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Geothermal Heat Exchanger in Sow Breeding Houses

A Possibility to Improve the Climate Parameters in Pig Houses and Reduce Emissions

Ventilation helps attain good house climate parameters. However, the ventilation required is associated with emissions, which must be minimised. Among the low emission ventilation systems which generate good house climates is fresh air intake through a geothermal heat exchanger in front of the animal house entrance. A sow rearing house was tested during the summer and winter seasons. Besides lowering the summer temperature peaks, the ammonia emissions could be reduced by up to 30 %.

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Air conditioning is a main problem in the design and operation of pig houses. Especially high temperatures during the summer period can be a problem for the pigs, because the pigs cannot carry-off heat by sweating. If the inside temperature is above 28 °C and the relative humidity more than 80 % then the fattening pigs and the sows have problems [1]. The inside temperature should be lower than 28 °C during the warm season,- and if possible lower than 25 °C, and at the same time the relative humidity should be above 80 %. During the winter period the inside temperature should not be lower than 16 °C and the humidity should not be more than 90 %. An essential aim of air conditioning in animal houses is to keep the microclimate parameters in the mentioned reasonable range. The current practice of air conditioning pig houses is that when outside temperatures are high, a high air volume flow is applied [2, 3]. If in this case the fresh air will be conducted through the space under the roof, then a high inside temperature has to be expected. So heat stress for the animals will occur with the expected consequences. Furthermore, high air exchange rates lead to high emission flow. The application of geothermal heat exchangers gives us the possibility to reduce the air volume flow through the building and with this the reduction of the emission flow. Besides, the heat-storage capacity of the ground leads to a decrease of the inside temperature peaks in the summer season and to a reduced heat energy input in the winter season. More detailed information about the situation described above will be given in the following on the basis of measurements in an existing pig house.

Investigated pig house

The investigated pig house, equipped a with geothermal heat exchanger was newly built in 2000 and the concept is a so called „double-comb-house“. The house is 49.50 m long and 23.60 m wide. Five compartments are arranged on both sides of the centre aisle (which is 2.00 m wide) All compartments are managed by the „in-out-principle“. The compartments are designed such that four pens with „transverse-through-arrangement“ are arranged on both sides of the control- and drive-alley (which is 1.00 m wide). Feeding is carried out three times a day by a computer-aided liquid feeding system. Each pen is equipped with a nipple drinker. The pens have the dimension 3.50 m • 2.55 m with a slatted floor. In each pen there are ten pigs (80 pigs per compartment; 800 pigs in the house). The height between floor and ceiling is 2.80 m. The fattening period starts with 25 to 30 kg live weight per animal and the pigs stay in one compartment during the whole fattening period, up to 100 to 110 kg live weight. The manure removal system is based on slurry without straw. The ventilation is carried out as exhaust ventilation. The fresh air flows into the exchange tubes alongside the outer walls. First the tubes go vertically into the ground soil up to 2.00 m depth and then with small horizontal downward slope to the middle of the house. There the tubes lead directly into the „fresh-air cellar“ underneath the centre aisle. The diameter of the exchange tubes is 260 mm and the distance between the tubes is 450 mm. Beneath the centre aisle of the compartments there is the fresh air channel. This channel is covered by a grid floor. The negative pressure in the compartment extracts the fresh air through the cellar and this guides the fresh air into the compartments. The exhaust air is guided through a flanged socket, which is equipped with a turning vane and into the exhaust air channel. This channel is arranged above the centre aisle. Four fans in the exhaust air stacks are connected with the exhaust air channel and blow the exhaust air over the roof ridge to the outside.

Measurements

The measurements were done during two measuring periods: summer period from 3rd till 30th August 2004 and winter period from 2nd February till 1st March 2005. In each measuring period the measurements are carried out in two compartments. The „test compartments“ are chosen in a way that a wide range of animal live weight mass is included (one compartment in the lower range of weight: 35 to 70 kg per pig and the second compartment in the higher range of weight 70 to 110 kg per pig).

The climatic conditions are recorded by a temperature and relative humidity data logger. The determination of the air volume flows in the „test compartments“ is carried out by three different methods:

- Measuring air velocity with an anemometer in the exhaust air tube (short-time measuring) by tracing the cross-section and measuring continuously in the middle of the cross-section.
- CO_2-balancing method [4] (measuring continuously possible)
- Tracer gas measurement using SF_6 as tracer gas (continuous dosing of tracer gas - measuring continuously).

The course of CO_2, NH_3 and SF_6 concentration is determined by multi-gas monitoring.

The emission mass flow of a gas is the product of air volume flow multiplied by the gas concentration, measured at the same time. Because of the variation of air volume flow and gas concentration the emission mass flow varies as well. Therefore to make a proposition regarding ammonia emission, it is necessary to determine the emission flows during longer time intervals and to integrate these emission flows.

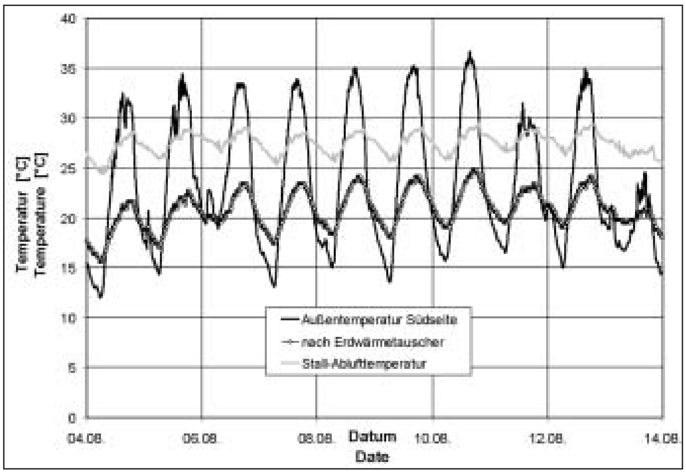

Fig. 1: Course of air temperature outside and inside the pig house during chosen time interval in summer 2004

Results

Regarding the climate parameters inside the compartments it can be stated that the expected positive effect of the geothermal heat exchanger has been achieved. This effect is particularly shown in the air temperature during the summer period (*Fig. 1*). For better clarity, in *Fig. 1* only three temperatures are represented. Between 4th and 14th August 2004 very high maximum values occur and typical diurnal variation of the summer period (air temperature in the inlet opening of the geothermal heat exchanger) was observed. After the geothermal heat exchanger the air temperature over the day is strongly dampened and is up to 11 K lower than the highest values of outside temperatures. Therefore the inside temperatures in the compartments are up to 7 K lower than the highest outside temperature. The measured relative humidity inside the compartments is in the optimal range. During the winter period the outside temperature varies between -11 and +10 °C, while inside the compartments the air temperature ranges from 17 to 21 °C. The fresh air temperature for example increases in the geothermal heat exchanger from -11 °C outside temperature by 10 K. The relative humidity in the compartments varies between 45 and 85 %. In summer as well as in winter the values of ammonia concentration are between 5 and 8 mg/m³. But during the daily feeding times the ammonia concentration increases up to 21 and 31 mg/m³ because of higher activities of the animals.

The emission mass flows of ammonia will be determined by the air volume flows measured by the CO_2-balance method and the ammonia concentration in the exhaust shaft. With these methods longer time intervals can be evaluated compared to using SF_6 as tracer gas (reason: cost of tracer gas SF_6). Comparing the CO_2-balance and the SF_6-method shows similar results. The average emission mass flows for ammonia are calculated in *Table 1* under the assumptionthat pigs are in the compartments 365 days per year. Averaged over all values, an emission mass flow for ammonia of 2.73 kg/m³ per animal can be determined. This value is 25 % lower than the standard value of 3.64 kg/m³ („TA Luft“ standard in Germany).The positive effects of the geothermal heat exchanger regarding microclimate parameters and emission, require additional investments. In reference to [5] additional investment of 26 € up to 37 € per fattening place for different versions of ventilation systems are mentioned. When using over a period of 30 years, the annual costs total to 2.80 € per fattening place. The loss of income because of heat stress in the summer season is 3.00 € per fattening place [6]. Therefore by using the geothermal heat exchanger, an improvement of management conditions for the animals and a reduction of ammonia emission will be achieved.

Conclusions

- Application of geothermal heat exchangers has a positive effect on microclimate in animal houses, on animal welfare, on animal performance and on emission
- The ammonia emission can be reduced by 25 % as minimum in comparison to conventional ventilation systems without geothermal heat exchanger
- The additional costs for the geothermal heat exchanger are the same as the loss of income due to heat stress in the summer season

	Life mass per animal kg	ammonia emission mg/h per animal	ammonia emission kg/a per animal
Summer	82 to 97	434	3,80
	42 to 57	337	2,96
Winter	92 to 110	291	2,55
	54 to 72	181	1,58
Average		311	2,72

Table 1: Ammonia emission flows from a sow rearing house, equipped with geothermal heat exchanger (averaged over the respective measurement period and projected for one year)

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