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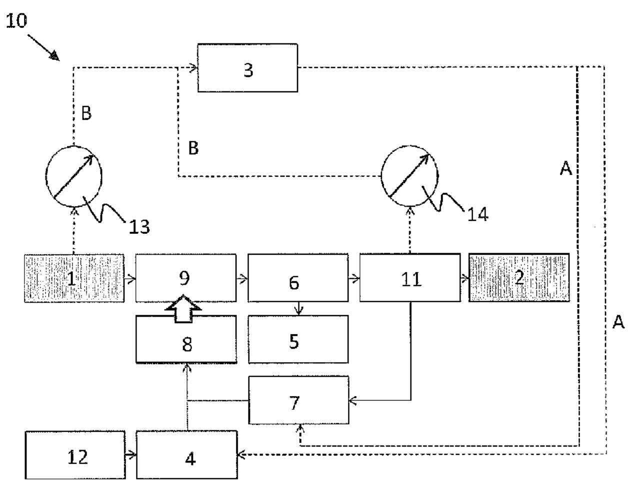

FIG. 1

(57) Abstract: The invention relates to a process and a biofilter system (10) for removing H_2S from a H_2S contaminated energy production gas stream containing methane. The aqueous biofilter system comprises a biofilter (6) having biofilter support material constituting a biofilter bed supporting a humidified biofilm having microorganisms that are capable of oxidizing H_2S. The process comprises the steps of contacting the H_2S contaminated energy production gas stream with the microorganisms of the humidified biofilm, and oxidation of at least part of the H_2S in the H_2S contaminated energy production gas stream by the microorganisms, resulting in a H_2S depleted energy production gas stream, wherein the process further comprises the step of adding an aqueous nitrate solution to the H_2S contaminated energy production gas stream prior to being contacted with the microorganisms, enabling the microorganisms to oxidize the H_2S under anoxic conditions. The invention furthermore relates to the use of such a biofilter system (10) in the removal of H_2S from a H_2S contaminated energy production gas stream containing methane.

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PROCESS AND BIOFILTER SYSTEM FOR H_2S REMOVAL FROM A H_2S CONTAMINATED ENERGY PRODUCTION GAS STREAM CONTAINING METHANE AND USE OF SUCH A BIOFILTER SYSTEM

FIELD OF THE INVENTION

The invention relates to a process for removing H_2S (hydrogen sulphide) from a H_2S contaminated energy production gas stream containing methane, using an aqueous biofilter system comprising a biofilter having biofilter support material constituting a biofilter bed supporting a biofilm having microorganisms that are capable of oxidizing H_2S. The process therewith comprises the steps of contacting the H_2S contaminated energy production gas stream with the microorganisms and oxidation of at least part of the H_2S in the H_2S contaminated energy production gas stream by the microorganisms, resulting in a H_2S depleted energy production gas stream.

Examples of such H_2S contaminated energy production gases containing methane are biogas, natural gas or shale gas, these examples however not being limitative.

Biogas is a mixture of gases that is produced by the biological breakdown of organic matter in the absence of oxygen. Biogas is produced through the anaerobic digestion or fermentation of biodegradable material such as biosolids, manures, sewage, municipal waste, green waste, plant material and energy crops. Biogas is comprised primarily of methane and carbon dioxide.

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane. It commonly furthermore includes varying amounts of other higher alkanes and lesser percentages of carbon dioxide, nitrogen and hydrogen sulphide.

Shale gas is a natural gas that can be found trapped within shale formations. Shale gas is extracted from fine-grained sedimentary rocks known as shale that can be rich sources of petroleum and natural gas. This gas is trapped within shale formations which are extracted by technology-oriented processes.

When biofilter systems are applied as air or other gas stream treatment systems, these biofilter systems use microorganisms to remove impurities or contaminants in the air or gas stream. In a typical biofilter system, an air or gas stream is urged to flow through a moist, biologically active, packed biofilter bed consisting of biofilter support material containing microorganisms that are immobilized on the biofilter support material and forming a biofilm on the biofilter support material.

The process underlying the operation of the biofilter is a three-step process. In a first step, a phase transfer occurs wherein impurities in the air / gas stream such as H_2S are transferred from the gaseous phase to the liquid phase, i.e. to the aqueous solution used to humidify the biofilm. This first step is followed by a second, adsorption step wherein, once in the liquid phase, the impurities are absorbed to the biofilter support material of the biofilter bed. Finally, in a biodegradation step, the impurities are biodegraded by the microorganisms of the biofilm.

The invention furthermore relates to an aqueous biofilter system arranged to remove H_2S from a H_2S contaminated energy production gas stream containing methane. The aqueous biofilter system therewith comprises a biofilter having biofilter support material constituting a biofilter bed supporting a biofilm having microorganisms capable of oxidizing H_2S, the biofilm being arranged to be contacted with the energy production gas stream and the microorganisms being arranged to remove at least part of the H_2S out of the energy production gas stream resulting in a H_2S depleted energy production gas stream.

The invention also relates to the use of an aqueous biofilter system according to the invention for removing H_2S from a H_2S contaminated energy production gas stream containing methane.

BACKGROUND OF THE INVENTION

Since energy production gas such as biogas is produced with the purpose of energetic use, the gas quality needs to meet the technical requirements of combustion engines. Impurities (or contaminants) such as H_2S are found in concentrations between 1.000 to 10.000 ppm, while combustion systems require typically concentrations lower than 200 ppm of H_2S.

The most common technologies to remove H_2S from biogas are processes that are downstream of the production step. Often physio-chemical processes as wet gas oxidation are used. However, these have high investment and operational costs.

Biological gas treatment processes are based on microbial digestion of contaminants in the biological gas. Established systems for this purpose are bioscrubbers, biotrickling filters and biofilters. In general, biofiltration uses naturally occurring microorganisms to biologically break down odors, solvents and other VOCs (volatile organic compounds) present in air streams such as waste air streams or gas streams such as energy production gas streams, into carbon dioxide and waste water. It is a completely natural process that does not use chemicals or produce waste. Biofiltration is a reliable and cost-effective way to eliminate odors, VOCs and H_2S at manufacturing, municipal and processing facilities. The microorganisms which reside on the surface of the biofilter support media forming a biofilm use the pollutants as a food source. A cleaned air gas stream is then discharged to the environment. Biofiltration systems need to be run without strong variations in turnover of gas and contaminants as the microbial community reacts slowly on changes and has to be balanced.

The use of biofilter systems in removal of contaminants such as, amongst others, H_2S from air and gas streams has already been known for a long time. In US 4,086,167 for instance, already dating from 1978, a biofilter for treatment of waste waters and gases, comprising a bed of coniferous tree barking residue containing microorganisms, is disclosed.

Since that time, the technology of biofiltration has been developed according to VDI guideline 3477 describing today's standards. The latest developments in biofiltration technology have amongst others been summarized in the book titled "Air pollution prevention and control: bioreactors and bioenergy", edited by Christian Kennes and Maria C. Veiga, published 2013 by John Wiley & Sons, Ltd.

Z. Shareefdeen and A. Singh (Ed.) "Biotechnology for Odor Air Pollution Control", Springer-Verlag (2005) have in Table 8.2, page 171 given an overview and comparison of different technologies for waste gas treatment. These are three different processes where the present invention is of the biofilter type which is a "dry" process. Biotrickling filters are operated with a wet through biofilm and in a bioscrubber process the biofilm is immersed in liquid.

8 Bioscrubber Technology

Table 8.2. Comparison of major technologies for waste gas treatment

Characteristics	Biofilter	Biotrickling filter	Bioscrubber
Reactor design	Single reactor	Single reactor	Two reactors
Capital and operating cost	Low	Comparatively higher	Comparatively higher
Carrier	Organic or synthetic	Synthetic	No carrier
Area	Large area required	Compact equipment	Smaller volume of equipment
Mobile phase	Gas	Liquid	Liquid
Surface area	High	Low	Low
Process control	Limited process control	Limited process control	Good process control
Gas flow rate	100–150 $m^3 m^{-2} h^{-1}$		3,000–4,000 $m^3 m^{-2} h^{-1}$
Operation	Easy startup and operation	Relatively complicated startup procedure	Relatively complicated startup procedure
Operational stability	Channeling of airflow common	Channeling of water is common	High operational stability
Pressure drop	Medium to high	Medium to high	Low
Target compound conc.	$< 1 g m^{-3}$	$< 0.5 g m^{-3}$	$< 5 g m^{-3}$
Suitable for compounds with Henry coefficient	< 1	< 0.1	< 0.01
Nutrients	Nutrients cannot be added	Ability to add and control nutrients	Ability to add and control nutrients
Biomass	Fixed biomass	Fixed biomass	Suspended biomass
Clogging of packing	Clogging problem	Clogging problem	No clogging problem
Excess sludge	No such problems	Disposal of excess sludge required	Disposal of excess sludge required

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Also, several more recent patent documents describe the use of biofilter systems in the removal of contaminants out of air and gas streams, more specifically in the removal of H_2S, and more specifically out of H_2S contaminated energy production gas streams containing methane.

In WO 2005/037403 for instance, a biofilter media is disclosed including grains having a hydrophilic nucleus and a hydrophobic coating including microorganisms and a metallic agent that both assist in the breakdown of amongst others H_2S. The biofilter media is housed in a biofilter system including elements for the irrigation and humidification of the air stream of the biofilter media by steam or spray to ensure that the biofilter media is operating at appropriate temperature and moisture levels to avoid build-up of biomass or chemical deposits. The nutrients required for microorganism viability are therewith present in the hydrophobic coating, this preferably as a blend of trace elements. The disadvantage of the system as disclosed in WO 2005/037403 for providing the nutrients required for microorganisms viability in the hydrophobic coating is that the nutrients are not renewed once the nutrients as present in the hydrophobic coating are exhausted.

In WO 2005/005605, a system for removing H_2S from methane (CH_4) is disclosed which uses aerobic microorganisms to remove the hydrogen sulphide from the gas stream and oxidize it back to sulphate, which will then combine with water to form sulphuric acid. The system includes providing at least one biofilter cartridge that functions to sustain microbial activity which will function to consume H_2S contained in a stream of methane gas.

Since aerobic microorganisms need an electron acceptor to be able to oxidize H_2S, and in a methane gas stream, no such electron acceptors are present in sufficient amounts, air has to be injected in the biofilter cartridge as described above in order to provide oxygen to be used as the electron acceptor. As air is injected, also plenty of nitrogen is introduced into the gas stream, i.e. around 78%, diluting the methane gas and disturbing the quality thereof.

Also in US 2012/0264197, a process for removing hydrogen sulphide from a raw natural gas stream such as biogas from landfills or controlled anaerobic digestion is disclosed using oxygen, commonly in the form of air, to remove the H2S out of the raw natural gas stream. In order to solve the abovementioned problem, the natural gas stream is therewith passed through a separation unit to form on the one hand, a product stream comprising a high concentration of methane and on the other hand, a low pressure tail gas containing H_2S which is passed through a biofilter including bacteria that degrades the H_2S to sulphur and sulphate compounds that are washed from the biofilter.

Such a process however requires more costly equipment.

Therefore, there exists the need to provide a simple and cost effective but at the same time efficient way to remove H_2S from a H_2S contaminated energy production gas stream containing methane using a biofilter system, furthermore maintaining the quality of the treated (H_2S depleted) energy production gas stream.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, a process is provided for removing H_2S from a H_2S contaminated energy production gas stream containing methane, using an aqueous biofilter system, comprising a biofilm having biofilter support material constituting a biofilter bed and supporting a humidified biofilm having microorganisms that are capable of oxidizing H_2S, wherein the process comprises the steps of

- contacting the H_2S contaminated energy production gas stream with the microorganisms of the humidified biofilm, and

- oxidation of at least part of the H_2S in the H_2S contaminated energy production gas stream by the microorganisms, resulting in a H_2S depleted energy production gas stream,

wherein the process further comprises the steps of adding an aqueous nitrate solution to the H_2S contaminated energy production gas stream prior to being contacted with the microorganisms, enabling the microorganisms to oxidize the H_2S under anoxic conditions.

The term “anoxic” means “nearly in absence of, or in the presence of a very low amount of oxygen”, so that the oxidation reduction potential of the subsequent reaction ranges between 800 mV and -200 mV, preferably is about 400 mV.

For anoxic H_2S oxidation, about 2g NO_3- is needed to oxidize 1g H_2S according to the following chemical reaction:

$$5\ H_2S + 8\ NO_3^- \rightarrow 5\ SO_4^{2-} + 4\ N_2 + 4\ H_2O + 2\ H^+$$

The abovementioned single step process using a biofilter system provides a simple and cost effective way to obtain a H_2S depleted energy production gas stream. Furthermore, by oxidizing the H_2S under anoxic conditions, the inflow of nitrogen in the biofilter system is limited, through which the quality of the energy production gas stream after treatment with the biofilter is maintained.

In the biofilter support material, the microorganisms generate inert agents as well as other substances, i.e. mainly elemental sulphur, insoluble sulphate salts, formed by the microorganisms through the anoxic oxidation of the H_2S such as calcium sulphate and/or organic sulphur compounds that precipitate in the biofilter support material. In order to prevent clogging of these inert precipitating agents and other substances, the nitrate solution comprises a chelating agent.

For prevention of clogging of calcium sulphate precipitation, this chelating agent preferably comprises ethylene diamine tetra acetic acid (EDTA).

The nitrate solution that is used to enable the microorganisms to anoxically oxidize H_2S preferably comprises a calcium nitrate solution.

In an advantageous embodiment of a process according to the invention, the process comprises the step of recirculating part of the H_2S depleted energy gas stream to the biofilter and adding to the recirculated energy production gas stream a nutrient solution prior to being contacted with the microorganisms of the biofilm.

This recirculation is beneficial for the biofilter system since the H_2S depleted energy gas stream, once passed through the biofilter support material, contains microorganisms, originating from the biofilm, and as a result of the recirculation, these microorganisms will also be reintroduced into the inlet of the biofilter system again. This increases the oxidation activity of the microorganisms in the entry area of the biofilter system, what would not be the case in the case of absence of recirculation.

In a more advantageous embodiment of a process according to the invention, the process comprises the step of automatically adjusting the dosage of the nutrient solution, added to the H_2S contaminated energy production gas stream, in relation to the H_2S content in the H_2S contaminated energy production gas stream at an inlet of the biofilter system.

In a favourable embodiment of a process according to the invention, the biofilm is humidified by means of the energy production gas stream which has been pre-humidified prior to contacting the biofilm.

According to a further aspect of the invention, an aqueous biofilter system is provided that is arranged to remove H_2S from an H_2S contaminated energy production gas stream containing methane, the aqueous biofilter system comprising a biofilter having biofilter support material constituting a biofilter bed and supporting a biofilm having microorganisms capable of oxidizing H_2S, the biofilm being arranged to be contacted with the H_2S contaminated energy production gas stream and the microorganisms being arranged to remove at least part of the H_2S of the H_2S contaminated energy production gas stream, resulting in an H_2S depleted energy production gas stream, wherein the aqueous biofilter system comprises means for adding an aqueous nitrate solution to the H_2S contaminated energy production gas stream prior to being contacted with the microorganisms of the biofilm, enabling the microorganisms to oxidize the H_2S under anoxic conditions.

In a preferred embodiment of an aqueous biofilter system according to the invention, the means for adding an aqueous nitrate solution to the H_2S contaminated energy production gas stream comprise an atomizer nozzle adapted to atomize the nutrient solution into the energy production gas stream.

In the preferred embodiment according to the invention where part of the H_2S depleted energy production gas stream is recirculated, and an atomizer nozzle is used to atomize the nutrient and / or the nitrate solution, this recirculation will ensure that the atomization of the nutrient and / or the nitrate solution into the energy production gas stream produces a very fine droplet size. Pure hydraulic injectors can for instance not provide such fine aerosols. In this way, because the nutrient and / or the nitrate solution are applied as fine droplets in the energy production gas stream, the nutrient and / or the nitrate solution will reach the microorganisms of the biofilm evenly. Also fouling and over-wetting of the biofilm is prevented in this way. In the known standard systems, solutions are not evenly sprayed over the biofilm since these solutions are only sprayed from a few points in the biofilter above the biofilter bed onto the biofilm.

In an advantageous embodiment of an aqueous biofilter system according to the invention, the biofilter system comprises a controller that is arranged to

- measure the H_2S content in the H_2S contaminated energy production gas stream present in the operational state of the biofilter system at the inlet of the biofilter,

- calculate the nutritional demand for the microorganisms, and

- adjust the nutritional dosage ratio of a carbon source, a nitrogen source and a phosphor source of the nutrient solution equalling to 100 : 10 : 1.

In one embodiment, the controller can be arranged to adapt simultaneously the dosage of the nitrogen and the phosphor source in the nutrient solution.

In another embodiment, the controller can be arranged to adapt the dosage of the nitrogen and the phosphor source in the nutrient solution separately.

The controller is preferably furthermore arranged to calculate a demand for re-circulation of the part of the H_2S depleted energy gas stream and to adjust the re-circulation of the part of the H_2S depleted energy gas stream in view of the demand of the nutrients solution.

The controller is also preferably further arranged to dose the nutrients solution automatically in function of the H_2S content in the H_2S contaminated energy gas stream that is measured at the inlet according to a relation between the H_2S -content in the energy gas stream, the nitrogen content and the phosphor content in the nutrient solution equalling to 20 : 10 : 1.

The aqueous biofilter system according to the invention is preferably arranged to perform a process according to the invention as described above.

According to another aspect of the invention, the use of an aqueous biofilter system according to the invention as described above for removing H_2S from a H_2S contaminated energy production gas stream containing methane is disclosed.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 shows a scheme of the different parts of an exemplary embodiment of an aqueous biofilter system according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The process according to the invention for removing H_2S from a H_2S contaminated energy production gas stream containing methane, uses an aqueous biofilter system comprising a biofilter having biofilter support material constituting a biofilter bed which supports a humidified biofilm. This humidified biofilm has microorganisms that are capable of anoxically oxidizing H_2S.

It is herewith remarked that the exact type or configuration of the biofilter support material, neither the type of microorganisms, nor the exact type of biofilter support material, nor the configuration of the biofilter bed used is critical to this invention, as long as the biofilter is capable of oxidizing the H_2S in the energy production gas stream under anoxic conditions, resulting in a H_2S depleted energy production gas stream.

A variety of materials can be used as the biofilter support material including peat, compost material, soil, activated carbon, synthetic polymers, synthetic hydrogels and porous rocks. The biofilter support material may furthermore take a variety of forms such as cylindrical pellets, spheres, Raschig rings, irregular shapes, hollow tubes or fibers. The biofilter support material needs to be wetable with an aqueous solution and the surfaces of the support material are preferably porous. The support material must be such that microorganisms adhere thereto.

Humidification of the biofilm is necessary because the moisture content of the biofilm plays an important role in the H_2S removal efficiency. It is common to use water to humidify the biofilm.

The process according to the invention comprises the steps of

- adding an aqueous nitrate solution to the H_2S contaminated energy production gas stream;

- contacting the H_2S contaminated energy production gas stream with the microorganisms of the humidified biofilm;

- anoxic oxidation of at least part of the H_2S present in the H_2S contaminated energy production gas stream by the microorganisms using the aqueous nitrate solution added to the H_2S contaminated energy production gas stream prior to being contacted with the microorganisms of the biofilm. In this way, after the H_2S contaminated energy production stream has passed through the biofilter system, a H_2S depleted energy production gas stream is obtained, meaning an energy production gas stream out of which the major part of the H_2S has been removed, preferably fulfilling the technical requirements of combustion engines as described above.

Any type of microorganisms, e.g. bacteria, can be used that are capable of oxidizing H_2S present in the H_2S contaminated energy production gas stream under anoxic conditions. Such standard and commonly used microorganisms in biofilter systems are known to the man skilled in the art and will not be listed and described in more detail here.

The biofilter bed can take on every shape that is known to the skilled person, such as a flat bed, trickle bed, column bed, tubular bed, etc.

The nitrate solution preferably comprises a calcium nitrate solution in order to allow the microorganisms to anoxically oxidize the H_2S. The concentration of the nitrate solution is preferably 45 weight% to 50 weight%.

In order to prevent clogging of inert precipitating agents and other substances formed through the anoxic oxidation of H_2S by the microorganisms, the nitrate solution comprises a chelating agent. To prevent, for instance, calcium sulphate (gypsum) precipitation, ethylene diamine tetra acetic acid (EDTA) is usable to solubilize calcium sulphate and other substances that might precipitate during the process.

The nutrient solution for the microorganisms is preferably added to the energy production gas stream, this prior to being contacted with the microorganisms in the biofilm, through which the nutrients become available to the microorganisms at the moment the energy production gas stream including the nutrient solution passes over the biofilm. To that end, preferably part of the H_2S depleted energy production gas stream is recirculated to the biofilter, together with the nutrient solution that is added thereto. Also the nitrate solution is preferably added to the recirculated part of the H_2S depleted energy production gas stream. The nutrient and / or the nitrate solution, together with the recirculated part of the H_2S depleted energy production gas stream, are preferably injected to the biofilter using an atomizer nozzle.

The nutritional dosage ratio of the nutrient solution is preferably automatically adjusted by measuring the content of the H_2S in the H_2S contaminated energy production gas stream at the inlet of the biofilter using a controller. The controller then calculates the nutritional demand for the microorganisms and adjusts the nutritional dosage ratio of a carbon (C) source, a nitrogen (N) source and a phosphor (P) source in the nutrient solution preferably according to the ratio 100 : 10 : 1. In order to optimize the working of the biofilter system, this ratio is preferably adjustable by means of the controller, resulting in a better performance of the biofilter system and a lower demand of chemicals.

The necessary demand of the nitrogen and the phosphor source in the nutrient solution with respect to the amount of H_2S in the H_2S contaminated energy production gas stream is preferably applied according to the relation H_2S: N : P = 20 : 10 : 1. The controller can therewith be arranged to adapt the dosage of the nitrogen and the phosphor source in the nutrient solution simultaneously, but can also be arranged to adapt the dosage of the nitrogen and the phosphor source in the nutrient solution separately.

The invention is herewith illustrated with the scheme as shown in figure 1 which illustrates a non-limiting exemplary embodiment of an aqueous biofilter system (10) for removing H_2S from a raw, H_2S contaminated energy production gas stream containing methane according to the invention.

The untreated, raw H_2S contaminated energy production gas stream (1) is injected by means of an atomizer nozzle (not shown on the figure) through a junction (9) into a biofilter (6). This biofilter (6) comprises a biofilter bed consisting of biofilter support material supporting a biofilm with microorganisms that are arranged to anoxically oxidize the H_2S present in the H_2S contaminated energy production stream (1) (as described above). At the end of the biofilter (6), a H_2S depleted (cleaned) energy production stream is obtained. This H_2S depleted energy production gas stream is passed through a splitter (11). The major part of this H2S depleted energy production gas stream is carried off to be used as energy production gas. A minor part of this H_2S depleted energy production gas stream is recirculated to the biofilter (6) to be injected by the atomizer nozzle at the junction (9) in the biofilter (6) together with a nutrient solution and / or a nitrate solution that is used to anoxically oxidize the H_2S in the H_2S contaminated energy production gas stream.

The nutrient solution preferably is a N/P solution that is stored in a nutrient solution tank (12) and that is applied in a predetermined dose using a nutrient dosage pump (4). The recirculated H_2S depleted energy production gas stream is brought from the splitter (11) to the injector (8) using a gas pump (7).

At (13), the temperature, H_2S content, the flow and the pressure of the inflowing H_2S contaminated energy production gas stream is measured. At (14), the temperature and the H_2S content in the outflowing H_2S depleted energy production gas stream is measured. As indicated by the dashed arrows (B) on figure 1, these measurements are sent to a controller (3). By monitoring the H_2S content in the H_2S contaminated energy production gas stream present in the operational state of the biofilter system at the inlet of the biofilter (6), the controller (3) is able to calculate the nutritional demand for the microorganisms of the biofilm, and adjust the nutritional dosage ratio of a carbon source, a nitrogen source and a phosphor source of the nutrient solution equalling to 100 : 10 : 1. By measuring the H_2S content at the outlet of the biofilter (6), the nutritional dosage ratio can be further adjusted. As indicated in figure 1 with the dashed arrows (A), the controller (3) is thereto provided to control the gas pump (7) and the nutrient solution dosage pump (4).

Since the biofilter (6) will produce some surplus sludge, mostly consisting of sulphuric acid from the anoxic oxidation of H_2S, this sludge is removed from the biofilter (6) as effluent (5).

This biofilter system (10) achieves an efficiency of 99.5% in H_2S removal from a H_2S contaminated energy production gas stream.

CLAIMS

1. Process for removing H_2S from a H_2S contaminated energy production gas stream containing methane, using an aqueous biofilter system (10) comprising a biofilter (6) having biofilter support material constituting a biofilter bed supporting a humidified biofilm having microorganisms that are capable of oxidizing H_2S, wherein the process comprises the steps of

- contacting the H_2S contaminated energy production gas stream with the microorganisms of the humidified biofilm; and
- oxidation of at least part of the H_2S in the H_2S contaminated energy production gas stream by the microorganisms, resulting in a H_2S depleted energy production gas stream,

CHARACTERIZED IN THAT the process further comprises the step of adding an aqueous nitrate solution to the H_2S contaminated energy production gas stream prior to being contacted with the microorganisms, enabling the microorganisms to oxidize the H_2S under anoxic conditions.

2. A process according to claim 1, CHARACTERIZED IN THAT the nitrate solution comprises a chelating agent that is adapted to prevent clogging of inert precipitating agents and other substances formed through the anoxic oxidation of the H_2S by the microorganisms.

3. A process according to claim 2, CHARACTERIZED IN THAT for prevention of clogging of calcium sulphate precipitation, the chelating agent comprises ethylene diamine tetra acetic acid (EDTA).

4. A process according to any one of claims 1 to 3, CHARACTERIZED IN THAT the nitrate solution comprises a calcium nitrate solution to enable the microorganisms to oxidize the H_2S under anoxic conditions.

5. A process according to any one of claims 1 to 4, CHARACTERIZED IN THAT the process comprises the step of recirculating part of the H_2S depleted energy gas stream to the biofilter and adding to the recirculated energy production gas stream a nutrient solution prior to being contacted with the microorganisms of the biofilm.

6. A process according to any one of claim 5, CHARACTERIZED IN THAT the process comprises the step of automatically adjusting the dosage of the nutrient solution added to the H_2S contaminated energy production gas stream in relation to the H_2S content in the H_2S contaminated energy production gas stream at an inlet of the biofilter system (10).

7. A process according to claim 5 or 6, CHARACTERIZED IN THAT the process comprises the step of adding the nitrate solution to the part of the recirculated H_2S depleted energy production gas stream prior to being contacted with the microorganisms of the biofilm.

8. A process according to any one claims 1 to 7, CHARACTERIZED IN THAT the biofilm is humidified using the energy production gas stream which has been pre-humidified before contacting the biofilm.

9. Aqueous biofilter system (10) arranged to remove H_2S from an energy production gas stream containing methane, the aqueous biofilter system (10) comprising a biofilter (6) having biofilter support material constituting a biofilter bed and supporting a biofilm having microorganisms capable of oxidizing H_2S, the biofilm being arranged to be contacted with the H_2S contaminated energy production gas stream (1) and the microorganisms being arranged to remove at least part of the H_2S out of the H_2S contaminated energy production gas stream (1), resulting in a H_2S depleted energy production gas stream (2), CHARACTERIZED IN THAT the aqueous biofilter system (10) comprises means (4, 8) for adding an aqueous nitrate solution to the H_2S contaminated energy production gas stream (9) before being contacted with the biofilm, enabling the microorganisms to oxidize the H_2S under anoxic conditions.

10. Aqueous biofilter system (10) according to claim 9, CHARACTERIZED IN THAT the means (8) for adding an aqueous nutrient solution to the H_2S contaminated energy production gas stream (1) comprise an atomizer nozzle adapted to atomize the nutrient solution into the H_2S contaminated energy production gas stream.

11. Aqueous biofilter system (10) according to claim 9 or 10, CHARACTERIZED IN THAT the biofilter system (10) comprises a controller (3) that is arranged to

- measure the H_2S content in the H_2S contaminated energy production gas stream (1) present in the operational state of the biofilter system (10) at the inlet of the biofilter (6),
- calculate the nutritional demand for the microorganisms, and
- adjust the nutritional dosage ratio of a carbon source, a nitrogen source and a phosphor source of the nutrient solution equalling to 100 : 10 : 1.

12. Aqueous biofilter system (10) according to any one of claims 9 to 11, CHARACTERIZED IN THAT the controller (3) is arranged to adapt simultaneously the dosage of the nitrogen and the phosphor source in the nutrient solution.

13. Aqueous biofilter system (10) according to any one of claims 9 to 11, CHARACTERIZED IN THAT the controller (3) is arranged to adapt the dosage of the nitrogen and the phosphor source in the nutrient solution separately.

14. Aqueous biofilter system (10) according to any one of claims 9 to 13, CHARACTERIZED IN THAT the aqueous biofilter system (10) is arranged to perform a process according to any one of claims 1 to 8.

15. Use of an aqueous biofilter system (10) according to any one of claims 9 to 14 for removing H_2S from a H_2S contaminated energy production gas stream containing methane.

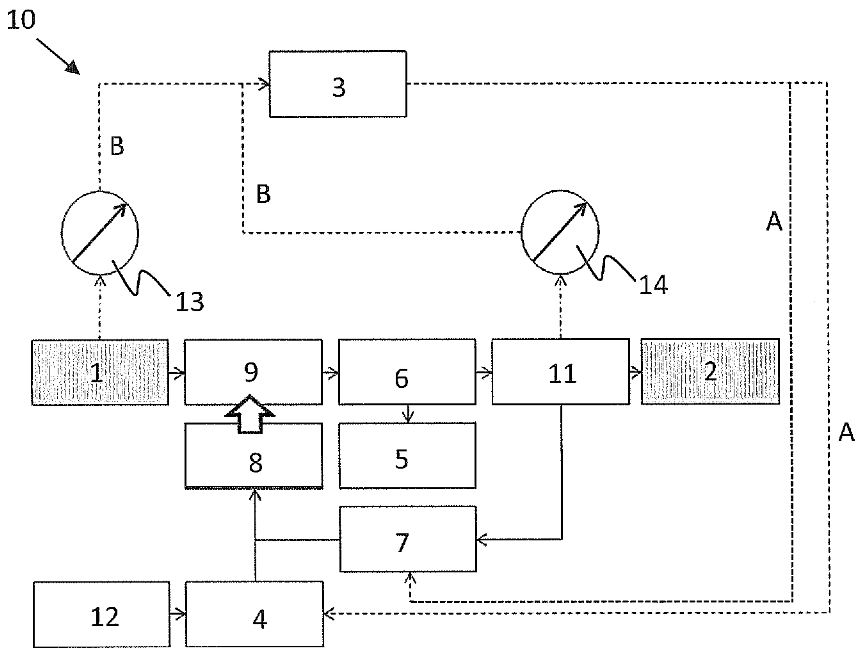

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/069866

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D53/52 B01D53/84
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Y	EP 0 845 288 A1 (THIOPAQ SULFUR SYSTEMS B V [NL]) 3 June 1998 (1998-06-03) the whole document -----	1,4-9, 11-15 2,3,10
Y	MAIKEL FERNÁNDEZ ET AL: "Hydrogen sulphide removal from biogas by an anoxic biotrickling filter packed with Pall rings", CHEMICAL ENGINEERING JOURNAL, vol. 225, 13 April 2013 (2013-04-13), pages 456-463, XP055122164, ISSN: 1385-8947, DOI: 10.1016/j.cej.2013.04.020 page 457, paragraph 2.1 -----	2,3
Y	WO 2008/131034 A2 (MOSER MARK A [US]) 30 October 2008 (2008-10-30) paragraph [0019]; claim 1; figure 1 -----	10
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 November 2014	08/12/2014

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/069866

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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