Lecture 23 Psychrometric chart

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Refrigeration and Air-conditioning

Lecture- 23
Psychrometric Chart

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Hello, I welcome you all in this course on refrigeration and air conditioning today we will discuss psychometric chart psychometric chart are very helpful in designing any air conditioning system or to understand processes involved in any air conditioning system.

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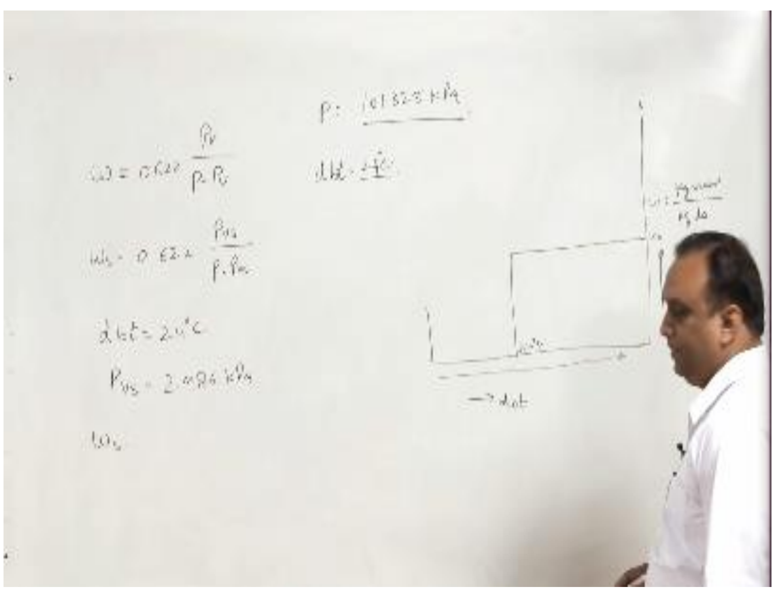

These charts or this chart is drawn between specific humidity specific immunity means kg of water per kg of dry air and dry ball temperature, so dry ball temperature increases in this direction it goes in this direction and the specific humidity increases in this direction now as you know that specific humidity of any wet air is 0.622 partial pressure of vapor divided by total pressure minus partial pressure of vapor total pressure we can take from a barometer but in psychometric chart total pressure is taken as a pressure at mean sea level that is 101.325 kilopascal that is fixed that is P.

If the vapor is saturated vapor is saturated then we will get specific heat sorry specific or humidity specific humidity at saturation state, so PVs/ P –PVS PVS is nothing but partial pressure of water vapor in the saturation state so this pressure the value of this pressure we can get from the steam table suppose outside temperature or DBT we will assume some DBT let us say DBT is 25% 25^0 centigrade if DBT is 25^0 say we have 25^0 centigrade value is not given we will assume for 24^0centigrade.

So suppose DBT is 24^0 centigrade at this dry bulb temperature the partial pressure of DBT 24^0 centigrade the partial pressure of water vapor is going to be equal to in air in 2.986 kilo Pascal now we have all the values partial pressure of the water vapor pressure we can find the value of Ω s, so for a particular temperature 24^0 centigrade here we can find the value of Ωs Ω or Ω s that is 0.1, similarly suppose I want to have suppose the travel temperature instead of 24^0 centigrade travel temperature is 10^0 centigrade.

So at 10 ^{0}degree centigrade level temperature the saturation pressure is 1.2 to 8 kilo Pascal now again using this value and this value we can find the value of Ωs at 10^0 centigrade now Ωs at 10^0 centigrade will be less than Ω s at 24^0centigrade because if you look at the partial pressure of vapor at 10^0 centigrade it is this and partial pressure of water vapor at 24^0 centigrade this is 10^0 centigrade is 2.986.

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°C	p	h_f	h_{fg}	h_g	°C	p	h_f	h_{fg}	h_g
2	0.706	8.39	2496.2	2504.6	28	3.783	117.37	2434.5	2551.9
4	0.814	16.81	2491.4	2508.2	30	4.247	125.73	2429.8	2555.5
6	0.935	25.22	2486.7	2511.9	32	4.760	134.09	2425.1	2559.2
8	1.073	33.63	2482.0	2515.6	34	5.325	142.45	2420.4	2562.8
10	1.228	42.02	2477.2	2519.2	36	5.948	150.81	2415.5	2566.3
12	1.403	50.41	2472.5	2522.9	38	6.633	159.17	2410.7	2569.9
14	1.599	58.79	2467.7	2526.5	40	7.385	167.53	2406.0	2573.5
16	1.819	67.17	2463.0	2530.2	42	8.210	175.89	2401.2	2577.1
18	2.065	75.54	2458.3	2533.8	44	9.112	184.25	2396.4	2580.6
20	2.339	83.91	2453.5	2537.4	46	10.099	192.62	2391.6	2584.2
22	2.645	92.28	2448.8	2541.1	48	11.177	200.98	2386.8	2587.8
24	2.986	100.65	2444.1	2544.7	50	12.352	209.34	2382.0	2591.3
26	3.364	109.01	2439.3	2548.3	52	13.631	217.71	2377.09	2594.8

Now here in this expression if we further manipulate this 6.22 1 /P / PVS – 1 this can be written like this also. So the moment we increase PVS the moment we increase PVS or sorry decrease the temperature degree decreases in degree this expression will increase the moment we increase PVS the p / PVS will increase, so P / PVS in case of because P is constant so in case of 24^0 centigrade is less in case of 10^0 degree centigrade this expression is more -1 1 by this expression.

So definitely as the PVS reduces saturation pressure of vapor reduces the specific humidity also reduces so this will come down at 10^0 centigrade further we can go for the 5^0 centigrade as well if I increase the temperature let us say temperature is 30^0 centigrade the specific humidity will increase let us say 40^0 centigrade it will further increase and we will get a line this line which is shown here this line is a saturation line saturation line means at this line the humidity is 100% which humidity the relative humidity.

Because relative humidity is equal to PV by PVS, now for these points we have assumed that partial pressure of vapor is equal to partial pressure of saturated vapor at that particular temperature, so φ = PVS / PVS = 100%, so relative humidity at these points so that is why it is called saturation line along this line, so if I take this point intermediate point so at any intermediate point for example this one let us say 28^0 centigrade this is going to be the humidity ratio specific humidity at 100% relative humidity.

So this is Rh 100% now I want to have constant RH of 90% also, so what we will do we will divide these line in ten parts in ten parts and then we will join these parts one by one on each line so this will give 90% RH now another eight if eight point is connected for all the vertical lines that will give 80%, now again seventh is connected that will give 70% relative humidity this is these are constant relative humidity curves they are shown in psychometric chart. Now I will show you the actual psychometric chart here.

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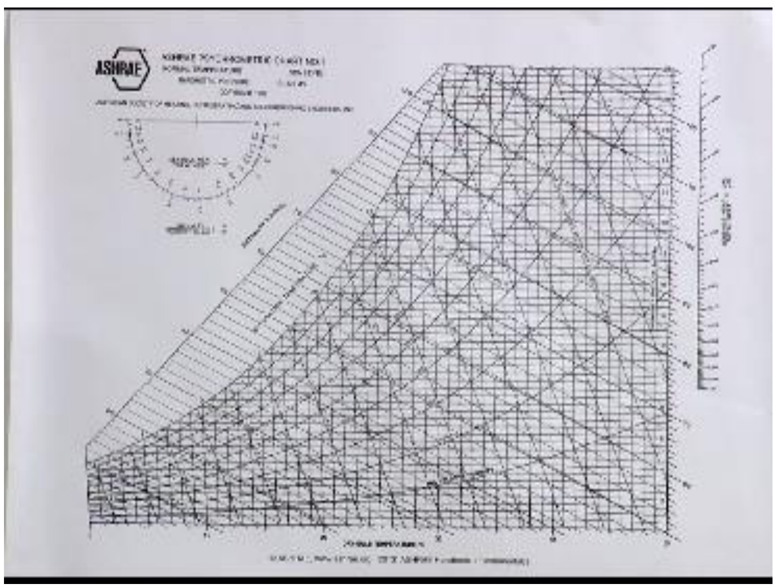

And we will discuss the characteristic curves in psychometric chart one by one now in this psychometric chart if you look at this psychometric chart this is a dry bulb temperature line.

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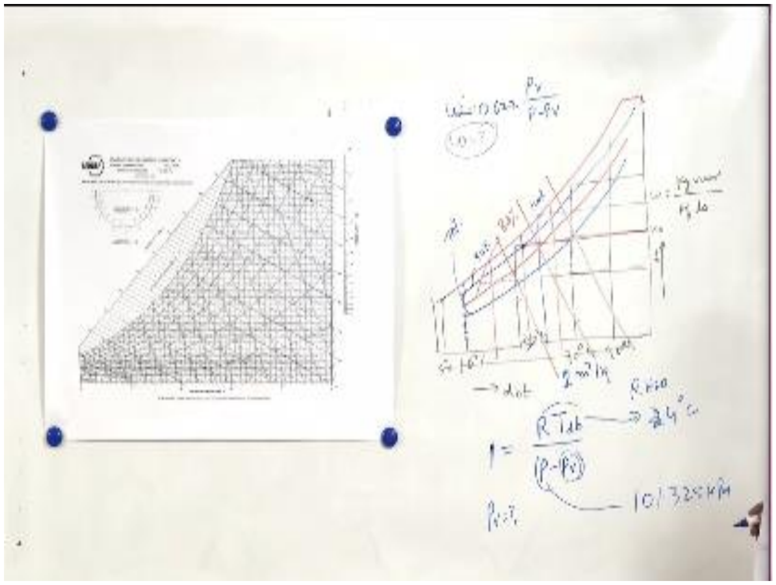

This psychometric chart I have taken from ashtray handbook 2030 and Ashlee is American Society stands for American Society for heating refrigerating and air conditioning engineers it is a society it has more than 50,000 members and I am also one of the member of the Society and they publish handbooks at every year and in 2013 they published the handbook on fundamentals and this chart has been taken from the Ashlee handbook on fundamentals on x-axis there is a dry bulb temperature.

So in this chart the vertical lines here they are constrained dry bulb temperature lines, so in this chart also you can see the solid vertical lines they are constrained driver temperature lines and they are horizontal lines also and these horizontal lines are constant specific humidity lines now if you are moving from this point to this point the specific humidity is increasing from two grams per kg to grams per kg - it is going up to 30 grams per kg and these called these curves these curves which are shown here these curves which are shown here they are constant relative humidity curve this is 10% relative humidity 20% 30% 40% 60% up to100%.

Now these psychrometric charts they have constant specific volume lines also like this now constant specific volume lines can be drawn on this chart I mean how they are drawn they are drawn let us say we want to have a constant specific volume of 2 meter cube per kg or 1 meter cube per kg so one meter cube per kg specify if I want to have a PV is equal to RT duration we will use, so RT meter cube per kg, so M will not be there and P - PV this is pressure of care.

So RET is dry wall temperature so temperature of driver multiplied by R gas constant divided by P – PV, no one is with us I want to have constant volume line of 1 meter cube per kg R we know for air right let us assume what driver temperature as 24^0centigrade 24^0 centigrade, now R is with the driver temperature with us P is already with us it is given here seen a 101.325 kilo pascal now what is unknown here is PV.

So from this equation we can find the value of PV for one bitter one meter cube per kg of volume now with the help of this PV we can find the value of this specific humidity that is 0.62 PV / P-PV now P we have calculated from here PV we will put the value of PV here and we will get the value of specific humidity so once we have the value of a specific enthalpy here we can draw lines so let us say 24^0 centigrade we have value of a specific humidity and this will give the value of this will give the value of first point of constant volume line.

Now again we can keep on changing the value of dry ball temperature and we will be getting different value of if we increase the rival temperature we will be getting different values of specific humidity and if you join all these lines will get a constant volume line so constant volume line their solid lines they are shown here in addition to this in addition to this constant they are solid lines they are very inclined lines I mean relation is more for constant volume lines it is starting from I will read out the values.

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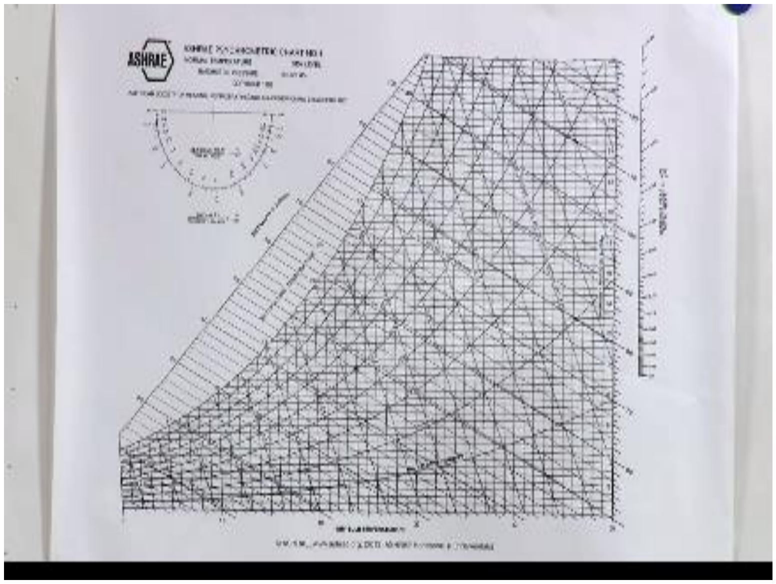

0.8 it is starting then 0.8 to 0.4 and it is increasing up to0.91, then we have you can see there are certain dotted lines, these dotted lines are constant wet bulb temperature line and close to these variable temperature lines there are solid lines also, there are, they are constant enthalpy lines. So enthalpy of air which air water vapor mixture can be taken as enthalpy of air plus specific humidity enthalpy of vapor, now enthalpy of air it is CP a P DV driver temperature, because the reference point is when the temperature is zero.

This is in degree centigrade and this so this enthalpy of air is taken as CPa T driver temperature and CPa is also assumed to be one so it is going to be like this or if you wish you can also take 1.005, this is the specific heat of air, now specific humidity is with us, now this enthalpy of a purpose is we are considering here saturated vapor enthalpy because, if you look at the value of surface saturated vapor enthalpy and enthalpy of superheated vapor there is not much difference.

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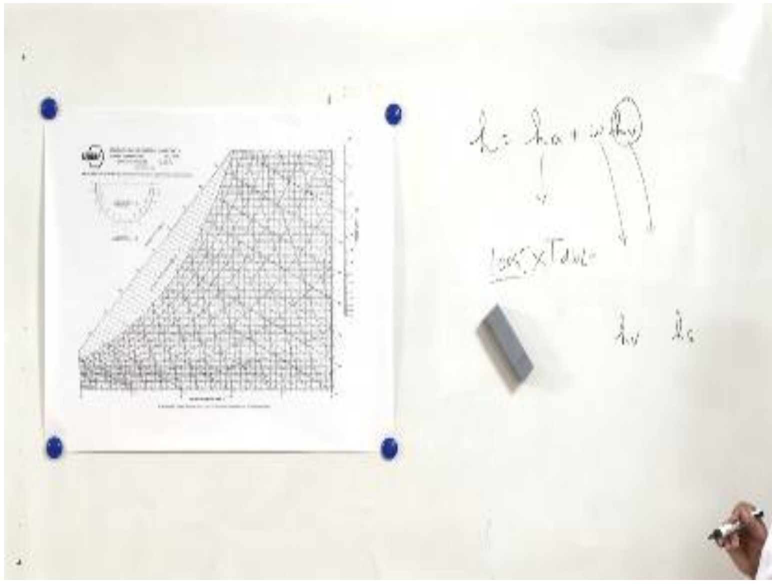

So for the sake of convenience instead of taking superheated enthalpy of superheated steam enthalpy of saturated vapor is taken here and it is multiplied by Ω. Now in this case again for a particular dry bulb temperature for a particular enthalpy, for enthalpy if I want to have constant enthalpy line, will assume particular enthalpy suppose enthalpy we can take here as let us say 80 kilo joules per kg, assume certain driver temperature and find the value of specific humidity and same process will be repeated here and we will be getting a constant enthalpy line.

Now you can see here that in the vicinity of the constant enthalpy line there is a dotted line, this dotted line is constant wet bulb temperature line, right. Now this constant wet bulb temperature line in some of the charts this is this is charged by astray, so they are shown as two distinct lines in some of the chart you will find both the lines are shown as one line and then there is enthalpy deviation some code you will find here those, like this you will find here they will give you enthalpy deviation.

Now in this chart because these two lines are giving is distinctly shown and you can see that the difference between these two lines is increasing or if I choose constant wet bulb temperature line, constant wet bulb temperature line so, initially it is it has it has less enthalpy but when it is moving in this direction the enthalpy has slightly increased along the constant where bulb temperature line the enthalpy is not constant it has slightly increased, why it has increased? it has increased because more water vapor is added during this process and enthalpy of water vapor is also accounted while calculating enthalpy of this, enthalpy of the air.

So that is why the inclination of this so in relation of this line is a slightly more than the inhalation of constant enthalpy line right, now in this chart there are certain box also on the right hand side and there is a half circle, you can see here and it has also certain numbers. So these box and these numbers will be used while doing the load calculations in an air conditioning system at the center of this chart there is a small circle.

Now this circle indicates the ideal condition, now here ideal condition is 24 degree centigrade temperature and 50 % RH but in most of the books you will find that ideal condition is 25 degree centigrade temperature and 50 percent RH, reason being it is a statistical value the temperature at which the most of the people feel comfortable is 76 Fahrenheit, now if you convert this 76 Fahrenheit to degree centigrade it turns out to be 76 - 32 /180 =degree centigrade /100, so 76 -32 *5 / 9 , so it will give 24.44 degree centigrade.

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So it is a rounded off to near integer here and it is taken as 24 degree centigrade but we take 25 degree centigrade because in India most of the case we are doing cooling so we don't recommend to be cooled up to 24 degrees centigrade, we said if you cool up to 25degree centigrade ideally state is at 8 this can save some energy also and that 25% degree centigrade temperature most of the people in our country they feel comfortable.

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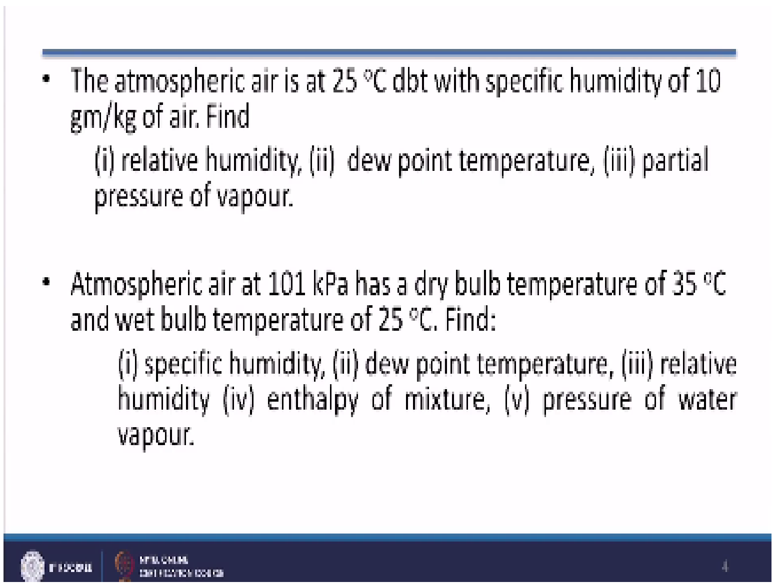

Now after this we'll take some examples I think that will make things more clear here now atmospheric air 25 degree centigrade driver temperature with the specific humidity of 10 grams per kg of air find relative humidity, now simply otherwise you may have to do elaborate calculations in this case, but here it is very simple to do 10 grams relative unity constant relative ability line is this one and driver temperature 25 degree is this one.

So where it is cutting the time it is here, so it is between 42 it is around 47% so, immediately looking at this chart without doing any calculations you can find the relative humidity. Dew point temperature, now dew point temperature is a temperature where dry bulb wet bulb and where dry bulb and wet bulb temperature are same. So if I want to have in a psychometric chart dew point temperature, I will locate it on saturation line so at the saturation line the dry bulb temperature, wet bulb temperature and dry bulb temperature and wet bulb temperature are same and this is known as dew point temperature.

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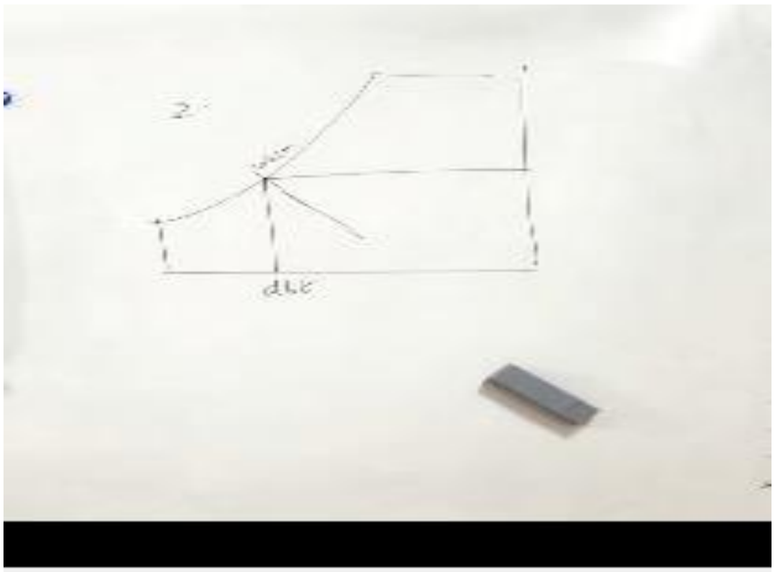

So here if now I have located this state of vapor here now , if I move in a horizontal direction then I will get a dew point temperature which is approximately which is actually 40 degree centigrade so, from the state of the air if you draw a horizontal, if you follow holes in the line and where it is cutting the saturation line that is the dew point temperature of air, partial pressure of vapor, so partial pressure of vapor again you have the specific heat and you will have to use that equation, Ω is equal to or we can use relative humidity is equal to partial pressure of vapor partial vapor in vapor at saturation State.

So at 25 degrees centigrade, we will take the partial pressure of the vapor from this chart and will put that value here relative humidity is already with us we can find the partial pressure of vapor. So in this next one atmospheric air at 101 kilo Pascal as a driver pressure 35 so, dry bulb temperature is 35 and wet bulb temperature is 25 ,so we will take it 25 degree centigrade wet bulb temperature line which will lie between this to this.

So somewhere here this is 25 wet bulb temperature line and it will 25 this much, so the state is here and from this state we can find number of values for example specific humidity ongoing in the right side then dew point will go to the left hand side dew point will be around 22 degree centigrade the relative humidity is we can take from here it is around 45% and enthalpy of mixture we can take enthalpy of mixture here as 70 and 70, 70 ,75 and we this is 70 and this is 80 so 72,74, 76, 76.5, 76.5 and pressure of water vapor again we can use the same formula P V by T vs.

So these psychometric charts are very helpful in order to find the properties of moist air. In the next lecture we will take up the psychometric processes that are all for today. Thank you.

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