

Gas Injection System

Field

The present invention relates to a gas injection system, preferably an abatement inlet gas injection system for automatically controlling injection of a gas flow into a process gas stream.

The present invention also relates to a method for controlling injection of a gas flow into a process gas stream in an abatement inlet.

Background

Abatement apparatus are known and are typically used for treating an effluent gas stream from a manufacturing processing tool used in, for example, the semiconductor or flat panel display manufacturing industry. During such manufacturing, residual compounds exist in the effluent gas stream pumped from the process tool.

Some known abatement apparatus use combustion to remove the compounds from the effluent gas stream. One or more gases may be mixed with the effluent gas stream within the inlet of the abatement apparatus (i.e. the abatement inlet). The one or more gases may include, for example, fuel gas(es) and/or oxidant gas(es). The gas stream mixture is conveyed into a combustion chamber. The gas stream mixture may effect combustion within the combustion chamber, consuming not only fuel gas supplied to the burner, but also combustibles present in the gas stream mixture.

In abatement apparatus of the prior art, the injection rate of the fuel gas and/or oxidant may be controlled by one or more needle valves. Said needle valves are typically manually set prior to operation, which is both time consuming and complex as a result of the limited space within the abatement apparatus for operator access. Due to this complexity, once the needle valves have been set they are typically not readjusted. This may lead to problems of uneven flow distribution of the fuel gases and/or the oxidant, as the needle valves cannot adjust flow rate in response to variations in supply flow. These variations in the supply flow rate may be caused by, for example, pressure drop downstream of the injection block comprising said needle valves.

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

Summary

In an aspect, the present invention provides an abatement inlet gas injection system for automatically controlling injection of a gas flow into a process gas stream. The system comprises a gas supply configured to provide a gas flow. The system further comprises an injection block connected to the gas supply. The injection block is configured to inject the gas flow into an inlet head of an abatement apparatus for mixture with a process gas stream.

The system further comprises a flow measurement device configured to substantially continuously measure the gas flow rate upstream of the injection block and send a flow rate signal to a controller. The controller is configured to receive the flow rate signal from the flow measurement device, and to provide a flow control signal to a flow control device in response to a change in the flow rate signal. The flow control device is configured to change the gas flow rate entering the injection block in response to the flow control signal.

Preferably, the flow control device is arranged upstream of the flow measurement device. In some embodiments, the flow control device may be arranged downstream of the flow measurement device.

It will be appreciated that the gas supply may be regulated upstream of the system. In other words, the gas supply may provide a gas flow at a particular pressure and/or flow rate. The gas supply entering the system may be regulated by regulation means that are separate to those of the system of the present invention. However, the regulation of the gas supply upstream of the system may not be able to account for variations in flow rate caused by, for example, pressure drop at the outlet of the abatement apparatus. Thereby, the system of the present invention may be configured to automatically control of the flow rate of the gas flow entering the abatement inlet in real time.

In some embodiments, the gas supply may be a combustion reagent gas supply. The reagent may be a fuel gas and/or an oxidant. The fuel gas may be, for example, a hydrocarbon, methane, propane, butane, hydrogen, or the like.

For the purposes of the present invention, the flow measurement device being configured to substantially continuously measure the gas flow rate may be defined as

a measurement being taken at least 1 times per second, or at least 5 times per second or more. The flow measurement device may be configured to substantially continuously send a flow rate signal to the controller. Preferably, the flow rate signal produced by the flow measurement device may be an analogue signal. Said analogue signal may correspond to the flow rate measured by the flow measurement device.

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 controller may be a programmable logic controller (PLC). The controller may be the controller of the abatement apparatus. Alternatively, the controller may be independent of the controller of the abatement apparatus.

The controller may comprise or be connected to a display. Said display may provide a human-machine interface. The display may indicate the flow rate in real time. The controller may be configured such that the operator may interact with said controller to operate the flow control device. This may allow manual operation of the system.

A target flow rate may be input to the controller. The target flow rate may be input to the controller by the user, and/or automatically set according to the process step occurring in a process tool to which the abatement apparatus is connected. The target flow rate may be defined by upper and lower boundary flow rates. The flow control device may be configured to automatically adjust the flow rate and/or pressure of the gas flow to substantially equal the target flow rate. It will be appreciated that the target flow rate, and the upper and lower boundary flow rates may depend on the system configuration, the gas being supplied, the process occurring upstream of the abatement furnace, and other factors.

In some embodiments, the target flow rate may be a pressure setpoint. In other words, the flow rate may be controlled by adjusting the pressure of the gas flow.

In embodiments where the gas supply is regulated upstream of the system, the target flow rate may be substantially the same as the flow rate of the regulated gas supply. In such embodiments, the system may be able to account for deviations from the target flow rate caused by pressure drop at the outlet of the abatement apparatus.

The controller may be configured to send a flow control signal to the flow control device if the flow rate signal is outside of the upper and lower boundaries of the target flow rate. The flow control signal may be an analogue signal that is proportional to the flow rate signal.

The target flow rate may be a single value or it may be a range. The target flow rate may be dynamic. In other words, the target flow rate may be variable during operation. For example, the target flow rate may change according to the process occurring in the process tool to which the abatement apparatus is connected.

The controller may send a signal to the flow control device if the measured flow rate is within upper and lower boundary flow rates of the target flow rate. This signal may indicate that the flow control device should maintain the current flow rate.

The flow control device may be configured to change the gas flow rate that enters the injection block according to the flow control signal received from the controller. Thereby, the system may control the gas flow rate into the abatement inlet to mix with the process gas stream therein. The injection block may be a distinct component that is fluidly connected to the abatement inlet.

In some embodiments, the flow control device may be configured to change the pressure of the gas flow that enters the injection block according to the flow control signal received from the controller.

Advantageously, the system of the present invention may provide a feedback loop to maintain the flow rate substantially at a target flow rate in real time during operation. Furthermore, this process may be automated, reducing the complexity of operation. The present invention may be able to account for variations in gas pressure within the system to maintain gas flow at a target flow rate.

Typically, the system may further comprise a purge gas flow connected to the injection block. In some embodiments, the purge gas flow may be a dilutant gas flow. The purge gas flow may be configured to maintain forward flow of gases through the injection

block. Additionally, or alternatively, the purge gas flow may be configured to reduce particulate build-up within the injection block. The injection block may be configured such that the purge gas flow mixes with the gas flow in the injection block, prior to the mixed gas flow entering the abatement inlet.

The purge gas flow may be a nitrogen gas flow. The purge gas flow may be in operation substantially continuously during operation of the system. Alternatively, the purge gas flow may be selectively activated during operation of the system.

The purge gas flow may be mixed with the gas flow within the injection block. The injection block may define one or more conduits configured to convey the gas flow. In some embodiments, the purge gas flow may be a trickle purge. The purge gas flow may pass through an orifice to enter the conduit containing the gas flow. The orifice may have a relatively small cross-sectional area relative to the cross-sectional area of the conduit containing the gas flow. For example, the orifice may have a substantially circular cross-section having a diameter less than about 1 mm. Preferably, the diameter of the orifice may be from about 0.2 mm to about 0.6 mm, preferably about 0.4 mm. The diameter of the conduit containing the gas flow, into which the purge gas is introduced, may be at least four times greater than the diameter of the orifice or more.

In embodiments wherein the injection block comprises a plurality of gas flow conduits, each gas flow conduit may be fluidly connected to a purge gas flow.

Typically, the flow measurement device may be a mass flow meter. The flow measurement device may be connected to the line conveying the gas flow from the gas supply to the injection block.

Typically, the flow control device may be a pressure regulator, a mass flow controller, or a proportional control solenoid valve.

In some embodiments, the injection block may comprise a single outlet.

In alternative embodiments, the injection block may comprise a plurality of outlets. Each outlet may be configured to inject a portion of the gas flow into a process gas stream. The injection block may be a manifold injection block. In other words, gas flow entering the injection block may be divided between a plurality of outlets within the injection block. Preferably, the gas flow may be substantially evenly divided between

the plurality of outlets of the injection block. The injection block may comprise from about 2 to about 24 outlets, for example 8, 10, or 12 outlets.

Each outlet of the injection block may be fluidly connected to a separate process gas stream of the abatement inlet. The injection block may be connected to a plurality of process gas streams.

Typically, each outlet may comprise a solenoid valve configured to control the gas flow through the outlet. Each solenoid valve may have an open configuration in which the gas flow may pass through the outlet, and a closed configuration in which the gas flow is prevented from passing through the outlet. Each solenoid valve may be connected to the controller. Each solenoid valve may be configured to transfer between an open configuration and closed configuration upon receiving a signal from said controller. Each solenoid valve may be arranged with the injection block.

Typically, each outlet may be defined by an outlet fitting. Preferably, the geometry of each outlet fitting may be selected according to a target flow rate of the gas flow exiting the injection block. The geometry of the outlet fitting may refer to the cross-sectional area, the cross-sectional shape, and any tapering of the outlet conduit defining the path through which the gas flow may exit the injection block. By selecting the geometry of the outlet fitting for each outlet of the injection block, the flow rate through each outlet can be controlled and the gas flow can be distributed between the outlets more evenly.

One or more of the outlet fittings may be positioned substantially within the injection block. Additionally, or alternatively, one or more of the outlet fittings may be positioned substantially outside of (i.e. protrude from) the injection block.

Preferably, each outlet fitting may be removable. For example, each outlet fitting may comprise a screw thread configured to engage a corresponding screw thread of the injection block. It will be understood that alternative fixings for coupling each outlet fitting to the injection block may be used. This may allow the outlet fitting to be removed and replaced with an outlet fitting having a different geometry. Accordingly, the flow rate of the gas flow through the outlet of the injection block may be changed by changing the outlet fitting.

Typically, the injection block may be configured to divide the gas flow substantially evenly between the plurality of outlets.

Typically, the system may comprise a plurality of gas flows into the injection block. The system may comprise a flow measurement device and a flow control device for each gas flow.

In some embodiments, the system may comprise a first gas flow into the injection block and a second gas flow into the injection block. The first gas flow and the second gas flow may be separate. The first gas flow and the second gas flow may be different gas compositions. Alternatively, the first gas flow and the second gas flow may have substantially the same gas composition.

In some embodiments, the first gas flow may be a fuel gas flow for a coaxial inlet of the abatement inlet. The second gas flow may be a fuel gas flow for a lance of the abatement inlet.

The system may comprise a first flow measurement device configured to substantially continuously measure the gas flow rate of the first gas flow upstream of the injection block and send a flow rate signal to the controller. The system may comprise a first flow control device arranged upstream of the flow measurement device and configured to change the first gas flow rate entering the injection block in response to a flow control signal from the controller. The controller may be configured to send a flow control signal to the first flow control device as described elsewhere herein.

The system may comprise a second flow measurement device configured to substantially continuously measure the gas flow rate of the second gas flow upstream of the injection block and send a flow rate signal to the controller. The system may comprise a second flow control device arranged upstream of the flow measurement device and configured to change the second gas flow rate entering the injection block in response to a flow control signal from the controller. The controller may be configured to send a flow control signal to the second flow control device as described elsewhere herein.

It will be appreciated that third, fourth, or further gas flows may be provided, and the system may further comprise corresponding a flow measurement device and a flow control device for each additional gas flow as described herein.

The injection block may comprise one or more first outlets configured to convey a first gas flow into the process gas stream in the abatement inlet, and one or more second outlets configured to convey a second gas flow into the process gas stream in the abatement inlet.

The first outlet(s) may be configured to inject the first gas flow into one or more coaxial inlets of the abatement inlet to mix with the process gas stream therein. The second outlet(s) may be configured to inject the second gas flow into one or more lances of the abatement inlet to mix with the process gas stream therein. The flow rate of first/second gas flows may differ.

Preferably, the injection block is configured to keep the first gas flow separate from the second gas flow.

In a further aspect, the present invention provides an abatement apparatus comprising an abatement inlet, and an abatement inlet gas injection system according to any embodiments of the preceding aspect.

In a further aspect, the present invention provides a method for automatically controlling injection of a gas flow into a process gas stream in an abatement inlet. The method comprises the steps of:

- a) providing a system according to any embodiment of an aspect herein;
- b) coupling the injection block to a process gas stream;
- c) conveying a gas flow from the gas supply to the injection block;
- d) substantially continuously measuring the gas flow rate of the gas flow prior to entering the injection block via the flow measurement device;
- e) sending a flow rate signal from the flow measurement device to the controller;
- f) in response to a change in the flow rate signal, sending a flow control signal from the controller to the flow control device;
- g) controlling the flow rate of the gas flow into the injection block with the flow control device.

The method may further comprise the step of independently controlling the flow rate of a plurality of gas flows into the injection block.

The method may further comprise the step of, prior to operation, selecting and fitting an outlet orifice to the or each outlet of the injection block according to a target flow rate.

Advantages and further features may be as set out in relation to preceding aspects.

For the avoidance of doubt, aspects and embodiments described herein may be combined, *mutatis mutandis*.

Brief Description of Figures

Preferred features of the present invention will now be described with respect to the accompanying figures, in which:

Figure 1 shows a schematic of a first embodiment of a system of the present invention;

Figure 2 shows a schematic of a second embodiment of the present invention;

Figure 3 shows a flow diagram of a method according to an embodiment of the present invention.

Detailed Description of Figures

Figure 1 illustrates a schematic of a first embodiment of a system (1) of the present invention. The system comprises a gas supply configured to provide a gas flow (2). In this embodiment, the gas flow (2) may be a fuel gas or an oxidant gas.

The system (1) further comprises an injection block (3). The injection block (3) is connected to the gas flow (2). The injection block (3) is configured to inject the gas flow (2) into an abatement inlet of an abatement apparatus (not shown).

The system (1) further comprises a flow measurement device (4). The flow measurement device (4) is arranged upstream of the injection block (3). The flow measurement device (4) is configured to substantially continuously measure the gas flow rate of the gas flow (2). The flow measurement device (4) is configured to substantially continuously send a flow rate signal (5) to a controller (6).

The controller (6) is configured to receive the flow rate signal (5) from the flow measurement device (4). The controller (6) is configured to provide a flow control signal (7) to a flow control device (8) in response to a change in the flow rate signal (5).

Figure 2 illustrates a second embodiment of a system (9) in accordance with the present invention. In this embodiment, the system (9) comprises a gas supply (10) configured to supply a gas flow. The gas supply (10) comprises a fuel gas supply.

The gas supply (10) is divided between two separate gas flows, a first gas flow (11) and a second gas flow (12). In this embodiment, the first gas flow (11) and the second gas flow (12) are from the same source and therefore have the same composition.

There is a first flow measurement device (13) that is configured to substantially continuously measure the flow rate of the first gas flow (11). The first flow measurement device (13) is configured to send a first flow rate signal (14) to a controller (15).

The controller (15) is configured to receive the first flow rate signal (14) from the first flow measurement device (13), and to provide a first flow control signal (16) to a first flow control device (17) in response to a change in the first flow rate signal (14). In this embodiment, the first flow control device (17) is arranged upstream of the first flow measurement device (13). The first flow control device (17) is configured to change the flow rate of the first gas flow (11) in response to the first flow control signal (16).

The first gas flow (11) is connected to an injection block (18). The injection block (18) is configured to inject the first gas flow (11) into an abatement inlet port (not shown).

The system (9) further comprises a second flow measurement device (19). The second flow measurement device (19) is configured to substantially continuously measure the flow rate of the second gas flow (12). The second flow measurement device (19) is configured to send a second flow rate signal (20) to the controller (15).

The controller (15) is configured to receive the second flow rate signal (20) from the second flow measurement device (19), and to provide a second flow control signal (21) to a second flow control device (22) in response to a change in the second flow rate signal (14). The second flow control device (22) is configured to change the flow rate of the second gas flow (12) in response to the second flow control signal (21).

The second gas flow is connected to the injection block (18). In this embodiment, the first gas flow (11) is configured to be injected by the injection block (18) into a coaxial fuel inlet of the inlet head assembly of the abatement apparatus (not shown). The

second gas flow (12) is configured to be injected by the injection block (18) into a fuel lance of the inlet head assembly of the abatement apparatus.

In this embodiment, both the first flow measurement device (13) and the second flow measurement device (19) are mass flow meters.

The first flow measurement device (13), the controller (15) and the first flow control device (17) provide a feedback loop to maintain the flow rate of the first gas flow (11) at a first target flow rate. The second flow measurement device (19), the controller (15), and the second flow control device (22) provide a feedback loop to maintain the flow rate of the second gas flow (12) at a second target flow rate. The first target flow rate and the second target flow rate may be the same or may differ.

The injection block (18) may be configured to divide the first gas flow (11) and/or the second gas flow (12), respectively, between a plurality of outlets of the injection block. Each outlet may have an outlet fitting (not shown).

Figure 3 illustrates a flow diagram of a method in accordance with an embodiment of the present invention.

The method comprises the step of providing a system according to an embodiment of the present invention (23). Said system may be, for example, the embodiments illustrated in Figure 1.

The method further comprises the step of coupling the injection block of the system to a process gas stream (24). Said coupling may be coupling the outlet(s) of the injection block to the abatement inlet of the abatement apparatus. The method further comprises the step of conveying a gas flow from the gas supply to the injection block (25).

The method further comprises the step of substantially continuously measuring the gas flow rate of the gas flow prior to entering the injection block via the flow measurement device (26). The method further comprises the step of sending a flow rate signal from the flow measurement device to the controller (27). The method further comprises the step of, in response to a change in the flow rate signal, sending a flow control signal from the controller to the flow control device (28).

The method further comprises the step of controlling the flow rate of the gas flow into the injection block with the flow control device (29). Steps 26-29 repeat as required to account for a change in the flow rate of the gas flow during use.

Reference Key

1. System
2. Gas flow
3. Injection block
4. Flow measurement device
5. Flow rate signal
6. Controller
7. Flow control signal
8. Flow control device
9. System
10. Gas supply
11. First gas flow
12. Second gas flow
13. First flow measurement device
14. First flow rate signal
15. Controller
16. First flow control signal
17. First flow control device
18. Injection block
19. Second flow measurement device
20. Second flow rate signal
21. Second flow control signal
22. Second flow control device
23. Method step
24. Method step
25. Method step
26. Method step
27. Method step
28. Method step
29. Method step

Claims

1. An abatement inlet gas injection system for automatically controlling injection of a gas flow into a process gas stream, the system comprising:
 - a gas supply configured to provide a gas flow;
 - an injection block connected to the gas supply, the injection block being configured to inject the gas flow into an inlet head of an abatement apparatus for mixture with a process gas stream;
 - a flow measurement device configured to substantially continuously measure the gas flow rate upstream of the injection block and send a flow rate signal to a controller;
 - wherein the controller is configured to receive the flow rate signal from the flow measurement device, and to provide a flow control signal to a flow control device in response to a change in the flow rate signal;
 - wherein the flow control device is configured to change the gas flow rate entering the injection block in response to the flow control signal.
2. The system according to claim 1, further comprising a purge gas flow connected to the injection block.
3. The system according to claim 1 or 2, wherein the flow measurement device is a mass flow meter.
4. The system according to any preceding claim, wherein the flow control device is a pressure regulator, a mass flow controller, or a proportional control solenoid valve.
5. The system according to any preceding claim, wherein the injection block comprises a plurality of outlets, wherein each outlet is configured to inject a portion of the gas flow into a process gas stream.
6. The system according to claim 5, wherein each outlet comprises a solenoid valve configured to control the gas flow through the outlet.
7. The system according to claim 5 or 6, wherein each outlet is defined by an outlet fitting, preferably wherein the geometry of each outlet fitting is selected according to a target flow rate of the gas flow exiting the injection block.
8. The system according to claim 7, wherein each outlet fitting is removable.

9. The system according to any of claims 5 to 8, wherein the injection block is configured to divide the gas flow substantially evenly between the plurality of outlets.
10. The system according to any preceding claim, comprising a plurality of gas flows into the injection block, and wherein the system comprises a flow measurement device and a flow control device for each gas flow.
11. The system according to claim 10, wherein the injection block comprises one or more first outlets configured to convey a first gas flow into process gas stream, and one or more second outlets configured to convey a second gas flow into the process gas stream; preferably wherein the injection block is configured to keep the first gas flow separate from the second gas flow.
12. An abatement apparatus comprising an abatement inlet and an abatement inlet gas injection system according to any preceding claim.
13. A method for automatically controlling injection of a gas flow into a process gas stream in an abatement inlet, comprising the steps of:
- a) providing a system according to any preceding claim;
 - b) coupling the injection block to a process gas stream;
 - c) conveying a gas flow from the gas supply to the injection block;
 - d) substantially continuously measuring the gas flow rate of the gas flow prior to entering the injection block via the flow measurement device;
 - e) sending a flow rate signal from the flow measurement device to the controller;
 - f) in response to a change in the flow rate signal, sending a flow control signal from the controller to the flow control device;
 - g) controlling the flow rate of the gas flow into the injection block with the flow control device.
14. The method according to claim 13, further comprising the step of independently controlling the flow rate of a plurality of gas flows into the injection block.
15. The method according to claim 13 or 14, further comprising the step of, prior to operation, selecting and fitting an outlet orifice to the or each outlet of the injection block according to a target flow rate.