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The Challenge of Design Low Temperature and Low Humidity Environment in Hot and Humid Tropical Country.

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ABSTRACT

The average temperature and humidity in a hot and humid climate is DBT 32.4ºC /WBT 26.6ºC (RH 70%, DP 25.5ºC). For some industrial process in the tropical country needs low temperature and low humidity environment, such as the pharmaceutical industry, military, food processing, coating process, lithium battery. These industries need minus dew point temperature. We need to design a proper VAC system to achieve the target temperature and humidity.

(keywords : Keywords: #dehumidifier, #desiccant, #refrigeration, #lowhumidity, #low temperature, #tropicalcountry)

INTRODUCTION

In this paper, we will show how to design a proper VAC system for hot and humid climate (DBT 32.4ºC, RH 70%, DP 25.5ºC)[(1)], which is different from the conventional VAC system for daily usage in the commercial building. The traditional method of VAC uses a cooling coil to pull down temperature then reheat to gain its target humidity. The coil surface temperature usually is around 3~7 ºC, not enough to condensate or trap more water content in the air[(2)(3)].

There are two types of dehumidifying methods, refrigeration dehumidifying and desiccant rotor dehumidifying methods. The refrigeration dehumidifying method uses low coil temperatures to condensate the higher dew point temperature of the air. The desiccant rotor method uses the absorption method to dry the air. The heater can regenerate the desiccant rotor after saturated.

Based on our engineering experience, by using a refrigeration dehumidifying system, the lowest dew point temperature is 10~14 ºC (around RH50% at dry-bulb temperature 22ºC). For some environment in which one needs a lower dew point temperature, must use the desiccant rotor method.

The desiccant rotor needs heater for regeneration. The heater can be an electric heater or steam. Usually, the regeneration temperature is above 100ºC. After the regeneration process, the water content in the rotor will evaporate and removed from the system by the blower[(4)].

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By using sensible heat and latent heat equations to calculate the air process, the equations as the following [(5)(6)]:

$q_s = Q\ \rho\ c_p\ \Delta T$ ………… sensible heat equation

Where

q_s = sensible heat, W
Q = air flow rate, cms
P = air density, kg/m^3
c_p = specific heat of air, J/kg K
ΔT = temperature difference between inlet and outlet, K

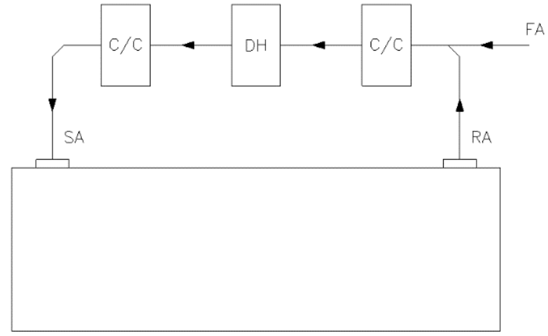
And

$q_l = Q\ \rho\ D_h\ \Delta W$ ………… latent heat equation

Where

Q_l = latent heat, W
Q = air flow rate, cms
P = air density, kg/m^3
D_h = change in enthalpy to convert 1 kg water from vapor to liquid, kJ/kg
ΔW = humidity ratio difference between inlet and outlet, kg_w/kg_{da}

In this experiment, we use two sections of the cooling coil (precool and post cool) and one section of the desiccant rotor. Fresh air or return air was introduced into the system. An additional post cool coil is used to adjust the air to reach the target condition (22°C, RH 30%). The schematic diagram is shown in pic 1.



Pic 1 Schematic Diagram

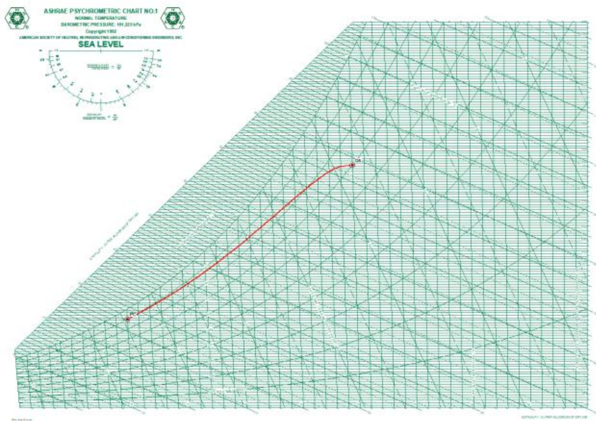
For comparison of the performance data, we did the different conditions of the operation mode of the VAC system (table 1). All the processes were done under full fresh air conditions. Outdoor air condition is DBT 30°C, RH 70%.

No.	Description	Post Cool	Rotor Dehumidifier	Precool
1	Precool Only	Off	Off	On
2	Rotor Only	Off	On	Off
3	Precool + Rotor	On	On	On
4	Post Cool + Rotor + Precool	On	On	On

Table 1 Different operation mode of the VAC system.

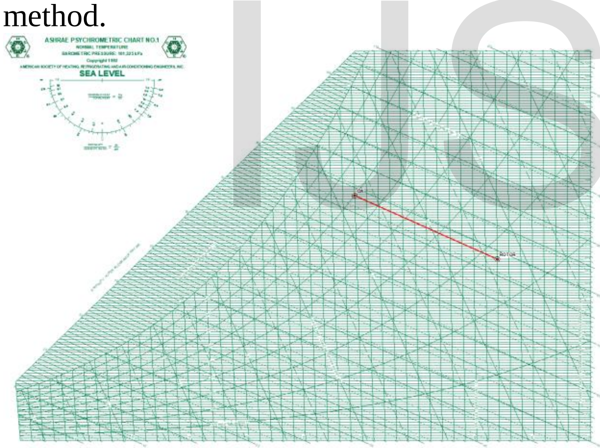
Results and discussions

The first experience is a refrigeration dehumidifying or cooling with sensible heat and latent heat process only. This process is a typical psychrometric process[(7)] for the room air conditioner. The fresh air is cooled to reach approximately the coil temperature, then water content in the air begins to condensate, then the water content in the air can be removed from the room, as shown in the pic 2.



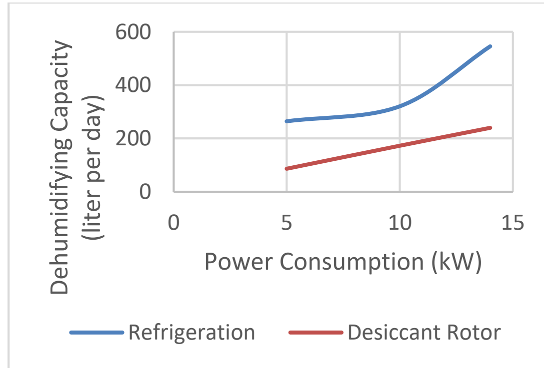
Pic 2 Psychometric process, refrigeration dehumidifying process only.

In pic 3 shows the air process by rotor dehumidifier. The air temperature is raised, and the water content in the air can be reduced. The refrigeration dehumidifying process only has better performance, compared with the rotor dehumidifying method.



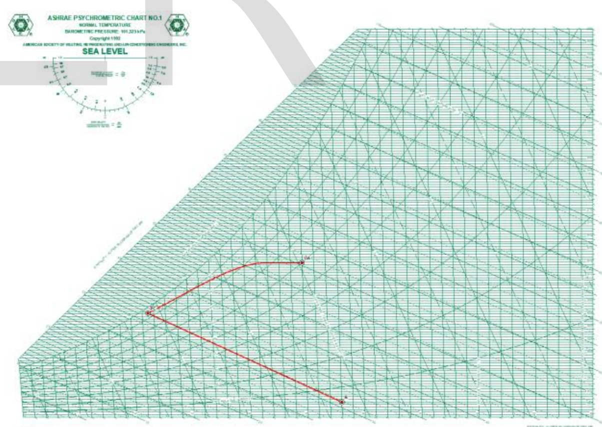
Pic 3 Psychometric process, desiccant rotor dehumidifying process only.

Graph 1 shows, under air inlet condition 30ºC and RH 70%. Let the refrigeration and the desiccant rotor system run alone. With the same power consumption, the performance of the refrigeration system performs better than the desiccant rotor.



Graph 1 **Comparison of dehumidifying rate vs. power consumption between the desiccant rotor method and the refrigeration method**.

After the first and the second experiments, we continue the next test with the combination of refrigeration dehumidifying and rotor dehumidifying process. Pic 3 shows, by the combination of the refrigeration dehumidifying process and rotor dehumidifying process, the air effectively reaches the lower dew point.



Pic 4 Psychometric process, cascade method, combine of refrigeration dehumidifying process and desiccant rotor dehumidifying process.

The last experiment is the combination of the precool (refrigeration dehumidifier), rotor dehumidifier, and the post cool (sensible cooling only). Air condition which one was supplied into the room can reach low

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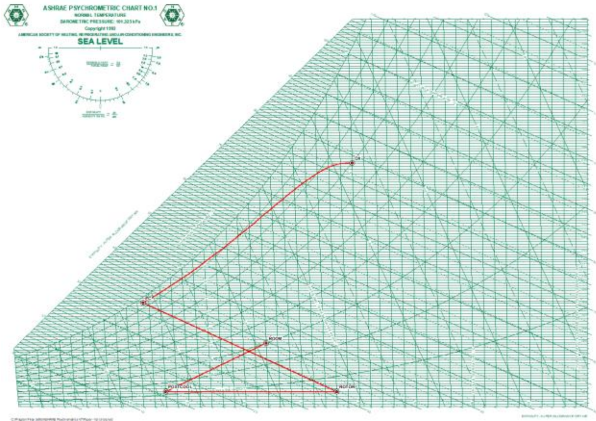
temperature and low water content, as shown in Pic 6.



Pic 5 Full circle process of the low humidity VAC system

Pic 6 Experiment No.4 full circle process, the actual room temperature and relative humidity, with full fresh air under condition DBT 30ºC and RH 70%.

Conclusions

VAC system uses a desiccant rotor dehumidifier that can perform well to reach dew point temperature, which one below coil temperature. Due to the desiccant rotor dehumidifier is more expensive than the refrigeration dehumidifier. We must consider using a combination system to get cost optimization.

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