Lehmann, Bernd; Baumeister, Jochen and Klindtworth, Klaudia

Use of a high-pressure water spraying system for cooling fattening pig houses

Fattening pigs nowadays are mainly kept in closed stables with forced ventilation. Because pigs have only a moderate adaptability to high temperatures, the use of cooling systems is actually in discussion. In this paper, high-pressure water spraying systems are focused on especial effects of cooling and controlling strategies during summer periods. A study has been conducted within a period of two years. As a main result of investigations a maximum cooling effect of 6 K could be verified.

Keywords
Pig farming, fattening pigs, climatization, cooling system

Abstract
Landtechnik 66 (2011), no. 3, pp. 191–193, 2 figures

Within the framework of the BMELV pilot project "Landwirtschaftliches Bauen 2008–2010 – Kühlung von Schweineställen" (Agricultural Building 2008–2010 – Cooling of Pig Housing) investigations were conducted in a pighouse with a high-pressure misting plant (HP plant) applied for cooling. The HP plant involved was fitted in insulated housing with places for 265 fattening pigs. The system was directly fitted into the feeding department (**figure 1**). The pigs were housed in eight pens with 33 animals in each. Flooring was fully slatted with sensor-controlled liquid feeding. Air supply was via porous ceiling with exhaust air drawn out above the inspection passage.

System design and function principle

On each longitudinal side of the pighouse the water supply pipes for the HP plant were fitted 2 m above floor level with 16 high-pressure nozzles per side. When in operation the pressure in the pipeline up to the nozzles built up to ≥ 70 bar. The nozzles gave an average emission of 4.3 l/h emitted as a fine mist directly into the interior. The water mist evaporates so that relative humidity within the pighouse increases and temperature sinks in relationship to the amount of evaporated water (adiabatic cooling). The system comprises the following components:

- Water supply pipeline and water treatment through central filter unit
- High-pressure pump unit with subsequent high-pressure pipeline system and high-pressure nozzles
- Housing interior climate sensors for relative humidity and air temperature
- Control computer with operating unit

Regulating strategy

The HP plant operates in conjunction with the ventilation system. The required interior temperature (according to age of pigs) in the temperature curve is entered into the climate computer. Within a "required temperature + 4 K" corridor the

Fig. 1

Experimental housing with adiabatic cooling system (water pipes and high-pressure nozzles installed directly in the stable above the windows)

airflow rate is first adjusted and then the temperature in the pighouse compartment regulated. If "required value + 4K" is exceeded, the cooling system starts-up (HP plant start-up temperature). Should the actual interior temperature decrease into the required corridor ("required value + 4K"), the cooling system switches off again. During the cooling phase the HP plant alternate periods of misting and pauses between misting are varied through calculation of the required amount of water whereby spray intervals are from 10 to 45 seconds and pause periods regulated from 10 to 0 s (continuous operation). Should the interior temperature increase over a value of "required temperature + 6K" the relative humidity in the housing is then taken into the calculation as regulation parameter –a necessary action to avoid excess dampness.

Figure 2 presents an example of the interaction of the described pighouse climate factors including the functioning periods of the HP plant. Presented in the diagram (from summer 2010) are: the intensity of the mist cooling, the predetermined required temperature with the start-up temperature curve of the HP system, the limiting curve for maximum permitted relative air humidity, as well as the measured actual pighouse interior temperatures and relative humidity figures.

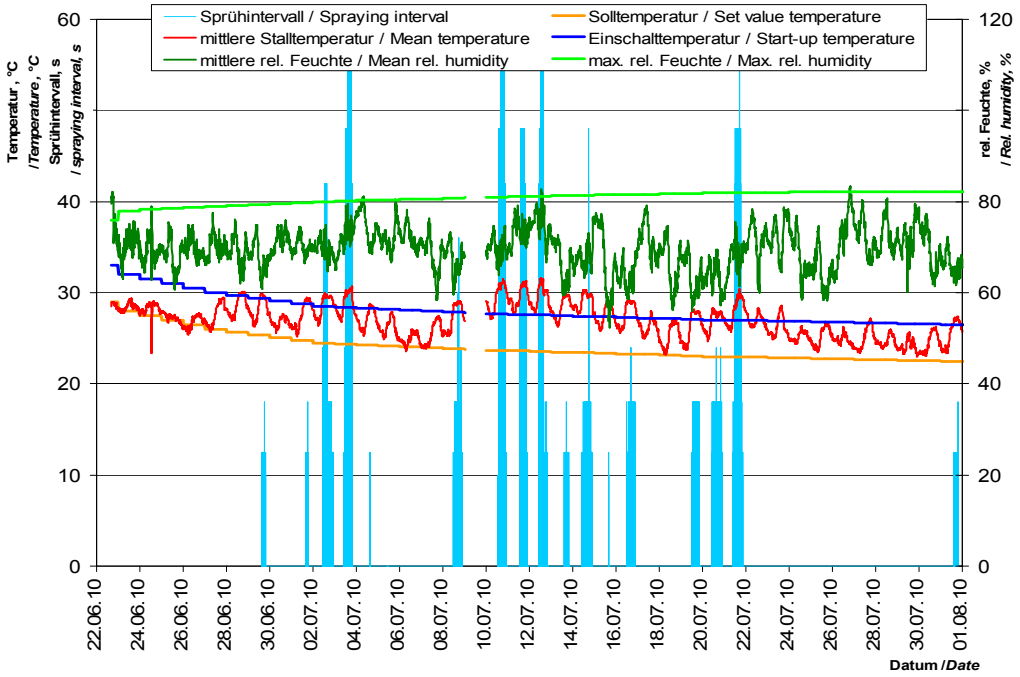
It was clear that the pighouse interior temperature during selected periods was, with very few exceptions, always over the predetermined required temperature. On the days when the HP plant was operating the pighouse interior temperature exceeded the predetermined start-up temperature in all cases (required temperature + 4K).

The maximum permitted interior humidity was reached above all on the days when mist cooling was in operation. On 27.07.10, there were only a very few readings marginally over the maximum humidity figure. In this case the maximum humidity might have been the limiting factor for activation of the spray cooling. It can be recognised, however, that on 27.07.10 it was not the maximum humidity that led to no misting taking place. In this case the pighouse interior temperature failed to reach the required start-up level for the cooling (required temperature + 4K = maximum temperature).

Trial results and experiences

The investigated model farm enterprise had experienced some years of HP plant operation for optimising the pighouse climate situation in fattening pig production. Alongside the reduction of temperature peaks in the summer months (up to 6 K) the manager also applied the system in hot periods to increase relative humidity. In the trial pighouse the required additional investment amounted to 17.55 €/feeding place (without installation). During the investigation period the cooling ran for a total 159 hours and thereby used 21.3 m³ water. The electricity consumption of the HP plant totalled 239.5 kWh, representing 2.5 % of total consumption. Since operation of the system (two years) seven of the 32 nozzles have had to be replaced. Any direct influence of the HP plant on ammonia emission performance of the pighouse could not be proven in the investigations. Further, much more involved, investigations into this would be necessary. The system never failed to function technically

Fig. 2



Spraying intervals [s], mean temperature [°C], mean rel. humidity [%] as well as control pattern set value temperature [°C], max. rel. humidity [%] and start-up temperature [°C] for cooling in the period of 22.06.2010 to 01.08.2010

during the investigation, although the nozzles were revealed as weak points. These should be inspected regularly to ensure breakdown-free operation of the cooling system whenever required.

Conclusions

Without doubt, discussions about cooling plants in livestock production housing depend on the frequency and length of hot summer phases. These define the real requirements for cooling. The use of high-pressure misting systems in enclosed livestock housing requires careful balancing with the housing interior climate controls as well as sufficient observation by the system operator. Under "extreme conditions – dry and hot" it is fundamentally possible to achieve substantial temperature reductions. On the model farm enterprise featured the cooling system was additionally operated for increasing air humidity in winter and, with that, as a method for general optimising of the pighouse climate, thus helping to justify the technical input.

Authors

Prof. Dr. agr. Bernd Lehmann is Professor for Agricultural Engineering, Architecture and Physics, **Dipl.-Ing. (FH) Jochen Baumeister** is member of the scientific staff for these subjects and **Dipl.-Ing. agr. Klaudia Klindtworth** was temporary member of the scientific staff at the Osnabrück University of Applied Sciences, Faculty of Agricultural Sciences and Landscape Architecture (Agricultural Course), Am Krümpel 31, 49090 Osnabrück, e-mail: b.lehmann@hs-osnabrueck.de

Acknowledgement

The pilot project was financially supported by the German Federal Ministry for Food, Agriculture and Consumer Protection.