Cooling Technology: Why and How utilized in Food Processing and allied Industries

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Module No 12

Lecture 57
Cold Chain and Cold Storage

Good afternoon, my dear students and friends. Now, we come to another very important one as far as cold is concerned, or cooling and subsequent its use, that we should maintain cold chain, because, the moment you are freezing, it should have a cold chain, which will lead to the cold storage, and from there, it will go to the retail users. Unfortunately, in our country, as of today, cold chain is a concept only, it is not in reality, though may be several governments, whether, central or local, they are trying their best, but as of now, I don't think, it has come to that level. However, it is not today, does not mean, it will not be tomorrow, because it is highly needed, that is why, it is, it has to be. So, what we can say that, in cold chain, and cold storage, the same, which we started with, that is the cold preservation, that comes directly in. Every 10 degree centigrade rise or fall will make the rates of reaction double or half, roughly, this we had said earlier also, right.

$Q_{10} = K_{10+T} / K_T$

10 ^oC lowering of temperature makes shelf life almost double

Then, we can say so, what is a cold chain? A cold chain, typically, consists of, pretreatment at the place of harvest, refrigeration or freezing, or food processing plant, why you are saying refrigeration, and freezing, because it is not necessarily all the materials to be frozen. It depends on, there are many materials, which are not below sub 0, but they are cold, right, like apple, it Is around 2 degree, potato is around 2 degree. So, it is not required that it has to be frozen, yes, if you are handling with meat fish etc. then, they are to be frozen obviously, for long preservation. We can say that, we will not do that cold, or freezing, rather for every material, right.

Then, we can say that, refrigeration, during transit, it is a must, whether it is frozen, or unfrozen. Now, you imagine that, you have taken apple from Kashmir. Kashmir is at very low temperature, so, you have no problem, apple can be there, but you want to go to Kerala from Kashmir. So, it is a huge distance, and during this huge distance, apple is supposed to be at 2 degree centigrade, and if you, and if it is not sub 0, is supposed to be at 2 degree centigrade, why, I take it for commercial purpose that, it is plus minus 2 degree centigrade. So, it may be minus, I mean it may be 1 degree to 3 degree, if we take

1 degree as a variation, right.

Then, unless you have this cold chain, up to the end point obviously, apple, which was at Kashmir, the quality of apple at Kerala will not be the same, right. So, it is ultimately you, that is the user, you as the user, is deprived. So, our objective is that, the refrigeration, during transit should be maintained. Then, if it is that, it is not from Kashmir, it is going directly to Kerala, may be from Kashmir, it is coming to say, somewhere in between Bombay, and from Bombay it is going to Kerala. So, there has to be some storage facility.

So, that is why storage, in cold storages, that is also required. Then, refrigerated displays at supermarkets, that when it reaches to the end user, then obviously, that could be displayed, could be a concern. Refrigerated storage at customer place before consumption. So, every stage, you are from the field to the fork, that is what it is said, from the field to the fork, that must be maintained, that cold chain must be maintained. This is the basic concept of cold chain. Now, benefits of cold storages are many, like it equalizes the prices throughout the year.

Then, no distress sell during harvest season, and products will be available round the year and products available in areas, where they are not grown at all, right. Like potato is one of the component, one of the commodity, which is not produced all over India. It is not produced all over India, at places, like places in Bengal, maybe places, some in Bihar, maybe places in UP, like that it is produced and they are feeding all over the Indian map, right. So, all these factors are required to be given due concern. Unfortunately, again and again, I am saying that, as of today, it is not up to the mark. Now, definitely, you see that, effect of the storage temperature, products like meat, average useful storage life, if it is stored at 0 degree, 6 to 10 degree, 10 days, if it is 22 degree it is 1 day, if it is 38 degree centigrade less than a day.

Similarly, for fish, if it is 0 degree, 2 to 7, if it is again 22, 1 day, and again, 38, less than a day, but dry meats and fish, 0 degree, it is more than 1000. So, 2 to 3 years or even more even at 22 degree centigrade 350 to 1000 days or at 38 degree centigrade, even it is 100 to 350 days. If it is dry or dry fish or meat, the moment dry fish, meat we are talking about, we are talking about water content, right, or M_w, what is the water content of the material. Since it is dry so, that earlier, I said about water activity, A_w. So, that water activity is also much much reduced in the dried fish or meat.

So, chances of its getting rotten is much much less. So, that is why, to the tune of 1000 days it is kept at even higher temperature, right, but, for fruits like 0, it is 3 to 20 days, again 22 degree, 1 to 20 days, depending on the fruit and 38 degree, between 1 to 7 days.

Yes, it is 1 day 38 degree centigrade it is 1 day, or 2 days 7 day rarely rarely some fruits. Again dry fruits, the moment you are talking about dry, the moisture content and ultimately water activity comes in. So, 1000 days or 150 or 350 days are not that impossible, but if it is leafy vegetable, 0 degree around 3 to 20 days, 22 degree centigrade 1 to 7 days, and 38 degree centigrade 1 to 3 days, here it has, these are leafy vegetable.

And you know, leafy vegetables are very much moisture content material, right. Root crops, root crops, one of the root crops, best that is potato, which is widely used in India all over the world of course. So, that is 0 degree 90 to 300 days, not 90 it is around 300 days because, if you go, when we will go to cold store we will see that it is 0 degree, but not 0 somewhere plus 2 degree, it can be stored around 9 to 10 months. And this is the time when the cold stores will be starting releasing all the materials, and the maintenance of the plants will be done. Then, dry seeds, again dry, the moment it is dry, your storage days are also up right.

Then we come to classification of refrigerated storage which we have said perhaps earlier a little that short term storage is 1 to 15 days long term storage is 10 to 10 days to 6 to 8 months, and frozen storage is as I, as high as few years. Ice cream, generally can be stored for even 2 years in a cold store if maintained at minus 18 or below, right, that is one of the most vulnerable product. For short term and long term storage between 0 to 16 degree centigrade which are above freezing point and for frozen storage between 23 to minus 18 minus 18 is the common, it is for frozen storage. Of course, for storage, you are using vapor compression refrigeration system, when you are talking about, that time I repeatedly said one of the major application will be during may be freezing apart and storage another part. So, the same compressor, sorry, the same compressor condenser expansion valves and evaporator, this is the cycle right.

And once this cycle, we have studied in detail, and this is a typical cold storage, which I said, no, I will tell you, I will show you, when we are coming to cold store, that these are the compressor units, right. So, this is that compressor units, it is very difficult, of course, to say that, we have also said in some cases, that there are some accumulators, which is coming out from the compressor, right, where the lubricant is separated, right. So, you see that, these are that reciprocating type of compressors, may be 80 hp, 100 hp, or even more, but you see, the size is so big. If you still compare with the one, which you have at your home, you will see, if this is this big, that becomes this much only, right. And this is 80 to 100 hp and that is perhaps 0.5 hp around, right. Obviously, the more the hp, the bigger is the size, right, and more are the piping and other things. Now, in handling the cycles, in many cases, we could not have taken care of the pipelines, but in some cases, afterwards, we have used using Bernoulli's equation, but generally, they are

very very complicated, in the sense that, if they are not, the other day I said, that, if matching is not done properly, then oversize or undersize will jeopardize the entire system. That is one of the prime factor, that no over sizing or unnecessarily no undersizing is allowed. Then, we come to the other one, which I was repeatedly saying that condenser, this is a commercial type of condenser, right. I could not take the bigger size of the condenser in photograph, because view was not proper, but this is good enough to explain many many things to you.

As you see that, there are water spray facilities over the coils. Now, as you also see, say, a single coil, if we take from here, that will be easier, at least for me, say this one, right. So, this is coming up to this, then a vertical down, then again horizontal down, then a vertical up. So, this way say, if this is said 3 meter, or 4 meter. So, 4 meter by say 2 meter, again 4 4 8 2 2 4.

So, around 10 to 12 meter per unit right. There are so many tens of 100 such units are there. If you remember, I said the condenser and evaporator coils, they range from, maybe 30 to 35 kilometers in length right. And this one being typically for ammonia, with that, I know because, I have taken the photograph. So, that I know that this is for ammonia right.

So, there the water, which comes over it, sorry, the water which comes over, it is spread all over, right and air is blown right. So, like our cooling tower, so, when, air is blown, how much temperature it can be cooled, that also I said earlier, that it can be cooled up to a temperature or little above than the T_{WB}, that is, wet bulb temperature, right. So, little above wet bulb temperature, we can cool down the condenser. This cooling rather, temperature, right. So, what air will moving up, it is taking the latent heat of vaporization and that gets cold and ultimately the condenser, which is at high pressure and high temperature at the inlet of the condenser is coming down to, maybe the pressure, condenser pressure is same, but the temperature is much lower. So, though if we see our cycle, which was there, the condenser was under constant temperature T c, because basically the vapor is getting cooled.

The refrigerant vapor which came out from the compressor at high pressure P condenser and high temperature T condenser. So, now P condenser is maintained and T condenser is maintained, but the phase is getting changed, it was vapor, now it is liquid right. So many things are to be said here, one is that we told that, water, which is used for cooling this condenser, as it is appearing, the pipes, if it is for ammonia then, it has to be not copper, or steel, it is mild steel, because, it is corrosive. So, after sometime, mild steel is less expensive. So, after some years, or sometime, maybe part or whole has to be replaced or repaired.

So, if the water and the temperature being T c very high, T c is inside, but T c is from the outside, what we are observing right. So, that is being cooled by the water. Now if the water is not good, then what will happen, and you remember the other day we had said that hard water and soft water. So, if it is not soft water, hard water, then some precipitate of the salts will take will occur in the pipelines. And the moment, that precipitation of the salts are happening, the heat transfer is drastically reduced, right.

Fine film of the coating of the sediment is good enough to reduce the heat transfer drastically, right. This normally, the people who are operating, do not understand, neither they do take care of it. So, the water, which you are supplying for cooling, has to be very very soft and treated water. Here you are not blowing any air through some fan, or blower. It is normally by the natural convection of the nature that is reality in every cold store.

So, if it is normally by the natural convection in this. So, this is to be situated in a place where if this is the coal store and if this is south normally our air flows at least towards the eastern part from south to north in most of the part of the air except winter season when it is from north to south. So, this condenser coils should be away from the building where freely air can move, then only, it will be cooled very easily very fast. Unfortunately, to save the space, or whatever, if you go and study most of the cold stores they are primarily behind the coal room space. So getting the air flow obstructed.

So water is not purified, water is not rectified, water is not rather treated this is a defect, second is air flow, right. So both are reducing the heat transfer drastically. So, what will happen, your Pc will be and Tc, this PcTc fine, but some unconverted vapour may come out from the exit, which may get into the inlet of the valve, that is expansion valve. So, this most of the people do not consider, so nicely or easily ok. I think our time is today over, in the next class we will complete this cold store.

So that we can go for the last two classes, for ice cream that is one of my very favourite, ok. Thank you so much of you.