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Gas sensor equipment

Examining the efficiency of odour-reduction in waste air treatment

The emission of smells from pig feeding units can, to a large extent, be avoided through waste air treatment. Results of measurements from differing loads on the FAL waste air treatment plant are presented here. They indicate that, even with heightened demands on washer and biofilter sectional area, a 90% reduction in odour is achievable. Added are results of a successful comparison between the olfactometrical procedure according to VDI 3881 and a continually working odour measuring instrument.

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Keywords

Waste air treatment, odour, gas sensors, pig fattening

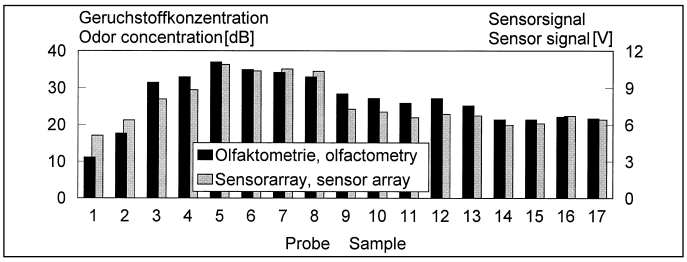
A basic fact of pig keeping is that emissions are produced. Towards reduction of these emissions a waste air treatment system, which does not produce waste water or other waste materials, was developed by the FAL Institute for Technology. This offers, alongside ammonia separation and retrieval, a reduction in odour emissions [1,2]. The plant, which has been running since February 1998 has been tested many times with regard to odour reduction under differing procedural circumstances. Additionally, in one investigation a continually-working odour measurement instrument was applied parallel to an olfactometric measurement system.

Practical results from the waste air cleaning plant

Depending on seasonal and livestock housing influences, odour concentration in the raw air is variable. In the test measurements, it varied between 688 and 2187 GE/m^3 (GE = livestock units lu) (*table 1*). The sulphuric acid wash with a full-body washer led to a substantial reduction in the concentration of odour substances. The degree of efficacy varied between 33 and 74%. At this point it should be explained that the wash liquid was held in an enclosed circuit with no intermittent skimming up to the production of a saturated ammonia sulphate solution. The efficacy of the washer depended on the first place on the composition of the raw air (ammonia, dust, hydrogen sulphide) which can vary considerably. Where there is a high concentration of dust or ammonia, but a low intensity of hydrogen sulphide, higher degrees of efficacy are achievable compared with in the opposite case. Within the tested area, no association was apparent between the sectional load of the washer and the reduction in odour. Despite the reduction in odour concentration, the washer-treated gas still gave off a typical livestock house odour in all cases. Through subsequent biofiltration by a filter filled with organic absorbent material (bark mulch/brushwood) and fitted in the exit air stream, the odour concentration was once again reduced in every case. The biofiltration efficacy varied between 35 and 95% according to the concentration and the composition of the washer-treated gases , the condition of the biofilter and the load on the biofilter. The tendency is that a high degree of efficacy is reached where the odour concentration is high and the load on the filter up to 85 Nm^3/m^2•h. Where the area load on the filter was from 164 to 222 Nm^3/m^2•h the results showed a strong scattering with degree of efficacy from 35 to 83%. Total efficacy of the waste air cleaning plant generally lay, however, over 80% with only one exception (*table 1*). Only where there were low concentrations of odour in the raw air (688 GE/m^3) did efficacy fall back to 71%, not least because of the smell from the biofilter material itself. Especially with the samplings, where the total efficacy sank beneath 90%, the odours of the biofilter gases were described as slightly reminiscent of slurry and marshland, whereas in the other samplings the odours were described as reminiscent of a biofilter, earthy and neutral. In order to explain in detail the association between degree of odour reduction, loads on the filter area, raw gas concentration and condition of the biofilter, an on-line smell measurement would be of considerable importance.

Table 1: Odour reduction of a two-stage waste air treatment plant at different loading rates

Date	Raw air [GE/m^3]	Washer-treated gas [GE/m^3]	Sectional load [Nm^3/m^2 h]	Biofilter-treated gas [GE/m^3]	Filter area-load [Nm^3/m^2 h]	Total degree of efficacy [%]
5.10.98	1960	1302	2709	66	85	97
7.12.98	915	504	3852	87	220	90
7.12.98	915	504	3852	47	42	95
10.5.99	688	356	3760	201	164	71
24.8.99	2187	569	4608	368	222	83
24.8.99	2187	569	4608	138	28	94
24.8.99	2187	569	4608	109	37	95



Sample	Measuring point	Sample	Measuring point
1	Outside air	10	Washer-treated gas 2
2	Livestock house vicinity	11	Biofilter 1, Pure gas
3	Raw gas 1	12	Biofilter 1, Pure gas
4	Raw gas 2	13	Biofilter 1, Pure gas
5	Raw gas 3	14	Biofilter 2, Pure gas
6	Raw gas 4	15	Biofilter 2, Pure gas
7	Raw gas 5	16	Biofilter 3, Pure gas
8	Raw gas 6	17	Biofilter 3, Pure gas
9	Washer-treated gas 1		

Fig. 1: Comparing odour concentrations as determined by the olfactometric method and the sensor array signals at various measuring points

Demands on on-line measuring of odour

Alongside the main components oxygen, nitrogen, water vapour, carbon dioxide, ammonia, methane and hydrogen sulphide, the waste air from pig housing contains a variety of other chemical substances in different and varying concentrations. Additionally, the waste air contains varying concentrations of dust. The human recognition threshold for individual ingredients of waste air can vary widely. In the case of indol, a microbial by-product of the amino acid tryptophan, this lies at 0.00015 mg/m^3, for ammonia around 4 mg/m^3. Accordingly, the smallest concentrations of certain substances can lead to a definite odour awareness. The “sum” of all the substances contained in the exit-air leads in the end to a certain smell awareness. A comprehensive review over odour, odour recognition, measurement and removal is delivered by [3]. From this background, an on-line odour measuring instrument should be able to demonstrate the following properties:

- high sensitivity and low selectivity
- no cross sensitivity to water vapour or, alternatively, effective pre-separation of water
- effective dust removal
- sensors must be stable over a long term and be able to demonstrate an as short as possible recognition time.

Odour measurement instrument OMD 1.10

The measurement of odours with the OMD 1.10 is based on the evaluation of signals from different metal oxide sensors. A stationary, continually-working, sampling unit takes air samples from up to four measuring positions. At the same time, air from the vicinity of the housing is sucked-in and processed to “zero air” within the instrument. Sample air and zero air are enclosed inside a conditioning unit and after that, each in a sensor chamber. In each of the two chambers, five sensors are aligned in an array. The zero air is blown into one chamber and the sample air into the other. After each measuring procedure there follows an equalisation with the zero point through switching over the measuring chambers, whereby the timing of the switching over is variable. The starting signals for the sensors come from the type of odour typical for the gas when so treated, whereby the parameters of the examples are proportional to the odour concentration [4].

Results of the comparisons

For the comparisons, samples were taken at various times from different measuring points in the waste air treatment plant for the olfactometrical evaluation according to the VDI- standard 3881 and, at the same time, for the odour measurement instrument OMD 1.10. All samples were analysed at once. A comparison between the results of the sensor arrays and the olfactometry gave a clear association (*fig. 1*). The results produced by the olfactometrical procedure are presented as GE/m^3•10 in analogy of the human odour recognition as logorithm of the odour concentration.

Additionally, through so using logorithms, calibration functions can be presented in each case for the raw gas and the cleaned gas (*fig. 2*). In the evaluation of the quality of the calibration function the fact must be taken account of that neither the choice of the sensors nor the possible adjustment of their sensitivity were optimised especially for the type of usage described here. Through the recording of further comparison measurements , especially in the case of badly-working biofilters and minimal loadings of raw gases, the functioning of the calibrations should still be able to be improved. The results also show, however, that for different measuring points (raw gas, washed gas) differing calibration functions also have to be established. Among other things, this can be attributed to the cleaning of alkali compounds (ammonia, amines) due to the washer. In this association, investigations in the future must show whether a calibration function determined for one measuring point can also be used in the medium and long term.

Conclusion

The results presented on the reduction of smells from a two-stage waste air treatment plant with sulphuric acid wash and subsequent biofiltration show that, even in the case of high loadings of the plant, odour reductions of 90% are achievable.

However, in the case of high biofilter area loads considerable efficacy variations appear which, up until now, have not been able to be definitely explained. An on-line odour measuring instrument is of great advantage in the explanation of this association. First comparative measurements between the olfactometry and the odour measurement instrument OMD 1.10 have confirmed the suitability of these systems in principle for these cases.

Literature

Books are identified with •

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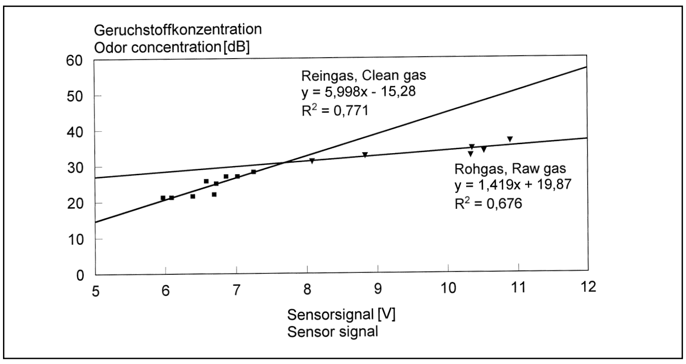

Fig. 2: Linear matching and coefficient of determination of results from the sensor array and the olfactometric method