Successful reduction of odour emissions

NEW SOLUTION | Vereinsbrauerei Apolda, a brewery located in eastern Germany between Weimar and Jena, has a long-standing tradition. The company's history dates back to its founding in 1887. Because the brewery is situated in a valley the odour emissions from the brewing process have a stronger influence on the surroundings. This lead to increasing complaints from the neighbourhood. Now the brewery is testing a new method for odour reduction.

PARTICULARLY in the 1980s, the brewery in the city of Apolda became famous for its „Dominator" brand, which was even exported to Bulgaria, Romania and Hungary. Since the political change in 1990, the brewery has made considerable investments, for example the modernization of the boiler house, the construction of a new brewhouse [1], a new bottling department and a new storage facility for full and empty bottles including a shipping office. However, structural changes occurred in the brewery's neighbourhood as well. After extensive reconstruction of adjacent large buildings and their sale as condominiums, the brewery got new neighbours, people who have very little understanding for odour emissions from the brewing process. The modification of the vapour stacks, intended to improve the situation with an extended discharge height of the vapours, did not lead to the desired success, because the brewery is situated in a valley. Particularly under adverse weather conditions and in the cold season, the brewhouse vapours were pushed towards the ground and moved in the direction of the residential buildings and the almost adjacent marketplace.

Increasing complaints and pressure on the brewery then led to a joint project of Vereinsbrauerei Apolda, Luwatec GmbH and Huppmann GmbH. A new system for the reduction of odours in brewhouse vapours was installed, tested and optimized (Fig. 1).

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Method for odour reduction

All odour reduction systems are installed downstream of an existing vapour condenser. With this, the vapour volume and thus the total mass of organic carbon is minimized. At the same time, the vapour condenser also ensures the reduction of emission peaks during dynamic low-pressure boiling.

Already in 2004, the Huppmann engineers implemented a "zero emission" process at the Grolsch Brewery in Enschede. The vapours and the exhaust air from the brewing vessels and the vapour condenser are led into a common vapour pipe. Through this collecting pipe, the vapours together with combustion air flow to a small vessel that is fired by methane from the brewery's own sewage plant. In case of oxygen-rich combustion, the aroma components are completely oxidized to CO_2 and water and thus made odourless. However, the combustion system, the engineering and the installation of the collecting pipes require significant efforts and costs [2]. Therefore a cheaper alternative system had to be found which reli-

Fig. 1 View on the new brewhouse from the parking deck of a shopping centre (vapours from the wort kettle and the bottle washer are moving towards the marketplace)

ably neutralized the majority of odours and required minimum maintenance efforts.

Today, systems with gas scrubbers and biofilters do not yet provide sufficient operational reliability and efficiency in odour reduction. The efficiency of gas scrubbers can be enhanced by using oxidants and surface-enlarging foaming agents. If the spent liquid from the bottle washer can be used for this purpose, additional pollution of the waste water can be avoided. If vapour temperatures are very high, the process gas to be treated has to be cooled down before it passes through the biofilter. Otherwise, the microorganisms in the filter bed are killed. Longer brew rests pose significant problems for the biofilters used to reduce odours in brewhouse vapours. In this case, the microorganisms in the filter bed must be supplied with organic material and heat energy in order to survive. When a new culture of microorganisms is introduced, a certain start-up phase is required until the biofilter has reached its full efficiency again. Continuous maintenance of the filter bed requires a lot of care and permanent control [3].

Odour reduction by means of cold combustion

A new method to reduce odour emissions utilizes oxidation reactions in which the odourless components carbon dioxide and water are generated from aroma substances.

This process can also be called cold combustion (Fig. 2). By supplying a carefully dosed amount of energy, ions with an excess of electrons (negative charge) and a shortage of electrons (positive charge) are generated from molecular oxygen. These charged oxygen molecules attack hydrocarbons and, in case of sufficiently high dosing, oxidize them completely to carbon dioxide and water.

A similar process occurs in nature during a thunderstorm. The abrupt discharge of the different potentials of meeting air masses leads to the formation of flashes of lightning, which, on their way through the atmosphere, supply the required activation energy to the oxygen molecules in the air to produce charged oxygen ions. These ions oxidize the odour molecules in the air and lead to the perception of "clean" air, which is very common after such extreme weather situations.

Company Luwatec GmbH in Weißenfels was selected to supply such an air treatment system. For several years already, Luwatec GmbH has been successfully using this method [4] for water disinfection and air sterilization. Huppmann was responsible for the mixing and reaction units as well as for process integration.

Application of the ionization system in the brewhouse

The non-condensable components of the vapours produced during wort boiling (during heating-up and atmospheric post-boiling) at Vereinsbrauerei Apolda are mixed with the oxygen ions (ionized air) produced by the ionization system in a swirl chamber and emitted to the air through a vapour stack. The ionization system is supplied with fresh air from the surroundings of the brewhouse. The power consumption of the ionization system is 1.5 kW. Since the installation of the ionization system, the brewery has not received any complaints from residents about the smell (Fig. 3, 4).

To confirm the subjective success of the installed ionization system, TÜV Süd was contracted to perform comparative

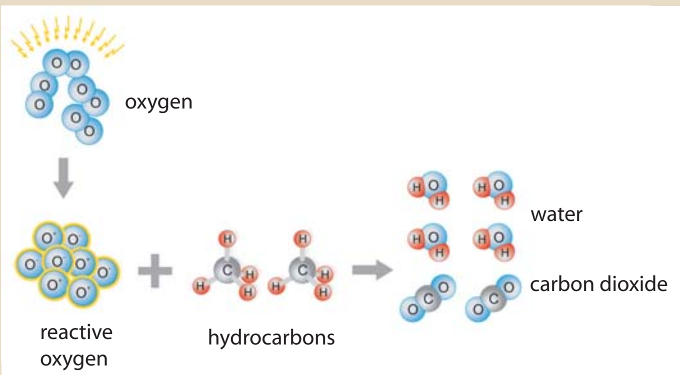

Fig. 2 Simplified representation of "cold" combustion

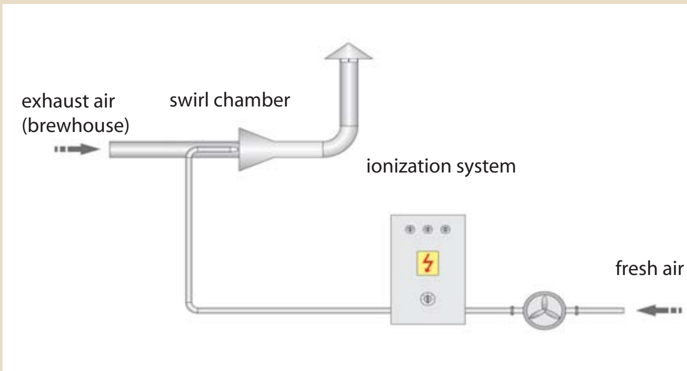

Fig. 3 Schematic of an air ionization system

emission measurements both when the ionization system was operating and when it was not.

The comparative measurements considered the human sense of smell by means of olfactometric evaluation as well as the reduction in odorous organic carbon molecules (TOC = total organic carbon), which can be measured with a flame ionization detector (FID).

For the evaluation of the odour impression, sterile plastic bags are filled with process gas during the measuring period and then subjected to olfactometric evaluation after defined predilution (with sterile air).

During the measurement, the hydrocarbon compounds (TOC) in the vapours are led into the flame of the FID and increase, dependent on their concentration, the current flow between the two electrodes in the flame. An increase in the current flow is shown as peak in the corresponding diagram. The measurements were made during the same brew, as two vapour stacks with identical nominal diameter were available. Untreated vapours were flowing through vapour stack 1, while the mixture of ionized air and wort vapours was emitted to the environment through vapour stack 2. As Vereinsbrauerei Apolda is working with dynamic low-pressure boiling, odour emissions are mainly produced during heating of the kettle content at the beginning of the wort boiling process and in the phase of atmospheric post-boiling.

For each of the examined brews, two odour samples were taken and subjected to olfactometric evaluation by a qualified TÜV panel. The results of the sensory evaluation are summarized in table 1.

The interpretation of the olfactory perception poses a great challenge to the evaluating TÜV employees (continuity of sampling, reproducibility of the predilution and high odour concentrations).

Under consideration of the measurement errors and the uncertainty of the measuring method (unfortunately, the data collected during heating-up of brew 2 could not be used), it can be said that with this method a reduction in odour intensity by at least 70 percent is achieved. Fig. 5 shows the curves for the TOC measurements (determination of total carbon) in untreated vapours of a brew at Vereinsbrauerei Apolda:

Fig. 4 Ionization system in the staircase

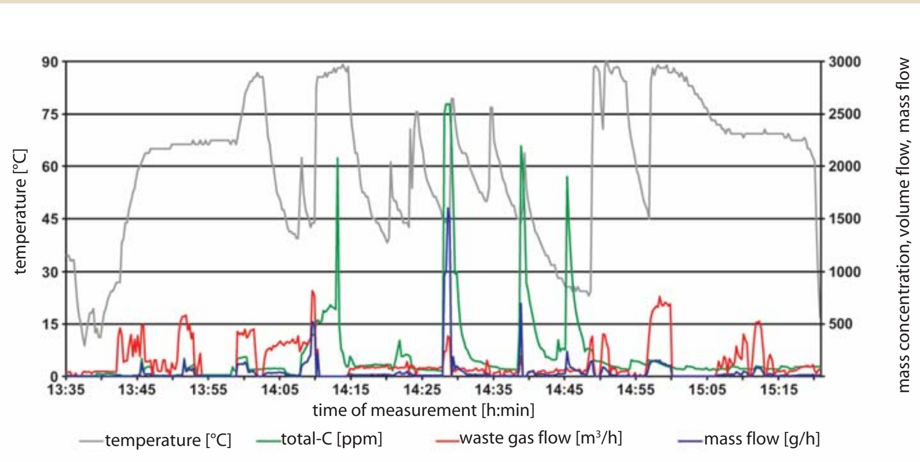

Fig. 5 Curves for the measurement of total carbon of brew 2 (measurements in untreated vapours = "raw gas")

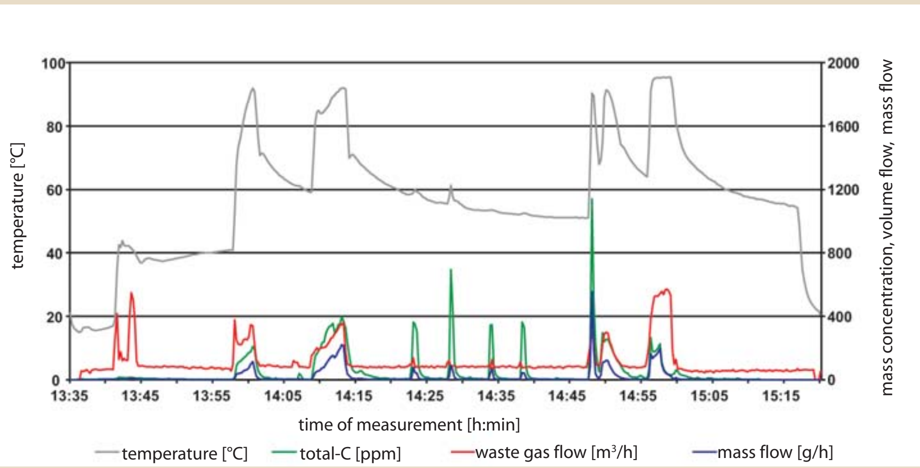

Fig. 6 Curves for the measurement of total carbon of brew 2 (treatment with ionized air = "clean gas")

During raw gas measurement (untreated vapours) in test brew 2, the exhaust gas volume flow (red curve) is subject to major fluctuations. Emission peaks between 300 and 2600 g/m³ TOC were detected. The highest odour intensity in connection with a low exhaust gas volume flow was measured during the pre-boiling phase (addition of hops) and the final pressure relief phase. The vapour temperature (grey) follows the curve of the mass flow of total carbon (blue). The maximum value of the total carbon mass flow is about 1580 g/h.

Fig. 6 shows the curve for the measurements of total carbon in vapours treated with ionized air:

During the clean gas measurement of test brew 2 (vapours treated with ionized air), the exhaust gas volume flow (red) increases considerably during pre-boiling of the wort kettle content (14:10 - 14:15), then decreases strongly and remains almost constant during the entire phase of dynamic low-pressure boiling. When the pressure relief phase towards atmospheric pressure begins, the exhaust gas volume flow increases again before the start of atmospheric post-boiling.

During the post-boiling phase, however, the value declines to the original level again (baseline). When cast-out is started, it rises to the maximum value of approx. 550 m^3/h for a short time. The maximum value of total carbon concentration of approx. 1150 g/m^3 is reached during the relief phase at the end of dynamic low-pressure boiling (14:47). During the remaining emission peaks, the values range between 200 und 680 g/m^3 total carbon. A maximum value of approx. 500 g/h was determined for the total carbon mass flow. The vapour temperature correlates with the curve of the exhaust gas flow (red) and that of the total carbon mass flow (blue).

The average TOC mass flow of 500 g/h specified in the Technical Directive on Clean Air is observed. With this method, the concentration value does not fall below the also requested limit of 50 mg/m^3 TOC (green, see total carbon [ppm]) [5]. Thus, the efforts to prevent, by political means, the application of the Technical Directive on Clean Air to brewhouse emissions should be continued.

Table 2 shows the reduction of total organic carbon in the vapour:

In contrast to the odour concentration, the organic carbon content in the vapour is only reduced by about 50 percent. According to TÜV, this phenomenon can be explained by the different odour threshold values of organic molecules in dependence on their chain length. When ionized air comes in contact with long-chain hydrocarbons in the vapour, decomposition products of different chain length are formed. These decomposition products are subjected to further oxidation reactions. Highly odorous, short-chain molecules are degraded faster. Thus, the influence on the olfactory impression is stronger than that on the analytically determinable content of organic carbon.

Summary

With the installation of an ionization system at Vereinsbrauerei Apolda, the original intensity of odour emissions from wort boiling could be reduced by at least 70 percent. During a walk through the brewery's neighbourhood, the subjectively perceived reduction in odour intensity was at least 90 percent.Thus, the longstanding conflict between the brewery and the residents could be resolved with a comparatively cheap installation for odour reduction.

ODOUR INTENSITY [%] WITH AND WITHOUT THE IONIZATION SYSTEM

Process	Heating		Atmospheric post-boiling	
	ionization system		ionization system	
	OFF	ON	OFF	ON
Brew 1	100	16.7	100	4.9
Brew 2	-	-	100	3.5
Brew 3	100	14.3	100	10

Table 1

TOTAL CARBON IN WORT VAPOURS [%] WITH AND WITHOUT THE IONIZATION SYSTEM

Process	Heating		Atmospheric post-boiling	
	ionization system		ionization system	
	OFF	ON	OFF	ON
Brew 1	100	67	100	38
Brew 2	100	45	100	48
Brew 3	100	42.6	100	33

Table 2

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