Preconditioning Dedicated OA for Improved IAQ — Part 1

In this column, the central thrust is a discussion of the components used in an outdoor air (OA) preconditioning equipment required to meet Standard 90.1-1999.

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In the Winter 2001 issue of IAQ Applications, the author's column "Dedicated OA Systems" provided an overview of the subject. In this column, the central thrust is a discussion of the components used in outdoor air (OA) preconditioning equipment required to meet ANSI/ASHRAE/IESNA Standard 90.1-1999, *Energy Standard for Buildings Except Low-Rise Residential Buildings*. The equipment includes passive desiccant wheels, sensible heat exchangers and deep cooling coils to reduce the first and operating costs of cooling, heating, and humidification.

The separate dedicated outdoor air system discussed is intended to meet the ventilation requirements of ANSI/ASHRAE Standard 62-1999, *Ventilation for Acceptable Indoor Air Quality*, and also supply air dry enough to remove all of the space latent loads efficiently. Each of the individual components of the system is discussed here.

OA Preconditioning

The dedicated OA must be cooled and dehumidified in the summer, and humidified and heated or cooled at other times. In the simplest form, the preconditioning could be achieved with a preheating coil, a cooling coil, a reheating coil, and a humidifier. However, Standard 90.1-1999 in Section 6.3.6.1 Exhaust Air Energy Recovery requires: *"Individual fan systems that have both a design supply air capacity of 5,000 cfm (2360 L/s) or greater and have a minimum outside air supply of 70% or greater of the design supply air quantity shall have an energy recovery system with at least 50% recovery effectiveness. Fifty percent energy recovery effectiveness shall mean a change in the enthalpy of the outdoor air supply equal to 50% of the difference between the outdoor air and return air at design conditions."* Consequently, since dedicated OA systems are 100% OA systems, energy recovery is required to supplement the simplest form of preconditioning equipment mentioned earlier.

Standard 90.1-1999 places the following limitations on reheating (defined in the standard as*: raising the temperature of air that has been previously cooled either by mechanical refrigeration or an economizer system*) as it relates to preconditioning the OA. Section 6.3.2.3 Dehumidification: *Where humidistatic controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream.*

Exceptions to 6.3.2.3: (e) At least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered energy source.

The Standard 90.1-1999 requirements clearly mandate that a total energy recovery device, i.e., an enthalpy wheel, also known as a passive desiccant wheel, be used to reduce the load on the cooling coil. Further, if the supply air is to be delivered at a temperature above the required supply air dew-point temperature, a sensible energy recovery device is required. While many combinations of equipment are possible, the author favors the arrangement illustrated in *Figure 1*.

System Configuration

A general layout of the DOAS, consisting of a preheat coil, an enthalpy wheel, a deep cooling coil, a sensible heat exchanger, and the prime movers is illustrated in *Figure 1*. The acronym DOAS means the set of equipment specified earlier, although many other configurations can be conceived.

In *Figure 1*, the sensible heat exchanger is a sensible heat wheel. This will be the assumed arrangement, although equally good heat exchangers in the form of plate-type or heat pipe are used.

As will be discussed, the effectiveness of the sensible heat exchanger must be variable down to zero. Modulating rotational speed alters the effectiveness of the sensible wheel. Heat pipe heat exchangers have some control of effectiveness by altering the unit tilt, but it is not possible to reduce it to zero in this manner.

Plate-type and heat pipe heat exchanger effectiveness must be controlled by the flow rate of one of its air circuits. That means these latter two heat exchangers require face and bypass dampers to limit effectiveness, an alternative that will not be developed further here. The rationale for each of the components in the system and their performance characteristics will be presented next.

Enthalpy wheel

The enthalpy wheel (also called a passive desiccant or total energy wheel) recovers both sensible (temperature) and latent (moisture) energy. The wheel's desiccant-loaded honeycomb rotor design (its appearance is like the edge of a cardboard box) provides for high-heat transfer, with low pressure-loss parameters. Psychrometrically, State 2 is on a straight line connecting States 1 and 6. An 85% effective enthalpy wheel will put State 2 close to State 6, (i.e., within 15% of the distance between States 1 and 6).

Application Issues

The benefits of this level of total energy recovery are strong in the summer in load and energy consumption reduction. It is also beneficial for minimizing heating and humidification energy-use during cold months. A word of caution concerning winter operating conditions: if the straight line joining States 1 and 6 crosses the saturation curve, condensation will occur in the wheel. If the temperature of State 1 is below freezing, then condensate may freeze in the wheel. To avoid this condition, preheating is required under certain conditions to prevent frosting of the enthalpy wheel.

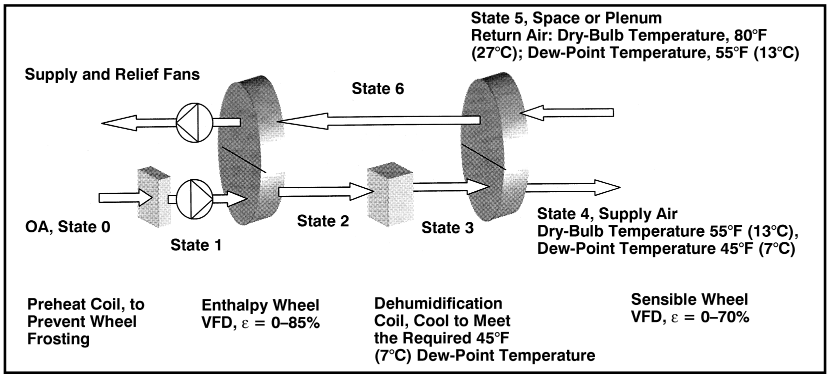

Figure 1: General arrangement of the DOAS.

Preheat Coil

As noted earlier, a small preheat coil is required in many locations if the enthalpy wheel is to be used in the winter. With a proper preheat setpoint reset control schedule, only minor preheat energy will be required to avoid freezing, and further heating of the outdoor air is virtually eliminated with the enthalpy wheel.

Deep Cooling Coil

For the applications addressed in this article, relatively low dew-point temperature (42–48°F [6–9°C]) air is required to remove the entire latent load from the space with the ventilation air and still maintain a target space dew-point temperature around 50–55°F (10–13°C). When outdoor air dew-point temperatures exceed that required for supply, the cooling coil must be controlled to maintain the low dew-point temperature. However, when the outdoor air dew-point temperatures are below that required by the supply air, the control setpoint may be reset up to the desired supply air temperature. In this case, the cooling coil is no longer needed to perform dehumidification.

Sensible Wheel

If the space sensible loads were always sufficiently high to permit the cold air leaving the cooling coil to directly enter the space without local reheat, the sensible wheel would not be necessary. However, in many applications, the internal and envelope sensible cooling loads are not sufficiently high to prevent overcooling with the low-temperature ventilation air. Therefore, it is desirable to elevate the supply air temperature. For the sake of discussion, it will be assumed that the supply air temperature is elevated to 55°F (13°C). The sensible wheel will accomplish this, although as mentioned earlier, other forms of sensible heat transfer equipment could be used. When two equal flow rate airstreams exchange energy in the sensible wheel, virtually no moisture is exchanged.

For the sensible wheel illustrated in *Figure 1,* the 45°F (7°C) air leaving the deep cooling coil is reheated sensibly to 55°F (13°C) with energy extracted from the return airstream. The return air is sensibly cooled by 10°F (6°C) in this process, lowering the energy content of the return airstream, reducing further the enthalpy of the outdoor air leaving the enthalpy wheel and entering the deep cooling coil.

Supply and Return Fans

These fans must be selected to overcome the resistance to flow from the wheels, coils, and duct systems they serve. In some manufacturers' equipment, they must also be able to handle the excess air in the purge cycles (when used to flush the return air from the wheel before it enters the clean supply air) of the enthalpy wheel. These fans would be required at all times the building is occupied.

Filtration

Filters are not shown in *Figure 1*, since the emphasis is the thermodynamic performance of the system. However, at least coarse filtration will be required upstream of the equipment in the OA and relief airstreams.

Economizer

A frequent question related to dedicated OA systems is the use of the economizer cycle. Standard 90.1-1999 generally requires the use of an airside or a waterside economizer, unless it can be shown that there is no reduction in energy-use when employed. An airside economizer is only possible with dedicated OA systems when the parallel sensible-only system is an all-air system. For all other parallel system technologies, (i.e., fan coil units, etc.) a waterside economizer is the required option. The following exception to the operation of a waterside economizer taken from Standard 90.1-1999 will be required for the DOAS when in the dehumidification mode. Exception to Section 6.3.1.2.1: "*Systems in which a water economizer is used and where dehumidification requirements cannot be met using outside air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb must satisfy 100% of the expected system cooling load at 45°F (7°C) dry bulb/40°F (4°C) wet bulb.*"

Bibliography

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