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Are Waste Gas Scrubbers useful in Reducing Dust Emissions?

Technical requirements in Germany may stipulate measures for reducing dust emissions from animal facilities to comply with federal limitations. Tests on a two-stage scrubber showed that particles with a diameter of at least 2 µm could be separated with at least a 95% efficiency level. More than 70% dust reduction can be maintained with various waste gas treatment systems, if they are dimensioned and operated properly.

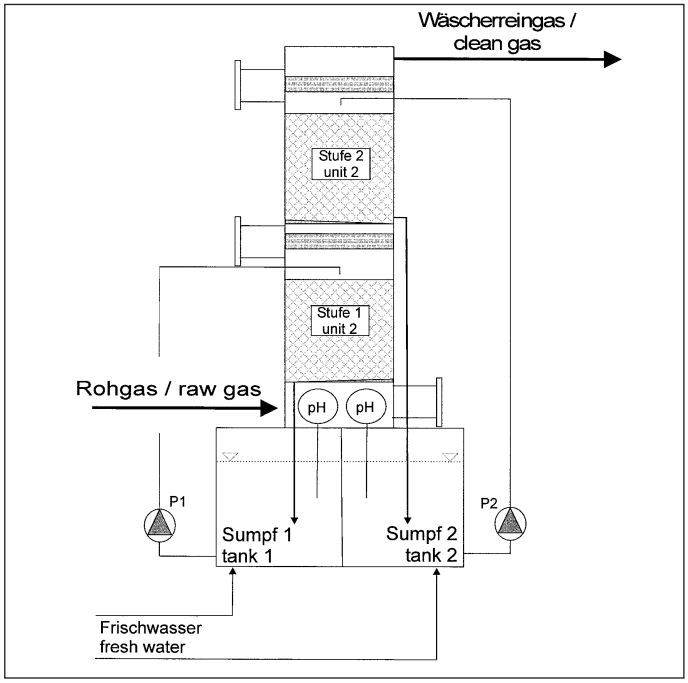

Fig. 1: Flow chart of the two-stage scrubber for waste gas purification from fattening pig houses

Besides odours and ammonia animals facilities cause dust emissions. Among general requirements on emission reduction, immission limit values for human health protection are determined in the Technical Instructions on Air Quality (TA-Luft) [1] which both are applied for animal facilities. Total dust concentrations of 20 mg/m^3 or mass flows of 0.2 kg/h have to be kept as emission limit values. Immission limit values for particulate matter > 10 µm (PM 10) must not exceed 40 µg/m^3 in annual mean or 50 mg/m^3 in circadian mean. The latter value can be exceeded on 35 days per year at maximum. The mass flow of total dust can be above 0.2 kg/h at bigger animal facilities,

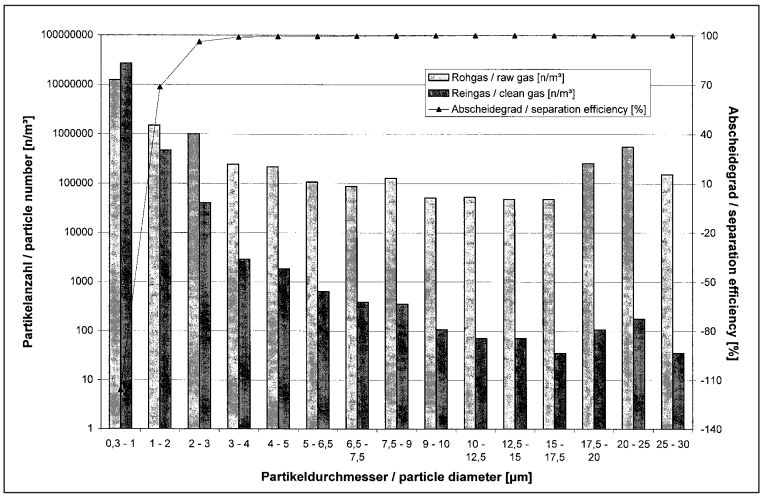

Fig. 2: Particulate matter distribution and separation efficiency for purifying waste gas from fattening pig houses with the two-stage scrubber

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Keywords

Dust, dust separation, waste air treatment, waste gas scrubber, animal husbandry

Literature

[1] BMU (Hrsg.): Erste allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz (Technische Anleitung zur Reinhaltung der Luft - TA Luft). GMBL vom 30. 7. 2002, H. 25 - 29, S. 511 - 605

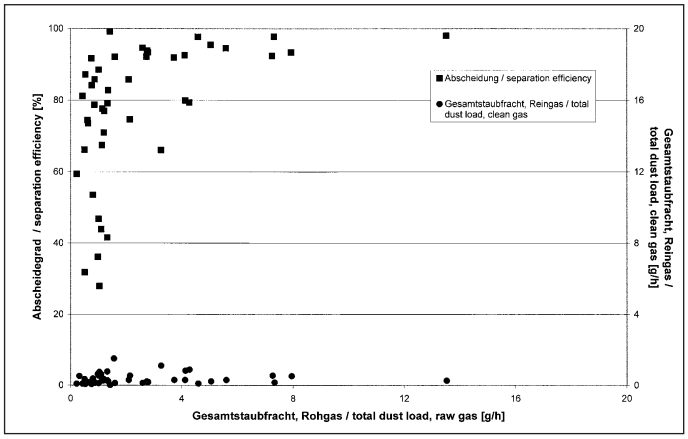

Fig. 3: Total dust reduction of purifying waste gas from fattening pig houses with the two-stage scrubber

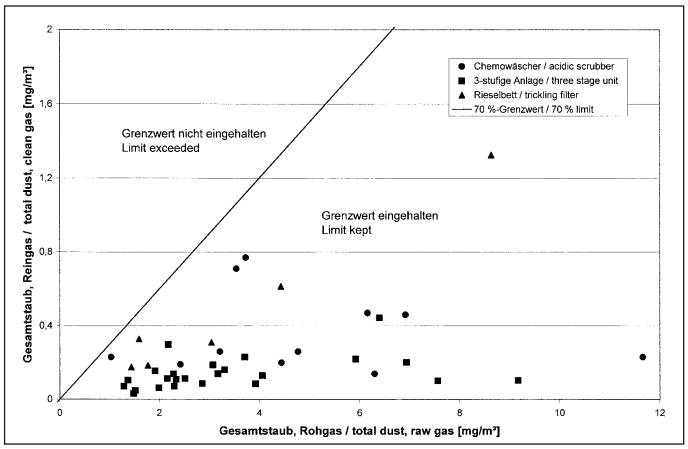

Fig. 4: Total dust reduction of different waste gas purifying systems for treating waste gas from fattening pig houses

while the total dust concentrations in the exhaust air are clearly below 20 mg/m^3 in the normal case. At a new stable building project, reducing dust emissions may be demanded, due to the size of the livestock facility or to the dust preload at the planned location. Then the question arises, whether and to what extent waste air treatment systems can contribute to a reduction of dust emissions.

Test description and methods

Over a period of several month total dust measurements as well as particle size distributions in raw and clean gas were carried out at a two-stage scrubber which is used for the cleaning of waste gas from piggeries (*Fig. 1*). The waste gas scrubber consisted of two completely separated water circulations. Plastic hollow globes with a specific surface of 98.4 m^2/m^3 were used, whereas each stage was filled with 0.25 m^3 of that material. The height of each filling was 0.9 m. As droplet catchers plastic wire mesh droplet separators with a layer thickness of 150 mm were used. For sprinkling the filling bodies a self-built sprinkler was used in the first stage and an axial full cone nozzle in the second stage. The sprinkling density in both stages was varied between 3 and 10 m^3/(m^2•h) and the gas load between 2.100 and 4.200 m^3/(m^2•h), whereas the gas velocity ranged between 0.6 and 1.2 m/s. For the analysis of particle size distributions two identical optical particle monitors (SFP, FMS 31c/30) came into operation. Simultaneous gravimetric dust measurements were done in the raw and the outlet gas by using the VDI method 2066, page 7.

Results

Mean particle size distributions resulted from all in all 18 particle measurements in raw and clean gas of the scrubber used for the treatment of waste gas from piggeries (*Fig. 2*). The mean separation efficiency was calculated from each size range. More than 73 % of all particles in raw gas had a particle size of less than 1 µm. 8.9 % of all particles had a particle size between 1 and 2 µm, while 6 % of all had a particle size between 2 and 3 µm. The other size ranges were of less numeral importance and varied between 0.3 % (particle size: 9 to 10 µm) and 3.3 % (20 to 25 µm). The number of particles with a particle size from 0.3 to 1 µm increased significantly through the waste gas scrubbing (+ 115 %) and amounted to 98 % of all particles in the clean gas. In contrast to this, the number of all other particle sizes was significantly reduced. This becomes clear when considering the particle size separation efficiencies. It was 68.5 % for particles between 1 and 2 µm, 96 % (2 to 3 µm) and more than 99 % for all other particle size ranges (Fig. 2).

The separation efficiency for total dust was measured 44 times in the same period and beyond it (*Fig. 3*). At total dust concentrations between 0.32 and 11.66 mg/m^3 in raw gas (mean: 2.41 mg/m^3, median: 1.67 mg/m^3) concentrations between 0.01 and 2.36 mg/m^3 (mean: 0.43 mg/m^3, median: 0.26 mg/m^3) were measured in the clean gas. The total dust separation efficiency was 77.6 % for the mean (median: 82 %). It increased significantly with the dust load in the raw gas at the tested gas loads. An influence of the gas load in the range between 2.100 to 4.200 m^3/m^2•h was not noticeable. Also the calculated outlet dust load did not show any correlation with raw dust load. On the basis of current results it is assumed that the scrubber itself creates a particle emission, also without any raw dust load (e.g. by water aerosols with solved minerals). This results in lower separation efficiencies at very low dust loads in raw gas.

Within the scope of the testing of waste gas treatment systems by the DLG (German Agricultural Society), the total dust separation of different systems was determined (*Fig. 4*). Results show that a dust reduction of at least 70 % was definetly achieved by all the tested waste gas treatment systems if they are dimensioned and operated properly.

Conclusions

Two-stage waste gas scrubbers in the described design are suited to separate particles with a diameter of more than 2 µm with an efficiency of at least 95 %. Investigations on the total dust reduction show that all tested waste gas treatment systems achieve a 70 % reduction under practical conditions, if they are dimensioned and operated properly.