MEBS6006 Environmental Services I

Question 4

A variable air volume (VAV) air conditioning system supplies air to two rooms. It is found that: -
Room Temperature setting (both rooms) = 22^{o}C
Temperature difference between supply air and room air = 8^{o}C
Specific humidity of air leaving cooling coil = 0.0076
Summer external design temperature = 27^{o}C db and 22 ^{o}C wb
Turn down ratio of the VAV air conditioning system = 2.8:1
Temperature rise across fan = 2^{o}C

Room	Minimum fresh air	Maximum sensible gain	Latent heat gain	Maximum simultaneous sensible gain
1	0.6 kg/s	49 kW	6 kW	14 kW
2	0.8 kg/s	49 kW	6 kW	49 kW

Calculate:

1. Recirculation Ratio (Ratio of mass flow rate of re-circulated to fresh air);
2. Temperature and percentage saturation in Room 1 and 2 during maximum simultaneous gains
3. Maximum Cooling Coil's Load
4. The return air temperature (after mixing from the return from room 1 and 2).

Question 4 Further Hints

Ratio of re-circulated to fresh air

Plot the process on the psychrometric chart.
With the same max. sensible heat gain and turndown ratio, each zone will have the same maximum and minimum mass flow rates
The max. mass flow rate = 49 kW/ (1.02kW/KJ.K x 8K) = 6 kg/s
Minimum mass flow rate = 6 kg/s/ 2.8 = 2.14 kg/s
Since both zones have the same min. mass flow rate, the zone requiring the most fresh air will control the re-circulation ratio.
Re-circulation ratio = (2.14-0.8)/0.8= 1.7

Temperature and percentage saturation in each zone during maximum simultaneous gains

Supply air temperature = 22 – 8 = 14 ^{o}C
Zone 1 , Room Ratio Line = 14/(14+6) = 0. 7
Zone 2, Room Ratio Line = 49/(49+6) = 0.89
The minimum load to maintain zone A at 22 ^{o}C is 49/2.8 = 17.5 kW with a load of only 14kW the

temperature must fall below this.

Room 1: room temperature = 14 + 14/(2.14 x 1.02) = 20.4 ^{o}C

Room 2: room temperature is at design temperature, i.e. 22 ^{o}C

The two room ratio lines can be drawn from the supply state to establish the room states R1 and R2. From the chart, Room 1 is 60 % and Room 2 is at 50 % saturation.

(For Room 1: Starting from S, Room ratio line = 0.7, room temp = 20.4^{o}C, you should get 60%)

The maximum cooling coil load

The mass flow rate thru the central plant is (6 + 2.14) = 8.14 kg/s.

Cooling Coil load = 8.14 (51 – 31) = 163 kW (difference in enthalpy between leaving coil and mixing)

The return air temperature (after mixing)

The return air state R will lie along a line joining R1 and R2. It can be fixed by proportioning the lines or calculating the mixed temperature, i.e.

The return air temperature = (2.14/(2.14 + 6) x 20.4) + (6./(2.14+6) x 22) = 21.6 ^{o}C

The psychrometric cycle can now be completed using the re-circulation ratio of 1.7:1 to establish point M:

Mixed temperature = (27 x 1/2.7) + (21.6 x 1.7/2.7) = 23.6 ^{o}C

Remark : Figures from psychrometric charts are approximate values only.