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

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Lecture 39

Basics of Refrigeration and Air Conditioning

Good morning, my dear students and friends. Till date or last class we had covered the there are many cycles I do not say only the cycles which we have covered up I gave you the reference of Professor R. C. Arora book and many other C. P. Arora book and many other books are there, thermodynamic books are also there, many our professors, Prof.

P. K. Nag, my teacher, he is also having a thermodynamics, book very good. So, you can, whatever book you have, you can refer that, and read apart from the normal classes, but till now, the cycles which are required for us, for cooling, for production of cooling, right we have covered up.

That means, now, we know, what are the cycles, how they will be implemented, what is the analysis of those cycles, those we have done. Then, in the very first class, we said that, as the name of the course suggests that, cooling technology, why and how it is utilized in food, right. So, if that be true, that means, till now, why we have said in the beginning, how the cycles, we have said. Now again, for that, how for utilization, we have to go to the refrigeration and air conditioning, right. So, we have to tell about the basics of refrigeration and air conditioning.

Again, this class also will require, may be some of the classes, because, it is also a big chapter. Because, this is the application, not directly, that cooling production application, production of cooling, that application is the basics of refrigeration and air conditioning. Of course, some of which, we know already, like this one, that refrigeration and air conditioning basics, right. How does it work? We have already seen, but, yes, though it is a repetition, but, still required, because, recapitulation is also helpful. The refrigeration and the air conditioning is used to cool products, or a building environment, depending on what? Building environment, we are not, I am not keeping it away, because, in cold storages, you have to also cool the buildings also, storages or cool storages.

So, that is why, it is part, both cooling the product, as well as the building. And the

refrigeration or air conditioning system, that is refrigerator, transfers heat from a cooler at low temperature or low energy reservoir, to a warmer high energy reservoir, right. We have given as one reference that we have taken a refrigerator, we have taken a refrigerator. So, heat is absorbed by the refrigerator from the low temperature reservoir and there is a refrigerator, some work is being done and heat is rejected by the refrigerator to the ambient. This is what, very simple cycle.

So, we can now go to that how it is being produced, whether, it is door or product, does not matter, may be under this cycles. First one is indoor air loop, right that is supply of air through fans, that is done through a cooling unit or cooling coil. So, this is a cycle, then, chilled water loop, that is chilled water, pump is continuously going through, and the pump is supplying the chilled water. Refrigerant loop, refrigerant is going to the unit where, it is to be cooled, chilled water is cooling the refrigerant, if it is required, or condenser. Condenser water loop, it is a condenser pump, and water is being circulated.

And finally, cooling water loop, where cooling water through fan is being used by the air back to air. So, it is a cycle, that is, thermal energy moves from left to the right through 5 loops of heat transfer, as we have shown just now right. Next, we come to that, what these loops are doing? Indoor water loop, that as it was shown in the previous figure. Indoor air loop is driven by the supply of air with the help of a fan through a cooling coil, where, it transfers heat to chilled water, and the cool air then cools the building, or the space, wherever, it is. Then, chilled water loop.

What it does? It is driving the chilled water pump, water returns from the cooling coil to the chillers evaporator to be recooled. Then, the refrigerant loop, it is using a phase change refrigerant, the chiller's compressor pumps heat from a chilled water to the condenser water. Then, what condenser water does? Water absorbs heat from the chillers condenser and the condenser water pump sends it back to the cooling tower. The cooling tower, does, the fan of the cooling towers drives air across an open flow of the hot condenser water and by that, transfers the heat to the condenser. So, this is how the refrigeration cycle in cooling is used.

Then, next comes the AC system, that is air conditioning system, that is what normally used for, maybe human being, or maybe some product like, we have, so many instruments equipments everywhere they are also required to be used. So, the options and combinations are like this that air conditioning for either personal or machine comfort is used and in that split air conditioners can also be used and fan coil units in a large system can also be used, fan coils mean, the entire coil system, that refrigeration system, is in there, and a fan is blowing the air through that. So, that is also possible. Then, air handling units. In a large system, I told many times, or if I have not told in this

class that, I hope, you have seen ice cream making, and in that ice cream making the semi liquid, which you get from walls, and other places, that semi liquid ice cream also comes out from the ice cream freezer.

I will try to cover up in one class as one application, but, there this semi liquid or semi solid, they cannot be transported from one place to other place because, by that time it will melt. So, they are hardened in a hardening room, there the cooling unit is air, air in 3 turn, like one refrigerant is cooling one heat exchanger, that heat exchanger is cooling air, and this air is cooling the ice cream. So, there, it is air handling unit, that is mostly used. Now, refrigeration systems for industrial processes are also there, like small capacity modular units of direct expansion type, where, it is 50 tons of refrigeration, or 50 TR is utilized. Centralized chilled water plants with chilled water as a secondary coolant, where, it is 52 to 50 tons of refrigeration, are used.

Brine plants with brines as lower temperature secondary coolants are also used, where, the tonnage of refrigeration is greater than 250 tons of refrigeration. Others, are small capacity modular units of the direct expansion type, similar to domestic refrigerators. Centralized chilled water plants with chilled water as a secondary coolant, or for a temperature range over typically 5 degree centigrade, they can also be used for ice bank formation. Now, brine plants, I have told earlier that, brine means, liquid solution with salt. It can be any combination of salts, will come more in detail when the application parts are being taught.

So, brine plants, which, use brines as a lower temperature secondary coolant, for typical secondary coolant, means primary is the refrigerant itself, secondary is this brine. So, secondary coolant for typically sub 0 temperature applications, which, come as modular unit capacities as well as rather, large modular unit as well as large capacity units, are also available. The plant capacities of the 50 ton of refrigeration are usually considered as small capacity, whereas, 50 to 250 tons are considered as medium capacity, and over 250 tons are considered to be large capacities. Now, refrigeration at large companies are used, bank of units with common chilled water pumps, then, condenser water pumps or cooling towers. I hope, in many beautiful buildings of offices, you might have seen that, in front of the office, there are some good looking cooling towers, which, are very good to look at, but it serves as the cooling tower for the refrigeration cycle.

This is available in many good buildings or hotels as the cooling tower. More levels of refrigeration or air conditionings are required for comfort air conditioning, over 20 to 50 degree centigrade, chilled water system over 8 to 10 degree centigrade is used and brine system less than 0 degree centigrade is used. So, large company may have bank of units, often, with common chilled water pumps, condenser water pumps, cooling towers as an

offsite utility. The same company may also have 2 or more, 2 or 3 other, 3 levels of refrigeration and air conditioning, as we have already mentioned. Now, the refrigeration systems which are used are vapor compression refrigeration systems, which, we have already studied and uses mechanical energy.

And another one is vapor absorption refrigeration system, that is, VAR, uses thermal energy. And in most of the cases, that vapor absorption refrigeration systems are not so utilized as vapor compression refrigeration systems are commonly used. So, 2 principle types of refrigerator or refrigeration units or plants found in industrial use are vapor compression VCRS and absorption refrigeration system or VARS. VCRS uses mechanical system as the driving force for refrigeration, while, VARS uses the thermal energy as the driving force for refrigeration. Now, in the vapor compression refrigeration system, it is highly compressed fluids, tends to get colder when allowed to expand.

If pressures are high enough then compressed air, hotter than source of cooling, or expanded gas, cooler than desired cold temperature, may be utilized. Now, compression refrigeration cycles take advantages of the fact that highly compressed fluids at a certain temperature tend to get colder, when, they are allowed to expand which, is available in the expansion device, or turbine. If the pressure change is high enough, then, the compressed gas will be hotter than our source of cooling, that is, outside air, for example, and the expanded gas will be cooler than our desired cold temperatures. In this case, of course, fluid is used to cool a low temperature environment, and reject the heat to a high temperature environment. So, if we look at vapor compression, we have already done, say recapitulation, that too advantages are there, that lot of heat can be removed, that is, lot of thermal energy is required to change liquid to vapor, and heat transfer rate remains, high temperature of working fluid is much lower than what is being cooled to.

So, in the vapor compression refrigeration cycles, there are two advantages, number one, a large amount of thermal energy is required to change a liquid to a vapor, and therefore, lot of heat can be removed from the air conditioned space. The isothermal nature of the vaporization, allows extraction of heat without raising the temperature of the working fluid to the temperature of whatever is being cooled. This means that the heat transfer rate remains high, because, the closer the working fluid temperature approaches that of the surroundings, the lower the heat of, lower the heat transfer rate. Then, this is how, we have already seen that in refrigeration cycle, there is a condenser, there is an expansion device, there is a compressor, and there is one evaporator right. This side is called high pressure side, this side is called low pressure side, beyond this line, above is high pressure, lower is low pressure line right.

So, similar to this, if we look at refrigeration cycle, right which, we have already done.

So, I hope, we can skip little, going through quickly, if we see that, low pressure liquid refrigeration, in evaporated, evaporator, absorbs heat and changes to gas that is what here is, and then, it goes to the compressor, next cycle it will come from the compressor, it will go to the condenser, third side, it will come and from the condenser, it will come to the expansion device, right. So, if we look at more, we get that refrigeration cycle here, it is for the compressor, the separated vapour enters the compressor, where, pressure is very high. Then the refrigeration condenser, the high pressure superheated gas is cooled in several stages in the condenser and then once it is condensed, then liquid passes through an expansion, through an expansion device, which, reduces its pressure, and controls the low temperature to the evaporator, and it flows through the evaporator. So, there are different types of refrigerants used, which, we have not talked about.

The refrigerant determined by the required cool temperature and normally chlorofluorocarbons or chlorinated carbons, CFCs, normally known, or Freons, normally, again, known, are used. They have the refrigeration number as R 11, R 12, R 21, R 22 and R 502. A variety of refrigerants are used in vapour compression system. The choice of the liquid is determined largely by the cooling temperature required. Commonly used refrigerants are the family of chlorinated carbon or fluorocarbons, or normally known as CFCs, and are also known as Freons, and as we said there are, R 11, R 12, R 21, R 22, R 502 etc.

Then, we come to the choice of compressor, design of condenser, evaporator. These can be determined by the refrigerant, by required cooling, by load, which we have already done. All these, ease of maintenance, that is one of the prime factor, physical space requirements, how much it is required, where, the floor area is very highly priced, physical space requirements and availability of utilities, such as, water and power. So, these are the basic things which are required, right. Now the other one is the vapour absorption refrigeration.

We go quickly through this, because, the class is almost over. We will go to the next, other thing, for air conditioning and refrigeration. Vapour absorption refrigeration, normally is not so commonly used. You might have not come across. So, here, what is happening, you see, there are two vertical lines, this one vertical line, right.

So, one absorber, one this is the cold side, and this is the hot side, there is a condenser, there is an evaporator, and obviously, some pumps are there, and hot side, absorber and generator. These two are in the hot side. I do not want to go more detail into this vapour absorption refrigeration system though the system has, as of now high promise, but, this is not achievable, because in the absorbers, in the generators, in the evaporators, and also condensers, lot of research work is still required. So, that is why, it is not so popular as of

now. So, I would like to skip them, the detail process, but, as we said that, there is a generator, there is an evaporator, there is one absorber, and also one condenser.

These are the 4 units, generally used, and it is complicated also. Unlike, vapour compression refrigeration system, you have a compressor, itself is complicated, but, others are condenser, a heat exchanger, expansion device is again one unit, not so complicated and evaporator, again one heat exchanger, but here lot of things are there, like, the concentrations of this solutions. So, these things are very much required, right. So, with this we complete the first part of the refrigeration and the air conditioning. Thank you all.