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

Prof. Tridib Kumar Goswami
Department of Agriculture Engineering
Indian Institute of Technology, Kharagpur

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Lecture 12
Basics of Thermodynamics Contd.

Good morning. If you remember that in the previous class, we had said about the fluid flow through pipe. Why we have said? Because, in refrigeration also, the refrigerants, they are also liquid. So, they will be also flowing. So, a little of that, which of course, had come off, it is not that, suddenly, I had stated as I told you in the beginning, that whenever a new thing will come, I will try to explain as much as I can, so that it becomes convenient for you, you can recapitulate, you can you can brush up your past memory etc, for which I had said. So, let us now continue where we started, that is the basics of thermodynamics, right.

It is a big one, it will take a little time because the basic of thermodynamic is a little very high. Now, the point where we stopped in the last thermodynamic class, if you recall that we were saying about equilibrium, and I gave some example also right. So, this is one example which is absolutely understandable, that what you are doing? You are taking, 1 kg of a gas having specific heat of 1 kilo joule per kg per kelvin that is kept in an insulated cylindrical container at an uniform temperature of say, 30 degree centigrade. These are, these numbers are absolutely to make you understand right, it is fictitious number, just to make you understand.

So, we have taken 1 kg of a gas having a specific heat of 1 kilo joules per kg kelvin at 30 degree centigrade in one insulated cylindrical container right. Now, if suddenly 10 kilo joules of heat is added to the cylinder, at one corner of the cylinder, for example, I hope it works, ok. For example, if say this is the cylinder ok, if this is the cylinder, and we have 1 kg of gas and it is insulated right. Now, we are suddenly adding 10 kilo joules of heat to one corner, say this corner right and then what happens? What did we do? We have added 10 kilo joules of heat at one corner of the cylinder. We have said it to be say, left corner, it can be in right corner, it can be bottom any side.

So, we have added some heat and remove the source after adding. Now, this will increase the temperature of the gas at that point where the heat was supplied right, so that, the kinetic energy of those molecules of the gas will increase. So, at this time the kinetic energy being high, the molecules of the gas will start moving randomly right. So, with the elapse of some time, the kinetic energy of the, we said left corner of the cylinder will be transferred, to all the molecules of the gas and eventually the temperature of the gas at every place in the container will also increase right. And this will become uniform after some time, it will take some time of course, it just cannot be instantly.

Yes, there are many systems which may be instantly done, but in this typical example it will take little time, that is why we are saying that with the elapse of time this will increase the internal energy of the gases, all around and say, temperature of 40 degree centigrade is achieved all around. This condition is said to be a new state point of equilibrium, and this state of equilibrium is sufficient to determine the heat transfer in the gas and thermodynamic properties are also available, or you can find out at that state point, when it is under equilibrium at 40 degree centigrade right. So, what did you say in equilibrium? We said, we have taken one cylindrical box and there it is insulated and we have put 1 kg of some gas and having some specific heat say, 1 kilo joules per kg, as we said per kelvin, and we have added at one corner, some quantity of heat, say 10 kilo joules of heat. Similarly, it was at 30 degree centigrade all around in the entire cylinder. Now, after adding this 10 kilo joules of heat, it has become the kinetic energy of the gas molecules have increased.

So, they have, from the kinetic theory of gases, we know that they will move randomly to all directions, exchanging the energy with the other molecules, and thereby, after sometime, not instantly, after sometime, if we see, we will see that the entire gas has achieved the temperature of say 40 degree centigrade and the former one where it was 30 degree centigrade. Now, when we achieved 40 degree centigrade, these are the two state points right, these are two state points, one state point was at 30 degree centigrade, which was under equilibrium at that temperature, and another is 40 degree centigrade, and which is at equilibrium at that temperature. So, these are, the two state points, where all the properties, thermodynamic properties, you can find out, you can determine, you can know right. We have not come to psychrometry, after this class we will go to psychrometry, there you will be coming across more in that, right. So, we call it to be at equilibrium, right, ok.

Now, these properties of thermodynamic equilibrium gas molecules which was there right. So, if it is a gas the temperature and pressure, temperature and volume or pressure and volume are required to be fixed by the thermodynamic state. As we said, point one was 30 degree centigrade, obviously, pressure was atmospheric pressure we did not say anything about pressure and at 40 degree centigrade, when another state point came up. So, they are also at equilibrium at 40 degree centigrade at standard pressure rather we have not changed pressure. So, we need to know either pressure temperature or temperature volume or pressure volume to know the thermodynamic state points right.

Now, there are two types of systems. So, one is called closed system and another is called open system right. So, these two types of systems, in the space is identified for consideration of any analysis. Now, we also define one terminology that is called control volume. Now, control volume we tell that where the boundary of the system is called system boundary or control volume.

Whatever is outside this boundary is called surroundings. There are two types of systems in thermodynamics, one as we said closed and another is open. For example, if we say that this is a, say this one exactly this black right beyond my beyond me, if we tell that this is a control volume right this is the control volume anything, beyond this is the surrounding, anything, the entire world or universe is the surrounding. So, as we said that let us take one control volume. So, this is the control, of course, if we take three dimensional then it becomes a ball kind of thing, So, if that be a system then rest of the world, rest of the universe is known as surrounding right.

So, within the control volume, whatever is happening that is our consideration, may not be all the time what is in the surrounding, right, that we have to keep in mind and this is true for closed system. If the system is closed, this one is a closed system right. So, if the system is closed then this, but this can be also open system, right as we said there are two types of systems, one is closed and another is open as you see from this that we have taken one, we have taken one control volume right and this is the system boundary right this is the system boundary. And if we put Q quantity of heat then W quantity of work is available. You are giving heat Q.

So, you will get work, right. If you extract heat, it is the reverse, W quantity of work will be available. So, this is by the system right, this work is done by the system, and you will come across afterwards, that, when it is by the system, we call it to be positive right. When, it is by the system we call it to be positive and when it is on the system, if it would have been reverse, like this and if it would have been reverse, like this, then we would have said, it is on the system right. So, this we have to keep in mind that by the system, it is positive and on the system it is negative right.

So, this is a closed system, where you have given Q quantity of heat, you got W quantity of work right. And as we said, it is a positive quantity, because by convention, rather, I should say, by convention it is said, it is taken always positive if work is done by the system, right. So, same matter, at all times if it is there then, energy is transferred in the form of heat transfer and work occurs across its boundary, right this is for closed system. See, if we take an open system, right like this one, we have taken an open system ok. Though this is set point 1, and this is set point 2 right.

So, we know all the thermodynamic properties and other physical properties like m dot or m 1 dot, u 1. u 1 we have not said yet, we will say also, internal energy right. Then rho 1 is the density, V 1 is the volume, and z 1 is the height, and here it is m 2 is the mass, u 2 is the internal energy, rho 2 is the density, v 2 is the velocity, and z 2 is the height, right, height or distance whatever you call. So, if we see this, then by open system, you are allowing this m dot quantity, m 1 dot quantity, of mass to flow whose all properties both physical and thermodynamic properties are known. Then you are getting at the point, set point 2, a different mass, internal energy, then density, then velocity, and at a different height.

So, this is a closed system right. Now, for laws of thermodynamics, 4 empirical principles such as zeroth law, first law, second law and third law of thermodynamics are known right. In thermodynamics, there are 4 laws zeroth law, first law, second law and third law, these 4 laws are known and these cannot be proved, but no exceptions to these have been observed as on date. So, they define thermodynamic properties, such as zeroth law, defines temperature, zeroth law defines temperature, first law defines internal energy, second law defines entropy and the third law defines absolute 0 temperature cannot be reached or achieved right. So, these 4 laws will come across in detail gradually.

So, what you say that in thermodynamics there are 4 laws zeroth, first, second and third law, and zeroth law tells about temperature, first law tells about internal energy, second law tells about entropy, and third law tells about absolute 0 cannot be achieved right. Then, we talk about zeroth law. Then, if we assume 3 systems such as A, B, and C, and if A is in thermal equilibrium with B, right, A system is in thermal equilibrium with B. So, this is a system A, this is a system B and this is a system C right. So, in all these 3 systems, in which A is in thermal equilibrium with B.

So, we can write it, in this way the equilibrium sign is, like this, A is in equilibrium with B and A is in thermal equilibrium with B and independent of shear logic right. This is independently, shear in equilibrium, thermal equilibrium by shear logic. So, to exist in thermal equilibriumk all the 3 systems, should have some common property such as temperature. Otherwise, how can we say whether A or B or C, they are in equilibrium or all of them are in equilibrium. Which is the property, that is temperature, right.

So, temperature is the common property by which we can say about the equilibrium. So, all the 3 systems, should have the same temperature, to exist in equilibrium with each other. The measuring device of thermodynamic temperature is also to be in equilibrium right such as thermometer, or any other temperature indicator, should also be in thermal equilibrium with the system. Otherwise, suppose, I hope, you have seen that household thermometers, they are having a probe or bulb like this. So, if this bulb is not in equilibrium with T A or T B or T C, then there will be a difference.

So, to register the temperature, it will be, that is why you remember that, if someone falls sick, then both doctors or your senior people they say that if we are putting it into mouth or under the arm, keep it for some time, and that is the time elapse, which you are giving, so that the temperature is attained and this can be called thermodynamic equilibrium between the body and the thermometer, which you are using. Of course, nowadays there are many ways of thermometers have come up even without giving any body touch from outside also the temperatures can be measured right, but we are not talking about them, we are talking about those thermometers, which you are using in your body either in mouth or under the arm. So, then that thermometer has to be in equilibrium with the system, you are measuring, then only, you can say, the temperature is so much. So, the zeroth law is telling about the temperature of the system right. So, with this I think, we can proceed further, with the first law, second law in the subsequent classes, but mind it, that equilibrium concept which we have given you, is very much applicable all over during this course because thermodynamic equilibrium, now the moment, we call it, thermodynamic equilibrium, it is equilibrium in all state properties right.

This state properties in detail will come across when we are talking about the psychrometry that time, you will see so many thermodynamic properties are also to be known right. So, with this let us stop today's this class of zeroth law of thermodynamics and we will proceed to the next one. Thank you.