Dairy and Food Process & Products Technology

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Lecture - 46
Milk Homogenization

So now, we are in the 46th class in Dairy and Food Process and Products Technology right, we had finished with standardization, but to have a little more.

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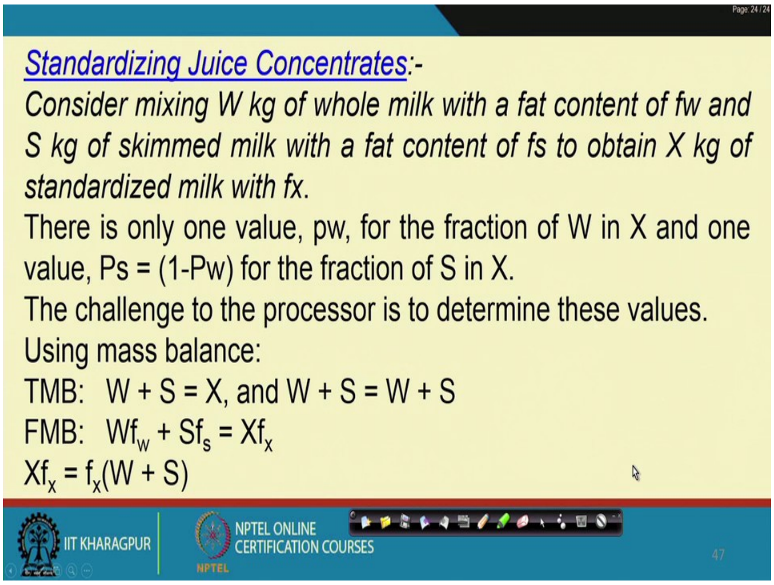

So, I am just showing it, I am not going through it because now we will go to Milk Homogenization. So, before that just showing that standardizing juice concentrates, so this is one such way you can do the standardization.

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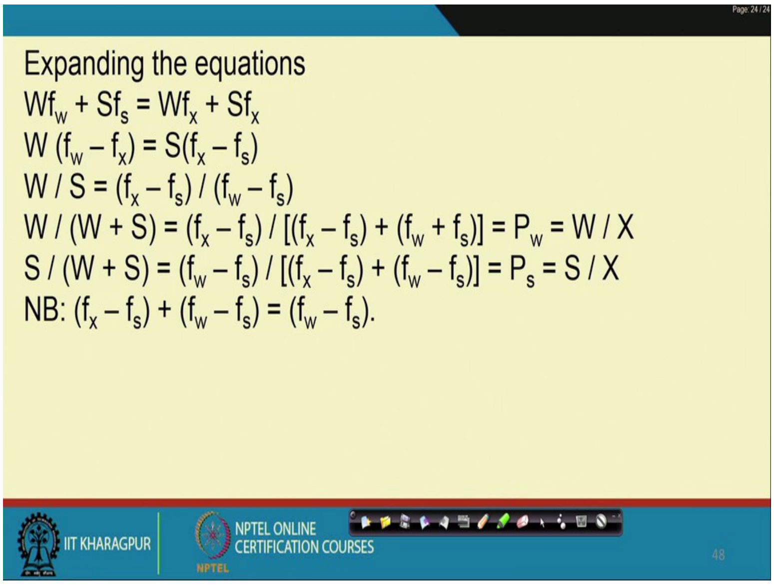

And that is simply by mass balance, so by doing mass balance you can also do this.

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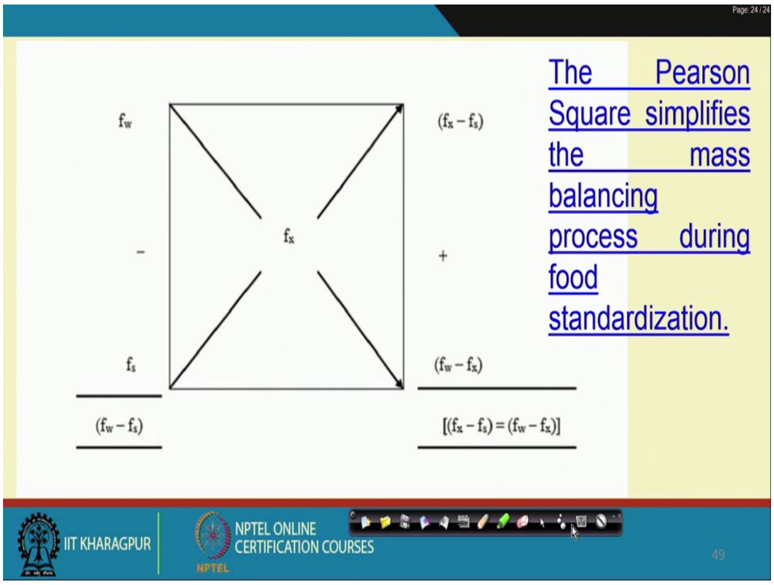

And using the Pearson square which we have already said earlier this is a more elaborative example of doing that Pearson square.

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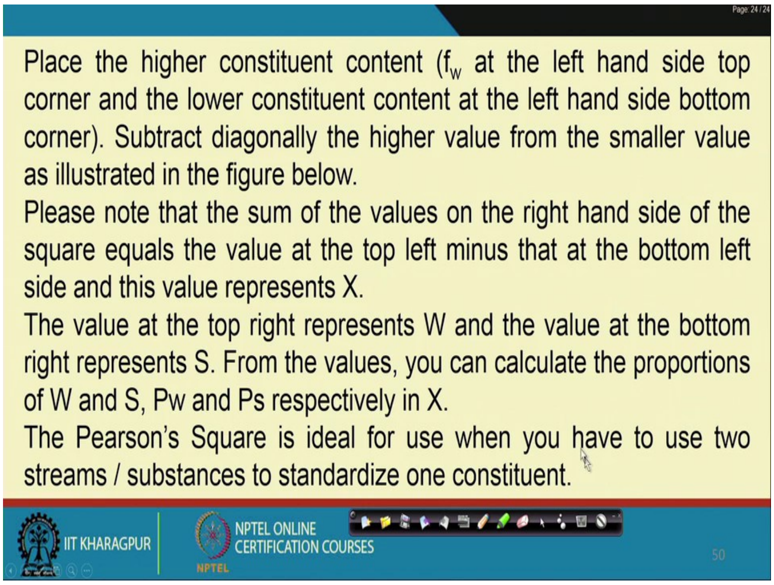

How the Pearson square is being used this is here been shown and some examples we have dealt with, and these examples you can also work out and do that right using the Pearson's square technique also.

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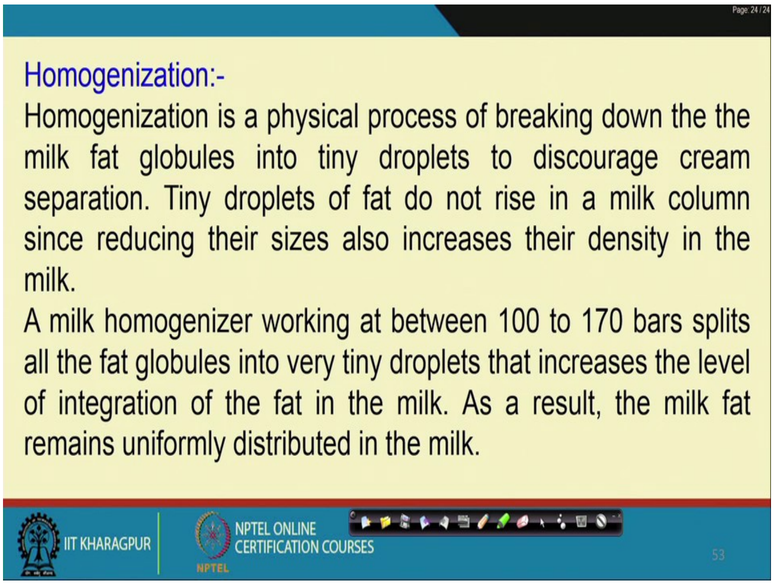

Now, we come to homogenization, so this homogenization is very very important step in milk because as we have said earlier also that milk do contain fat in different sizes right. So, ranging from say decimal micron to around 25-30 µm this sizes are there and fat do have a common tendency to agglomerate. So, after agglomeration they became bigger sizes and from that they do come out to the surface right this is by going we have said by Stokes law you can find out at what rate this fat will get separated given a diameter right.

So, to avoid that for a longer period to keep the milk for a longer period at no separation of fat. The next step required is pasteurization. In pasteurization, you have killed all the pathogenic organisms. So, after that you need to homogenize, so homogenization is for the for the settlement; for the fixation of the fat content right. So, that fat content will not reduce because of separation to do that you need to do say homogenization.

Now, homogenization is a physical process of breaking down the fat right, milk fat globules into tiny droplets small, small that will dictate at what may be 1 micron, may be 2 micron, may be 3 micron.

That size you will decide and to that all the bigger sizes will be brought down of course, smaller sizes you cannot you cannot elevate, but the bigger ones will be brought down to the smaller ones to discourage cream separation; tiny droplets of fat do not rise in a milk column since reducing their sizes also increases their density in the milk. Because more the size bigger the size was there less was the number now less is the size bigger will be their numbers. So, more fat dense will be there in the particular or in a density in a particular one or uniformly it will be.

A milk fat a milk homogenization is working at between 100 to 170 bars that splits all the fat globules into very tiny droplets that increases the level of integration of the fat in the milk. As a result the milk fat remains uniformly distributed in the milk right.

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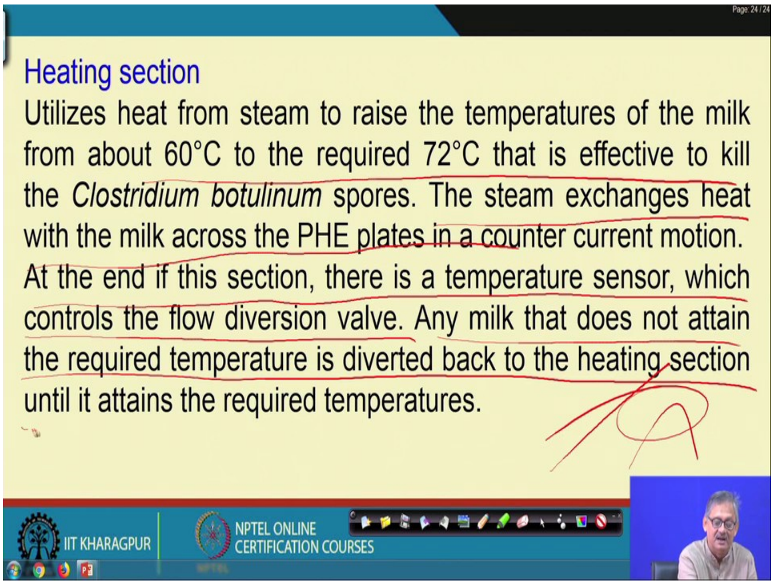

Now, there is a heating section because milk homogenization subsequently is seen that homogenization is also a function of temperature, the higher the temperature better is the homogenization right. But there is also an optimum it is not that it will go on increasing like this steadily right, it will not go on increasing like this steadily that is also there that it will go like this it will be like this. So, there will be some optimum or maximum were the temperature is good.

So, that is why it is that about 60 to 72°C is effective to kill the *Clostridium botulinum* spores. The steam exchanges the heat with the milk across the plate heat exchanger in a counter current motion at the same time at the end of this section. There is a temperature sensor which controls the flow diversion valve in a milk that does not attend the liquid temperature is diverted back to the heating section until it attains the required temperatures right.

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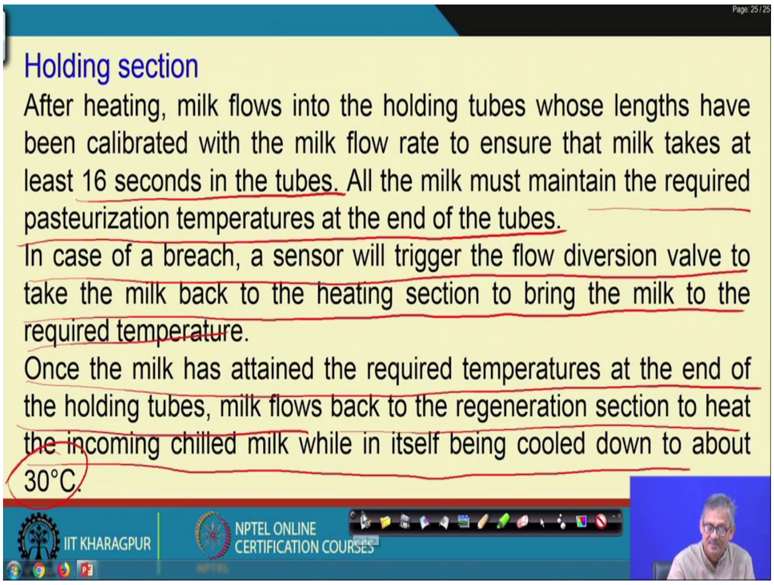

Once you got the temperature then holding section there is a after heating milk flows into the holding tubes, whose lengths have been have been calibrated with the milk flow rate to ensure that the milk takes at least 16 seconds in the tubes. All the milk must remain in the required pasteurization temperatures at the end of the tubes. In case of breach, a sensor will trigger the floor diversion valve to take back the milk to the heating section to bring the milk to the required temperature.

Once the milk has attend the required temperature at the end of the holding tubes milk flows back to the regeneration section to heat the incoming chilled milk while in itself being cooled down to about 30°C. Now, after that that is again back to a pasteurization after that it goes to chilling or cooling which again is being done by a plate heat exchanger.

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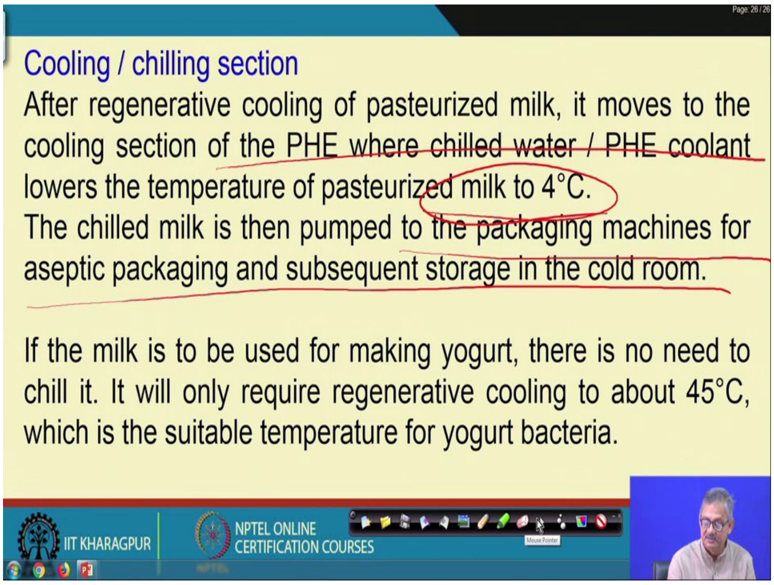

So, that it is brought down to after pasteurization brought down to 4°C and the chilled milk is then pumped to the packaging machines for aseptic packaging ok, but before that this is homogenized which we have said that this is done right.

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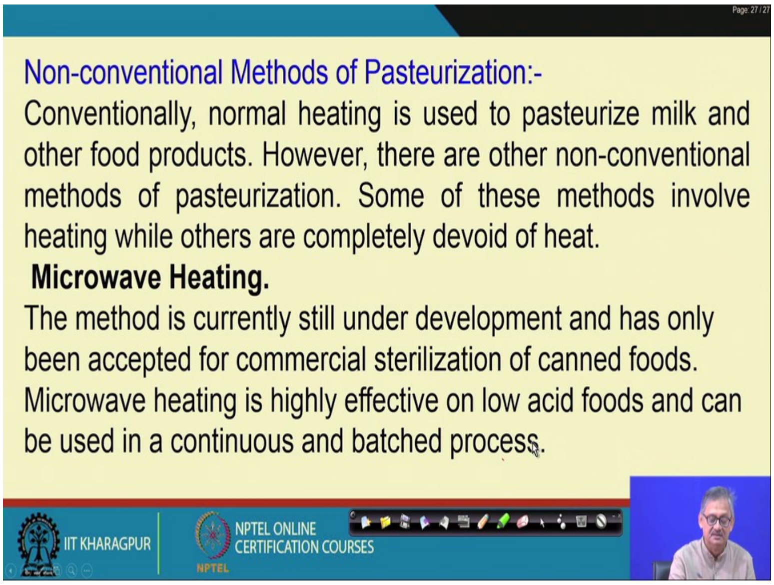

So while homogenization we do.

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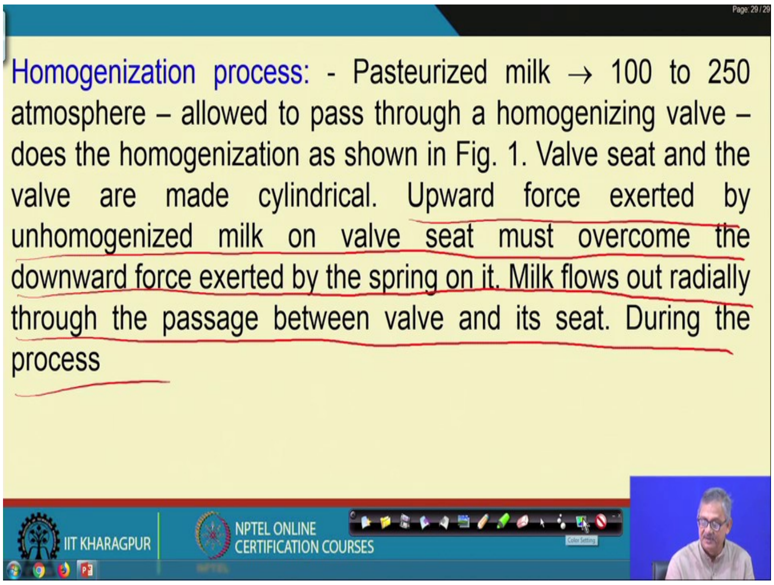

That homogenization what it does pasteurize milk around 100 to 125 atm is allowed to pass through a homogenizing valve right. This homogenizing valve it does the homogenization right, as given in the next figure will show the figure is like this let us go back to that figure which will be easier to understand.

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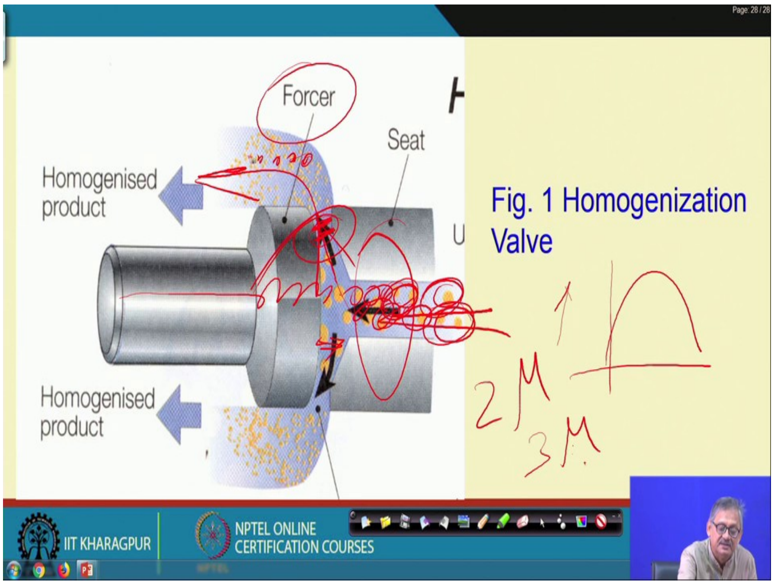

So, this is that homogenization is being done here, so milk is flowing like this right. So, these are the fat bigger fat globules they are moving right through this slit; this is the slit gap right this is slit gap.

So, through this slit it is going; I hope if you have gone through our earlier class that was on that the naming of the class was not on milk that was general class on the fluid flow right. The fluid flow if you had gone through there you might have seen that the velocity profile and all others we have done when it is flowing through a slit like this right that we have done. So, there we have not taken like this the fat globules we have taken a general fluid, but and there we have shown the velocity profile how the velocity profile is coming like this right ok.

But when this fat globules are going through this slit whose size is according to your desirable size, what do you want 2 μm then this size will be 2 μm, if you want 3 μm then this size will be 3μm. Therefore, according to your requirement this is right and this is a seat this is the forcer which you are adjusting what the distance will be or how the how the pressure will be. So, this is going that homogenized fat globules which are of smaller size like this right these are the smaller sizes homogenized product is going right.

So, this is the homogenization valve, so if we go back to that if we go back to that then we say that the valve seat and the valve are made cylindrical, made of cylindrical structure upward force exerted by the homogenized milk on valve seat must overcome the downward ex exerted downward force exerted by spring on it milk flows out radially through the passage between the valve and the seat during the process what happens during this process we have show already shown the valve.

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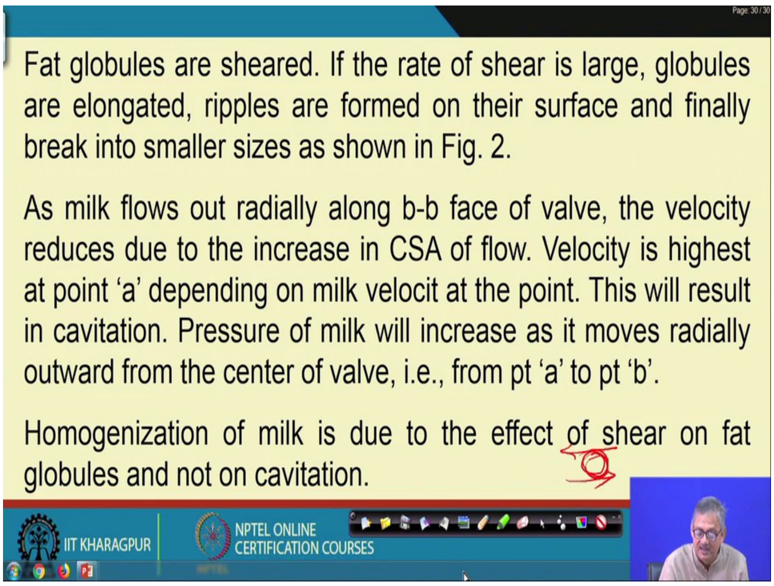

So, during this process the fat globules are sheared right this is the fat globule. So, a force is acting like this, so by that they are there is shear action on the fat globule and this fat globules then if you look at the other figure it will be like this right.

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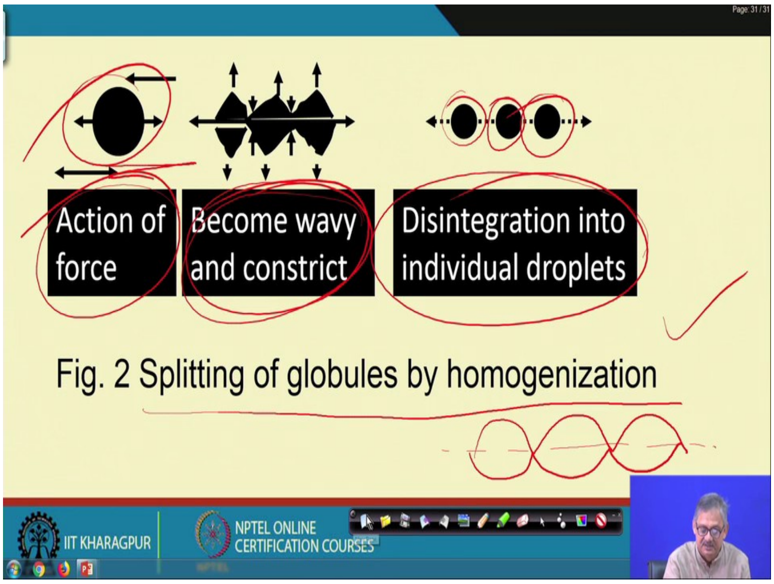

So, this is the fat globule, so there is a shear action that is happening like this and because of that the fat globule is getting say it is enlarged view like this they are getting segmented right and ultimately this is becoming the intermediate become wavy and constrict right. So, this is the action of the force this becomes wavy and constrict and this disintegrate into the individual droplets from this bigger droplet to the smaller ones they are getting by the shear action. So, this is splitting of globules by homogenization this mechanism follows right.

So, now we go back to that, so that is what is happening in the in the homogenization valve that if the rate of shear is large globules are elongated, ripples are formed on their surface and finally, break into smaller sizes as we have shown in the next figure right, as milk flows out radially along the face say bb that is not we have not shown here right. So, on the face of the valve the velocity reduces due to the increase in the cross sectional area right.

Velocity is highest at point say ‘a’ depending on the milk velocity at that point this will result in cavitation and pressure of milk will increase as it moves radially outward from the centre of the valve that is from the point ‘a’ to the point ‘b’. So, that if we can we can see this show radially here radially so; that means, it is going like this right. So, if this is point ‘a’ and if this is point ‘b’ according to that what we are referring to right. So, that is how it is, so from point ‘a’ to point ‘b’.

Homogenization of milk is due to homogenization of milk is due to the effect of shear on the fat globules and not on the cavitation though there will be cavitation, but the fat globules are fat globules are disintegrated into smaller ones by the shear action right this shear action takes place and that is what.

Now, in that cavitation one thing which will may not be able to explain in more in detail that you know that if there is pressure in a bubble, and then it gets exploded right that is called explosion. The inside pressure is more than the outside pressure, but if it is the other way if the outside pressure is more than the inside then that is called earlier it was explosion. Now, this one will become implosion right in cavitation that implosion takes place and by which. So, in the fat globules also get disintegrated right this also you keep in mind.

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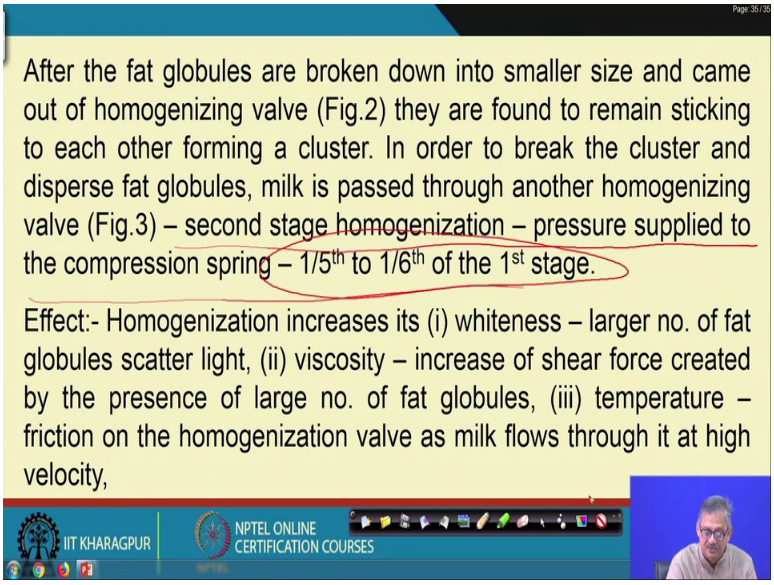

Then this we have already said, so after the fat globules are broken down into smaller size and shear and came out of homogenizing valve they are found to remain sticking to each other form a cluster and in forming a cluster, in order to bring the cluster and dispersed fat globules milk is passed through another homogenizing valve, that is that is the second homogenizing valve and this second homogenizing valve takes place, second homogenization and the pressure is around one-fifth to one-sixth of the first right.

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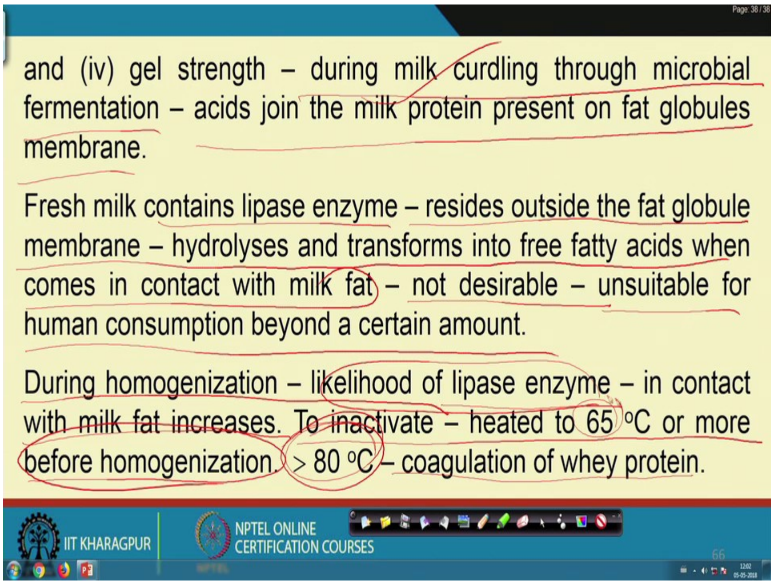

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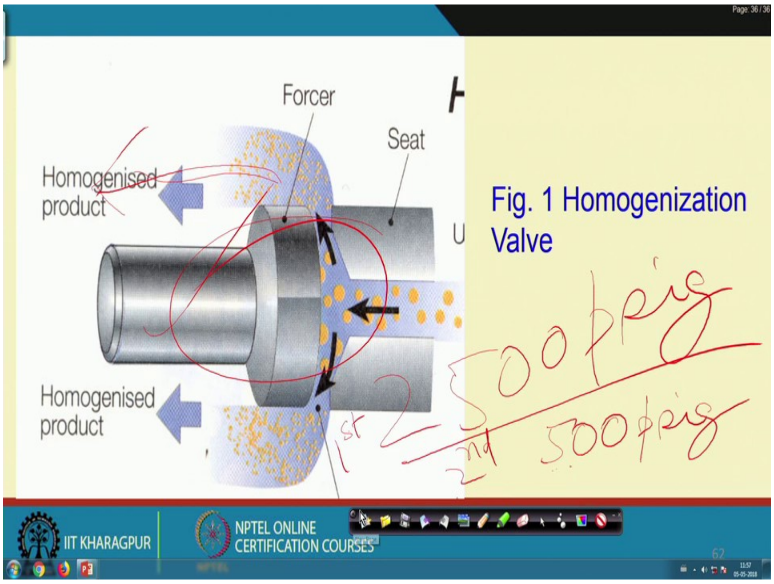

However, this second homogenization valve so that is like this one from here which goes to another valve this one it goes to another valve right, along with this say this is one valve and say this is acting around say 2500 psig right, if this is acting at that another valve similar to this that was around one of this that is 500 psig right. So, that is called this is called first stage this is called second stage homogenization that is two stage homogenization right.

So, if we take that then we can say that in the second homogenization it is taking place at around one fifth of the first that is that is if the original was 2500, now it is 500 psig, why it is required because why it is required because when the first stage homogenization from the bigger to the smaller ones it happen these smaller ones start to agglomerate again and again become bigger one right.

So, this, so that in future in further this should not happen that second stage is there and which works at much lower pressure then the former one around one fifth of the former one say if the former one is 2500, now it is 500 only psig that is why I am saying because in bar it will be much low less in number.

So, it is and you can convert in atmosphere and in Pascal. So, those are convertable, but since the number is unique to 2500 psig and this is 500 psig that is why I am giving the difference with respect to psig. So, that the numbers you can remember 2500 and 500. So, these are the two stages and these in the second stage this agglomeration gets further ruptured, and then permanently it is form into the smaller size as you have decided 2 µm, 3 µm whatever right.

The what are the effects of homogenization, effect of homogenizations are like that that the homogenization increases its whiteness larger number of fat globules are produced that is why light is scattered then viscosity increases, viscosity increases and this is increases the shear force created by the presence of large numbers of fat globules. Then temperature is also increases because of the friction on the homogenization valve as milk flows through it, high at high velocity temperature is also increases the hand and fourth one is that gel strength, gel strength during milk curdling through microbial fermentation acids joins the milk protein present on the globule membrane.

So, gel strength increases, fresh milk contains lipase enzymes; resides outside the fat globule membrane hard and hydrolyzes that and transforms into free fatty acids, when comes in contact with the fat this is not desirable and undesirable for human consumption be under certain level. So, lipase enzyme has to be inactivated and this is done during both pasteurization and homogenization both are at high temperature right.

Now, during homogenization there is a likelihood of lipase enzymes to be active in contact with milk fat increases to inactivate this is heated up to 65°C before homogenization or 80°C is coagulation of whey protein if it is beyond 80°C this is done at 65°C.

If it is beyond 80 degree centigrade then coagulation of whey protein occurs because we said whey protein is a soluble protein, but it is soluble till the temperature is low solubility goes down if the temperature goes beyond 80 degree centigrade. So, that is why you cannot heat beyond 80 degree centigrade otherwise that that this soluble whey protein will come out or separate out from the milk right.

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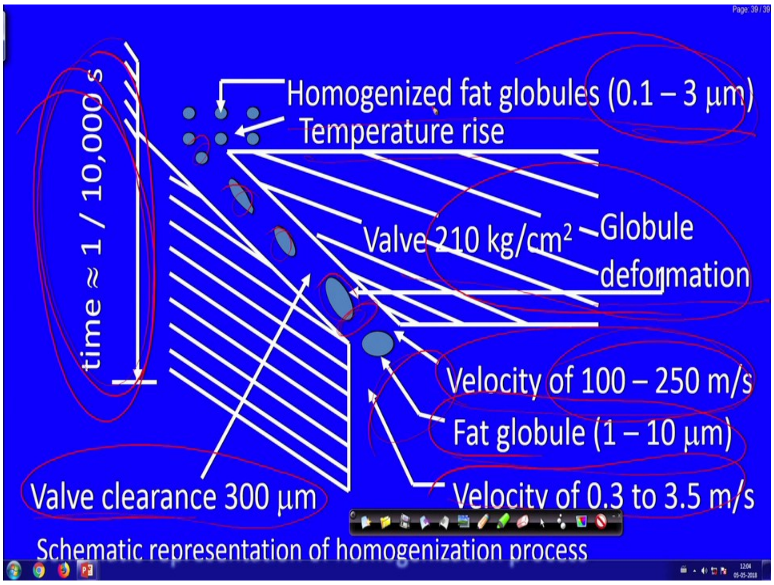

(Refer Time: 23:45) if you look at this is a true picture of the valve where it is going through, the fat globules are like that right it is getting shattered and then becoming smaller you see the time scale given is around 1/10000 second that time it is happening.

And velocity or valve clearance is around 300 µm, this is the schematic presentation of the homogenization process velocity of point 3 to 3.5 m/s is a fluid that is milk velocity that is occurring, fat global size is between 1 to 10 µm say velocity of around 100 to 200 m/s is at the at the inlet and because outside it was low. So, the moment is going into the smaller diameter you need a smaller size velocity is increasing drastically.

Valve is around 200 kg/ cm^2 that is the pressure is being applied and their global deformation take place, like this was the one from where this is gradually deforming and then coming to that. So, homogenized fat globules between point 1 to 3 µm as you are deciding that is being produced right. So, this is the flow diagram or the pictorial diagram of the fat globules.

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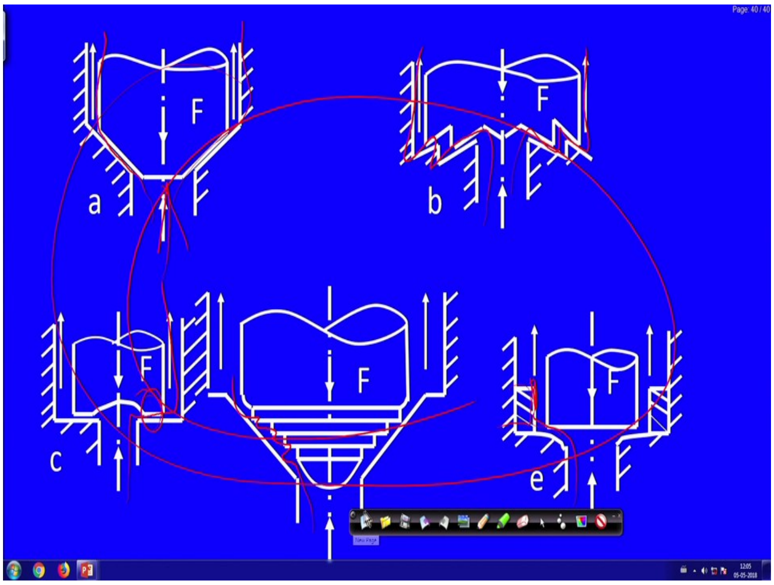

And the valves are like that there are different types of homogenization valves different ways different types right and you see depending on this is a flow diagram. So, They are going through this one is such and there is that this is good going a zigzag path like this right then another one where the slit is here.

So, going like this the another one is stapered like this going like this is stapered right. And the fifth one could be there is a baffle in between and that is going through that should bending on that different size different type different different geometry. They will be different configuration there will be different type of pressure generation, and different fragmentation also will happen right.

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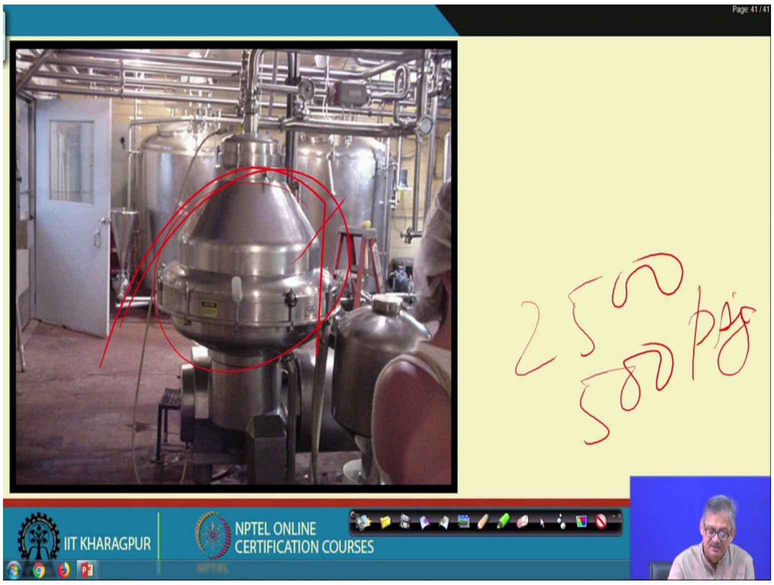

So, this is a generalized homogenizer that homogenizer looks like that the pictorial view homogenizer looks like that, hopefully in any diary industry or institute this type of homogenizer is there, and that will dictate a pressure, there are two stage one pressure is generally 2500 psig and another pressure is 500 psig right, this is the pictorial view of the valve right.

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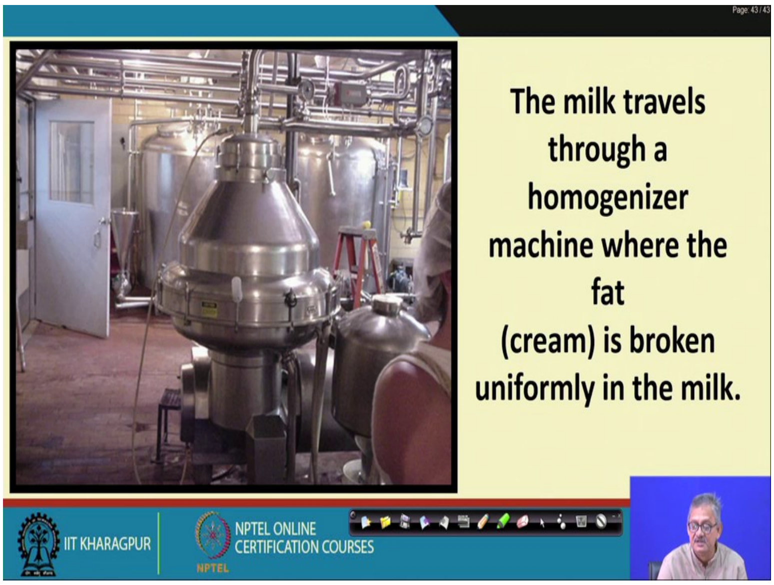

And milk travels to the homogenizer machine where the fat that is cream is broken in uniformly right.

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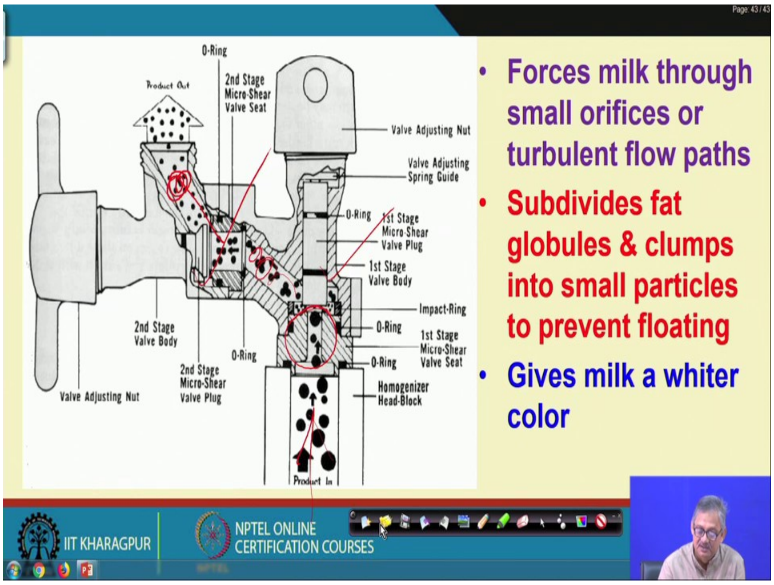

So, this whish you I was looking for that that two stage this is that typical two stage valve or picture as you had given figure 2. This is like that this is the first stage, this is the second stage the milk is flowing through the first stage again getting agglomerated and through the second stage it is coming to the smallest size as you have given right this is the two stage homogenizer valve right.

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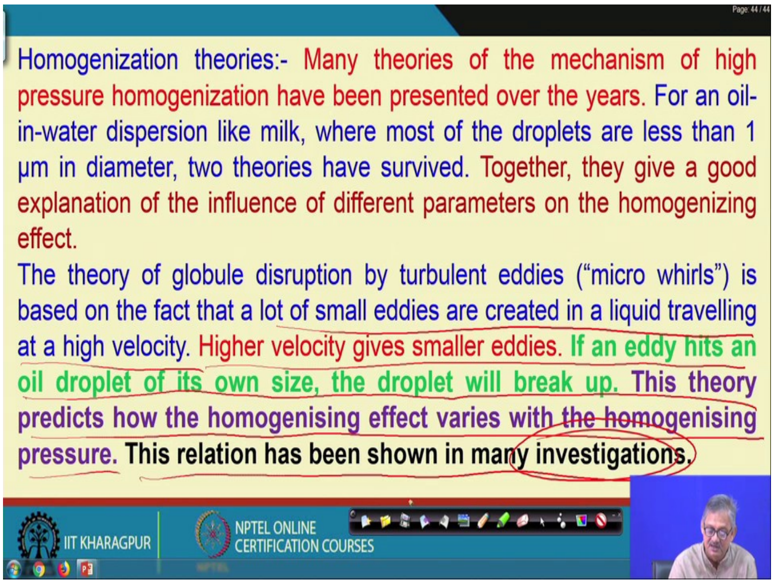

The theory is like this; let us go quickly many theories of the homogenization of high pressure homogenization have been presented over the years for and oil in water dispersion like milk where most of the droplets are less than 1 µm in diameter, two theories have survived. Together they give a good explanation of the influence of different parameters on the homogenizing affect.

The theory of globule disruption by turbulent eddies that is micro whirls is based on the fact that a lot of small eddies, are created in a liquid travelling at a high velocity higher velocity give the smaller radius. If any eddy hits an oil droplet of its own size the droplet will break up this theory predicts how the homogenizing effect varies with the homogenizing pressure this relation has been shown in many investigation, the other one is like this that the cavitation theory.

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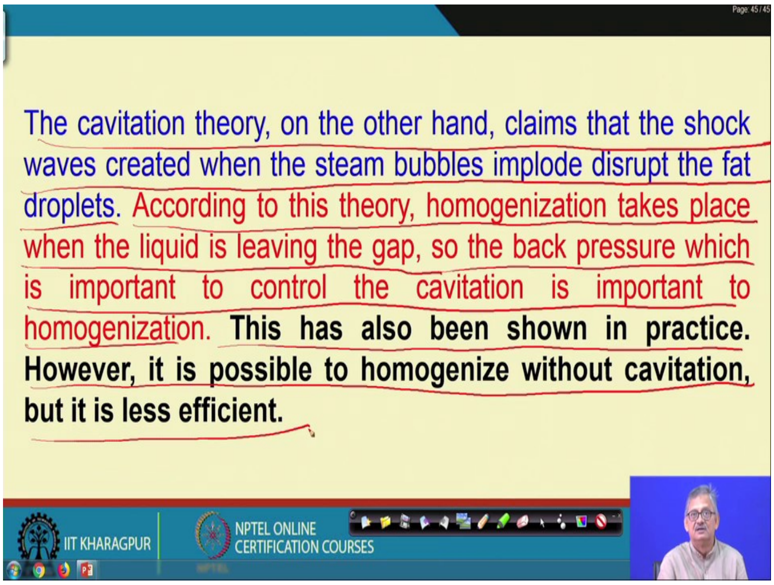

The cavitation theory says that on the other hand claims this cavitation theory claims that the shock waves created, when the steam bubbles implode disturb the fat droplets according to this theory homogenization takes place when the liquid is leaving the gap.

So, the back pressure which is important to control the cavitation is important to homogenization this has also been shown in practice. However, it is possible to homogenize without cavitation, but it is less efficient right, so we have ended up to this class.

Thank you.