

PROCESS EXHAUST AIR TREATMENT SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an exhaust air treatment system, and more particularly, to a process exhaust air treatment system.

2. Description of the Related Art

Processes in semiconductor and optoelectronic industries are often done by using chemical reactions, and such chemical reactions are likely to produce a lot of toxic organic exhaust air, such as volatile organic compounds (VOCs). These VOCs mostly belong to hazardous air pollutants (HAPs), and long-term exposure of the human body to an environment with a high concentration of VOCs may lead to reactions such as poisoning and carcinogenic tumors. In addition, VOCs in the atmosphere may produce photochemical reactions, leading to an increase in ozone concentration in the atmosphere and the production of highly oxidative pollutants. Therefore, the exhaust air containing VOCs must be treated before being discharged and cannot be discharged directly into the atmosphere.

The technologies generally used for exhaust air treatment include incineration (such as thermal incineration, catalyst incineration, boiler incineration, and an exhaust air combustion tower), dust filtration, concentrated incineration, condensation, a scrubbing tower, and others. However, each of various environmental protection devices has its own treatment effects. Emissions of the current VOC treatment apparatuses still have pollutants such as dust, nitrogen oxides, acidic or alkaline air, etc. Therefore, in consideration of ambient air in the process, how to adopt a cost-effective treatment apparatus from numerous treatment technologies to make the emission of the process exhaust air meets the increasingly stringent environmental protection regulations is an important issue for factory managers to carry out environmental protection work.

SUMMARY OF THE INVENTION

In view of the above, in order to overcome and solve the foregoing deficiencies, through extensive research combined with application of theories, the inventors of

the present invention finally propose this invention that has a reasonable design and can effectively overcome the foregoing deficiencies.

To achieve the foregoing objective, the present invention provides a process exhaust air treatment system, which includes at least: an exhaust air concentration unit including a zeolite rotor, a rotor surface of the zeolite rotor being divided into an adsorption zone, a cooling zone, and a desorption zone, where the adsorption zone is used to introduce a process exhaust air for adsorbing at least a part of VOCs in the process exhaust air and outputting a filtered air; the cooling zone is used to introduce a cooling air for cooling the zeolite rotor that accumulates heat and heats up as a result of desorption, the cooling air being a branch flow of the process exhaust air or an external air; and the desorption zone is used to introduce a desorption air for desorbing the VOCs adsorbed by the zeolite rotor and outputting a VOC-concentrated air; an incineration unit having at least an incineration apparatus and communicated with the exhaust air concentration unit for incinerating the VOCs in the VOC-concentrated air to generate an incinerated air; and a dust removal unit including at least a dust filtering device, the dust filtering device being in air communication with the incineration apparatus for removing dust or nitrogen oxide pollutants from the incinerated air and further for removing acidic or alkaline pollutants in conjunction with a waste heat recovery apparatus and a rear-phase scrubbing tower.

According to an embodiment of the present invention, the cooling zone is in air communication with the desorption zone, and the cooling air passing through the cooling zone heats up to turn into the desorption air which enters the desorption zone.

According to an embodiment of the present invention, the exhaust air concentration unit is further provided with a first heat exchanger, where a cold flow end of the first heat exchanger is communicated with the desorption zone of the zeolite rotor and the incineration unit for receiving and heating the VOC-concentrated air and then delivering the same to the incineration apparatus in the incineration unit.

According to an embodiment of the present invention, the exhaust air

concentration unit is further provided with a second heat exchanger, where a cold flow end of the second heat exchanger is communicated with the cooling zone and the desorption zone of the zeolite rotor for receiving the cooling air that passes through the cooling zone and transferring the same to the desorption zone after being heated to the temperature required for the desorption air.

According to an embodiment of the present invention, the incineration apparatus, the first heat exchanger, and the second heat exchanger are in air communication sequentially; and after being discharged from the incineration apparatus, the incinerated air is introduced into hot flow ends of the first heat exchanger and the second heat exchanger sequentially as a heat source for heat exchange.

According to an embodiment of the present invention, a ceramic filter tube or a filter bag is disposed inside the dust filtering device; and the ceramic filter tube or the filter bag is at least one of a tubular ceramic filter tube, a tubular catalyst-containing ceramic filter tube, a rectangular ceramic filter tube, a rectangular catalyst-containing ceramic filter tube, a tubular or rectangular film-coated catalyst filter bag, and a tubular or rectangular double-layer filter bag.

According to an embodiment of the present invention, when the filter bag disposed inside the dust filtering device is made of a non-ceramic material, the dust filtering device is a low-temperature dust collector; and a third heat exchanger is further disposed in the exhaust air concentration unit, where a hot flow end of the third heat exchanger is communicated with the second heat exchanger and the dust filtering device for receiving the incinerated air from the second heat exchanger, and a cold flow end of the third heat exchanger is communicated with the adsorption zone of the zeolite rotor for receiving a part of the filtered air W_1 discharged from the adsorption zone of the zeolite rotor.

According to an embodiment of the present invention, the dust removal unit further includes a scrubbing tower that is disposed at a downstream end of the dust filtering device and is in air communication with the dust filtering device.

According to an embodiment of the present invention, the dust removal unit further includes a waste heat recovery apparatus disposed at a downstream end of the dust filtering device, and the waste heat recovery apparatus includes a heat recovery

steam generator (HRSG) or an ORC waste heat recovery device for receiving the incinerated air passing through the dust filtering device.

According to an embodiment of the present invention, the dust removal unit further includes a scrubbing tower that is disposed at a downstream end of the waste heat recovery apparatus or an upstream end of the dust filtering device for removing acidic or alkaline pollutants after incineration.

According to an embodiment of the present invention, when the scrubbing tower is a wet-type scrubbing tower, it is disposed at a downstream end of the waste heat recovery apparatus and is in air communication with the waste heat recovery apparatus.

According to an embodiment of the present invention, when the scrubbing tower is a dry-type scrubbing tower, it is disposed at the upstream end of the dust filtering device and is in air communication with the dust filtering device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic architecture diagram of a process exhaust air treatment system in a first embodiment of the present invention;

FIG. 2 is a schematic architecture diagram of a process exhaust air treatment system in a second embodiment of the present invention; and

FIG. 3 is a schematic architecture diagram of a process exhaust air treatment system in a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The constitution and technical content of a process exhaust air treatment system of the present invention are described in detail below by listing various appropriate examples and with reference to the accompanying drawings. However, the present invention is not limited to the listed embodiments, drawings or detailed description.

Further, those skilled in the art should also understand that: the listed embodiments and the accompanying drawings are only for reference and description, and are not intended to limit the present invention. The inventions that can be done based on the modifications or alterations easily implemented according to the descriptions are also considered as falling within the scope of the spirit and

intent of the present invention; and definitely, these inventions are also included in the claims of the present invention.

In addition, in order to get a clearer understanding of the technical features, purposes and effects of the present invention, the specific embodiments of the present invention are now described in detail with reference to the accompanying drawings. The detailed description and technical content of the present invention are described below with reference to the drawings. However, the attached drawings are only for reference and description, and are not intended to limit the present invention. The foregoing and other technical contents, features and effects of the present invention will be clearly presented in the following detailed description of the embodiments with reference to the drawings. The directional terms mentioned in the following embodiments, such as "up", "down", "left", "right", "front", "rear", etc., are only directions with reference to the attached drawings. Therefore, the used directional terms are user for illustration, and are not intended to limit the present invention. Moreover, in the following embodiments, the same or similar elements are indicated by the same or similar numerals.

First, referring to FIG. 1, FIG. 1 is a schematic architecture diagram of a process exhaust air treatment system in a first embodiment of the present invention. The process exhaust air treatment system in the figure can be used to treat a process exhaust air W containing VOCs, where the source of the process exhaust air W is not particularly limited. For example, the process exhaust air W may come from the petrochemical industry, semiconductor industry, or steel plants; or may be a process exhaust air that requires the use of organic solvents. The VOCs contained in the process exhaust air W may be alkanes, aromatics, esters, or ketones, which, for example, may be, but are not limited to, propane, butane, benzene, toluene, ethylbenzene, methanol, ethanol, isopropanol, isoamyl alcohol, acetone, butanone, tetrachloroethylene, chlorobenzene, propylene glycol methyl ether acetate (PGMEA), monoethanolamine (MEA) and dimethyl sulfoxide (DMSO).

As shown in FIG. 1, the process exhaust air treatment system includes an exhaust air concentration unit 1, an incineration unit 2, and a dust removal unit 3. The exhaust air concentration unit 1 includes a zeolite rotor 10, and a rotor surface

of the zeolite rotor 10 may be divided into an adsorption zone 101, a cooling zone 102, and a desorption zone 103. The zeolite rotor 10 may be driven by a motor (not shown in the figure) to continuously rotate at a specific speed to sequentially pass through the adsorption zone 101, the desorption zone 103, and the cooling zone 102. The adsorption zone 101 is used to introduce the process exhaust air W for adsorbing at least a part of the VOCs in the process exhaust air W and outputting a filtered air W₁, where the filtered air W₁ may be discharged to the outside via a chimney 4 or is used for other purposes. The desorption zone 103 is used to introduce a desorption air D for desorbing the VOCs adsorbed by the zeolite rotor and outputting a VOC-concentrated air T. The cooling zone 102 is used to introduce a cooling air C for cooling the zeolite rotor 10 that accumulates heat and heats up as a result of desorption. The cooling air C is a branch flow of the process exhaust air or an external air. As the zeolite rotor 10 rotates, the zeolite rotor 10 that approaches an adsorption saturation status comes to the desorption zone 103. During contact with the high-temperature desorption air D, the VOCs are desorbed to enter the desorption air D, so that the zeolite rotor 10 is regenerated. The regenerated zeolite rotor 10 is cooled through the cooling zone 102 and then returns to the adsorption zone 101, thus completing a loop process of adsorption, desorption, and cooling.

Moreover, the incineration unit 2 is designed to be in air communication with the desorption zone 103 of the zeolite rotor 10. Further, the incineration unit 2 includes an incineration apparatus 20 that can incinerate the VOCs in the VOC-concentrated air T to generate an incinerated air H. A suitable incineration apparatus includes, but are not limited to, a direct-fired incinerator, catalytic incinerator, regenerative thermal incinerator, or regenerative catalytic incinerator.

The incineration unit 2 may further include a combustion fan 21 that is connected to the incineration apparatus 20. When the VOC-concentrated air in the incineration apparatus 20 has an insufficient calorific value and cannot be burned to the required temperature, the combustion fan 21 can deliver natural air and other fuels to assist in air incineration. A burner using the auxiliary fuel may be a low nitrogen oxide burner, so as to ensure that the concentration of the discharged

nitrogen oxides meets the requirements of environmental protection laws and regulations.

According to the technical idea of the present invention, the exhaust air concentration unit 1 is further provided with a first heat exchanger 11 and a second heat exchanger 12. The first heat exchanger 11 and the second heat exchanger 12 may be plate-type heat exchangers or shell-and-tube heat exchangers, and are preferably shell-and-tube heat exchangers, which are not particularly limited herein. A cold flow end of the first heat exchanger 11 is communicated with the desorption zone 103 of the zeolite rotor 10 and the incineration unit 2 for receiving and heating the VOC-concentrated air and then delivering the same to the incineration apparatus 20 in the incineration unit 2. A cold flow end of the second heat exchanger 12 is communicated with the cooling zone 102 and the desorption zone 103 of the zeolite rotor 10 for receiving the cooling air that passes through the cooling zone 102 and heating the same to the temperature required for the desorption air, and then transferring the same to the desorption zone 103. In addition, the incinerated air H discharged from the incineration apparatus 20 sequentially goes into hot flow ends of the first heat exchanger 11 and the second heat exchanger 12 to serve as a heat source for heat exchange while the incinerated air H is cooled and then is introduced into the dust removal unit 3.

Due to the increasingly stringent environmental protection regulations, based on the detection requirements of the regulations, ventilation doors 104 and 105 are opened after the cooling air C heats up to the desorption temperature, so as to ensure that the desorption temperature of the desorption air D reaches a set temperature, thus guaranteeing the treatment efficiency of the rotor.

As described above, the dust removal unit 3 includes a dust filtering device 30, and at least a filter material such as a ceramic filter tube or a filter bag is disposed inside the dust filtering device 30. The ceramic filter tube or the filter bag may be, for example, a tubular ceramic filter tube, a tubular catalyst-containing ceramic filter tube, a rectangular ceramic filter tube, a rectangular catalyst-containing ceramic filter tube, a tubular or rectangular film-coated catalyst filter bag, or a tubular or rectangular double-layer filter bag, that can remove dust, silica and other

solid pollutants from the incinerated air. The outer layer of the double-layer filter bag is a high-temperature dust removal filter bag (such as Teflon, or glass fiber), and the inner layer thereof is a size-compatible catalyst filter bag. In addition, the catalyst contained in the ceramic filter tube or the filter bag has at least one of the followings functions: denitrification, dioxin removal, VOC removal, heavy metal removal, excess metal removal, greenhouse air removal, and ozone removal. Moreover, a flow inlet end of the dust filtering device 30 is provided with a guide plate to receive the incinerated air H after being cooled and introduce the same into the dust filtering device 30.

In addition, in the process exhaust air treatment system of the present invention, a plurality of fans may be further disposed on the pipeline to assist in air delivery. The number and the positions of these fans are not particularly limited and may be set according the process requirements. For example, in this embodiment, two primary lateral fans 13 are disposed on a flow inlet end of the adsorption zone 101 and one secondary lateral fan 14 is disposed on a flow outlet end of the adsorption zone 101; and one desorption fan 15 is disposed on a flow outlet end of the desorption zone 103.

According to the technical idea of the present invention, the flow inlet ends of the adsorption zone 101 and the cooling zone 102 may be separately provided with a filtering device 16, and the process exhaust air W first passes through the filtering device 16 before entering the zeolite rotor 10. An emergency discharge pipeline P is also disposed at an upstream end of the zeolite rotor 10 to facilitate the process exhaust air to be firstly guided to other place or the chimney 4 in the case of an emergency, avoiding the loss of the apparatus or affecting the pressure balance of the process apparatus. The filtering device 16 may be equipped with a chemical filter in consideration of the ambient air, thus guaranteeing the air quality.

Further, the process exhaust air treatment system of the present invention includes a protection measure against abnormal high temperature, including high temperature protection at a desorption outlet, N₂ or water spraying, which in the case of a high furnace temperature warning, enables extinction and cooling, and in the case of a fault in the desorption fan, enables the breaking ventilation door to be

closed and the external ventilation door to be opened, thus avoiding the hot air in the furnace from flowing back to the rotor area and causing a hazard.

Next, referring to FIG. 2, FIG. 2 is a system architecture diagram in a second embodiment of the present invention. In this embodiment, the exhaust air concentration unit 1 and the incineration unit 2 are identical to those described in the first embodiment, so the details are not described herein again. The main difference between this embodiment and the first embodiment lies in that the dust removal unit 3 of this embodiment further includes a waste heat recovery apparatus 31 and a scrubbing tower 32.

The waste heat recovery apparatus 31 is disposed at a downstream end of the dust filtering device 30, and includes a heat recovery steam generator (HRSG) or an ORC waste heat recovery device. The waste heat recovery apparatus uses the incinerated air passing through the dust filtering device 30 as a heat source, to heat the incoming water into hot water or water vapor for use in the process or power generation.

The scrubbing tower 32 may be a dry-type or wet-type scrubbing tower. In this embodiment, the scrubbing tower 32 is a wet-type scrubbing tower and disposed at the downstream end of the waste heat recovery apparatus 31. When the scrubbing tower 32 is a dry-type scrubbing tower, it is disposed at the upstream end of the dust filtering device 30.

Further, according to the technical idea of the present invention, when the filter material disposed inside the dust filtering device 30 is a non-ceramic filter bag, the dust filtering device 30 is a low-temperature dust collector, and the incinerated air H entering the dust filtering device 30 must be further cooled. As shown in FIG. 3, which is a system architecture diagram of a third embodiment, a third heat exchanger 17 is disposed in the exhaust air concentration unit. A hot flow end of the third heat exchanger 17 is communicated with the second heat exchanger 12 and the dust filtering device 30 and a cold flow end thereof is communicated with the adsorption zone 101 of the zeolite rotor 10 and the chimney 4.

Therefore, the incinerated air H discharged from the second heat exchanger 12 enters the hot flow end of the third heat exchanger 17, and the filtered air W₁

discharged from the adsorption zone 101 of the zeolite rotor 10 partially flows into the cold flow end of the third heat exchanger 17. The incinerated air H and the filtered air W₁ undergo heat exchange in the third heat exchanger 17, so that the incinerated air H is further cooled and then is introduced to the dust filtering device 30 of the dust removal unit 3. Further, in this embodiment, because the incinerated air H has been subjected to three-phase cooling, the addition of the waste heat recovery apparatus in the dust removal unit 3 may be not required, and only the dust filtering device 30 and the scrubbing tower 32 are disposed.

In addition, in other embodiments of the present invention, there may be a plurality of zeolite rotors 10. The type selection, such as the rotor size, speed adjustment, concentration rate adjustment, rotor thickness adjustment, etc., for these zeolite rotors 10 may be made according to different airflows and concentrations, and the required efficiency. The number and the form of series/parallel connection of these zeolite rotors 10 may be adjusted according to actual demands, thus improving the system treatment efficiency.

Although the content of the present invention has been described in detail by using the foregoing embodiments as examples, the present invention is not limited to these embodiments. Those of ordinary skill in the art to which the present invention belongs should understand that various changes and modifications can be made without departing from the spirit and scope of the present invention. For example, the technical contents illustrated in the foregoing embodiments are combined or changed to form new embodiments, and these embodiments are certainly regarded as the contents of the present invention. Therefore, the protection scope of this case also includes the appended claims and the scope defined by the claims.

Meanings of numerals:

1	exhaust air concentration unit
10	Zeolite rotor
101	Adsorption zone
102	Cooling zone
103	Desorption zone

104, 105	Ventilation door
11	First heat exchanger
12	Second heat exchanger
13	Primary lateral fan
14	Secondary lateral fan
15	Desorption fan
16	Filtering device
17	Third heat exchanger
2	Incineration unit
20	Incineration apparatus
21	Combustion fan
3	Dust removal unit
30	Dust filtering device
31	Waste heat recovery apparatus
32	Scrubbing tower
4	Chimney
W	Process exhaust air
W ₁	Filtered air
C	Cooling air
D	Desorption air
T	VOC-concentrated air
H	Incinerated air
P	Emergency discharge pipeline

What is claimed is:

1. A process exhaust air treatment system, comprising at least:

an exhaust air concentration unit comprising a zeolite rotor, a rotor surface of the zeolite rotor being divided into an adsorption zone, a cooling zone, and a desorption zone, wherein the process exhaust air contains VOCs exhausting from the petrochemical industry, semiconductor industry, or steel plants, the adsorption zone is used to introduce a process exhaust air for adsorbing at least a part of volatile organic compounds (VOCs) in the process exhaust air and outputting a filtered air; the cooling zone is used to introduce a cooling air for cooling the zeolite rotor that accumulates heat and heats up as a result of desorption, the cooling air being a branch flow of the process exhaust air or an external air; and the desorption zone is used to introduce a desorption air for desorbing the VOCs adsorbed by the zeolite rotor and outputting a VOC-concentrated air;

an incineration unit having at least an incineration apparatus and communicated with the exhaust air concentration unit for incinerating the VOCs in the VOC-concentrated air to generate an incinerated air; and

a dust removal unit comprising at least a dust filtering device, a waste heat recovery apparatus, and a scrubbing tower, in which the dust filtering device being in air communication with the incineration apparatus for receiving the incinerated air, the waste heat recovery apparatus is disposed at a downstream end of the dust filtering device and is in air communication with the dust filtering device; the scrubbing tower is disposed at a downstream end of the waste heat recovery apparatus or an upstream end of the dust filtering device; wherein

in the inside of the dust filtering device further comprises a ceramic filter tube or a filter bag, in which the ceramic filter tube is at least one selected from the group consisting of a tubular ceramic filter tube, a tubular catalyst-containing ceramic filter tube, a rectangular ceramic filter tube, and a rectangular catalyst-containing ceramic filter tube; the filter bag is at least one selected from the group consisting of a tubular or rectangular film-coated

catalyst filter bag, and a tubular or rectangular double-layer filter bag;

the waste heat recovery apparatus comprises a heat recovery steam generator (HRSG) or an ORC waste heat recovery device for receiving the incinerated air passing through the dust filtering device;

the scrubbing tower is a wet-type scrubbing tower or a dry-type scrubbing tower.

2. The process exhaust air treatment system of claim 1, wherein the cooling zone is in air communication with the desorption zone, and the cooling air passing through the cooling zone heats up to turn into the desorption air which enters the desorption zone.
3. The process exhaust air treatment system of claim 1, wherein the exhaust air concentration unit is further provided with a first heat exchanger, wherein a cold flow end of the first heat exchanger is communicated with the desorption zone of the zeolite rotor and the incineration unit for receiving and heating the VOC-concentrated air and then delivering the same to the incineration apparatus in the incineration unit.
4. The process exhaust air treatment system of claim 3, wherein the exhaust air concentration unit is further provided with a second heat exchanger, wherein a cold flow end of the second heat exchanger is communicated with the cooling zone and the desorption zone of the zeolite rotor for receiving the cooling air that passes through the cooling zone and transferring the same to the desorption zone after being heated to the temperature required for the desorption air.
5. The process exhaust air treatment system of claim 4, wherein the incineration apparatus, the first heat exchanger, and the second heat exchanger are in air communication sequentially; and after being discharged from the incineration apparatus, the incinerated air is introduced into hot flow ends of the first heat exchanger and the second heat exchanger sequentially as a heat source for heat exchange.
6. The process exhaust air treatment system of claim 1, wherein when the filter bag

is disposed inside the dust filtering device and is made of a non-ceramic material, the dust filtering device is a low-temperature dust collector; and a third heat exchanger is further disposed in the exhaust air concentration unit, wherein a hot flow end of the third heat exchanger is communicated with the second heat exchanger and the dust filtering device for receiving the incinerated air from the second heat exchanger, and a cold flow end of the third heat exchanger is communicated with the adsorption zone of the zeolite rotor for receiving a part of the filtered air discharged from the adsorption zone of the zeolite rotor.

7. The process exhaust air treatment system of claim 1, wherein the scrubbing tower is a wet-type scrubbing tower, disposed at a downstream end of the waste heat recovery apparatus and is in air communication with the waste heat recovery apparatus.
8. The process exhaust air treatment system of claim, wherein the scrubbing tower is a dry-type scrubbing tower, disposed at the upstream end of the dust filtering device and is in air communication with the dust filtering device.