HVAC&R
Skills Workshop

MODULE 122

HUMIDIFYING AND DEHUMIDIFYING

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Skills summary

What?
An introduction to humidifying and dehumidifying.

Who?
Building owners and managers, maintenance specifiers and providers, regulatory authorities, system designers, installers and commissioners, consumers, tenants, occupants and HVAC hygiene and indoor air quality industry professionals.

PULLOUT

Managing humidity is one of the key functions of an HVAC system. As well as affecting the comfort of occupants, humidity control also plays a vital role in ensuring indoor air quality. High humidity levels can increase the growth of mould and mildew, which can affect people's health.

But it's not always about reducing humidity. Depending on the ambient conditions, it may be necessary to dehumidify or humidify an area. Humidification is often required to maintain comfortable indoor relative humidity, usually under heating conditions.

This Skills Workshop looks at some of the techniques used to do this, as well as the thermodynamic processes behind it.

Humidifying air

Just as food stored in a refrigerator requires a certain humidity or moisture level in the air to prevent dehydration or permit normal evaporation of surface water, so people require a level which will maintain comfort and permit normal evaporation of fluids from the skin, lips, nose and lungs without the discomfort of 'dryness' necessitating frequent replacement by 'thirst quenchers'.

In dry climates, or when ambients fall below 5°C in winter, conditions within a room heated to 24°C can result in unpleasantly dry atmospheres which are not only uncomfortable but can also cause timber to shrink and a dangerous build-up of static electricity.

The human body is sensitive to both temperature and humidity, and is most comfortable in temperatures of 22–24°C with relative humidity of about 50 per cent.

If temperatures are lower, comfort can be maintained if humidity is increased – for example, 18°C and 80 per cent relative humidity would be acceptable. However, at higher temperatures, humidity should be lower – for example, 26°C and 35 per cent would be an acceptable combination.

Many air conditioners are not equipped for 'humidification', but those which are equipped with water sprays before the cooling coil achieve a bonus from maintaining a relatively high humidity, in the form of both economies of operation and reduced complaints.

Methods of "humidification" include:

(a) Increased recirculation of air
(b) Water sprays in the duct before the cooling coil
(c) Direct injection of steam
(d) "Heater and humidifier" units
(e) Evaporative cooling.

(a) Increased recirculation

This is practical only within specific limits, because it relies upon water vapour derived from the occupants of the space and any appliances which add water vapour, such as tea and coffee urns, hair dryers, cooking appliances and so on.

The main limit is set by the need to maintain air purity and for the elimination of the odours which inevitably accompany water vapour from these sources. These can only be eliminated by introducing fresh air but, when this air is 'dry', space humidity falls.

(b) Water sprays in the central air conditioning duct

Sprays are often installed on the upstream side of the evaporator or cooling coil, but in colder climates may be installed downstream of an outside air preheater coil, because cold outside air would not be capable of holding much more moisture until heated to at least 10°C.

When located upstream of the cooling coil, any surplus moisture may be removed by the cold coil, and the finned coil acts to catch the water drops and prevent free water being carried into the ducts.

If located downstream of the coils, 'spray eliminators' would be required. Figure 1 shows the location of sprays in a typical system.

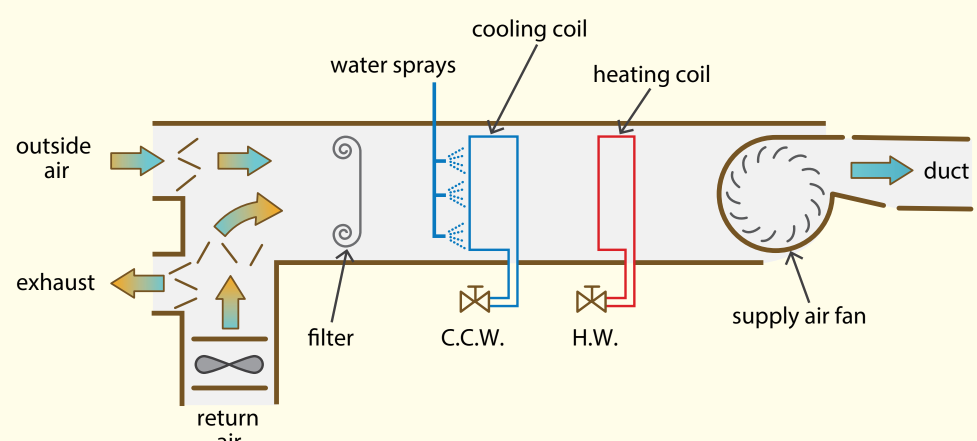

Figure 1: A central station air conditioning plant showing the location of water sprays used for humidification

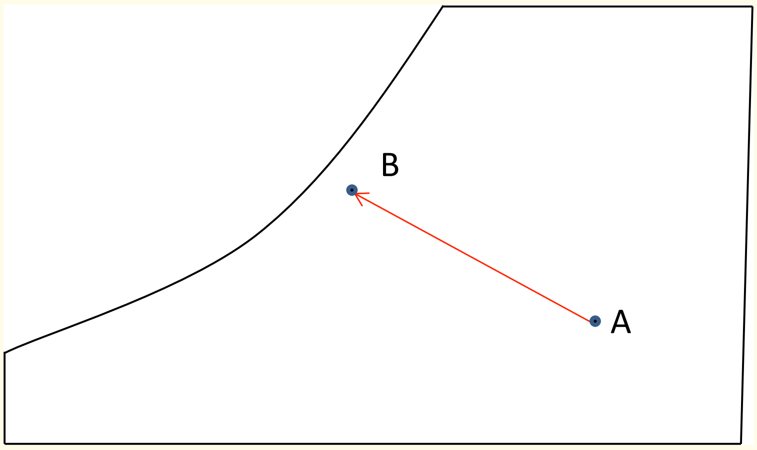

Figure 2: Humidifying process along a line of constant wet-bulb temperature

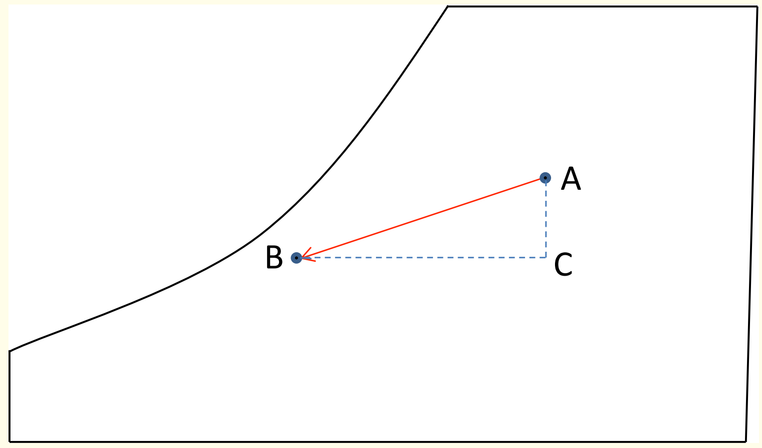

Figure 3: Cooling and dehumidifying process

(c) Direct injection of steam into the duct

This method can best be applied when both heating and humidification are required.

It has an advantage where existing steam supplies can be tapped, and installation is simple, as there would be no need for pressure-reducing spray eliminators.

(d) Heater humidifying units

Compact humidifiers, which can be readily installed in any room or space, are common in the United States and Canada, where winter temperatures are much lower than in most of Australia. Many serve dual duties by using heat to vaporise the water, so heating the air at the same time.

Others drop water onto a spinning plate, and use a fan to direct the atomised particles into the air.

(e) Evaporative cooling

As described earlier, the process of direct cooling by evaporation results in increased water vapour content in the supply air. In dry climates, therefore, evaporative cooling can perform the same task as more expensive mechanical systems, with the added bonus of a more comfortable humidity.

Some large air conditioning plants utilise water sprays that can be used in hot, dry weather to supplement the chiller plant and reduce energy use.

Water sprays for humidity control – plus evaporative cooling

In areas where low relative humidity may present a problem, water sprays can be installed to add moisture to dry air before the cooling coil.

Some plant operators have found an additional cost-reducing benefit in the cooling which results from the evaporation of water. In hot, dry summer weather, plants can be run with 100 per cent fresh air (no recirculation) with water sprays producing effective cooling plus satisfactory humidification. Under ideal conditions, the starting of the water-chilling plant can be delayed by two to three hours at considerable cost savings. Spray eliminators are necessary to prevent water being carried into the duct.

Humidification in specialised applications

For hospitals, operating theatres, computer rooms, laboratories and museum treatment areas, it is often necessary to add moisture to the air to maintain a specified relative humidity, say 60–70 per cent, in the conditioned spaces. In hospitals, this is necessary for the health of patients, especially those with lung problems worsened by "dry" air.

Computer room conditioners are required to maintain 60–70 per cent relative humidity to control static electricity and keep paper, tapes and electronic equipment in a state of equilibrium. Laboratory and museum needs may vary according to the type of work done. Generally, high relative humidity is required where "living" specimens and plants are involved, and low relative humidity is required where books, paintings and archaeological specimens are stored.

Water sprays are not always suitable for adding moisture and specialised humidifiers, which inject steam or water in an atomised spray, are installed in these smaller applications.

In particular, water sprays can leave deposits of solids on the cooling coils and should be kept clear of the coils, except where the water has low solids content.

Thermodynamic processes – humidifying

Humidification means that the moisture content of the air is increased. Liquid water or steam can be injected into a moist airstream to increase its humidity.

The simplest case to consider is to spray water into a moist airstream and assume all the water sprayed is evaporated. Since the total evaporation has occurred, air state B must lie nearer to the saturation curve. How much nearer to the saturation curve depends on the amount of water sprayed.

The effect of water sprayed into the airstream depends on the temperatures of airstream and water sprayed. If the temperature of the water sprayed equals to the wet-bulb temperature of the airstream, the change of state will be along the line of constant wet-bulb temperature.

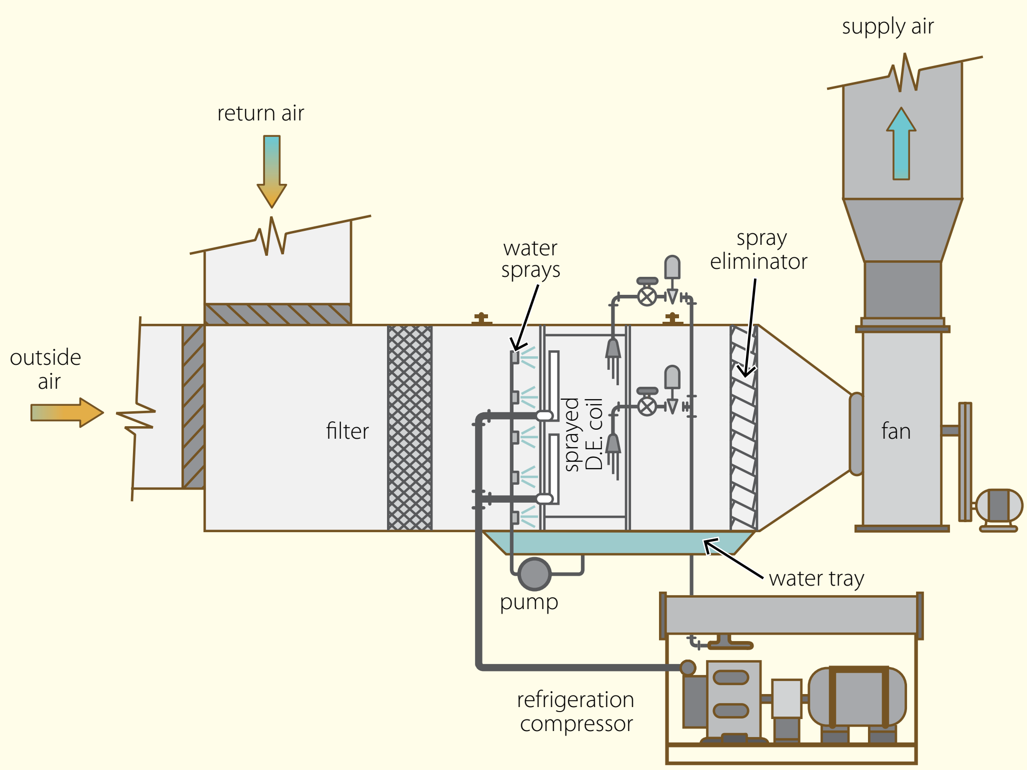

Figure 4: System with central fan, split direct expansion refrigerant coil, filters, distributing ductwork, refrigeration compressor and controls, plus water spray

(Reproduced from Trane original graphic, courtesy of Trane, Ingersoll Rand.)

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If steam is injected into an airstream, the change of air state takes place almost along a line of constant dry-bulb temperature, provided the steam is in a dry saturated condition.

If the steam is superheated the dry-bulb temperature of the airstream may increase by any amount, depending on the degree of superheat.

The amount of moisture added and the energy transfer rate can also be determined by Equation (1) and Equation (2), respectively.

Dehumidifying air

Normal comfort conditions for humans require temperatures of approximately 22° to 25°C, with relative humidities between 60 and 40 per cent.

It is a characteristic of air that the warmer it becomes, the more water vapour it can hold. When warm air is progressively cooled with a certain quantity of water vapour contained within it, the relative humidity increases until the air becomes "saturated" (100 per cent relative humidity) and any further cooling causes some of that water to separate as dew or "condensate". This point is called the dew point.

In the Earth's atmosphere, the mixing of warm, moist air and cold air usually results in the condensation of water, first as "cloud"' then rain. Mountain ranges push airflows to colder, higher altitudes and again produce rain.

It follows, therefore, that the normal processes that cause a drop in air temperature can be used to reduce the moisture content of air. The main dehumidification processes can be summarised as:

(a) Using refrigeration to cool air below its dew point

(b) Introduction of increased quantities of outside air when its moisture content is low

(c) Chemical dehumidification using moisture absorbers.

(a) Refrigeration dehumidification

If air is cooled to approximately 12°C, it will be able to hold just enough water vapour to give a relative humidity of 50 per cent at 22°C, with all surplus water being left as condensate or dew on the surface of the evaporator or cooling coil.

The standard air conditioner is therefore designed to cool the air circulated through it to approximately 12°C, so that it both cools and dehumidifies to an acceptable level. Only if the incoming air contains insufficient water vapour will water sprays or similar humidifiers be necessary to restore 'comfort'.

(b) Introduction of increased quantities of dry air

Large air conditioning plants can be so controlled that outside and inside air humidities can be measured, balanced against temperatures, and the proportions of fresh and recirculated air varied to produce the ideal temperature and humidity conditions at the minimum cost in energy. Thus high internal space humidities could be effectively reduced by introducing increased proportions of dry outside air.

Obviously this must be done without increasing the cooling or heating loads on the plant but, in the interests of energy conservation, increasing use must be made of this technique.

(c) Chemical dehumidification

This method can only be applied to certain applications where the other methods are unacceptable, and therefore has very little use in normal air conditioning.

The most obvious application would be in space vehicles, where the complete regeneration and recirculation of oxygen and water are essential for survival of the crew.

Thermodynamic processes – dehumidifying

There are four principal methods whereby moist air can be dehumidified:

(i) Cooling to a temperature below the dew point

(ii) Adsorption

(iii) Absorption

(iv) Compression followed by cooling.

Here we mainly introduce the first method.

Moisture condensation occurs when moist air is cooled to a temperature below its dew point. Since the aim is the dehumidification, some of the spray water or part of the cooling coil must be at a temperature less than the dew point of the air entering the equipment.

When moisture air flows over a surface, part of the airstream is cooled to a temperature below its dew point and some of the water vapour will condense and leave the airstream.

Figure 3 shows a cooling and dehumidifying process. Although the actual process may vary considerably (depending on the type of heat exchanger surface, surface temperature, and flow conditions), the net heat and mass transfer during the process can be expressed in terms of the initial and end states.

The amount of moisture removed can be determined by Equation (1). The energy transfer rate (Q) can be determined by Equation (2). The last term on the right-hand side of Equation (2) is usually small compared to the others and is often neglected. ■

$$m_w = m_a (W_A - W_B)$$

Equation (1)

$$Q = m_a (h_A - h_B) - m_a (W_A - W_B) h_W$$

Equation (2)

Where

m_w = the amount of moisture removed (kg/s)

m_a = air mass flow rate (kg/s)

W_A = air moisture content at state A (kg/kg)

W_B = air moisture content at state B (kg/kg)

h_A = air enthalpy at state A (kJ/kg)

h_B = air enthalpy at state B (kJ/kg)

h_W = the enthalpy of condensate (kJ/kg)

This month's Skills Workshop has been adapted from *Australian Refrigeration and Air-Conditioning Volume 2*, by Graham Boyle, F.AIRAH, and AIRAH's accredited Professional Diploma in Building Services – HVAC&R.

Next month: Noise in ductwork systems