Air-Conditioning & Refrigeration

BSc

Lecture 7

Course weekly Outline &

Ch.1 (Introduction to Air conditioning & Refrigeration)

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Example:

Applications : The following examples represent practical applications to the psychrometrics processes in air conditioning field .

Q1- 30 cmm of stream of moist air at DBT = 15 ċ and WBT= 13 ċ are mixed with 12 cmm of a second stream at DBT = 25 ċ and WBT= 18 ċ . Determine the DBT and WBT of the resulting mixture .

cmm cubic meter per minute

Use the mixing equation for DBT :

$$T_m = (v_1\ T_1 + v_2\ T_2) / (v_1 + v_2)$$
$$T_m\ (v_1 + v_2) = (v_1\ T_1 + v_2\ T_2)$$
$$T_m\ v_m = (v_1\ T_1 + v_2\ T_2)$$

or

$$DBT_m\ cmm_m = DBT_1\ cmm_1 + DBT_2\ cmm_2$$

$DBT_m\ cmm_m = DBT_1\ cmm_1 + DBT_2\ cmm_2$

DBT_m= 16 ċ

Locate on the psychrometric chart the three points (i.e. point 1 , point 2 and the mixing point) . From the chart you may find the WBT_m= 14.5 c .

Notes :

i- You may given the flow rates as a ratio of one stream to the other (for example , mix one part of the first stream to three parts of the second stream)
The mixing equation then takes the following form :

DBT_m= $DBT_1\ (V_1/V_m) + DBT_2\ (V_2/V_m)$

$$T_m\ v_m = (v_1\ T_1 + v_2\ T_2)$$

or

$$DBT_m = DBT_1\ (v_1 / v_m) + DBT_2\ (v_2 / v_m)$$

Example:

Where : $V_m = V_1 + V_2 = 1 + 3 = 4$,
$V_1/V_m = 1/4 = 0.25$.
$V_2/V_m = 3/4 = 0.75$
Substitute and find DBT_m

ii- You may given the flow rates as a percentage (%), (for example , 80 % fresh air is mixed with 20 % room or return air) .

The mixing equation then takes the following form :

$$DBT_m V_m = DBT_o V_o + DBT_r V_r$$

Or :

$$DBT_m = 0.8\, DBT_o + 0.2\, DBT_r$$

Where : $V_m = 0.8 + 0.2 = 1.0$ or 100 %
$V_o/V_m = 0.8$ or 80 %
$V_r/V_m = 0.2$ or 20 %

Q2- In an air conditioning system 39.6 cmm of a mixture (room air and fresh outdoor air) enter a cooling coil at DBT=31 c and WBT= 18.5 c . The effective surface temperature (T_{ADP}) of the coil is 4.4 c .The cooling coil capacity (Load) is 12.5 kW Determine :

$T_{ADP} = T_{dp}$ = Dew Point Temperature

a) the dry and wet bulb temperature of the leaving air from the coil = Supply Temperature

b) the by pass factor (BPF) of the coil .

$Q_{coil} = 1.2\, V_s (h_m - h_s)$ where V_s in m^3/s

$V_s = 39.9 / 60$

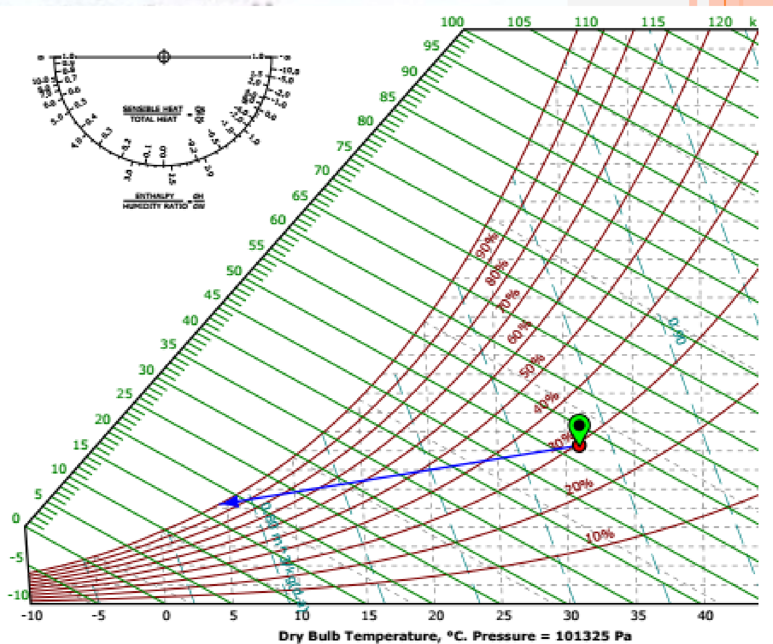
Find h_s = 36.7 kJ/kg . Connect the point of mixing , the supply point and the ADP where the T_{ADP} lies on the saturation line . Find the wet and dry temperature of the supply state or as it called in the question the state of air l

DBT = 18.6 c

WBT =12.5 c

Use the equation of the bypass factor

$BPF = (T_s - T_{ADP}) / (T_m - T_{ADP}) = 0.53$



Q3- The sensible heat and the latent heat gain of a given space are 20 kW and 5 kW respectively . The inside design condition of the space are DBT = 25 c , RH= 50 %. The out side design condition are DBT =43 c , WBT = 27.5 c . The room (return) air is mixed with outside (fresh) air before entering the cooling coil of the air conditioning plant in a ratio of 4:1 by volume .The supplied air may be taken 1.3 cms.

Determine :

cms cubic meter per second

a) T_{ADP}
b) the condition of the leaving air (the supply condition)
c) the dehumidified (supplied) air quantity
d) ventilation (outside) air load
e) the refrigeration (cooling) load of the plant .

Solution :

Find the mixing point as before .
Locate the given conditions and the mixing point on the chart
Calculate the SHF
$SHF = Q_s/Q_T = 0.8$ and plot it on the chart
Find the the supply state (i.e the temperature or enthalpy)

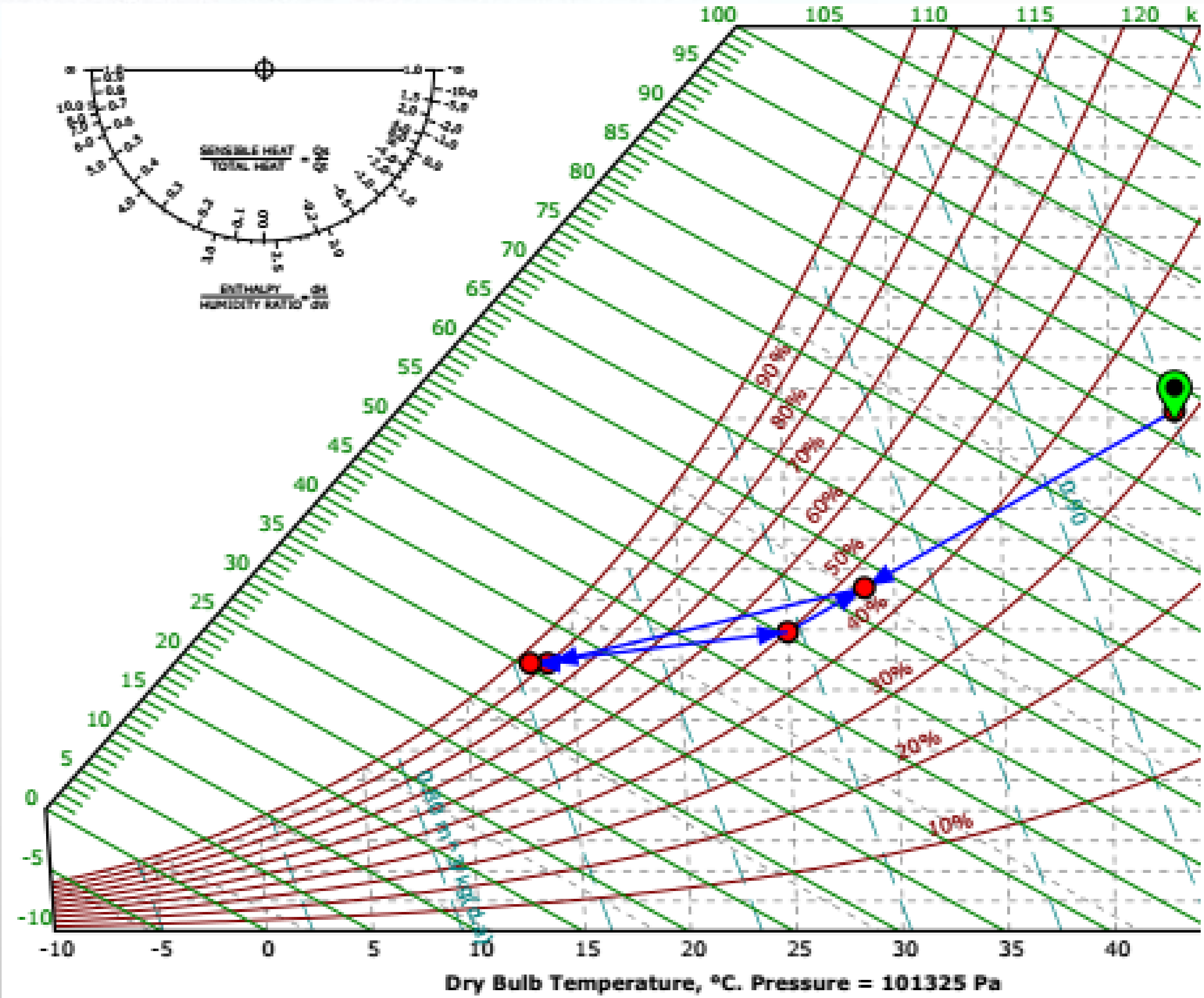
$Q_s=1.22\ V_s\,(T_r - T_s)$ OR $Q_T = 1.2\ V_s\,(h_r - h_s)$

$T_s= 13.3$ c or $h_s= 35.2$ kJ/kg
Locate the supply conditions on the chart .
Connect the mixing point and the supply point up to the saturated curve . This will

give $T_{ADP} = 11.6$ c .

Find the ventilation load $Q_{vnt} = 1.2\, V_o (h_o - h_r) = 11.8$ kW

Find the refrigeration load $Q_{coil} = 1.2\, V_s (h_m - h_s) = 36.8$ kW



Saturation efficiency

We need to find the point before the air entering the air washer and this is obtained using the saturation efficiency of the air washer to find $\omega_{saturated}$ as :

$\eta = (\omega_s - \omega_m)/(\omega_{saturated} - \omega_m)$ $\omega_{saturated} =$ 8.72 g.w.v/kg.d.a

or

$\eta = (g_s - g_m) \backslash (g_{saturated} - g_m)$ $g_{saturated}$ 8.72 $g_{water} / kg_{dry\ air}$

where the supply point (s) is the point between the mixing state and the saturation state that cut the SHR line say point (1) .

The location of point 1 on the chart gives the conditions of air entering air washer:

$T_1 = 11.6$ $WBT_1 = 11.5$ $h_1 = 33$ kJ/kg

At air washer the temperature of water may be assumed to be

$T_{water\ out} = WBT_1$

Use the heat balance in the air washer between air and water gives

$m_w\, cp_w\, \Delta T_w = m_a (h_1 - h_m)$

$T_{water\ in} = 34.$ c

Make up water $= m_s (\omega_1 - \omega_m) = 0.25$ kg/s

or

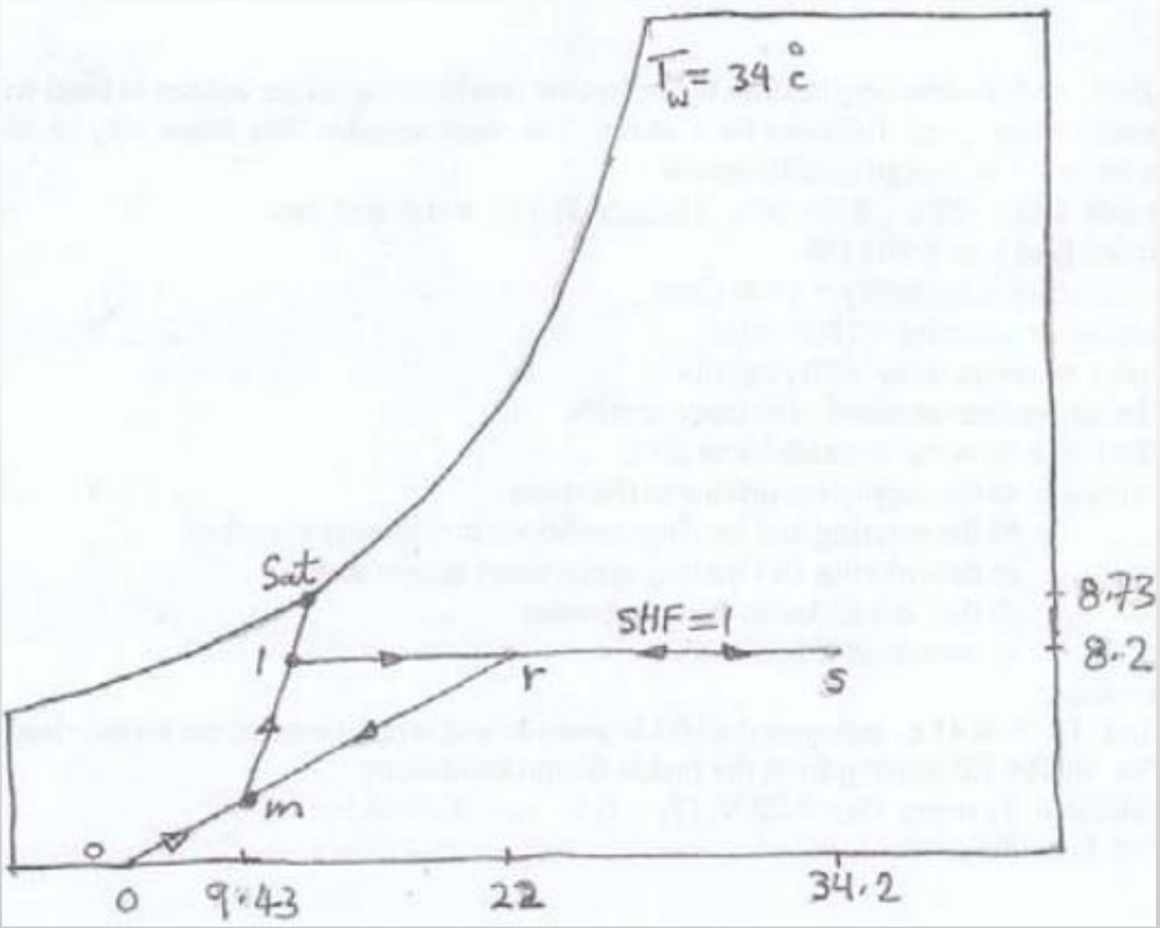
Make up water $= m_s (g_1 - g_m) =$ 0.25 kg/s

$Q_{makeup} = m\ cp\ \Delta T_{makeup}$ $\Delta T_{makeup} = 34 - 20$

$Q_{water} = m\ cp\ \Delta T_{water}$ $\Delta T_{water} = 34 - 11.5$

$Q_{spray\ water} = Q_{makeup} + Q_{water}$

$Q_{rehet} = 1.22\ V_s\ (T_s - T_1) = 1290\ kw$



Q4- The following data apply to an air conditioning systems :

Room sensible heat = 10 kW
Room latent heat =10 kW
The inside design conditions is DBT = 25 c , RH = 50 %
The outside design conditions is DBT = 35.0 , WBT = 27.8 c
The mixing ratio of room air to fresh air is 4: 1
The room air is mixed with the air after the cooling coil in the ratio of 1:4
The cooling bypass factor is 0.1
The air may be reheated if necessary before supplying to the room
The apparatus dew point temperature T_{ADP}= 10 c . Determine :

a) Supply air conditions
b) heat load due to reheat
c) coil capacity in Tones Refrigeration (TR)
d)the quantity of fresh air supplied
e)plot all the psychrometric processes.

Solution :
Find the first mixing point T_{m1}= 27. c
Find T_{s1} = 11.7 c from the BPF
Find the second mixing point T_{m2} = 14.4
Find SHF = 0.5
Find T_{s2} =21.8 c , you can see that this point need to be preheated .
Find V_s= 153.2 from Q_s= 1.22 V_s (T_r – T_{s2})
Find the reheat load Q_{reheat} = 22.5 kW
and refrigeration load Q_{coil}= 64.7kW = 64.7/3.51 = TR

Q5- In an industrial application for winter air conditioning an air washer is used with heated water spray followed by a reheat . The room sensible heat factor may be taken as unity . The design conditions are :

Inside DBT =22 c , RH= 50% ,Outside DBT= 0.0 c and dry

Room heat loss = 703 kW

Ventilation air quantity = 1600 cmm

Supply air quantity = 2800 cmm

Spray water quantity = 500 kg/min

The air washer saturated efficiency is 90%

The make up water is available at 20 c .

Calculate a) the supply conditions to the space

b) the entering and leaving conditions at the spray chamber

c) the entering and leaving spray water temperatures

d) the heat added to the spray water

e) the reheat if necessary .

Solution:

Find T_m = 9.43 c and plot the inside ,outside and mixing conditions on the chart

Plot SHR= 1.0 starting from the inside design conditions .

Calculate T_s using $Q_s = 1.22\, V_s (T_s - T_r)$, $T_s = 34.3$ c

Plot T_s on the chart .