Angelika Häußermann, Eberhard Hartung and Thomas Jungbluth, Hohenheim

Development of innovative ventilation systems for fattening pigs

Part I - Method and First Results

Due to a comprehensive data acquisition within the Hohenheim research pig facility, several newly developed ventilation control strategies are tested. The aim of the examination is on the one hand the reduction of environmentally toxic and greenhouse gases and on the other hand an improved ventilation control to guarantee a good indoor air quality. Part I explicates mainly the developed experimental lay-out, the operating mode of the control strategies, their realisation and the approach of the investigation and the data acquisition.

Dipl.-Ing. A. Häußermann is Ph.D.-student, PD Dr. habil. E. Hartung is associated Professor at the department of process engineering in animal production and farm building (Head of Department: Prof. Dr. T. Jungbluth), Institute of Agricultural Engineering, University Hohenheim, Garbenstraße 9, D-70599 Stuttgart; e-mail: haeusser@uni-hohenheim.de.
The project is carried out at the Universität Hohenheim within the framework of the graduate studies „Mitigation strategies for the emission of greenhouse gases and environmentally toxic agents from agricultural and land use" founded by the Deutsche Forschungsgemeinschaft (DFG).

Summarized contribution to LANDTECHNIK. You will find the long version under LANDTECHNIK-NET.com

Keywords

Ventilation control, indoor air quality, emissions

Literature

[1] • *Hartung, E.:* Konzeption, Realisierung und Evaluierung einer Versuchseinrichtung zur Entwicklung und differenzierten Beurteilung von Haltungssystemen für Mastschweine. VDI-MEG Schrift 392, Habilitationsschrift Institut für Agrartechnik, Universität Hohenheim, 2001

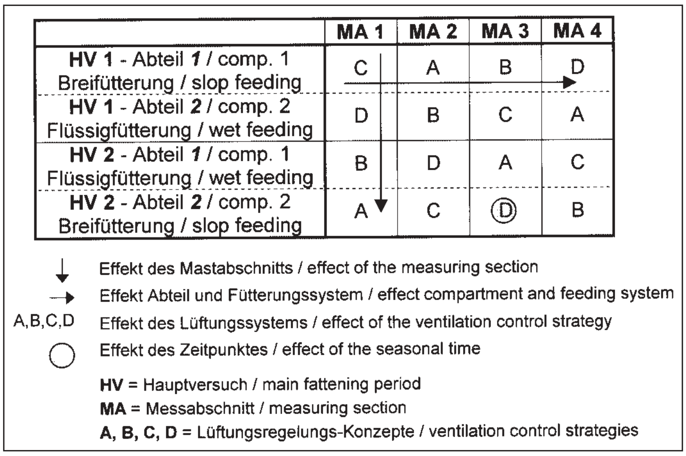

Fig. 1: Randomised distribution of the ventilation control strategies

All in all there are four different ventilation control strategies to be compared with each other. The basic idea of the innovative, enhanced experimental lay-out is based on a more efficient accomplishment of tests regarding the impact of different ventilation systems on air quality in and emissions out of a pig facility for fatteners. The experiments meet general criteria for the execution of tests to quantify representative data on harmful gases in and from livestock husbandry that were worked out and described in [1]. In this case the traditional approach of long-term measurements would be to compare four different strategies over one year parallel in four compartments, which were taken to be equal. Compared to the traditional approach, the four strategies and the two feeding systems were distributed over a total of two test compartments in the enhanced experimental design, using defined measuring sections. The advantage of this procedure is, that within the final evaluation the potential effect of the compartment as well as the effect of the feeding system can be split from the effect of the strategy which is to be investigated. To realise the comparison of the ventilation control strategies among themselves, each fattening period is subdivided into four three-week-long measuring sections (MS). The statistical distribution of the ventilation strategies over the fattening periods, the measuring sections the compartments and the feeding systems, is made by using Latin squares (*Fig. 1*).

Operating mode of the control concepts

The non-linear set temperature of the different ventilation control strategies as well as the minimum and maximum ventilation rate as percentage of the ventilation capacity are based on the settings for the reference strategy (strat. R). Except for the reference all ventilation control strategies to be tested (strat. A, B and C, *tab. 1*) feature additional humidifying (strat. B) of the indoor air and the incoming air. The water fogging is activated when the indoor humidity gets below 50 % (r. h. < 50 %) as well as when the indoor air temperature exceeds the set temperature for more than 1.5 Kelvin while the indoor humidity does not exceed 80 % ($T > T_{set} + 1.5$ K and r. h. < 80 %).

Within strategy A, the ventilation rate and the activating of the water fogging is controlled additionally by the animal activity. One objective of this strategy is to counteract at an early stage an increase of the indoor

Strategy	A (animal activity)	B (humidifying)	C (CO_2-controlled)	D (reference)
Control variables	temperature & animal activity	temperature	CO_2-indoor-concentration & temperature	temperature
Water fogging	activated (pulse-pause-rhythm)	activated (pulse-pause-rhythm)	activated (pulse-pause-rhythm)	not activated

Table 1: Description of the different ventilation control strategies

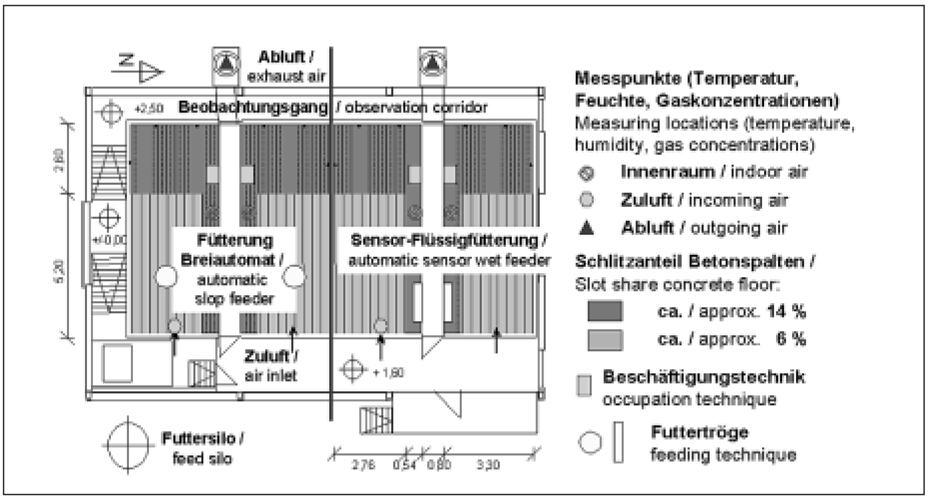

Fig. 2: Ground plan of the Hohenheim research stable

temperature, caused by the animal activity. The objective of the CO_2-controlled ventilation strategy C is to control the indoor air climate adequately with a ventilation rate as low as possible but not to exceed e.g. the German threshold for the CO_2-indoor concentration (3000 ppm).

Research facility

For the investigations the husbandry system of research facility [1] was upgraded in both compartments, according to current requirements for keeping fattening pigs in Germany. Both compartments are subdivided into two large pens, offering place for 27 pigs each, with a net area of 0.9 m^2 per animal (*fig. 2*). The structuring of the functional area results in the separation of a lying and feeding area and a so called excremental area.

The pens feature a concrete floor, with a reduced slot share of 6 % in the lying and feeding area and 14 % in the excremental area (*fig. 2*). The feeding system in the particular pens is arranged at the lying and feeding area with the reduced slot share. One of the compartments is equipped with a sensor wet feeding system (short feeding trough) with 20 feeding times between 6:00 a.m. and 10:00 p.m. In the other compartment an automatic slop feeder (ad libitum, round feeding trough) is built-in, which is filled 6 times per day beginning at 6:10 a.m. till 8:10 p.m.

The low pressure ventilation system supplies fresh air from the central anteroom through two pore channels per compartment, arranged centric above the pens. Each compartment is equipped with a separate exhaust chimney (diameter = 63 cm) which is assembled outside the building. The ETAvent-energy-saving ventilators, mounted at the outlet, are controlled each via a digital, PC networked and LON-bus-capable ventilation controller.

Per compartment a separate ventilation controller is used, which allows standardly the signal processing of the outside and inside temperature and of the relative air humidity. As an additional actor, controlled by the respective ventilation controller, both compartments are equipped with a high pressure water fogging system (7•106 Pa). The humidifying of the incoming and the indoor air is realised by two separately controllable fogging lines per compartment, assembled at the central anteroom at the outside of the compartments in front of the air inlet channels and indoors centric above the control corridor respectively.

Data acquisition

Indoor air climate and emissions

The air temperature and the relative humidity of both compartments are measured simultaneously indoors and in the incoming and the outgoing air (measuring locations for temperature, humidity and gas concentrations, *Fig. 2*). For determining the gas concentrations on NH_3, CO_2 and CH_4, gas samples of the particular sampling points at the compartments as well as at the air inlet and outlet of both compartments (Fig. 2) are pumped to the gas analysers in a quasi-continuous sequence for one sampling point after another. The used gas analysers each work according to the principle of non-dispersive infrared spectroscopy (NDIR). The ventilation rate is determined using calibrated measuring fans, assembled at the upper part of both exhaust chimneys at a distance of 1.70 m above the ventilation fan. The approximate animal activity of the animal group within each pen is measured by passive infrared sensors, which work similar to commercially available motion detectors. Also continuously the slurry temperature is measured below the particular sampling point for the gas measurements in the pens.

Side-effects

In addition to the continuously acquired data on the indoor air climate and on emissions, data on the animal performance, the slurry composition and the water and electricity consumption are collected discontinuously, partly in a daily-, weekly- or 3-week rhythm.

First selected results

The temperature of the incoming air and the indoor air as well as the ventilation rate of the animal activity-controlled strategy (strat. A) and the humidifying-added strategy (strat. B) with and without activated water fogging are pictured in *Figure 3*. The collected results so far show that the pictured ventilation strategies are widely in accord with their requirements. The upper part on the left hand side of Fig. 3 (9. - 11. 7. 03) shows the reaction of the ventilation rate on the animal activity in the activity-controlled compartment. The effectiveness of the used high pressure water fogging, regarding the arising cooling effect on the indoor temperature can be seen after the deactivation of the water fogging (11. - 15. 7. 03). While a widely consistent outside temperature occurs over the whole period, the indoor temperature of both compartments differs up to 6 Kelvin, comparing the time periods with and without the use of water fogging (Fig. 3 lower part, whole time period).

The effects of an increased or decreased ventilation rate, combined with the different control strategies, on the indoor air quality and on the emissions will be focused in the following proceedings (part II and III). For a detailed description of the approach and the first results and for some references the full-length version of this report in LANDTECHNIK-NET is recommended.

Fig. 3: Indoor temperature and ventilation rate within the two ventilation strategies activity (Var. A) and reference with humidification (Var. B) with and without air cooling by water fogging