Latest developments in high efficiency biofiltration

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ABSTRACT. High performance biofilters do not only have to convince by their constructional details, their high reliability and permanent high degrees of effectiveness but primarily by the coherent integration of all units into compact, mobile containers. This offers two decisive advantages: In such a closed system the conditions can be exactly defined and controlled. Also, the containers can be merged for most different configurations and supplemented without problems when required. Fan and scrubber of varying constructions are just as problem-orientedly used as secondary crude gas conditioning techniques such as degreasing, particle elimination or cooling.

1 INTRODUCTION

In the early 60's the first open surface biofilters were being installed for the purification of odorous gases (Figure 1). Beginning within the rural range, afterwards increasingly used in technical production enterprises. For a long period of time these were considered as state of the art and were often modified and optimized. Borders for the usage of these open type biofilters were set by environmental influences the industry in particular demanded less uncertainties and more stability of operation. In the 90’s, intensive research proved that with a higher technical standard and selected elements the efficiency could substantially be improved. The totally enclosed modular bio filter was born.

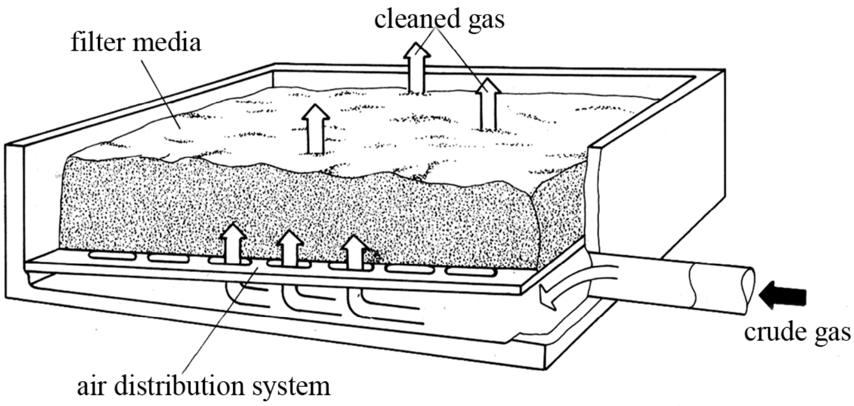

Figure 1. Outdated open type biofilter system.

2. HIGH PERFORMANCE CONTAINER MODULES

The method of biofiltration has proven to be a very economical and environmentally friendly technology to eliminate odours and VOCs in waste gases to a very high degree. As a result of intensive research in the early 90s, increasing numbers of modular biofilters are employed. By capsuling the biofilters no effects from the ambient will affect the conditions within the filter material. For the first time, it is possible to guarantee homogeneous and equalized conditions within the filter material. Other benefits of these modular systems are the possibility to stack up the modules in order to gain floor space and to enlarge the biofilter plant in cases of a increasing production. The next step was the invention of the automatical change of flow direction in connection with the moistening of the filter material.

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Figure 2. DaimlerChrysler AG, Airflow 160.000 m^3/h.

Figure 3. Enclosed biofilter system at a starch production plant to treat 45.000 m^3/h.

2.1. Typical applications

Breweries
Sewage works, dump gas disposal
Foundries
Coffee & cocoa roasting
Purification plants
Composting plants
Mechanical biological composting plants
Plastic recycling plastics processing
Food industry
Milk processing
Mushroom breed
Smokehouses, Slaughterhouses
Rendering plants

Figure 4. DaimlerChrysler; Multi-Stage Biofilter, Airflow 100.000 m^3/h.

3 MULTI STAGED HIGH PERFORMANCE BIOFILTER MODULES

Meanwhile, the latest state of technology is presented by dividing the biofilter module into separate chambers. By doubling the velocity of the flow within the filter layer the airflow is transformed from laminar to turbulent. In this case the mass transfer of pollutants from the waste gas into the filter layer is at a much higher level. A limitation of the compound degredation becomes obsolete. The remaining limitation is the degradation velocity of the microorganisms. Apart from this, the operational reliability is increased as well. A break through of waste gas in fact of a malfunction of the scrubbing system is minimized in fact of the two layers of filter material which have to be passed. In very special cases it is possible to triple the biofilter stages. Using a coarse filter material in the first stage, particles like dust or microorganisms can be separated.

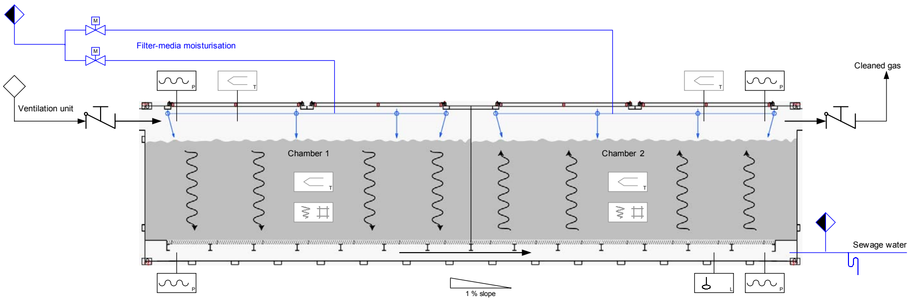

Figure 5. Conceptual drawing of a multi-staged biofilter.

Successes of first industrial applications in the most different ranges like the VOC-elimination in the painting and coating industry, the starch production, the foundry industry and the mechanical biological garbage treatment confirm this development. Thus, the degree of elimination efficiency depends substantially on the efficiency of the micro-organism population. Here is, where the optimization potentials of the future are.

Figure 6. Municipal waste treatment; Multi-Stage Biofilter, Airflow 80.000 m^3/h.

Spatially separated functional areas are achieved by the division into two or more parts of the biofilters. Many degrading processes run off next to each other. By spatial separation, disassembly processes that could not run next to each other unhindered before, can now be fully completed in different chambers. By the division into two parts the possibility further exists to regulate the respective compartments each on its own. For example, the pH value, amount of moisture within the filter material as well as a special nutrient cocktail can be offerd to different types of micro-organisms. These biofilters already show an obvious increase of reliability and are prone against break-through.

Figure 7. BMW AG. Multi-Stage Biofilter, Airflow 6.000 m^3/h.

3.1. Typical applications
Chemical industry
Paint shops
Volatile organic components emitting industry

4. INTELLIGENT CONTROL SYSTEMS

The water content of the filter material is the most important parameter for the efficiency of a biofilter and at the same time the most difficult parameter to measure and to control. Both for the absorption of the pollutants and for the vitality of the micro-organisms water is the "key element" in biological exhaust air purification. Sufficiently high moisture as well as a homogeneous and even distribution of moistness in the filter media is of highest importance. If some parts of the filter material run dry, tears and channels will form in which the only insufficiently purified exhaust air is passed through. Since the pressure loss in these places is obviously reduced, an increased flow connected with a further break-through and/or short-circuit flow will occur. This dry filter material develops hydrophobic surfaces, which can only be remoistened with great efforts. Changing the filter material is often inevitable and causes considerable costs. Therefore, biofilters are usually very generously dimensioned, usually with an addition of 100% on the calculated surface. If a reliable moisture monitoring and control within the filter material could be guaranteed, biofilters could be dimensioned smaller and would be accordingly more economical in many cases.

An absolute novelty is presented by the modular control system for biological installations. During the operation of biofilters, problems mainly arise if the filter material gets too wet or too dry. Up to now, it had not been possible to permanently determine the humidity of biofilter material with sufficient accuracy. By making use of intelligent control methods, ideal and stable operating conditions and compliance with the highest degrees of efficiency are achieved. For instance, as the moisture within the filter media of biofilters can only be measured by making use of very complex methods, a different approach was developed. For the first time, cost-efficient sensors to measure the humidity distribution and air current allocation within the filter material are deployed. The data of this three-dimensional view is also included into the control system.

Figure 8. Intelligent control systems enable the operator to take a look inside the "black-box" biofilter.

These developments have all in all increased the efficiency of biofiltration at significant dimished space capacity. Meanwhile it is possible to run such a system to the fivefold loading in comparison to a conventional biofilter without any loss of efficiency.

It is task of process engineers to ensure optimal living conditions for micro-organisms within biological exhaust air purification plants in order to obtain a high efficiency of removal and to ensure a stable operating mode. However, controlling and an influencing the biological process is not as easily realised in "living" plants as it is in purely technical plants. Rising requirements of the cleaning grade, which can be achieved by biological waste air purification plants, require operational methods with increased reliability and high process stability. To meet these demands, a measuring and a control system has to be developed which particularly integrates the parameter "filter-media moisture" into the control system.