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Dust and Particulate Matter Reduction in Animal Husbandries

Techniques for reducing dust emissions are going to gain in importance. This particularly applies to poultry farming, but also to large pig livestock units. Procedural problems consistently appear during wet dust removal (sedimentations, aggregations) . A dry dedusting filter is described here, which can reduce dust by 83 % on the average with low pressure drops. Particulate matter (PM_{10}) can also be reduced by at least 70 %.

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Keywords

Waste air treatment, animal husbandry, dust, filter, particulate matter, PM_{10}

Livestock husbandry is connected with considerable dust emissions. A series of measuring data is available, broken down to animal kind and housing system [1]. Poultry keeping causes the highest dust emissions in general, followed by pig and cattle keepings [2]. Waste air treatment systems are increasingly used in livestock husbandry to minimise environmental impacts [3]. Measurements on waste air treatment systems at litter-free pig keepings generally showed separation efficiencies of more than 70 % for total dust [4]. Particles with a diameter of more than 2 µm can be separated with an efficiency of more than 95 % at two stage waste gas scrubbers [4]. These pleasantly high reduction efficiencies identified for pig keepings might result in considerable procedural problems in waste air treatment in poultry houses, however. Total dust emission factors for broilers are given in a range between 0.02 and 0.06 kg per animal place and year [1]. Thus the total dust emission from a broiler house with 40,000 heads can be calculated to be in a range between 800 and 3200 kg per year. With a 70 % reduction by waste air treatment 560 to 2240 kg dust would be collected in the system. The dust input into the waste air treatment system is not simultaneous and is conditioned by many factors (climate, ventilation, live weight, litter, animal activity etc.). Dust, unsteadyly accumulated in the waste gas treatment system, will not be degraded completely by microorganisms. Dust accumulations will also result in depositions on the transfer areas (filling material) and in the water distribution systems of scrubbers.

Material and methods

A filter apparatus for dry dedusting, prevention of dust depositions in waste air treatment systems and for the improvement of their reliability was developed (*Fig. 1*).

The filter apparatus consists of a regenerative synthetic filter pad (HS 15/350, HS Luftfilterbau GmbH), which was stuck together to an endless belt and clamped by four rollers. All rollers are activated by a chain drive if required. For regeneration the filter belt can be pulled ahead and cleaned by an exhaustion system with a feed motion of 2 to 3 cm /min. The required lining of the filter pad towards the walls is ensured by u-profiles.

The filter apparatus was used for preliminary purification of waste air from piggeries with total dust concentrations between 0.2 and 1.24 mg/m^3 (n = 11). By operating the apparatus with and without a filter pad it could be assessed which size of dust separation results from the cross section widening on its own.

Besides gravimetric measurements according to VDI 2066 also particle distributions have been made with two identical optical particle counters.

Results

The dust separation efficiency at a constant

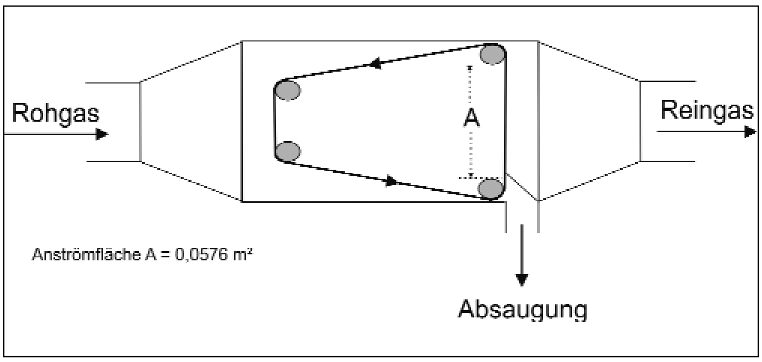

Fig. 1: Design of the dust filter for cleaning waste air from stables

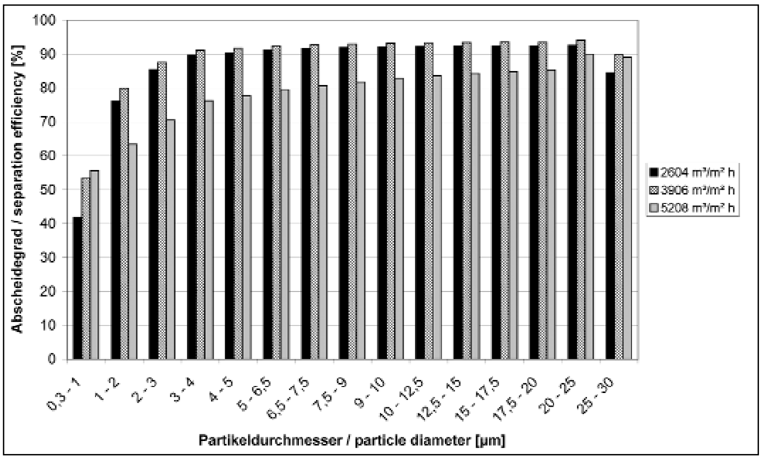

Fig. 2: Mean particles separation of the dust filter loading rates during cleaning of waste air from fattening pig stables

filter load of 5208 m?/m? h (relating to area A in *Figure 1*) ranged between 76.8 and 94.6 % in a six day operation time without interim regeneration and was 83 % on average (n = 6). At a constant volume flow and total dust concentrations between 0.2 and 1.24 mg/m^3 the pressure drop increased about 2 Pa/h (correlation of determination R^2 = 0,94). Without filter pad the dust separation efficiency ranged between 9.8 and 34.2 % (n= 5) and was 28 % on average.

Particle distribution measurements in raw and outlet gas showed high separation efficiencies also for small particle fractions if the filter pad is used (*Fig. 2*).

Figure 2 shows mean separation efficiencies from 202 (for a load of 2604 m^3/m^2 h), 169 (3906 m^3/m^2 h) and 163 (5208 m^3/m^2 h) simultaneous measurements in raw and outlet gas of the dust filter apparatus. The separation efficiency for the 2 to 3 µm fraction was over 70 % and for the 9 to 10 µm fraction even above 80 %. The total number of particles was reduced about 61.1 % (2604 m^3/m^2 h), 72.1 % (3906 m^3/m^2 h) and 66.7 % (5208 m^3/m^2 h).

Figure 3 shows the variation range of the particle reduction by the filter apparatus. The minimum reduction efficiency was above 70 % for the 9 to 10 µm fraction, 34 % for the 1 to 2 µm fraction and 44 % for the 2 to 3 µm fraction.

Corresponding measurements at a filter load of 5208 m^3/m^2 h (n = 173 pairs of variates) without the filter pad showed a mean separation efficiency of 18.9 % for the 0.3 to 1 µm fraction. All following particle fractions up to 20 µm showed negative separation efficiencies (-22 to -46 %) at considerable lower particle numbers. Coarse particles above 20 µm were separated with mean efficiencies of 46 % (20 to 25 µm) and 87 % (25 to 30 µm). The total particle number was reduced from 13.7 • 10^6/m^3 to 12.6 • 10^6/m^3 (-8 %) on average.

The separation efficiencies for all particle fractions tended to increase (R^2 between 0.62 and 0.85) with cumulative operation time as *Figure 4* shows for a filter load of 5208 m^3/m^2 h. This effect was noticeable in particular for the small particle fractions. Acc. to this the separation efficiency for the smallest particle fraction (0.3 to 1 µm) increased from 47 % after an operation time of 10 h to 66 % after 100 h (relative separation improvement of 40 %).

Conclusions

A separation efficiency of more than 70 % for total dust and PM10 can be maintained with the described filter apparatus at filter loads up to 5208 m^3/m^2 h. Multi-stage waste air treatment systems can be protected effectively against technical operation problems. Additional applications are available for reduction of dust emissions from poultries.

Literature

[1] KTBL (Hrsg.): Handhabung der TA Luft bei Tierhaltungsanlagen. KTBL-Schrift 447, Darmstadt, 2006

[2] Umweltbundesamt (Hrsg.): Beste verfügbare Technik in der Intensivtierhaltung. UBA Texte 75, Berlin, 2002

[3] *Hahne, J.*: Aktuelle Entwicklung der Abluftreinigung in der Tierhaltung. Landtechnik 62 (2007), H. 3, S. 178 - 179

[4] *Hahne, J.*: Sind Abluftwäscher zur Minderung von Staubemissionen geeignet? Landtechnik 61 (2006), H. 2, S. 88 - 89

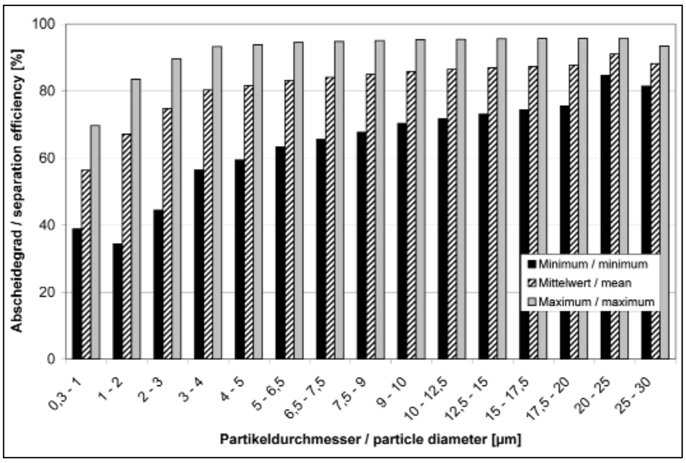

Fig. 3: Fluctuation of range of particle separation of a dust filter loading rate of 5208 m³/m² h

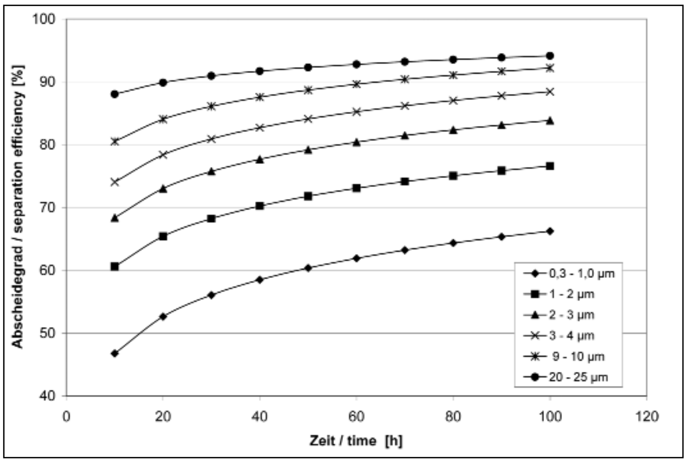

Fig. 4: Influence of the dust filter operation time on particle separation at a filter loading rate of 5208 m³/m² h