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ABSTRACT

Mechanical ventilation with outside air is often required to prevent the buildup of indoor-generated air contaminants in residences with low infiltration rates or high contaminant source strengths. When the ventilation system is equipped with an air-to-air heat exchanger, most of the energy normally lost through ventilation can be recovered. As part of its investigation of ventilation and indoor air quality, the Lawrence Berkeley Laboratory has established a program to evaluate the performance of residential heat exchangers. This paper presents the results of effectiveness measurements on five models of residential heat exchangers and also reports the results of fan performance tests for two of these models. In a heat exchanger, "effectiveness" is a measure of its ability to recover energy. Effectiveness and fan power consumption varied among the models tested and with airstream flow rate. Effectiveness ranged from 52 to 84 percent and fan power consumption ranged from 24 to 185 watts. Future research will include studies of freezing within heat exchangers and contaminant transfer in heat exchangers designed to transfer moisture as well as heat.

INTRODUCTION

Many builders and homeowners are implementing procedures to reduce infiltration--the exchange of outdoor and indoor air. Reducing infiltration is an effective strategy for conserving energy; however, it can have adverse effects on the quality of the indoor air. In some tightly sealed homes, humidity can rise to high levels and cause excessive condensation on windows and damage to building materials. More importantly, the levels of indoor-generated air contaminants are likely to be higher in tightly sealed homes. Some of the more common indoor contaminants and their sources are nitrogen dioxide from combustion appliances, radon gas from the soil surrounding basements and foundations, and formaldehyde from building materials and furnishings (Hollowell et al., 1979).

One way to alleviate most indoor air quality problems without sacrificing all of the energy savings resulting from reduced infiltration is to install a mechanical ventilation system that incorporates an air-to-air heat exchanger. The purpose of the heat exchanger, is to transfer heat from a warm outgoing airstream (in winter) to a cooler airstream entering the house from outside. In the summer, the process is reversed: the heat exchanger cools and, in some cases, dehumidifies the hot outside air that passes through it and into the house. Thus ventilation can be accomplished without the high energy loss normally associated with ventilation systems having no heat-recovery devices.

A residential heat exchanger is used with two fans--one to bring outdoor air into the house and the second to exhaust an equal amount of air. In many cases a fan system (fans and fan motors) is supplied with the heat exchanger; however, some manufacturers supply only a "core" which is the section of a heat exchanger in which heat is transferred between airstreams.

Some models of residential heat exchangers are designed to be used with a duct system for air distribution. Other models are simply installed through the wall or window of a residence. Because window-or wall-mounted heat exchangers are not used with an air distribution system, they may not be as effective as ducted units in ventilating all regions of a residence.

Little data is available on the performance of residential heat exchangers. Two important aspects of heat exchanger performance that have been investigated by Lawrence Berkeley Laboratory (LBL) are thermal performance and fan system performance. The thermal performance of a residential heat exchanger is often characterized by its "effectiveness", which is a measure of its ability to preheat or precool ventilation air. If a heat exchanger is 75 percent effective, it can preheat or precool ventilation air by approximately 75 percent of the difference between indoor and outdoor temperatures. A number of factors can cause the field performance of a heat exchanger to differ from that indicated by laboratory measurements of effectiveness (Fisk et al., 1980); however, effectiveness is a useful criterion for comparing heat exchangers and for indicating approximately their performance in a residence. Because the effectiveness of a heat exchanger decreases as the flow rate of air passing through the heat exchanger increases, effectiveness measurements are generally performed for a range of flow rates.

To characterize the performance of a heat exchanger's fan system, we employ three parameters--airstream flow rate, airstream static pressure drop, and total fan power consumption . For heat exchangers that are supplied with a fan system, the airstream flow rates are a function of the fan speed and the resistance to flow in the duct systems attached to the heat exchanger. An increase in fan speed or a decrease in resistance causes an increase in airstream flow rates. For ducted heat exchangers, the flow rates are typically adjusted by using valves to vary the resistance of the supply and exhaust duct systems. Some ducted heat exchangers also have multi-speed fans for flow-rate control. Window-or wall-mounted heat exchangers, which have no air distribution systems, are typically supplied with a multi-speed fan system for controlling air-flow rates.

The parameter used to describe the resistance of a duct system is the drop in airstream static pressure as it passes through the ducts. This pressure-drop increases with an increase in flow rate and can be predicted if the characteristics of the duct system are known.

The third parameter used to describe the performance of a heat exchanger's fan system is the total fan power consumption. An economic analysis of heat exchanger use being performed at LBL indicates that fan power consumption can be an important economic consideration. Fan placement is also important because it determines the fraction of the fan's energy consumption that is delivered to the residence.

In this paper we present a summary of results from measurements of effectiveness on five models of residential heat exchangers. Data describing the fan performance of two of these heat exchangers is also presented. In a previous LBL report (Fisk et al., 1980) similar performance data is presented for five additional heat exchangers, together with a description of the procedures and facilities used for this testing program.

RESULTS

Before presenting the test results, the manufacturer of each heat exchanger model is identified. (Complete descriptions and prices for the heat exchangers are available from the manufacturers.)

Identification of Models Tested

Two of the heat exchanger models tested are manufactured by Des Champs Laboratories, Inc. in East Hanover, New Jersey (Models 79 M.2 and 79M). These two units are essentially identical except for the inclusion of a single-speed fan system in Model 79M. A third heat exchanger tested was manufactured by Enercon Industries, Ltd. in Regina, Canada and a fourth is a heat exchanger core manufactured by Heatex AB in Hammarsvagen, Sweden. The Enercon heat exchanger is supplied with external fans but the fan system was not tested. Several Swedish companies use one or more of the Heatex cores in their heat exchangers. The fifth heat exchanger tested is the Mitsubishi VL-1500 unit which is available from Mitsubishi Electric Sales America, Inc. in Compton, California.

The first four heat exchangers are used with an air distribution system; the Mitsubishi unit is designed for wall or window installation. The Mitsubishi exchanger is also designed to transfer moisture as well as heat between airstreams. Moisture transfer is desirable in hot humid weather but can be a disadvantage in homes with high humidity problems during the winter. In addition, a heat exchanger that transfers moisture may also transfer some indoor contaminants between airstreams. No data on the moisture transport capabilities of the Mitsubishi heat exchanger are presented in this report.

Effectiveness Test Results

A summary of test results for the five heat exchanger models is presented in Table 1. The effectiveness of the heat exchangers varied significantly among models, ranging from a high of 84 percent to a low of 52 percent for flow rates of 85 to 340 m^3/hr (50 to 200 ft^3/min).

The effectiveness data presented in Table 1 for the Mitsubishi heat exchanger has been discounted because, for this heat exchanger, the flow rate of the exhaust airstream is greater than that of the supply airstream. The imbalance in flow rates will cause this heat exchanger to save less energy than indicated by the non-discounted effectiveness. The effectiveness data was discounted by 19, 18, and 14 percent, respectively, for the high, medium, and low fan speeds because of corresponding imbalances in flow rate for the three fan speeds. When interpreting the effectiveness data for the Mitsubishi, it should also be noted that this unit was tested with its fan system operating and that heat from the fan motor causes the measured effectiveness to differ from the true effectiveness.

Fan Performance Test Results

As indicated in Table 1, the fans used with the Des Champs Model 79M heat exchanger have a high power consumption, approximately 180 watts; however, the fans are positioned so that most of the energy they consume is delivered to the residence. In our test system, the maximum air flow rate provided by this heat exchanger's fan system was approximately 178 m^3/hr (105 ft^3/min). Higher flow rates would be obtainable if this unit was used with a very low-resistance duct system.

As mentioned earlier, for the Mitsubishi heat exchanger, the exhaust airstream has a higher flow rate than the supply airstream. The amount of ventilation air provided by this heat exchanger is equal to the the higher, or exhaust, flow rate and this flow rate is presented in Table 1 for the low, medium, and high fan speeds. The fan power consumption for the Mitsubishi heat exchanger, also shown in Table 1, is considerably less per unit of ventilation air than that of other heat exchangers tested by LBL.

CONCLUSIONS

Based on test results presented in this report and in a previous LBL publication, a 70 to 80 percent effectiveness is a reasonable expectation for a residential heat exchanger. The effectiveness of heat exchangers varies significantly, however, and many models have an effectiveness that is less than 70 percent.

The fan power consumption of residential heat exchangers tested by LBL ranges from 0.4 to 2.1 watts per m^3/hr of ventilation air. Fan power requirements can be reduced by using efficient fans and fan motors, minimizing the resistance to air flow through heat exchangers and duct systems, and using fan speed instead of damper valves for the control of air-flow rates.

Further research is underway to investigate the problem of ice or frost formation within heat exchanger cores, and to determine contaminant transfer rates in heat exchangers that transfer moisture. Long-term field studies are needed to investigate additional aspects of heat exchanger performance.

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Table 1. Summary of Thermal Performance and Fan Performance Test Results for Five Models of Residential Heat Exchangers

Heat Exchanger	Flow Rate m^3/hr (ft^3/min)	Effectiveness (%)	Total Fan Power Consumption (watts)	Static Pressure Drop[a] mm wg (in wg)
Des Champs[b] Model 79M.2	85 (50)	83		
	170 (100)	82		
	340 (200)	79		
Des Champs[c] Model 79M	85 (50)	84	176	12 (0.47)
	170 (100)	81	185	8 (0.32)
	340 (200)	79		
Enercon[b]	85 (50)	71		
	170 (100)	65		
	340 (200)	56		
Heatex AB[b]	85 (50)	60		
	170 (100)	60		
	340 (200)	52		
Mitsubishi[d] VL-1500	65 (38)	65	24	
	110 (65)	60	42	
	144 (85)	56	57	

[a]Static pressure drop in the duct systems attached to the heat exchangers.

[b]No fan system tests were performed for this model.

[c]The maximum flow rate provided by this model's fan system in our fan performance test system was 178 m^3/hr (105 ft^3/min).

[d]This model is used without an air distribution system. Flow rates and fan power consumption are for low, medium, and high fan speeds. Effectiveness data has been discounted because of the imbalance in airstream flow rates for this model.