

SYSTEM AND METHOD USING COOL HYDROGEN FLAME FOR DESTRUCTION OF VOCs AND ODOROUS COMPOUNDS

Field of the Invention

[0001] The present invention relates in general to the destruction of odorous compounds from industrial exhausts. More particularly, the invention relates to a system and method for using cool hydrogen flame for destruction of odorous compounds.

Background of the Invention

[0002] Factories and industrial processes produce a variety of exhaust gases which need to be treated before being released into the atmosphere. Regulations and protocols require that these exhaust gases undergo pretreatment to remove or reduce toxic compounds present. Furthermore, with heightened awareness of environmental conservation, releases of chemicals like the "greenhouse gases" have also begun to be regulated.

[0003] Some compounds in certain exhaust streams contain Volatile Organic Compounds (VOCs) and also other odorous compounds which are often a nuisance in the work environment as well as ambient air even at low concentrations. Such odorous compounds are often sulfur and nitrogen containing and some examples of which are dimethyl sulfide (DMS) and dimethyl sulfoxide (DMSO). DMS and DMSO are used as organic solvents in the semi-conductor industry. Unfortunately, they are difficult to treat with conventional methods, which can also be costly.

[0004] One of the present methods used to contain and control DMS and DMSO is by activated carbon adsorption which is also costly and is merely transferring the pollutant from the gaseous phase into solid form.

[0005] Other conventional methods may be simply to incinerate these offending compounds. This conventional treatment system requires additional space for installation of new equipment coupled to existing exhaust systems. The costs for such additional equipment may be quite high. Furthermore, extensive modifications to the existing exhaust systems are usually required for such treatment to be integrated properly.

[0006] There is thus at present a lack of and a need for a system and method for treatment or destruction of odorous compounds with minimal cost, use of space, and modifications to the existing exhaust system.

Summary of the Invention

[0007] The present invention seeks to provide a system and method for using cool hydrogen flame for destruction of VOCs and odorous compounds.

[0008] Accordingly, in one aspect, the present invention provides, a method for using cool hydrogen flame for destruction of VOCs and odorous compounds in an exhaust stream, comprising the steps: producing a hydrogen surface-mixed diffusion flame; and exposing the hydrogen surface-mixed diffusion flame to the exhaust stream; wherein the hydrogen surface mixed diffusion flame further produces free radicals for destroying the VOCs and odorous compounds.

[0009] In another aspect, the present invention provides, a system for destruction of VOCs and odorous compounds in exhaust gases of an exhaust system, the system comprising: at least one burner nozzle for producing a configurable hydrogen surface mixed diffusion flame; wherein the at least one burner nozzle is disposed within an exhaust duct of the exhaust system.

Brief Description of the Drawings

[0010] A preferred embodiment of the present invention will now be more fully described, with reference to the drawings of which:

[0011] FIG. 1 illustrates a system in accordance with the present invention;

[0012] FIG. 2A illustrates an alternative arrangement of FIG. 1;

[0013] FIG. 2B illustrates another alternative arrangement of FIG. 1;

[0014] FIG. 3 illustrates a further alternative arrangement of FIG. 1;

[0015] FIG. 4 illustrates another implementation using a flame spreader of FIG. 1;
and

[0016] FIG. 5 illustrates a flowchart of a method in accordance with the present invention.

Detailed description of the Drawings

[0017] In this description, a system and method for using cool hydrogen flame for destruction of VOCs and odorous compounds is disclosed. In the following description, details are provided to describe the preferred embodiment. It shall be apparent to one skilled in the art, however that the invention may be practiced without such details. Some of the details may not be described at length so as not to obscure the invention.

[0018] Referring to FIG.1, a system 10 for using cool hydrogen flame for destruction of VOCs and odorous compounds comprises an existing exhaust system 6 for an industrial process or a factory 5. The existing exhaust system 6 comprises at least an exhaust duct or a chimney 8 for exhaust gases 12. The exhaust gases 12 may comprise of odorous compounds such as DMS, DMSO and other VOCs. The system 10 further comprises at least one burner nozzle 20 for generating a configurable hydrogen surface-mixed diffusion flame (CHSMDFs) 22.

[0019] The at least one burner nozzle 20 is situated inside the exhaust duct or chimney 8 of the existing exhaust system 6. The burner nozzle 20 is also situated such that the burner nozzle 20 is substantially in the path of the exhaust gases 12.

[0020] The flame from the burner nozzle 20 can be described to be gentle, "cool" and clean burning. The CHSMDF 22 is produced by burning pure hydrogen in either pure oxygen or purified air with or without oxygen enrichment. However, the hydrogen and oxygen are not pre-mixed before being ignited. Instead, the burner nozzle 20 may be of a tube in orifice design. That is to say, a main nozzle ejecting oxygen gas, and a central nozzle positioned inside the main nozzle ejecting hydrogen gas.

[0021] When the burner nozzle 20 is in operation, hydrogen gas is being ejected with an envelope of oxygen gas surrounding it. When this hydrogen gas is ignited, it burns only at the envelope of the hydrogen gas and oxygen gas interface. This produces a flame referred to as a configurable surface-mixed diffusion flame (CHSMDF) 22. It can be described as a "cool" burning flame as its temperature is much lower than conventional pre-mixed flames. The burner nozzle 20 may not necessarily be limited to the tube in orifice design and may also be a slot type burner nozzle. To ensure complete combustion of the hydrogen gas, an excess of oxygen is ejected from the burner nozzle 20.

[0022] The flame length and flame front of the CHSMDF 22 may be configurable by adjusting the pressure and rate of flow of the hydrogen and oxygen gases.

[0023] Using fire and thermal oxidation for the destruction of odorous compounds and VOCs in exhaust streams is by no means new. However, conventional flames using hydrocarbon and sulfur rich fuels would produce soot and other contaminants that would also further contaminate the exhaust gas. Furthermore, the high temperatures produced by conventional flames may require additional cooling systems to be installed to prevent overheating of the existing exhaust system and the exhaust gases.

[0024] The hydrogen surface mixed diffusion flame is advantageously "cool" enough not to require additional cooling systems and will not substantially raise the temperature of the exhaust gases. Experiments and tests have shown that the temperature of the exhaust gases after exposure to the CHSMDF 22 exhibited increases of less than 150°C. The absence of soot during combustion also significantly reduces radiative heat release by hydrogen flames further making it a "cool" flame. The main by-product from this hydrogen flame is water and free radicals.

[0025] These free radicals produced during hydrogen combustion, especially the hydroxyl radicals are extremely reactive and highly oxidative in nature and are thus extremely effective in the oxidation of organic compounds. As such, odorous compounds such as VOCs, DMS and DMSO would easily be destroyed by these free radicals produced during hydrogen combustion.

[0026] Referring to FIG.2A, an alternative arrangement to that of FIG.1 is shown. Instead of a single burner nozzle 20, there may be a plurality of burner nozzles 20 producing a plurality of CHSMDF 22.

[0027] Referring to FIG.2B, an alternative arrangement is shown whereby the throat of the chimney 8 is substantially reduced by the introduction of a venturi 40

into the throat of the chimney 8. This reduces the area of the throat of the chimney 8 such that a CHSMDF 22 with a relatively small flame front is still able to produce enough radicals to destroy the odorous compounds in the exhaust gases 12. There may be a change in pressure due to the reduction in area caused by the venturi 40, but may be negligible depending on the flow of the exhaust gases 12.

[0028] Referring to FIG.3, yet another alternative arrangement is shown, where a reaction chamber 45 may be installed in line with the ducts or pipes leading into the chimney 8. The reaction chamber 45 comprises a chamber 42 for housing a plurality of burner nozzles 20. The plurality of burner nozzles 20 are arranged such that the plurality of CHSMDF 22 produced is in the path of the exhaust gases 12 as they pass through the ducts.

[0029] The arrangements of the burner nozzles 20 disclosed are for create more CHSMDF 22 or for attempting to expose more of the CHSMDF 22 to the exhaust gases 12. The arrangements also serve to create more free radicals for the destruction of the odorous compounds. Referring to FIG.4, another implementation is shown using a flame spreader 50 to spread the CHSMDF 22 for maximum exposure across the throat of the chimney 8. The flame spreader 50 is essentially a wire mesh for diffusing and spreading the CHSMDF 22 from the burner nozzle 20. In addition, the flame spreader may be made from a metal that exhibits catalytic properties that enhance the production of free radicals during the combustion of hydrogen. Some non-limiting examples of these metals are manganese and palladium. Flames may also be shaped by various burner/nozzle designs such as the use of a swirl burner, or other aerodynamic enhancements.

[0030] Referring to FIG.5, the method 500 in accordance with the present invention starts with the step of producing 510 a configurable hydrogen surface mixed diffusion flame 22. Next, the step of exposing 515 said configurable hydrogen surface mixed diffusion flame 22 to the exhaust stream which may comprise of odorous compounds. The free radicals produced by the CHSMDF 22 will then destroy these odorous compounds.

[0031] The production of free radicals by hydrogen combustion which is important to the present invention can further be enhanced by addition of certain predetermined chemical agents or modifiers. Examples of such chemical agents are ozone gas and hydrogen peroxide. The apparatus 10 of the present invention can further comprise a plurality of gas nozzles and a plurality of spray nozzles for the introduction of ozone gas or hydrogen peroxide into the chimney 8 to enhance the production of free radicals. The method 500 can also further comprise additional steps of introducing or spraying ozone gas or hydrogen peroxide into the chimney 8.

[0032] Hydrogen peroxide may be introduced into the exhaust duct or chimney 8 in the form of fine mists by at least one spray nozzle. The spray nozzle is preferably located near the burner nozzles 20. The spray nozzles could also be arranged such that the spray nozzles are co-axial to the burner nozzles 20. The fine mist of hydrogen peroxide directed into the exhaust duct or chimney 8 results in more free radicals being formed as the hydrogen peroxide dissociates due to the heat generated by the CHSMDF 22. Any water formed as a result of the dissociation of the hydrogen peroxide is converted into steam by the CHSMDF 22 and exits the exhaust duct or chimney together with the exhaust gases 12. Correspondingly, the method 500 in accordance with the present invention further comprises an additional step of spraying a fine mist of hydrogen peroxide into the exhaust duct or chimney. This spraying of fine mist of hydrogen peroxide occurs simultaneously with the providing of the CHSMDF 22.

[0033] The introduction of steam into the chimney 8 may also further assist in the destruction of the odorous compounds. Steam may also be introduced into the chimney 8 by way of the spray nozzle, but may be situated away from the burner nozzles 20.

[0034] Furthermore, the use of the flame spreader 50 having catalytic properties will also aid in the enhanced production of free radicals and enhance the effectiveness of the method 500.

[0035] It will be appreciated that various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.

Claims

1. A method for using cool hydrogen flame for destruction of VOCs and odorous compounds in an exhaust stream, comprising the steps :

- a. producing a hydrogen surface-mixed diffusion flame; and
- b. exposing said hydrogen surface-mixed diffusion flame to said exhaust stream;

wherein said hydrogen surface mixed diffusion flame further produces free radicals for destroying said VOCs and odorous compounds.

2. The method according to claim 1, wherein said hydrogen surface-mixed diffusion flame is configurable.

3. The method according to claim 1, wherein said hydrogen surface-mixed diffusion flame is produced by burning pure hydrogen in pure oxygen without pre-mixing.

4. The method according to claim 3, wherein said pure oxygen is in excess of said pure hydrogen.

5. The method according to claim 1, further comprising the step:

- c. spraying a fine mist of hydrogen peroxide towards said hydrogen surface-mixed diffusion flame and said exhaust stream.

6. The method according to claim 1, further comprising the step:

- d. introducing steam into said exhaust stream.

7. The method according to claim 1, further comprising the step:

- e. introducing ozone gas into said exhaust stream.

8. The method according to claim 1, further comprising the step:

- f. utilizing a flame spreader for diffusing and spreading said hydrogen surface-mixed diffusion flame.

9. The method according to claim 8, wherein said flame spreader is made of a catalytic metal for enhancing free radical production during hydrogen combustion.
10. A system for destruction of VOCs and odorous compounds in exhaust gases of an exhaust system, said system comprising:
 - at least one burner nozzle for producing a configurable hydrogen surface mixed diffusion flame;
 - wherein said at least one burner nozzle is disposed within an exhaust duct of said exhaust system.
11. The system according to claim 10, wherein said at least one burner nozzle is substantially in the path of the exhaust gases.
12. The system according to claim 10, wherein the exhaust duct comprises a chimney.
13. The system according to claim 10, wherein said system further comprises a venturi for limiting throat of said exhaust duct.
14. The system according to claim 13, wherein said at least one burner nozzle is substantially in a constriction of said venturi..
15. The system according to claim 10, wherein said system further comprises at least one spray nozzle for introducing one or a combination of chemical agents.
16. The system according to claim 15, wherein said chemical agents comprises hydrogen peroxide, ozone gas and steam.
17. The system according to claim 10, further comprising a flame spreader for diffusing and spreading said configurable hydrogen surface-mixed diffusion flame.

18. The system according to claim 17, wherein said flame spreader is made of a catalytic metal for enhancing free radical production during hydrogen combustion.