INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURSE

Refrigeration and Air-conditioning

Lecture-40
Problem Solving

with
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Hello I welcome you all in this course on refrigeration and air conditioning today is the last lecture of this wholes we will take up some problem solving before that I like to discuss some trouble troubleshooting issues in troubles and troubleshooting issues in troubleshooting in air conditioning system normally air conditioning system works.

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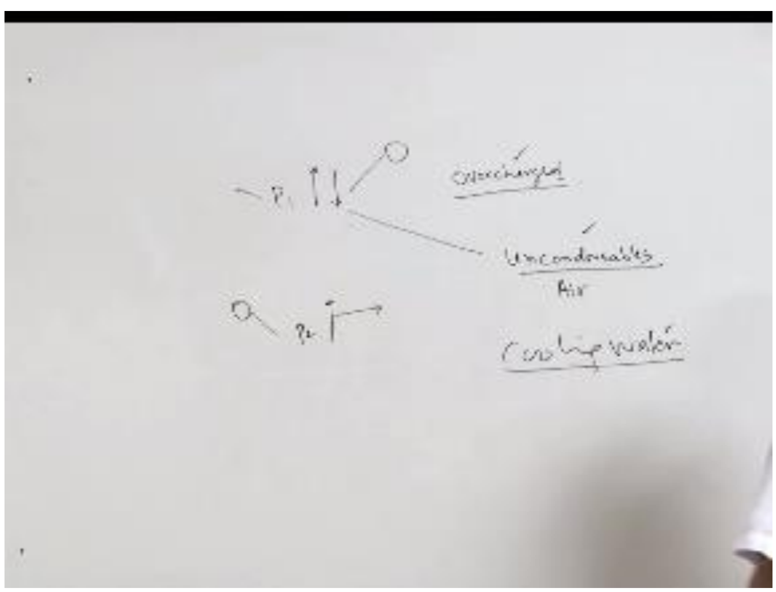

Between two pressure limits P_1 and P_2 sometimes it is observed that this P_1 is starts increasing or P_1 is high higher than the rated value because for air conditioning system it is always written the gauge pressure at this P_1 is going to be this much right and if this gauge pages pressure is exceeding or same is the case with the P_2 will also work at a certain gauge pressure so this P_2 also gauge pressure is exceeding what can be the probable reason first reason is probable reason is the system is overcharged when system is overcharged these pressures will shift right and you will not get proper cooling effect here.

And here also the pressure will shoot and this shooting of this pressure is not welcome and it is not desired because it has many side effects it gives the lubrication system of the compressor and ultimately some failure will take place inside the compressor another reason for this high-pressure can be the presence of uncontainable and our presence of air if air is mixed with the refrigerant saturation pressure of refrigerant plus the partial pressure of air will be the total pressure inside the system so I will give you an example suppose if you take refrigerant in a new vessel right and it is a mixture of liquid and vapor it is saturated vapor of refrigerant in a vessel at a room temperature right now it is mixed with the air also so what is going to happen in this cylinder the stratification of air and refrigerant will be there so the moment you open the wall here will come out the moment air comes out the pressure of this cylinder will fall it means the pressure was there inside the system.

Now the moment the air comes out the partial of the pressure of the air reduces and that is that results introduction in the total pressure so in the system also if after uni com system few purge some part of the pulse from the top first on the top because air is lighter than refrigerant right so if system is not running a stratification will take place in concentration of air in the top part of the system will be more so the moment the air is pushed the pressure will fall if there is no air if you are purging the system boiling of liquid will take place and pressure will remain constant so that is how we can ensure that the system is without air second thing is or he overcharged.

That is overcharge uncondensedabels third thing can be that the water being circulated cooling water temperature Is high if it is water pool or ambient temperature is high in old days when domestic refrigerators were used and the condenser was provided at the back side of the refrigerator it was always recommended that at least 9 to 10 each gap should be maintained in between the refrigerator and the wall so that there is a proper circulation of air even if in such a small machine if you clean the condenser just clean the dust provides considerable lubricant and this insulation effect.

So in a air-cooled condenser if you clean the condenser coils they make them free from dust the cooling capacity of the system will increase and here also if it is overheated if dust is removed then pressure may reduce if that is the reason if dusting is the reason or if the cooling water temperature is not appropriate why cooling pop water temperature is not appropriate because this pooling water in what happens in a water cooled condenser suppose there is a water cooled condenser.

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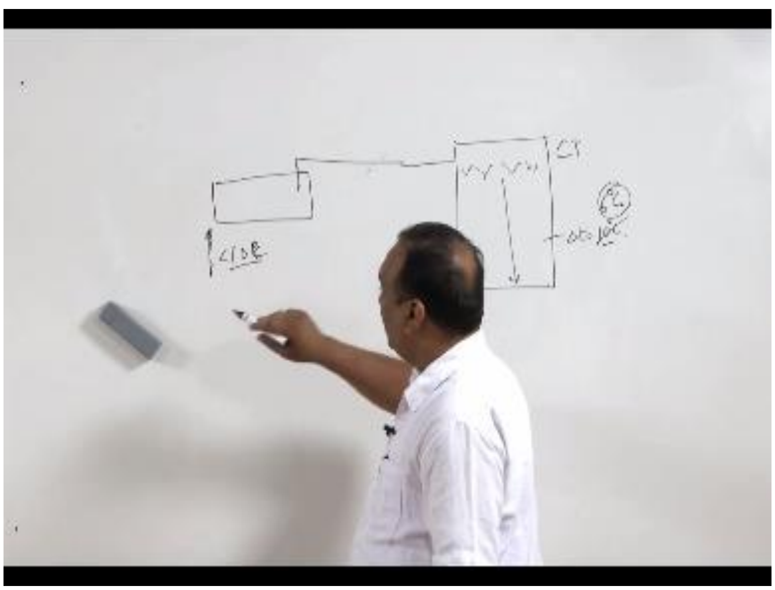

After picking heat in the condenser the water goes to the cooling tower cooling tower you must have seen cooling towers it outside the hotels in the buildings where air condition which are a centrally air-conditioned so this cooling tower is used for cooling the cooling water so cooling water picks the heat in the condenser where the condensation of vapors takes place and this in this cooling water plus cooling water has a I mean normally when system is designed it is assumed that the temperature drop in cooling water will be approximately 10°C that is why the temperature rise in the cooling water.

In the condenser should not be more than 10°C but for certain reason this pooling water is not effective temperature reduction here is only 6degree centigrade maybe some outdoor conditions because the performance of cooling tower is also dependent upon the outdoor conditions suppose outdoor air is humid is already saturated temperature drop will not be very high but here the requirement is high so slowly the temperature of holy water keep on increasing and that will shoot the pressure of.

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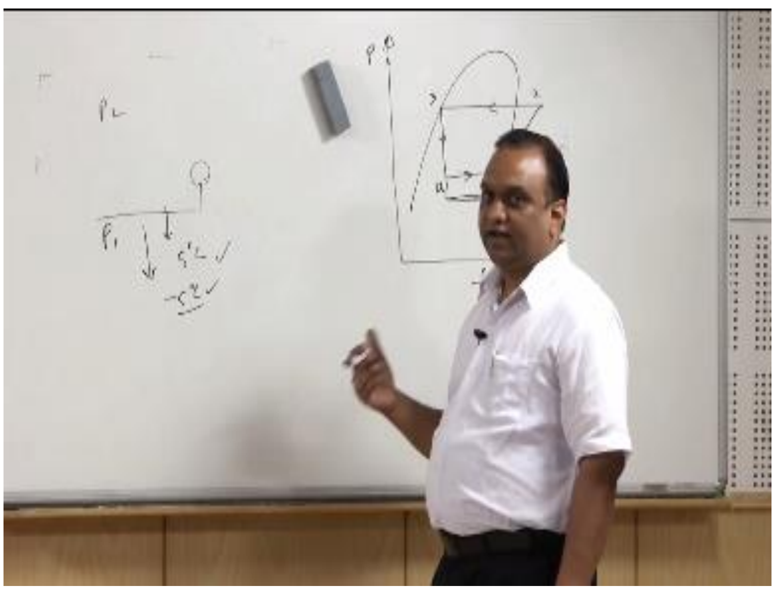

Refrigerant in the compressor now another case the pressure in the evaporator is low pressure in the evaporator certain gauge pressure has to be maintained in the evaporator it can be vacuumed also in some of the cases it is vacuum also so some gauge pressure normally for example R134a gauge pressure has to be maintained it means the pressure inside the operator is higher than the surrounding pressure and if this pressure is low so what you are getting on the PV diagram this is normal pressure but yes pressure enthalpy diagram not PV diagram pressure enthalpy diagram state one two three four.

So if the pressure is going down definitely the cooling capacity will reduce and it is misleading because here on the coils you will be getting temperature suppose actual temperature is 5°C in coil you will be getting - 5°C right it is misleading it appears that the cooling capacity has increased though the temperature has reduced the reduce but in this case cooling capacity has also reduced so when the pressure is low in the evaporator cooling capacity is also low temperature is low and cooling capacity is also look and this no temperature is normally do to undercharging of the system it means the system is under charge and it needs more refrigerant to be charged in the system now after these troubleshooting.

We can take some of the typical of some of the typical problems related with the refrigeration like a simple saturation cycle of R134a.

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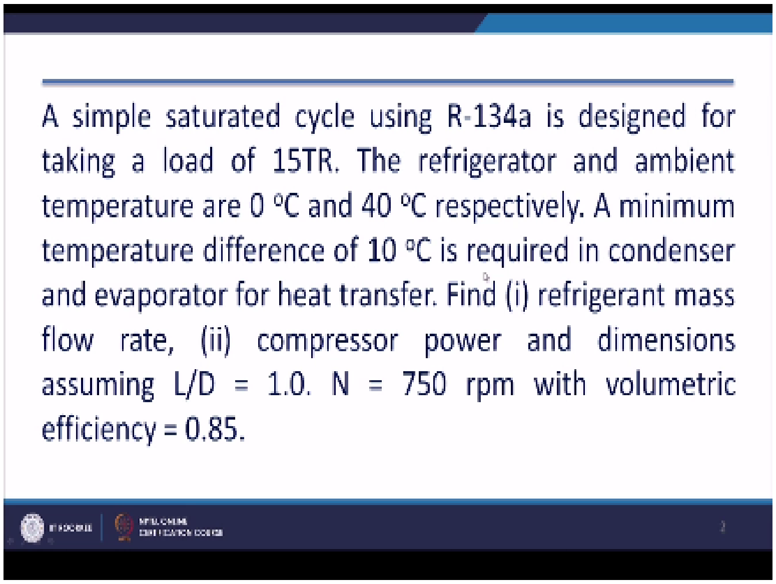

Designed to taking a load 15 TR refrigerator ambient temperature 0 and 40°C refrigerator and ambient temperature are 0 and 40°C and minimum temperature difference of 10°C is required in condenser and evaporator for heat transfer it means cycle is not between 0 and 40.

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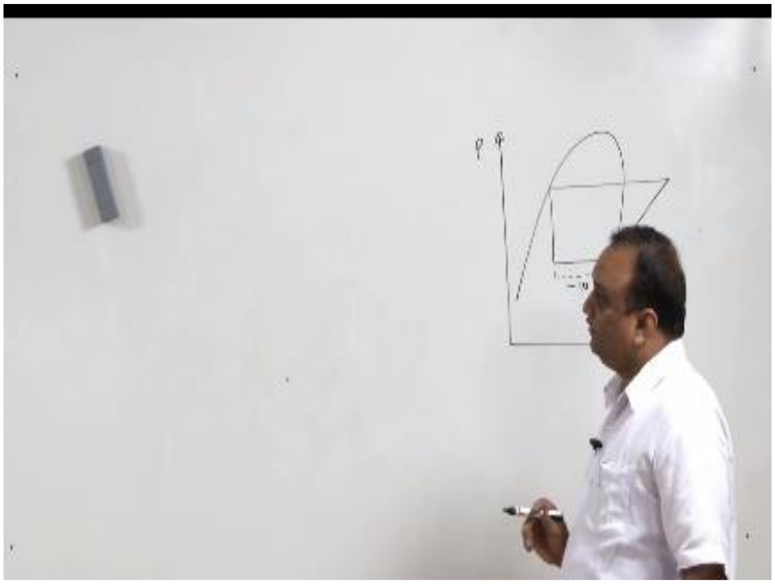

Cycle this pH diagram the refrigeration cycle is not operating between 0 and 40°C this is the outside temperature it I mean so ambient temperature or 40°C so temperature of so evaporator temperature is going to be how much it is going to be - 10 sorry evaporator temperature – 10 and what about the condenser ambient temperature is 40°C it means.

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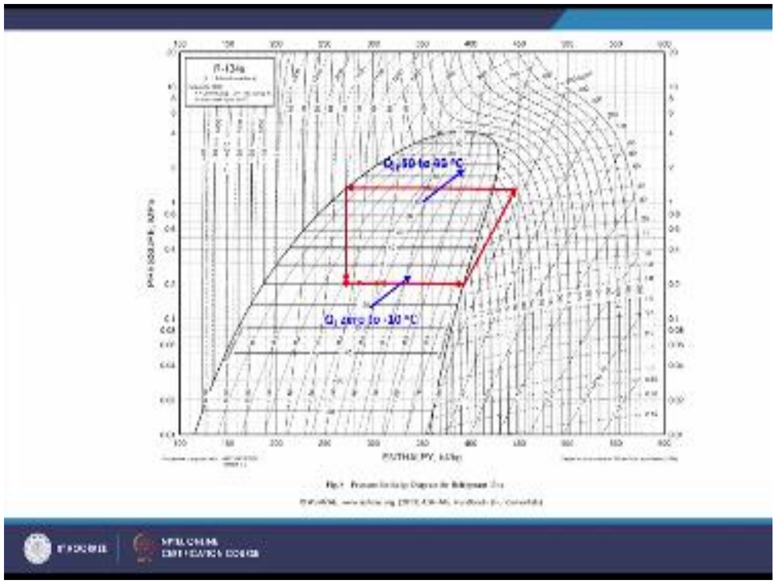

The temperature in the condenser will be 50°C refrigerant will condense at because at 50°C it will be dissipating heat add 40°C.

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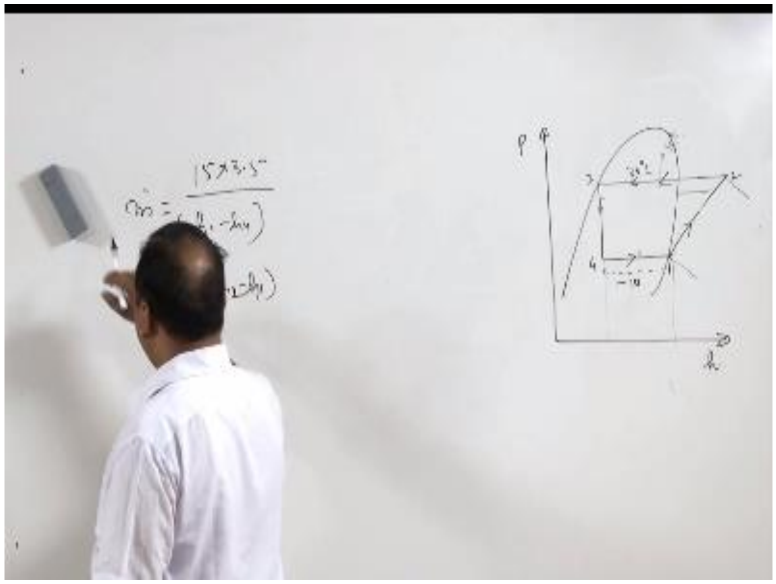

Outside temperature is 40 °C and you can use the formula Q is equal to UA LMTD right so this is how we get the value of area of the condenser so normally that 15 10 to 15°C temperature is maintained between the fluid working fluid and the surrounding environment so here it is – 10 0°C here it is outside is 40°C now the cycle will analyze rest of the endless is a simple whatever I have told you regarding the this vapour compression refrigeration system it is easy to draw below the saturation cycle so in light of the compressor will be a saturation vapor then two three and four but here the temperature limits are to be decided by the ambient temperatures.

Now second thing in this numerical is we can compressor power we can always find out because mass flow rate is equal to h1 - h4 right and damage is required 15th and so this is h1 sorry master it is not as fun voyage for mass flow rate is tonnage is already given 15 tons of refrigeration so it is going to be h1 - h4 so h1 - h4 h value of h1 and h four straight away you can take from pH diagram work of compressor you can take work is h1 – h4 mass flow rate h1 - h h2 - h1 will give the work of the compressor now the third one is dimensions of compressor now we assume here it is a single acting signal cylinder compressor.

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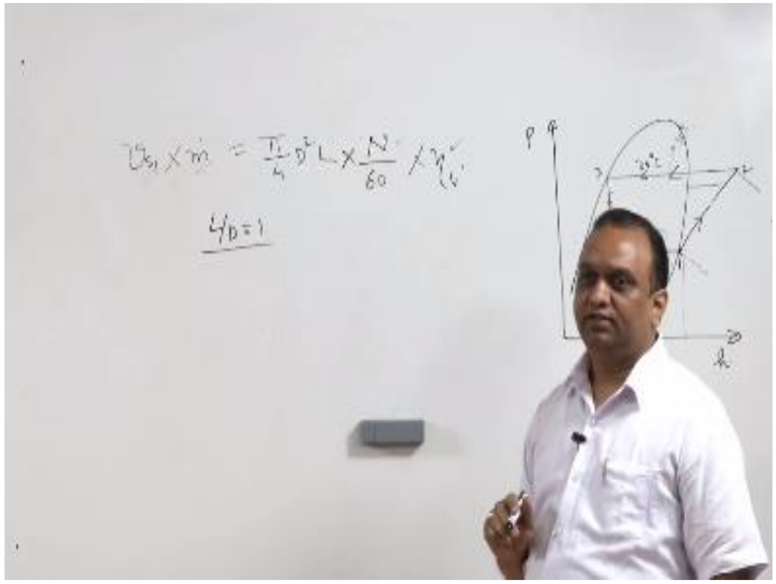

So for this we will have to find a specific volume that we can take that Lee from the pH diagram is specific volume at state 1 right x mass flow rate right this is the total volume which has to be discharged now this volume is going to be equal to swept volume of the compressor this is the diameter of the compressor piston or the current compression cylinder l is the length of the stroke number of his strokes per second here 750 RPM or n750ok n / per second so 60 so this much of volume will be handed by the compressor x volumetric efficiency now here L by D^2 cylinder so L by D is one.

So from these three equations you can bros mm dot is already with you vs1you can take from here and is given efficiency is given you can find the length L by D for the compressor so that is one typical example another is regarding the air conditioning on the system now air conditioning two things are given.

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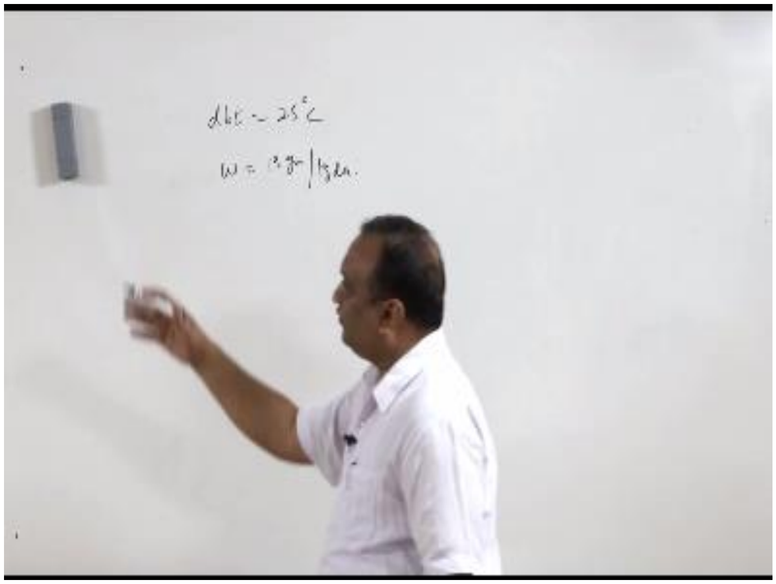

DBT is equal to 25°C and specific humidity is equal to 13 grams per kg of dry air and we have to find all this now from here we can take.

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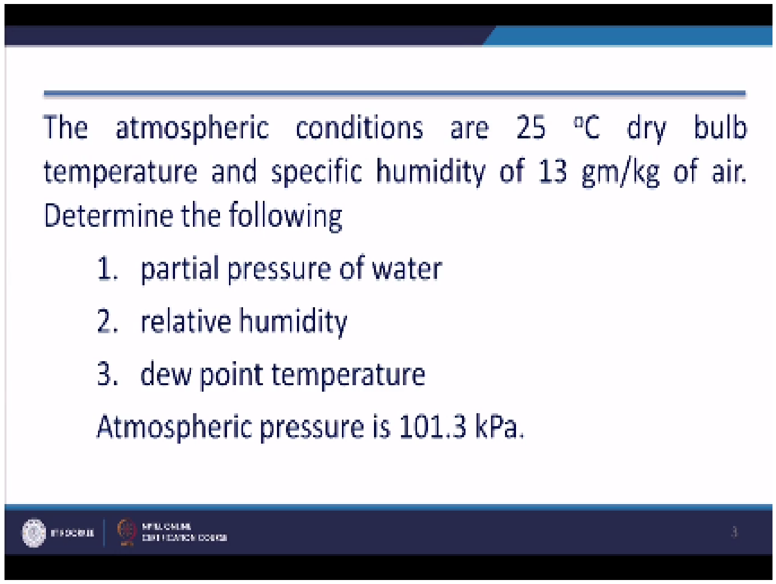

Specific humidity as 0.622.

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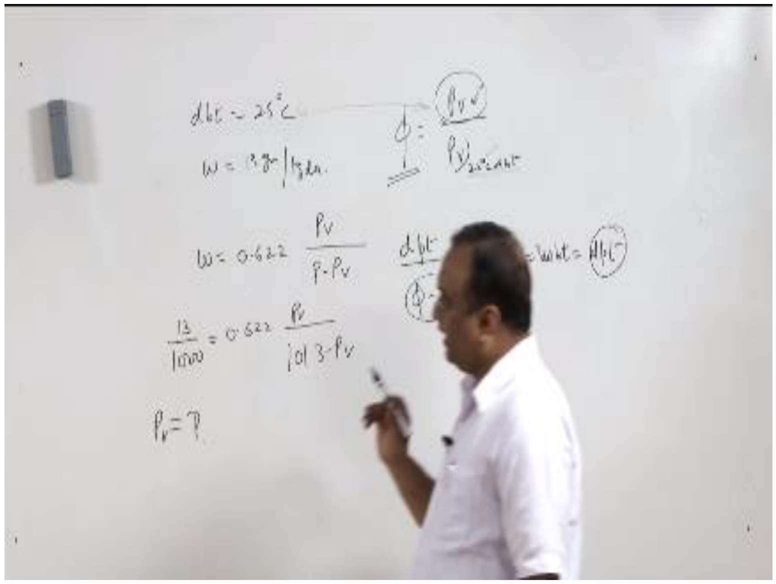

Partial pressure of water vapour divide by total pressure minus partial pressure water vapour, now W is 13 g/kg trial so 13/1000=0.622Pv atmospheric pressure 101.3 so 101.3-Pv and this will give us the value of Pv this can do by yourself, right from here we will get the value of partial pressure of vapour. Now this partial pressure of vapour is first is already at N relative humidity, relative humidity is partial pressure of vapour, partial paper of vapour when it is saturated at let us 25˚C dpt so this we can take from the properties of steam.

We just take the steam table and from a steam table partial pressure of water vapour can be taken at 25˚C and partial pressure we have calculated from here that these two ratio between these two will give the relative humidity due point temperature due point temperature, now due point temperature where the due point will arrive, the due point will arrive when the vapour is completely saturated a sample of vapour is there which has certain relative humidity due point will arrive when 5=1 it means Pv, Pv this Pv becomes the saturation pressure, right.

So we will keep on reducing the temperature now dpt will keep on reducing dpt will keepon reducing and where the dpt become waved bulb temperature and this is equal to due point temperature. So we will keep on reducing the dpt till the value of dpt becomes corresponding to partial pressure of vapour. When the value of dpt becomes correspond or it turns to be corresponding to the partial pressure water vapour that is the due point temperature, so this is how we can calculate the due point temperature.

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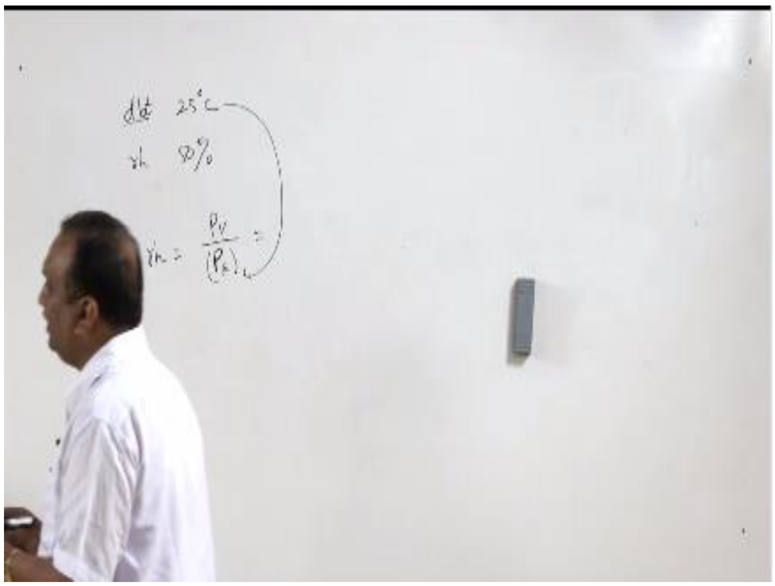

I can give you one example in addition to this because normally if you look at the weather data you will find that dpt is today dpt is 25˚C temperature is 25 they do not say dpt temperature is 25 and relative humidity is 50%, right so if we take this case temperature 25˚C relative humidity is 50% now in this case so relative humidity is partial pressure water vapour divided by the saturation pressure of water vapour at this dpt, so if we look at the properties of saturated vapour at 25˚C it is not given here. So partial pressure of water vapour at 25˚C so 24 it is 24 it is how much.

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°C	p	h_f	h_{fg}	h_g
2	0.706	8.39	2496.2	2504.6
4	0.814	16.81	2491.4	2508.2
6	0.935	25.22	2486.7	2511.9
8	1.073	33.63	2482.0	2515.6
10	1.228	42.02	2477.2	2519.2
12	1.403	50.41	2472.5	2522.9
14	1.599	58.79	2467.7	2526.5
16	1.819	67.17	2463.0	2530.2
18	2.065	75.54	2458.3	2533.8
20	2.339	83.91	2453.5	2537.4
22	2.645	92.28	2448.8	2541.1
24	2.986	100.65	2444.1	2544.7
26	3.364	109.01	2439.3	2548.3

°C	p	h_f	h_{fg}	h_g
28	3.783	117.37	2434.5	2551.9
30	4.247	125.73	2429.8	2555.5
32	4.760	134.09	2425.1	2559.2
34	5.325	142.45	2420.4	2562.8
36	5.948	150.81	2415.5	2566.3
38	6.633	159.17	2410.7	2569.9
40	7.385	167.53	2406.0	2573.5
42	8.210	175.89	2401.2	2577.1
44	9.112	184.25	2396.4	2580.6
46	10.099	192.62	2391.6	2584.2
48	11.177	200.98	2386.8	2587.8
50	12.352	209.34	2382.0	2591.3
52	13.631	217.71	2377.09	2594.8

2.986, 2.986 kilo Pascal and 26˚C it is 3.364, 3.364 kilo Pascal so 25˚C it is going to be 2.986+3.3364/2 3.175, 3.175 kilo Pascal.

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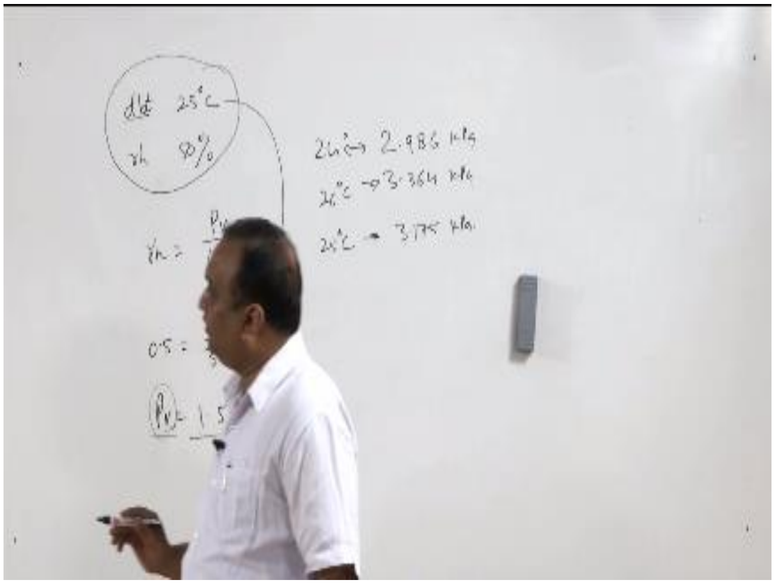

Now relative humidity is 50% so 0.5=Pv/3.175 and if you want to find the Pv at this temperature that is going to be Pv is 1.587 kilo Pascal. Now we will find in order to find the due point temperature for this air for this state of air we will find temperature which is corresponds saturated temperature corresponding to this Pv, so 1.587 will be close to 14 it will be between 12 and 14 1.58, yes it will be between 12 to 14˚C, so this will be this temperature we can attain by doing interpretation, linear interpretation all the values between 12 and 14˚C.

I think it is going to close to 30˚C at 1.403+1.599, 1.501 slightly I have 13˚C anyway it is going to between 12 and 14˚C in order to find the exact temperature linear interpretation can be done. Now after this cycloramic numerical we can take another part of this cyclamatory that is heating systems. Now this numerical this problem involves a heating system.

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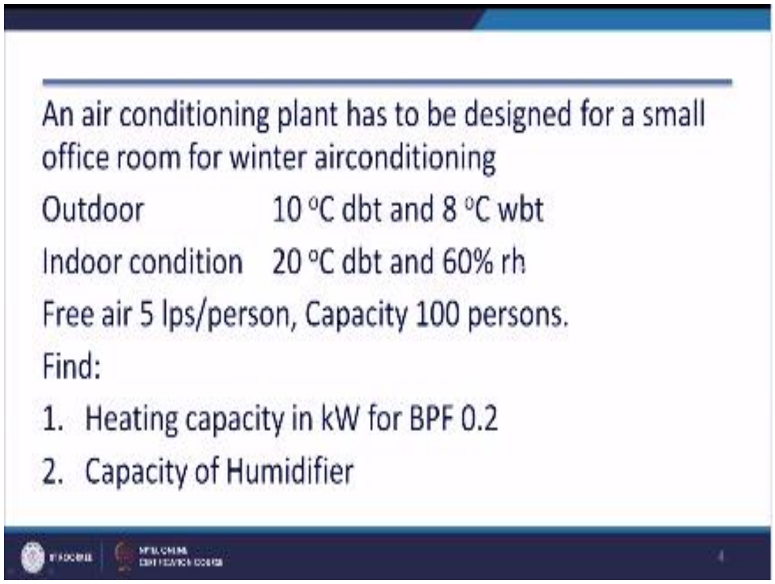

An air conditioning plant has to be designed for a small office room for winter air conditioning so far we have discussed summer air analyzer we have done the numerical on summer air conditioning this is for winter air conditioning. Outdoor is 10˚C and 8˚C wet bulb temperature, indoor is 20% 20˚C and 60%rh, so here in this case if we take the outdoor conditions that are 10˚C dry bulb temperature so this is 10˚C dry bulb temperature and this is constant dry bulb temperature line an 8˚C wet bulb temperature.

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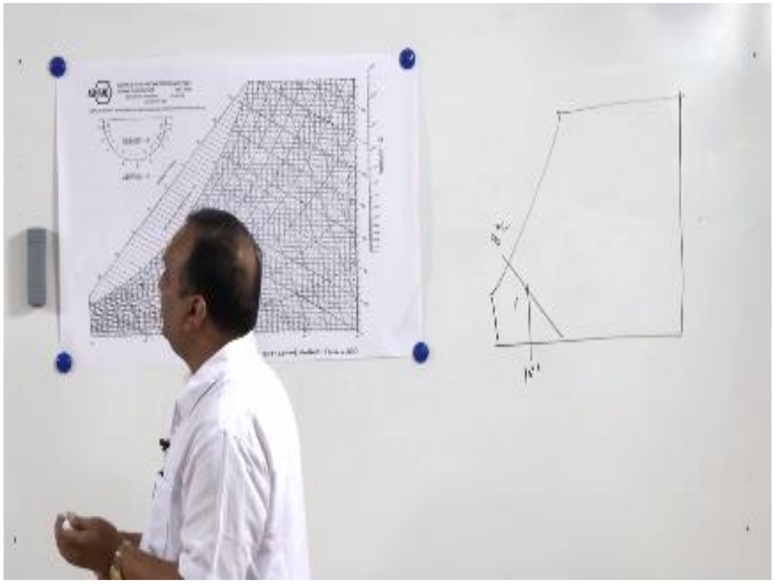

So 5,5,6,7,8 so this is the wet bulb temperature and we will follow this line this is the outside air condition, if we show this on cycolmatic chart it is something like this is wet bulb temperature 8˚C and this is dry bulb temperature 10˚C this is the state, this is the state let us say 1. Now indoor condition is 20˚C dry bulb temperature now 20 dry bulb temperature 60%rh so 50% and 60% this is the indoor condition and here we can show in indoor condition somewhere here and this is 20 state 2 is 20% 20˚C dry bulb temperature and 60% relative humidity, right.

Now heating a humidification the two process involved here first of all we have to heat the air and then humidification has to be done. Now for heating air and humidification first of all we will draw a straight line here.

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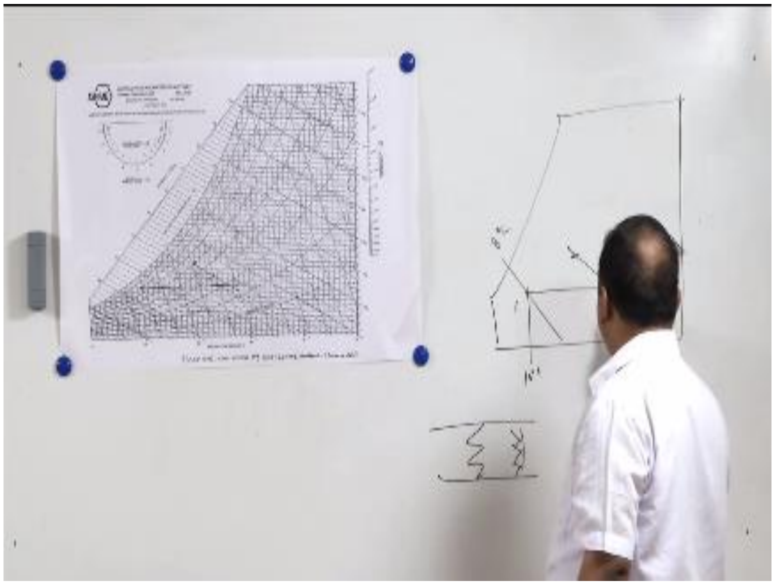

Straight line, and then we will draw a straight line constant wet bulb temperature is straight line passing through this point and that will give us the supply temperature, so we will follow this process from 1 to this is 2 this 3 so we will come 1,2,3 and from 3 after heating evaporating cooling will be done. So in actual arrangement in that there is going to be a heater and after the heater there is a spray of water, so heating and humidification is being carried out so here also we can show that heating and humidification this is state 3.

Now after this it is let it by pass sector is 0.2 bypass sector means there is another state 4 we have to identify and T4-T3 bypass vector if we consider bypass vector.

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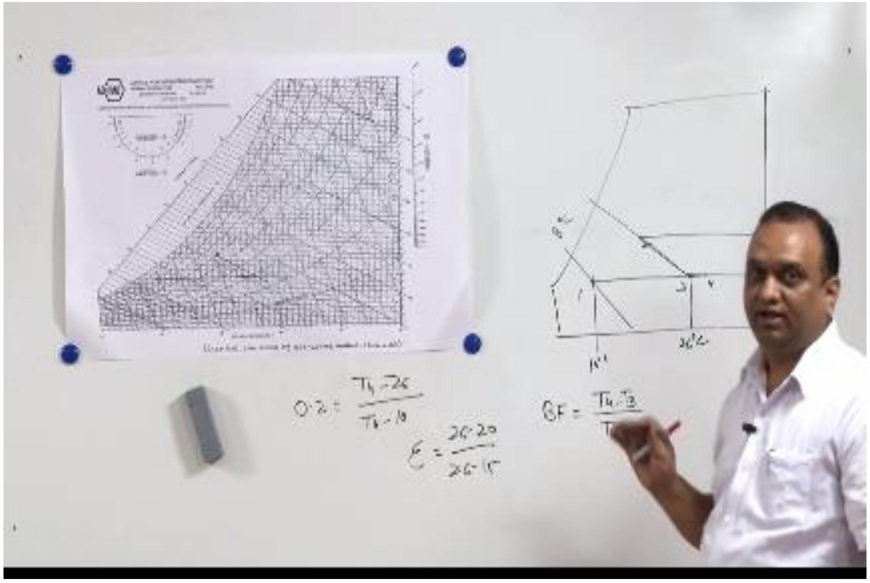

Then by pass vector is this is 4 T4-T3/T4-T1 maximum divided by difference, sorry difference divided by maximum so this is how we will get the temperature T4 so now for this temperature this is 26˚C so T3 is 26˚C if bypass vector is 0.2 so 0.2=T4-26˚C/T4 is T4 - 10°C and from here we will get the value of T4 for that is the coil temperature and capacity of humidifier yes this is the new term capacity of humidifier capacity of the humidifier is how much water has been added by the humidifier per kg of air now water added by the humidifier per kg of air.

We can take from here it is from inside condition it is a nine and four this is 9 grams per kg and from outside condition it was 6 so 6 to 9 to 3 grams per kg of air water has been added effectiveness of evaporative cooler can we take their two things one is capacity of humidifier another is effectiveness of evaporative cooler now if happiness of a particular will be if you move along this evaporative cooler so if you move along this line 50°C.

So if we were able to achieve 50°C the effectiveness would have been hundred percent so it is 20 - sorry 26-20 so it is the effectiveness of a particular is going to be 26 - 20 - point is 26-20 / 26 – 15 actual / maximum possible this is actual temperature drop there was / a maximum possible temperature of or in case of unity also you can calculate actual humidity rise humility rise in the case of when the air is totally saturated that is known as effectiveness of air washer now here it is capacity of humidifier that is expressed in terms of how much water is added into the air so this water addition today now how much air is circulated free air is five liter second per person five liters per second per person. So how many persons hundred persons so 100 percents five liters per second means the.

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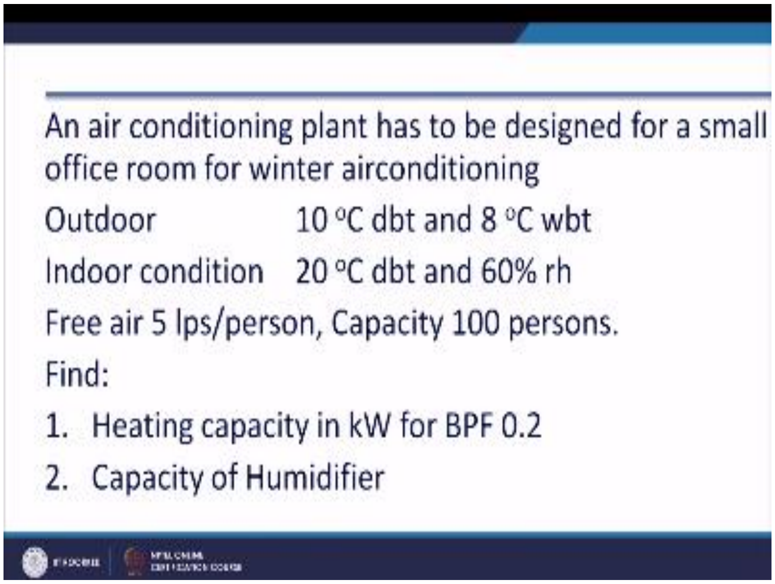

Airs flow rate has to be 500 liters per second so air flow rate is 500 liters per second.

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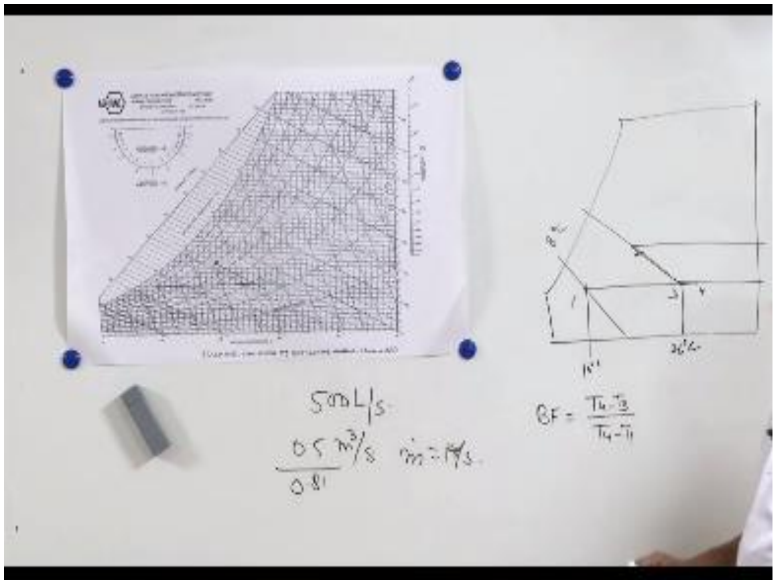

Now this litter per seconds means 0 point 5m^3 per second now supply care is coming from here we can take the volume is point 8 1 meter cube per second so meter cube per kg so / 0.81 give us the mass flow rate of air that will be kg per seconds this is how once we have the mass flow rate of air we can find the total capacity of absolute caps t of humidifiers so per kg it is three grams then it will be multiplied by the mass flow rate of the air then we' will get total capacity of the humidifier so likewise we can also calculate the heating capacity of heating coil as well now this is the this was the last lecture of this course.

I have completed this course all the lectures of this course I hope you enjoyed and learn from these lectures you can keep on doing practice with the number of books are available on refrigeration and air-conditioning in the market in those books you will find and a variety of numerical so more you practice more you learn so you practice with those books so keep on keep on doing practice from these books soon your examination will be conducted for this course I wish best of your luck for this examination thank you very much for attending this course.

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