space to a desired state each time through multilevel adjustment of the spray volume of the mist and in combination with mist and another staging device.

[0007] With the configuration disclosed in PTL 1, a mist screen can be formed which has a locally increased mist concentration. However, no consideration has been given to an idea of adjusting the mist concentration in the indoor space in multiple levels, and such a multilevel adjustment is not possible in terms of the structural aspect.

[0008] Accordingly, as in PTL 2, a configuration of a spray system which uses two-fluid spray nozzles that mix liquid and gas to produce mist has been proposed. In the configuration, the spray volume is adjusted with a liquid flow control valve capable of adjusting the valve opening degree by pulse control and controlling the supply volume in multiple levels.

[0009] However, in the configuration of PTL 2, it may be that the pressure difference between the gas and the liquid supplied to the nozzles exceeds the allowable pressure difference of the liquid flow control valve, and the pressure greater than or equal to the driving torque of the liquid flow control valve is applied to the liquid flow control valve. As a result, the liquid flow control valve may have a malfunction such as opening and closing failure.

[0010] To solve the above-mentioned conventional problems, the present disclosure provides a spray device, a spray method, and a mist space staging system capable of adjusting the mist concentration in a mist staging space in multiple levels by spraying mist, which is atomized liquid, into an indoor space with two-fluid nozzles.

[0010a] In an aspect, the present disclosure refers to a spray device comprising:

a two-fluid nozzle which sprays a mist obtained by mixing a liquid and a gas and atomizing the liquid;

a spray-device-side gas flow path for supplying the gas to the two-fluid nozzle;

a gas supply source which supplies the gas to the spray-device-side gas flow path;

a spray-device-side liquid flow path for supplying the liquid to the two-fluid nozzle;

a liquid supply source which supplies the liquid to the spray-device-side liquid flow path;

a liquid flow control valve which is provided in the spray-device-side liquid flow path between the two-fluid nozzle and the liquid supply source, the liquid flow control valve being driven by a pulse and having a valve opening degree that is adjusted according to a pulse signal to control a flow rate of the liquid in the spray-device-side liquid flow path;

a gas pressure gauge which is provided in the spray-device-side gas flow path between the two-fluid nozzle and the gas supply source to detect a pressure of the gas in the spray-device-side gas flow path;

a liquid pressure gauge which is provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source to detect a pressure of the liquid in the spray-device-side liquid flow path; and

an on-off valve which is provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid pressure gauge to open and close the spray-device-side liquid flow path; and

a controller, when the pressure of the liquid detected by the liquid pressure gauge is greater than the pressure of the gas detected by the gas pressure gauge and a pressure difference between the pressure of the liquid and the pressure of the gas is greater than or equal to an allowable pressure difference preset to the liquid flow control valve, closes the on-off valve, and when the pressure difference is less than the allowable pressure difference, the controller opens the on-off valve.

[0010b] In an aspect, the present disclosure refers to a mist space staging system comprising:

the spray device according to the above aspect; and

a staging device,

wherein the controller adjusts the concentration of the mist in multiple levels in accordance with an output from the staging device.

[0010c] In an aspect, the present disclosure refers to a spray method comprising:

supplying a gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path;

supplying a liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a liquid flow control valve which is provided in the spray-device-side liquid flow path and is driven by a pulse;

spraying, from the two-fluid nozzle, a mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid; and

when the mist is sprayed from the two-fluid nozzle, (i) closing an on-off valve when a pressure of the liquid detected by a liquid pressure gauge is greater than a pressure of the gas detected by a gas pressure gauge and a pressure difference between the pressure of the liquid and the pressure of the gas is greater than or equal to an allowable pressure difference preset to the liquid flow control valve, and (ii) opening the on-off valve when the pressure difference is less than the allowable pressure difference, the on-off valve being provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid pressure gauge, the liquid pressure gauge being provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source, the gas pressure gauge being provided in the spray-device-side gas flow path between the two-fluid nozzle and the gas supply source.

[0010d] In an aspect, the present disclosure refers to a spray method comprising:

supplying a gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path;

supplying a liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a liquid flow control valve which is provided in the spray-device-side liquid flow path and is driven by a pulse;

spraying, from the two-fluid nozzle, a mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid; and

when the mist is sprayed from the two-fluid nozzle, (i) discharging the gas from the gas supply source at a pressure less than an allowable pressure, and (ii) causing a pressure reducing valve to reduce a pressure of the liquid discharged from the liquid supply source such that a pressure difference between a pressure of the gas discharged from the gas supply source and the pressure of the liquid discharged from the liquid supply source is less than an allowable pressure difference, the pressure reducing valve being provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source to reduce the pressure of the liquid discharged from the liquid supply source.

[0011] In one example, this present disclosure includes a spray device which comprises: a two-fluid nozzle which sprays mist obtained by mixing liquid and gas and atomizing the liquid; a spray-device-side gas flow path for supplying the gas to the two-fluid nozzle; a gas valve which opens and closes the spray-device-side gas flow path; a gas supply source which supplies the gas to the spray-device-side gas flow path; a spray-device-side liquid flow path for supplying the liquid to the two-fluid nozzle; a liquid valve which opens and closes the spray-device-side liquid flow path; and a liquid supply source which supplies the

liquid to the spray-device-side liquid flow path. The spray device according to the present disclosure also includes: a liquid flow control valve which is provided in the spray-device-side liquid flow path between the two-fluid nozzle and the liquid valve, is driven by a pulse, and has a valve opening degree that is adjusted according to a pulse signal to control a flow rate of the liquid in the spray-device-side liquid flow path; and a

controller which adjusts the valve opening degree of the liquid flow control valve according to the pulse signal from a console externally provided to the spray device. The controller adjusts, in multiple levels, the concentration of the mist sprayed from the two-fluid nozzle by adjusting the valve opening degree of the liquid flow control valve.

[0012] In one example, a mist space staging system according to the present disclosure includes a spray device and a staging device. The controller adjusts the mist concentration in multiple levels in accordance with an output from the staging device.

[0013] In another example, this present disclosure includes a spray method which comprises: supplying gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path which is opened and closed by a gas valve; supplying liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path which is opened and closed by a liquid valve; spraying, from the two-fluid nozzle, mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid; receiving, by a controller, a pulse signal from a console when the mist is sprayed from the two-fluid nozzle; and adjusting, in multiple levels, a concentration of the mist sprayed from the two-fluid nozzle by adjusting, by the controller, a valve opening degree control pulse of a pulse-driven liquid flow control valve provided in the spray-device-side liquid flow path between the two-fluid nozzle and the liquid valve to control a flow rate of the liquid in the spray-device-side liquid flow path.

[0014] In another example, the controller adjusts the valve opening degree of the liquid flow control valve to spray mist, which is atomized liquid, into the indoor space with the two-fluid nozzles. Accordingly, the mist concentration in the indoor space can be adjusted in multiple levels. As a result, the mist space can be staged in various forms by adjusting the mist concentration in accordance with the intensity of an output, such as the sound or light flux, from another staging device to be combined with the mist.

[0015] In another example, this present disclosure includes a spray method which comprises: supplying gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path; supplying liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a pulse-driven liquid flow control valve provided in the spray-device-side liquid flow path; and spraying, from the two-fluid nozzle, mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid. The spray method according to the present disclosure also includes, when the mist is sprayed from the two-fluid nozzle, (i) closing an on-off valve provided in the spray-device-side liquid

flow path between the liquid flow control valve and the liquid pressure gauge when the pressure of liquid detected by a liquid pressure gauge provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source is greater than the pressure of gas detected by a gas pressure gauge provided in the spray-device-side gas flow path between the two-fluid nozzle and the gas supply source and a pressure difference between the pressure of the liquid and the pressure of the gas is greater than or equal to an allowable pressure difference preset to the liquid flow control valve, and (ii) opening the on-off valve when the pressure difference is less than the allowable pressure difference.

[0016] In another example, this present disclosure includes a spray method which comprises: supplying gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path; supplying liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a pulse-driven liquid flow control valve provided in the spray-device-side liquid flow path; and spraying, from the two-fluid nozzle, mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid. The spray method according to the present disclosure includes, when the mist is sprayed from the two-fluid nozzle, (i) discharging the gas from the gas supply source at a pressure less than an allowable pressure, and (ii) causing a pressure reducing valve to reduce a pressure of the liquid discharged from the liquid supply source such that a pressure difference between a pressure of the gas discharged from the gas supply source and the pressure of the liquid discharged from the liquid supply source is less than an allowable pressure difference. The pressure reducing valve is provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source to reduce the pressure of the liquid discharged from the liquid supply source.

[0017] In another example, this present disclosure includes a spray method which comprises: supplying gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path; supplying liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a pulse-driven liquid flow control valve provided in the spray-device-side liquid flow path; and spraying, from the two-fluid nozzle, mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid. The spray method according to the present disclosure also includes, when the mist is sprayed from the two-fluid nozzle, causing a check valve provided in the spray-device-side liquid flow path between the liquid flow control valve and the two-fluid nozzle (i) to allow the liquid to flow from a liquid flow control valve side to a two-fluid nozzle side and (ii) to prevent

CLAIMS

1. A spray device comprising:

a two-fluid nozzle which sprays a mist obtained by mixing a liquid and a gas and atomizing the liquid;

a spray-device-side gas flow path for supplying the gas to the two-fluid nozzle;

a gas supply source which supplies the gas to the spray-device-side gas flow path;

a spray-device-side liquid flow path for supplying the liquid to the two-fluid nozzle;

a liquid supply source which supplies the liquid to the spray-device-side liquid flow path;

a liquid flow control valve which is provided in the spray-device-side liquid flow path between the two-fluid nozzle and the liquid supply source, the liquid flow control valve being driven by a pulse and having a valve opening degree that is adjusted according to a pulse signal to control a flow rate of the liquid in the spray-device-side liquid flow path;

a gas pressure gauge which is provided in the spray-device-side gas flow path between the two-fluid nozzle and the gas supply source to detect a pressure of the gas in the spray-device-side gas flow path;

a liquid pressure gauge which is provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source to detect a pressure of the liquid in the spray-device-side liquid flow path; and

an on-off valve which is provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid pressure gauge to open and close the spray-device-side liquid flow path; and

a controller, when the pressure of the liquid detected by the liquid pressure gauge is greater than the pressure of the gas detected by the gas pressure gauge and a pressure difference between the pressure of the liquid and the pressure of the gas is greater than or equal to an allowable pressure difference preset to the liquid flow control valve, closes the on-off valve, and when the pressure difference is less than the allowable pressure difference, the controller opens the on-off valve.

2. The spray device according to claim 1,

wherein, when a received pulse signal, which is a pulse signal received by the controller, changes from an increasing state to a decreasing state, the controller corrects a

pulse for driving the liquid flow control valve to be less than the received pulse signal, and when the received pulse signal changes from the decreasing state to the increasing state, the controller corrects the pulse to be greater than the received pulse signal.

3. The spray device according to claim 1 or claim 2, further comprising:

a flow meter which is provided in the spray-device-side liquid flow path to detect the flow rate of the liquid flowing through the spray-device-side liquid flow path,

wherein the controller adjusts the valve opening degree of the liquid flow control valve in accordance with the flow rate detected by the flow meter.

4. A mist space staging system comprising:

the spray device according to any one of claims 1 to 3; and

a staging device,

wherein the controller adjusts the concentration of the mist in multiple levels in accordance with an output from the staging device.

5. The mist space staging system according to claim 4,

wherein the staging device includes at least one of a lighting device or a video projection device, and

the controller adjusts the concentration of the mist in accordance with an intensity of a light flux from the at least one of the lighting device or the video projection device.

6. The mist space staging system according to claim 4 or claim 5,

wherein the staging device includes an audio device, and

the controller adjusts the concentration of the mist in accordance with an intensity of a sound output from the audio device.

7. The mist space staging system according to any one of claims 4 to 6,

wherein the staging device includes at least one of an odor generation device or an odor elimination device, and

the controller adjusts the concentration of the mist in accordance with an intensity of at least one of an odor generated by the odor generation device or an odor remaining in a space after an odor elimination performed by the odor elimination device.

8. The mist space staging system according to any one of claims 4 to 7,

wherein the staging device includes at least one of an air blower or an air conditioning device, and

the controller adjusts the concentration of the mist in accordance with an intensity of wind from the at least one of the air blower or the air conditioning device.

9. The spray device according to claim 1, further comprising:

a pressure reducing valve provided in the spray-device-side liquid flow path between the liquid pressure gauge and the liquid supply source to reduce the pressure of the liquid discharged from the liquid supply source,

wherein the pressure reducing valve reduces the pressure of the liquid such that the pressure difference between the pressure of the gas detected by the gas pressure gauge and the pressure of the liquid detected by the liquid pressure gauge is less than the allowable pressure difference.

10. The spray device according to claim 1, further comprising:

a pressure reducing valve provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source to reduce a pressure of the liquid discharged from the liquid supply source,

wherein the gas supply source discharges the gas such that a pressure of the gas is less than an allowable pressure, and

the pressure reducing valve reduces the pressure of the liquid such that a pressure difference between the pressure of the gas discharged from the gas supply source and the pressure of the liquid discharged from the liquid supply source is less than an allowable pressure difference.

11. The spray device according to claim 10, wherein

the controller adjusts the pressure reducing valve such that a pressure difference between the pressure of the gas detected by the gas pressure gauge and the pressure of the liquid detected by the liquid pressure gauge is less than the allowable pressure difference.

12. The spray device according to claim 1, further comprising:

a check valve which is provided in the spray-device-side liquid flow path between

the liquid flow control valve and the two-fluid nozzle to allow the liquid to flow from a liquid flow control valve side to a two-fluid nozzle side and to prevent the liquid from flowing from the two-fluid nozzle side to the liquid flow control valve side.

13. A spray method comprising:

supplying a gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path;

supplying a liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a liquid flow control valve which is provided in the spray-device-side liquid flow path and is driven by a pulse;

spraying, from the two-fluid nozzle, a mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid; and

when the mist is sprayed from the two-fluid nozzle, (i) closing an on-off valve when a pressure of the liquid detected by a liquid pressure gauge is greater than a pressure of the gas detected by a gas pressure gauge and a pressure difference between the pressure of the liquid and the pressure of the gas is greater than or equal to an allowable pressure difference preset to the liquid flow control valve, and (ii) opening the on-off valve when the pressure difference is less than the allowable pressure difference, the on-off valve being provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid pressure gauge, the liquid pressure gauge being provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source, the gas pressure gauge being provided in the spray-device-side gas flow path between the two-fluid nozzle and the gas supply source.

14. A spray method comprising:

supplying a gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path;

supplying a liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a liquid flow control valve which is provided in the spray-device-side liquid flow path and is driven by a pulse;

spraying, from the two-fluid nozzle, a mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid; and

when the mist is sprayed from the two-fluid nozzle, (i) discharging the gas from the gas supply source at a pressure less than an allowable pressure, and (ii) causing a

pressure reducing valve to reduce a pressure of the liquid discharged from the liquid supply source such that a pressure difference between a pressure of the gas discharged from the gas supply source and the pressure of the liquid discharged from the liquid supply source is less than an allowable pressure difference, the pressure reducing valve being provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source to reduce the pressure of the liquid discharged from the liquid supply source.