Jochen Hahne, Wilfried Asendorf and Klaus-Dieter Vorlop, Brunswick

Online odour measurement with exhaust air filters

With a gas sensor fitted with metal oxide sensor, online sampling and measuring was possible after calibration with olfactometry odour concentrations of over 120 GE/m³. The calculated odour concentrations correspond in tendency to the intensity levels as perceived by randomly chosen test persons. Further, the equipment enabled the classification of typical odour patterns; their correct interpretation, however, required comprehensive knowledge.

Dipl. Biol. Jochen Hahne (e-mail: *jochen.hahne@fal.de*) is member of the scientific staff and Wilfried Asendorf is technician at the Institute for Technology and Biosystem Technique (manager of department of technology: Prof. Dr. K.-D. Vorlop), the Federal Research Institute for Agriculture (FAL), Bundesallee 50, 38116 Brunswick

Keywords

Gas sensors, odour patterns, waste air treatment, pig fattening

Olfactometry for the determination of odour concentrations is cost-intensive and, because of the methods involved, not suitable for online measurement. For monitoring odour-intensive processes, or for the controlling of exhaust gas cleaning plants, online odour concentration recording would, however, be advantageous. The objective character of online odour measurements would also be very helpful for dealing with livestock enterprise odour emission complains. Along with such advantages, gas sensors also offer the possibility of odour pattern identification. This can be of importance in the identification of emission sources. This report describes results of odour measurements taken by a gas sensor from the FAL plant for exhaust air cleaning in feeding pig houses.

Description of gas sensor equipment

A gas sensor instrument (OMD 1.10) from Födisch Umweltmesstechnik GmbH was used for online odour measurement. This took gas to be measured from the exhaust air flow and passed it over an extraction probe, pumped it over an accompanying heated gas measuring pipeline to a cooler, and then reduced it to a dew point of 4 °C. Afterwards, the gas sample is channelled to a sensor array comprising five different metal oxide sensors and measured. Parallel to this, the regeneration of the second, identical, sensor array with ambient air additionally purified through active carbon. Through a measuring point change after a period of time which can be adjusted, a switch onto the regenerated sensor array also took place. With help from olfactrometric investigations, the instrument was calibrated for the exhaust gas to be measured and appropriate calibration functions were given [1]. These covered an odour concentration range from 120 to 660 GE/m^3 (pure gas) and 1360 to 2860 GE/m^3 (raw gas) and are strictly speaking only applicable for these areas. Below 120 GE/m^3 a quantification of the results is no longer practical because of the type of zero air preparation, sensor differences between the measurement chambers, and the responses of the individual sensors.

Results

For a complete feeding cycle, the gas sensor equipment was applied for monitoring the FAL trial plant for cleaning exhaust gases from feeding pig housing. The odour values determined by the gas sensor (*fig. 1*) give daily averages comprising 12 individual measurements taken in each case for 30 minutes every 2 hours. The raw gas concentrations determined in this way moved between 962 and 1625 GE/m^3 and averaged 1327 GE/m^3. The odour concentrations rose in line with the length of the feeding period. In that the raw gas was mixed from five separate test compartments, each with different stocking and air extraction in order to ensure a representative exhaust air mix, no animal-specific emission data could be determined. With a gas scrubber loading of 2650 m^3 (m^{2}h), an average 129 to 1010 GE/m^3 or 554 GE/m^3 was measured on average at the scrubber exit. Present at the biofilter exit, with filter area loading of 85 m^3/(m^2/h), were average odour concentrations of 354GE/m^3 with variations from 35 to 642 GE/m^3. The odour reduction degree of the scrubber calculated with the help of the gas sensor instrument over the total feeding

Table 1: Assessing the intensity and odour perception in raw gas, scrubber outlet gas (loading rate: 2650 m³/(m² h)) and biofilter outlet gas (filter loading rate: 85 m³/(m² h)) by 83 randomly selected test persons, data in number of persons

Odour intensity	Raw gas	Scrubber outlet gas	Biofilter gas
Very strong	24	2	0
Strong	38	16	3
Weak	21	56	7
Barely noticeable	0	8	48
Not noticeable	0	1	25
Odour impression			
Extremely unpleasant	7	0	0
Very unpleasant	29	2	1
Unpleasant	41	58	1
Neutral	3	13	67
Pleasant	3	10	14

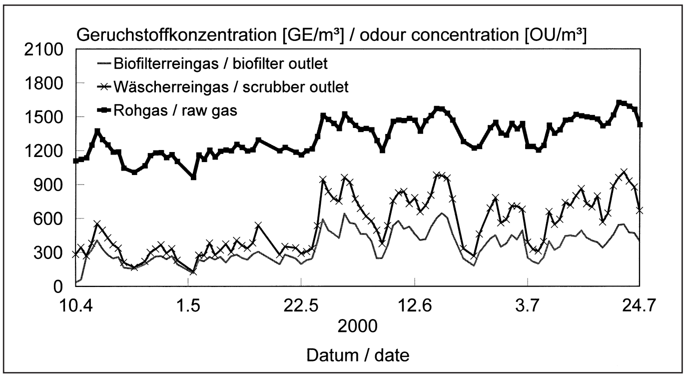

Fig. 1: Temporal course of odour concentrations calculated from the odour measuring device in the raw gas, scrubber outlet gas (scrubber loading rate: 2650 $m^3/(m^2$ h)) and biofilter outlet gas (filter loading rate: 85 $m^3/(m^2$ h)

period was 58%, that of the complete system 73%. To be taken into consideration with these results is that odour-less methane was present in the exhaust air in increasing amounts through the feeding cycle. This caused a sensor signal but – as opposed to other components – is not up until now able to be degraded in the filter. This mix produced small odour concentrations (after biofiltration) but constantly high methane concentrations, demonstrating the performance limits of the measuring instrument. A similar situation applied to the breakdown of material with comparably high odour thresholds. Their degradation led to a weakening of the signal and, with this, a calculation-based odour reduction, without this actually being achieved.

As part of the measurement programme 83 randomly chosen people were asked to judge the odour intensity as well as the subjective effect of the raw gas (livestock housing exhaust), scrubbed gases and the biofiltered gases against a predetermined scale as part of the FAL Open Day on June 25, 2000. With regard to odour intensity, the majority of the testers described the raw gas as "strong" and its subjective effect as "unpleasant" (*table 1*). The washer or scrubber treated gas described as "weak" smelling by the majority, but experienced as "unpleasant". Only after biofiltration did the majority of testers find the sample air "barely noticeable" and subjectively "neutral": The odour measuring instrument at this time gave odour concentrations of 1319 GE/m^3 (raw gas), 576 GE/m^3 (scrubber gas) and 360 GE/m^3 (biofilter gas). The degree of odour reduction determined by the results of the gas sensor instrument was 73.7%. Regarding the odour intensity, these first results showed that the odour measurement instrument, after an appropriate calibration through olfactometry, tended to give results comparable to evaluations by a large number of randomly chosen test people. Additionally, the evaluations by the test persons showed a clear alteration in odour quality, although not following the scrubber, but first after the biofiltration (table 1). This effect was not, however, reflected by the applied gas sensor instrument – results also confirmed by the presentations of the odour patterns (*fig. 2*). The presented pentagram shows the strength of signal of each of the five sensors over a scale from 0 to 1 units on the three different measurement points raw gas, scrubber gas and biofiltered gas. Should the intensity value of the individual sensors be linked to one another, there would result a pentagram, a typical odour pattern. Figure 2 shows that the strength of signal and, with that, the odour intensity was reduced especially strongly by the scrubber. Additionally, the odour pattern experienced deformation through the exhaust wash which in the main could be traced to the change in intensity of the sensor 5 (washing out of soluble and alkaline material through rinsing with diluted sulphuric acid). Despite altered odour patterns the majority of test persons described the raw gas and the scrubber exhaust gas equally as "unpleasant". On the other hand, the test persons found definite improvements in the odour characteristics of the biofiltered gases which they classified completely in the majority as "neutral" to "pleasant", although the odour pattern of the biofilter gases barely deviated from that of the scrubber exhaust gases. The odour patterns gathered by the described odour measurement instrument are, according to the produced results, only to be interpreted in a practical sense with recognition of the test conditions and the sensor equipment. This applies especially to the background that certain gases such as methane are without smell but still cause a gas sensor signal. The removal of certain material from the exhaust air altered the strength of the signal of individual sensors significantly (and with that the odour pattern) without the odour judgements of the testers altering. Despite that the investigation which has been running since April 2000 gave odour patterns described as "typical" from feeding pig housing exhaust air (*fig. 3*). The pentagram shows the odour patterns determined in April/May and October/November, which show remarkable similarity and in the main only differ through signal strength. Measurements from June/July correspond with this pattern (not displayed).

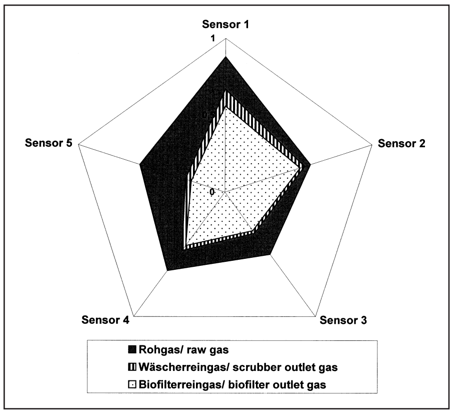

Fig. 2: Change of odour patterns during treatment of waste gas from pig houses

Summary

After a calibration via olfactometry the gas sensor instrument described is suitable for online control of odour emissions as well as reduction of odours in treatment of exhaust air from feeding pig housing. Regarding odour intensity, the results correspond classification by the majority of randomly chosen test persons. The subjective effect of the odours as described in this report cannot be reflected by the odour pattern in the reported case. This showed the comparison of the (similar) odour patterns in the case of exhaust air scrubber and biofiltration which were judged as very different in their subjective effect. A selective measuring and evaluation of the methane would significantly improve the strength of testimony of the result.

Literature

[1] *Hahne, J., K.-D. Vorlop, R. Hübner* und *D. Müller*: Gassensorgerät. Landtechnik 54 (1999), H. 6, S. 350 – 351

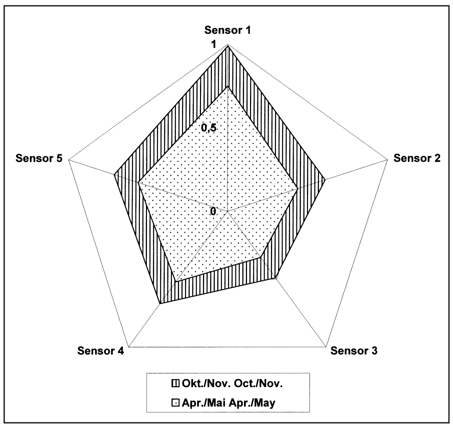

Fig. 3: Formation of characteristic odour patterns from the waste air of pig houses