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An air velocity transmitter for the determination of air volume flow in livestock buildings

Apart from heating, the air volume flow is up until now the only regulating possibility for the adjustment of desired interior temperature and air quality in livestock housing. With the development of air velocity transformers there are now sensors which allow air velocity to be measured in a very simple way and the results able to be included in the regulating system of ventilation systems. The following report indicates to what extent this measuring instrument is suitable for use in livestock buildings.

Exhaust fans in the air outlet shafts of livestock housing were up until now the only method for checking computer controlled air volume flows in such buildings. The disadvantage of this method is the high material and energy input (in general terms, measurement fans require about 10% of the energy for exhaust air fans) which varies strongly according to the building equipment and number of compartments.

Air velocity transmitters are rod-shaped sensors designed for the measurement of air velocities (mass flows). Measurement is based on the warm film anemometer principle whereby so-called thin layer sensor elements are applied [1]. Use up until now in ventilation and air conditioning technology have given good results. Such elements have not been applied up until now in livestock housing.

Aim of the investigation reported here is to prove to what extent this sensor technique can replace conventional measurement fans, and if there is a possibility of improving the regulation of the climate computers applied currently.

Measurement conditions and methods

The livestock building in which the trial was carried out was for rearing weaners. Floor area was 42 • 12 m divided into six compartments. Stocking per compartment was 200 head in eight same-size pens of 25 head [2].

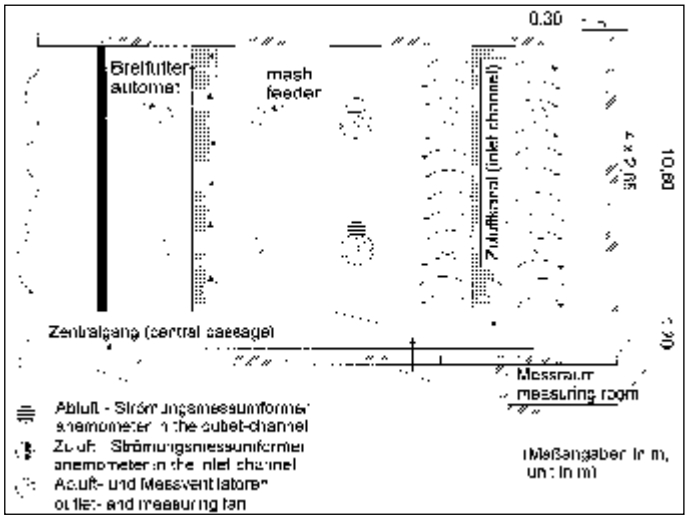

Fig. 1: Position of air velocity transmitter in the compartment for piglets (layout)

Climate control was through vacuum-system powered ventilation. Installed per compartment were two air trickle channels built over the central passageway of hard foam hole plates. Fresh air was fed through these. Two axial fans of 50 and 45 cm diameter and positioned in the middle of each compartment were activated as a group, whereby one fan could be switched off when ventilation demands were low (e.g. in winter). Adjustment flaps within the exhaust shafts enabled a further throttling of the air stream at minimal fan speed.

The testing of the air velocity transmitters took place during the period Feb. 14 to March 14, 2000, e.g. under typical winter conditions. Presented in *figure 1* are the measurement points for the inlet and exhaust air within the ground plan of the investigated compartment. Because the continuous recording of physical parameters represented a permanent problem through the aggressive climate conditions in the housing system, the air flow measurement transformer was tested in the exhaust shafts as well as the inlet air channels.

Ammonia production from manure was main cause of the aggressive climate conditions which had a damaging effect, not only on living organisms, but also on work materials through oxidisation [3]. A further factor

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Keywords
Sensor, ventilation system, air velocity transmitter

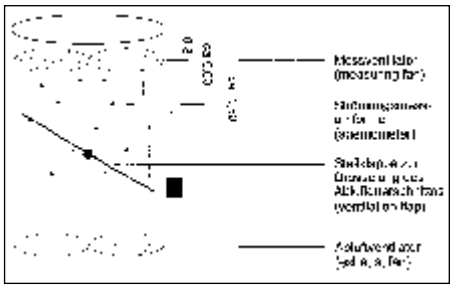

Fig. 2: Air velocity transmitter in the outlet channel (cross-section)

Table 1: Parameter in the course of measurements to examine the air velocity transmitters

Time period (d)	Compartment temperature C°	Rel. air moisture content (%)	NH_3-Concentration (ppm)	Dust concentration > 0,5 um ($\mu g/m^3$)
14. 2. bis 20. 2.	23,12	54,44	5,64	3374
21. 2. bis 27. 2.	25,38	52,00	7,92	6619
28. 2. bis 5. 2.	24,21	54,49	8,19	2370
6. 3. bis 14. 3.	24,54	54,80	9,69	4904

which substantially influenced the measuring accuracy of the air velocity transmitters was the high dust content within the building. This came in the first place from the dry feed used, but was also sourced from animal skin particles and through the movements of the animals [3]. In association with high air moisture content, so-called aerosols were produced which stuck to all equipment surfaces. *Table 1* contains important parameters describing the measurement conditions during the testing of the airflow measurement transformers.

Exhaust air measurement fans and airflow measurement transformers were directly compared during the continuous working of the weaner rearing system.Whilst the measurement fans measured the air volume flow through approximate sensors based on revolution frequency, the airflow measurement transformers used the measured voltage as a basis for the calculation of airflow velocity.

The cross-section of each exhaust air shaft (here 500 mm), within which measurement fan and air velocity transmitter were fitted in series above the exhaust fan (*fig. 2*), allowed the volume flows to be compared with one another and statistically calculated.

It was possible to attach the measuring devices in the middle of the inlet air shaft. With an average height of 150 mm, the vertical airflow area could be optimally recorded. The horizontal fitting also caused no problems here.

Analogue measurement maps were applied for data recording which were set for a maximum inlet voltage of 10 V. All data was transmitted online on a PC; the sensor rate was 15 min.

Results

During the laboratory trials (calibration shaft) very positive results could be achieved. The situation, however, was different in practical conditions. For instance in the exhaust air shaft no functional relationship could be determined between measured voltage and air volume flow. The main reasons are as follows:

• The livestock building exhaust air shaft represented an area with the highest pollution gas and dust contamination in the building. With a cross section of 50 mm^2 the airflow measurement transformer had a too small measurement cell to withstand the dust pollution over a longer period.

• Ammonia is a very aggressive gas which attacks metal, especially light metal (aluminium, magnesium) [3]. Contact with metals leads to production of so-called complex salts. Additionally, hydrogen sulphide and metal sulphides are produced, representing insoluble salts. All these compounds coat and corrode metals so that a diffusion of the voltage, and therefore the measurement values, results.

• Exhaust air volume flows in exhaust air shafts are characterised by turbulence. The point of sensor fitment within the shaft is therefore decisive and this was not able to be standardised in this case because of varying volume flows and flap adjustments.

Much better measuring conditions were available in the inlet air shaft. There, dust content and polluting gases lay only minimally over the outside air values. The flow properties of the inlet air were, in the main, stable and with low turbulence which made placement of the measurement elements substantially easier.

This allowed the closest relationship to be determined between measured voltage from the air velocity transmitter and the air volume flows of the exhaust. *Figure 3* emphasised this whereby around 40 % of the air volume flow in the exhaust air shaft could be explained by the measured voltage.

Through spot measurements with a hand anemometer it could be shown that, not only between the inlet channels, but also within the inlet air channels, substantial flow differences existed. Thus standard deviations of between 0.3 and 0.5 m/s at high flow velocities, through which the variability of the measurement parameters could be shown.

A big problem was the protection of the sensors during compartment cleaning with high pressure washers. Whilst the plastic covers were able to protect the moisture-sensitive sensor elements, it was still necessary to remove the sensors from the measurement points during cleaning operations.

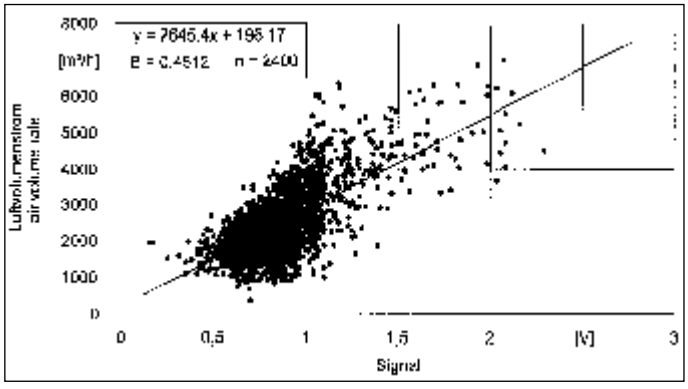

Fig. 3: Correlation between sensor signal and air volume rate in the inlet-channel for the whole measurement

Summary

Currently, the only controlling parameter for air exchange rate in livestock housing is the temperature factor.Many interior air analyses have shown that control of the air exchange rate is often insufficient. For this reason air flow measurement transformers were fitted experimentally within the ventilation systems of livestock buildings.

While the application of the air velocity transmitters in the exhaust air shafts is currently unsuitable because of the properties of the component materials, their use in inlet air shafts is possible. But considering the increasing demands on the precision of such measurements, the use of a single sensor is not enough.

Literature

Books are signified with •

[1] Anonym: Herstellerinformation

[2] *Büscher, W.* und *J. Kluge*: Heiz- und Elektroenergiekonsum in der Ferkelaufzucht. Landtechnik 54 (1999), H. 4, S. 238 – 239

[3] • *Mehlhorn, G.*: Lehrbuch der Tierhygiene. Teil 1, G.-Fischer Verlag, Jena, 1979, S. 99 – 101 und S. 117 – 123