Mass Transfer Operations II

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Lecture No 4

Humidification and Air Conditioning

Design of Cooling Tower

Welcome back to Mass Transfer operations II and we are now discussing on module humidification and air conditioning. In the last class we have discussed on the cooling tower design using this individual gas space mass transfer coefficient. In this class we will be discussing the cool humidification problem using this overall mass transfer coefficient that is K_Y'

Humidification Problem 2

It is planned to cool water from 43.3^{0}C to 29.4^{0}C in a packed countercurrent water-cooling tower using entering air at 29.4^{0}C with a wet bulb temperature of 23.9^{0}C. The water flow is 9764.9 kg/h.m^2 and the air flow is 6835.4 kg/h.m^2. The overall mass transfer coefficient is $K_Y'a$=2500 kg/m^{3}h ($\Delta Y'$). Calculate (a) minimum air rate that can be used and (b) tower height needed if air flow of 6835.4 kg/h.m^2 is used.

Given: Height of transfer unit, $H_{toG}=G_s/K_Y'a$. Tie lines are vertical.

Enthalpies of saturated air-water vapor (Base temperature: 0^{0}C)

Temperature (^{0}C)	H$'$(kJ/kg dry air)	H$''$ (kJ/kg dry air)	Temperature (^{0}C)	H$'$(kJ/kg dry air)	H$''$ (kJ/kg dry air)
15.6		43.68	37.8	122.4	148.2
26.7		84.0	40.6	139.4	172.1
29.4	71.7	97.2	43.3	154.8	197.2
32.2	88.4	112.1	46.1		224.5
35.0	105.4	128.9	60.0		461.5

Welcome back to Mass Transfer operations II and we are now discussing on module humidification and air conditioning. In the last class we have discussed on the cooling tower design using this individual gas space mass transfer coefficient. In this class we will be discussing the cool humidification problem using this overall mass transfer coefficient that is Ky prime. The problem is it is planned to pull water from 43.3 degree Celsius to 29.4 degree Celsius in a packed counter current water-cooling tower using the entering air at 29.4 degree Celsius with the wet bulb temperature of 23.9 degree Celsius. The water flow is 9764.9 kg per hour meter square and the air flow is 6835.4 kg per hour meter square. Now overall mass transfer coefficient that is Ky prime a, is equal to 2500 kg per meter cube hour. Now we have to calculate the minimum air rate that can be used and tower height needed if the air flow rate is 6835.4 kg per hour meter square.

And the height of a transfer unit H tog is equal to Gs by Ky prime a and as we discussed earlier also the tie lines for this case also will be vertical from this temperature axis and parallel this one across the Enthalpy axis. And the Enthalpy values and then this one Enthalpy values at the saturation point are given in this table like say at 29.4 degree Celsius the Enthalpy value is 71.7 kilo Joule per kg dry air hour as this Enthalpy at saturated air or 100 percent saturation is 97.2 kilo Joule per kg dry air and say for 43.3 degree Celsius that is we can say that entering temperature of the hot water, the Enthalpy value is 154.8 kilo Joule per dry air whereas that saturated Enthalpy value H star prime is 197.2 kg joule per dry air.

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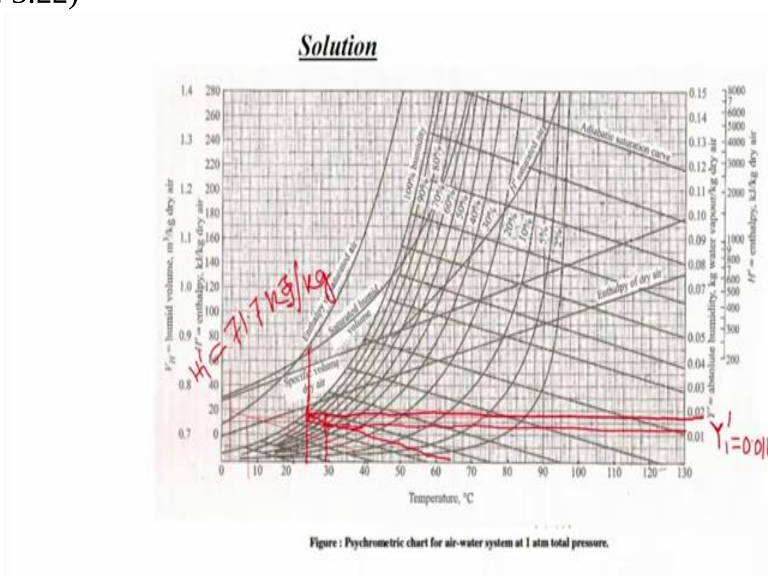


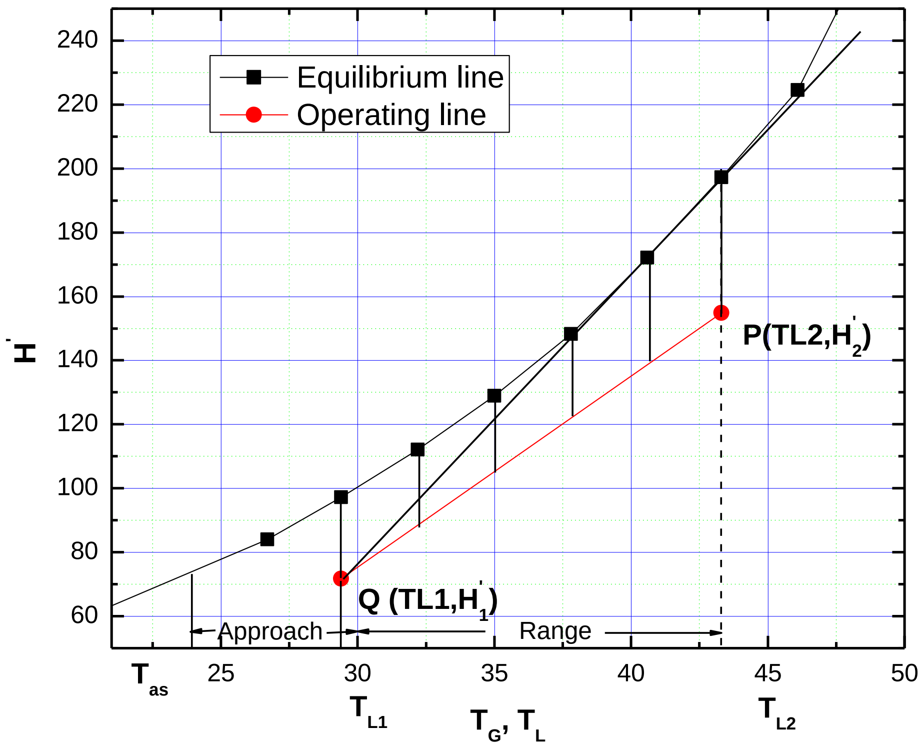
Y_1' =0.0165 kg/kg dry air [From Psychrometric chart]

H_1' =71.7 kJ/kg

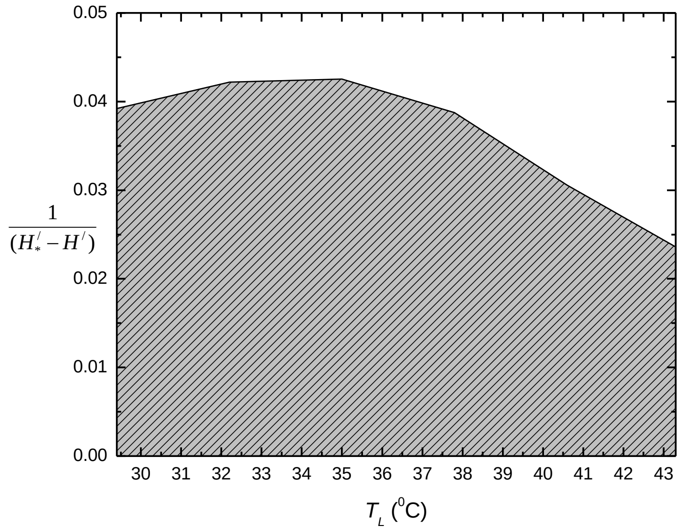
H_2' =154.8 kJ/kg

From Graph, at $G_{s,\,min}$, H_2' =197 kJ/kg at 43.3^{0}C

(a) $G_{s,\,min}$=4546.4 kg/h.m^2.



T_L	$H^/$	$H^/_*$	$1/[H^/_* - H^/]$
29.4	71.7	97.2	0.039216
32.2	88.4	112.1	0.042194
35	105.4	128.9	0.042553
37.8	122.4	148.2	0.03876
40.6	139.4	172.1	0.030581
43.3	154.8	197.2	0.023585



N_{toG}=Area under the curve= (154.8-71.7)×0.036148=3.004

H_{toG}=2.734 m

(b)Tower height= 2.734×3.004 m=8.213 m (Ans.)

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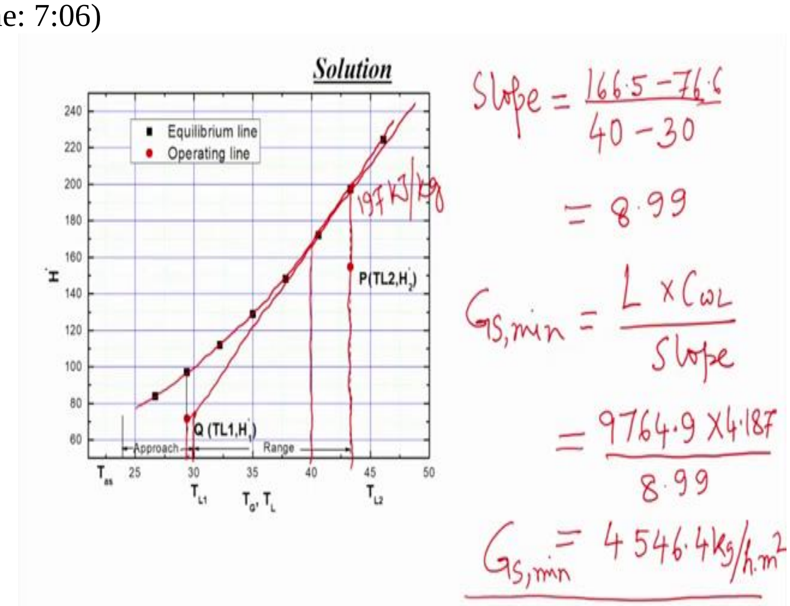

Both the values we have so that the bottom point that is Q is pointed here like this a TL1 is 29.4 degrees Celsius and Enthalpy value is 71.7 kilo Joule per kg dry air. So this Q point is the bottom point of the operating line. Now we have to do one thing. We have to draw the equilibrium curve So this for this equilibrium curve this Enthalpy values are already giving whatever the H star prime is given for different temperature starting from say 15.6 degrees Celsius like this. We started with say at 15.6 degrees Celsius the Enthalpy the equilibrium Enthalpy value was 43.68 kilo joules per kg dry air. And from there actually say the all the equilibrium values are plotted here like this. Say, here we can now join these all the Equilibrium lines to get the equilibrium point say curve.

So now we have this equilibrium curve and so this bottom point or we can see this Q is already identified. The next step will be we need to draw attention to this equilibrium line like this we need to draw say that way we need to draw attention to the Equilibrium line. And now we have to find the slope is called line which is touching the we can say equilibrium line. So from this condition we can say this one. The minimum gas flow rate can be calculated using this slope using this tangent because it is as we discussed earlier also the whenever the we draw a tangent from the bottom point to the equilibrium line, the corresponding condition will give them minimum flow rate of the gas and for that we can actually we can say this one slope will be calculating.

So now we will be finding the slope of the operating line which is operated at the minimum gas flow rate. So let us take the one point as 40 degrees Celsius then one corresponding Enthalpy value will be say 166.5 kilo joules per kg 166.5 kilo joules per kg for 40 degree Celsius ad for 30 degrees Celsius say we have this 76.6. That is for 30 degree Celsius this value is say 76.6 kilo joules per kg dry air. So it will be like this, ultimately it will be 8.99. Ok. So we can now find out what will be the minimum gas flow rate from the equation like this. Say Gs minimum is equal to say liquid flow rate in to Cwl divided by slope. So now we will be putting this we know that liquid flow rate is given as 9764.9 into Cwl is 4.187 divided by slope is equal to 8.99. So that is nothing but if we calculate this one will be getting that Gs minimum is equal to 4546.4 kg per hour meter square. So that we can see this one.

This is the minimum gas flow rate for this cooling tower. For this because you see this the final temperature of the water or we can say this one. Whatever the inlet temperature of water that is given as 4313 degrees Celsius and if we just move this on through these lines of 43.3 degrees Celsius will be getting this Enthalpy value this one for that will be getting this is around so we can say Enthalpy value this edge to prime will be 190 this is you can see this one 197 kilo Joule per kg dry air. So that is we can say this one for minimum gas flow rate so Enthalpy value will be 197 kilo Joule per kg dry air.

Now you see in the problem. So it is given that whatever the minimum air flow rate that can be used, so we can see this one the minimum gas flow rate will be like this the 4546.4 kg per hour meter square and now we need to this one calculate for this. For the second problem the tower height needed if air flow rate is 6835.4 kg per hour meter square. So in this case this air flow rate is already given. So there is no need to multiply these minimum gas flow rate with 1.2 to 1.252, 1.5 will directly take that Gs. So for that case actually we will be taking these Gs as such.

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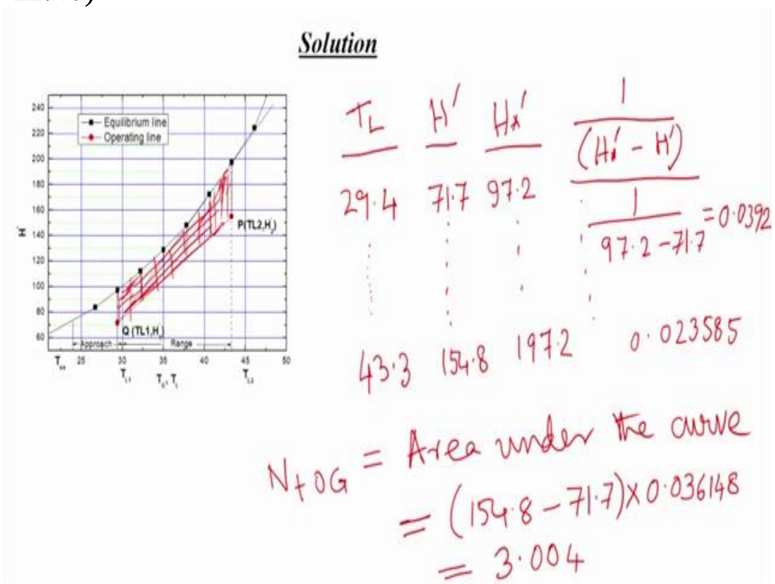

Now so we will be doing this one for this second case. We will be taking this. Now actually we say we need to get this area under the curve so that will be requiring for getting this in T0C so for that case what we will be doing. So we need to do this calculation like say we will be taking this just TL and then corresponding say H prime.

What is your Enthalpy value then corresponding a star prime. And we will be calculating this one by a star prime minus H prime. From there actually the area under the curve, we can say this one this TL and we can say that one by H star minus H prime will be getting that say what will be the area under the curve from there will be getting just what will be the NTOG. So let us take we will start from this minimum temperature or we can say this one cold water temperature that is 29.4 degrees Celsius. And for that from this curve actually we will be getting these whatever the point is minimum point (())(13:57).

The Enthalpy value is 71.7 kilo Joule per kg and corresponding equilibrium this one Enthalpy value that is if because if we need to move vertically up to this equilibrium line there will be getting this Enthalpy value as say 97.2 kilo joules per kg dry air then one by H star minus this one H prime that will be say 97.2 minus 71.7. This is nothing but 0.0392. So accordingly will be calculating like this for different temperature so we can give the increment or say 1.5 or say 2 degrees Celsius or whatever maybe we can give this one and then we can move up to say 43.3 degrees Celsius. For that we will be getting this Enthalpy value will be like this 154.8 kilo Joule per kg dry air and corresponding equilibrium Enthalpy value will be 197.2 and then this one way H star prime minus H prime will be say this one just by calculating this one will be getting this 0.023585.

So that we do will be calculating all this and then all the one by H star prime minus H prime will be calculating using this formula. Now we see this one all the lines like this all the vertical line whatever is drawn inside this one will be getting this area under the curve like this part actually we have this one the inter part actually will be getting whatever the area under the curve will be getting from there will be calculating this Ntog. That Ntog is nothing but say this N tog. So gas phases this one what is called number of gas transfer units that is we can see this one area under the curve. Under the curve, So that is nothing but we can see this one if we take from here say for this area under the curve will be getting this 154.8 minus 71.7 in to 0.036148. That is nothing but we can say 3.004. So now we have this Ntog is equal to 3.004. So this is the number of gas phase transferring unit.

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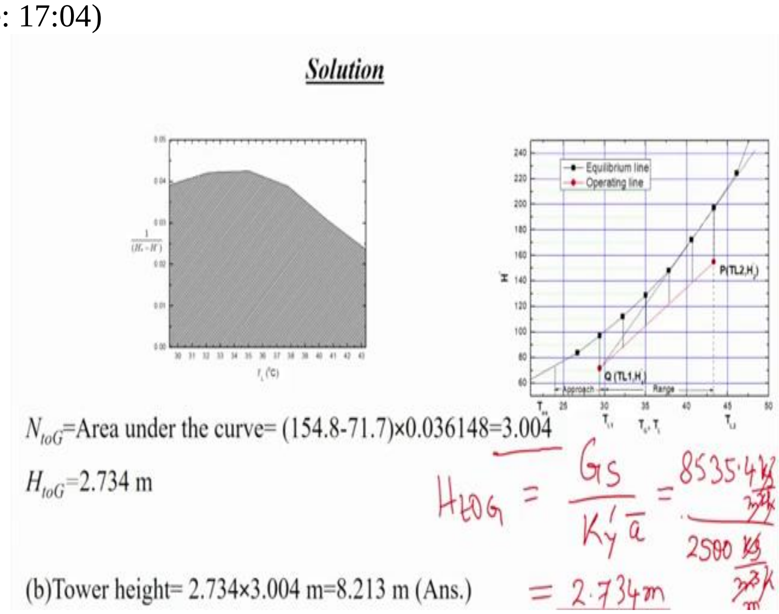

Now we will be calculating this Htog. That Htog will be calculating just by we can say this one Htog that is we can say this one Htog that is from the formula whatever is we know Gs by capital Ky prime a bar is equal to say that is Gs is given as 8535.4 say kg per meter square hour so kg per meter square hour divide by that is Ky prime is given as 2500 kg per meter cube hour. So from here we will be getting this kg kg then hour hour will go in meter square and meter cube will go will be getting only meter. So that is 2.734 meter. So now we have this NtoG is equal to 3.004 and HtoG is equal to 2.734 so total height of this tower is equal to NtoG in to HtoG so we will be getting total tower height is equal to 2.734 in to 3.004 meter is equal to 8.213 meter. So this is the we can say this one height of the tower say if this gas flow rate is given as 8535.4 kg per meter square hour.

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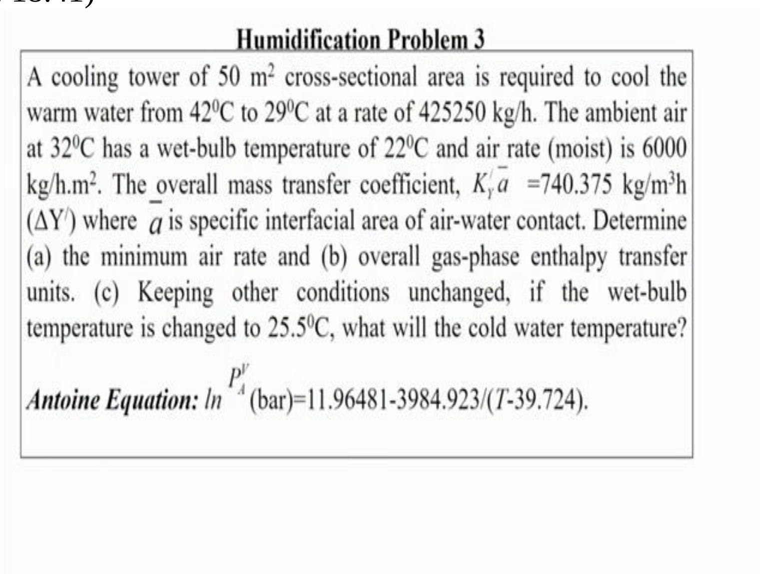

Humidification Problem 3

A cooling tower of 50 m^2 cross-sectional area is required to cool the warm water from 42^0C to 29^0C at a rate of 425250 kg/h. The ambient air at 32^0C has a wet-bulb temperature of 22^0C and air rate (moist) is 6000 kg/h.m^2. The overall mass transfer coefficient, $K_Y^{/}\bar{a}$ =740.375 kg/m^3h ($\Delta Y^{/}$) where $\bar{a}$ is specific interfacial area of air-water contact. Determine (a) the minimum air rate and (b) overall gas-phase enthalpy transfer units. (c) Keeping other conditions unchanged, if the wet-bulb temperature is changed to 25.5^0C, what will the cold water temperature?

Antoine Equation: $ln\ P_A^{V}$ (bar)=11.96481-3984.923/(T-39.724).

Now will be solving this another problem where say we need to calculate that minimum air flow rate, then overall gas transfer, Enthalpy unit and keeping other conditions unchanged if the temperature is 10 change to other temperature. What will be the cold water temperature or we can say this one what will be the output of this we can say this one water what is coming out from the cooling tower. Like the problem is a cooling tower of 50 meter square cross sectional area is required to pull the warm water from 42 degrees Celsius to 29 degrees Celsius at a rate of 4 lakh 25000 to 50 kg per hour. The ambient air at 32 degrees Celsius has a wet bulb temperature 22 degrees Celsius and air rate that is moist actually is 6000 kg per hour meter square.

So now we need to find out the absolute humidity from there actually we will be getting the air flow rate without moisture. So that will be getting GS actually we will be getting from there.

The overall mass transfer coefficient the capital Ky a bar is equal to 740.375 kg per meter cube hour where a prime is actually specific interfacial area of the water air water contact. So now we need to determine the minimum air rate and overall gas space Enthalpy transfer unit then 3rd this one question is that keeping other conditions unchanged if the wet bulb temperature is changed to 25.5 degrees Celsius. So what will be the cold water temperature?

And we also discussed this one earlier that the cooling tower performance is solely controlled by the environmental conditions so if the dry bulb temperature, wet bulb temperatures are changed with the climatic change. So the performance of the cooling tower or we can see this one final temperature of the cold water which will be exiting from the cooling tower will change. So it is definite that if the wet bulb temperature is increased say from 22 to 25 degrees Celsius 25.5 degree Celsius definitely cold water temperature will increase or in other words we can say that the performance of the cooling tower will decrease if the wet bulb temperature is increased so Antoine equation LNPB that is in bar is equal to 11.96481 minus 3984.923 by T minus 39.724 where temperature is Kelvin. So we need to solve this problem.

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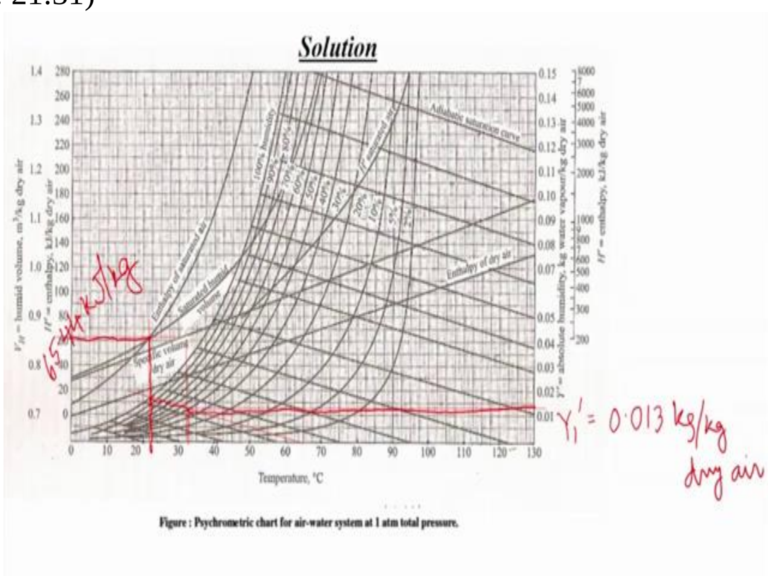

So firstly we start with the psychometric chart that what will be the we can say the absolute humidity and Enthalpy value local in the beginning we need to find out the absolute humidity and Enthalpy value. So TGO1 that is we can say this one 32 degrees Celsius and wet bar temperature is 22 degrees Celsius, so if we move to this 22 degrees Celsius this one up to saturation line then if we take this we can say this what is called Adiabatic saturation curve and then if we this one reach this 32 degree Celsius and from there we can say humidity will be getting from this y2 axis. That y1 prime that will be nothing but we can say this one 0.013 kg per kg dry air. So that will be getting. And the Enthalpy value as we calculated earlier also if we just move to up to this you can see this Enthalpy of saturated air and from there if we just get the Enthalpy from the x y1 axis will be getting this Enthalpy as 65.44 kilo Joule per kg.

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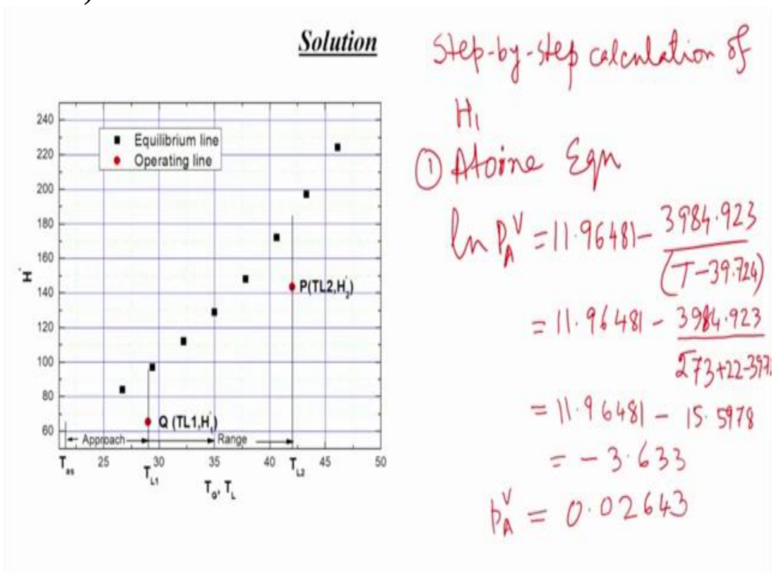

Now we say, we can get this Enthalpy value also using this one three step processes is also that also we discussed earlier like this we will start from here like this will start this say the Antoine equation we know this one this is step one will be say step by step calculation of we can see this Enthalpy value step by step calculation of H1, so firstly we will take this Antoine equation that is in PAV is equal to 11.96481 minus 3984.923 divided by T minus 39.724. So here temperature is given as 22 degrees Celsius so we will be taking this one 11.96481 minus 3984.923 divided by 273 plus 22 minus 39.724. That is nothing but we can see this one 11.96481 minus 15.5978; that is nothing but minus 3.633 therefore PAV is equal to this one saturated vapor pressure will be exponential of this in PAV that is nothing but 0.02643.

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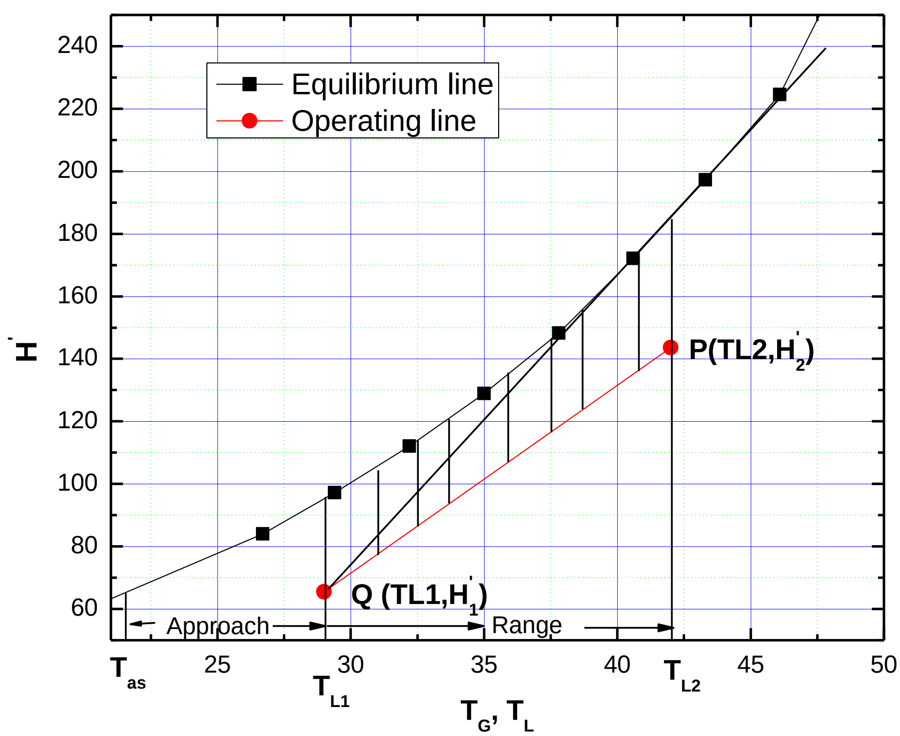

T_{G1}=32ºC, T_{w1}=22ºC, From psychrometric chart, $Y_1^{/} = 0.013\ kg/kg\ dry\ air$

$H_1^{/} = 65.44\ kJ/kg$

(a) Draw tangent to equilibrium curve from point Q.

Slope of the operating line for minimum air rate:

$$S = \frac{Lcw_L}{Gs_{\min}} = 9.37$$

L=425250/50 kg/h.m^2=8505 kg/h.m^2

c_{wL}=4.187 kJ/kgºC

Gs_{min}=3800.47 kg/h.m^2

Gs=6000/(1+0.013) kg/h.m^2 =5923 kg/h.m^2

Slope of the operating line for actual air rate:

$$S = \frac{Lcw_L}{Gs} = \frac{8505 \times 4.187}{5923} = 6.006$$

Draw operating line with slope 6.006 through point Q. T_{L2}=42ºC. Locate point P. (Get $H_2^/$ from graph).

or,

$$Lcw_L(T_{L2} - T_{L1}) = Gs(H_2^/ - H_1^/)$$

$$8505 \times 4.187(42 - 29) = 5923(H_2^/ - 65.5)$$

$$H_2^/ = 143.6 \ kJ/kg$$

$$H_{toG} = \frac{Gs}{K_Y^/ a} = \frac{5923}{740.375} m = 8 \ m$$

$$N_{toG} = \int_{H_2^/}^{H_1^/} \frac{dH^/}{(H_*^/ - H^/)} = 2.82$$

Height of the cooling tower=8×2.82 m=22.56 m

(b) Overall gas-phase enthalpy transfer unit (Nto_G)=2.82

(c) T_{L1} is unknown. Height of the cooling tower is same, i.e., 22.56 m. Slope of the operating line is as before, i.e., 6.006. T_{L1} should be greater than 29ºC.

Assume T_{L1} as 32ºC.

Get height of the cooling tower.

If height is 22.56 m, 32ºC is the answer. Otherwise guess another T_{L1}.

Or,

T_{G1}=32ºC, T_{w1}=25.5ºC, From psychrometric chart, $Y_1^/ = 0.017 \ kg/kg \ dry \ air$

$$H_1^/ = 75.682 \ KJ/kg$$

$$Lcw_L(T_{L2} - T_{L1}) = Gs(H_2^/ - H_1^/)$$

$$8505 \times 4.187(42 - T_{L1}) = \frac{6000}{(1 + 0.017)}(143.6 - 65.5)$$

T_{L1}=30.8ºC

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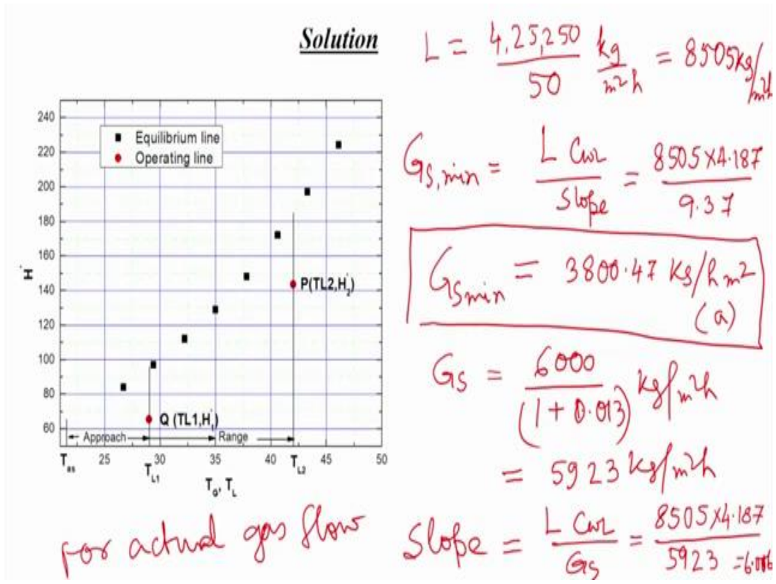

Now we need to find out that what with be the liquid flow rate, so liquid flow rate L will be equal to this 4,25250 by 50 this is kg per meter square hour, So this is coming out to be 8505 kg per meter square hour. So this is the liquid flow rate. Now will be getting this minimum gas flow rate say using this same formula GS minimum that is will be getting by this formula L in to CWL divide by slope so that is nothing but say liquid flow rate we have this now 8505 into CWL 4.187 divided by slope whatever we got 9.37 so that is we can say it is coming out to be 3800.47 kg per hour meter square.

So this is the minimum flow rate so this one GS minimum so these we have this problem the first question was like this determine the minimum air flow rate. This GS minimum is equal to the 3800.47 kg per hour meter square. Now we need to solve the second and third problem like this overall gas phase Enthalpy transferring unit we need to find out this NTOG, we need to find out and so for NTOG we need to find this one whatever the actual air flow rate is given here, the overall mass transfer coefficient is given as 740.375 kg per meter cube hour. Gas flow rate is given as 6000 kg per hour meter square where that is actually with the moisture. Okay.

So now we need to find that GS, whatever the GS is we can say whatever the GS actually we calculated that is dry air basis, so we need to this one subtract that whatever moisture is there so that is why we can say 6000 divided by whatever moisture actually is there in that condition that is 1 plus 0.013 that is kg per meter square hour or hour meter square so this is coming out to be 5923 kg per meter square hour. It is not going to change any way because we have eliminated this moisture from this calculation so it is always dry air basis on GS will remain unchanged throughout this column. But you see this we know that this whenever gas will be flowing from bottom to top this humidity will go on increasing and due to this evaporative cooling that temperature of this hot water decreases.

For actual air flow rate so because this is the gas flow rate that is supplied so the for this condition, slope will be for actual gas flow slope will be L CWL by GS. So L is liquid flow rate that is constant that is we can say this one 8505 and CW is 4.187 divided by the GS will be 5923 so from here actually we will be getting this slope the actual slope will be that is say 6, 6.006 for precise calculation we can say this 6.006. So slope will be getting as 6.006.

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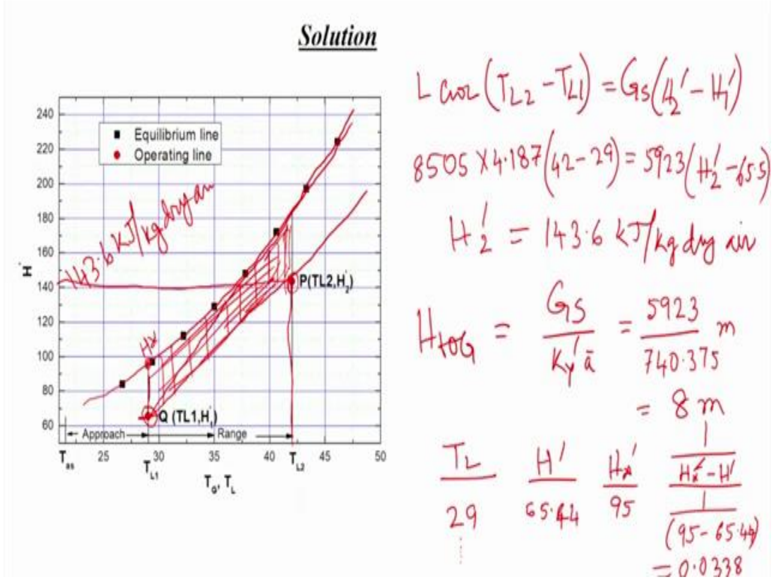

Now say we have this equilibrium line then we have this slope, will say 6 using this slope 6.006 we can draw this line actually. But you see this one using this minimum flow rate we have drawn this line so this for we can minimum gas flow rate. This is for actual gas flow rate using this we can say 5923 kg per hour meter square. Okay.

Now we have this inlet temperature of water is already supplied that is nothing but we can say inlet water temperature is 42 degree Celsius using this 42 degree Celsius we can say this one now we can say the Enthalpy of this one point we can calculate from this we can say this one common point. So there actually we can say this Enthalpy value that is we can find from this graph that is coming out as say this one we can say from this graph we can say that is 143.6 kg joules per kg this is 143.6 kilo joule per kg dry air per kg dry air. For in other word also we can find the Enthalpy of this one from the envelop to or we can say this one of overall we can say this one Enthalpy balance that we know that Lcwl into TL2 minus TL1 is equal to GS in to H2 prime minus H1 prime. So out of this this one parameters only H2 prime is unknown and say we can put all this like L is equal to 8505 into 4.187 that is cwl and TL2 is equal to 42 and TL1 is equal to 29. GS is equal to 5923 and H2 prime we need to find out and H1 prime actually is 65.5.

So from here we will be getting this H2 prime that is is equal to that same 143.6 so kilo joules per kg dry air. So that will be getting. Now we have to find out that height of this gas phase transfer unit that H tog that the from the formula we can say this one GS by capital Ky prime a bar that is given as GS is equal to we know this one 59 is equal to 5923 divided by Ty prime that is given as 740.375 that is in meter so it is coming out as 8 meter. So height of the transfer unit actually is 8 meter. Okay. Now will be getting this member of gas phase transfer unit that Ntog. For getting this Ntog we need to the this one whatever we did this one in beginning also, we will be doing this for getting Ntog. We will be doing this TL then will be getting this H prime then H star prime and then one by star prime minus H prime.

So we will start from here also 29 degree Celsius the Enthalpy value form the graph actually will be getting say this one the Enthalpy value for this will be say 65.44 that we have already find out 65.44. And corresponding this H star value actually here say H star value for this that is we can say will be getting as 95 and then one by 95 minus 65.44. So that is will be coming out as 0.0338, so this way we will need to increase the temperature from 29 to say 42 degree Celsius then will be getting the area under the curve here also we say from here here this the entire portion actually will be getting the what we can say the area under the curve that will be getting like this one.

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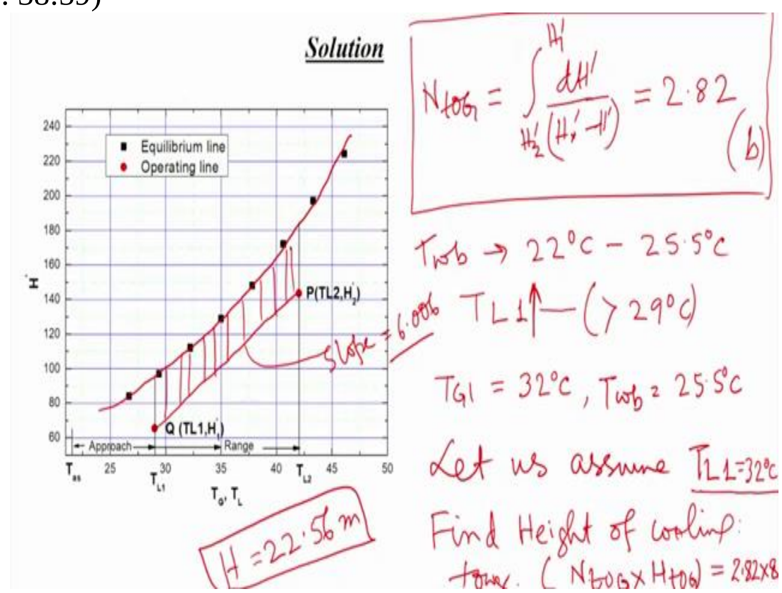

So this Ntog will be equal to say integration H2 prime to H1 prime and DH prime by H star prime minus H prime. So it will be coming at 2.82. So just area under the curve whatever we have drawn this one like this area under the curve from this point to this and say this portion from this we can say this one total area under the curve that is Ntog.

So this is the we can say this one Ntog that is second problem that is we can say this one for this b. So we can say this one overall gas phase Enthalpy transfer unit is found out as 2.82. Now the third question that is very important and interesting question also so that is given as say if we can say the every condition unchanged means whatever the this gas flow rate, whatever the liquid flow rate and we can say the specific surface area and we can say K y prime these are all constant. Only the change is also this dry bulb temperature is also constant. Now this wet bulb temperature is increased from 22 degree Celsius to say 25.5 degree Celsius. So now you see this Twb has changed form 22 degree Celsius to 25.5 degree Celsius. Now what will be the cold water temperature so we can say this one. What will be the TL1? Now the question is whether TL1 will change or not? Definitely we discussed this one. TL1 whatever the TL1 is there that will definitely go on increasing. So TL1 also will increase.

So initially this TL1 was given in as 29 degree Celsius so it should be you can say this one greater than 29 degree Celsius. So TL1 should increase and greater than 29 degree Celsius. So how to proceed this one? So will we can start like this say 2 approaches are there; one approach will be like this, approach one is say we know just say TG1 we know, TG1 is equal to is given as 32 degree Celsius and delta state Twb is equal to 25.5 degree Celsius and say let us take any of the slope. Like this say whatever the slope that we have taken as for this actual operation we have taken this slope as this slope actually is slope is taken as this 6.006. Now we say this, now we can assume any TL temperature TL1, let us assume TL1 is equal to say 32 degree Celsius. Okay.

And then we need to get the then find height of the cooling tower. So if the we can say this one, if the height of the cooling tower is coming out as say whatever the cooling tower we got this one from Ntog into Htog, Ntog into Htog, that actually we have got as 2.82 into that Htog actually whatever we got height of the transferring unit that is 8. So it is coming out so we can say this one height actually is coming out as 22.56 meter. Okay. So if we say that whenever we will be assuming any TL1 as suppose 32 degree Celsius and we will find out the height of the cooling tower. If we find the height of the cooling tower also is coming out as 22.56 then we can say the 32 degree Celsius will be the outlet temperature. But if it is not coming means if it is coming another temperature another height of this cooling tower then we need to assume another TL1. So that by trial and error method so we can do one thing that we will be assuming one TL1 and then we will move forward, then we will be ultimately will be find out that what is the height of this cooling tower.

So whenever we will be getting as 22.56 meter as the height of the cooling tower then we can say this is the final height of this one final temperature or TL1 or we can say this one outlet temperature. And other procedure is that say this is also we can say this one this will be getting by trial and error method, but another method also is there.

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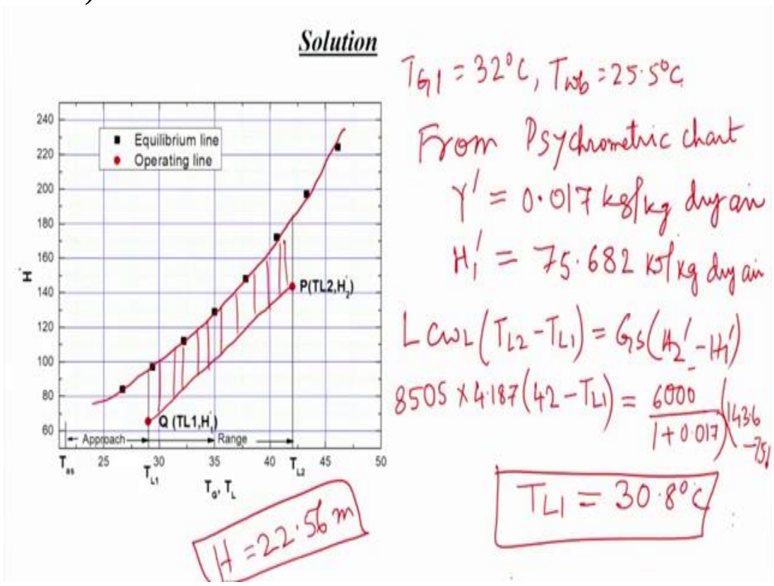

So we can use one thing. Let us take TG1 is equal to say TG1 is equal to 32 degree Celsius. And T weight bulb is equal to 25.5 degree Celsius. And from this psychometric chart say will find out what is the y prime. Just by in the beginning what we did this one will be getting the psychometric this absolute humidity is equal to 0.017 kg per kg dry air. Okay. Now we will be getting that from this we can say this one saturation point whatever the H1 prime.

So H1 prime will be getting that say 2 ways we told that if we just extend this this one wet bulb temperature to this one saturation Enthalpy line will be getting or by 3 step procedure like form the Antoine equation getting this P v bar, PV and from their after that actually using this one y prime will be getting and from their will getting Enthalpy. So the using this 3 step or just by extending this wet bulb temperature to adiabatic saturation Enthalpy line will be getting this Enthalpy as 75.682 kg joule per kg joule per kg dry air. Okay. Now we need to do this the overall this one Enthalpy balance like this for the entire Enthalpy envelop or we can say this one for the entire cooling tower like this Lcwl into TL minus TL1 is equal to GS into H2 prime minus H1 prime. So now we have this one, Lcwl we have and so will be getting TL1 this how from this equation everything is known except this TL1. So we need to find out the TL1.

We will be doing this one. We will be putting this all the known parameters here in this equation. So like Al is equal to 8505 in to cwl is equal to 4.187 and TL2 that is already given that it will be entering at 42 degree Celsius and TL1 what will be the liquid temperature into GS is equal to that air also will be getting this GS will be 6000 divided by 1 plus now this humidity is 0.017 in to H2 prime that is we can say whatever we have H2 prime we have got this one that is already obtained 143.6 minus H1 prime that we find out is 75.68. So that is from here we can say this one TL1 is equal to we find out that it is 30.8 degree Celsius. So you see the temperature of water which is leaving from this cooling tower has increased to 30.8 degree Celsius whenever the wet bulb temperature was 22 degree Celsius that time we can say this one cold water temperature was that was much more lower. Okay.

So from here we can say that whenever the wet bulb temperature and dry bulb temperature of this we can say this one environment or we can say this one air will be changing then we can say this one outlet temperature or cold water temperature also will be changing. And if we go on increasing this we can say wet bulb temperature then outlet cold water temperature will go on increasing or by any OA if we are able to decrease the wet bulb temperature means if we we can say this one decrease the relative humidity. So we can say this one by any means the relative humidity of the air is changed or decreased then wet bulb temperature will definitely will go on decreasing and then that liquid this one as a cold water temperature will decrease.

So!

Thank You. In the next class we will be discussing on the air conditioning or the humidification.