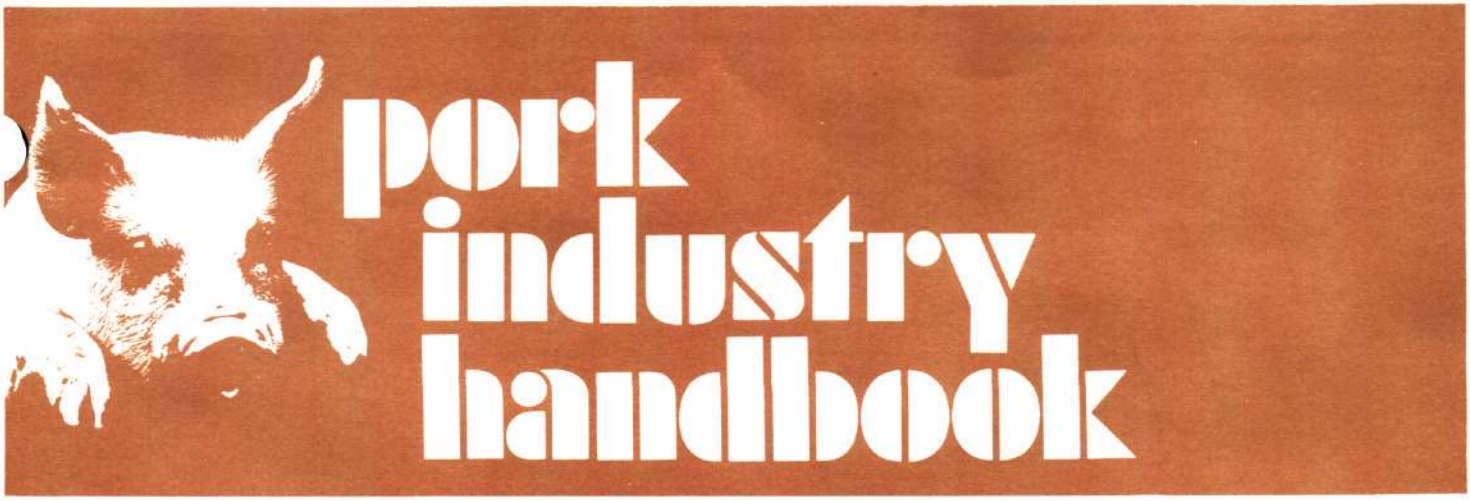
Heat Exchangers in Swine Facilities: Pork Industry Handbook
Michigan State University Extension Service
Larry D. Johnson, University of Minnesota; Martin Hellickson, Oregon State University; Vernon M. Meyer, Iowa State University
Issued April 1990
4 pages

EXTENSION BULLETIN E-2236
APRIL 1990 (NEW)



COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

Heat Exchangers in Swine Facilities

Authors
Larry D. Jacobson, University of Minnesota
Martin Hellickson, Oregon State University
Vernon M. Meyer, Iowa State University

Reviewers
Dexter Johnson, North Dakota State University
Howard Person, Michigan State University
Courtney Price, Spring Grove, Virginia

Ventilation air-to-air heat exchangers are used in swine housing facilities to reduce supplemental heating cost and to preheat incoming fresh air. There is potential for heat exchanger use in some swine barns, since as much as 90% of the total heat loss from an insulated swine nursery facility occurs through the minimum ventilation air exchange. Heat exchangers recover a portion of this loss, depending upon design and maintenence. In addition to reducing fuel use, heat exchangers preheat the incoming ventilation air thereby reducing the potential for drafts on piglets and reducing frosting problems when air enters directly from outside. Heat exchangers also improve air distribution, because warmed inlet air will not drop as rapidly as cold inlet air.

Heat exchangers are not economical in all swine housing facilities. This is especially true in units housing large pigs, i.e., hog finishing, but even in small pig facilities, other energy saving methods such as accurate control of minimum ventilation rate is often more economical than adding a heat exchanger. Also, the addition of a heat exchanger will not make up for poorly insulated walls and ceilings.

Heat Recovery Process

In an air-to-air heat exchanger the heat recovery process is accomplished when warm, moist room air is moved past cold fresh inlet air, separated by a heat conducting plate or surface (Fig. 1). Heat transfers across the plate because of the difference in temperature, often cooling room air to the dew point causing moisture condensation. While condensation releases large amounts of heat it also causes a need to drain water from the unit, and during extreme cold temperatures, the need for a defrost cycle to remove frozen condensate.

In a heat exchanger the two airflows may be in opposite directions (counter flow), at right angles to one another (cross flow), or in the same direction (parallel flow). Most units use the counter flow design since it is most efficient, but some employ the cross flow method because it allows for a more compact unit. Although the basic design of an air-to-air heat exchanger is simple, selection and design of heat exchanger components (fans, ducts, etc.) which are functional and compatible make a home-built unit less likely to perform properly.

Heat is transferred through a solid surface thereby avoiding mixing of the two airflows. This is a very important characteristic when comparing heat exchangers to "blenders," devices that resemble heat exchangers. Blenders physically mix warm room air with cold fresh air (Fig. 2), a process, which under certain conditions can create fogging unless additional supplemental heat is supplied to the barn.

Deciding on a Heat Exchanger

Factors such as: airflow rate, efficiency and initial cost of the heat exchanger, plus fuel costs, size and number of

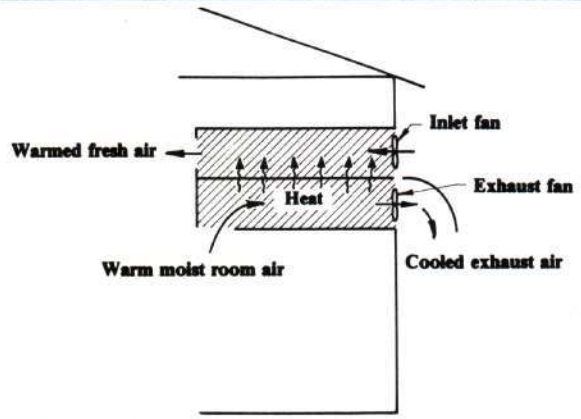


Figure 1. Schematic cross-sectional view of a heat exchanger with an exhaust and an inlet fan.

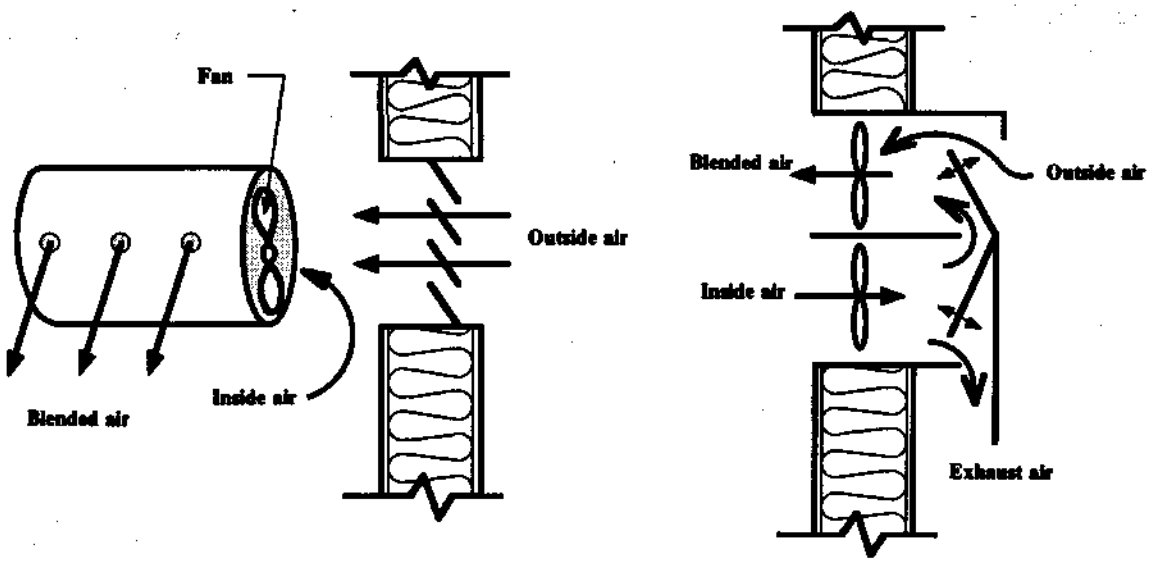


Figure 2. Examples of air "blenders," —not heat exchangers.

pigs, and climate all influence the decision to use a heat exchanger in a swine housing facility. Estimates from a computer model at the University of Wisconsin suggest that fuel savings from a heat exchanger in swine farrowing or nursery facilities located in Wisconsin, will pay for the initial investment in a minimum of four to a maximum of ten years. Heat exchangers require periodic cleaning and more attention than most conventional ventilation systems.

Selecting a Heat Exchanger

An air-to-air heat exchanger is an integral part of the ventilation system. A unit should be sized according to its rated air exchange capacity, rather than its "heat" output. The air exchange rate of the heat exchanger, as rated in cubic feet of air per minute (cfm), should be at or slightly above the recommended minimum ventilation rate for the number and size of pigs in the facility. Rates are listed in PIH-60, *Mechanical Ventilation of Swine Buildings* and are guidelines to follow when designing any type of ventilation system.

The minimum ventilation rates are generally sufficient in cold weather to remove moisture, manure gases and other airborne contaminants from a swine barn. By selecting a heat exchanger that delivers an air exchange level at or slightly above these rates, adequate air quality can be provided in the swine facility. Ventilating higher than twice the minimum rate shown in Table 1 in very cold weather increases supplemental heat costs.

Most heat exchangers have two fans, one exhausting moist stale air and one blowing fresh air into the barn. Two fans are preferred over a single fan system (exhaust fan only) because the narrow airflow channels on the inlet side of the heat exchanger create significant resistance to airflow that large amounts of air will enter through "leaks" or unplanned inlets rather than through the heat exchanger. Heat exchangers, where the exhaust fan has slightly more capacity than the inlet fans are desirable, especially in remodeled facilities, since it is difficult to seal building shell leaks.

Table 1. Minimum ventilation rates for swine.

Pig type and weight	cfm/pig type
Sow & litter (400 lb.)	20
Prenursery pig (12-30 lb.)	2
Nursery pig (30-75 lb.)	3
Gestating sow (325 lb.)	12
Boar (400 lb.)	14

Compatibility with Ventilation Systems

Installing a heat exchanger involves more than simply selecting a unit with the proper air exchanger rate. The heat exchange must "fit in" with the rest of the ventilation system.

The presence of a heat exchanger does not affect the selection of mild or hot weather ventilation fans. When thermostatically controlled exhaust fans are activated, a negative pressure, or vacuum, is created. Inlets are needed that automatically open to allow air into the room when these fans operate (Fig. 3). A possible choice would be a weighted baffle or curtain, which would close when only the heat exchanger runs, and opens slightly when the larger fan or fans operate. If no baffle or dampers are present in inlets (unrestricted openings such as slot or ceiling inlets), backdrafting of warm moist air into the attic can occur causing serious deterioration of building materials (Fig. 4).

Since a heat exchanger replaces the continuously running fan in a swine facility, it should operate 24 hours a day. Manual control is recommended. It is essential that thermostatically controlled fans be on separate electrical circuits in the event of heat exchanger circuit failures. Additional supplement heat is needed with heat exchangers during cold weather and when the swine barn is not filled to capacity.

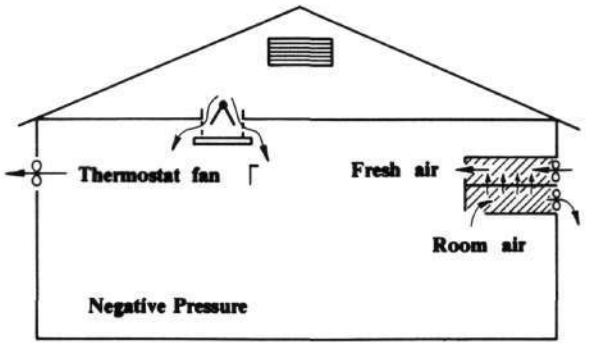


Figure 3. Facility with additional thermostatically controlled fan operating, resulting in a negative pressure or vacuum in the barn and the need for an "automatic" open baffle on the inlets.

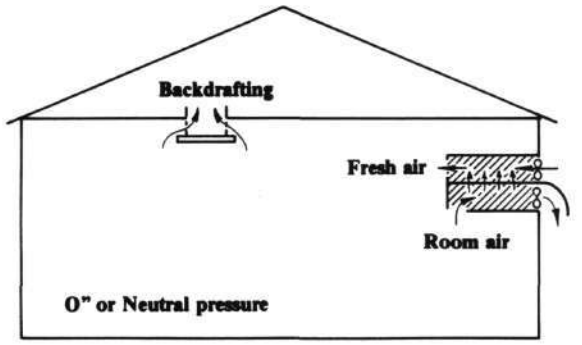


Figure 4. Facility with no baffles in the inlets and resulting backdrafting when only the heat exchanger is running.

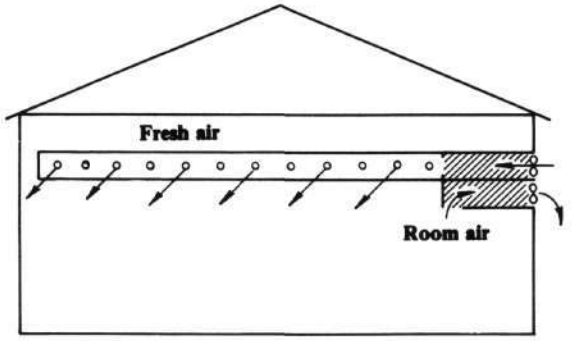


Figure 5. Facility showing duct on inlet fan of heat exchanger to distribute incoming air.

Many facilities where air-to-air heat exchangers are used have only one location for incoming fresh air (inlet side of the unit). Unless the room being ventilated is small, poor distribution of air can result. An exception to this would be in a facility where more than one heat exchanger (inlets) is present. A single heat exchanger should have some type of distribution duct attached on the inlet side to provide adequate mixing of air within the ventilated room. This generally would be some type of rigid duct, either PVC or plywood, permanently attached to the heat exchanger (Fig. 5) with openings along the length for even distribution of air, but a polyethylene tube is sometimes used.

Cleanability and Durability

A major disadvantage of air-to-air heat exchangers in swine facilities is clogging of exhaust air channels with moisture and dust. Although this "fouling" limits the heat transfer process and the unit's efficiency, the primary concern is airflow restriction. Since heat exchangers supply minimum ventilation, even a small reduction in air exchange affects the room's air quality. Heat exchangers must be cleaned on a regular basis. Depending upon the design of the unit, this may be on a daily, weekly, biweekly, or monthly schedule. Therefore, consider the ease and frequency of cleaning when selecting a heat exchanger.

Environments in swine barns contain corrosive gases. Heat exchanger manufacturers typically use materials that resist corrosion, such as wood, plastic, fiberglass, stainless steel or aluminum. The materials conductivity (ability to conduct heat) is not of overriding importance, since the thermal resistance of a thin plate is significantly less than the thermal resistance of the air films on either side of that solid material. Thus, the difference between a metal and nonmetal plate is not large because the air film resistance is the same in each case. Therefore, noncorrosive materials are a better choice.

Summary

Benefits of air-to-air heat exchangers in swine facilities are preheating of the inlet air and reducing cold drafts while lowering energy costs and supplemental heat requirements. The feasibility of heat exchangers is highest in swine nurseries and farrowing barns, where warmer room temperatures are needed, drafts are a problem, and fewer animal numbers require supplemental heat. Other potential use of heat exchangers is in individually stalled gestation units, which in the upper-midwest also require supplemental heat. Swine growing and finishing barns benefit little from heat exchangers, because auxiliary heat in these facilities is not necessary except in extreme and special cases.

One needs to consider the feasibility of an air-to-air heat exchanger carefully before deciding to use it in a swine housing unit. Certainly, the economic cost and returns of a heat exchanger are important, but also other items such as correct air exchange, compatibility with the ventilation system, and durability of the unit must be considered. It is one of several energy saving alternatives available to pork producers. Heat exchangers can provide a good environment in facilities with proper design and management.

Issued in furtherance of Cooperative Extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. J. Ray Gillespie, Interim Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

New 4:90 3M-KDP-UP, 25¢, single copy free to Michigan residents.
O-18633