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Investigating Sub-floor Incoming Air Supply for Fattening Pigs

Influence on Microclimate and Ammonia

Forced ventilation is preferred in pig fattening. It should be low in investment and running costs, and still provide good microclimate conditions and have low emissions. Here a ventilation system is investigated, where fresh air flows through ducts in the floor. In contrast to geothermal heat exchangers the ducts are not 2 m deep in the ground, but the duct covering is quasi the flooring. The shallower depth and the smaller heat exchange surface inevitably lead to a lower exploitation of the heat exchange capacity from the ground, compared to a geothermal heat exchanger.

Economic necessities as well as demands by animal protection and environment protection force the farmer to look always for new solutions of keeping systems. An essential element of keeping animals in their natural environment is compliance with demanded microclimate parameters in the standard DIN 18910-1 [1] and in "Animal protection regulation for farm animals" [2]. In the summer time the high peaks of ambient temperature and their strong fluctuation are problems. Under such conditions the feed consumption goes down and with this the daily gain of the animals [3]. A particularly critical situation exists, if together with high temperatures high air humidity occurs [4]. Therefore especially under high temperatures should be the air humidity in a range good for both, animals and humans, inside the building. By geothermal heat exchanger it is possible to reduce the fresh air temperature by about 11 K. Thereby the inside temperature can be kept 7 K below the outside temperature. At the same time the maximum air flow rate in summer can be reduced. During winter the sucked outside air will be preheated by the geothermal heat exchanger. Thereby heating energy can be saved at the beginning of the fattening period. In the existing case it was to observe, if in summer and winter, by using a sub-floor fresh air system resulted in similar positive effects. For that purpose a newly erected livestock building in the north of the state Brandenburg was investigated during summer 2006 and winter 2007. In the following the main measuring results will be described and discussed. The effects are particularly evaluated on microclimate and on ammonia emission stream.

Investigated pig house

The fattening pig house with sub-floor suction of the waste air was new build as a double-comb-barn in 1998. The building is: 55.6 m long, 23.5 m wide. The central passage is 1.4 m wide and the compartments are arranged to the left site and to the right side of this passage. At one side there are 4 compartments, each with 2•4 pens, one compartment with 2•2•4 pens as well the office with service section. At the other side of the central passage are three big compartments with with 2•2•4 pens as well as two isolation compartments. The central passage, the passages in the compartments and two-thirds of the pig pen areas are designed with concrete slatted floosr. The residual third of the pen area is paved with concrete and designed with the floor water-heating system. For feeding between two pens, a wet mix feeding automat is installed together with two drinking nipples. The pig house has a capacity of 1200 fattening places. The air inlet system is different in summer and winter. During the summer period the fresh air will be sucked in

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Keywords

Pig fattening, sub-floor ventilation, microclimate in animal houses, emission

Literature

Literature references can be called up under LT 07409 via internet http://www.landwirtschaftsverlag.com/landtec/local/literatur.htm.

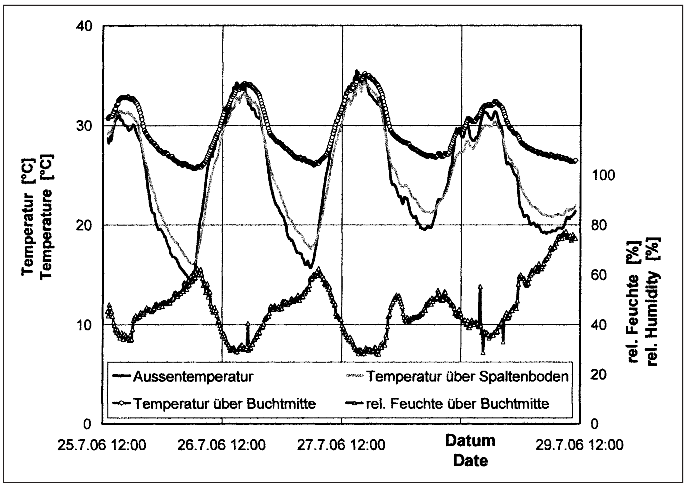

Fig.1: Typical course of temperature outside and inside the pig-fattening house as well as of humidity inside in the summer with a sub-floor inlet air system

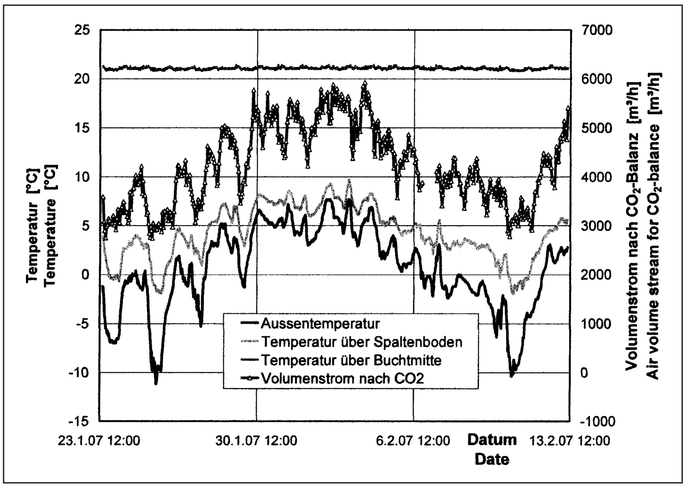

Fig.2: Typical course of temperature outside and inside the pig-fattening house as well as air volume flow in winter

through the doors in the gables and flows through the slatted floor of the central passage in the sub-floor area. From there the sub-floor fresh air channels divert it into the compartments. These channels are covered by concrete slatted floors (the slats have the function of the air inlets) and have also the function of the compartment passage. The closed division walls of the pens guide the fresh air upward, before the air goes into the compartments and in the animal zone. Depending on the size of the compartment, one or two exhaust stacks extend into the room ca. 0.5 m. The stacks are equipped with a fan and a measuring fan. The waste air will be sucked away from the compartment. During winter operation, the fresh air is sucked in through the openings near the eaves and flows through the roof room and into the central passage (through automatically adjustable openings in the ceiling). The gable doors are closed in this time. The air flows now into the sub-floor channels and into the compartments.

Measurements

The investigations were carried out during two measuring periods:

- Summer period: 25. 7. – 16. 8. 2006
- Winter period: 23. 1. – 13. 2. 2007

Two different compartments in size from the house were chosen (in the summer and winter period the same compartments) occupied with fattening pigs of different age. The development of the animal weight in the compartments and investigation periods are shown in *Table 1*.

The climate parameters are recorded by temperature / humidity data logger. The measuring points are the following: outside (in the area of the eaves under the roof), fresh air inlet (slatted floor of the air channel) in the compartment, different measuring points above the pens (out of reach of animals) and during winter an additional measuring point after the entrance of fresh air from the roof room into the central passage. The air volume flow is determined by the following three methods:

- Measuring air velocity in the suction area of the exhaust air stacks (short term measurements)
- CO_2-balance method
- Recording of the fan performance (percentage of the maximum air flow rate of the fan – displayed at the controller) three to five times per day

The course of the CO_2- and NH_3-concentration is recorded by multi gas monitor. The emission mass flow is calculated as product from both the air volume flow and the gas concentration. Since both parameters are available as run measurements, development of the emission mass flow can be shown.

Results

The main effects of the sub-floor fresh air system can quickly be read by the development of the temperature at the different measuring points. In the *Figures 1 and 2* typical temperature courses for the summer and winter measuring period are shown. Since during summer the relative humidity plays a role as "stress factor" the course of the humidity at one measuring point inside the compartment is diagrammed. By reason of clarity only the days with the highest temperature peaks are chosen. It is interesting that the fresh air, regarding the daily temperature peaks, showd no essential decrease due to pass of the air through the sub-floor channel. It must be considered that the outside temperature at the southern side of the building (there are the investigated compartments) are more than 3 K above the temperature at the northern site. As a result, the ventilation system can take into account a cooling effect in some respects, even if the inside and outside temperature are nearly the same (*Fig. 1*). The low relative humidity (about 30 %) is favourable for the microclimate inside during the maximal temperature values. At the lowest outside temperatures in the night, the fresh air temperature will be heated up nearly 1 to 2 K – in summer without relevance for the microclimate. The winter case in *Figure 2* shows that the climate control system works. The inside temperature is nearly constant while the outside temperatures vary from -11.0 °C to +7.5 °C. *Figure 2* shows that this achieved by control of the air volume stream. The warming of the fresh air up to 9 K is a positive effect, regarding additional the heating. The temperature in the central passage at low outside temperatures slumps under the freezing point (risk of refreezing). This cold fresh air streams also into the compartments trough the slatted floor of the compartment passage and this is unpleasant for the stable manager.

The average emission mass flows are compiled in *Table 1*. The annual emission streams are calculated on condition that house is fully occupied with pigs 365 days per year. Averaged over all values an ammonia emission mass flow of 2.68 kg per year and per animal place is computed. This value is definite lower than the value 3.64 kg per year and per animal place in the German guideline "TA Luft". The mentioned positive effects regarding microclimate and ammonia emission demand no nameable financial additional expenses in comparison to conventionally built houses.

Conclusion

- A sub-floor fresh air system reduces the heat stress during summer for the animals and the heat stress related performance losses
- During winter a significant warming of the fresh air will be achieved
- The ammonia emission can be reduced by the presented solution by 25 % compared to a conventional system
- No extra costs result from the presented solution, compared to houses with conventional ventilation

Table 1: Ammonia emissions from a pig-fattening house equipped with sub-floor inlet air supply (averaged over the respective measuring period and projected for one year)

	Lebendmasse je Tier kg	Ammoniak-emission mg/h je Tier	Ammoniak-emission kg/a je Tier
Sommer	48 bis 69	299	2,62
	77 bis 97	286	2,51
Winter	70 bis 85	321	2,81
	79 bis 94	318	2,78
GesamtØ		306	2,68