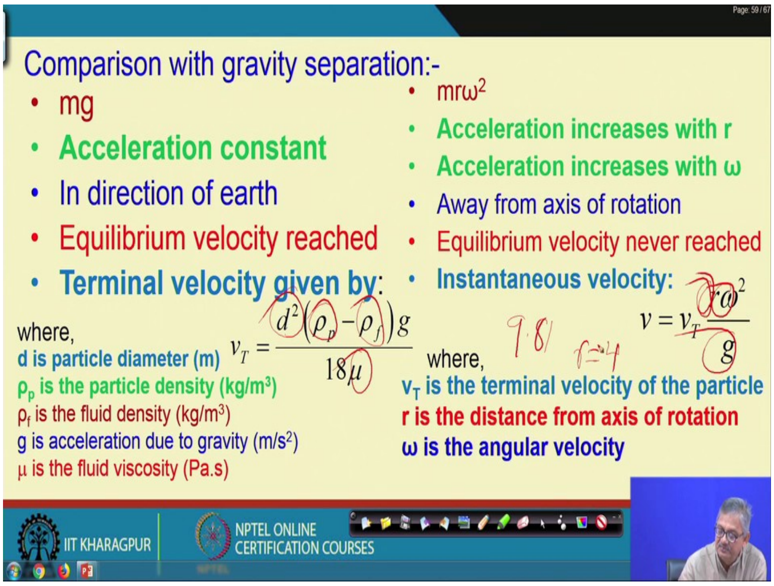

Then if you compare the two separation one is centrifugal separation, another is gravity settling right. If we compare these two, then what we see that that, if we compare this to that gravity separation with the centrifugal separation, then in this gravity separation, it becomes mg and in this $mr\omega^2$ the force, which it is working that is acceleration is constant in the gravity separation.

But in the centrifugal separation acceleration increases with r because, here there is no r m g that is how it depending on g, at that g this m g is working, but this is depending also on omega as well as on the r, through which it is rotating right. So, this is also accelerating with r, also accelerating with the increase of omega, but it is the constant acceleration right, then in direction in this is in the direction of the earth. This is away from the axis of rotation, this is the direction of earth it is working, but this is away from the axis of rotation, if this is the axis of rotation.

Then this away from the axis of rotation that is getting acted, equilibrium velocity is reached in this there is an equilibrium velocity is reached here, equilibrium velocity is never reached, never you will reach because this r and ω, because of that equilibrium velocity will not be reduced, terminal velocity is given by that

$$v_T = \frac{d^2(\rho_p - \rho_f) g}{18 \mu}$$

This is the terminal velocity with which the gravity is getting separated. Where d is the particle diameter; what is the particle diameter having mass m, then ρ_p is the density of the particle in kg/m^3, ρ_f is the density of the fluid in kg/m^3, g is the acceleration due to gravity in m/s^2. And μ is the viscosity of the fluid in Pas.

Whereas, in this we get the instantaneous velocity here, it was terminal velocity here.

It is instantaneous velocity that is $v = v_T \frac{r\omega^2}{g}$

Where v_T is the terminal velocity of the particle, r is the distance from the axis of rotation and ω is the angular velocity.

This v is v_T times this whereas, this is v_T right. So, they keeping this thing in mind keeping this thing in mind.

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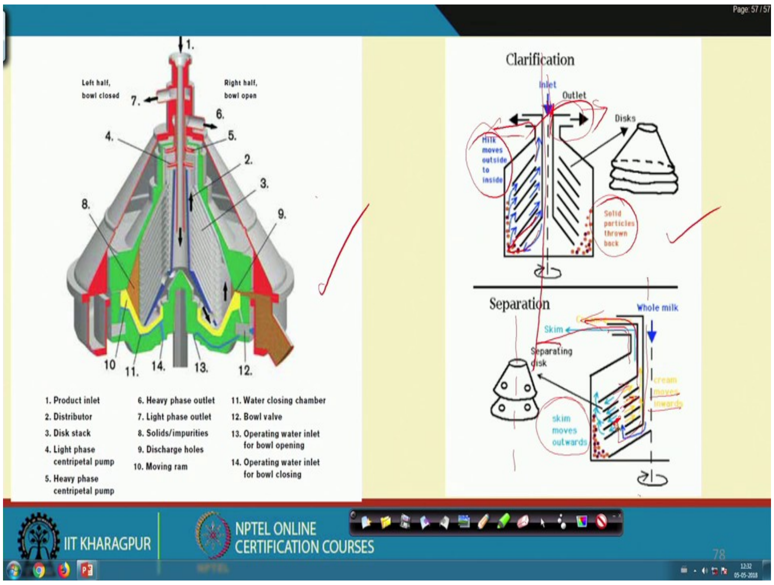

Let us see that how it is getting separated right. So, if we look at this is a typical color picture of a centrifugal separator, write all the segments are there all the things are there, one is the product in let this is the product in let 2 is the distributor. So, 2 is the distributor that is this one right. So, this is the distributor. So, 2 is the distributor, 3 is the disk stack.

So, these are the disk stack 1 disk, 2 disk, 3 disk, 4 disk, 5 disks like that disk stacks right. So, 4 is the light phase centripetal pump this one right. So, light phase that comes out from the inner one that is where it is centripetal and, 5 is the heavy phase centripetal pump, which is this one.

So, it comes out from here right, then 6 is the heavy phase outlet, this is the heavy phase outlet from the outer side and, 7 is the light phase outlet, this is from the inner side light, face outlet, then 8 is the solid impurities or solids are impurities if there be any then that solid, or impurities that come out. So, this is that solid or impurities right that is this then 9 is the discharge holes right. So, that discharge holes are this and then 10 is the moving ram.

So, moving ram is like that this disk, when they are put like this. So, 10 is the moving ram 11 is the water closing chamber, then 12 is the bowl valve so, 12 is the bowl valve then 13 is a operating water inlet for bowl opening, that is the operating water inlet for bowl opening, then 14 is the operating water inlet for bowl closing, 14 is that operating water inlet for the bowl closing right. So, this is a typical colored pictorial view of the description of this centrifugal cream separator right.

So, if you look at this picture where, it is saying the clarification, or separation is like this that this is the outlet, this is the inlet through which it is coming right and, then it is going like this like this and, then doing like that right milk moves out to inside that is the lighter milk moves out like this, that is the heavy heavier one is the milk and lighter one is the is the is the cream right. So, and this is the outlet, that is another. So, the heavier one goes to the outer one, that is the milk without fat milk, but without fat. So, that is going into the outer one and the fat from the inner one it is coming out right.

And you see the separation takes place this is a skim milk this is coming out and interior, this is the outer one interior; there is a cream which is happening. So, if we make this is the symmetrical. So, if you take one of that should like this. If you take one part, then it looks like that scheme moves out outer wards right. This skim is skim milk is moving outer ward and, the cream moves inner wards the cream in because of the light density.

But you can also find out because, at a moment it will come here right now, moment it is coming here it will not be separated, it will go a little. And then the cream will start going out this and the cream will go out of this. So, one velocity is occurring that also can be estimated, or that also can be predicted right, but that becomes more theoretical. So, which at this moment I do not want to go because we are not having.

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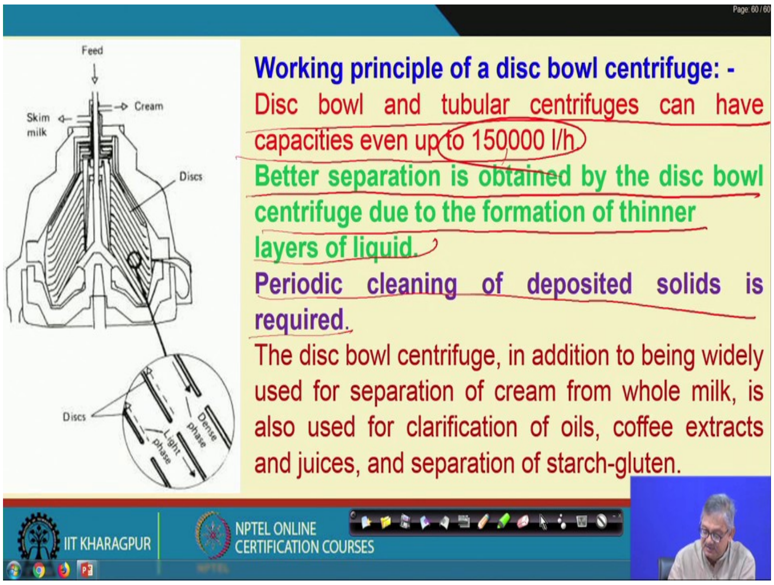

So, much time to do in showed it detail right. So, working principle if you look at, it looks like, this that working principle of a disc bowl centrifuge is like that, this is the typical disk right. This is what I was referring to that, when it is coming like this. So, it goes little and then the lighter phase comes towards the inner side and, the heavier phase goes to the outer side right.

So, this is the dense phase this is the light phase right. So, these are the discs ok. And if we take a sectional view like this, then it looks like that. So, skim milk that comes out from the outer one and, the cream that comes out from the inner one right. So, if you look at disc bowl and tubular centrifuge can have capacity is even up to 150000 liters per hour better separation is obtained by the disc bowl centrifuge due to the formation of the thinner layers of liquid.

Periodic cleaning of a deposited solid is required, you remember sometime back we have said that deposited solid. Let me show it again, deposited solid that we had said earlier here. So, that deposited solid was this 8. So, this is a solid or impurities. So, that must be cleaned periodically otherwise, that will create again some source of infection, which is not desirable right that is what we are also saying here.

So, what is that that better separation is obtained by the disc bowl centrifuge ok, better and, due to the formation of the thinner layers of liquid right. So, the other one was your tubular centrifuge, but in the tubular centrifuge, then that the disc bowl centrifuge is much better because, it is making some thinner layer. So, for which and because, you see that disc how they are right this is available, in very lab in any dairy institute this is available.

So, small size and all the disc in like that the previous one, which I have shown you that the disc one like this right, these are there in every lab it is there and, they are they look like this. So, this height and yes they are so, compact that is why, it is much better than the tubular ones right. So, disc bowl centrifuge is and, till that I tell you till that people could not make anything better than that for the separation of the cream. This is very easy very I mean low cost, but separation is very high and, till now as no alternative could have switched over from these two the new one because, it a till now it has been found that this is the most viable and, most utilized most efficient one that say disc bowl centrifuge right.

Other if you see as we said tubular centrifuge, or many others they are in no comparison closure to the disc bowl one right. So, if you want to separate cream, then you have to use the disc bowl centrifuge only right. So, periodic cleaning of deposits, or solids they are compulsory, or mandatory, then disc bowl centrifuge disc bowl centrifuge in addition to bring widely used for separation of cream from whole milk is also used for clarification of oils, then coffee extracts and juices right and separation of starch, gluten etcetera right.

So, the application of disc bowl centrifuge, not only for this say fat separation, but also for clarification of oils, or coffee extracts and juices, and separation of starch gluten, all these applications the disc bowl centrifuge is used very well right. Now, if you remember I said the other day, or even in the last class also that the fat globules, they are try to agglomerate and then get separated right and, these here also we have shown that the gravity separation as well as the centrifugal separation right.

So, if I give you a problem, can you do that and do not expect that tomorrow I mean the next class I will do it, this is for you only, that let us frame one problem utilizing the information given here right, this information if we utilize that in one case this and in the other case that. The found find out, you write the problem that find out.

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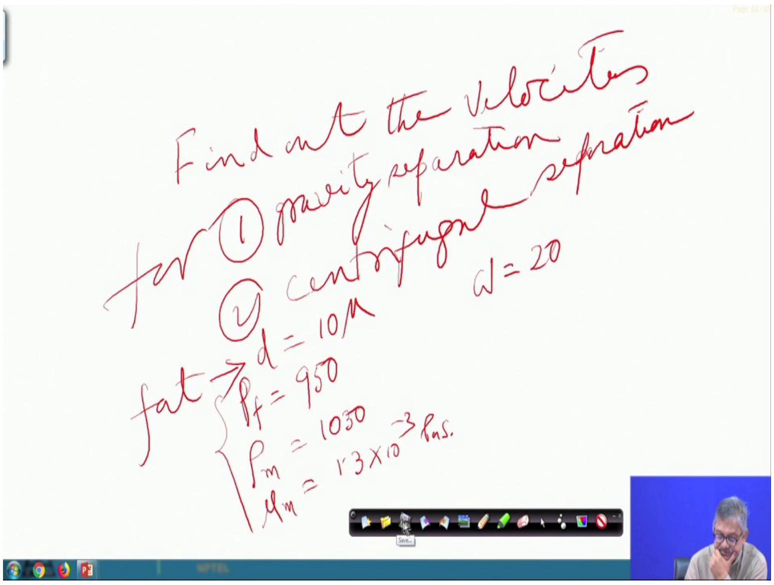

So, let me write here find out the velocities for

(1) Gravity separation,

(2) The centrifugal separation,

For a milk fat having a diameter (d) = 10μm,

The density of the particle of low fat $\rho_f = 950\, kg/m^3$

Density of milk $\rho_m = 1030\, kg/m^3$

So, in that case your all gravities are over and μ= 1.3×10^{-3} Pa.s

So, with this same information the other one is say angular velocity ω, this is 20 radians per second and, other then ω what you need this is all given right. So, if you come back to our original, if you come back to the original ok.

If we come back to the original what else is required, this already given right this already given this is also given one g value of course, you take 9.81 m/s^2. We have given d this d is the diameter of the fat and r is equals to 0.4 meter.

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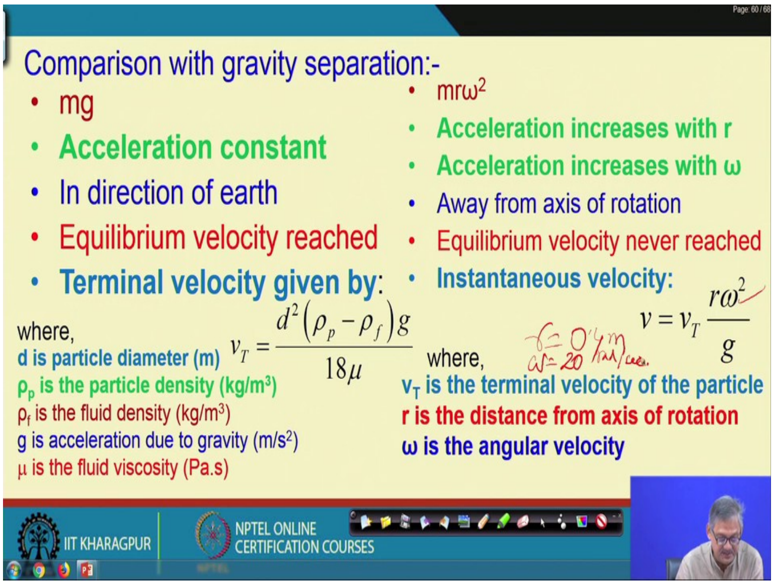

If we say this r is equals to 0.4 meter right omega, we have given angular velocity that, we have given 15 or 20 say 20, then it becomes easier 20 radius per second right. If this is given, then find out what is the v_T and what is the v. So, if this you compare and see the difference you will find v is much higher than v_T ok.

Thank you.