Fumes purification method (by mixing)

CLAIMS

1. Method of fume purification from condensable airborne contaminants, comprising the steps of:
   - Generating in a heated area (2) a flow of fumes to be treated;
   - Generating a cold fluid flow such that the fluid temperature is lower than that of the fumes to be treated;
   - Mixing the flow of cold fluid with the flow of fumes to be treated or using a cross-flow heat exchanger cooled by the cold fluid to generate a mixture in which a condensation of the contaminants is induced due to the decrease in the temperature of the fumes to form an aerosol;
   - Adducting said aerosol into an inertial separator unit (5) to carry out a separation of the contaminants condensed in the aerosol.
2. Method according to claim 1, comprising the step of providing a centrifugal fan (10) downstream of the inertial separator and receiving the flow of gas leaving the inertial separator (5).
3. Method according to any of the preceding claims, comprising the step of providing the flow of cold fluid at the inlet of the fumes or inside the inertial separator (5).
4. Method according to claim 1, further comprising the step of dehumidifying the cold fluid when in gaseous phase and subsequently cooling the fluid to generate the flow of cold fluid.
5. Method according to any one of the preceding claims, comprising the step of injecting a low vapor tension substance in the flow of fumes to be treated upstream of the inertial separator unit (5).
6. Method according to any one of the preceding claims, comprising the

further steps of adducting the purified air exiting the inertial separator unit into the heated zone (2), wherein the heated area is a chamber closed by a supply door, to create a closed fume circuit.

7. Method according to claim 6, comprising the step of branching off a flow rate downstream of the inertial separator and cooling said flow rate to generate said cold fluid and generating a closed circuit of the fumes.

8. Method according to any one of claims 1 to 6, wherein the step of generating a cold fluid flow comprises the step of placing a refrigeration unit (11) which generates said cold fluid flow.

9. Method according to one of claims 6 or 7, wherein the refrigeration unit (11) is a carbon dioxide with double compression and double lamination unit.

10. Method according to any one of the preceding claims, wherein the inertial separator assembly (5) is cyclonic.

11. Method according to any one of the preceding claims, wherein the heated zone is selected from a pyrolysis chamber for wood or a curing chamber, or a coffee roasting chamber or a fryer.

Fumes purification method

DESCRIPTION

TECHNICAL FIELD

The present invention refers to a method of purification of fumes with low vapor pressure contaminants, and therefore accompanied by a high boiling temperature, provided with a highly efficient fumes cooling device.

STATE OF ART

It is known to remove aromatic contaminants having low vapor pressure via condensation and adsorption on surfaces, in particular, electrostatically charged surfaces. However, this is effective for contaminant particles with a size below the micrometer by requiring relatively limited velocity of the fumes across the surfaces and, furthermore, it requires a regeneration process of the adsorbent surface which requires relatively frequent stopping of the fumes purification process.

Alternatively, in particular to remove large quantities of organic contaminants, it is possible to resort to an oxidation process by means of thermal or catalytic incineration. In this case, however, complex and expensive devices are used, which require large amounts of energy and, moreover, the fumes from the incinerator must be further treated.

US-A1-2016279556 illustrates a device for the purification of fumes in which the cooling phase of the flow is carried out by means of a device acting only on the peripheral part of the fume evacuation duct. This negatively impacts the effectiveness of the contaminant condensation process. Furthermore, the document refers to the treatment of cooking fumes of a kitchen. The treatment of fumes deriving from industrial heating processes in a closed chamber e.g. an oven such as the pyrolysis of wood, the vulcanization of polymers, the roasting of coffee, require to effectively process large fume quantities.

SCOPES AND SUMMARY OF THE INVENTION

The object of the present invention is to provide a method for the purification of fumes which is effective and with low installation and operating costs.

The object of the present invention is achieved by means of a method of purification of fumes with condensable gaseous contaminants, comprising the steps of:

- Generating a flow of fumes to be treated in a heated area e.g. a heated chamber;

- Providing a flow rate of cold fluid so that the temperature of the fluid is lower than that of the fumes to be treated;

- Mix the flow of cold gases with the flow of the fumes to be treated to induce a condensation of the contaminants due to a decrease in the temperature of the fumes to form an aerosol or use a cross-flow exchanger to cool the fumes through a colder fluid flow;

- Conveying the mixture with the aerosol into an inertial separator unit to carry out a separation of the condensed contaminants within the aerosol.

The cold air allows the contaminant to condense, which is subsequently separated through the inertial separator unit. It is also important to note how the heat exchange with the fumes affects the flow rate as a whole, thus favoring the efficiency of the nucleation of condensed particles and droplets of the contaminants. Low vapor pressure contaminants, i.e. contaminants that at ambient pressure and temperature (10000 Pa and 24 ° C) are in the liquid state such as toluene, are for example present in fumes from bitumen, fried foods, smokehouses, plasticizers, rubbery substances, textiles.

The method of the invention is also applicable to relatively small systems and may require a refrigeration system that is widespread, i.e. is already present, or is easily installed, both in industrial plants and in commercial establishments such as kitchens e.g. fast food etc.

By adjusting the differential temperature between the generated fumes and fluid gases, e.g. air, temperature, flow rate and saturation level it is possible to obtain satisfactory results for numerous contaminants even when their concentrations vary. In addition, the use of mixed or cross-flow exchangers simplifies maintenance e.g. cleaning: it is in fact possible to dispose of any deposits directly with a pressure liquid jet, e.g. of hot water. This operation is simple and fast.

Substances are also used, i.e. air, water vapor, refrigerant fluid widely available and / or usable in a closed circuit, lowering operating costs. The inertial separator unit also contributes to this, notoriously easy to be efficiently maintained, also thanks to the cleaning operations that can be performed during operation e.g. by simple gravity action that allows evacuation into a collection container and / or an automatic disposal conveyor belt. Alternatively, by scraping, shaking and vibration.

According to a preferred embodiment, the method includes the steps of dehumidifying the air and, subsequently, cooling it to generate the cold air flow.

In this way, the cooling of air is more efficient and it is possible to obtain the condensation of most of the airborne contaminants.

According to a preferred embodiment, the method comprises the step of injecting an auxiliary fluid into the flow rate of fumes to be treated. According to a variant embodiment, a low vapor pressure substance, such as dipropylene glycol, is nebulized in the already at least partially cooled flow rate.

In this way the enlargement of the contaminant particles is favored and this improves the effectiveness of the separation in the inertial separator unit. Furthermore, the water is separated from the contaminant in the inertial separator unit and, in this way, it can be reused e.g. closed circuit without further treatment or be released into the external environment with low or zero environmental impact, in particular when the contaminant is not soluble in water, as in the case of oil used in food processes e.g. frying.

According to a further embodiment, the heated chamber is closed via a door or flap and the fumes leaving the inertial separator are reintroduced into the heated chamber. In addition, the flow of gas to be cooled is branched off downstream of the inertial separator and sent to the refrigeration system.

This is applicable for all processes, especially industrial, in which the atmosphere inside the chamber does not need to be exchanged with fresh air or other gases that react chemically inside the chamber. The closed fume gas circuit allows the passage through the inertial separator to be carried out several times, increasing the quantity of contaminants eliminated. Furthermore, it is possible to avoid connecting the chamber to a fume gas disposal chimney into the atmosphere: this makes it particularly easy to retrofit existing chambers or ovens i.e. it is not necessary to provide a connection to the chimney and / or to move the heated chamber within the plant and therefore there is no need to redesign the connection to the chimney. The closed fume circuit is particularly suitable in industrial processes in which the fumes are not generated as a result of chemical reactions, but contain gaseous pollutants generated by change of state e.g. liquid to gaseous or solid to gaseous, due to process temperatures. Furthermore, according to the present invention, the pressure in the chamber, except for the operation of the fan, is close to the atmospheric pressure.

Other advantages of the present invention are discussed in the description and cited in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described below on the basis of non-limiting examples illustrated by way of example in the following figures, which refer respectively to:

- Fig. 1 a schematic view of a plant for carrying out the method according to the present invention;

- Fig. 2 an enlarged schematic view of the component of figure 1; and

- Fig. 3 refers to a diagram of a cross flow heat exchanger.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 indicates with 1 as a whole a combined fume generation and purification plant comprising a heated chamber 2, preferably closed by a supply door, inside which a material is heated, generating fumes comprising low vapor pressure contaminants, for example an oven for the vulcanization of an article comprising a thermosetting material such as an elastomer. However, it is possible to apply the invention also to fumes with gaseous impurities at low vapor pressure in other industrial sectors, such as coffee roasting or in the pyrolysis process. It is also possible to apply the invention also to fumes generated in open heated areas, such as in the presence of a fryer.

By means of a fan 3 the fumes to be treated are sucked from the heated chamber and conveyed into a duct 4.

The duct 4 carries the fumes towards an inertial separator 5 and receives a flow of cold air through a duct 6 preferably interposed between the fan 3 and the inertial separator 5. The flow of cold air and the fumes exchange heat by mixing and this favors nucleation of condensed particles throughout the volume of fumes in the duct 4. In particular cold air, preferably at a temperature of about 100 ° C below the condensation temperature of the contaminant and / or below 0 ° C, induces a condensation process of the contaminants in the portion of the duct 4 downstream of the duct 6 towards the inertial separator 5. This causes the generation of an aerosol, i.e. a suspension of particles in which the terminal sedimentation speed in air is less than 1 meter / second corresponds to spherical particles with a density of 1000 kg / m ^ 3 with an equivalent aerodynamic diameter of about 180 micrometers. According to an alternative embodiment, the flow of cold gases is substantially mixed at the inlet of the inertial separator 5 and in this case the distance traveled by the fumes between the duct 6 and the inertial separator 5 is minimal e.g. less than 15 cm.

The condensed contaminants, but still suspended in the fume gas flow, enter inertial separator 5 in which the separation process is favored by the inertial effect of the particles whose condensation is induced by the cold fluid. For this purpose, inertial separator 5 includes an outlet 7 from which the condensed substances are evacuated e.g. by gravity and an outlet 8 for the air purified from condensed substances.

It is possible that the purified air is reintroduced into the atmosphere, thus creating an open purification circuit. According to the embodiment of Figure 1, a closed flue gas circuit is provided through a duct 9 to connect the outlet 8 to the heated chamber 2. Preferably a fan 10 generates a flow of purified air from the inertial separator 5 to the heated chamber 2 and, in particular, it generates a vacuum at outlet 8 which favors the separation between air and condensed particles. According to an embodiment not shown, it is possible to eliminate fan 3 and design fan 10 as a radial flow fan: in this way it is possible to process large flow rates of fumes and, at the same time, benefit from the geometry of the impeller to evacuate any particles of contaminants adhering to the impeller itself thanks to centrifugal acceleration. The impeller is housed in a casing that will need to be cleaned periodically from the particles of contaminant evacuated by centrifugal acceleration.

Conduit 6 receives a cold gas e.g. cold air from a refrigeration unit 11 which can either operate in open loop, e.g. taking air to be cooled from the external environment, or in a closed loop by branching off a flow of air to be cooled from duct 9, as shown in the figure. For example, refrigeration unit 11 includes a closed circuit for a heat transfer fluid and in a known way it removes heat from the air through an evaporator in which the heat transfer fluid passes to be subsequently sucked by a compressor and release heat to the outside through a condenser. In order to obtain the temperatures suitable to make the condensation process of the contaminants in the fumes efficient, e.g. temperatures well below 0°C, the refrigeration unit is two-stage with double lamination and double compression and the heat transfer fluid is carbon dioxide (R-744) to go through a subcritical cycle with evaporator around -30 ° C.

Figure 2 illustrates a preferred example of construction of inertial separator 5. It is a cyclone separator comprising a hollow main body 20 open downwards to define outlet 7 and defining a converging surface towards outlet 7 itself. The hollow main body 20 is elongated and, on the longitudinal side opposite the exit 7, defines a preferably tangential entrance 21 and exit 8.

Via fan 3, the flue gas flow enters hollow main body 20 with a predetermined kinetic energy through the inlet 21 and, thanks to the downward converging shape of body 20, it favors the separation of condensed particles by coalescence and growth thanks to centrifugal force. The increasingly large and heavier particles tend to exit by gravity from outlet 7. On the contrary, the purified and lightened air tends to flow towards the center of body 20 and to exit from outlet 8, also thanks to the depression generated by fan 10.

During a washing phase of the separator 5, a fluid is injected through a special upper opening in order to remove residues adhering to the walls on which the coalescing particles grow. This fluid, whose composition varies depending on the contaminant of the fumes, is evacuated from outlet 7. During washing, the separation and therefore purification action is not compromised. However, when the contaminant is recovered, as in the case of 'wood oil' generated during a pyrolysis process, the scrubbing fluid is mixed with the condensed contaminant and then either the mixture is discarded or it has to be further treated to separate the fluid. washing.

According to a preferred embodiment, the evaporator of refrigeration unit 11 is integrated with a surface heat exchanger to decrease the temperature of the air to be injected into duct 4. Furthermore, it is preferable to provide a dehumidifier, e.g. through a cooling below the dew temperature to eliminate a good part of the water and a subsequent dehumidification using a desiccant e.g. silica gel or other hygroscopic material, to lower the water vapor level in the air to be cooled by refrigeration unit 11.

According to the invention, it is possible to update a heated chamber, e.g. a pre-existing oven to obtain the advantages of the invention. In this case, a flue of the heated chamber, possibly already equipped with its own fan 3, is connected to inertial separator 5 through duct 4 designed to receive cold air. The latter is generated by refrigeration unit 11 suitably installed or connected, as it pre-exists such as the heated chamber but is intended for other purposes. Optionally, the flue gas circuit is closed by means of duct 9 with the relevant fan, possibly pre-existing, connected to an air intake A of chamber 2. Also the cold air circuit, if the fume gas circuit is closed, can also be closed by connecting duct 9. According to a preferred embodiment, there are two fans, one between the heated chamber and the inertial separator to force a current of air to be treated and another between the inertial separator and the external environment or the heated chamber to force a current of treated air and thus balance the air circuit.

Finally, it is clear how to the method described and illustrated here it is possible to apply modifications or variations without thereby departing from the scope of protection as defined by the attached claims.

For example, it is possible to inject water vapor so that downstream of the cooling point of the fumes, the particles in the aerosol increase their mass in order to facilitate their capture in separator 5. The water, for some condensed contaminants such as the organic matter in the fumes originating from the use of oils such as during frying, can be separated from the condensed contaminants after leaving the inertial separator.

It is also possible to dehumidify the air before cooling in refrigeration unit 11.

According to an embodiment not shown, the fumes before entering intertial separator 5 pass through a cross-flow exchanger e.g. figure 3 configured in such a way as to extend the heat exchange surface through the flue gas flow i.e. by means of heat exchange surfaces interposed between a maximum transverse dimension of a passage area of the duct 4 and the relative axis. This allows to favor the nucleation of condensed particles in the entire volume of fumes. In the case of a cross-flow exchanger, it is possible to use a liquid refrigerant fluid or one that can change phase from liquid to gaseous and vice versa in the cold generation circuit.

According to an embodiment not shown, the walls of cyclone separator 5 are also cooled by the cold fluid.

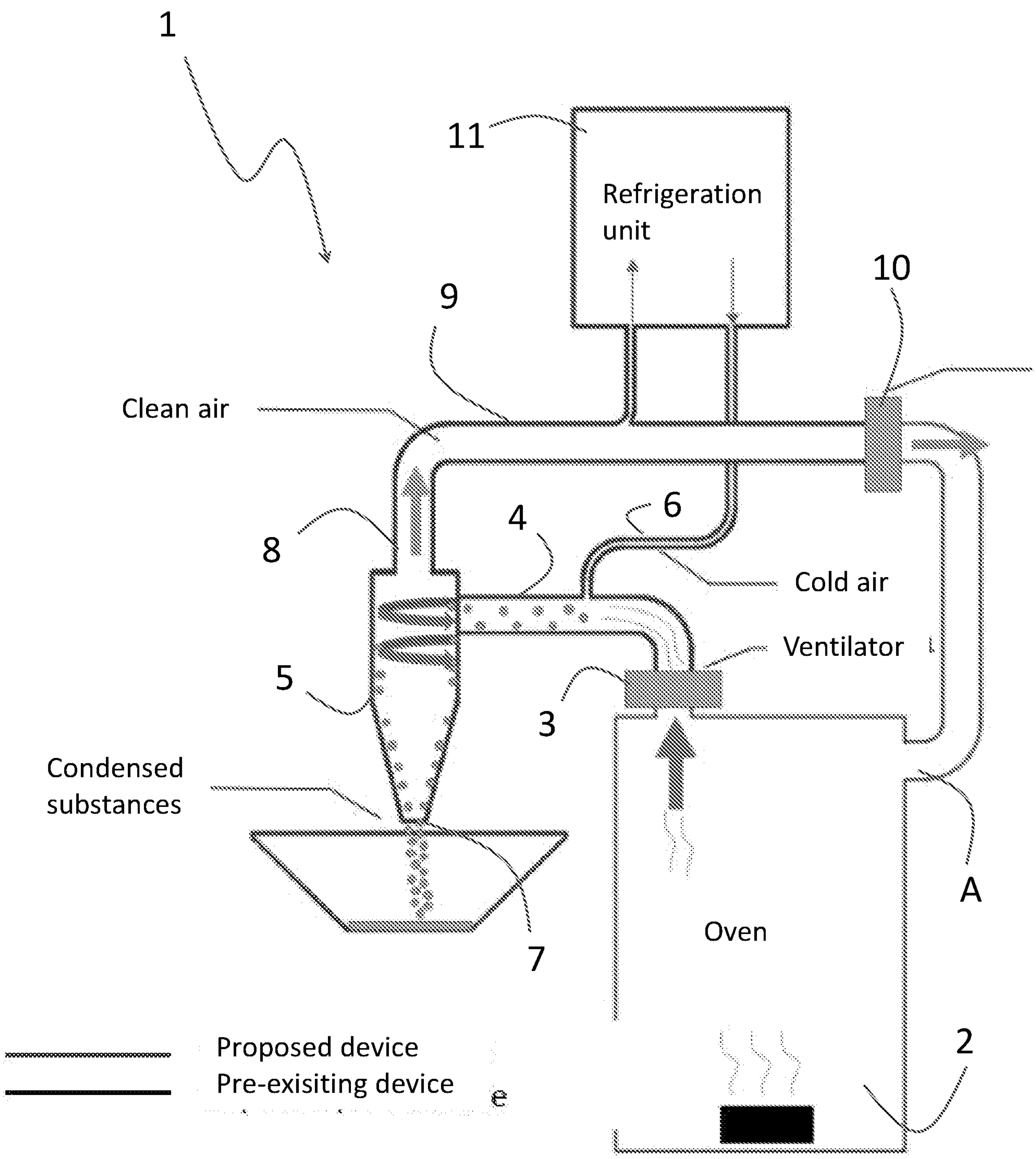
1
11
Refrigeration unit
9
10
Clean air
6
4
8
Cold air
Ventilator
5
3
Condensed substances
A
Oven
7
Proposed device
Pre-exisiting device
2

Fig. 1

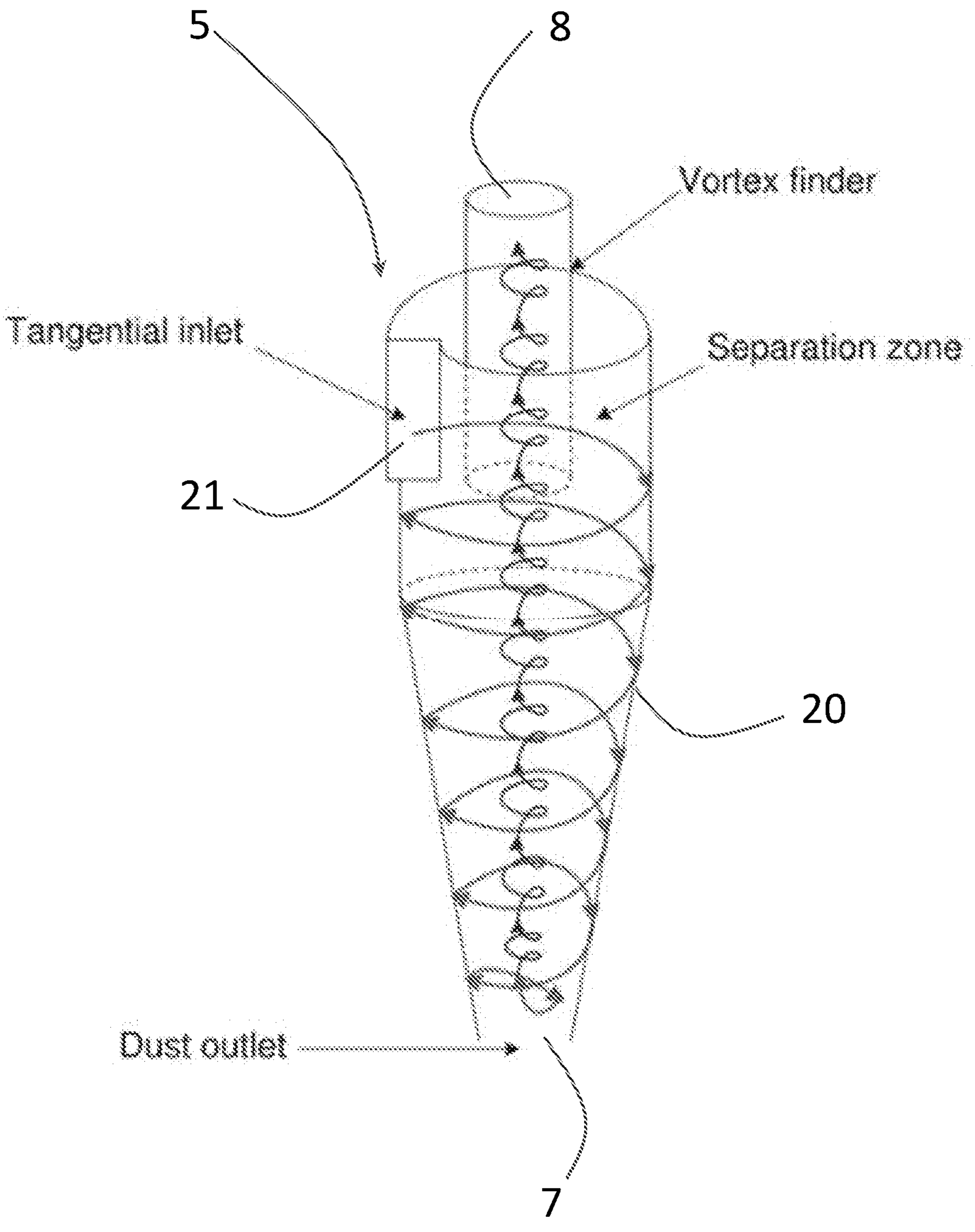
5
8
Vortex finder
Tangential inlet
Separation zone
21
20
Dust outlet
7

Fig. 2

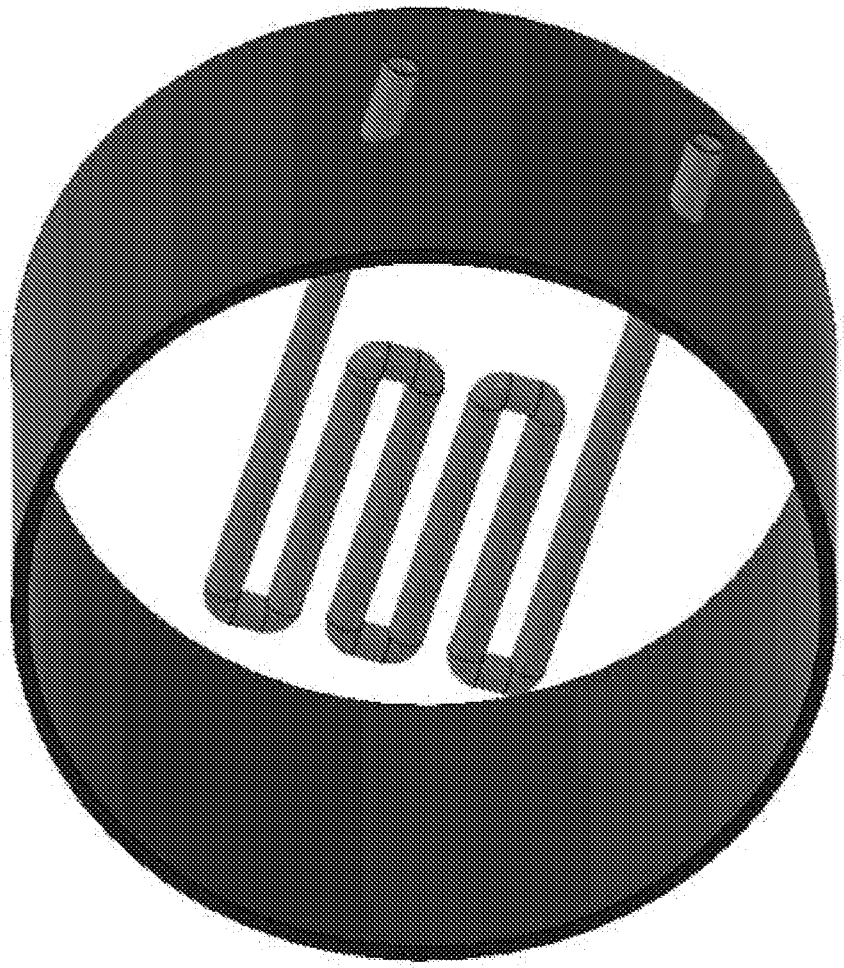

Fig. 3

ABSTRACT

A method of purification of fumes with condensable gaseous contaminants, including the steps of generating a flow of fumes to be treated in a heated area (2); generating a flow of cold fluid so that the air temperature is lower than that of the fumes to be treated; mixing the flow of cold fluid with the flow of the fumes to be treated to generate a mixture flow in which a condensation of the contaminants is induced and to force a nucleation of the condensed contaminants; conveying said mixture flow into an inertial separator unit for its purification.

Fig. 1