Dairy and Food Process & Products Technology

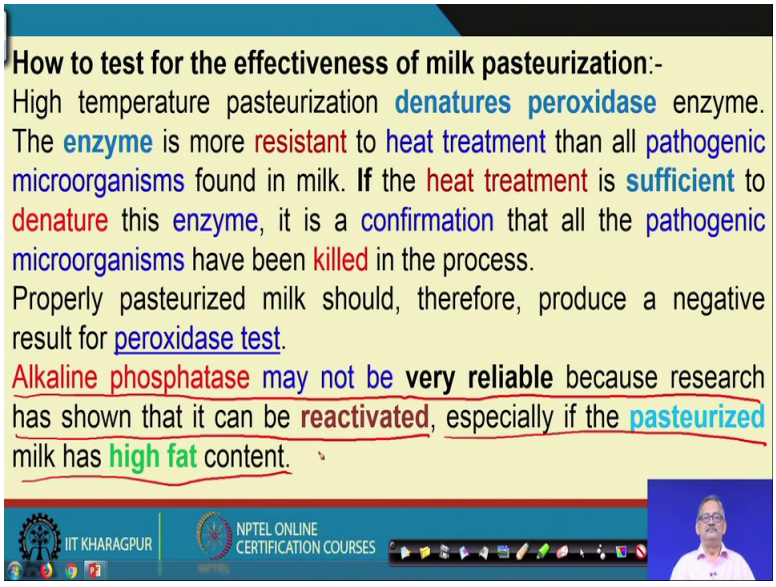
Prof. Tridib Kumar Goswami
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur

Lecture - 43
Pasteurization Effectiveness

So, we are seen in pasteurization or low temperature low time also high temperature, high temp perhaps high temperature high time we will discuss a little more. So, in this Dairy and Food Process and Product Technology course we are in lecture number 43. We also will try to cover up the effectiveness of pasteurization that you have pasteurized how much it is effective right. So, that should also be known. So, is that pasteurization is correct or not.

So, how to know that so, there is some process; some techniques by which you can know that how the pasteurization was effective or not how whatever you have done is good or not that should be known. So, we will do today that also along with maybe some high temperatures,or high temperatures short time pasteurization right.

(Refer Slide Time: 01:23)



So, how to test for the effectiveness of the milk pasteurization so, high temperature pasteurization denatures peroxidase; so, peroxidase is an enzyme right. So, this is highly heat resistant enzyme peroxidase. So, if the enzyme preroxidase is inactivated then we

can call that the pasteurization is effective right this is one there may be some other technique also.

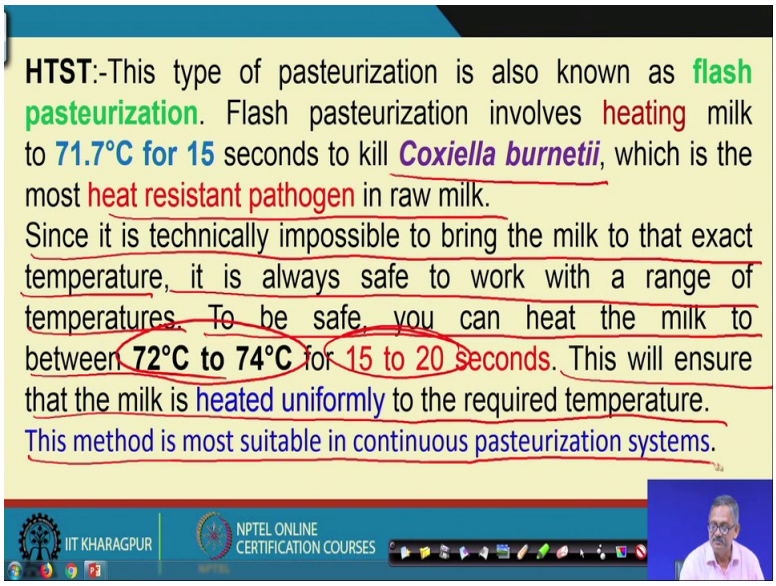
So, peroxidase test is one of them where if it is denatured or if it is destroyed then it can be said that pasteurizations is ok. The enzyme is more resistant to heat treatment then all pathogenic organisms or microorganisms found in milk and if the heat treatment is sufficient to denature the enzyme, then it is a confirmation that all the pathogenic organisms are also destroyed or killed right in by this process. So, properly pasteurized milk should give a negative peroxidase test, peroxidase test if you perform so, that should give you a negative test right.

Now, another way is that another way is that alkaline phosphatase test that may not be very reliable because research has shown that it can be reactivated, especially in pasteurized milk as high fat content right. So, as I said now there are many techniques by which you can know you can judge pasteurization was effective or not. So, in early days earlier times that alkaline phosphatase used to be taken as one of the target test or one of the tests by which the effectiveness pasteurizations can be judged. If alkaline phosphatase used to give you negative result; that means, pasteurizations is effective.

But after our subsequently research on these apps that studies on this have you reviled that the alkaline phosphatase is not good enough because it may regenerate reactivate some of the organisms which might not have been killed, but phosphatase might have seen to be negative. So, that pasteurization reactivates that phosphatase test. So, that is because high fat content in the milk may reactivate that the some of the phosphatase and it may not be again negative. So, that is why it is not dependable.

Whereas, peroxidase test if it is negative then confirmly it may you can say that you are a you are pasteurization process that is heat killing or heat method heating method that was absolutely and you can depend on this result right.

1(Refer Slide Time: 05:27)



2

3We may again come back to HTST because some more things are to be said about HTST
4that is a high temperature short time. So, this type of pasteurization is also known as the
5flash pasteurization because time requirement is very low. Flash pasteurization involves
6heating milk to 71.7°C for 15 seconds to kill the target organisms that is your *Coxiella*
7*burnetii*, that can be killed at 71.7°C for 15 seconds which is the most resistant pathogen
8in the milk, in raw milk this is the most resistant pathogen.

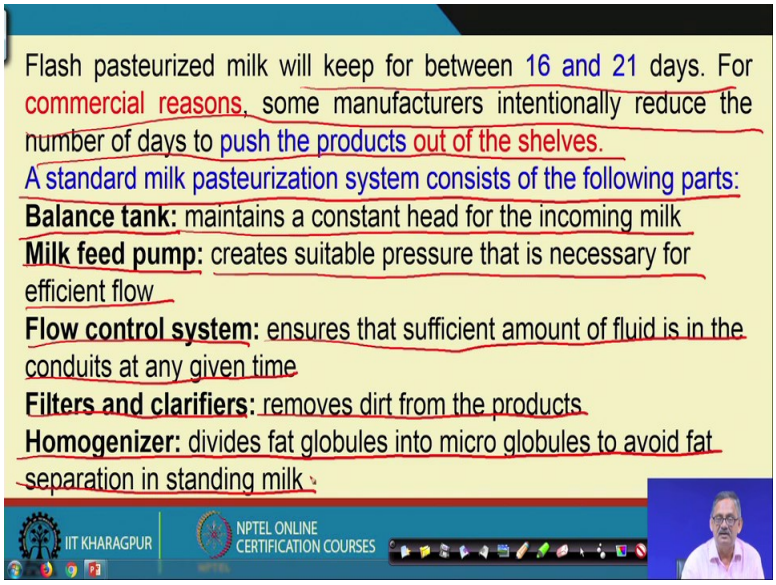
9Since, it is technically impossible to bring the milk to that exact temperature normally it
10is always safe to work with range of temperatures right. To be safe we can do it that milk
11heating between 72 to 74°C for 15 to 20 seconds, this is for all precautionary purpose
12that coming exactly on 71.7°C maintaining it for 15 seconds may not be all the time
13technically feasible.

14So, for from the technicality or from the technical point of view you increase the
15temperature a little may by some decimal like 71.7 to 72.3 degree is nothing or 72 to 74
16within that temperature if you can hold it for 15 to 20 second. Then you are safe that
17your pasteurizations that is high temperatures short derived pasteurizations is over and
18you can be very much safe, that it will not cause any infection to the consumer. This will
19ensure that the milk is heated uniformly to the required temperature and this method is
20most suitable in continuous pasteurizations systems because we said the error batch
21pasteurizations, batch pasteurizations normally called LTLT that is low temperature long

1time. But high temperature short time that can be you batch or that can also be 2continuous because your time duration is very small 15-20 seconds.

3So, that is the holding period. So, if your heat exchanger is this inlet fluid is coming from 4here, exit is going from there within this it is staying within 15 to 20 seconds that is their 5whole exchanger is at 72-74°C and your allowing it to inlet to exit 15-20 seconds. And 6that is good enough for killing all organism because you have killed with that target 7organism *Coxiella burnetii* right. So, *Coxiella burnetii* is the most resistant pathogen if 8there is kill all the organisms are killed pathogen organisms of course, right.

9(Refer Slide Time: 09:12)



10

11Then flash pasteurizations are pasteurized milk will keep will keep for between 16 and 1221 days. For commercial reasons, some manufacturers intentionally reduce the number 13of days to push the products out of the shelves, because if it is lasting for 20-20 days 14right then the sell may be depleted. So, to avoid that the manufacturers might make it 15purposefully that know you to till not last for 20 days. So, 5-7 days by which if we have 16to consume otherwise it is not safe so that the demand remains in the market.

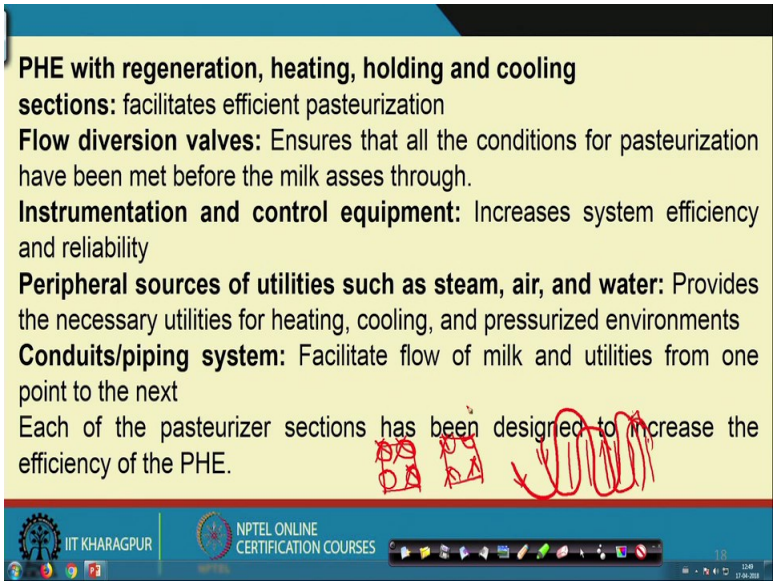
17So, that is business tactics not the scientific tactics, scientifically 72 to 74°C for 15 18seconds good enough to keep pure milk for around 20 days safe right. Standard milk 19pasteurization system consists of the following parts like balance tank that maintains a 20constant head for the coming milk, incoming milk. Milk feed pump which creates 21suitable pressure that is necessary for efficient flow. Flow control system that ensures

2

1sufficient amount of fluid in the conduits at any given time filters and clarifiers that 2removes dirt from the products.

3Then homogenizer that divides the fat globules into micro globules to avoid fat 4separation in standing milk. Of course, homogenization will come separately in detail 5because that is also one very vital step in milk processing, like pasteurization is one 6similarly homogenization is another also standardization. So, these three we will cover it 7there in this are subsequently class very thoroughly right.

8(Refer Slide Time: 11:45)



9

10Then we come to this that PHE that is plate heat exchanger were this heat transfer takes 11place right. Plate heat exchangers on like that so many plates are there right. So, 12alternatively this may go like this and may come like this is one way and if I could 13change the pen colour. However, I do not know how to make that.

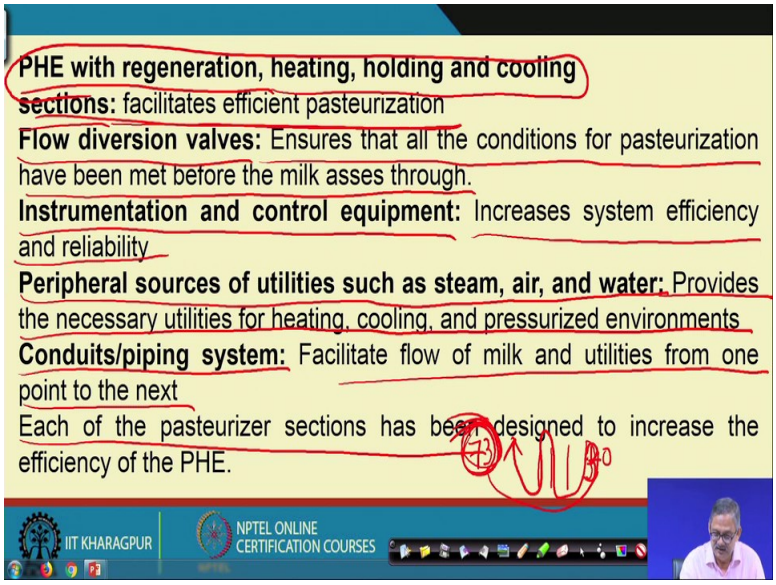
14So, let us give the arrow. So, if this is your one and this is that one another, this we it is 15coming. So, another thing may be like that it is going like this like that like this right so, 16that may be another. Now, depending on this flow in PHE I am not of course, discussing 17much on PHE because when will be covering the entire world not possible. Plate heat 18exchanger were plates are there and depending on that say a plate looks like this right 19and it has 4 holes so, 1 2 3 4.

2

So, depending on which hole is open and which hole is close say this one. So, it will come here and fill up and then go to the next by this and then depending on the next one to where it is open maybe this, this, this and that. So, where it is open may be say this one is open and all these are closed. So, there it will go out. So, like that that ports are arranged in such a way that in one plate it will be the milk and the other plate the heating medium normal it is steam, normally it is steam right. So, that way the plate heat exchanger works right.

So, the when you are using plate heat exchanger then you can have the regenerator.

(Refer Slide Time: 14:16)



Now, regenerator means that your as again which said so, if your milk has come like this. So, this milk it was at a inlet temperature of say 40°C say or say 30°C room temperature. Now, it is heated to 73°C right; now these 73°C we have to cool right. So, these extra heat if you can extract then that becomes a pre-coolant for the other or pre-chilling for the other pre-heating sorry pre-heating for the other.

So, that pre heating can be done which is that going at 30 degree now with that can be made. So, that is again getting heat exchange. So, that the exit which came out at 73°C lot of heat can be removed from that, that is what is the regeneration right, where in PHE this regeneration or heating or holding and cooling this can be done. These sections are also very much important. The facilities efficient pasteurizations for these selections are required, these section selections are required. Flow diversion valves are there that

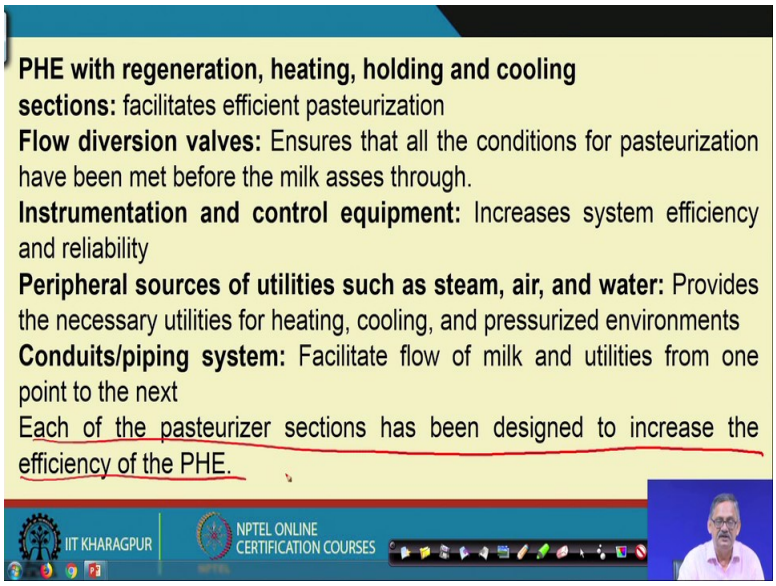
ensures that all the conditions for pasteurization have been have been met before the milk access through because ultimately the pasteurize milk will be assed with it is pasteurized or not. So, before that is done. So, you have correctly pasteurize that will be controlled by the flow direction valve.

Instrumentation and control equipment there is one of the primary, because instrumentation and control will dictate whether the time temperature combination has correctly done or not because based on that your pasteurization efficiency will depend. So, that is one of the primary as your selection or section process primary section when you are selecting; increases system efficiency and reliability. Peripheral sources of utilities such as steam, air and water, in most of the cases as I said the heating medium is steam.

In most of the cases heating medium is steam, but incases it can be water also right. Normally, air is not used as may be used for cooling, but not for that right because air is not a good medium for a heat transfer; here you need that efficiency it to be high. So, steam and water normal is use hot water. So, that provides the necessary utilities for heating cooling and pressurized environments. Then conduits piping system there are because if it is not a small unit if it is a large unit so, there may be from one end to other end you have to move several meters or several 10's of meters and in that case that piping properly to be done.

One good example if you are very close to Mother Dairy or Amul right you can visit and see how exorbitant those systems are right. Then this facilitates flow of milk and utilities from one point to the next point.

1(Refer Slide Time: 18:30)

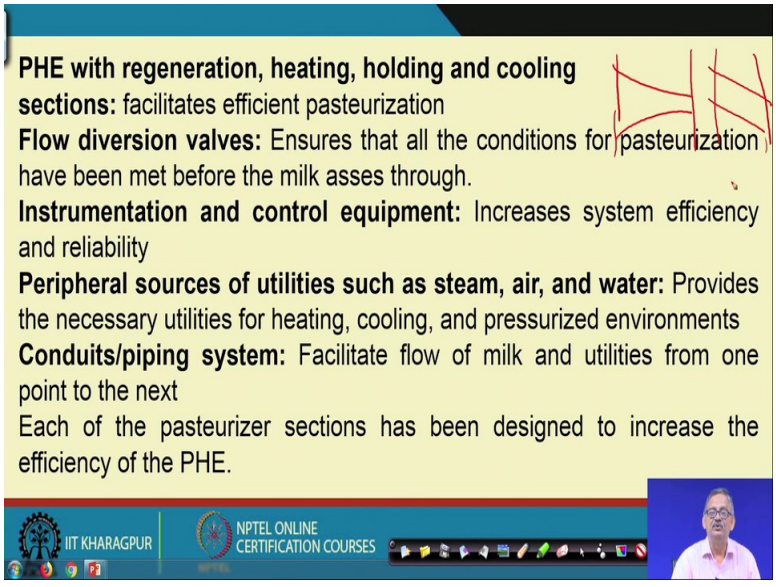


2

3Each of the pasteurizer sections have, each of the pasteurizer sections has been designed 4to increase the efficiency of the plate heat exchanger, ultimately your blood heat 5exchanger efficiency has to be used.

6So, you what you are doing you are regaining or regenerating the heat so, that your 7efficiency of the plate heat exchanger goes up and again when you learn PHE, plate heat 8exchanger then you will see that co-currency and counter currency these are the two 9terms which are very important.

10(Refer Slide Time: 19:11)



11

1

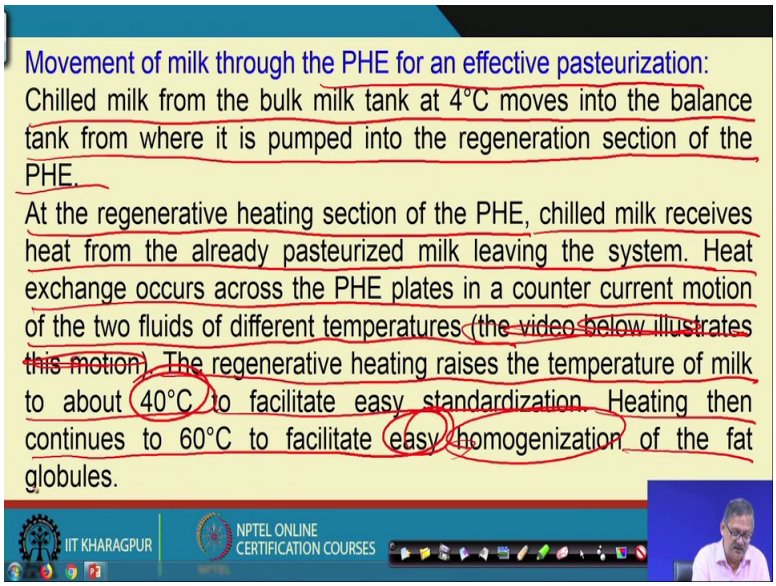
2

We know that in any heat exchanger when it has come up here let me also tell that if any heat exchanger if it is parallel heat transfer then your curve looks like this right. And if it is a counter current heat exchanger then your heat transfer looks like this.

So, depending on whether the flow was parallel or counter current so, that word which is coined as co-currency or counter currency. So, how much co-current, how much counter current that will depend on your flow in the through the plates. So, if your in one case it is co-current or in other case it is counter current then your represents will differing, counter will be better than the co. So, how much co-current how much counter current that will also depend, that will also dictate the efficiencies of the heat exchanger will PHE right.

So, this you have to keep in mind.

(Refer Slide Time: 20:21)

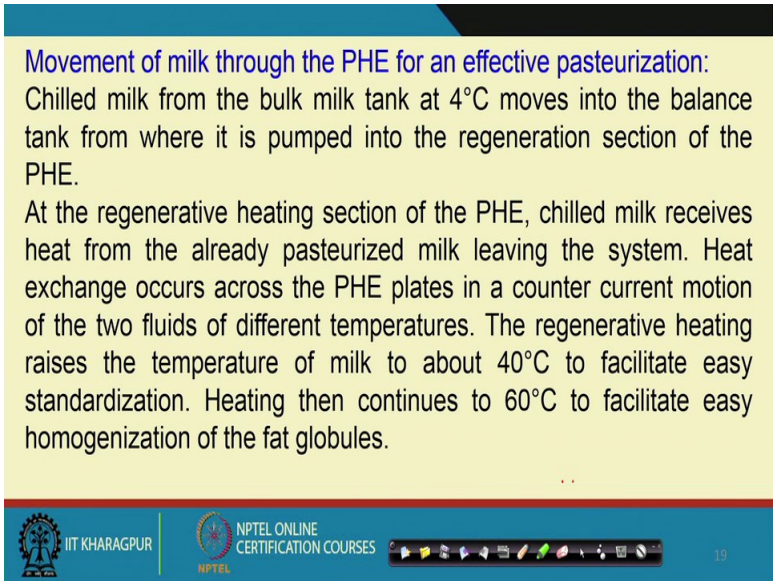


Then movement of milk through the PHE for an effective pasteurization; Chilled milk from the bulk milk tank at 4°C moves into the balance tank from where it is pumped into the degeneration section of the PHE, regeneration section means where the output is again passed through the input. So, that there is also an heat exchange and you are gaining some heat from the already pasteurized milk they are not coming directly in contact of course, but heat exchanger through the PHE it can be done. So, that is another thing.

1 At the at the at the regenerative heating section of the PHE, chilled milk received from 2the already pasteurized milk leaving the system and heat exchange occurs across the 3PHE plates in a counter current motion of the two fluids of the different temperatures 4right. And this if we cannot show the video here. The regenerative heating raises the 5temperature of the milk to about 40°C to facilities easy standardization. Heating then 6continues to 60°C to facilitate easy homogenization of the fat globules.

7Because, homogenization when you will see that time you will see that homogenization 8is also dependent on the temperature of homogenization right. Homogenization 9efficiencies is increases if the temperature is high, if the temperature is low 10homogenization efficiency also decreases. So, that we have to keep in mind right.

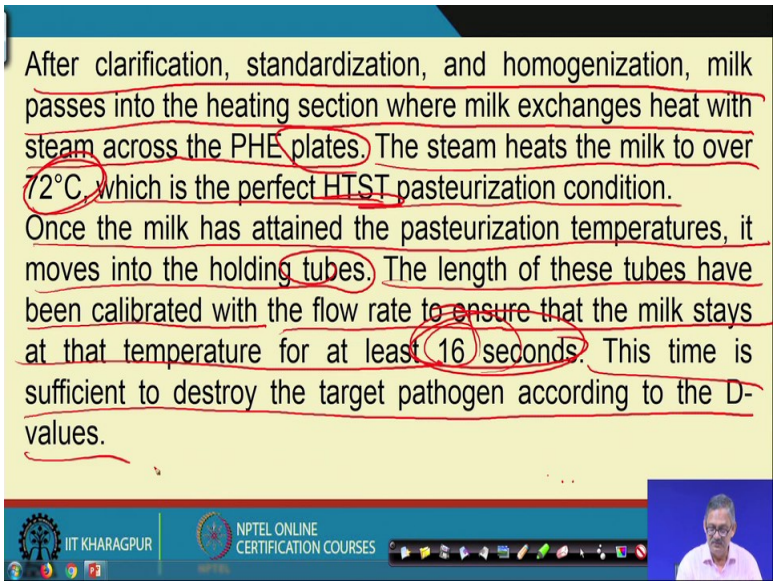
11(Refer Slide Time: 22:26)



12

13Then we come back to the next.

1(Refer Slide Time: 22:31)



2

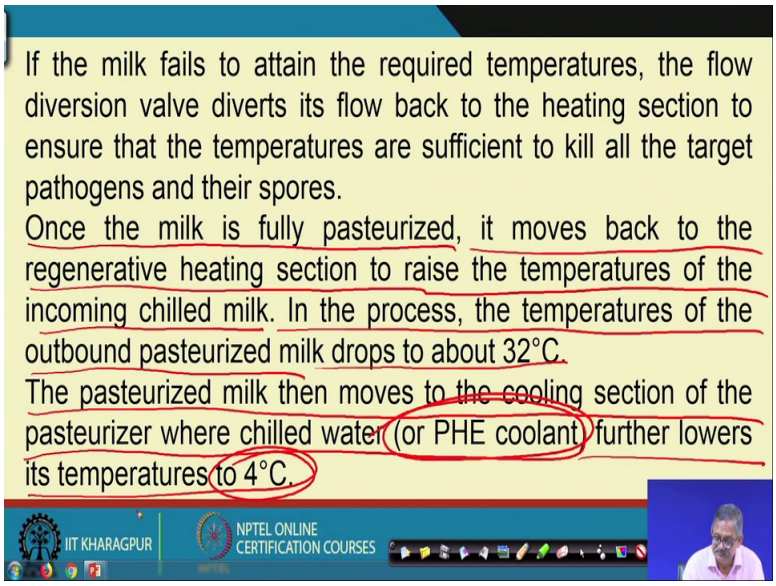
3That is after clarification, standardization and homogenization, milk passes into the 4heating section where milk exchanges heat with steam across the PHE plates. The steam 5heats the milk to over 72°C which is the perfect high temperature short time 6pasteurization condition.

7Once the milk has attained the pasteurization temperatures it moves into the holding 8tubes. The length of these tubes have been calibrated with the flow rate to ensure that 9milk stays at the temperature at least for 15-16 seconds, 16 seconds is for all safety 10because 1 second is nothing right. So, by the time you count it is already second over.

11So, better to be over then under because over though is not desirable but at least we will 12not spoil the milk in future. So, you can rely that your target is achieved. So, that is why 131 second excess that is why 15 second we have said 16 seconds if you measure and the 14length is designed such a way that it moves through 16 seconds are in the holding 15section.

16So, this time is sufficient to destroy the target organisms or pathogens according to the 17D-value which you have already seen right.

1(Refer Slide Time: 24:25)



2

3Now, if the milk fails to attain the required temperatures, the flow diversion valve diverts 4is flow back to the heating section to ensure that the temperatures are sufficient to kill all 5the target pathogens and their spores. This is the vital thing that might not had been 6chance that temperature could not have been attained whereas it as pass through the exit 7valve then what to do.

8So, there is a flow diversion valve by which the this fluid is again this milk is again 9diverted to the heating sections such that all the organisms are target organisms are killed 10or target organisms are killed so, that the pathogenic are also automatically killed. Once 11the milk is fully pasteurized, it moves back to the regenerative heating section to raise 12the temperature of the chilled milk.

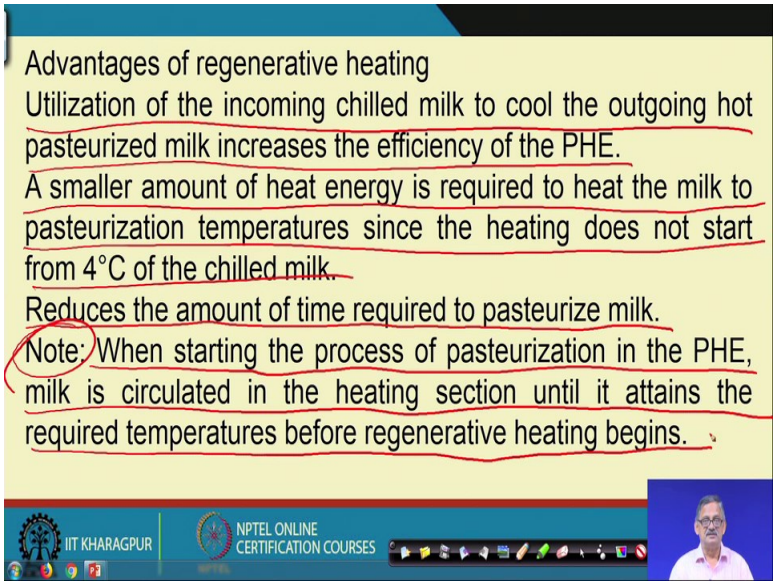
13In the process the temperature of the outbound pasteurized milk drops to about 32°C 14such a good heat transfer such a good heat exchanger right. That the outbound 15temperature is the exit of the already pasteurized after chilling after heat exchange in 16regeneration section it comes down to 32°C. Pasteurized milk then moves to the cooling 17section of the pasteurizer where chilled water or PHE coolant that is your that there in 18this case coolant is one which one which is going for pasteurization.

19So, that is the coolant because that is already chilled it is started with 4 degree so, it is it 20is getting it is it is chilling the outlet of the pasteurized milk and that is brought down 32.

2

1And this is again going up to around 40 because you started from 72 right, further lowers
2its temperature to 4°C ok.

3(Refer Slide Time: 27:03)



4

5Then because ultimately this 32°C you have to again brought down to 4 degree. So, that
6we safely kept for long time.

7Now, advantage of regenerative heating is that there are lot many advantage that
8utilization of the incoming chilled milk to cool the outgoing hot pasteurization milk
9increases the efficiency of the PHE. A smaller amount of heat energy is required to heat
10the milk to pasteurization temperature since, the heating does not start from 4 degree
11centigrade.

12Had it been you are you just calculate $mc_p\Delta T$ for a given m, for a given c_p if ΔT in this
13case will be from 4 to 72 is 68°C whereas, if it is preheated or if with the residual heat
14having the already pasteurized milk. So, that is exchanging. So, it is brought to around 40
15degree. So, you are $mc_p\Delta T$ will be from 72-42 so, around 32 degree 30-32°C. So, heat
16requirement will be much lower, efficiency of the pasteurizer will go up. So, this is the
17good system for regeneration of heat.

18So, reduces the amount of time required to pasteurized milk and you must keep in mind
19that when starting the process of pasteurized in the PHE, milk is circulated in the heating

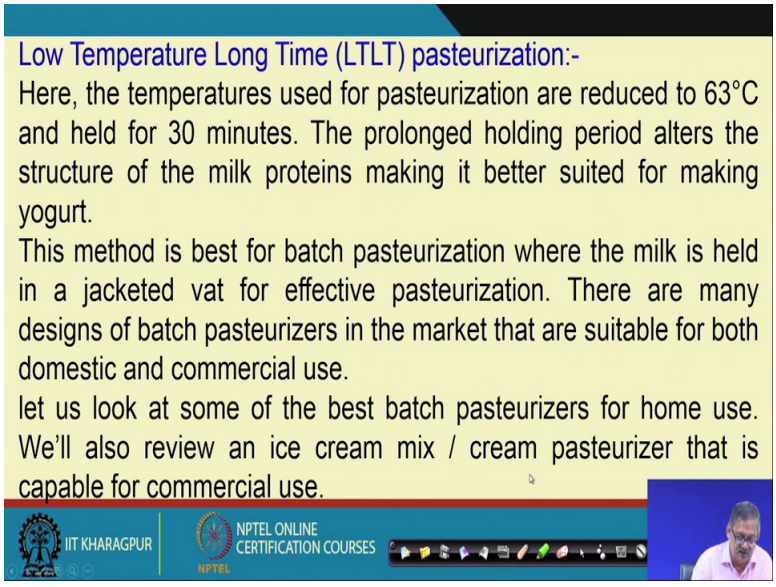
1

2

1section until it attains the required temperature required temperature before regenerative 2heating begins right.

3So, starting the process of pasteurization should be such that the PHE that milk is re-4circulated or circulated in the heating section, until it attains the required temperature 5before the regenerative heating begins right.

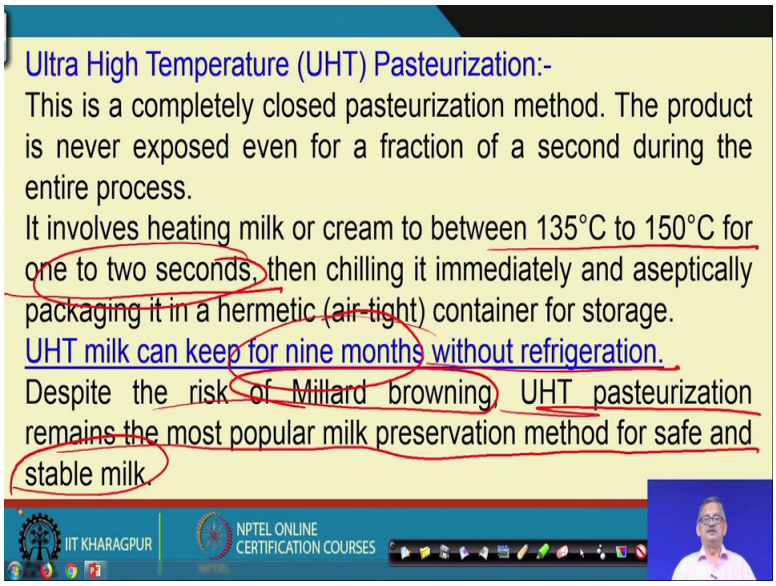
6(Refer Slide Time: 29:13)



7

8So, now let us go very quickly this because our time is very small may not be there. So, 9low temperature long time similarly this method is best for batch pasteurization that we 10know. Let us look into batch pasteurization for home use ok. We will also review the ice 11cream mix, cream pasteurizer that is capable for commercial use right.

1(Refer Slide Time: 29:40)



2

3And ultra high temperature pasteurizer so, where it is very high around 135°C, 135°C to 4150°C result for one of two seconds. It is ultra high temperature or UHT milk that can be 5kept for nine months without refrigeration.

6So, despite the risk of Millard browning, UHT pasteurization remains the most popular 7milk preservation method for safe and stable milk right. So, up to UHT pasteurization let 8us stop today because our time is up.

9Thank you.