Energy Recovery Ventilation (ERV) for High-Volume Fresh Air Applications

An Online Continuing Education Course for Engineers

Course Number: HV-1012

Credit: 1 Hour / 1 PDH / 1 CPD

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INTRODUCTION

Energy recovery ventilation (ERV) is the energy recovery process of exchanging the energy contained in normally exhausted building or space air and using it to treat (precondition) the incoming outdoor ventilation air in residential and commercial HVAC systems. During the warmer seasons, the system pre-cools and dehumidifies while humidifying and pre-heating in the cooler seasons. The benefit of using energy recovery is the ability to meet the ASHRAE ventilation & energy standards, while improving indoor air quality and reducing total HVAC equipment capacity.

This technology, as expected, has not only demonstrated an effective means of reducing energy costs and heating and cooling loads, but has allowed for the scaling down of equipment. Additionally, such systems allow for the indoor environment to maintain a relative humidity of an appealing 40% to 50% range. This range can be maintained under essentially all conditions.

Energy recovery can substantially reduce the mechanical heating and cooling requirements associated with conditioning ventilation air in spaces requiring large amounts of outside air. Spaces like battery rooms and laboratories typically require 100% outside air at high ventilation rates— between 6 and 15 air changes per hour—primarily for safety reasons. The heating and cooling energy needed to condition this air, as well as the fan energy needed to move it, is 5 to 10 times greater than the amount of energy used in spaces like offices that require a relatively low volume of recirculated air. Heating and cooling systems can be downsized when energy recovery is used, because energy recovery systems reduce peak heating and cooling requirements. The only energy penalty is the power needed for the blower to overcome the pressure drop in the system.

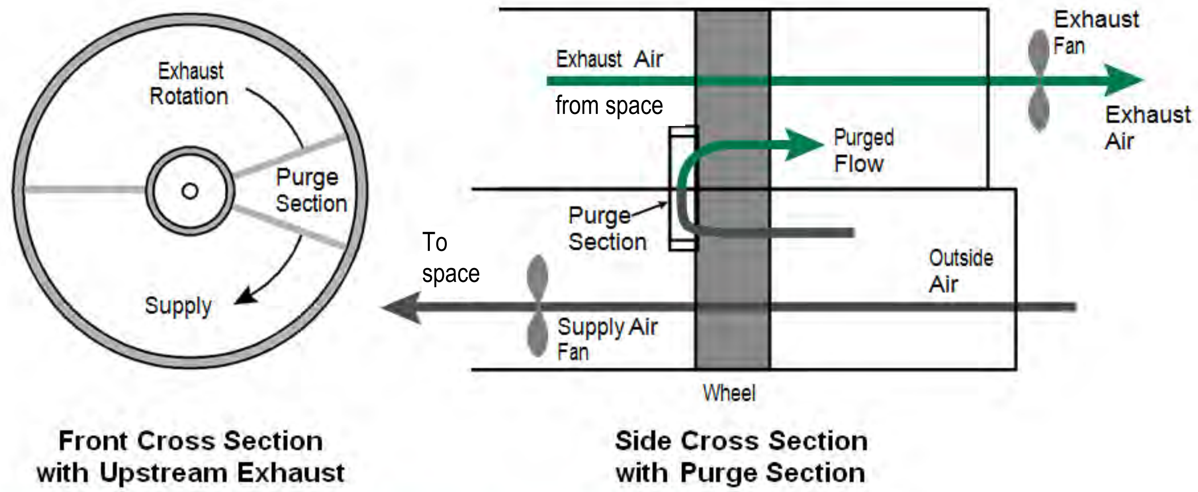


Figure 1. Cross sections (front and side) of enthalpy wheel system with purge section

There are many opportunities for energy recovery, and a few of them are covered here. Energy recovery can occur between any two media or processes that differ in energy content. The main focus of this course is on air-to-air energy recovery—using enthalpy wheels (Figure 1), recuperators, heat pipes, and run-around loops in new construction. Most commonly, energy is recovered from exhaust air and used to precondition supply air. Before deciding on an energy-recovery technology, engineers are encouraged to perform a life-cycle cost analysis. As a rule, the shortest payback periods occur when the heating and cooling load reduction provided by an energy recovery system is sufficient to install smaller hot water and chilled water systems.

Methods of transfer

An energy recovery ventilator (also abbreviated ERV) is a type of air-to-air heat exchanger that not only transfers sensible heat but also latent heat. Since both temperature and moisture is transferred, ERVs can be considered total enthalpic devices. On the other hand, a heat recovery ventilator (HRV) can only transfer sensible heat. HRVs can be considered *sensible only* devices because they only exchange sensible heat. In other words, whereas all ERVs are HRVs, not all HRVs are ERVs, but many people use the terms HRV, AAHX (air-to-air heat exchanger), and ERV interchangeably.

Throughout the cooling season, the system works to cool and dehumidify the incoming, outside air. This is accomplished by the system simply taking the rejected heat and sending it into the exhaust airstream. Sequentially, this air cools the condenser coil at a lower temperature than if the rejected heat had not entered the exhaust airstream. During the heating seasons, the system works in reverse. Instead of discharging the heat into the exhaust airstream, the system draws heat from the exhaust airstream in order to pre-heat the incoming air. At this stage, the air passes through a primary unit and then into a space. With this type of system, it is normal during the cooling seasons for the exhaust air to be cooler than the ventilation air and, during the heating seasons, warmer than the ventilation air. It is this reason the system works very efficiently and effectively. The Coefficient of Performance (COP) will increase as the conditions become more extreme (i.e., more hot and humid for cooling and colder for heating).

Energy recovery devices increase the pressure drop across the supply and exhaust fans. Enthalpy wheels generally have a lower pressure drop than heat pipes and run-around loops, although the pressure drop depends on the design. An additional pressure drop of no more than 1 inch water gauge (1 in. w.g.) in the supply and exhaust air streams is a reasonable design goal, and it will minimize the increase in fan energy. For example, an increase in pressure drop of 1 in. w.g. on a 76% efficient fan and a 95% efficient motor assembly results in an increase in fan energy of 0.16 watt per cubic foot of air per minute (W/cfm). The total increase for supply and exhaust fans together is 0.32 W/cfm.

For most applications, a design face velocity of 500 fpm or less is desirable. Lower face velocities result in lower pressure drops, higher effectiveness, and lower operating costs. The trade-off is larger air handling equipment and higher first costs. An energy recovery device will operate more efficiently with a variable-air-volume (VAV) system than with a constant-volume system, because VAV systems typically operate at face velocities lower than those of design conditions.

Efficiency

The efficiency of an ERV system is the ratio of energy transferred between the two air streams compared with the total energy transported through the heat exchanger.

With the variety of products on the market, efficiency is unquestionably going to vary from product to product. Some of these systems have been known to have heat exchange efficiencies as high as 70-80% while others have efficiencies as low as 50%. Even though this lower figure is preferable to the basic HVAC system, it is not up to par with the rest of its class. Studies are being done to increase the heat transfer efficiency to 90%.

The use of modern low-cost gas-phase heat exchanger technology will allow for significant improvements in efficiency. The use of high conductivity porous material is believed to produce an exchange effectiveness in excess of 90%.

Types of energy recovery devices

Energy Recovery Devices	Type of Transfer
Rotary Enthalpy Wheel	Total & Sensible
Recuperator	Total** & Sensible
Heat Pipe	Sensible
Run around loop	Sensible

**Total Energy Exchange only available on Hygroscopic units and Condensate Return units

Rotary air-to-air enthalpy wheel

The rotating wheel heat exchanger is composed of a rotating cylinder filled with an air permeable material resulting in a large surface area. The surface area is the medium for the sensible energy transfer. As the wheel rotates between the ventilation and exhaust air streams it picks up heat energy and releases it into the colder air stream. The driving force behind the exchange is the difference in temperatures between the opposing air streams which is also called the thermal gradient. Typical media used consists of polymer, aluminum, and synthetic fiber.

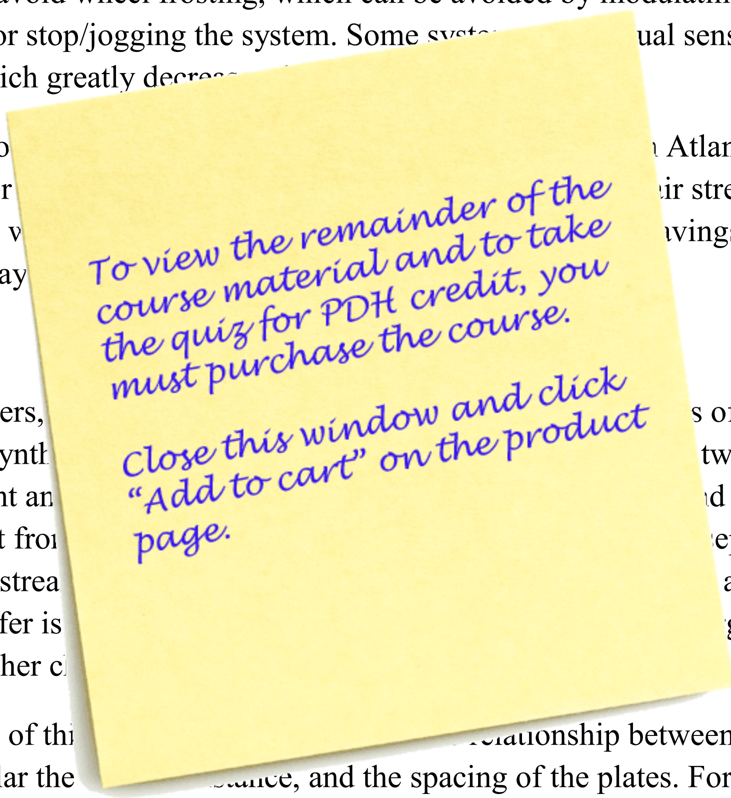
The enthalpy exchange is accomplished through the use of desiccants. Desiccants transfer moisture through the process of adsorption which is predominately driven by the difference in the partial pressure of vapor within the opposing air-streams. The type of desiccant used in a total energy wheel must be designed to transfer only moisture and not airborne contaminants. Typical desiccants consist of Silica Gel, and molecular sieves.

To further reduce potential contamination of the supply air stream, the wheel is flushed with supply air that is deflected by a damper in the purging section of the rotor. The damper redirects supply air leaving the wheel to the inlet side of the wheel exhaust. The purge section utilizes the pressure difference between the supply air and exhaust air streams (see Figure 1). Purge volumes are typically between 5% and 10%, so additional fan energy is required to move this air.

Enthalpy wheels are the most effective devices to transfer both latent and sensible energy, although sensible-only wheels are also available. A 50,000 cfm total energy wheel can have a sensible and latent effectiveness as high as 75%, which results in a total effectiveness of 75%. Control of the wheel at part loads is accomplished by varying the speed of the wheel, or using a bypass duct, or both.

There are many different types of construction that dictate the wheel's durability. The most common type of wheel is constructed of polymer (plastic) and can be plagued with high pressure drop and shorter life. Alternatives to plastic wheels include aluminum and fiberglass which have been shown to have a much longer life, often with a much lower pressure drop.

When using rotary energy recovery devices the two air streams must be adjacent to one another to allow for the local transfer of energy. Also, there should be special considerations paid in colder climates to avoid wheel frosting, which can be avoided by modulating wheel speed, preheating the air or stop/jogging the system. Some syst... ual sensible and latent energy transfer which greatly decre...



The Whitehead Bio... Atlanta, Georgia, uses enthalpy wheels for ... ir streams. The installation cost for the wheels v... vings are $125,000 per year. The simple pay...

Recuperator

Plate heat exchangers, ... s of aluminium, plastic, stainless steel, or synth... two sides to form twin sets of ducts at right an... d extract air streams. In this manner heat fro... eparating plates, and into the supply air strea... and non permeable, sensible only transfer is ... gy transfer these systems have a higher c...

The characteristics of thi... relationship between the physical size of the unit, in particular the ... stance, and the spacing of the plates. For an equal air pressure drop through the device, a small unit will have a narrower plate spacing and a lower air velocity than a larger unit, but both units may be just as efficient. Because of the cross-flow design of the unit, its physical size will dictate the air path length, and as this increases, heat transfer will increase but pressure drop will also increase, and so plate spacing is increased to reduce pressure drop, but this in turn will reduce heat transfer.

Due to the need to use multiple sections, fixed plate energy exchangers are often associated with high pressure drop and larger footprints. As a general rule a recuperator selected for a pressure drop of between 150 and 250Pa will have a good efficiency, whilst having a small effect on fan power consumption, but will in turn have a higher seasonal efficiency than that for a physically smaller, but higher pressure drop recuperator.