Ventilation in Poultry Production

Alberta Government

Introduction

On average, 44% of the electricity consumption in a poultry operation is attributed to ventilation (Figure 1). This equates to 36,080 kWh for a 50,000 head broiler operation.

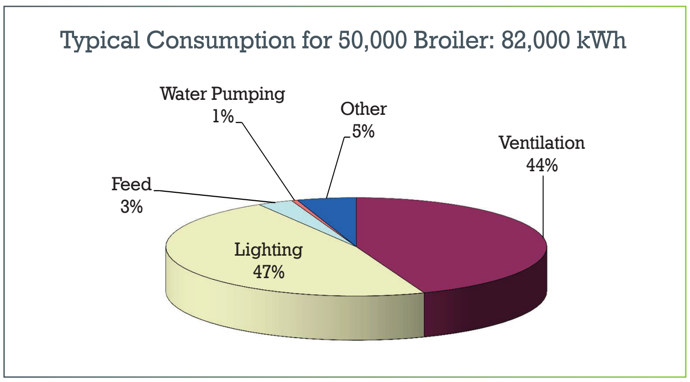

Figure 1. Electricity Usage and Distribution

Assuming the cost of electricity is $0.10 per kWh, this equates to $3,608 per year. Electricity prices over the last five years have been unpredictable ranging from $0.06 to $0.15 per kWh (Figure 2). This equates to a range of $2,165 to $5,412 per year for a 50,000 head broiler operation.

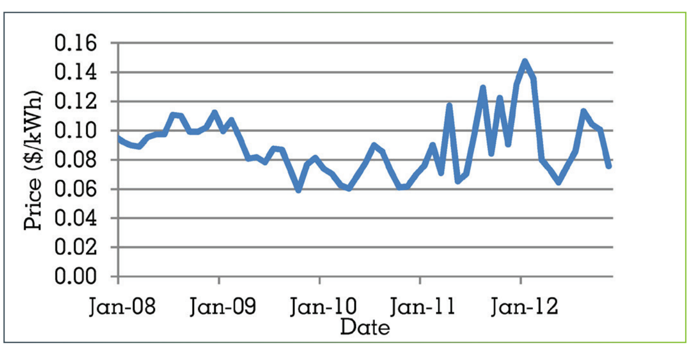

Figure 2. Alberta Price for Electricity from 2008 to 2012
Source: Alberta Agriculture and Rural Development

Ventilation systems for confined poultry facilities are important to maintain desirable environmental conditions inside the barns. There are usually two types of ventilation, natural and mechanical. Most poultry barns use mechanical ventilation (Figure 3).

Figure 3. Mechanical Ventilation on Livestock Barn
Source: www.jdmfg.com.

Mechanical ventilation systems use a number of different techniques to achieve desirable barn conditions. Essentially, these ventilation systems deliver the desired amount of fresh air to all parts of the facility and thereby maintain the desirable temperature, relative humidity and ammonia levels inside the barn. Mechanical ventilation systems consume large amounts of energy. Proper design, sizing, control selections, locations, modifications and maintenance can save energy and significantly reduce operating costs.

Animal Requirements

Fans Poultry birds are prone to heat stress at higher temperatures. Thus excess heat from the animal in the summer needs to be removed on a continuous basis to maintain the optimum animal performance conditions. In addition to removing moisture and heat, ventilation also helps to reduce the concentration of ammonia, to within the desirable range.

Proper sizing and selection of the number of fans are important for maintaining optimum barn conditions and high energy efficiency. Summer and winter design temperatures are usually considered in sizing fans. Winter ventilation rates are considerably lower than summer ventilation rates. Moisture removal is the primary function of ventilation in winter and heat removal is the primary function of ventilation in summer. The maximum and minimum ventilation rates for a poultry operation can be estimated using the mass and energy balance equations as well as other information available in ASAE EP270.5 R2008.

Table 1 shows the parameters and their recommended levels for a poultry operation. In general, the comfort temperature zone for poultry birds is between 20 and 30°C. However, day old chicks can't maintain their body temperature if the temperature is below 26°C. Therefore, the recommended barn temperature for the first week is 30 to 32°C. Thereafter, the temperature may be lowered by 2 to 3°C every week until the sixth week. After
the sixth week the temperature can be maintained between 10 and 27°C.

Table 1. Ventilation Guidelines for Swine Housing

Parameters	Recommended Levels
Temperature	
General comfort zone	20-30°C
Up to one week	30-32°C
Between one and six weeks	20-32°C
After 6 weeks	10-27°C
Humidity	50-70%
Ammonia	< 25ppm

The desirable humidity range is between 50 and 70%. Humidity levels above 70% will keep the litter too wet and as a result ammonia emission will increase. If the humidity level is below 50%, poultry litter may dry out and cause problems due to dust. The human nose can detect ammonia levels exceeding 15 ppm. Ammonia concentrations above 25 ppm are not desirable. High ammonia levels can cause respiratory damages to the birds

Also for broiler chicks up to two weeks old, air speeds greater 0.3 m/s at bird level are not recommended. After two weeks of age, the air speed at bird level may be increased up to 2.5 m/s.

Applicable Technology

There are a number of industrial ventilation systems available commercially. Figure 4 shows exhaust fans typically used in livestock barn ventilation systems. They are categorized based on pressure, speed and frequency. Choosing a suitable type of ventilation system for a particular application is very important in saving energy costs.

Figure 4. Typical Fans Used in Livestock Barns

Positive pressure systems force air into the building. They need to have a filter to make sure the incoming air is of good quality. Twenty to 30% of the energy used by fans is rejected as heat into the building which is advantageous during winter and disadvantageous during summer. If the air is humid, moisture may condense on walls and equipment.

Negative pressure systems force air outside from the building. Negative pressure systems need to have allowances for reduced fan efficiency as dust accumulation on fan blades is unavoidable. These fans may also get exposed to ammonia, corrosive gases, dust, high humidity etc. At low air flow rates, negative pressure systems will not provide uniform air distribution. There are systems available to capture heat from the air that is being exhausted to the atmosphere. These heat recovery systems are mostly used in modern commercial type and big residential buildings.

Multi speed fans are usually equipped to have two speeds. The lower speed is 60% of the full speed. Small fans can be equipped to have 5 different speeds.

Intermittent fans are controlled by a timer or a thermostat so that they operate at certain times during a period. Fans should be sized to operate at least 50% of the time with frequent cycles.

Variable speed fans can be adjusted down to 10% of the full fan speed. Speed is regulated by varying the root mean square (RMS) voltage or frequency to the motor by a variable transformer or a solid state control. A variable speed fan can be more efficient than the fans with either on/off or multi speed control (Teitel 2008). Typically the speed is varied as a function of barn moisture and temperature. Variable speed ventilation systems adjust their speed as needed and maintain the desirable barn conditions more accurately with optimal energy consumption.

Factors Affecting Ventilation Efficiency

Factors affecting ventilation efficiency are motor type; construction material; fan drive (direct coupled or belt driven); fan housing; using shutters, guards, cones and deflectors; inlet and exhaust location and size; thermostat location and maintenance. Installing discharge cones or wind hood deflectors can increase the efficiency up to 15%. Exhausting against the prevailing wind situation is not desirable. The recommended location of the thermostat is near the exhaust fan especially when the operating temperature is equal or below the thermostat's final settings. Keeping the fan in good condition through maintenance is very important for reducing energy costs. Poor maintenance can reduce the fan efficiency by 50% or more. Ventilation fans should be inspected periodically to remove the dust built up on the fan blades and motors should be serviced regularly.

Ventilation rates can affect the temperature and humidity levels in the barn. Therefore, using appropriate monitors and controllers may optimize the ventilation rates, increase animal performance and reduce energy consumption. Related items such as timers, thermostat, variable speed drive controls, humidity controllers etc., are commercially available. Installing such monitoring and controlling equipment will help maintain desirable barn conditions.

Table 2 has performance targets for different fan sizes with and without cones. VER 10 is the ventilating efficiency expressed in ft3/min/W at 0.10 inch water column (w.c.) static pressure. Exhaust fans in barns usually operate at negative 0.10 inch w.c. static pressure. This can change depending on the design of the facility as well as the maintenance issues such as dirt built up and damaged fan blades along with wind pressure affecting the exhaust. Airflow ratio is the ratio of airflow 0.2 inch to 0.05 inch w.c static pressure.

Table 2. Recommended Energy Performance Efficiency

Fan Size (in)	Cone	Performance Targets	
		VER 10	Airflow ratio
10 & 12	N	8.0	0.75
14 & 16	N	8.0	0.75
18 & 20	Y	10.5	0.75
	N	11.0	0.75
24	Y	15.0	0.70
	N	12.0	0.70
36	Y	17.0	0.70
	N	16.5	0.65
48	Y	18.0	0.75
	N	17.0	0.65

Source: American Society of Agricultural and Biological Engineers (ASABE)

In Table 2, it is evident that larger fans have higher efficiency. It is also evident from the same table that larger fans with cones are more efficient. The number of fans and sizes of the fans will depend on the minimum and maximum ventilation requirement as well as size and configuration of the facility. As mentioned before, proper sizing and selection of number of fans will save energy costs.

Calculating Operating Cost and Savings

Operating cost savings from using energy efficient ventilation fans can be estimated using the following equation (ASABE 2008):

Eq-1 $EOCS = (AFR_1/FE_1 - AFR_2/FE_2) \times AOH \times ER \times 0.001$

AFR_1 – air flow rate (ft_3/min) of fan No.1 at the selected static pressure

FE_1 – fan efficiency (ft_3/min/W) of fan No.1 at the selected static pressure

AFR_2 – air flow rate (ft_3/min) of fan No.2 at the selected static pressure

FE_2 – fan efficiency (ft3/min/W) of fan No.2 at the selected static pressure

AOH – average operating hours per year (h/yr) for the fan

ER – the electric rate (dollars/kWh) charged by electric power supplier

EOCS – electric operating cost savings per year (dollars/yr) in energy costs between the two

The following is a case study using Eq-1 to calculate the cost savings from energy efficient ventilation fans.

Case Study	
Fan 1	Fan 2
AFR_1 – 15,340 ft^3/min at 0.1 inch Static Pressure	AFR_2 – 15,500 ft^3/min at 0.1 inch Static Pressure
FE_1 – 15.6 ft^3/min/W at 0.1 inch Static Pressure	FE_2 – 12.9 ft^3/min/W at 0.1 inch Static Pressure

AOH – 8,760 hours per year (h/yr) for the fan
ER – $0.10 kWh charged by electric power supplier

Substituting the above values in Eq-1 (shown below)

Fan 1: $EOCS = (AFR_1/FE_1) \times AOH \times ER \times 0.001$
$= (15{,}340/15.6) \times 8{,}760$ hr/yr $\times 0.10 \times 0.001$
$= \$861.40$

Fan 2: $EOCS = (AFR_2/FE_2) \times AOH \times ER \times 0.001$
$= (15{,}500/12.9) \times 8{,}760$ hr/yr $\times 0.10 \times 0.001$
$= \$1{,}052.56$

This means savings of $191 per year. Payback period may be estimated using EOCS and considering average servicing or motor replacement costs.

Summary

Ventilation systems are important for maintaining the optimum performance in confined feeding operations (CFO). Most of the swine facilities use mechanical ventilation systems. These systems consume considerable energy to operate. Energy efficiency of the ventilation fan depends on a number of factors. Summer and winter design temperatures as well as number of animals and type of operation determines the maximum and minimum ventilation rates required for a CFO. Capacity and number of fans will in turn depend on the minimum and maximum ventilation rates. Different types of ventilation systems are commercially available. Multi-speed, intermittent, variable speed, belt driven and direct coupled are some of the examples. Choosing a suitable type of ventilation system can reduce operating costs. Motor type, construction materials and modifications such as installing cone, housing, hoods and wind deflectors can affect the efficiency. In addition, periodic maintenance including dusting off can improve the energy efficiency of the fans. Installing controllers such as thermostat, moisture control and variable speed drive can optimize energy consumption. Replacing existing inefficient fans with newer, more efficient fans using energy efficiency guidelines can conserve energy.

References

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