Energy Recovery Wheel Technology

INTRODUCTION

The need to introduce outside air into the modern building is becoming increasingly understood. Because most buildings are tightly sealed, indoor pollutants such as bacteria, viruses, radon and other gases become trapped inside and cause problems for the occupants. If these indoor pollutants become concentrated and rise above the minimum threshold limits tolerable by the individuals in the building, many health problems can arise.

The solution is to dilute the indoor pollutants by introducing greater quantities of outdoor air. ASHRAE 62 has established a minimum level of ventilation air to achieve standard dilution. This sometimes calls for as much as 50% of an air handler's volume to be made up of outdoor air. This outdoor air load often exceeds the air handler's capacity. A dedicated 100% outdoor air system is then required to condition the air prior to introducing it to the space.

If it is possible to exhaust inside air at the same location where the 100% outdoor air unit is located, it makes sense to use a device such as a heat wheel to pre-cool the air during summertime operation or pre-heat the air during the winter months. Refer to Figures 1, 2 and 3.

TYPES OF WHEELS

There are three general types of wheels being used today. They are sensible, enthalpy and regenerative. Many times they are referred to as "desiccant" wheels, but this only confuses rather than clarifies since only two of these types have desiccant as part of their designs. The actual definitions are:

SENSIBLE WHEEL - This wheel is not coated with a desiccant and therefore transfers only sensible energy. The wheel can be constructed of almost any material (paper, metal or plastic) and transfers energy between two air streams as the mass of the material gains or loses heat to the opposite air stream. The wheel rotates at a speed of 10 to 50 revolutions per minute.

ENTHALPY WHEEL - It is similar to the sensible wheel except that a desiccant media is added to the wheel's surface. As the wheel rotates, it now can transfer sensible energy and humidity. This wheel also rotates at 20 to 50 revolutions per minute.

REGENERATION WHEEL - This wheel is used when low dewpoint conditions (<45°F) are required, such as industrial applications. It achieves low dewpoints by slowing the wheel to a speed of between 0.25 and 1 revolution per minute and by using an air stream heated to 250°F or more to drive off moisture and regenerate the wheel. This heated air stream is typically focused on only 1/4 of the wheel's area thereby allowing 3/4 of the area to be available for the process side.

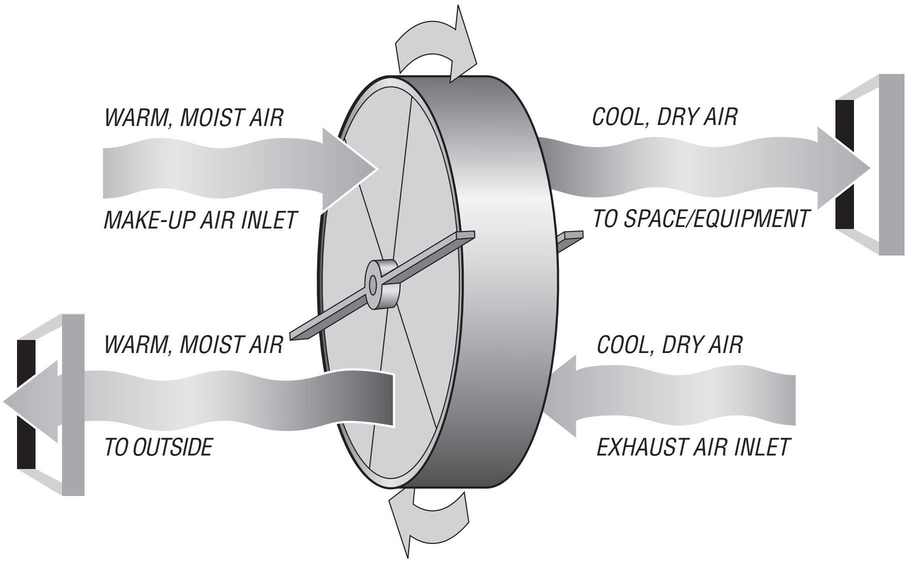


Figure 1 - Typical Enthalpy Wheel Operation (summer operation)

DESICCANT SELECTION

By their nature, all desiccants remove water from an air stream. Each desiccant has an equilibrium capacity which determines the amount of water that it can adsorb. Kinetics defines the rate at which this equilibrium capacity is achieved. Other factors that affect water adsorption are desiccant selectivity and desiccant life.

There are three classifications of desiccants used in dehumidification equipment within the HVAC industry:

1.) Lithium chloride
2.) Silica gel (including titanium silicate).
3.) Molecular sieves (e.g., 3Å, 4Å)

Lithium chloride was widely used 20 years ago in a majority of desiccant-based equipment. It is rarely used today because it dissolves (deliquesces) as it removes moisture from the wheel. This greatly limits the life of the product.

An enthalpy wheel manufactured with silica gel is an excellent desiccant for treating saturated or near-saturated air streams. Compared to most molecular sieves on an equal weight basis, silica gel can hold more water in air streams above 50% RH. It must be noted that in the case of an enthalpy exchanger, the wheel moves between two equilibrium relationships (isotherms), that of return air and outside air. The wheel never completely dries out, but in fact remains near saturated all the time. As a result, only a very small part (less than 1%) of the isotherm curve is used. In order to accurately measure the amount of moisture that's adsorbed by the wheel in a given revolution and on an equal desiccant weight basis, you must consider the differential between the adsorption capacity at the outdoor air and return air conditions. While silica gel holds more water at RH's above 50% than do molecular sieves, it also holds more water under the return air condition. Molecular sieves and silica gel do approximately the same amount of work in an enthalpy exchange application on an equal desiccant weight basis.

Desert Aire's enthalpy wheel uses molecular sieves made of nanocrysalline porous aluminasilicate or generically called zeolites. The zeolite framework is an assemblage of silica and alumina tetrahedra joined together in various regular arrangements through shared oxygen atoms. This configuration forms an open crystal lattice of molecular-sized pores into which guest molecules can penetrate. The crystal lattice creates a micropore structure that is precisely uniform with no distribution of pore size. A molecular sieve that's no greater than 4 Angstroms is a sodium aluminosilicate with an effective aperture size of 3.8 Angstroms. Since methane is the smallest of the organic molecules at a critical diameter of 4.2 Angstroms, molecular sieves effectively screen out adsorption of all organic compounds. On the other hand, water is smaller than 3.8 Angstroms so it is readily adsorbed.

In addition, an enthalpy exchanger's effectiveness is determined not only by the capacity of the desiccant it uses, but also by the quantity of desiccant it exposes to the air stream.

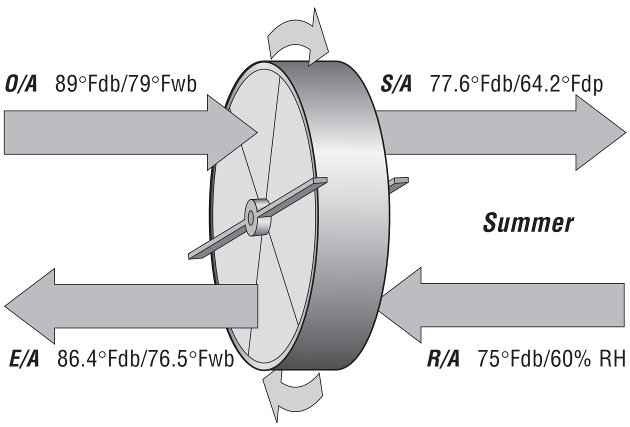


Figure 2 - Enthalpy Wheel Performance During Summer

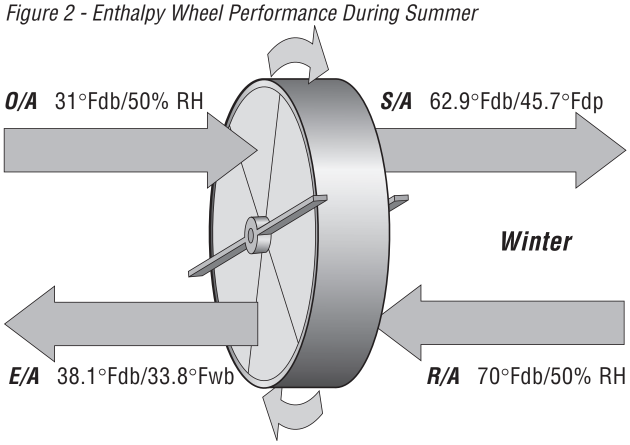


Figure 3 - Enthalpy Wheel Performance During Winter

DESERT AIRE'S ENTHALPY WHEEL DESIGN

Desert Aire's wheels contain a patented molecular sieve coating that selectively absorbs and desorbs water molecules in the air. This thin molecular sieve coating permanently adheres onto a sea water resistant aluminum alloyed that is composed of wave and flat, continuously wound layers to guarantee laminar flow and low static pressure loss. The wheel matrix, or its total mass, provides for highly efficient sensible and latent energy exchange.

Most other media will have the desiccant coated, bonded or synthesized onto the matrix. The desiccant material must usually be applied as a thick coating layer that is subject to delaminate or erode off the media through the normal life expectancy of the wheel. In contrast, the desiccant on Desert Aire's media is designed to permanently adhere to the surface of the aluminum alloyed. Our design offers excellent face flatness to minimize wear of the of the inner seal surfaces and reduce cross leakage while offering a minimum life expectancy of 15 years.

Our wheel frames are constructed of evenly spaced spokes, a galvanized steel band and an aluminum center hub. Frame component sizes and number of parts vary with wheel size.

Due to the low static pressure and slower rotation of the wheel, the power consumption is very low compared to other wheels on the market. Desert Aire uses fractional horsepower AC drive motors, spring loaded tensioning motor mounts and durable nylon reinforced drive belts as our standard drive systems.

It is not uncommon for frost to develop on the wheel under extremely cold winter conditions. The wheel can cool down to below 32°F and will then freeze moisture from the exhaust stream. Frost may reduce the airflow, but it will not damage the wheel. Desert Aire offers an optional electric heater to preheat the outdoor air and prevent the exhaust air from freezing.

CROSS CONTAMINATION/LEAKAGE

Cross contamination is a measure of the amount of unwanted compounds or impurities that are transferred from the return air stream to the supply air stream. This is usually not an issue in normal commercial heating and cooling applications although it can sometimes be important to some consulting engineers when specifying an energy recovery unit. In the effort to reduce the levels of undesirable impurities in the air, certainly heavy cross contamination can limit the effectiveness of ventilation. It is important to avoid cross contamina-tion in conditions where there is a high volume of polluted indoor or outdoor air. It is extremely important to prevent cross contamination in medical applications. These applications include laboratories, heavily industrialized areas, paint or solvent storage areas, morgues and health care facilities.

There are three different sources of cross contamination:

I.) carryover from return to supply stream due to wheel rotation

2.) seal leakage from return to supply stream

3.) adsorption by the desiccant with later release into air stream

A purge section will minimize carryover from return air to supply air. DEpending on the wheel size, Desert Aire offers an optional purge unit with two settings at 5 or 10 degrees. This provides ample latitude to prevent the carryover attributed to the wheel's rotation.

The best way to prevent seal leakage is to use quality seals and to ensure that the supply wheel face has a positive pressure differential between supply and return. Our Desert Aire cassettes seal peripherally on the wheel band, and diametrically along the centerline of the wheel face using full-contact felt bush seals which provide a good proximity seal. Tests have shown this proximity seal to limit air leakage to around 2% at 1 inch water column of differential between the air streams.

In addition to the molecular selectivity feature of molecular sieves (as explained under *Desiccant Selection*), it is also important to know that co-adsorption of commonly found impurities is limited. This is due to the fact that molecular adsorption rates are largely dependent on partial pressures. Since the partial pressure of water (i.e. moisture) is over 100 times greater than any of the commonly found impurities in a return air stream, adsorption of an impurity by the molecular sieve is highly unlikely. Also, molecular sieves have a natural affinity for polar molecules. Because water has the highest molecular polarity, it is readily absorbed by a molecular sieve.

SYSTEM EFFICIENCY

An enthalpy wheel's efficiency is a function of its size (diameter and depth) relative to the air volume, and the energy differential between the two air streams. In general terms, most enthalpy wheels can achieve a minimum recovery of 75% of sensible and latent energies. This high rate of energy recovery significantly decreases operating costs.

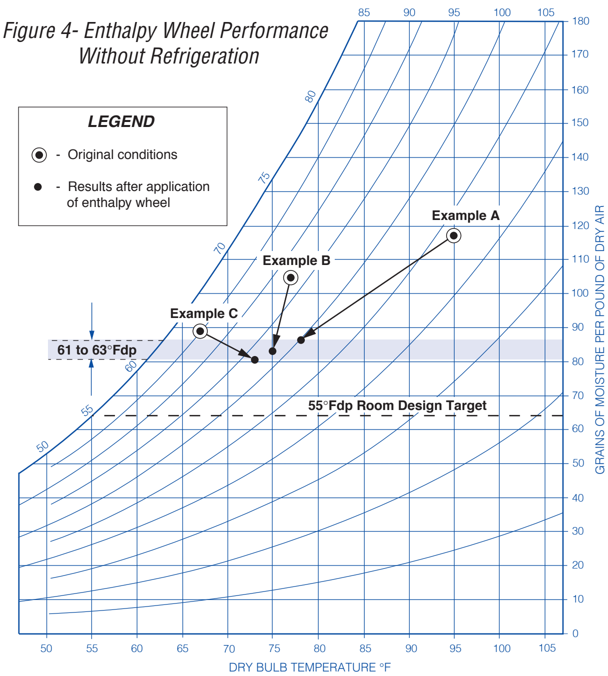
However, this is not the critical design issue according to the ASHRAE 62 ventilation code. The critical issue is whether you are supplying dry enough air to the space. An enthalpy wheel by itself will only dehumidify outside air to 61°Fdp to 63°Fdp. Most engineers require a design of 52°Fdp to 56°Fdp. Figure 4 demonstrates this point.

A refrigeration-based evaporator can be added to the system to lower the dewpoint and meet the required design. Figure 5 shows a complete solution to the IAQ design issue.

CONCLUSION

By themselves, enthalpy wheels will not achieve the desired IAQ design results. However, they can be packaged with a dehumidifier to provide the most energy efficient solution available. The wheel removes the load peaks in both winter and summer modes so that only a small refrigeration system is required to produce the desired dewpoint air.

Figure 4- Enthalpy Wheel Performance Without Refrigeration



TotalAire System Performance

Summer Mode

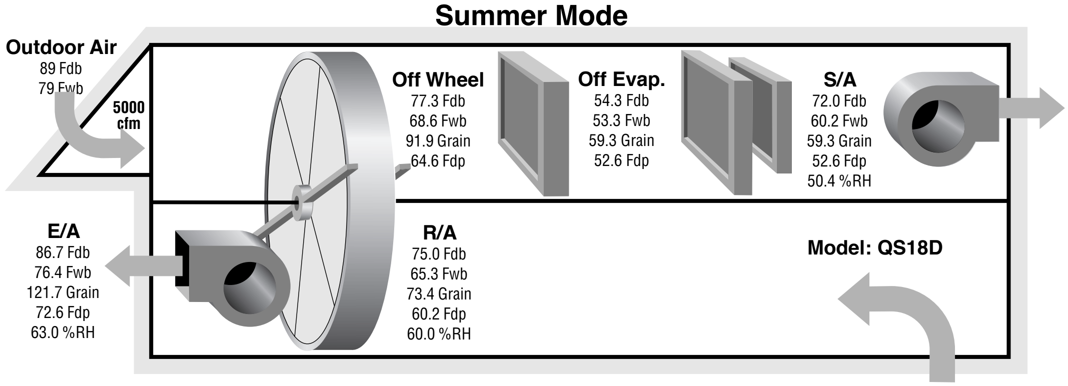


Figure 5 - Seasonal System Performance

OPTIMIZING SOLUTIONS THROUGH SUPERIOR DEHUMIDIFICATION TECHNOLOGY

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