D E S C R I P T I O N

# Sorption filter

## Field of the invention

The current invention relates in general to a sorption filter design. In particular, the invention relates to such a filter construction which enables the extraction of material samples without disrupting the operation of the filter or without destroying the entire filter construction. The invention also relates to a filtering process with said filter construction.

## Background of the invention, prior art

The removal of traces of gaseous substances as undesired addition to the air is of critical importance in many industrial applications as well as in applications related to object and personal safety.

Well known examples are found in the treatment of the escaping air in production processes as well as the treatment of the supply air and circulating air in production processes, as in the production of semiconductor structures or in the production of pharmaceutical substances in a clean room environment.

Examples for the removal of gaseous contaminations concern a multitude of substances from the family of organic compounds, even such substances that superficially do not react chemically, for instance with products or with the production equipment. Further examples concern alkaline reacting inorganic or organic substances such as ammonia or amines as well as acidic reacting

inorganic or organic substances such as hydrogen chloride or acetic acid.

For the protection of products, production equipment and operators from such substances a multitude of sorption filter systems and sorption material systems have been developed. The functionality of said systems is always based on the principal of removing all undesired impurities from the air that streams through said systems. Said impurities are therefore either specifically or non-specifically permanently bound to the sorption material whereby the air with its constituents such as nitrogen, oxygen, inert gases as well as carbon dioxide can pass through the filter unchanged.

The patent DE 38 13 563 A1 describes an adsorption filter with a high air permeability, comprising a mainly form stable, three dimensional carrier structure, on which a layer of granular adsorption particles of sizes between 0.1 to 1 mm is attached. The carrier structure can be constructed of wires, mono filaments or bars but can also consist of large-pored reticulated PUR foam.

US patent A-5,616,169 discloses an odor and contaminant filter that does not contain any sealing and frames comprising an air permeable carrier material based on large-pored reticulate PU foam on which the adsorption material is attached with the help of an adhesive. The adsorption filter layer can also comprise a multilayer of adsorption filter layers.

The consequence of the sorption of trace substances by specifically selected sorption materials is the step by step

loading of said specific sorption materials with the target substances.

Since all sorption materials, as long as they can are not regenerated in-situ, i.e. via a flushing process, have a limited and finite sorption capacity, the performance of said sorption materials in filter constructions decreases over time.

Knowledge concerning the already used total sorption capacity is a critical parameter for the evaluation of the remaining, usable service life of a filter construction.

This complies even more, where the incoming and outgoing concentrations of damaging trace gases are so small that they can not be directly and immediately detected with standard measuring systems.

In such situations to the typical accumulation and increased concentration of adsorbed substances is the necessary initial step in order to collect a critical amount to determine the contamination and quality of the air.

In this case, the determination, also time resolved, of the total amount of adsorbed substances within the filter constructions is an important control parameter for the safe and economic operation of production processes.

The determination of said contamination levels requires in general the extraction of a sample from the sorption material which is subsequently analyzed in a laboratory. In many cases the extraction of a sample results in the destruction of the filter system.

Sorption filters themselves often consist of a body and structure suitable to carry bulk sorption material, where the shape is determined by the densest packaging of the sorption material after filling or ballasting.

Typically the sorption filter is a 2-dimensional body and structure, which is arranged perpendicularly to the direction of the air flow of the air to be cleaned. In the direction of the air flow the target substances are adsorbed by the sorption material which results in a so called loading profile, i.e. a distribution of the substances over the depth of the body.

For the above mentioned evaluation of the service life, the loading profile must be determined over the entire depth of the body, since only the complete information can be evaluated. Therefore, samples must be taken representatively from the depth of the body in order to carry out a targeted and traceable loading analysis of the respective layers.

This traceable sampling as a function of the individual layers currently represents a nearly impossible problem for most sorption filters and sorption materials. The current sampling process results, in general, in the destruction of the entire filter structure, such as of the enveloping structure or the damaging of the sorption bed or sorption structure which are irreparably destroyed.

As a consequence the determination of the service life is therefore only possible by sampling, and consequently destroying an entire sorption unit. Considering the very small sample sizes that are required this current process represents a solution that is economically not viable, taking into account that

filters are high quality products consisting of specific and valuable sorption material.

Summary of the invention

It is therefore the objective of the current invention to provide a sorption filter that enables the representative sampling without destroying the entire structure prior to its expected service life.

These and further objectives are solved by the filter construction according to claim 1 and the sample body according to claim 7. Further advantageous embodiments are disclosed in the dependent claims.

Detailed description of the invention

The solution according to the invention comprises a sorption filter construction, which is built-up in layers of flexible filter media, in which one or many sample bodies of the same material are inserted exchangeably and layer representative, which means that the sample body exhibits the same series of material layers as the surrounding filter body.

The sample layers can be of equal thickness or they can have different thicknesses.

The sample body(ies) preferably contain an extraction help, preferably a pull-out loop, which penetrates the layered sample body completely and at the same time connects and holds the layers of the sample body together in a specific form, which means in the original layer order.

Preferably the sample body shows, in respect of the flow resistance, an identical flow characteristic as the filter body. In a further advantageous embodiment of the sample body according to the invention the sample bodies exhibit a 20-30%, preferably 25% lower flow resistance than the filter material.

The production process of the sample body, for example via stamping out of the filter medium during the production of the sorption filter, as well as the design of the pull-out loop do not restrict the permeability or the loading characteristics of the sample body. The sample body, such as the surrounding filter material, takes part in the cleaning process and is thereby loaded in a representative manner.

At a specific predetermined or random point in time the sample body is pulled out of the filter structure. The resulting stable space is replaced with a new, unused sample body with pull-out loop. Said sample body is available for examination at a later point, for example when the additional loading since the time of insertion is of interest.

In the most advantageous case, for example in sporadic occurrence of air pollution, it is possible to extend the life of the sorption filter beyond its specified date by regularly monitoring the sample bodies. This saves valuable resources.

In a further advantageous case, for example after an unexpected and not completely detectable leakage, a highly contaminated sorption filter can be detected and replaced before the continuous usage of said sorption filter results in a sudden break through which could result in danger or in damages to the production process.

The described advantageous embodiment of the sample body is also of advantage in structures where a layered build-up of the sorption filter based on the usage of different media was chosen and loading of the specific media is different for different impurities in the air. Therefore it is always possible to monitor the critical service life of the sorption filter with respect to each contamination present in the relevant filter medium, independent of the position of said layer located within the multi layered filter structure.

Example 1 Figure 1

In this example a slab formed sorption filter 10 with a total height of 85 mm and outer dimensions of approximately 530 x 380 mm was produced. The filter 10 comprised an all enclosing, U-profile of approximately 1,5 mm thick aluminum sheet metal (not shown) in which 4 identical layers of a PU foam based filter medium 12 of 20 mm thickness each were introduced. Other filter materials are naturally also conceivable and recognizable for a person skilled in the art. The layers of the filter medium contained 3500 $g/m^2$ of a spherical activated carbon, which was attached to the bars of open pored PU support foam using a well-know PU adhesion technique.

The sample bodies 14 comprised a three layered layering of round, stamped out pieces each of 5 mm in diameter from the filter medium, where the three layers were firmly connected to one another by a pull-out loop 16 made of nylon wire (for simplicity only shown once). The sample bodies 14 were inserted and tightly fitted, without further sealants, into prepared, stamped out openings 18 of the filter body 10 which extended from the side where the air first hits the filter (arrow 20)

into the depth of the filter. The last layer of the filter was not opened by the stamping process in this example since no sampling of said last layer was envisaged.

The entire filter body comprised three sample bodies 14 with equal characteristic, that were evenly distributed over area.

The sorption filter 10 was continuously streamed with a volume of 350 $m^3/h$ over a period of 12 month. Due to the specific sorption characteristic of the employed activated carbon the filter nearly exclusively precipitated components from the family of organic substances. Every four month a sample body was extracted from the filter body and was replaced by a similar, unused sample body. The analysis of the sample body demonstrated the increasing loading of the filter layers with organic compounds, in this case mainly from the group of the aromatics and acetic acid ester, but also organophosphates. Due to the fact that the organophosphates, which are a critical compound in the determination of the total operation time of the filter, could only be detected after a period of 12 month in the third layer of the filter, i.e. in the penultimate layer of the filter body, the service life of the filters could be confidently extended from an estimated 8 months to 12 months.

Example 2 (fig.2)

In this example a six layered filter body 22 comprising three layers 24 of an ammonia precipitating material A as well as three layers 26 of an acid precipitating Material B, was built-up on the basis of filter foams. In this case the layers 24 of the ammonia precipitating materials A formed the site, that is first hit by the incoming air (arrow 28) of the filter body 22

and the layers 26, used for the precipitation of acids, formed the site where the air dispersed from the filter body. Due to the varying degree of contamination of the air with ammonia and acid traces that needed to be filtered any predictions about the service life of the filter needed to be supported by analysis from a test run, where both kinds of filter material were analyzed.

The entire filter body 22 with dimensions of 800 x 485 x 120 mm comprised three sample bodies 30 (only one of which is shown in figure 2) that were, as planned, analyzed in 4 month intervals.

The first two analysis indeed showed a stronger loading of the ammonia precipitating layers per period, which, with respect to the remaining performance specification, were considered to be non critical. The third analysis however showed a sudden increase in the loading of the acid precipitating layers with sulfate ions which could be related to an undetected loading of the filter due to sulfur dioxide or sulfuric acid. Due to this analysis the filters could be changed in time before the optical components, that were stored below the filters, were permanently damaged. Due to the layered structure of the sample body it was also possible to investigate layers located in the depth of the filter which are normally unreachable for any analysis.

**C L A I M S**

1. A sorption filter (10, 22) comprising a multitude of super imposed single layers (12, 24, 26) of a filter medium on the basis of a compound material, **characterized in that** the removable sample structures (14, 30) are envisaged in the air flow direction (20, 28) within the filter material which consist of the same compound material and extend over at least a thickness of a single layer in the flow direction of the filter (10).

2. Sorption filter according to claim 1, **characterized in that** the compound material is a PU foam.

3. Sorption filter according to claim 1 or 2, **characterized in that** the single layers have an equal layer thicknesses.

4. Sorption filter according to claim 1 or 2, **characterized in that** the single layers have different layer thicknesses.

5. Sorption filter according to one of the preceding claims, **characterized in that** it comprises two to six single layers (12, 24, 26), preferably three to four single layers, of the filter medium.

6. Sorption filter according to one of the preceding claims, **characterized in that** it comprises at least one sample body (14, 30), preferably up to four sample bodies, regularly distributed over the filter area.

7. Sorption filter according to one of the preceding claims, **characterized in that** all single layers (12) consist of the same material.

8. Sorption filter according to one of claims 1 to 5, **characterized in that** the single layers (12, 24, 26) consist of two or more materials comprising different, specific precipitation characteristic.

9. Sample body (14, 30) for insertion in a sorption filter (10) according to one of claims 1 to 8, **characterized in that** it comprises an identical flow characteristic as the filter body with respect to the flow resistance.

10. Sample body (14, 30) for insertion in a sorption filter (10) according to one of claims 1 to 8, **characterized in that** it comprises a 20-30%, preferably 25% lower flow resistance with respect to the filter body.

11. Sample body (14, 30) according to one of claims 9 or 10, **characterized in that** all filter layers (12, 24, 26) are connected via a pull-out mechanism (16).

12. Sample body (14, 30) according to claim 11, **characterized in that** the pull-out mechanism (16) completely penetrates the sample body (10, 22) and holds the individual layers (12, 24, 26) together.

13. Sample body (14, 30) according to claim 11 or 12, **characterized in that** the pull-out mechanism (16) is a pull-out loop.

14. Method for filtering gaseous substances from the surrounding air, **characterized in that** for the filtration a sorption filter according to one of claims 1 to 8 is used.

15. Method according to claim 14, **characterized in that** the sample bodies are produced during the production of the sorption filters via a stamp out process of the filter medium.

16. Method according to one of claims 14 or 15, **characterized in that** the sample bodies are removed at specific times from the filter structure and are replaced by a similar, unused sample body.