Gerd Franke, Kassel

Development Tendencies in Stall Climate Technology

Farm animals must feel comfortable in their environment so that their performance potential can be fully exploited. A good stall climate makes a significant contribution towards the well-being of the animals. Irrespective of the outdoor climate, an optimal room climate for the animals must be striven for. Depending on the daytime and the seasonal conditions, ventilation- and climate control systems remove water vapour, heat, and gases by means of appropriate air exchange. In outdoor climate stalls, the climate is controlled by means of thermal ventilation and wind pressure. Cattle stalls more and more often feature supporting ventilation.

Dipl.-Ing. Gerd Franke works for the Hessian Service Centre for Agriculture, Horticulture, and Nature Protection in Kassel and compiled the present overview on behalf of the DLG.

Keywords

Fresh air and exhaust air ducting, cooling, heating, control

Suction systems are standard in pig- and poultry housing. Central or decentralized exhaust air ducts are installed depending on environmental or stall-specific requirements. Due to the tendency towards larger stall units and, hence, larger stall compartments, decentralized solutions are establishing themselves because they are easier to control. For reasons of immission protection or if heat recovery systems are used, central exhaust air ducting can be advantageous. In all systems, one must make sure that the exhaust air channels are sufficiently dimensioned. In poultry stalls, so-called tunnel ventilation is increasingly being used. In this ventilation system, the entire waste air is sucked off on one front side of the stall building, and the supply air is led into the stall on the eaves sides.

Ventilators

In stall ventilation systems, axial ventilators for the low-pressure range are used almost exclusively. Volume flow and pressure increase as well as the output of the ventilator are mainly determined by the rotational speed as well as the number of blades, their pitch, and the diameter of the ventilator. In practice, fast and slowly rotating ventilators whose rotational speed is approximately 1,400 or 900 rpm are equipped with both alternating current- and three-phase current motors. Fast rotating ventilators are installed in facilities where resistance is higher, whereas stalls where resistance is low are equipped with slowly rotating ventilators. The character of a ventilator is shown in a characteristic diagram. In DLG test reports, these characteristics (the characteristic curve of the pressure and the volume flow, specific and electric power consumption) are listed. In many applications, energy-saving ventilators have established themselves (cf. control). In the rpm-controlled area, 50% of the energy or more can be conserved. Hence, the higher purchasing costs can pay off within three to five years. Noise emission and durability can also be criteria for the choice of ventilators.

Fig. 1: Fresh air ducting through perforated ceiling channels

Accessories

Other elements of exhaust air ventilation are exhaust air shafts, inflow nozzles, and diffusers. The diameter of the exhaust air shafts must be exactly adapted to the ventilators in order to avoid unnecessary turbulence in the exhaust air shaft and resulting pressure losses. Diffusers and inflow nozzles can lead to a pressure reduction of up to 30 Pascal because these elements facilitate the outflow and inflow of air in the exhaust air shafts.

Control

As a result of the high technical standard which has meanwhile been reached as well as low purchasing costs, climate control computers have established themselves in recent years. Their use provides optimal control-technological possibilities for both central suction systems and suction ventilators for individual compartments. Modern climate-control computers can be networked by means of a BUS (binary unit system). In central ventilation systems, the central climate-control computer is increasingly being replaced by individual computers for each compartment. Information about the air requirements of each compartment is sent to a central system, which calculates the total volume flow, controls the base load ventilator, and switches other ventilators on, if necessary. In principle, central suction systems require more sophisticated control systems than individual compartment ventilation be-

Fig. 2: Fresh air ducting through the feeding alley

cause control variables from several stall compartments, such as temperature, humidity, and gas contents, must be measured and processed, and the volume flow which meets the demand of a compartment must be delivered. Here, climate control computers with their numerous possibilities have well proven themselves. The use of ventilators with a direct current motor and electronic commutation including electric components is predestined for individual suction. Especially in the rpm-controlled area, this ventilator is very economical. The single-phase frequency converter for the control of the rotational speed of ventilators with alternating current motors is relatively new in stall ventilation. Due to the low power consumption in the rpm-controlled area of the ventilators, the frequency converter is an interesting variant. An electronic thermostat can be used as a control signal generator for both the frequency converter and the ventilator with a direct current motor.

Alarm Systems

In the case of power failures and other malfuctions in stall facilities, the animals must be protected by alarm systems. This is mandatorily required by the regulations of the property insurance companies and animal housing decrees. The alarm system monitors different parameters, e.g. the temperature in the stall or the tension of the electric circuits and transmits them to alarm generators. Both acoustic and optical alarm generators can be used. In remote stall buildings, the alarm should be given via telephone or through radio signals. There are also companies which offer central monitoring services. Failure messages from stall facilities are transmitted to these companies which then inform the animal keeper. In addition, electronic monitoring systems provide the possibility of controlling the processes in stall compartments with the aid of fixed cameras and transmitting them to a central system.

Supply Air

Supply air ducting should guarantee that a high rinsing degree is reached in the stall compartment while preventing a draught in the animal area. The permissible air speed in the animal area depends on the supply air temperature, relative humidity, and the kind and size of the animals. In recent years, displacement ventilation has been increasingly preferred over nozzle ventilation. For fresh air supply in the stall, mainly air flow channels with perforated bottoms in the form of perforated plates or film are used (*fig. 1*). The air flow channels are generally made of temperature-insulated rigid foam plates so that condensate formation in the winter is prevented. In order to avoid large resistance in the system, the maximum air speed in the channel should be 2.5 m/s at the summer air rate. If the supply air enters the channel on one side, channel length should not exceed 15 m at an air throughput of approximately 250 to 300 m^3/h and m^2 of channel surface. These criteria result in a channel height of 30 to 50 cm. The channels should be installed above the pens, though not directly on the external walls in order to guarantee a good rinsing degree in the stall and to prevent cold air from sinking down along the exterior walls too fast (Coanda effect).

In smaller stall units, supply air ducting above the feed passage offers itself as a low-cost alternative (*fig. 2*). The dimensioning of the air volume flow is the limiting factor for feed passage ventilation. The criteria to be considered are a maximum passage length of 15 m, a supply air speed in the feed passage of no more than 2.5 m/s during summer ventilation, and a pen depth of no more than 4.5 m. In addition, the walls which separate the pens from the feed passage must be at least as high as the supply air opening in the door, and the stall air suction point should be near the point where the fresh air flows into the stall compartment. As an alternative to displacement ventilation, jet ventilation systems with centrally adjustable supply air elements are installed in particular in larger poultry and sow stalls. The supply air elements are controlled by a thermostat depending on the temperature. The following layout conditions must be considered: If possible, the supply air elements must be installed under the stall ceiling, and the ratio of room height and room width may not exceed 1:4. In addition, the maximum inflow speed is 4 m/s in the summer and 1 m/s in the winter. This kind of supply air ducting can provide a good rinsing degree. If not handled properly, however, it may cause draught in the animal area.

Cooling

A principle to be considered for all supply air systems is that the supply air should not be taken from the attic in the summer because temperatures of up to 70 °C may occur in this area as a result of intensive solar radiation. The fresh air should be fed into the supply air system on the north side. Later measures
taken to provide shading by trees, bushes, or other objects can be useful.

Water spraying or -evaporation devices allow the stall temperature to be lowered by up to 5 °C (*fig. 3*). The same applies to air suction through perforated supply air walls which are sprinkled with water. However, these measures should not be carried out on hot and humid days because the use of water

Fig. 3: Water atomiser facility beneath the fresh air duct in the stable

Fig. 4: Fresh air free ventilation through the side wall with roll-up covers

may reduce the temperature in the stall, but the heat content of the stall air increases significantly and can be a heavy burden on the circulatory system of humans and animals.

Earth heat exchangers, which lead the supply air through the soil or the ground water in a plastic pipe and cool it in the warm season before it enters the stall, can ease the climatic burden considerably. However, these systems are relatively expensive.

Heating

The choice of heating systems depends on the conditions on the farm. Gas cannons are still being used in stall compartments where the temperature demands are relatively low or in order to heat compartments before cleaning. The implements are relatively inexpensive and have a large power range. Since the heated air is blown through the stall at a relatively high speed, this may result in high air speeds in the animal area and a low rinsing degree.

In stall compartments for animals which are more demanding with regard to the room- and microclimate, systems which cause smaller temperature fluctuations in the compartment or guarantee controllable temperatures in the animal area are used. If the room temperature is only intended to be kept constant, gas convectors connected to folded spiral-seam pipes can be considered which evenly distribute the heated air in the stall compartment. Warm-water heaters in combination with delta- or twin pipes also offer themselves. Water distribution can be controlled by means of commercially available systems.

For zone heating in the piglet rearing- and farrowing area, warm water floor heating, often combined with infrared radiators, is most widely used. For floor heating, prefabricated heating plates out of plastic or light concrete are used frequently.

In poultry stalls and larger sow stalls, radiation heaters are mainly used in the form of dark radiators.

Outdoor Climate Stalls

Simple, low-cost stall systems in the form of outdoor climate stalls have proven themselves in cattle housing. They feature large-volume designs with one or more open stall sides. The large-volume design requires eaves heights of 4 to 5 m and a roof inclination of 20°. The relatively large roof inclination guarantees good exhaust air outflow and good draining of water that might condense. The open ridge only needs to be covered if the ridge opening is situated above the lying area of the animals. The lateral wall panelling consists of adjustable supply air elements or mechanically adjustable side parts, such as folded ventilation or grid nets.

If the animals are kept in the stall all year long, a roof cover out of heat-insulated or at least light roof plates is useful in order to minimize heat input due to solar radiation. Cows tolerate cold spells in the winter well. During longer-lasting, windless hot periods, however, performance slumps because in such situations the animals are unable to dissipate enough heat and water vapour into their environment. In such situations, even completely opened walls and gables are not sufficient to provide adequate ventilation of the building. In these exceptional situations, supporting ventilation systems with large ventilators have proven themselves which generate artificial air movement in the stall in order to make it easier for the animals to dissipate heat. The ventilators should be arranged such that they are supported by the main wind direction. In this case, however, neighbourhood problems, such as annoyance caused by noise and/or odour, must be taken into account. In longer stall buildings, several ventilator rows are installed behind each other. Depending on the output of the ventilators, the maximum distance between the ventilator rows should be 20 m. The first row should be mounted at a maximum distance of 2 to 4 m from the external wall (generally the gable wall). The ventilators should be installed at a height of at least 2.5 m and an inclination angle of 15 to 20°. The air volume flows recommended in the literature range between 500 and 2,000 m^3/h and cow.

The determination of the necessary location-specific air volume flows and the arrangement of the ventilators should be carried out by an expert. In principle, however, the position of the building in the terrain and in relation to the main wind direction must also be considered. If the building is situated at right angles to the main wind direction, it is flowed through optimally. Obstacles in the main wind direction, such as plants or other buildings, can significantly impair the rinsing degree of the stall and, hence, the well-being of the animals.

Freely ventilated outdoor climate stalls are also built for pig housing. The air in these stalls is changed by means of thermal ventilation and wind pressure. For the animals to be able to adapt to seasonal temperature fluctuations, it must be guaranteed that these stalls are divided into different temperature zones (resting-, communication-, and eating area). Altogether, the annual average air volume flows per animal are considerably larger than in force-ventilated stalls. For this reason, the stall air feels pleasanter. Under the above-described weather conditions in the summer, heat dissipation by the animals may also cause problems in these stalls.

Summary

In conclusion, it should be mentioned that pigs will continue to be housed mainly in conventionally built, closed stall buildings with mechanical ventilation systems in the nearest future. This is primarily due to reasons of labour management, environmental protection, and hygiene. Climate control systems, such as humidifiers, coolers, and heaters, will also be used to an increasing extent. Thanks to good measuring- and control technology, the different parts of a system can already be fine-tuned very efficiently today, and this fine-tuning will continue to be optimized in the future. Aspects of energy conservation will be considered in this development. This trend is also beginning to emerge in poultry housing.

In cattle housing, no alternatives to the above-described stall systems will be available in the near future. Here, the well-being of the animals and, hence, their performance ability should be increased by using mechanical ventilation systems, particularly in the warm season.