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Trends in animal housing climate-control technology

The development of better producer prices for various farm products has once more led to increased investment in new and renovated livestock housing.
Pig housing ventilation is being improved in detail or extra equipment is being added to save on energy input whereby fine-tuning of monitoring and control technology is an important development. The great majority of pig production will continue to be indoors so that further coupling of the various parameters such as feeding and interior climate control is indispensable for optimum management. The trend is similar in poultry production and with cattle housing only detail improvements are to be expected in current proven housing design and ventilation.

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Fig. 1: Directing intake air through feed passage doors, and removing it through extraction points near the inlets, heating with gas canons

An important influence on livestock welfare and performance is controlled configuration of climate within animal housing. Ventilation and heating systems, and recently cooling too, have all become important parts of this technology. Alongside good management, feeding and genetic potential, optimum temperatures and air quality are important for success. Withdrawal of heat, water vapour and gases and creation of optimum indoor climate irrespective of outdoor conditions are main tasks of ventilation and climate equipment which also have to meet welfare and emission control requirements.

Exhaust air extraction

Underpressure ventilation systems have become established in closed and insulated pig and poultry housing. Depending on housing or environment-specific conditions, these feature central or decentral exhaust air extraction systems with the latter the trend in larger buildings because they are easier to regulate and also advantageous in systems where heat exchangers are applied for heat recovery or where there are emission control requirements to be met. All systems depend on a sufficient dimensioning of exhaust air channelling. So-called tunnel ventilation has established itself strongly in poultry housing over recent years whereby all exhaust air is extracted through a gable end and fresh air inducted through inlets under the eaves.

Inlet air systems

Fresh air intake should ensure a high air replacement rate in the barn compartments without causing actual draughts where livestock are penned. Permitted air speed in the livestock areas is dependant on temperature of intake air, type and size of animals and air thermal capacity.

In the past mainly displacement ventilation has been installed in housing with intake via air trickle ceilings or ducting or passage door ventilation. Fitted in most housing is air trickle ducting with the majority of systems featuring hard foam components with perforated elements, such as hole plates, slit plates or perforated plastic sheeting. The following criteria are important for good functional ducting and distribution of the intake air:

- Maximum 15 m air canal length with one-side air intake
- Intake air speed not over 2.5 m/s in canal
- Air throughput per m^2 trickle area between 200 and 300 m^3/h (manufacturer-specific)

Based on the above criteria canal heights are from 30 to 50 cm with best positioning of canals for optimum distribution being over the pig pens. Ducting directly against outer walls should be avoided to prevent too rapid sinking of cold intake air down the inside of outer walls and thus less efficient air replacement rate. Intake air entry on both sides of the air canal can also lead to increased air speeds in the central canal section and thus in the animal accommodation area.

A further type of displacement ventilation is the cost-efficient inlet air induction via feed passage, an alternative especially for smaller pig barns. Limiting factor with feed passage ventilation (*Fig. 1*) is difficulty in assessing air volume flow per livestock compartment. Important points here are:

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

Additionally, pen walls to feed passage should be at least the height of door inlet air openings. Important, too, is the siting of exhaust air extraction points. These should be in the vicinity of the air inlet doors to ensure good air exchange rate. With smaller barn compartments, underfloor inlet air induction via perforated barn doors is possible, offering slight cooling in intake air in summer and warming in winter.

With larger housing for sows and especially with poultry production dilution ventilation is increasingly applied. Here, as a rule, the inlet air enters via central adjustable vents with the following important criteria:

- Fitting of inlet air vents in the upper area of the outside walls (with possible exceptions in poultry housing)
- Maximum interior height to breath ratio 1:4
- Inlet flow speed in summer maximum 4 m/s
- Inlet flow speed in winter maximum 1 m/s

Basically, all inlet air systems should not draw air from the roof cavity in summer (heating by the sun can raise the temperature of this air to as much as 70°). Best solutions include sourcing air from the shadow side of the building.

Exhaust air systems

Important components of the exhaust air system are the exhaust air shafts, diffusers, outlet shutters, and fans. Fan sizes should be exactly matched to the exhaust air shaft cross section areas to avoid turbulence and associated pressure loss. With diffusers and outlet shutters up to 30 Pa pressure reduction can be achieved. With underpressure ventilation systems in animal housing axial fans are almost exclusively fitted. Fan performance is mainly determined via rpm, diameter and number of blades and blade angle. The specifications indicate fan characteristics: the pressure volume flow curve, electric and specific power requirement. Fan characteristics are covered by DLG Test reports. Energy-saving fans have established themselves in many areas and, where regulated, can save up to 50% energy. Despite higher purchase costs such equipment pays for itself relatively quickly. Important criteria in selection of fans include durability and noisiness. When used within systems with exhaust air cleaning or heat exchangers total pressures can increase to 200 Pa. Standard commercial fans are then rapidly overworked.

Fig. 2: Warm water underfloor heating combined with infrared lamp in the piglet creep lid

Regulating technology

Because of their relatively low purchase costs and high technical standards, climate-control computers have become established in livestock housing climate regulation. Very good technical regulating possibilities result from their use in single as well as central extraction systems. Nearly all computers are now BUS compatible. Central extraction systems require more intricate controls compared with single ones because control parameters such as temperature, humidity or gas content have to be recorded and processed from several house compartments in order to determine the required air volume flow per compartment.

A practical solution for single extraction comprises fans with direct current motors and electronic commutation, including electronic components. Through speed regulation this type of fan proves far better than standard types and is a good energy saver. As variant to fan rpm regulation with alternate current motors the single phase frequency converter is also interesting. Here, an electronic thermostat can be applied as motor control signal generating device for frequency converter and also direct current motor fan. Here too, a saving in electricity through rpm regulation is possible.

Alarm systems

Animal production laws and specialist insurers require that livestock in housing be protected from the effects of a breakdown in power supply and similar situations. As indicators of breakdowns, alarm systems monitor housing under criteria such as interior temperature or current flow with any irregularities triggering warnings that can be visual and/or audio or via radio or telephone. Central surveillance services are also available. Occurrences in livestock housing compartments can also be monitored by electronic systems (cameras) and transmitted to a central office.

Heating

Selection and fitting of a heating system depends on the requirements of the respective housing. Gas canons continue to be a solution for heating compartments where temperature requirements are relatively limited, or at cleaning. These heaters are relatively cost-efficient and have a wide performance range. In that the warmed air is blown through the housing with relatively high velocity, this can cause high air speeds in the vicinity of the livestock and poor air exchange performance. For livestock compartments where macro and micro climate requirements are more exacting, systems have to limit temperature fluctuations in compartments or offer adjustable temperature levels in required areas. The following types of heating have proved successful in practical situations, depending on type of animal and housing:

- Radiation heating : Infrared radiation heaters are used especially widely in poultry production. The radiation heat produced by these ensures even temperature levels on the ground.
- Zone heating: Especially with piglet production/rearing the trend continues to be warm water underfloor heating combined with infrared radiators (*Fig. 2*). Creep areas should be insulated. Available are also heated prefabricated creep mats of plastic or light concrete.
- Warm water heating: Here, compartments are heated via delta or twin-tube systems or in some cases also standard round pipes. Standard temperature regulation systems are applied.
- Gas convectors: The heated air is evenly distributed in compartments via air ducting, mostly insulated perforated pipes.

Cooling

Water spray or evaporation equipment can lower temperature by around 5 K. This level of reduction is also possible where outdoor air is drawn through perforated walls over which water is trickled – although such a system should not be used on warm days with relatively high humidity because the trickle water can boost general interior humidity and, with that, heat content leading to stress for the respective livestock. Belowground heat exchangers can also be efficient for cooling intake air with inlet air channelled into the housing in underground pipes.

Additionally air-water heat exchangers can be applied for intake air cooling systems in summer with water as the coolant. Shielding air inlet ducts from the sun is advantageous for indoor climate.

Natural ventilation housing

Simple cost-efficient housing with natural ventilation has proved itself for cattle. This features large-volume barns with one or more side walls open. Eave heights of 4 to 5 m and roof angle of 20° give a large-volume interior with the relatively steep roof angle guaranteeing good withdrawal of exhaust air and possible condensation water. A roof ridge cover is only required where the opening is over the animal laying area. For closing-off outer wall openings (eave sides) mechanically-adjustable roller blinds have become established. On some occasions adjustable air intake guides constructed from plastic panels are fitted. To avoid damage from wind these may require a sensor-controlled adjustment system. Serving as basic parameters in their positioning are wind velocity and direction, solar radiation and/or temperature. In order to minimise the heat creation in summer with all-year housing of livestock the roof cladding should be of a light colour or insulated.

Longer hot weather spells with windstill mean drops in livestock performance can occur through animals unable to lose body heat through emission and perspiration. Even completely open walls and gables are not sufficient in such exceptional situations and auxiliary ventilation with large fans has proved itself in such cases creating artificial wind movement in the barn to make animal heat loss easier. Fan positioning should ensure that as little as possible sun-heated air is blown into the barn. Neighbourhood requirements, e.g. avoidance of noise and/or odour distribution must also be considered. With longer barns several rows of fans one behind the other will have to be used. Distance between fan rows should be a maximum 20 m whereby the first row should be mounted a maximum 2 to 4 m from the outer wall (mostly gable walls). Fan installation should be planned at least 2.5 m height with an inclination angle of a 12 to 15°. Advised by the literature is an air volume flow of 500 to 2000 m^3/h and cow whereby in practice mostly 600 to 1000 m^3/h is applied. Determination of the required site-specific air volume flow and the positioning of the fans should be undertaken by specialists.

Fig. 3: Feeding pig housing with natural ventilation

A fundamental requirement is consideration of on-site positioning of the barn and the prevailing wind direction. Building across the main wind direction gives optimal air exchange within the barn. Where wind is deflected (trees or other buildings) the welfare of the animals could be affected by the reduction in air exchange effect.

With natural ventilation housing for pigs (*Fig. 3*) air exchange in the pens is greatly affected by the influence of wind and thermals. To even-out seasonal temperature fluctuations the buildings should be divided into several temperature zones. This system allows a much higher air volume flow per animal - based on annual averages - compared with forced ventilation housing and is therefore much more comfortable for livestock. Problems can be caused by stationary temperature inversions with almost windstill which brings reduction in air exchange within the buildings and associated heat stress for livestock.

Exhaust air cleaning

Development of exhaust air cleaners started as far back as the 1970s. The process (biofilter, biological or chemical washer) was further developed and is applied in regions where pollution-based legal requirements for distances between intensive livestock housing and residential housing or biotopes cannot be met, where the initial level of pollution is too high or where a partial move of the farming buildings outside of a built-up area is not possible for various reasons. These systems are, however, only applicable in forced ventilation housing. Various manufacturers have now had their systems successfully tested by the DLG . Despite further developments of the processes involved, exhaust air cleaning systems have not yet reached the standards of low emission livestock production technology.

So-called indoor systems using fogging techniques to improve air quality are nowadays increasingly offered on the market. But most of the air quality improvements have not been confirmed by neutral testing results. Further developments here remain to be seen.