

SYSTEM FOR CONTROLLING GAS FLOW INTO AN ABATEMENT APPARATUS**Field**

The present invention relates to a system for controlling gas flow into an abatement apparatus. The present invention also relates to a method for controlling gas flow into an abatement apparatus.

Background

Abatement apparatus are known and are typically used in systems for treating a process gas stream from a process tool. The process tool may be, for example, a process tool used in the manufacture of semiconductors or flat panel displays. In such applications, the process gas flow exiting the process tool may contain toxic compounds and/or compounds having a relatively high greenhouse activity. The process gas flow must therefore be treated to remove such compounds to avoid their release into the atmosphere. Typically, a vacuum pump is connected to the outlet of the process tool. During operation, the vacuum pump evacuates the process gases from the process tool and conveys the process gas stream to an abatement apparatus for treatment.

In some instances, a system may include a vacuum pump and an abatement apparatus that, whilst compatible from a mechanical perspective, are incompatible in that the devices are unable to communicate with each other. This incompatibility may be because the vacuum pump and the abatement apparatus are from different manufacturers, and/or produce signals that are unreadable by the other. To enable the system to operate, a user may have to manually operate each of the components of the system. This may cause a variety of problems, such as an undesirable reduction in the destruction or removal efficiency (DRE) performance of the abatement apparatus.

The lack of compatibility between the vacuum pump and the abatement apparatus may also prevent the use of some features of the abatement apparatus, such as adaptable injection flows that can improve abatement efficiency. Other unwanted effects may include overheating of the inlet head of the abatement apparatus or a flame flashback event due to insufficient forward flow into the abatement apparatus.

The present invention aims to solve, at least in part, these and other problems associated with the prior art.

Summary

In an aspect, the present invention provides a system for controlling gas flow into an abatement apparatus. The system comprises at least one vacuum pump configured to

evacuate process gases from a process tool. The system further comprises an interface controller. The system further comprises a flow measurement device arranged downstream of the at least one vacuum pump and configured to measure the flow rate of the process gas flow and send a flow rate signal to the interface controller. The system further comprises an abatement apparatus arranged downstream of the flow measurement device, and an auto-tuning gas injection block arranged upstream of the abatement apparatus and configured to inject one or more gases into the process gas flow. During use, the process tool is configured to send a signal to the interface controller indicating the process step that is occurring in the tool, and the interface controller is configured to send a process step signal to the auto-tuning gas injection block to control the injection of the one or more gases according to the process step occurring in the tool. The interface controller is configured to send a flow rate signal to the auto-tuning gas injection block to control the injection of the one or more gases according to the gas flow rate measured by the flow measurement device.

Preferably, the gas flow into an abatement apparatus may comprise the process gas flow from the process tool, and one or more gases injected by the auto-tuning gas injection block. The gas flow into the abatement apparatus may additionally comprise an inert gas. In other words, the gas flow into the abatement apparatus may additionally comprise an inert gas that is configured to increase the forward gas flow rate into the abatement apparatus. However, the inert gas may not react once within the abatement apparatus (i.e. the inert gas is distinct from the gas(es) from the auto-tuning gas injection block).

For the purposes of the present invention, the terms “upstream” and “downstream” refer to the relative positioning of components along the flow path of the process gas flow. The term “upstream” may refer to immediately upstream (i.e. the nearest upstream component). Alternatively, the term “upstream” may refer to a component positioned anywhere upstream, and may have one or more other component(s) positioned therebetween. The term “downstream” may refer to immediately downstream (i.e. the nearest downstream component). Alternatively, the term “downstream” may refer to a component positioned anywhere downstream, and may have one or more other component(s) positioned therebetween.

The abatement apparatus may comprise, for example, an inward-fired combustor. It will be appreciated that the invention is not exclusively limited to a specific type of abatement apparatus. By way of non-limiting example, the abatement apparatus may be an Atlas™ as produced by Edwards Limited. The abatement apparatus may comprise an abatement controller, which may be a programmable logic controller (PLC). The abatement controller may be configured to control the operation of the abatement apparatus.

In some embodiments, the interface controller may be a distinct and separate component from the process tool, and/or the vacuum pump(s) and/or the abatement apparatus. In other words, the process tool, the vacuum pump(s), and the abatement apparatus may each have a built-in controller, and the interface controller may be an additional component within the system. In some embodiments, the interface controller may be retrofit to pre-existing systems to improve the interactivity of the components.

In some embodiments, the interface controller may be integrated within the abatement apparatus. For example, the interface controller and the abatement controller may be the same component.

The interface controller may comprise an electrical control box. The interface controller may be configured to receive input signals and send output signals. The input signals and/or output signals may be digital and/or analogue signals. The interface controller may comprise a programmable logic controller (PLC). The interface controller may comprise one or more relays. In some embodiments, the interface controller may be configured to operate one or more solenoid valves. The solenoid valve(s) may be configured to control the flow of one or more gasses at the auto-tuning gas injection block. The solenoid valve(s) may be part of the auto-tuning gas injection block.

It will be appreciated that the interface controller may be configured to send signal(s) to the auto-tuning gas injection block and/or the bypass valve via the abatement controller (i.e. PLC) of the abatement apparatus.

The interface controller may be coupled via relays to the built-in controllers of the vacuum pump(s) and the abatement apparatus (i.e. the abatement controller), respectively. The interface controller may be configured, in use, to communicate with the vacuum pump(s) and the abatement apparatus.

The skilled person will appreciate that the system of the present invention is not limited to a specific type of process tool, or specific compositions of process gases. The system can be adapted to work with a variety of types of vacuum pump, and/or abatement apparatus, and/or process tools. By way of example, the process tool may comprise a process tool used in, for example, the semiconductor, flat panel display, solar cell, or MOCVD industries. The composition of the process gas flow may depend on both the process tool, and the process step that is occurring. The composition of the process gas flow may vary whilst the system is in operation.

The signal sent by the flow measurement device to the interface controller may indicate the flow rate of the process gas flow.

In some embodiments, the auto-tuning gas injection block may be a part of the abatement apparatus. In such embodiments, the auto-tuning gas injection block may be arranged at the inlet of the abatement apparatus. In alternative embodiments, the auto-tuning gas injection block may be a separate component to the abatement apparatus, and may be arranged between the flow measurement device or the bypass valve, and the abatement apparatus. For the purposes of the present invention, "auto-tuning" may refer to the ability to adjust the gas injection in response to one or more input signals, as will be described later herein.

The composition of the one or more gases injected into the process-gas flow by the auto-tuning gas injection block may depend on the composition of the process gases that are entering the abatement apparatus. By way of non-limiting example, the gas(es) may comprise oxygen, methane, propane, and/or hydrogen. The one or more gases may comprise fuel gas(es) configured to aid combustion within the abatement apparatus. The composition of the gases being injected may be adjusted whilst the system is in operation. Specifically, the injection rate of each gas may be adjusted whilst the system is in operation. Additionally, or alternatively, the ratio of gases injected by the auto-tuning gas injection block may also be adjusted whilst the system is in operation. Preferably, the adjustment(s) of the composition of the gas(es) may be in response to signal from the interface controller.

The process tool, the vacuum pump(s), the flow measurement device, auto-tuning gas injection block, and the abatement apparatus, may be fluidly connected by a line configured to convey the process gas flow therethrough.

During use, the process tool is configured to send a signal to the interface controller indicating the process step that is occurring in the tool. The interface controller is configured, upon receipt of the signal from the process tool, to send a process step signal to the auto-tuning gas injection block to control the injection of the one or more gases according to the process step occurring in the tool. In some embodiments, the interface controller may send the process step signal to the abatement controller, which then sends a process step signal to the auto-tuning gas injection block.

The auto-tuning gas injection block may comprise a plurality of outlets. Each outlet may be configured to inject a gas into the process gas flow. Each outlet may be connected to an inlet nozzle of the abatement apparatus. The controlled injection of one or more gases may include controlling the delivery rate of the gas(es) through a plurality of outlets of the auto-tuning gas injection block into the abatement apparatus. The flow rate of gas through each outlet may be independently controlled.

Advantageously, the composition and/or quantity of the one or more gases may be adjusted in real time according to the specific process step occurring in the process tool. This may avoid

unnecessary gas usage, and may improve the efficiency of abatement. Additionally, this may improve the automation of the system.

The interface controller is configured, upon receipt of the flow rate signal from the flow measurement device, to send a flow rate signal to the auto-tuning gas injection block to control the injection of the one or more gases according to the gas flow rate measured by the flow measurement device. The interface controller may send an analogue flow rate signal to the auto-tuning gas injection block. In some embodiments, the interface controller may send an analogue flow rate signal to the auto-tuning gas injection block via the abatement controller. The auto-tuning gas injection block may then automatically adjust the injection of one or more gases in response to variation of the flow rate signal. This may enable the automatic adjustment of the gas injection according to the measured flow rate of the process gas flow. This may aid in reducing unnecessary gas (e.g. fuel) usage, and may improve the efficiency of abatement.

Advantageously, the system of the present invention may improve the efficiency of abatement. Particularly, the system may provide efficient abatement even where the vacuum pump(s) and the abatement apparatus cannot interface directly, for example because they are made by different manufacturers. In such instances, the interface controller enables communication between components and greater automation of the operation of the system. The interface controller of the present invention may provide a means of communication between abatement apparatus and vacuum pumps even when components are not directly compatible.

Typically, the flow measurement device may be configured to substantially continuously measure the flow rate of the process gas flow during operation. For the purposes of the present invention, substantially continuously may be defined as a measurement being taken at least 1 times per second, or at least 5 times per second or more. In such embodiments, the flow measurement device may be configured to substantially continuously send a flow rate signal to the interface controller. Preferably, the flow rate signal produced by the flow measurement device is an analogue signal. Said analogue signal may correspond to the flow rate measured by the flow measurement device. Advantageously, the system of the present invention may enable the injection of the one or more gases (e.g. fuel gases) into the process gas flow to be adjusted according to a real-time measurement of the flow rate of the process gas flow. This may improve the efficiency of the abatement.

The system may further comprise an inert gas injection source. Preferably, the inert gas injection source may be arranged downstream of the flow measurement device. Alternatively, the inert gas injection source may be arranged upstream of the flow measurement device. The interface controller may be configured to initiate the injection of inert gas into the process gas

flow if the measured flow rate falls below a threshold flow rate. The inert gas injection source may primarily provide a mechanism for increasing forward flow of the process gas flow into the abatement apparatus.

Preferably, the inert gas injection source is a nitrogen injection source. The gas injection source may be configured to maintain the flow rate of gas into the abatement apparatus above a threshold flow rate during operation of the system. It will be appreciated that the value of the threshold flow rate may depend on the system and/or on the process occurring in the process tool. Advantageously, the gas injection source may provide safe operating conditions of the abatement by maintaining a forward gas flow into the abatement apparatus. This may reduce the likelihood of flame flashback.

The threshold flow rate may be the threshold flow rate per inlet nozzle of the abatement apparatus. By way of non-limiting example, the threshold flow rate may be from about 40 slm per inlet nozzle to about 160 slm per inlet nozzle, preferably about 50 slm per inlet nozzle to about 150 slm per inlet nozzle. The threshold flow rate may depend on a number of factors, which may include the type of abatement apparatus, the type and/or number of vacuum pumps, the type of process tool, and/or the process step occurring in the process tool. Preferably, the inert gas injection source may be configured to maintain the flow rate of gas into the abatement apparatus within about ± 5 slm of a target flow rate per inlet nozzle. The target flow rate per nozzle may be, for example, about 50 slm to about 150 slm per inlet nozzle.

In some embodiments, flow rate of gas injected via the inert gas injection source may be variable according to the flow rate of the process gas flow as measured by the flow measurement device. This may be particularly advantageous for embodiments in which a single abatement apparatus is coupled to a plurality of vacuum pumps. In such embodiments, there may be instances where one or more vacuum pumps is in operation whilst one or more further vacuum pumps is not. Accordingly, the flow rate of process gas may be decreased in comparison to a situation wherein all of the vacuum pumps are in operation. To account for this decrease in flow rate of process gas, the flow rate of the gas injected via the gas injection source may be increased to be at or above the threshold flow rate.

Typically, the system may further comprise a bypass valve arranged between the flow measurement device and the abatement apparatus. The bypass valve may be configured to direct gas flow either through the abatement apparatus or to bypass the abatement apparatus, in response to an input signal. Advantageously, the bypass valve may enable the abatement apparatus to be taken offline (i.e. fluidly disconnected from the vacuum pump(s)).

Preferably, the interface controller may be configured to send a pump run signal to the bypass valve when the flow rate as measured by the flow measurement device is above a pump run

flow rate threshold. In response to this pump run signal, the bypass may direct gas flow through the abatement apparatus. This pump run signal may be the input signal to the bypass valve. The system may be configured such that, when the flow rate as measured by the flow measurement device is above a pump run flow rate threshold, the bypass valve directs gas flow through the abatement apparatus. The system may further be configured such that, when the flow rate as measured by the flow rate measurement device is below a pump run flow rate threshold following injection of inert gas from the inert gas injection source, the bypass valve directs gas flow to bypass the abatement apparatus. This may also apply in embodiments comprising a plurality of bypass valves.

The pump run flow rate threshold may be determined by the minimum flow rate when a process step is occurring in the process tool. It will be appreciated that the pump run flow rate threshold may be dependent on the process step occurring, the process tool and the system configuration. Advantageously, this may enable the bypass valve to effectively operate even when the vacuum pump(s) cannot directly interact with the bypass valve.

For the avoidance of doubt, the threshold flow rate is distinct and separate from the pump run flow rate threshold described hereinbefore.

In some embodiments, the system comprises a plurality of vacuum pumps, each of which is configured to convey process gas into the inlet of the abatement apparatus. However, there may be times when not all of the vacuum pumps are operating simultaneously. In such instances, controlling the bypass valve according to the flow rate as measured by the flow measurement device may be advantageous. The system may comprise a plurality of bypass valves, with each vacuum pump having a corresponding bypass valve arranged downstream thereof.

Additionally, or alternatively, at least one vacuum pump may be configured to send a pump run signal to the abatement controller, in some instances via the interface controller. The abatement controller may then send the pump run signal to the bypass valve(s). The bypass valve(s) may be configured, upon receipt of a pump run signal, to direct gas through the abatement apparatus.

In some embodiments, the bypass valve may be configured to separate the process gas flow between a plurality of inlets of the abatement apparatus. Preferably, the bypass valve may be configured to substantially evenly separate the process gas flow between a plurality of inlets of the abatement apparatus. In some embodiments, the system may further comprise a plurality of secondary flow measurement devices. The secondary flow measurement devices may each correspond to a separate inlet of the abatement apparatus, and be arranged between the bypass valve and said inlet of the abatement apparatus. Each secondary flow

measurement device may be configured to measure the flow rate of the process gas flow into an inlet of the abatement apparatus and to send a flow rate signal to the interface controller. Advantageously, separating the process gas flow between a plurality of inlets of the abatement apparatus via the bypass valve may enable more efficient abatement because the process gas flow is better distributed within the abatement apparatus. The secondary flow measurement devices may be substantially the same as the other flow measurement device of the system, as described elsewhere herein. Measuring the flow rate of the process gas flow into each inlet of the abatement apparatus may allow for improved control and optimisation of the abatement apparatus.

In some embodiments, the system may comprise a plurality of bypass valves. In such embodiments, the system may comprise a plurality of flow measurement devices. A flow measurement device may be arranged upstream of the bypass valves. A secondary flow measurement device may also be arranged downstream of each bypass valve.

Typically, the system may comprise a plurality of vacuum pumps. Each vacuum pump may be configured to evacuate process gases from the process tool. Preferably, the system may comprise from about two to about fifty vacuum pumps. The vacuum pumps may be of the same type, for example turbomolecular pumps. Alternatively, one or more of the vacuum pumps may be different. As set out elsewhere herein, an advantage of the system of the present invention is that the system may enable communication and flow rate control regardless of whether the vacuum pump(s) and abatement apparatus are from the same manufacturer.

Typically, the flow measurement device may be a pressure drop device. Alternatively, the flow measurement device may be, for example, a thermal resistance device or an anemometer. It will be appreciated that various alternative flow measurement devices may be used.

Typically, operation of the system may be substantially automated. In other words, the interface controller may interface between the process tool, the vacuum pump(s), and the abatement apparatus, substantially without requirement for user input. The operation of the auto-tuning gas injection block and/or the inert gas injection source may be substantially automated.

In another aspect, the present invention provides a method for controlling gas flow into an abatement apparatus. The method comprises the steps of (a) providing a system according to any preceding aspect or embodiment, (b) operating the process tool, (c) operating the at least one vacuum pump to evacuate process gases from the process tool, (d) measuring the flow rate of the process gas flow with the flow measurement device, and (e) injecting one or more gases via the auto-tuning gas injection block according to the process step occurring in

the process tool, wherein the injection rate is controlled according to the flow rate of the process gas flow. Further description of the features and advantages of the system may be found in other aspects or embodiments described herein.

Typically, the method may further comprise the step of injecting an inert gas via the inert gas injection source if the measured flow rate falls below a threshold flow rate. Preferably, the inert gas may be nitrogen. Advantageously, this may maintain a continuous forward flow of gas into the abatement apparatus, and thereby reduce the likelihood of flame flashback.

Typically, the method may further comprise the step of directing gas flow through the abatement apparatus via the bypass valve when the flow rate measured by the flow measurement device is above a pump run flow rate threshold. The method may further comprise the step of directing gas flow, via the bypass valve, to bypass the abatement apparatus when the flow rate measured by the flow measurement device is below a pump run flow rate threshold. The pump run flow rate threshold may be as defined elsewhere herein.

Typically, steps (b), (c), (d), and (e) of the method may be controlled via the interface controller. Preferably, the steps may be substantially automated.

In another aspect, the present invention provides a system for controlling gas flow into an abatement apparatus. The system comprises at least one vacuum pump configured to evacuate process gases from a process tool. The system further comprises a interface controller. The system further comprises a flow measurement device arranged downstream of the at least one vacuum pump and configured to measure the flow rate of the process gas flow and send a flow rate signal to the interface controller. The system further comprises an abatement apparatus arranged downstream of the flow measurement device, and an auto-tuning gas injection block arranged upstream of the abatement apparatus and configured to inject one or more gases into the process gas flow. Said gases may be fuel gases for combustion within the abatement apparatus. The system further comprises an inert gas injection source arranged upstream of the flow measurement device. During use, the interface controller is configured to initiate the injection of inert gas if the measured flow rate of the process gas flow falls below a threshold flow rate.

Advantageously, this may ensure a continuous forward flow of gas into the abatement apparatus, even if the process gas flow from the process tool decreases. This may reduce the likelihood of flame flashback from the abatement apparatus, which can damage components of the system and may require maintenance.

Preferably, the inert gas injection source is a nitrogen injection source.

Further features of the system may be as described in embodiments of the preceding aspects.

For the avoidance of doubt, all aspects and embodiments described herein may be combined, *mutatis mutandis*. It is also to be understood that this invention is not limited to the embodiments and aspects set forth in the following detailed description or illustrated in the drawings. The invention may be implemented in various other embodiments and is capable of being implemented in alternative ways not expressly disclosed herein.

Brief description of figures

Preferred features of the present invention will now be described, by way of example, with reference to the accompanying figures, in which:

Figure 1 illustrates a schematic of a system according to the present invention;

Figure 2 illustrates a flow diagram of a method according to the present invention.

Detailed description of figures

Figure 1 shows a schematic of a system according to an embodiment of the present invention.

The system comprises a process tool (1). The system further comprises a vacuum pump (2). The vacuum pump (2) is fluidly connected to the process tool (1). In the schematic of Figure 1, the solid arrows indicate a line (e.g. a pipe) through which gas may be conveyed during use. The direction of the arrow indicates the general direction of the gas flow within the line. The vacuum pump (2) is arranged downstream of the process tool (1). During operation, the vacuum pump (2) is configured to evacuate process gases from the process tool (1).

In this embodiment, the system further comprises a bypass valve (3). The bypass valve (3) is fluidly connected to the vacuum pump (2). The bypass valve (3) is downstream of the vacuum pump (2).

In this embodiment, the system further comprises an inert gas injection source (4). The inert gas injection source (4) is configured to inject nitrogen gas into the process gas flow to maintain a forward flow.

The system further comprises a flow measurement device (5). The flow measurement device (5) is arranged downstream of the vacuum pump (2). In this embodiment, the flow measurement device (5) is arranged upstream of the bypass valve (3) and the inert gas injection source (4). It will be understood that in alternative embodiments, the flow measurement device (5) may be arranged downstream of the bypass valve (3).

The system further comprises an interface controller (6). The interface controller (6) is not fluidly connected to the other components of the system. The system further comprises an auto-

tuning gas injection block (7) and an abatement apparatus (8). The abatement apparatus (8) comprises an abatement controller therein.

In this embodiment, the interface controller (6) is electrically connected to the process tool (1), the bypass valve (3), the inert gas injection source (4), the flow measurement device (5), and the abatement apparatus (8). The interface controller (6) is connected to the auto-tuning gas injection block (7) via the abatement controller of the abatement apparatus (8).

The auto-tuning gas injection block (7) is arranged upstream of the abatement apparatus (8). In this embodiment, the auto-tuning gas injection block (7) is a separate component to the abatement apparatus (8).

In Figure 1, the dashed lines indicate signals being transmitted between components during operation. During use thereof, the process tool (1) sends a signal (9) to the interface controller (6). This signal (9) indicates the process step occurring in the process tool (1). Upon receiving this signal (9) from the process tool (1), the interface controller (6) sends a signal (10) to the abatement controller of the abatement apparatus (8) indicating the process step occurring in the process tool (1). Typically, this signal (10) is a digital signal. Upon receipt of the signal (10) from the interface controller (6), the abatement controller may initiate operation of the abatement apparatus (8). The operating conditions of the abatement apparatus (8) may be adjusted according to the signal (10) received indicating the process step occurring in the process tool (1). Accordingly, the interface controller (6) provides a means for communication between the process tool (1) and the abatement apparatus (8).

Upon receipt of the signal (10) from the interface controller (6), the abatement apparatus (8) may send a signal (11) to the auto-tuning gas injection block (7). The signal (11) may indicate the process step occurring in the process tool (1). The signal (11) may determine the appropriate gas injection settings for the auto-tuning gas injection block (7) according to the process step.

During operation, the flow measurement device (5) may be configured to measure the flow rate of the process gas flow. The flow measurement device (5) sends a signal (12) to the interface controller (6) indicating the flow rate of the process gas flow. The interface controller (6) then sends a signal (13) to the abatement controller of the abatement apparatus (8) indicating the flow rate of the process gas flow. Typically, this signal (13) is an analogue signal and is proportional to the flow rate of the process gas flow. The abatement controller of the abatement apparatus (8) then sends a signal (14) to the auto-tuning gas injection block (7) indicating the flow rate of the process gas flow. The auto-tuning gas injection block (7) may then adjust the gas injection (17) into the abatement apparatus (8) according to the flow rate of the process gas flow as measured by the flow measurement device (5). The auto-tuning

gas injection block (7) may adjust the fuel gas composition injected according to the signal (13) indicating flow rate of the process gas flow.

Upon receipt of the signal (12) from the flow measurement device (5), the interface controller (6) sends a signal (15) to the bypass valve (3). If the signal (12) from the flow measurement device (5) indicates that the flow rate is at or above a pump run flow rate threshold, then the interface controller (6) sends a signal (15) to the bypass valve (3) to direct gas flow through the abatement apparatus (8). It will be appreciated that the signal may be sent from the interface controller (6) to the bypass valve (3) via the abatement controller of the abatement apparatus (8). If the signal (12) from the flow measurement device (5) indicates that the flow rate is below a pump run flow rate threshold, then the interface controller (6) sends a signal (15) to the bypass valve (3) to direct gas flow to bypass the abatement apparatus (8). Accordingly, the system of the present invention enables the bypass valve (3) to operate based on the flow rate of gas exiting the vacuum pump (2). Thereby, the operation of the bypass valve (3) does not require direct communication between the vacuum pump (2) and the bypass valve (3) or abatement apparatus (8).

Upon receipt of the signal (12) from the flow measurement device (5), if the measured gas flow rate is below a threshold flow rate, then the interface controller (6) will send a signal (16) to the inert gas injection source (4). The inert gas injection source (4) then injects inert gas (e.g. nitrogen) into the process gas flow. The rate of gas injection may be varied according to the flow rate measured by the flow measurement device (5). This may reduce the likelihood of flame flashback at the inlet of the abatement apparatus (8).

Figure 2 shows a flow diagram of a method according to the present invention. The method comprises the step of providing a system according to any embodiment or aspect described herein (18). For example, the system may be as shown in Figure 1 and described herein.

The method further comprises the step of operating the process tool of the system (19). The operation of the process tool may include, for example, performing one or more deposition and/or cleaning steps. This step may further comprise the process tool sending a signal to the interface controller indicating the process step occurring in the process tool.

The method further comprises the step of operating the vacuum pump or pumps to evacuate process gases from the process tool (20). This step (20) may be initiated concurrently with the step (19) of operating the process tool. In some instances, the step (20) of operating the vacuum pump(s) may be initiated for a period prior to operation of the process tool. In some cases, the operation of the process tool may automatically initiate operation of the vacuum pump(s). The vacuum pump(s) may continue to evacuate process gases from the process tool throughout operation of the process tool.

The method further comprises the step of measuring the flow rate of the process gas flow with the flow measurement device (21). The flow measurement device may typically be arranged between the vacuum pump(s) and the abatement apparatus. The flow rate of the process gas flow may be measured after exiting the vacuum pump(s) and before entering the abatement apparatus. This step may comprise substantially continuously measuring the flow rate of the process gas flow during operation of the process tool. Preferably, this step (21) may further comprise the flow measurement device sending a signal to the interface controller indicating the flow rate of the process gas flow.

The method further comprises the step of injecting one or more gases via the auto-tuning gas injection block into the abatement apparatus. The composition of the gases may be determined and/or varied according to process step occurring in the process tool, wherein the injection rate is controlled according to the flow rate of the process gas flow (22). The interface controller sends a signal to the auto-tuning gas injection block indicating the process step occurring in the process tool. Thereby, the auto-tuning gas injection block injects the appropriate gas(es) into the process gas flow according to the process step. The interface controller sends a signal to the auto-tuning gas injection block corresponding to the flow rate measured by the flow measurement device. This signal enables the auto-tuning gas injection block to adjust the injection rate in real time according to the flow rate of the process gas flow.

In this embodiment, the method further comprises the step of injecting gas (e.g. nitrogen) via the gas injection source if the measured flow rate falls below a threshold flow rate (23). At any time during operation of the system, if the flow rate measured by the flow measurement device drops below a threshold flow rate, the interface controller sends a signal to the inert gas injection source to inject inert gas into the process gas flow upstream of the abatement apparatus.

In this embodiment, the method further comprises the step of directing gas flow through the abatement apparatus via the bypass valve when the flow rate measured by the flow measurement device is above a pump run flow rate threshold (24). Conversely, if the flow rate measured by the flow measurement device is below a pump run flow rate threshold, then the bypass valve directs gas flow to bypass the abatement apparatus.

In this embodiment, the steps are controlled by the interface controller, such that the method is substantially automated.

For the avoidance of doubt, features of any aspects or embodiments recited herein may be combined *mutatis mutandis*. It will be appreciated that various modifications may be made to the embodiments shown without departing from the spirit and scope of the invention as defined by the accompanying claims as interpreted under patent law, including the doctrine of

equivalents. Any reference to claim elements in the singular, for example, using the articles “a”, “an”, “the” or “said”, is not to be construed as limiting the element to the singular.

Reference Key

1. Process tool
2. Vacuum pump
3. Bypass valve
4. Inert gas injection source
5. Flow measurement device
6. Interface Controller
7. Auto-tuning fuel injection block
8. Abatement apparatus
9. Signal
10. Signal
11. Signal
12. Signal
13. Signal
14. Signal
15. Signal
16. Signal
17. Gas injection
18. Method step
19. Method step
20. Method step
21. Method step
22. Method step
23. Method step
24. Method step

Claims

1. A system for controlling gas flow into an abatement apparatus, the system comprising:
at least one vacuum pump configured to evacuate process gases from a process tool,
an interface controller,
a flow measurement device arranged downstream of the at least one vacuum pump and configured to measure the flow rate of the process gas flow and send a flow rate signal to the interface controller,
an abatement apparatus arranged downstream of the flow measurement device,
and
an auto-tuning gas injection block arranged upstream of the abatement apparatus and configured to inject one or more gases into the process gas flow;
wherein, during use, the process tool is configured to send a signal to the interface controller indicating the process step that is occurring in the process tool, and the interface controller is configured to send a process step signal to the auto-tuning gas injection block to control the injection of the one or more gases according to the process step occurring in the process tool;
and
wherein the interface controller is configured to send a flow rate signal to the auto-tuning gas injection block to control the injection of the one or more gases according to the gas flow rate measured by the flow measurement device.
2. The system according to claim 1, wherein the flow measurement device is configured to substantially continuously measure the flow rate of the process gas flow, preferably wherein the flow rate signal produced by the flow measurement device is an analogue signal.
3. The system according to claim 1 or 2, further comprising an inert gas injection source, wherein the interface controller is configured to initiate the injection of inert gas if the measured flow rate falls below a threshold flow rate, preferably wherein the inert gas injection source is a nitrogen injection source.
4. The system according to claim 3, wherein the threshold flow rate is from about 50 slm to about 150 slm.
5. The system according to any preceding claim, further comprising a bypass valve arranged between the flow measurement device and the abatement apparatus, and

configured to direct gas flow either through the abatement apparatus or to bypass the abatement apparatus, according to receipt of an input signal.

6. The system according to claim 5, wherein the interface controller is configured to send a pump run signal to the bypass valve when the flow rate measured by the flow measurement device is above a pump run flow rate threshold.

7. The system according to claim 5 or 6, wherein at least one vacuum pump is configured to send a pump run signal to the bypass valve when in use, and the bypass valve is configured, upon receipt of said pump run signal, to direct gas through the abatement apparatus.

8. The system according to any of claims 5 to 7, wherein the bypass valve is configured to separate the process gas flow between a plurality of inlets of the abatement apparatus, preferably wherein the system further comprises a plurality of secondary flow measurement devices, each secondary flow measurement device being configured to measure the flow rate of the process gas flow into an inlet of the abatement apparatus and to send a flow rate signal to the interface controller.

9. The system according to any preceding claim, comprising a plurality of vacuum pumps configured to evacuate process gases from the process tool.

10. The system according to any preceding claim, wherein the flow measurement device is a pressure drop device.

11. The system according to any preceding claim, wherein during operation, the system is substantially automated.

12. A method for controlling gas flow into an abatement apparatus, comprising the steps of:

- a) providing a system according to any preceding claim;
- b) operating the process tool;
- c) operating the at least one vacuum pump to evacuate process gases from the process tool;
- d) measuring the flow rate of the process gas flow with the flow measurement device;
- e) injecting one or more gases via the auto-tuning gas injection block according to the process step occurring in the process tool, wherein the injection rate is controlled according to the flow rate of the process gas flow.

13. The method according to claim 12, further comprising the step of injecting an inert gas via the inert gas injection source if the measured flow rate falls below a threshold flow rate.

14. The method according to claims 12 or 13, further comprising the step of directing gas flow through the abatement apparatus via the bypass valve when the flow rate measured by the flow measurement device is above a pump run flow rate threshold.
15. The method according to any of claims 12 to 14, wherein the steps are controlled via the interface controller, preferably wherein the steps are substantially automated.