

COMBUSTION NOZZLE AND COMBUSTION-TYPE EXHAUST GAS TREATMENT APPARATUS

TECHNICAL FIELD

5 [0001] The present disclosure relates to a combustion nozzle and a combustion-type exhaust gas treatment apparatus.

BACKGROUND

10 [0002] Combustion nozzles for combustion-type exhaust gas treatment apparatuses that detoxify a target gas, which is discharged from semiconductor manufacturing apparatuses or the like, containing noxious components diluted with a nitrogen gas, before releasing the gas to the atmosphere are known. For example, see Patent Literatures (PTLs) 1 and 2.

15 [0003] The combustion nozzle has a first cylinder, a second cylinder, an annular wall connecting the first and second cylinders, through holes penetrating the annular wall and forming a fuel gas injection port, and a target gas injection port formed inside the first cylinder. Each of the through holes is provided so that a flow path formed of the through hole by a radially outer edge and a radially inner edge in a longitudinal cross-section including a
20 central axis of the first cylinder extends in a direction inclined radially inward toward an axial tip side.

[0004] The combustion-type exhaust gas treatment apparatus has the combustion nozzle and a combustion cylinder in which a target gas injected from the radial center of the combustion nozzle and a fuel gas form a
25 combustion reaction zone inside. The target gas is treated in the combustion reaction zone.

CITATION LIST

Patent Literature

30 [0005] PTL 1: JP 6734821 B2
PTL 2: JP 4535558 B2

SUMMARY

35 [0006] Depending on the components, concentration, and the like of a target gas, such as when the target gas contains components such as tungsten hexafluoride (WF_6) that generate powder through oxidation or thermal

decomposition reaction, the metal-containing powder may be deposited on a nozzle tip portion and affect the performance of a combustion nozzle. However, the metal-containing powder is hard, and hence is difficult to clean automatically with a mechanical powder removal apparatus or the like. The metal-containing powder usually needs to be removed in maintenance work such as overhaul. Preventing the deposition of the metal-containing powder on the nozzle tip portion can provide desirable effects including reduction in the frequency of the maintenance work and the like.

[0007] It would be helpful to provide a combustion nozzle and a combustion-type exhaust gas treatment apparatus that easily prevent deposition of metal-containing powder on a nozzle tip portion.

[0008] An aspect of the present disclosure is as follows.

[0009] [1]

A combustion nozzle including:

a first cylinder;

a second cylinder;

an annular wall configured to connect the first cylinder and the second cylinder;

a through hole configured to penetrate the annular wall, the through hole configured to form a fuel gas injection port; and

a target gas injection port formed inside the first cylinder,

wherein the through hole is provided so that a flow path formed of the through hole by a radially outer edge and a radially inner edge in a longitudinal cross-section including a central axis of the first cylinder extends in a direction inclined radially inward toward an axial tip side, that an outer periphery of a tip portion of the first cylinder is present on the extension of the flow path, and that the thickness of the annular wall in an axial direction is reduced toward inside in a radial direction.

[0010] [2]

The combustion nozzle according to [1], wherein in the longitudinal cross-section, the radially outer edge and the radially inner edge of the through hole are in the shape of straight lines parallel to each other.

[0011] [3]

The combustion nozzle according to [1] or [2], wherein the through hole is in the shape of a slit extending straight in the radial direction when viewed in the axial direction.

[0012] [4]

A combustion-type exhaust gas treatment apparatus including:
the combustion nozzle according to any one of [1] to [3]; and
a combustion cylinder in which a target gas and a fuel gas injected from
5 the combustion nozzle form a combustion reaction zone inside,
wherein
the combustion nozzle includes a nitrogen gas injection port radially
outside of the target gas injection port and radially inside of the fuel gas
injection port,
10 the combustion nozzle includes another fuel gas injection port radially
outside of the nitrogen gas injection port and radially inside of the fuel gas
injection port, and the other fuel gas injection port is configured to inject a
fuel gas of a higher concentration than the fuel gas injection port is, and
the combustion cylinder includes a supporting gas injection port
15 configured to inject a supporting gas to the combustion reaction zone.

[0013] [5]

A combustion-type exhaust gas treatment apparatus including:
the combustion nozzle according to any one of [1] to [3]; and
a combustion cylinder in which a target gas and a fuel gas injected from
20 the combustion nozzle form a combustion reaction zone inside,
wherein
the combustion nozzle includes a nitrogen gas injection port radially
outside of the target gas injection port and radially inside of the fuel gas
injection port, and
25 the combustion cylinder includes a premixed gas injection port
configured to inject, to the combustion reaction zone, a premixed gas in which
a supporting gas is premixed into a fuel gas.

[0014] According to the present disclosure, a combustion nozzle and a
combustion-type exhaust gas treatment apparatus that easily prevent deposition
30 of metal-containing powder on a nozzle tip portion can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In the accompanying drawings:

FIG. 1 is a longitudinal cross-sectional view illustrating a combustion-
35 type exhaust gas treatment apparatus according to a first embodiment of the
present disclosure;

FIG. 2 is a diagram illustrating operations of the combustion-type exhaust gas treatment apparatus illustrated in FIG. 1;

FIG. 3 is an enlarged view of a part of FIG. 2;

FIG. 4 is a graph indicating the amounts of deposition of metal-containing powder measured in Examples; and

FIG. 5 is a longitudinal cross-sectional view illustrating a combustion-type exhaust gas treatment apparatus as Comparative Example 1.

DETAILED DESCRIPTION

10 [0016] Embodiments of the present disclosure will be exemplarily described below with reference to the drawings.

[0017] As illustrated in FIGS. 1 to 3, in a first embodiment of the present disclosure, a combustion nozzle 1a has a first cylinder 2, a second cylinder 3, an annular wall 4 connecting the first cylinder 2 and the second cylinder 3, a first injection port 5 as a first fuel gas injection port, and a second injection port 6 formed as a target gas injection port inside the first cylinder 2. The first injection port 5 is formed of a plurality of through holes 7, which are provided so as to be arranged in a circumferential direction and each penetrate the annular wall 4.

20 [0018] A direction along a central axis O of the first cylinder 2 is referred to as an axial direction. A direction along the axial direction toward a tip of the first cylinder 2 (or the combustion nozzle 1a) is referred to as an axial tip side. The opposite direction thereof is referred to as an axial base side. A direction along a straight line orthogonal to the central axis O of the first cylinder 2 is referred to as a radial direction. A direction surrounding the central axis O of the first cylinder 2 is referred to as a circumferential direction. A cross-section including the central axis O of the first cylinder 2 is referred to as a longitudinal cross-section.

[0019] The combustion nozzle 1a of the first embodiment has a third injection port 10 formed between a third cylinder 8 and a fourth cylinder 9, and a fourth injection port 11 formed between the fourth cylinder 9 and the first cylinder 2. The third injection port 10 injects, in parallel with the axial direction to the axial tip side, a gas that flows to the axial tip side through a flow path formed of an outer periphery of the third cylinder 8 and an inner periphery of the fourth cylinder 9 (see the double-dotted arrow in FIG. 3). The fourth injection port 11 injects, in parallel with the axial direction to the axial tip side, a gas that flows

to the axial tip side through a flow path formed of an outer periphery of the fourth cylinder 9 and an inner periphery of the first cylinder 2 (see the double-dotted arrow in FIG. 3).

5 [0020] The third injection port 10 is formed of a circular annular opening that is formed between a tip of the third cylinder 8 and a tip of the fourth cylinder 9 and that forms a circular annular shape when viewed in the axial direction. The fourth injection port 11 is formed of a circular annular opening that is formed between the tip of the fourth cylinder 9 and the tip of the first cylinder 2 and that forms a circular annular shape when viewed in the axial direction.
10 Each of the third and fourth injection ports 10 and 11 is not limited to the configuration formed of the circular annular opening as described above. The circular annular shape is only required to be substantially circular annular, and is not limited to a shape that perfectly coincides with a geometrical shape formed of two concentrically arranged circles of different sizes.

15 [0021] The first cylinder 2, the second cylinder 3, the third cylinder 8, and the fourth cylinder 9 are arranged coaxially and each have cylindrical shapes. The cylindrical shape is only required to be substantially cylindrical, and is not limited to a shape that perfectly coincides with a geometrically cylindrical shape. Also, the coaxial arrangement is only required to be substantially
20 coaxially arranged, and is not limited to an arrangement in which the axial centers geometrically perfectly coincide with each other.

[0022] The second cylinder 3 is a radially outermost cylinder that constitutes the combustion nozzle 1a. The combustion nozzle 1a may be configured with another cylinder radially outside of the second cylinder 3. The third cylinder 8
25 is a radially innermost cylinder that constitutes the combustion nozzle 1a. The combustion nozzle 1a may be configured with another cylinder radially inside of the third cylinder 8.

[0023] In the first embodiment, the third injection port 10 is used as a nitrogen gas injection port, and the fourth injection port 11 is used as a second fuel gas
30 injection port (another fuel gas injection port). In other words, in the first embodiment, the nitrogen gas injection port is provided radially outside of the target gas injection port and radially inside of the first fuel gas injection port, and the second fuel gas injection port is provided radially outside of the nitrogen gas injection port and radially inside of the first fuel gas injection
35 port.

[0024] The second fuel gas injection port injects a fuel gas of a higher

concentration than the first fuel gas injection port does. For example, a fuel gas injected from the first fuel gas injection port can be a premixed gas in which a supporting gas such as compressed air, compressed oxygen-enriched air, or compressed oxygen is premixed into a fuel gas with a concentration of 100%, and the fuel gas injected from the second fuel gas injection port can be the fuel gas with the concentration of 100% itself. Both the first and second fuel gas injection ports may inject premixed gases, and the concentration of a fuel gas contained in the premixed gas injected from the second fuel gas injection port may be set higher than that of a fuel gas contained in the premixed gas injected from the first fuel gas injection port.

[0025] The fuel gases are gases that contain hydrogen atoms, such as hydrocarbons, hydrogen, and ammonia. However, the fuel gases are not limited to gases containing hydrogen atoms, but can be selected from a variety of fuel gases depending on the type of a target gas.

[0026] The target gas is an exhaust gas emitted from a semiconductor manufacturing apparatus, a liquid crystal panel manufacturing apparatus, a photovoltaic panel manufacturing apparatus, or the like, and contains components, such as combustible components, toxic components, corrosive components, or global warming-causing components, that are undesirable to be released into the atmosphere untreated. The target gas, as a diluted gas with a nitrogen gas, is supplied to the combustion nozzle 1a via a dry pump and injected from the target gas injection port (the second injection port 6) of the combustion nozzle 1a.

[0027] The target gas may be supplied to the combustion nozzle 1a as a diluted gas with a gas other than the nitrogen gas, or may be supplied to the combustion nozzle 1a without dilution. To supply the target gas to the combustion nozzle 1a, a pump other than the dry pump or a means other than pumps may be used.

[0028] The target gas injection port (the second injection port 6) injects, in parallel with the axial direction to the axial tip side, the target gas that flows to the axial tip side through a flow path formed of an inner periphery of the third cylinder 8 (see the double-dotted arrow in FIG. 3). The second injection port 6 is formed of a circular opening that is formed of the tip of the third cylinder 8 and that is in the shape of a circle when viewed in the axial direction. The second injection port 6 is not limited to the configuration formed of the circular opening as described above.

[0029] The annular wall 4 connects a part of a tip end portion of the first

cylinder 2 on the axial base side relative to the tip of the first cylinder 2 and a tip end portion of the second cylinder 3, and forms a circular annular shape when viewed in the axial direction. An outer end face 4a (an end face on the axial tip side) of the annular wall 4 is in the shape of a conical surface that centers at the central axis O of the first cylinder 2 and that inclines radially outward toward the axial tip side. The outer end face 4a of the annular wall 4 is not limited to this, but may be configured, for example, in the shape of a concave curved surface that centers at the central axis O of the first cylinder 2 and curves radially outward toward the axial tip side. An inner end face 4b (an end face on the axial base side) of the annular wall 4 is in the shape of a plane perpendicular to the central axis O of the first cylinder 2. The inner end face 4b of the annular wall 4 is not limited to this, but may be configured, for example, in the shape of a conical surface or a concave curved surface that centers at the central axis O of the first cylinder 2 and inclines or curves radially outward toward the axial tip side, or may be configured in the shape of a conical surface or a concave curved surface that centers at the central axis O of the first cylinder 2 and inclines or curves radially outward toward the axial base side.

[0030] The plurality of through holes 7 provided in the annular wall 4 is preferably arranged at equal intervals in the circumferential direction, but is not limited to this. One or more particular (preferably all) through holes 7 are preferably in the shape of slits extending straight along the radial direction when viewed in the axial direction, but are not limited to this. In each of the above particular (preferably all) through holes 7, in the longitudinal cross-section, a radially outer edge 7a and a radially inner edge 7b of the through hole 7 are preferably in the shape of straight lines parallel to each other, but are not limited to this.

[0031] Each of the above particular (preferably all) through holes 7 is provided so that a flow path formed of the through hole 7 by the radially outer edge 7a and the radially inner edge 7b in the longitudinal cross-section extends in a direction inclined radially inward toward the axial tip side, that an outer periphery of the tip portion of the first cylinder 2 is present on the extension of the flow path, and the the thickness T of the annular wall 4 in the axial direction is reduced toward inside in the radial direction. Note that, the expression “the outer periphery of the tip portion of the first cylinder 2 is present on the extension of the flow path formed of the through hole 7 by the

radially outer edge 7a and the radially inner edge 7b in the longitudinal cross-section" means that, in the longitudinal cross-section, a projection of an end opening of the through hole 7 on the axial tip side to an extension direction (the direction of the double-dotted arrow through the through hole 7 in FIG. 2) of the flow path overlaps with the outer periphery of the tip portion of the first cylinder 2 (an overlapping portion is indicated as a portion "A" in FIG. 3).

[0032] Each of the above particular (preferably all) through holes 7 injects the fuel gas to the direction of the flow path (see the double-dotted arrows in FIG. 2), and forms a combustion flame (not illustrated) that extends from the through hole 7 in the direction of the flow path. The combustion flame can contact and efficiently heat the outer periphery of the tip portion of the first cylinder 2 because the outer periphery of the tip portion of the first cylinder 2 is present on the extension of the flow path. In addition, in the flow path, the thickness T of the annular wall 4 in the axial direction is reduced toward the inside in the radial direction, so the momentum of a flow along the radially inner edge 7b of the flow path is suppressed, compared to a case in which the thickness T is constant. As a result, the momentum when the combustion flame contacts the outer periphery of the tip portion of the first cylinder 2, as described above, can be suppressed to the minimum necessary. Therefore, the adverse effects of contact of the combustion flame with the tip portion of the first cylinder 2 on the flow of the combustion flame and a combustion reaction zone 12, specifically, decrease in stability of the combustion flame and decrease in heating efficiency to the combustion reaction zone 12, can be reduced, and consequently, the adverse effects on the treatment efficiency of the target gas can be reduced. From the viewpoint of obtaining such effects, it is preferable that the radially inner edge 7b of the through hole 7 be provided as radially inside as possible, and more specifically, it is preferable that an end of the radially inner edge 7b of the through hole 7 on the axial tip side be located on the outer periphery of the tip portion of the first cylinder 2.

[0033] A combustion-type exhaust gas treatment apparatus 1 has the combustion nozzle 1a and a combustion cylinder 13 in which the target gas and the fuel gases injected from the combustion nozzle 1a form the combustion reaction zone 12 inside. The combustion reaction zone 12 is formed at a confluence of the fuel gas (combustion flame) injected from the first injection port 5 (the through holes 7) and the target gas injected from the second injection port 6, and is located on the central axis O of the first cylinder 2 on

the axial tip side relative to a nozzle tip portion. The combustion cylinder 13 has an outer peripheral wall portion 13a that is disposed radially outside of the combustion nozzle 1a. The outer peripheral wall portion 13a is in the shape of a cylinder that is disposed coaxially with the first cylinder 2.

5 **[0034]** In the first embodiment, the combustion cylinder 13 has a fifth injection port 14 that injects a gas to the combustion reaction zone 12 (see the double-dotted arrows in FIG. 2). The fifth injection port 14 is formed of a plurality of openings that is provided so as to be arranged in the circumferential direction on the outer peripheral wall portion 13a of the combustion cylinder
10 13. The fifth injection port 14 may be configured to be formed of a single opening. In the first embodiment, the fifth injection port 14 is used as a supporting gas injection port that injects a supporting gas to the combustion reaction zone 12 in order to promote the combustion of the fuel gas injected from the second fuel gas injection port.

15 **[0035]** According to the first embodiment, even when the target gas contains components, such as tungsten hexafluoride (WF_6), that can cause the occurrence of metal-containing powder at the nozzle tip portion, the tip portion of the first cylinder 2 can be easily heated above the sublimation temperature of the metal-containing powder by contact of the combustion flame from the
20 first injection port 5 with the outer periphery of the tip portion of the first cylinder 2. As a result, deposition of the metal-containing powder on the outer periphery of the tip portion of the first cylinder 2 can be easily prevented. The metal-containing powder is, for example, metal powder, metal oxide powder, or the like.

25 **[0036]** According to the first embodiment, the nitrogen gas injected from the third injection port 10 (the nitrogen gas injection port) allows the combustion reaction zone 12 to be formed away from the nozzle tip portion, and also cools the third cylinder 8 and the fourth cylinder 9, which prevents increase in the temperature of the inside of the second and third injection ports 6 and 10 and
30 the inner wall of the fourth injection port 11 (the outer periphery of the fourth cylinder 9) even under conditions in which the outer periphery of the tip portion of the first cylinder 2 is made hot. As a result, deposition of various types of powder, which is generated depending on the components of the target gas, on the nozzle tip portion and on the second, third, and fourth injection
35 ports 6, 10, and 11 can be prevented.

[0037] According to the first embodiment, the fuel gas injected from the fourth

injection port 11 (the second fuel gas injection port) and the supporting gas injected from the fifth injection port 14 (the supporting gas injection port) heat the combustion reaction zone 12, resulting in improved treatment efficiency of the target gas.

5 [0038] The combustion nozzle 1a or the combustion-type exhaust gas treatment apparatus 1 of the first embodiment may be configured without the fourth injection port 11 (the fourth cylinder 9), or may be configured without injection of the fuel gas from the fourth injection port 11.

10 [0039] The combustion-type exhaust gas treatment apparatus 1 of the first embodiment may be configured without the fifth injection port 14, or may be configured without injection of the supporting gas from the fifth injection port 14.

15 [0040] Next, a second embodiment will be described using FIGS. 1 to 3, which are common to the first embodiment. In the second embodiment, the third injection port 10 is used as a first nitrogen gas injection port, and the fourth injection port 11 is used as a second nitrogen gas injection port. In other words, in the second embodiment, the two nitrogen gas injection ports are provided radially outside of the target gas injection port and radially inside of the first fuel gas injection port. In the second embodiment, the fifth injection port 14 is
20 used as a premixed gas injection port that injects, to the combustion reaction zone 12, a premixed gas in which a supporting gas is premixed into a fuel gas. The other configurations are the same as those in the first embodiment.

[0041] According to the second embodiment, as in the first embodiment, even when the target gas contains components that can cause the occurrence of
25 metal-containing powder at the nozzle tip portion, the tip portion of the first cylinder 2 can be easily heated above the sublimation temperature of the metal-containing powder by contact of the combustion flame from the first injection port 5 with the outer periphery of the tip portion of the first cylinder 2. As a result, deposition of the metal-containing powder on the outer periphery of the
30 tip portion of the first cylinder 2 can be easily prevented.

[0042] In the first embodiment, metal-containing powder may be generated by direct reaction between the fuel gas injected from the fourth injection port 11 (the second fuel gas injection port) and the target gas injected from the second injection port 6 (the target gas injection port). In contrast, in the second
35 embodiment, no fuel gas is injected from the fourth injection port 11, so no such metal-containing powder is generated. Therefore, according to the second

embodiment, deposition of the metal-containing powder on the nozzle tip portion can be more easily prevented than in the first embodiment.

5 [0043] According to the second embodiment, the nitrogen gas injected from the third injection port 10 (the first nitrogen gas injection port) and the fourth injection port 11 (the second nitrogen gas injection port) allows the combustion reaction zone 12 to be formed away from the nozzle tip portion, and also cools the third cylinder 8 and the fourth cylinder 9, which prevents increase in the temperature of the inside of the second and third injection ports 6 and 10 and the inner wall of the fourth injection port 11 (the outer periphery of the fourth cylinder 9) even under conditions in which the outer periphery of the tip portion of the first cylinder 2 is made hot. As a result, deposition of various types of powder, which is generated depending on the components of the target gas, on the nozzle tip portion and on the second, third, and fourth injection ports 6, 10, and 11 can be prevented.

15 [0044] According to the second embodiment, the premixed gas injected from the fifth injection port 14 (the premixed gas injection port) heats the combustion reaction zone 12, resulting in improved treatment efficiency of the target gas.

20 [0045] The combustion nozzle 1a or the combustion-type exhaust gas treatment apparatus 1 of the second embodiment may be configured without the fourth injection port 11 (the fourth cylinder 9), or may be configured without injection of the nitrogen gas from the fourth injection port 11.

25 [0046] The combustion-type exhaust gas treatment apparatus 1 of the second embodiment may be configured without the fifth injection port 14, or may be configured without injection of the premixed gas from the fifth injection port 14.

[0047] The present disclosure is not limited to the embodiments described above and can be modified in various manners without departing from the gist thereof.

30 [0048] Accordingly, the combustion nozzle 1a of the embodiments described above can be modified as long as the combustion nozzle 1a includes the first cylinder 2, the second cylinder 3, the annular wall 4 connecting the first cylinder 2 and the second cylinder 3, the through holes 7 penetrating the annular wall 4 and forming the fuel gas injection port, and the target gas injection port formed inside the first cylinder 2, wherein each of the through
35 holes 7 is provided so that the flow path formed of the through hole 7 by the

radially outer edge 7a and the radially inner edge 7b in the longitudinal cross-section including the central axis O of the first cylinder 2 extends in the direction inclined radially inward toward the axial tip side, that the outer periphery of the tip portion of the first cylinder 2 is present on the extension of the flow path, and that the thickness T of the annular wall 4 in the axial direction is reduced toward inside in the radial direction.

[0049] For example, the combustion nozzle 1a is not limited to use for the combustion-type exhaust gas treatment apparatus 1. The target gas to be treated by the combustion nozzle 1a is not limited to the exhaust gas from apparatuses such as the semiconductor manufacturing apparatuses. Each of the first cylinder 2, the second cylinder 3, the third cylinder 8, and the fourth cylinder 9 is not limited to the configuration with a cylindrical shape, but may be configured to have a tubular shape other than the cylindrical shape, for example, an elliptical cylindrical shape.

[0050] The combustion-type exhaust gas treatment apparatus 1 can be modified as long as the combustion-type exhaust gas treatment apparatus 1 includes the combustion nozzle 1a, and the combustion cylinder 13 in which the target gas and the fuel gas injected from the combustion nozzle 1a form the combustion reaction zone 12 inside. For example, the outer peripheral wall portion 13a of the combustion cylinder 13 is not limited to the configuration with a cylindrical shape, but may be configured to have a tubular shape other than the cylindrical shape, for example, an elliptical cylindrical shape.

EXAMPLES

[0051] Combustion tests to treat, as a target gas, tungsten hexafluoride diluted with a nitrogen gas were conducted using the combustion-type exhaust gas treatment apparatus of the first embodiment as Example 1, using the combustion-type exhaust gas treatment apparatus of the second embodiment as Example 2, and using, as Comparative Example 1 as illustrated in FIG. 5, an apparatus in which only the thickness of the annular wall and the radial positions of the radially inner edges of the through holes are different from those in the combustion-type exhaust gas treatment apparatus of the first embodiment, and the amount of metal-containing powder deposited on the nozzle tip portion was confirmed. In Comparative Example 1, the thickness of the annular wall in the axial direction was kept constant in the radial direction. The radial position of the radially inner edge of each through hole was set

radially outside in Comparative Example 1 than in Example 1. In Example 1, the end of the radially inner edge of each through hole on the axial tip side was set so as to be located on the outer periphery of the tip portion of the first cylinder.

5 **[0052]** The flow rate of tungsten hexafluoride in the target gas was 1 L/min, and the flow rate of nitrogen gas in the target gas was 50 L/min. The flow rates of the gases (or components of the mixed gas) injected from the gas injection ports in each of Examples and Comparative Example were as follows. In
10 Example 1, 6 L/min of fuel gas and 65 L/min of air were injected from the first injection port, 5 L/min of nitrogen gas was injected from the third injection port, 1 L/min of 100% fuel gas was injected from the fourth injection port, and 5 L/min of air was injected from the fifth injection port. In Example 2, 6 L/min of fuel gas and 65 L/min of air were injected from the first injection port, 2.5 L/min of nitrogen gas was injected from the third injection port, 2.5 L/min of
15 nitrogen gas was injected from the fourth injection port, and 1 L/min of 100% fuel gas and 5 L/min of air were injected from the fifth injection port. In Comparative Example 1, 6 L/min of fuel gas and 65 L/min of air were injected from the first injection port, 5 L/min of nitrogen gas was injected from the third injection port, 1 L/min of 100% fuel gas was injected from the fourth
20 injection port, and 5 L/min of air was injected from the fifth injection port.

[0053] FIG. 4 indicates the amounts of metal-containing powder deposited on the nozzle tip portions resulting from the above conditions. FIG. 4 indicates the amounts of metal-containing powder deposited on a combined area of the outer end face of the annular wall, the outer periphery of the tip portion of the first cylinder located on the axial tip side relative to the annular wall, the tip
25 faces of the first, second, third and fourth cylinders, and the inner periphery of the tip portion of the third cylinder, as ratios when the amount of deposition in Comparative Example 1 is set as 1. From the results indicated in FIG. 4, a remarkable effect was confirmed in Example 1, and an extremely remarkable
30 effect was confirmed in Example 2.

CLAIMS

1. A combustion nozzle comprising:
a first cylinder;
5 a second cylinder;
an annular wall configured to connect the first cylinder and the second cylinder;
a through hole configured to penetrate the annular wall, the through hole configured to form a fuel gas injection port; and
10 a target gas injection port formed inside the first cylinder,
wherein the through hole is provided so that a flow path formed of the through hole by a radially outer edge and a radially inner edge in a longitudinal cross-section including a central axis of the first cylinder extends in a direction inclined radially inward toward an axial tip side, that an outer periphery of a
15 tip portion of the first cylinder is present on an extension of the flow path, and that a thickness of the annular wall in an axial direction is reduced toward inside in a radial direction.
2. The combustion nozzle according to claim 1, wherein in the
20 longitudinal cross-section, the radially outer edge and the radially inner edge of the through hole are in shape of straight lines parallel to each other.
3. The combustion nozzle according to claim 1, wherein the
through hole is in shape of a slit extending straight in the radial direction when
25 viewed in the axial direction.
4. A combustion-type exhaust gas treatment apparatus comprising:
the combustion nozzle according to any one of claims 1 to 3; and
30 a combustion cylinder in which a target gas and a fuel gas injected from the combustion nozzle form a combustion reaction zone inside,
wherein
the combustion nozzle comprises a nitrogen gas injection port radially outside of the target gas injection port and radially inside of the fuel gas
35 injection port,
the combustion nozzle comprises another fuel gas injection port

radially outside of the nitrogen gas injection port and radially inside of the fuel gas injection port, and the other fuel gas injection port is configured to inject a fuel gas of a higher concentration than the fuel gas injection port is, and

5 the combustion cylinder comprises a supporting gas injection port configured to inject a supporting gas to the combustion reaction zone.

5. A combustion-type exhaust gas treatment apparatus comprising:

the combustion nozzle according to any one of claims 1 to 3; and

10 a combustion cylinder in which a target gas and a fuel gas injected from the combustion nozzle form a combustion reaction zone inside,

wherein

the combustion nozzle comprises a nitrogen gas injection port radially outside of the target gas injection port and radially inside of the fuel gas injection port, and

15 the combustion cylinder comprises a premixed gas injection port configured to inject, to the combustion reaction zone, a premixed gas in which a supporting gas is premixed into a fuel gas.