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Evacuation System with Exhaust Gas Cleaning and Operating Process for It

The invention concerns an evacuation system with exhaust gas cleaning for the cleaning of exhaust gases with components which can be condensed above room temperature, with at least one vacuum pump unit for the generation of a pressure difference with at least a factor of 5 between an intake pipe and a gas connecting pipe, and with at least one cleaning unit placed after it, with at least one device from the group of adsorbers, incineration furnaces, gas scrubbers, gas reactors and neutralizers for the fluid media supplied by the vacuum pump unit.

Such evacuation systems are known. They are used, for example, in connection with manufacturing installations of the semi-conductor industry in which a whole series of toxic and reactive gases are used. Thus, for example, in the chemical deposition process, so-called CVD process, gases such as certain silicon hydrides, phosphorous hydrides, boron hydrides, TEOS are used. In the dry etching process, a whole series of fluorine and chlorine compounds may be used. Since the processes involved are carried out under vacuum, gases of the above-mentioned types are constantly drawn off. Since these represent a substantial hazard to the environment, the exhaust gases from the vacuum pumps must be cleaned, for which purpose a whole series of exhaust gas cleaning processes and systems are available.

As vacuum pumps, oil sealed, rotary sliding vane compressors, dry sealed vacuum pump such as claw pumps, rotary piston pumps, screw compressors and the like are preferably used, before which can also be placed other vacuum pumps which operate in lower pressure ranges.

It is known how to install behind such vacuum pumps exhaust gas cleaning systems in which the following cleaning processes are carried out:

- Conversion of the gases into salts in such a manner that the gases are converted to an inert solid,

- Incineration and scrubbing of the gases with subsequent neutralization so that the original gases can be converted into dissolved solids and disposed of,
- The adsorption of the gases into special adsorption beds which bind the gases to their surfaces and are enclosed in canisters or cartridges (for example, activated charcoal or zeolite).

It is also known how to connect multiple production installations for semi-conductor elements to manifolds. Since the production processes in the individual production units do not run synchronously, gas mixtures are formed in the manifold whose components react with each other and form new, sometimes harmful, compounds.

At the current state of technology, there are, however, between the vacuum pumps or vacuum pump sets and the cleaning devices, long pipes whose length can be up to 15 m or more. As a result, enormous heat losses are involved, so that the piping cools below the dew point of the components capable of condensation. This has the decisive disadvantage that at least a part of the gases condenses in the piping involved, and is sublimated at a later time. This leads not only to substantial maintenance and cleaning costs, but also to hazards to the employees who carry out this work. Especially hazardous in this regard are certain fluorine compounds which react with the humidity in the air to form hydrofluoric acid, which is found in liquid form in the piping systems described. Even a single drop of hydrofluoric acid can lead to substantial etching of the skin; vapor and gaseous fluoride compounds represent a substantial danger to the respiratory system.

In part, the above described condensation of harmful materials in the pipe was accepted because the result was only an apparently improved cleaning effect in the exhaust gas cleaning systems.

The cleaning of piping, however, results in a substantial risk for the environment, personnel and for the installations,

since the condensates sometimes lead to leaks in the flange connections and even to the pipes being eaten through. Further, a backward diffusion of exhaust gases into the vacuum pumps has been observed in which, for example, the dry pump process has been substantially damaged.

In the end, on the one hand the vacuum pumps, and on the other hand the gas cleaning systems, need their own installation surfaces, which leads to a substantial increase in the investment costs of such installations, not to mention the fact that in some cases appropriate installation surfaces at a suitable location are not available. This leads to a substantial increase in the length of the piping systems which are already problematic.

Through DE 43 14 942 A1, it is known to place a separator and a suction fan on a single frame where the suction fan is placed after the separator. The known installation is neither provided nor suitable for vacuum operation because, as a result of using a suction fan, only moderate pressure decreases can be achieved. In the known sequence of separator and suction fan, the problem of dirtying the connecting pipes does not arise.

The problem which the invention is to solve is therefore to provide an evacuation system of the type described at the beginning in which the formation of condensates with the consequences described is avoided, but at least is reduced substantially and which needs a substantially smaller installation surface.

The solution to this problem is carried out by the evacuation system described at the beginning, in accordance with the invention, by:

- a) combining the at least one vacuum pump unit and the at least one cleaning unit into a single component, and
- b) limiting the gas connecting piping to a length in which the gas connecting piping is at least substantially without the addition of outside heat, capable of being kept at a temperature above the condensation temperature of the components which are capable of being condensed, by the heat

of compression of the vacuum pump unit.

The combining of at least one vacuum pump unit on the one hand and at least one cleaning unit on the other hand to a single component leads to an extremely compact construction, but especially to substantial shortening of the gas connecting pipe between the vacuum pump unit and the cleaning unit.

Consequently, as a rule, outside heating (the positive addition of heat) of the gas connecting piping and subsequent piping and valves up to the cleaning unit can be dispensed with. It is, however, advantageous to provide these pipes, etc. with a thermal isolation wrapping in order to support the effects of the gas heating through the vacuum pump unit, so that in every case condensation of harmful or toxic substances is prevented to the greatest extent possible.

In this regard, it is especially advantageous if the vacuum pump unit and the cleaning unit share a common frame.

The expression "common frame" does not necessarily mean that what is involved must be a single frame. Rather, it is perfectly possible to make up the basic frame from smaller partial frames. This is in substantial contradiction to the state of technology in which individual frames for the vacuum pump on the one hand and for the cleaning unit on the other hand are completely separated from each other and set up at different locations. The dimensions of such - horizontal - basic frames are preferably between 400 to 1200 cm x 450 to 1300 cm.

The extremely short piping leads to two advantages which mutually support each other: for one, only very small surfaces are available for the condensation of harmful substances, and small volumes for the collection of any liquid condensate. On the other hand, the relatively high gas temperatures at the output of the (last) vacuum pump result in a heating or keeping hot of the gas connecting pipes at temperatures at which no or only a negligible amount of condensation takes place. These output temperatures lie in general between 80 and 240°C.

The expression "essentially without adding heat from outside"

means that as a rule outside heating of the gas connecting piping can be dispensed with, namely if the dew point of the components capable of condensing is correspondingly low and the output temperature of the exhaust gases from the pumps lies above the dew points. By using pumps with low output temperatures and/or gas components with high dew points, it may be necessary to use external heating of the gas piping from the pump to the cleaning unit.

An example may clarify this: in the case of a 20 m long pipe, in accordance with the state of technology which, due to resistance to flow, must also have a correspondingly large cross-section, a thick wall and a large surface, an enormous amount of heat must be applied to the pipe by means of a heating mantle, in connection with which, during the start-up, the mass problem must be taken into account (cold start). Without outside heating, the dew point cannot be exceeded over the entire length of the pipe due to the very small mass flow of gases.

In the case of the object of the invention, the maximum length of the gas connecting pipe is approximately 2 m, so at most approximately 10% and, due to the small resistance to flow, its cross-section, its wall thickness and the surface can be kept clearly smaller so that the mass problem in the case of a cold start plays a secondary role. A possible continuous heating output could be reduced to less than 10% as compared with the state of technology, if it is needed at all. The heating up in the case of a cold start, by means of the exhaust gases, is possible in a substantially shorter time and it can be achieved through short-time pumping of compressed air which is completely impossible in the state of technology.

The smaller pipe cross-section which is possible in the case of the invention, also makes possible a higher rate of flow, so that the static pressure rises relatively and the danger of condensation of harmful substances is further reduced.

What is involved here is a synergistic effect: the hot exhaust gases leaving the vacuum pump unit arrive through along the shortest possible path in the shortest time and at a very high temperature in the cleaning unit. In case of a cold start, the

condensation risk can be prevented by bringing the gas connecting pipe to the desired temperature using air and only then introducing the exhaust gases with the harmful substances into the gas pipe.

The installation surface is not larger or at least not substantially larger than the installation surface of previously known vacuum pumps and, as a result, it is possible to install the evacuation system in accordance with the invention on a surface which would previously have been suitable for the installation of a vacuum pump or a set of vacuum pumps.

In this regard, it is an additional advantage if the common frame is formed in the known manner as a movable chassis. As a result, it is possible, in case of a breakdown or an inspection, to separate not only the vacuum pump but also, together with it, the cleaning unit from the production installation to which it is attached, and replace it with a replacement unit which has the same design and the same advantages.

By way of further development of the invention, it is especially advantageous if the vacuum pump and the cleaning unit are arranged within an imaginary square whose horizontal cross-section is determined by the outside perimeter of the basic frame. As a result, it is possible to supplement the basic frame with vertical supports and horizontal beams to a carrier of housing walls so that the entire aggregate can be produced as a completely enclosed unit.

It is further advantageous if the at least one vacuum pump is assigned a central control unit for the vacuum pump and for the cleaning unit. In an especially advantageous manner, there is assigned to the control unit an indicating unit for at least a portion of the operating parameters of the vacuum pump and cleaning unit in connection with which this control unit also can contain a control device for further functions such as, for example, for the rinsing of the vacuum pump with an inert gas.

In this regard, it is especially advantageous if the vacuum pump unit - if applicable as the last stage - has a three-bladed dry rotor pump which works in the pressure range between 10^{-2} mbar

and 1100 mbar.

Such a three-bladed dry rotor pump - which is basically known - has the following characteristics and advantages:

1. High output temperatures of the gases and
2. Small pressure pulsation.

The use of such a pump in accordance with the invention, as a result of its integration into the single component with the cleaning unit, leads to the already named advantages and also promotes the operating process of the cleaning units involved, especially in the case of combustion furnaces which work with a flame.

Furthermore, the use of exhaust mufflers can be dispensed with. This has the additional advantages that the exhaust gas path must not be expanded by passage through the muffler and its inner surfaces. The power loss is therefore less, and a cleaning point with potential hazards is removed since a muffler would be a device in which the condensation of harmful materials occurs preferentially.

This is especially the case if - regarded in the direction of flow of the exhaust gases - a roots pump is placed as the first stage before the three-bladed dry rotor pump, which operates in a pressure range between 10^{-3} mbar and 10 mbar.

It is further advantageous if a switch-over valve is placed in the gas connecting piping through which the exhaust gases can be fed optionally to the combustion furnace and the exhaust gas pipe. This makes it possible to continue the operation of the installation during a replacement of the cleaning unit.

The cleaning unit can advantageously consist of at least one device from the group adsorbers, combustion furnaces, gas scrubbers, gas reactors and neutralizers.

The invention also concerns an operating process for the above-described evacuation system. In order to solve the same problem, it is provided that the cleaning unit is operated with an

input temperature of the fluid medium of at least 80°C, preferably of at least 160°C.

Two sample embodiments of the invention are described in greater detail on the basis of Figures 1 and 2.

The following is shown:

Figure 1 A partially cut-away frontal view of a complete evacuation system, and

Figure 2 the lower part of a variant of the item shown in Figure 1.

In Figure 1, an evacuation system 1 is represented in which, on a rectangular horizontal frame 2, a vacuum pump unit 4 is attached, consisting of a series arrangement of a roots pump 4a and a three-bladed dry rotor pump 4b. These are driven by an electric motor 5 and a gear box 6, which are integral components of the vacuum pumps 4a and 4b.

The vacuum pump unit 4 includes an intake pipe 7, which is connected through a pipe coupling 8 to a manufacturing installation for semi-conductor components which is not shown. The pressure side of the vacuum pump unit 4 is connected through a gas pipe 9 to a cleaning unit 10, which in this case is equipped as a combustion furnace with a burner and a vertical main axis A-A. The design of a such a cleaning unit is explained in greater detail below, so that the internal design details given above are only indicative. The combustion gas is brought in through a pipe 11 and the cleaned exhaust gases in compliance with legal requirements of the TA air are released to the atmosphere through an exhaust gas pipe 12 either immediately or through a manifold not shown here ("TA air" in English is "TLV = threshold level value" for air).

The base frame 2 is supplemented by four braces 13, an intermediate frame 14 and an upper frame 15 to a supporting structure which at least in its area between the base frame 2 and the intermediate frame 14 can be closed in by wall elements which are not shown. It should be recognized that the vacuum pump unit 4 and the cleaning unit 10 are placed inside an imaginary rectangle

whose horizontal cross-section is determined by the outside perimeter of the base frame 2 and the vertical braces 13.

The cleaning unit 10 has a combustion furnace 21 in which the gas feed pipe 9 empties through a switch-over valve 22 and a pipe segment 9a. The combustion gas is brought in through the pipe 11. A pipe 23 serves to feed in combustion air in a quantity such that the combustion takes place with an excess of oxygen. Through a further pipe 24, a washing liquid, for example potassium hydroxide (KOH), is added and by means of a cone nozzle which is not shown is sprayed in the shape of a cone. The washing liquid is brought into circulation through a storage tank 25.

In the downward direction, a reaction chamber 26 follows the combustion furnace 21; in the reaction chamber, the combustion gases are further converted using the washing liquid. The washing liquid is finally returned to the storage tank 25 using a drain pipe 27.

The combustion gases finally flow upward and are brought through an aerosol filter 28 in which a further pipe 29 for the addition of the washing liquid from the storage tank 25 opens. On its ends as well, there is a cone nozzle, which is not shown, producing a cone shaped spray of washing liquid.

From the switch-over valve 22, a further pipe segment 9b leads into the gas pipe 12. In normal operation of the device, the pipe segment 9b is blocked off. Only for short intervals of time in which the combustion furnace 21 and/or the reaction chamber 26 are being replaced or cleaned, the exhaust gases can be fed directly to the exhaust gas pipe 12.

Figure 2 shows that the entire evacuation system can also be provided with wheels 3 in order to facilitate a change in location. Further, inside the component between the pipe coupling 8 and the intake side of the vacuum pump unit 4, a filter 31 and a cut-off valve 32 are placed. This latter has the advantage that the cleaning unit can be replaced or serviced while the vacuum pump unit is running so that it is kept at temperature until a new start-up takes place. As a result, the device is immediately fully ready for operation and condensations of harmful substances inside

the vacuum pump unit are prevented. The cut-off valve 32 is actuated by a built-in control unit 16 so that an external control and its wiring can be dispensed with.

The total unit is fully encapsulated so that no significant dirtying is possible.

Above the intermediate frame 14, a central control unit 16 is placed, which has an input keyboard 17 and an indicating device 18. The control unit 16 is connected through a large number of data and control leads 19 with the vacuum pump unit 4, and/or associated adjusting devices. The two leads 19 which are drawn in represent all these leads. Through the central control unit 16 and the leads 19, it is, for example, possible to transmit control commands for a motor switch, rinsing gas valves and cooling water valves. On the contrary, the position signals are reported to the control unit 15 through the leads 19 and, if necessary, to the indicating equipment 18 for display.

Further, the central control unit 16 is connected through a large number of data and control leads 20, of which also only two leads are represented, with the cleaning unit 10. Through the leads 20 can be transmitted, for example, pressure and temperature of the gases in the gas connection pipe 9 to the control unit 16, similarly signals for flame monitoring, temperature monitoring, water flow monitoring and a weight measuring device, if for example the weight of an adsorber cartridge is measured, which would show the exhaustion of an adsorber cartridge. In the other direction, adjusting signals can be transmitted from the control unit 16 for water flow, for heating current switch and for a possibly present by-pass pipe for the cleaning unit 10. As a result of this, both the measuring data and the adjustment signals for the individual adjustment units of the cleaning unit 10 can be represented on the display unit 18. Adjustment commands, desired values, etc. can be input through the keyboard 17 into the control unit 16.

As can be seen from Figure 1, the close spatial arrangement of vacuum pump unit 4 on the one hand and the cleaning unit 10 on the other hand allows the use of a single control device for both units, which also takes up no additional installation space, but

rather can be placed on top of the vacuum unit 4. As a result, an extraordinarily compact evacuation system is achieved which can be replaced with a replacement system in an extremely short time. The operating person has all the data of the pump system on the one hand and of the cleaning unit on the other hand in his field of view so that a monitoring pathway between separate control units can be avoided, as can the running of correspondingly long control and data leads, which would be necessary if the above-described equipment were installed in different locations. If necessary, the central control device 16 can also be supplemented with a plotter or printer in order to provide documentation on the operating parameters.



Patent Claims:

1. Evacuation system (1) with exhaust gas cleaning for the cleaning of exhaust gases with components which can be condensed above room temperature, with at least one vacuum pump unit (4) for the generation of a pressure difference with at least a factor of 5 between an intake pipe (7) and a gas connecting pipe (9), and with at least one cleaning unit (10) placed after it sequentially, with at least one device from the group of adsorbers, incineration furnaces, gas scrubbers, gas reactors and neutralizers for the fluid media supplied by the vacuum pump unit (4), characterized in that:
 - a) the at least one vacuum pump unit (4) and the at least one cleaning unit (10) are combined into a single assembly and that
 - b) the gas connecting pipe (9) is limited to a length in which the gas connecting pipe (9) can be held at a temperature at least essentially without the addition of outside heat, through the compressor heat of the vacuum pump unit (4), which is above the condensation temperature of the components which can condense.
2. Evacuation system in accordance with Claim 1, characterized in that the vacuum pump unit (4) and the cleaning unit (10) share a common base frame (2).
3. Evacuation system in accordance with Claim 1, characterized in that the common frame (2) is formed as movable chassis with wheels (3).
4. Evacuation system in accordance with Claim 1, characterized in that the vacuum pump unit (4) and the cleaning unit (10) are arranged inside an imaginary rectangle whose horizontal cross-section is determined by the outside perimeter of the base frame (2).
5. Evacuation system in accordance with Claim 1, characterized in that there is placed over the at least one vacuum pump unit (4) a central control unit (16) for the vacuum pump unit



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(4) and for the cleaning unit (10).

Evacuation system in accordance with Claim 5, characterized in that there is placed over the at least one vacuum pump unit (4) a display unit (18) for at least a portion of the operating parameters of the vacuum pump unit (4) and the cleaning unit (10).

Evacuation system in accordance with Claim 1, characterized in that the vacuum pump unit (4) contains a three-bladed dry rotor pump (4b) which operates in a pressure range between 10^{-2} mbar and 1100 mbar.

Evacuation system in accordance with Claim 1, characterized in that - as seen from the direction of flow of the exhaust gases - a roots pump (4a) is placed before the three-bladed dry rotor pump (4b) as a first stage, which operates in a pressure range between 10^{-3} mbar and 10 mbar.

Evacuation system in accordance with Claim 2, characterized in that the cleaning unit (10) with a vertical main axis (A-A) is arranged above the base frame (2).

Evacuation system in accordance with Claim , characterized in that the cleaning unit (10) has a combustion furnace (21) with a feed pipe (9a) for the gas to be cleaned, a combustion gas feed pipe (11), an air feed pipe (23) and with a feed pipe (24) for a washing liquid, and that below the combustion furnace (21) a reaction chamber (26) is provided for placing the combustion gases and washing liquid in contact.

Evacuation system in accordance with Claim 10, characterized in that below the reaction chamber (26), in addition to the vacuum pump unit (4), a storage tank (25) is placed for the washing liquid which operates in a circulatory fashion.

Evacuation system in accordance with Claim 10, characterized in that a switch-over valve (22) is placed in the gas connecting pipe (9), as a result of which the exhaust gases can be fed optionally to the combustion furnace (21) and the exhaust gas pipe (12).

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Evacuation system in accordance with Claim 5, characterized in that inside the unit on the intake side of the vacuum pump unit (4), a cut-off valve (48) is installed which can be operated from the built-in control unit (16).

An operating process for the evacuation system (1) in accordance with Claim 1, characterized in that the cleaning unit (10) is operated with an incoming temperature of the fluid media of at least 80°C, preferably of least 160°C.

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