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John P. Stinn
Iowa State University, elwayjr1@iastate.edu

Timothy A. Shepherd
Iowa State University, tshep@iastate.edu

Hongwei Xin
Iowa State University, hxin@iastate.edu

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Optimizing Tunnel Ventilation Systems for Summer Conditions

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John P. Stinn, Graduate Research Assistant;
Tim Shepherd, Assistant Scientist;
Hongwei Xin, Professor,
Department of Agricultural & Biosystems Engineering

Summary and Implications

Tunnel ventilation is a popular choice for livestock housing systems as it allows producers to elevate the wind speed across the animals to increase heat dissipation during summer conditions. Recent work with tunnel-ventilated facilities has shown that at maximum ventilation stage the building static pressure (SP) often exceeds 0.12 inches of H_2O. The effects of reducing SP on electrical consumption and ventilation performance were investigated. Decreasing SP of the tunnel-ventilated barn increased the overall ventilation rate, increased air velocity within the barn, and decreased the temperature rise along the length of the barn. From May to September, maintaining a SP between 0.04 and 0.08 inches of water column (W.C. or H_2O) showed a potential energy savings of \$300 to \$570 for an 1800-sow gestation barn. Properly sizing and managing air inlets for summer ventilation is an inexpensive and quick modification that can better alleviate heat stress and reduce electrical consumption.

Introduction

Maintaining optimal environments in mechanically-ventilated animal barns requires proper design and active management of the ventilation system throughout the year. In general, barns utilizing ceiling inlets should maintain SP between 0.06-0.10 to ensure proper distribution of fresh air throughout the year. Tunnel ventilation is often utilized during summer conditions to create an elevated air velocity across animals to facilitate heat transfer and reduce heat stress.

Most tunnel-ventilated barns operate at high SP (0.12-0.20” W.C.) under summer conditions due to undersized end wall air inlets. Under these conditions the performance of the ventilation system may not achieve the maximum levels of heat-stress alleviation. The objective of this paper is to illustrate the potential benefits of maintaining a low SP in tunnel-ventilated barns under summer conditions.

Materials and Methods

Field data, including SP, ventilation rate (VR), and air temperature was collected from an 1800-head tunnel-ventilated swine gestation barn in central Iowa as a part of a separate project. Data from May to September of 2012 were used for the analysis. Figure 1 shows the relationship of average air flow rate of a 52”, 1.5-HP ventilation fan *vs.* SP that was determined from *in-situ* calibrations of eight tunnel fans, illustrating the reduction of air flow as SP increases.

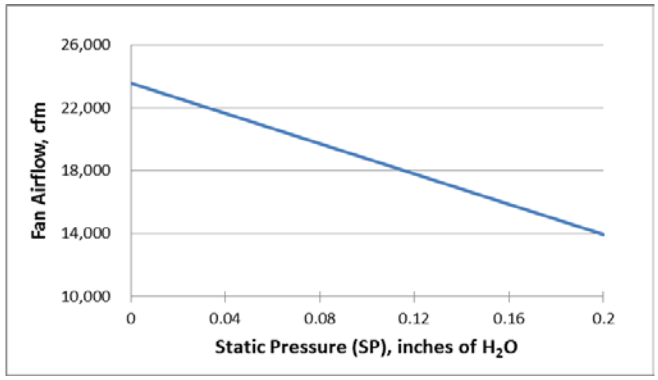

Figure 1. Average air flow *vs.* building static pressure, as measured *in-situ* from eight 52”, 1.5-HP ventilation fans.

Results and Discussion

From May to September 2012, 138 days of data were used to determine potential electrical savings by maintaining SP between 0.04-0.08” W.C. Figure 2 provides the distribution of average daily SP. Approximately 45% of the days had a SP greater than 0.12” W.C. These days generally represent the hottest part of the summer when ventilation is near maximum.

Utilizing the measured VR and SP for each day, the potential reduction in electrical use was determined by applying a given SP (0.04 or 0.08” W.C.) to the air flow curves. Figure 3 shows the potential daily savings of electricity use (\$0.08/kWh) by maintaining a lower SP for each monitored day. Over the summer period the cumulative energy savings would have amount to \$300-\$570.

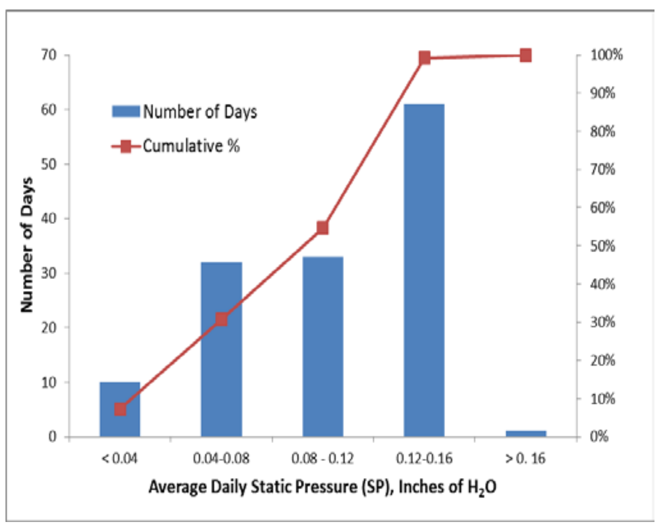

Figure 2. Distribution of average daily static pressure as measured from May to September 2012.

The impact of different SP on ventilation performance is summarized in Table 1. The barn VR values for the 15 tunnel fans were determined by applying the air flow curve in Figure 1 at different SP. As expected, increasing SP causes a decrease in barn VR. However, the reduction is quite substantial at high SP, namely, with only 64% of the VR at 0.04” W.C. occurring at 0.2” W.C. Maintaining the barn SP below 0.12” W.C. would ensure at least 80% of the expected ventilation is delivered.

The recommended air velocity for tunnel systems is 300-400 ft/min. While this target is met for all SP, it is beneficial to be on the high end or above that range. It is noteworthy that apparent air velocity at the human height (e.g., 5 ft above the floor) is not necessarily experienced by the animals. Instead, the animal-level air velocity is likely considerably lower. Hence, higher apparent air velocity is conducive to improvement of the microenvironment of the animals, facilitating heat dissipation thus heat stress relief. Table 1 also shows the impact of operating SP on the air exchanges per hour, which directly impacts the temperature rise from inlet to exhaust in a barn. At 0.04” W.C., an end-to-end temperature rise of 4.5°F is expected. In comparison, operating at 0.2” W.C. would increase the temperature rise to 6.5°F. This 2°F difference may seem small, but the two degrees combined with the increased air velocity will appreciably reduce the effective temperature experienced by the animals and thus enhance the heat stress relief.

Acknowledgments

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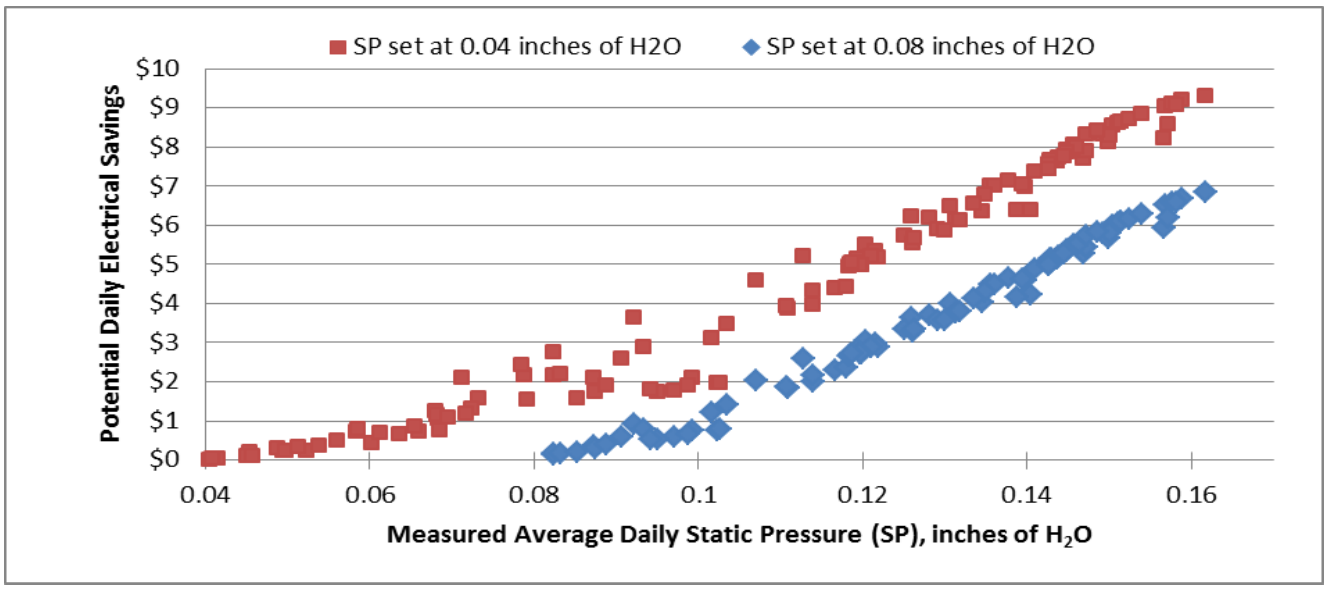

Figure 3. Potential electrical savings from May to September 2012 based on measured building ventilation rates and static pressure, relative to a baseline of 0.04” or 0.08” W.C. building static pressure.

Table 1. Performance of fifteen 52-inch ventilation fans at different building static pressures in tunnel configuration as installed in a 100’ by 400’ by 9’ swine gestation barn (1800-sow capacity).

Static Pressure, inches of H_2O	Barn Ventilation Rate, cfm	Percent of Max Ventilation	Average Air Velocity, ft/min	Air Exchanges per Hour	End-to-End Temperature Rise of the Barn, ^oF
0.04	325,000	100%	464	54	4.5
0.08	296,000	91%	422	49	5.0
0.12	267,000	82%	381	44	5.5
0.16	238,000	73%	340	40	6.0
0.20	209,000	64%	299	35	6.5