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Experiences with measuring fans for air volume flow determination

Air volume flow rates have a large influence on source emissions from livestock housing. It is not sufficient simply to multiply the airflow as determined in planning for summer by a factor to give an average requirement for the plant. It is necessary to determine air volume flow parallel to exhaust concentration measurement in order to calculate the source emission from both factors. In forced ventilated housing measurement fans also represent a suitable method for determining air volume flow over longer time-spans.

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The following measurement methods are available for determination of air volume flow in forced ventilation livestock housing [4]:

Direct volume flow determination

- Rotameter (measurement fans) for continuous recording
- Pressure difference measurements with “normblenden” for continuous data measurement

Indirect volume flow determination

- Sliding method with anemometer for statistical observations
- Network measurements with anemometer according to the heavy line system for statistical observations

Should the source emissions from livestock housing have to be measured over a longer period of time it is necessary, because of daily and annual time variations, to determine air volume flow continually [2]. Additionally, continuous recording is also recommended for short-term measurements because the fans of the ventilation system are run at various speeds by temperature-related regulating equipment and the actual flow caused by the fans is also very strongly dependant on the wind. In that such conditions are usual for forced ventilated housing, methods for direct volume flow measurement on their own are attractive. Because of the large outlay in measuring time and equipment the difference pressure measuring with “normblenden” falls out in most cases.

For only a few cases is a static observation of the momentary air volume flow sufficient [3, 4]. Should, e.g., the maximum power of a ventilation system have to be demonstrated or checked, indirect methods for determining air volume flow can be considered. Indirect methods are used here because the air volume flow will be calculated. The profile of the canal flow is determined through screen, slide or heavy line method. In that by indirect methods the volume flow is determined from individual measurements of the local air velocity, the precision of this method depends on the measurement equipment used to determine the required point measurements. Continuous measurements at only one point in pipeline or rectangular canal have failed to achieve a satisfactory precision, as results from own investigations have also indicated [2].

Method description

The critical testing of all requirements for a single sufficiently-precise measuring method for air volume flow determination for livestock housing leads to measurement fans being applied as a rule. In [1] the successful use of this technology is reported-on internationally for the first time. Measuring fans are large rotor wheel anemometers (Rotameter) which are rotated by the air flow. Ideally, the diameter of the rotor wheel equals that of the round air shaft. The speed of the rotor wheel above the inertia threshold is dependant on the air velocity or on the intensity of the airflow in the air canal [5]. Measurement fans consist of the function elements:

- Rotor wheel
- Wheel hub with easy-run bearing
- Approximate impulse sensor

The fans have two or four rotors, in form and setting-angle to a great extent the same as the rotor wheels in commercial axial fans. Fans available currently have diameters of up to 63 cm.

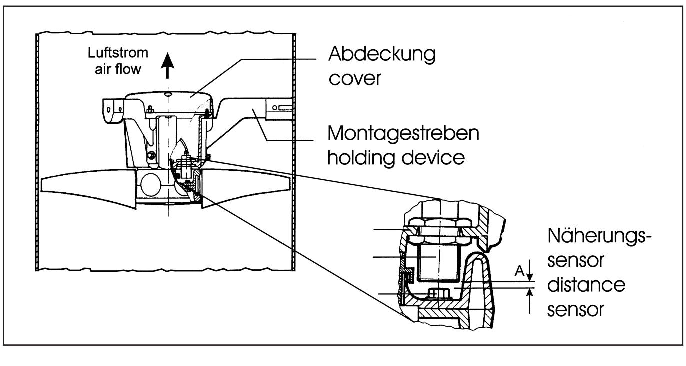

Fig. 1: Component parts of a built-in measuring fan

The impulse sensor is a simple approximate sensor (distance-signal transmitter) which, with every revolution of the fan, produces one of more voltage signals. Before use the distance between sensor and fan has to be controlled and, if necessary, adjusted (*fig. 2*). For the recording and calculating of the signal, one does not require the special the recording equipment of the different measuring fan manufacturers [4]. A frequency measuring instrument or a frequency measuring PC card can also fulfil this task.

Experiences and results

For practical reasons, the measuring range of measuring fans should be recorded together with average flow velocity in canal. The linear range of the calibration curve is relevant for a measurement that begins above the inertia threshold. In that measurement fans are not standardised products, calibration is necessary.

The *upper linearity limit* has not been investigated up until now. Flow velocities up to 12 m/s lie within the linear range. The measurement fans so far calibrated had a linear characteristic (*fig. 2*) above an average air velocity of 0.7 m/s.

The *proof limit* of the air volume flow determination with the help of measurement fans is calculated from the inertia limit of the axle bearing. Values below the flow velocity of 0.7 m/s are in the limits of recording possibility.

The *measurement precision* of measurement fans within the linear measurement range is very high. The precision of the calibration curve has so far always been over 99.8%. A DLG fan test stand was used as reference method. This type of test stand is based on the "normblend" system and takes into consideration nearly all relevant surrounding conditions. The calculated standard estimation error of three measurement fans gave, in association with the diameter of the rotor wheel, the following values:

65 cm fan diameter: 101 m^3/h

52 cm fan d.: 41 m^3/h

45 cm fan d.: 39 m^3/h

From the properties given above the high degree of *reproducibility* of measurement values can also be deduced. In that air flows are not in themselves completely reproducible, but instead always indicate random influences, the causes for poor reproducibility of measurements cannot basically be looked for in the measurement method [3].

Cross sensitivity to other physical parameters is not known with measuring fans. Also the degree of air particles (dust) has shown no influence on the measurements. Measurement fans are sensitive to air inflows. In order to achieve as precise as possible measurements, similar construction conditions should be present for calibration as during the recording. In that the profile and turbulence degree of airflows are very strongly influenced by installations, components and non-turbulence stretches the construction requirements and conditions have to be checked beforehand and considered in the calibration. Ideally, the air volume flow measurement should take place in a non-turbulent airflow, i.e., at a distance of at least 10 times the canal diameter from the last cause of turbulence. This, however, is not always possible in exhaust air shafts when air extraction is in the area of the ceiling and the exhaust air shaft is only a few metres long. The sensitivity of measuring fans to dirt encrusting on the edges of the rotors is overestimated as a rule (fig. 2).

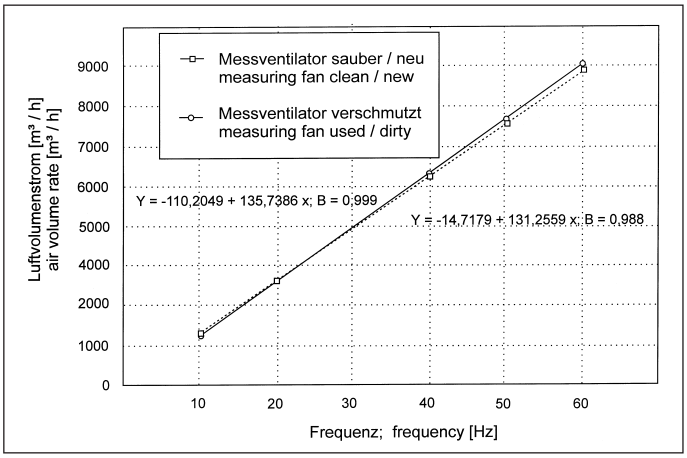

Fig. 2: Effect of polluting on characteristic of a measuring fan (diameter 50 cm) at beginning and after a six month measuring period in waste air shafts of a piglet rearing house

The *time solution* of the approximate sensors can be observed as high. When the frequency measuring card in the PC is set at a sampling rate of >1 Hz a reliable determination of the air volume flow can be reckoned with.

Drift of the measurement value through alterations in the approximate sensor are not known. It is thought that dirt can cause a systematic alteration of the characteristic (calibration curve). Own-measurements on this subject have not, however, confirmed this premise. *Figure 2* shows the effect of dirt over a six month period when applied in the exit air shaft of a piglet rearing house.

Disadvantages

Air throughflow is systematically indirectly influenced by the presence of measuring fans. The fan represents an obstacle in the airflow, the resistance of which increases as quadruple of the velocity and which must be overcome by the air propulsion source [5]. The dimension-less coefficient of flow resistance (ζ) of measurement fans is estimated at 0.1. Compared with the situation without measurement fan, around 2 to 5% lower air volume flows can be achieved in otherwise similar systems. According to company information, an additional flow resistance at full power of 5 Oa can be calculated.

The application in exhaust air shafts in winter has proved a problem where the fans are turned off via group switches. This leads to the measurement fans stopping and dirt settling between fan wheel and canal walls. When the exhaust shaft is switched on again, cleaning at such points may be necessary to facilitate low-friction running of the fan.

Concluding evaluation

With just a few exceptions, measuring fans are well-suited for the determination of air throughflow in all forced ventilation housing. They are especially suitable for the determination of air volume flows in pipeline canals when the above mentioned constructional conditions are taken account of. Continual measurements over long periods of time are possible with the help of PC supported recording systems. Intermediate calibrations are required at three monthly intervals. For highest precision, airflow must be without interference. In long-term utilisation, weekly function inspections have proved practical.

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