LATENT COOLING LEAD

Kecha Thirakomen
EEC Engineering Network

INTRODUCTION

Air-conditioning has been advanced from comfort cooling to "Quality air-conditioning", targeting Indoor Air Quality-IAQ. Equipment will not be selected on required cooling capacity as how many tonnage, but will be more emphasized on air supply condition.

Understanding Total cooling = Sensible cooling + Latent cooling and sensible heat ratio application is the key to control humidity, where humidity is the key for IAQ.

Since sensible cooling is simple and easy to control, latent cooling is where we should focus, in order to achieve quality air-conditioning. Besides, latent load is at least 30% of total cooling load, and may be more than 40% for energy efficient building and high fresh air requirement building, such as hotel and health care. Advanced air-conditioning always focuses on how to treat latent cooling effectively and efficiently. Therefore, we can say that **"Latent Cooling is the Lead"**.

This paper present development of dehumidification on 2 cases:

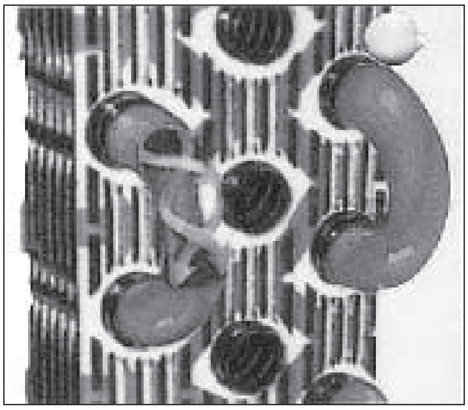
- Air-handling unit (AHU) with mixed return air and outdoor air
- Air side with Dedicated Outdoor Air System-DOAS

Conventional AHU with mixed return air and outdoor air is widely used in most application. DOAS has been introduced lately, but has better prospect due to its performance, even with wide range of outdoor condition variation and its demand control ability.

Over-cooling and reheat is not mentioned in this paper as it is considered as "obsolete".

LVHF

Low velocity (LV) cooling coil face velocity has been applied when better moisture removal is required. Air will have more contact time with cooling coil and more saturation. It is also



recommended to run fan coil at low speed during night time for bed room to obtain lower humidity. Cooling coil with 2 mps (400 fpm) has better moisture removal than cooling coil with 2.5-2.75 mps (500-550 fpm).

High Flow (HF) cooling coil has better heat transfer due to turbulent fluid, such as chilled water. Normally, the chilled water velocity in the cooling coil tube should be over 1.2-1.5 mps (4-5 fps), in order to create required turbulence. Better heat transfer will bring air closer to fluid temperature and better approach to saturation line. Therefore, better condensation and moisture removal.

Cooling coil expert can also design cooling coil with more even distribution of inlet fluid or chilled water in order to reduce effective mean cooling coil temperature. Some expert claim that they can design cooling coil that leaving air temperature is very close to chilled water inlet temperature and lower than 10 degree C. If so, moisture removal for such cooling coil will be excellent.

FACE AND BYPASS

When room air circulation is higher than cooling coil air circulation, face and bypass is the solution to control cooling face velocity. Face and bypass is normally applied for clean room, which usually require more than 15 air-changes in order to maintain air filtration.

Where cooling load varies, **"Multi Stage cooling coil"** with sequential control parallel cooling coil could be applied. At partial load, only one cooling could be active with air bypass through inactive cooling coil. During that time, it is function as face and bypass.

Face and bypass is AHU with mixed return air and outdoor air only, and can not be applied as DOAS, since outdoor air will bypass and entering the room directly without any control.

DESICCANT WHEEL

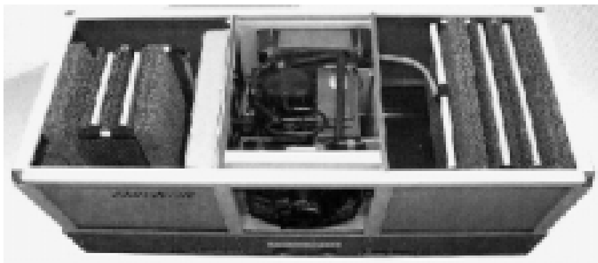
When humidity control is critical or when required humidity level is 40%RH or lower, designer may prefer to add desiccant wheel. Desiccant wheel has dew point temperature lower than 10 degree C, and lower than normal cooling coil surface temperature. Desiccant is silica, mostly. Therefore, it can provide extra moisture removal. Since desiccant wheel is expensive both first cost, operation and maintenance, clever designer will have desiccant wheel only for required extra moisture to the cooling coil. Good air filtration is necessary to protect the desiccant wheel from blocking.

Desiccant wheel is widely used in pharmaceutical industry. The desiccant wheel has also been used in lab and health care as DOAS.

LIQUID DESICCANT

Liquid desiccant has been introduced lately to compete with desiccant wheel by lower operating and maintenance cost. The product used heat pump for regeneration of desiccant, which is lithium chloride. Heat pump also cools the supply air. Therefore, the product was advertised to cool and dry air. Lithium chloride also kill germ, and provide additional air filtration when air pass through liquid desiccant honey comb wetting media. Dirt will be settled in the basin, which will be cleaned during regular service.

Unfortunately, lithium chloride is salt and corrosive. Therefore, manufacturer has to be reliable and well aware of the product design.

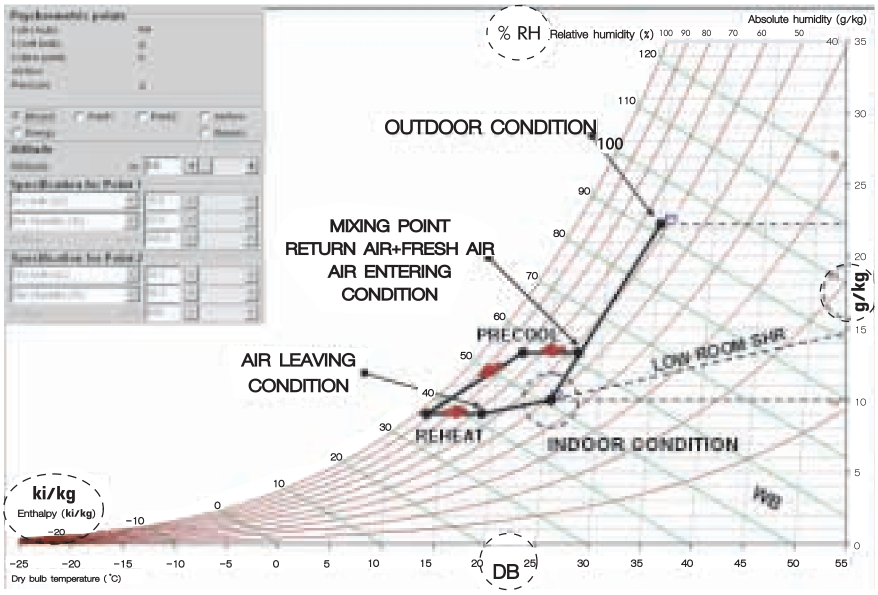


Liquid desiccant has been used in pharmaceutical industry. The liquid desiccant has also been used in lab and health care as DOAS.

PRE-COOL AND REHEAT

Pre-cool and reheat is a proven method to enhance cooling coil moisture removal. Looking at psychrometric chart, pre-cool bring air condition to the saturation line by pre-cooling air, enhancing cooling coil moisture removal capability. After that, the process brings the air back by reheating air. The pre-cooling and reheat is sensible cooling, reducing air entering temperature and increasing air leaving temperature at the same delta T. In some case, the pre-cooling may also provide latent cooling.

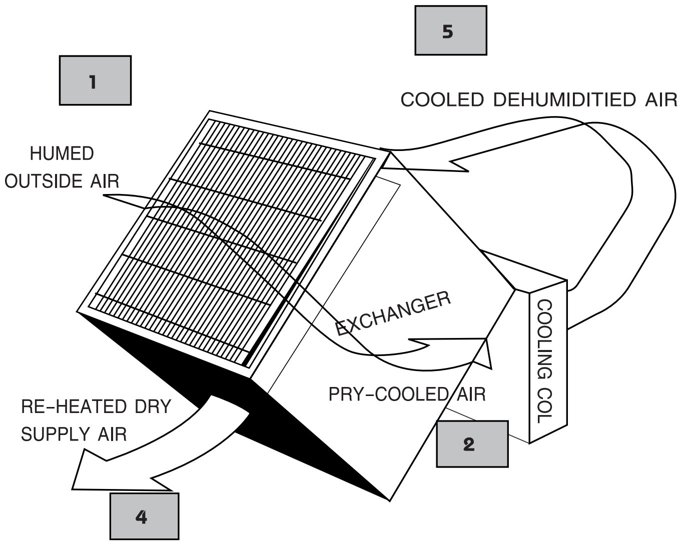
Some designer has **"Run around cooling coil"** added to the main cooling coil, with p re-cooling coil in front and reheat cooling after the main cooling coil. The run around cooling



coil used water as cooling fluid, and circulation by pump. The design was applied for outdoor air unit in electronic factory. Effectiveness of moisture removal depends on run around cooling coil design to have the air temperature close to cooling coil temperature. Delta T for pre-cooling and reheat is normally 3-4 degree C.

"Heat Pipe" is similar to run-around cooling coil, but using refrigerant as working fluid instead of water. Therefore, the effectiveness is normally higher with delta T of 8 degree C. The refrigerant flows naturally without pump or any moving device. Therefore, it is more energy efficient. Heat pipe has been widely used for outdoor air unit or fresh air unit in many applications, such as hotel, hospital, pharmaceutical, lab, food industry, etc.

Cross flow air to air plate heat exchanger can also be used to provide pre-cooling and reheat with very high delta T. However, air must be clean, since air path is very narrow. During condensation, water can also block the air.



All method will create air friction, and additional fan static pressure will be required.

Pre-cool and reheat is widely used in many applications. The pre-cool and reheat has also been used in lab and health care as DOAS.

CDQ

Cool, Dry, Quiet (CDQ) is Trane patented system, using own developed desiccant wheel for **latent** pre-cooling and reheat. Trane claimed that the desiccant had long life span and less cost than silica type desiccant wheel. The wheel runs between air entering AHU cooling coil and air leaving cooling coil. Thus remove moisture from air leaving and transfer to air entering. Air leaving AHU cooling coil could be very dry since desiccant has lower dew point than cooling coil. Moist air entering enhances higher moisture removal ability of the cooling coil.

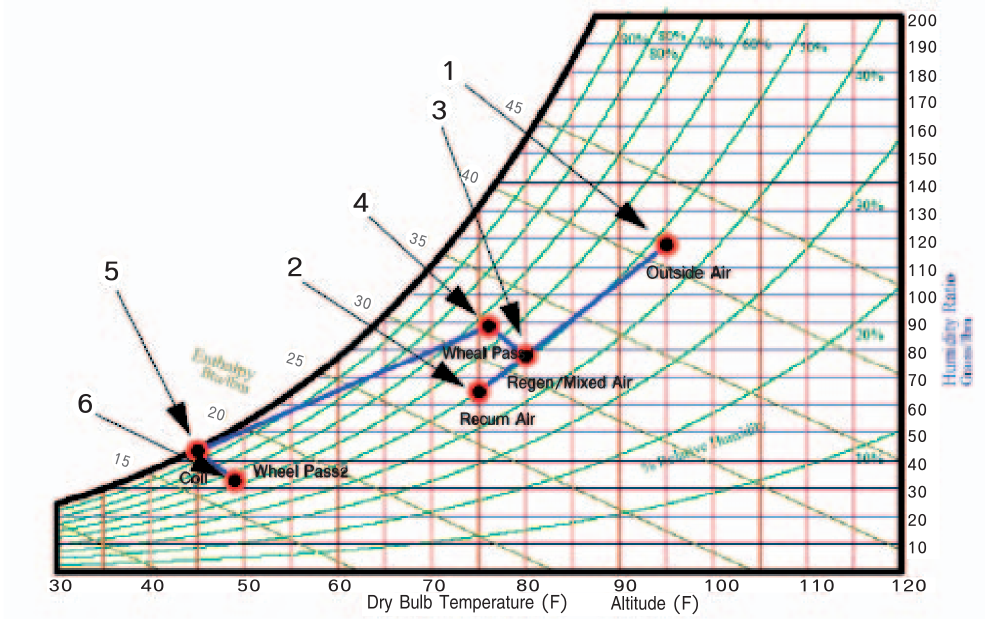
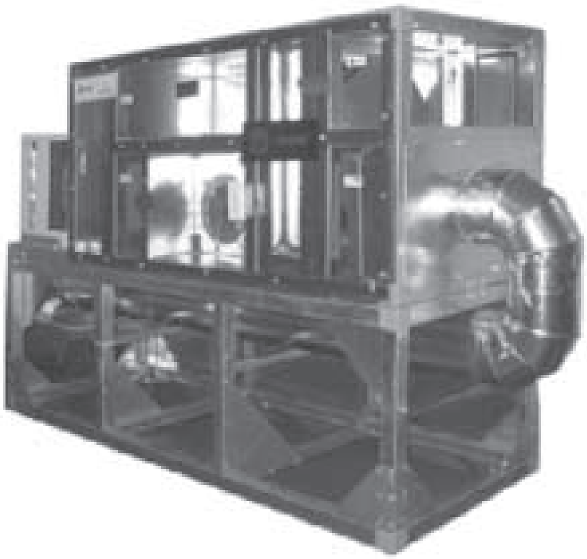


Figure 3. Representative dehumidication increase using Trane CDQ dehumidification system



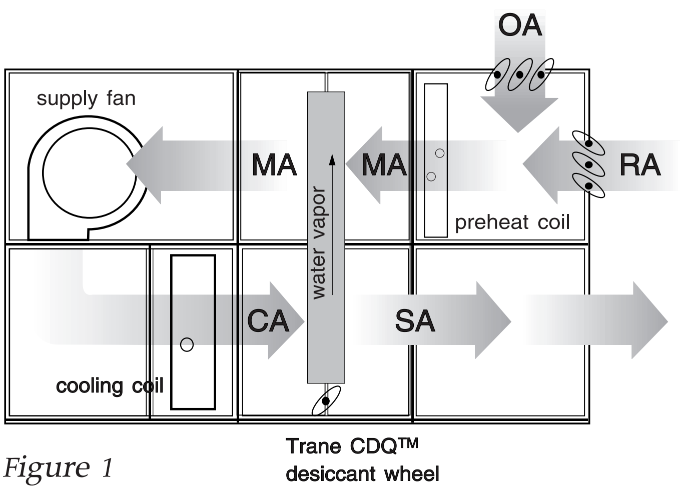


Figure 1

The system has been designed for AHU with mixed return and outdoor air. When using as outdoor air unit, additional heating would be required to dry the desiccant.

SMAC

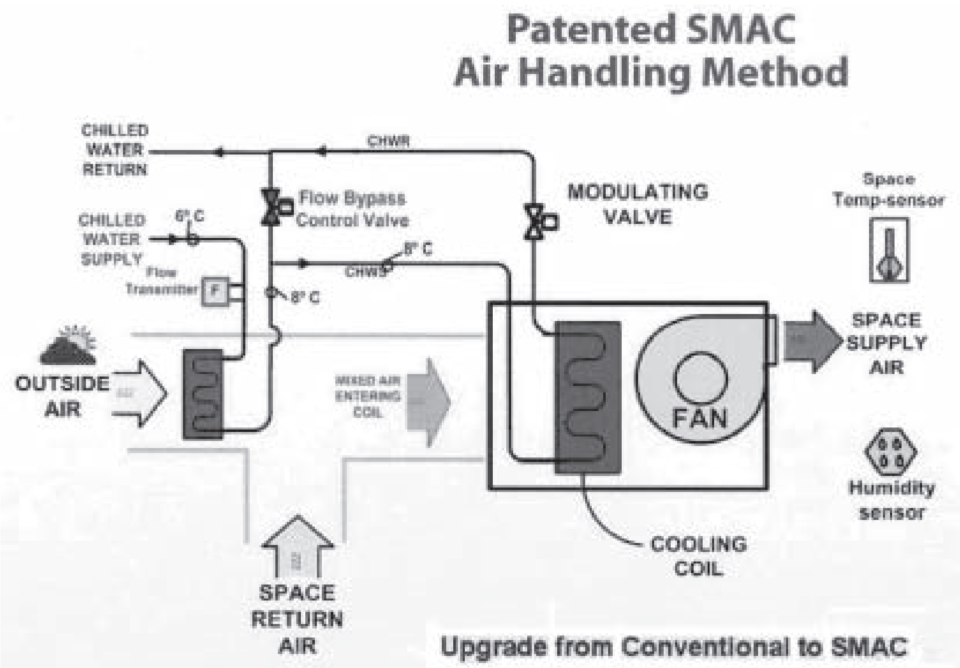
Shaw Method of Air-conditioning (SMAC) is patented system by Dr. Allan Shaw, with comprehensive approach including both hardware and software. The hardware includes separate cooling for outdoor air, special cooling coil for air-handling unit and chilled water piping. Software includes control of air leaving conditions and chilled water supply temperature back to chiller plant.

The expert claimed that they could control air leaving temperature at outdoor cooling coil close to chilled water supply temperature. When outdoor mix with return air, the dry air would provide latent cooling as well as sensible cooling. The AHU cooling coil would provide additional sensible cooling mainly.

Since air leaving temperature can be close to chilled water supply temperature, chilled water supply temperature can be higher than 7 degree C. As long as it is still below 10 degree C, it still can provide required latent cooling and moisture removal ability.

During system start up, chiller will supply chilled water at 7 degree C. When humidity has been pulled down to required level, say 50%RH, chiller could supply chilled water at higher temperature and save energy.

This is integrated system with comprehensive approach, and requires design engineering as well as commissioning.



The system has been designed for AHU with mixed return and outdoor air. Design as DOAS is possible.

DEECS

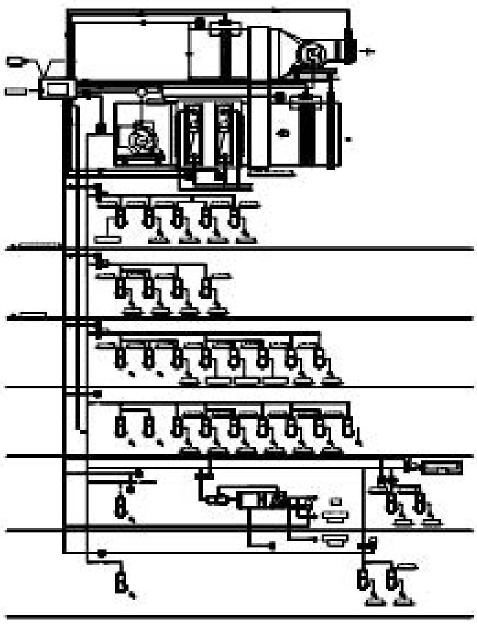
Dedicated External Environmental control System (DEECS) is EEC patented design, having dedicated outdoor air unit and ventilation zone demand control. The outdoor air unit supply dry fresh air and provide latent cooling to the "room". The zone demand control using "Fresh air valve" and CO_2 sensor. Dry fresh air is delivering into room directly with dedicated fresh air duct. The dry air in the fresh air duct has relative humidity lower than 65%RH to avoid mold growing in the air duct, as could be the case of conventional pre-cooled fresh air supply.

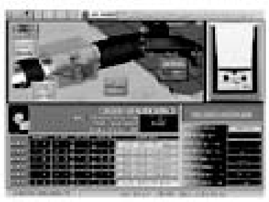
AHU or fan coil unit (FCU) are become "Terminal unit", providing local air-conditioning requirement. Since dry fresh air is dry and normally 18 degree C, the terminal unit cooling coil is performing under rather dry condition. Therefore, reduce problems due to wet cooling coil, condensation, drain pan, drainage, and slime. The system effectively control and improve indoor air quality by zoning.

The DEECS concept is in line with DOAS when zone demand control is applied.

CONCLUSION

When designer specify AHU and cooling coil, they specify air entering and air leaving condition to suit cooling load calculation and room sensible heat ratio, hoping that the supplied cooling coil will perform and match





the cooling requirement. In reality, the cooling coil will never really match real air-conditioning need. Because, cooling load has been calculated at peak condition, and designer will normally add 15% safety factor. In reality, real cooling requirement has more than 70% diversity. When cooling load is not real, room sensible heat ratio is not real, cooling coil performance is deviated. Therefore, the cooling coil has never been performed as the designer want.

Ideal solution is to figure the room sensible heat ratio and have the cooling coil with coil sensible heat ratio that match.

Room sensible heat ratio below 0.8 is more critical. With energy efficient building design and OTTV of less than 30 watt/m^2, room sensible heat ratio tend to be lower than 0.8, and latent cooling will be the key and most important in air-conditioning design. Latent load is likely to be 40% of total cooling load or even more. Outdoor air varies widely during the day and night, and contains humid air. Therefore, the designer must understand the method of “Latent cooling”, in order to cope with the energy efficient building design and indoor air quality.

AHU with mixed return air and outdoor air is less complicated and suitable for small and medium size system. DOAS should be designed for large air distribution or large area. According to past experience, DOAS has better indoor air quality control, reduces risk of cross contamination and flexible.