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Development trends in livestock building ventilation

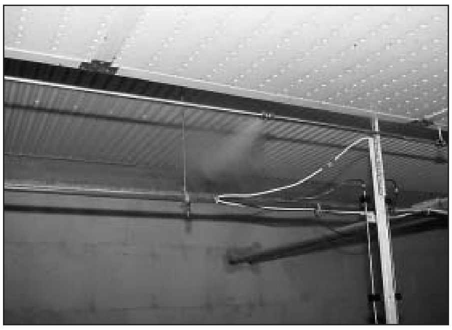

Fig. 2: Fogging can sink barn interior temperatures by up to 5°C..

Controlled of livestock housing climate has an important influence on livestock well-being and performance. Ventilation, heating and, increasingly, cooling have become established as permanent features in barn technology. Alongside performance-linked feeding, genetic potential and good management, appropriate temperatures and good air quality in livestock housing are important factors for successful animal production.

Fig. 1: With larger livestock housing the trend is towards decentralised exhaust air solutions.

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Keywords

Fresh and exhaust air ducting, cooling, heating, control

Main task of ventilation and air conditioning equipment in livestock housing is the dissipation of heat, water vapour and gases and establishment of optimum interior atmosphere independent of outside conditions with regard also paid to animal welfare and environment protection among many other demands.

Exhaust emissions

With closed and mostly insulated livestock housing for pigs and poultry, underpressure ventilation systems have become established. Depending on environmental protection requirements and also barn type systems, interior air emission can be achieved by decentralised or centralised systems. Structural change in agriculture and associated increase in livestock unit sizes has brought larger barns and, with these, a general trend towards decentralised systems (*Fig. 1*) where regulation, in particular, is simpler. Emission restrictions, or where heat recovery through exchangers has been introduced, can mean central exhaust systems being favoured, however. But whatever the system there must be proper dimensioning of exhaust air ducting. Especially with poultry barns, tunnel ventilation has been evolved in recent years. Here all exhaust air is sucked out centrally by fans in one gable end of the building while fresh air intake is through inlets in the eaves.

Air intake

Air intake should offer a draught-free supply of fresh air independent of the building type and with throughflow as uniform as possible whereby permitted air speed in the vicinity of the animals depends on intake air temperature, barn interior temperature and size and type of animals.

In the past, mainly air displacement ventilation was used in livestock housing with most-applied systems trickle ducts, trickle ceilings or feed passage ventilation. In practical farming trickle ducts represent the most popular approach with duct sides usually of expanded rigid foam plates to reduce condensation in winter. Duct flooring is of perforated plates, perforated plastic sheeting or similar. Where the ducts are used the following criteria are important for good induction and distribution of inlet air:

- Maximum duct length of 15 m where air intake is on one side of the building
- Intake air speed in duct not over 2.5 m/s
- Air throughput per m^2 trickle area between 200 and 300 m^2 (company specific)

Based on this criteria duct heights should be between 30 and 50 cm. For good air distribution it's best to site ducts over pens. Siting directly along exterior walls should be avoided to stop danger of too-rapid sinking of cold air (Coanda effect) down the outer wall. This prevents a good throughflow effect. Air intake on both sides of the duct can lead to increased air velocity in the duct and therefore also in the livestock area.

A cost-efficient alternative is a further proven type of displacement ventilation with air intake through the feeding passage. This solution is especially suitable for smaller compartments but here the regulating of air volume flow per compartment is the limiting factor. Important criteria are:

- Maximum passage length of 15 m
- Inlet air velocity not over 2.5 m/s in feed passage
- Pen depth not over 4.5 m

Additionally, separation walls between pens and feed passage should be at least the same height as the air inlet opening in the door and care must be taken that the exhaust air extraction point is in the vicinity of the air inlet to give a satisfactory ventilation effect for the whole compartment. With smaller building compartments an underfloor air intake system is possible. In such systems the inlet flow comes into the pens lightly cooled in summer and warmed in cold weather.

Especially in poultry production and with larger units for sows, dilution ventilation is used as an alternative to displacement ventilation whereby this usually features air intake elements where centrally-controlled flow can be determined according to interior temperature.

Such systems depend on the following criteria for best performance:

- Installation of air inlet elements in upper portions of outside walls (exceptions possible in poultry buildings)
- Ratio of interior height to breadth should not exceed 1:4
- Inlet air velocity in summer maximum 4 m/s
- Inlet air velocity in winter maximum 1 m/s

A basic proviso for all system is that in summer air intake should not be from the unventilated below-roof area. Intensive solar warming in this area can lead to temperatures of up to 70 °C. Instead, air intake should be from the shadow side of the barn.

Controls

High technical standards and relatively low purchase costs mean that computer control of air conditioning has become established for ventilation systems in livestock barns. This can be easily fitted into systems with central or individual compartment exhaust emission. Most climate computers are able to be networked through BUS. With central ventilation systems there is also a growing tendency to fit single computers for each compartment whereby the respective air requirements of each compartment is communicated to a central control where total volume flow is calculated and the fans appropriately adjusted Central ventilation plants require more complex regulating than individual compartmental ones because, e.g., temperature, air moisture content, gas content , etc, have to be collected from several compartments and calculated to determine required volume flow per compartment.

Fans with direct current motors and electronic commutation, including electronic components, are suitable for single exhaust systems. With controlled rpm such fans are very economical and much better than standard fans. An interesting variant to controlled rpm fans with alternating current (AC) is the single phase frequency converter. As set point control signaller, an electronic thermostat can be applied for frequency converter and fans with direct current (DC)motors. Here too, electricity can be spared in the controlled rpm area.

Exhaust air technology

The exhaust air equipment comprises fans, exhaust air ducting, diffusers, intake air inlets, etc. Cross sectional area of the exhaust air ducting and fan capacity have to be exactly matched to avoid turbulence and associated pressure loss. Applying intake jets and diffusers can achieve up to 30 Pa pressure reduction. With ventilation systems in barns, axial fans are almost exclusively applied. Pressure increases and the air volume stream of a fan mainly depend on diameter, rpm, number of rotors and rotor angle. Main fan characteristics are shown in graphic form as pressure volume stream lines plus recording of the electrical and the specific performances. Energy saving fans have established themselves in many sectors and with controlled rpm offer up to 50 percent energy savings so that despite higher purchase costs pay-back can be in three to five years. Other important criteria in fan choice is noise production and durability. In special applications, e.g. for exhaust air filter plants or heat pumps, there can at times be total pressure loadings of up to 200 Pa. In such cases only very high performance fans should be fitted because the standard article would be overloaded.

Alarm systems

Insurance requirements and EU livestock production directives demand the fitting of alarm systems to warn of power failures and similar breakdown of livestock plant equipment. These acoustic and/or optical alarms monitor, and are activated by, different parameters, e.g., circuit voltage levels, housing temperatures, etc. Especially where barns are some distance from other buildings, alarm signals should be communicated via radio or telephone. Central alarm monitoring services control barn alarm systems and forward news to farmers/managers. Electronic monitoring, via camera for instance, offers livestock surveillance as well as the safety aspects.

Heating

Individual farm conditions decide on the selection and application of heating systems. Gas cannons continue to be used in housing compartments where there are generally low temperature requirements and for the heating of compartments before penning under all-in all-out systems or after pressure cleaning. These are relatively cost-efficient, have a wide performance spectrum and are very adaptable. But using a cannon means warmed air is pushed through the house interior with relatively high velocities so that achieving overall uniform velocities and good degree of air exchange in the livestock areas cannot be taken for granted. In compartments where there are higher demands for the interior atmosphere quality or for microclimate areas, systems are required guaranteeing low variations in temperature in compartments or more precisely controllable temperatures. Depending on livestock type and building, the following heating systems have proved themselves:

- Radiation heating: With infrared systems especially popular in poultry production. Radiation heat developed by the infrared system gives uniform temperatures on the ground.
- Zone heating: Especially in piglet production the continuing trend is for warm water underfloor heating combined with infrared lamps. The creep area should be insulated to keep down heat loss and helping here, too, are heating plates of plastic or light concrete for the creep lying area.
- Warm water heating: This heats compartments via delta or twin piping and even round pipes - the standard trade solution whereby traditional controls can be applied for regulating heat distribution.
- Gas convector heating: Heated air is uni-

Fig 3: In many cases mechanically adjustable side screens have become established for aeration control in naturally ventilated barns.

formly distributed in compartments via air inlet pipes mostly of metal flexicoil.

Cooling

It is possible to reduce livestock barn temperatures by as much as 5 °C through fogging or misting systems (*Fig. 2*) or cooling intake air via trickle walls. In hot weather with high humidity such systems should not be used: they reduce the in-house temperature through adding water but thereby increase air moisture content and air thermal capacity which can stress animals – and humans – substantially. Also potentially useful for reducing intake air temperature is underground cooling whereby intake air is run underground through plastic piping before entering the barn. Such systems are relatively expensive, however, and may require constructional input. Simpler is shading of intake vents through planting trees or bushes or through adding artificial protection against the sun whereby it is important to avoid foreign material such as leaves ending up in the intake ducts.

Naturally ventilated buildings

Cheap and simple barn systems for cattle have evolved featuring natural ventilation in large barns with one or more open sides. Eave height is between 4 and 5 m with roof angle around 20° for better dissipation of exhaust air. With the roof ridge positioned over the trough or longitudinal passage, further weather protection is not required. But where the ridge is over the laying areas, large transparent sheeting may be required to prevent ingress of rain or driving snow. For protection along the sides of the buildings mechanically adjustable screens (*Fig. 3*) have become established. In some cases adjustable air inlet baffles have been fitted to assist air intake flow whereby sensor steering of these may be necessary with parameters wind speed, direction, solarisation and/or temperature as activation factors. For year-round housing, light coloured roofing material or insulated roofing should be chosen to avoid excessive heat building-up in summer.

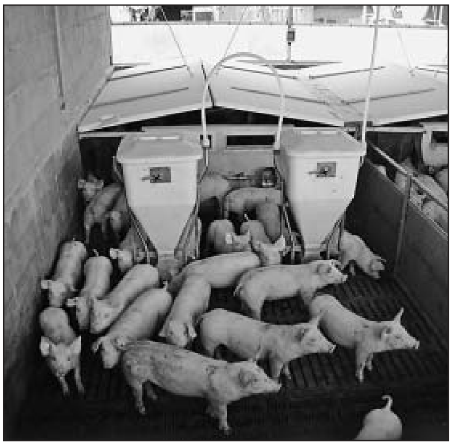
Fig. 4: Fans built into naturally ventilated barns reduce heat stress in summer.

During longer hot spells fans can be introduced for artificial air movement in the barn (*Fig. 4*) to help cool livestock.

Recommended air volume flow for these fans is from 800 to 1500 m^3/h and cow. Fans should not be sited against the prevailing wind direction. Aspects potentially bothersome to neighbours such as fan noise should be considered. For longer barns several rows of fans may be required, the first row beginning 2 to 4 m from the outside wall (mostly the gable) Depending on output, the gap between each row should be up to 20 m. The fans should be fitted at least 2.5 m high and angled from 15 to 20°.

Naturally ventilated unheated barns are also being built for pig production with air exchange managed usually through wind and thermal influences. To ensure optimum conditions for the animals year-round, and to compensate for the seasonal temperature variations, buildings can be divided into different temperature zones e.g. for feeding, movement, resting (*Fig. 5*). In such systems annual averages of air volume flow per animal are much higher than with forced ventilation systems. The high air exchange rates mean air quality is better. But livestock heat emission problems can arise in such buildings too, for instance during inversion weather in summer.

Prevailing wind direction must be considered for green field erection of such buildings. Siting across the prevailing wind direction and away from windbreaks allows optimum air throughflow.



BFig. 5: Becoming more popular are naturally ventilated pig barns with different temperature zones.