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

Module No 04

Lecture 20
Psychrometrics Contd

Good morning. We are in Psychometrics and this is continued class of psychometrics right. This is lecture 20, and continuation of psychometrics. We have covered up to the measurement of relative humidity, right. We have covered up to that measurement of relative humidity, but that was with the help of dry bulb and wet bulb temperature. We said there is one more way by which it can be done.

This is called hair hygrometer right. This is called hair hygrometer and I said the other class that expansion of hair is a function of moisture content. It elongates and contracts with the moisture content right and this typical behavior of the hair with moisture is used in hair hygrometer. As you see from this picture that it is very complicated though you are getting a graph also, but even then, both manufacturing and then using it, is very very difficult, That is why hair hygrometer is not so popular typically, in industry.

It could be very very helpful in academic purposes, where absolutely correct value you need. You can read the graph which is coming up, but it is very very difficult to read it. Similarly, with respect to the Indian industry concern, Indian industry, it is absolutely very tough, because the people who run these industries, not I am, not talking about scientist, or technologist, or things like that, typical workers, please do not take it otherwise, they are normally not educated, neither there is no way of making them educated, nor anybody takes care of the individual's education. So, for them, it becomes very tough, right and the most useful one is the one which we have already said, that is the dry and wet bulb temperature. I will show you, I just showed, one table earlier, which will come back, once we finish this hair hygrometer, that it functions on the basis of the expansion and contraction of the hair with respect to moisture content.

So humidity, stretches the hair whether it is human hair or animal hair or synthetic hair, whatever it be, it is a function of moisture content. So, while dryness, it shortens it, and while it is wet, it expands. The hygrometer has the job of stretching hair between a fixed and a moral point to measure humidity over time. Other kinds of hygrometers use materials, with electrical resistance, that also can be used electrical resistance, because

that is also a function of moisture, that varies with the amount of moisture absorbed by electrical resistance, if somebody makes, and then the making may be easy, but then making it, what we call that, it is the trial should be given, right and then only when it is matching with actual one, then it should be used. With such hygrometers a measurement of electrical resistance can be calibrated, that calibration is the fundamental thing, can be calibrated as a humidity measurement, right ok.

Now let us go back to this one where we started with.This is a table, as I told in our industry level, the people who work in the floor, most of them are not so much educated. So for them it becomes very difficult to handle and then find out from the chart the relative humidity or the other one which we have already said that hair hygrometer, it is really tough for which a very easy thing can be made. If you know, your level of temperature variation, both, dry and wet bulb then you can make a table like this, and give that table to the workers. They can read, at the most from the thermometer, what is the temperature right.

If it is digital then there is no problem, but mercury thermometer making digital may be difficult mercury in glass right. Got now, someday it may come up the way science is progressing, someday it may come up, but as of now mercury in glass has not been made or digitized. However, so they can read the wet and dry bulb temperature and the thermometers are swung as I said that it needs some latent heat to vaporize to get that latent heat it may require to swung or as I said that if it is fixed then some blow of air is made. So, if it is swung around the handle then the real wet bulb temperature is obtained. Then, when swung water, evaporates from the wick cooling the wet bulb temperature and thereby you know, the wet bulb temperature and dry bulb temperature, already it is open, you are able to find out.

So, drier air results at lower temperature right this example also I have given. So, when you have this both dry and wet bulb temperature as you see from the table as you see from the table here you are writing the difference between wet and dry bulb temperature in Fahrenheit again why Fahrenheit I have said many times that it is a whole number that is why it is easy to remember if it is a centigrade then it will always associate with decimal. So, this may not be helpful or difficult to handle. So, the difference between the wet and dry bulb temperature, that is in a column right and the dry bulb temperature, in Fahrenheit that is in many columns as, I told if, you know your normal working range of dry and wet bulb temperature then that dry and wet bulb temperature, you will make it. Here, just for understanding, we have taken 60 as the lower limit and 88 as the higher limit with a difference of 4 degree Fahrenheit right.

So 60, 64, 68, 72, 76, 80, 84, 88. This type of temperature of the dry bulb, we have

taken and on the left side, left column, we have taken, the difference between dry and wet bulb temperature right. And if the difference is 1 degree, it could be 1 degree, it could be 2, 3, 4, 5, 6, 7, 8, 9 or, as much as you want, right since it will not, it will be beyond the page. So, that is why I have not taken. So, if you know, the difference between dry and wet bulb temperature, you know that point say, 5 degree, the difference and if the dry bulb temperature is say, 76 degree then you go to 5 and 76.

This number tells you that what is the relative humidity, that is 62 coming as 62 right. Similarly, the other one, if the difference is 6 degree and if the dry bulb is 72 degree then the relative humidity is 54 percent right. So you can make one such table and give it to your subordinate who are not so educated and they can easily handle this type of hygrometer for finding out the relative humidity, right. So, I repeat, a little, that we have the difference between dry and wet bulb temperature on one column, and the dry bulb temperatures, in different columns, you could have taken 60, 61, 62, 63, 64, like that, no problem you could have taken, but again, as we said that within this frame it will not be possible to show like that. So, we have taken a 4 degree difference and we have found out the table and wanted to use to explain to you and we see that with the difference of dry and wet bulb temperature, we are able to show, if the temperature difference between the dry and wet bulb is 6 degree, and if the dry bulb is 72 degree, then the percent relative humidity is 54.

Instead of that if the dry bulb would have been 88 degree, then this way, if we move, it is 61 right. That is the difference between dry and wet bulb is 6 ,remaining constant, and the dry bulb is increasing from 72 to 88, then the relative humidity is also increasing from 54 to 61 right. Whereas, if it is the reverse way then at 60 percent rather 64 degree Fahrenheit dry bulb temperature the relative humidity would have been 44 percent. So, the lower the dry bulb temperature lower is the relative humidity of course, depending on the difference if it is 1 degree difference then at 60 it is 90 percent relative humidity right whereas, at 88 degree it is 93 percent relative humidity it is not varying so, widely 1991, 91, 92, 92, 92, 93, 93 like that whereas, if the difference is 9 degree then at 60 degree the relative humidity is 20 percent whereas, at 80 degree the relative humidity is 45 higher than that at 60 degree, but the number is not so high right. So, as the difference between them is increasing the relative humidity is also decreasing right because here one we have seen 90, 93 with 9, 20 and 9, 45.

So, this we can conclude that if the difference between the dry and wet bulb temperature is high then the relative humidity obtained will be low or if the difference between dry and wet bulb temperature is low then the relative humidity value obtained will be also very high right. So, this is what we conclude from this we conclude from this table right. If you have any problem you can definitely call me or contact our technical assistance,

but hopefully the way I have tried my best to make you understand there should not be any anything which is not told or which you have not been able to understand right. So, as a last chance last time I repeat that you have on the left column the difference between dry and wet bulb temperature in Fahrenheit ranging from 1 to 9 it could have been any as I said since the space is not so much. So, we have taken only 9 and on the afterward we have taken dry bulb temperatures in Fahrenheit we have we have taken a range of 60 to 88 degree we could have taken 60, 61, 62 like that then the space requirement would have been very high which may be not be possible to show in a table.

So, we have done 60 to 88 degree and then from the chart we have found out that if the difference is 1 degree dry bulb temperature is 60 and wet bulb temperature is 59 1 degree difference then the relative humidity from the chart came out to be 6 the 90. If the dry bulb temperature is 88 with a 1 degree difference of dry and wet bulb temperature the relative humidity came out to be 93 percent this is one extreme another extreme is if we take the difference to be 9 degree then at 60 degree Fahrenheit dry bulb temperature the relative humidity came out to be 20 percent whereas, the same at 88 degree Fahrenheit the relative humidity came out to be 45 percent. This means that you can make a table and give it to your subordinate in the company where your associates are not so educated and they can easily find out the relative humidity from the table ok. So, we leave this now other definitions are humidity ratio. Humidity ratio is the kg of water in the air per kg of dry air right kg of water in air per kg of dry air is the humidity ratio it is ratio both are in kg right kg of water in dry air to that kg of dry air right.

So, the common unit is kg water per kg dry air that is how it is expressed. Then comes volume the volume is that the space occupied by the air by 1 kg of dry air at standard temperature and pressure in meter cube the volume of space occupied by 1 kg of air I should not say dry air it can be that much air also. The volume occupied by 1 kg of air at standard temperature and pressure in meter cube is the volume and the last one is the enthalpy. So, enthalpy we know we have come across till now a lot of time that the total amount of heat in the air is the enthalpy. This includes the heat to raise the air to the temperature and the heat required to vaporize the water in the air.

So, this is expressed in terms of joules per kg of dry air because it is for air a water mixture. So, that is why it is joules per kg dry air kg of what kg of dry air right. So, I repeat enthalpy is the total amount of heat in the air the this includes the heat to raise the air to the temperature and the heat required to vaporize the water in the air. The unit is in joules per kg dry air. So, once we know all the 7 properties by definition then it comes what is that from where we will find out this ok.

That is where I am going to that this is what is the psychrometric chart right. In the next

class we will obviously, explain much more and do some problems also right, but here you see this is a much more zoomed one, but this psychrometric chart is a function of pressure also here you see it is written clearly at sea level psychrometric chart at sea level. So, it is a function of pressure. So, at sea level whatever is the psychrometric chart is not the same as high altitude say like Kashmir or Ladakh or Darjeeling or Uty or similar right. So, it is a function of pressure and what are the things here we see you see so many scales there is one scale here sorry there is one scale here that is this scale will tell much in detail in the next class.

This is the temperature scale all temperatures are here whether dry bulb, wet bulb or dew point only you have to know how it has to be read right and there is also a vertical scale and this vertical scale is known as humidity ratio or normally we write it to be h absolute humidity or humidity ratio right. Then there is also a graph like this is called the saturation line on the left side there is another scale which is called enthalpy scale right. The lines like this are the enthalpy lines and the scale is known as enthalpy scale. Normally the volume lines like this are there and some other lines are also along with this like this one this is called the wet bulb line right this is called wet bulb line. Let me remove otherwise everything is becoming congested.

So, this is called wet bulb line. So, wet bulb line, volume line, enthalpy line, humidity line and the temperature lines all put together is consisting of this psychrometric chart right all these are constituting the psychrometric chart. So, we can easily determine if it is a straight point say if this is a straight point say this point is the straight point how did you how can you find out by knowing the two property values out of the 7 by two property values you can come to this point right. Similarly you can find out another set another straight point here again you need to know this two property values once you know this two property values you can determine the other property values from this straight point at this straight point of course. The other properties values will be corresponding to this straight point right.

How to do it I hope today our time is over how to do it let us come to some. So, this we will refer today's class time is up. So, I thank you all for the for attending the class. Thank you so much.