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Inventor(s)	Ito; Shintaro et al.

Combustion device and gas turbine system

Abstract

A combustion device includes: a burner plate facing a combustion chamber; a plurality of injection hole groups formed in the burner plate so as to have an annular shape; and a slit having an annular shape and formed between the plurality of injection hole groups.

Inventors: **Ito; Shintaro (Tokyo, JP), Uchida; Masahiro (Tokyo, JP)**

Applicant: **IHI Corporation** (Tokyo, JP)

Family ID: **1000008751701**

Assignee: **IHI CORPORATION (Tokyo, JP)**

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
3844484	12/1973	Masai	239/404	F23D 11/107
11859822	12/2023	Fukuba	N/A	F23D 14/04
2011/0247338	12/2010	Bottcher et al.	N/A	N/A
2012/0036856	12/2011	Uhm et al.	N/A	N/A
2016/0010864	12/2015	Abe et al.	N/A	N/A
2017/0074521	12/2016	Horikawa	N/A	F23R 3/286
2021/0180518	12/2020	Koganezawa	N/A	F23R 3/16
2023/0167976	12/2022	Karishuku	60/739	F23R 3/343
2023/0358404	12/2022	Kubiak	N/A	F23R 3/283
2024/0328625	12/2023	Nagahashi	N/A	F23R 3/46

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2012-042194	12/2011	JP	N/A
2012-511687	12/2011	JP	N/A
2015-014400	12/2014	JP	N/A
2017-072271	12/2016	JP	N/A
2019-138560	12/2018	JP	N/A
6804755	12/2019	JP	N/A
2014/141397	12/2013	WO	N/A
2015/182727	12/2014	WO	N/A

Primary Examiner: Kramer; Devon C

Assistant Examiner: Chabreyrie; Rodolphe Andre

Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation application of International Application No. PCT/JP2022/043049, filed on Nov. 21, 2022, which claims priority to Japanese Patent Application No. 2022-013189 filed on Jan. 31, 2022, the entire contents of which are incorporated herein by reference.

BACKGROUND ART
Technical Field
(1) The present disclosure relates to a combustion device and a gas turbine system.
(2) A gas turbine system that combusts fuel in a combustor to obtain power has been used. As the

gas turbine system, for example, there exists a gas turbine system that uses hydrogen as fuel, as disclosed in Patent Literature 1. Emission of carbon dioxide is suppressed by using hydrogen as fuel.

CITATION LIST

Patent Literature

(3) Patent Literature 1: JP 2015-014400 A

SUMMARY OF INVENTION

Technical Problem

(4) In recent years, in a gas turbine system, a plate facing a combustion chamber, in which hydrogen is burned, is manufactured using additive manufacturing technology in some cases. In such cases, a metal lamination amount of the plate on the combustion chamber side is larger than a metal lamination amount of the plate on a side opposite to the combustion chamber. As a temperature of the metal laminated during manufacture of the plate decreases, the metal shrinks. At this time, the plate may deform to the combustion chamber side due to a shrinkage force on the side with the larger metal lamination amount.

(5) An object of the present disclosure is to provide a combustion device and a gas turbine system that are capable of suppressing deformation of a plate.

Solution to Problem

(6) In order to achieve the above-mentioned object, according to the present disclosure, there is provided a combustion device including: a plate facing a combustion chamber; a plurality of injection hole groups formed in the plate so as to have an annular shape; and a slit having an annular shape and formed between the plurality of injection hole groups.

(7) The plurality of injection hole groups may include a first injection hole group and a second injection hole group. The first injection hole group includes: a plurality of fuel injection holes facing an interior of the combustion chamber and formed so as to be spaced apart from each other in a circumferential direction of the combustion chamber; a first air injection hole having an annular shape, facing the interior of the combustion chamber, and extending in the circumferential direction on a radially outer side with respect to the plurality of fuel injection holes; and a second air injection hole having an annular shape, facing the interior of the combustion chamber, and extending in the circumferential direction on a radially inner side with respect to the plurality of fuel injection holes. The second injection hole group faces the interior of the combustion chamber, and includes fuel injection holes, a first air injection hole, and a second air injection hole. The second injection hole group is located radially inward of the first injection hole group.

(8) The combustion device may further include an annular cavity that is formed between the plurality of injection hole groups in the plate, and communicates with the slit.

(9) The combustion device may further include a through-hole that is formed in the plate on a side opposite to the combustion chamber, and communicates with the annular cavity.

(10) The through-hole may be displaced in a radial direction with respect to the slit.

(11) In order to achieve the above-mentioned object, according to the present disclosure, there is provided a gas turbine system including the combustion device described above.

Effects

(12) According to the present disclosure, deformation of the plate can be suppressed.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. **1** is a schematic view for illustrating a configuration of a gas turbine system according to an embodiment of the present disclosure.

(2) FIG. **2** is a view of a burner plate in the embodiment of the present disclosure as seen from a

combustion chamber side.
(3) FIG. **3** is a cross-sectional view taken along the line A**2**-A**2** of FIG. **2**.
(4) FIG. **4** is a cross-sectional view taken along the line A**3**-A**3** of FIG. **2**.
(5) FIG. **5** is a cross-sectional view taken along the line A**4**-A**4** of FIG. **2**.
(6) FIG. **6** is a schematic view for illustrating a flow of gas generated in the combustion chamber in the embodiment of the present disclosure.
(7) FIG. **7** is a schematic cross-sectional view for illustrating a configuration of a burner plate in a first modification example.
(8) FIG. **8** is a schematic cross-sectional view for illustrating a configuration of a burner plate in a second modification example.
(9) FIG. **9** is a schematic cross-sectional view for illustrating a first shape example of a cavity that is different from a cavity in the second modification example.
(10) FIG. **10** is a schematic cross-sectional view for illustrating a second shape example of a cavity that is different from the cavity in the second modification example.
(11) FIG. **11** is a schematic cross-sectional view for illustrating a configuration of a burner plate in a third modification example.
DESCRIPTION OF EMBODIMENTS
(12) Now, with reference to the attached drawings, an embodiment of the present disclosure is described. The dimensions, materials, and other specific numerical values represented in the embodiment are merely examples used for facilitating the understanding of the disclosure, and do not limit the present disclosure unless otherwise particularly noted. Elements having substantially the same functions and configurations herein and in the drawings are denoted by the same reference symbols to omit redundant descriptions thereof. Further, illustration of elements with no direct relationship to the present disclosure is omitted.
(13) FIG. **1** is a schematic view for illustrating a configuration of a gas turbine system **1** according to an embodiment. As illustrated in FIG. **1**, the gas turbine system **1** includes a turbocharger **11**, a power generator **12**, a combustor **13**, a burner **14**, a hydrogen tank **15**, and a flow rate control valve **16**.
(14) Of the gas turbine system **1**, the combustor **13**, the burner **14**, the hydrogen tank **15**, and the flow rate control valve **16** are included in a combustion device **10**.
(15) The turbocharger **11** includes a compressor **11***a* and a turbine **11***b*. The compressor **11***a* and the turbine **11***b* rotate integrally. The compressor **11***a* and the turbine **11***b* are connected by a shaft.
(16) The compressor **11***a* is provided in an intake flow passage **21** connected to the combustor **13**. Air to be supplied to the combustor **13** flows through the intake flow passage **21**. An intake port (not shown) is formed at an upstream-side end portion of the intake flow passage **21**. The intake port allows air to be introduced from an outside. The air introduced through the intake port passes through the compressor **11***a* and is sent to the combustor **13**. The compressor **11***a* compresses the air and discharges the compressed air to a downstream side.
(17) The turbine **11***b* is provided in an exhaust flow passage **22** connected to the combustor **13**. An exhaust gas discharged from the combustor **13** flows through the exhaust flow passage **22**. An exhaust port (not shown) is formed at a downstream-side end portion of the exhaust flow passage **22**. The exhaust port allows the exhaust gas to be discharged to the outside. The exhaust gas discharged from the combustor **13** passes through the turbine **11***b* and is sent to the exhaust port. The turbine **11***b* is rotated by the exhaust gas to generate rotational power.
(18) The power generator **12** is connected to the turbocharger **11**. The power generator **12** generates electric power with use of the rotational power generated by the turbocharger **11**.
(19) The combustor **13** includes a casing **13***a*, a liner **13***b*, and a combustion chamber **13***c*. The casing **13***a* has a substantially cylindrical shape. The liner **13***b* is provided inside the casing **13***a*. The liner **13***b* has a substantially cylindrical shape. The liner **13***b* is arranged coaxially with the casing **13***a*. The combustion chamber **13***c* is formed inside the liner **13***b*. That is, an interior space

of the liner **13***b* corresponds to the combustion chamber **13***c*. The combustion chamber **13***c* is a space having a substantially cylindrical shape. The exhaust flow passage **22** is connected to the combustion chamber **13***c*.
(20) As described later, hydrogen and air are supplied into the combustion chamber **13***c*. In the combustion chamber **13***c*, hydrogen is used as fuel to cause combustion. An exhaust gas generated as a result of combustion in the combustion chamber **13***c* is discharged to the exhaust flow passage **22**. A space S is defined between an inner surface of the casing **13***a* and an outer surface of the liner **13***b*. The intake flow passage **21** is connected to the space S. Air is fed into the space S from the compressor **11***a* via the intake flow passage **21**. An opening is formed in an end portion (left end portion in FIG. **1**) of the liner **13***b*. The burner **14** is inserted through the opening in the end portion of the liner **13***b*.
(21) The burner **14** includes a burner plate (plate) **14***a* and a plurality of fuel supply pipes **14***b*. The burner plate **14***a* faces the combustion chamber **13***c*. The burner plate **14***a* seals the opening in the end portion of the liner **13***b*. That is, the burner plate **14***a* seals an end portion of the combustion chamber **13***c*. The burner plate **14***a* has a disk shape. However, the shape of the burner plate **14***a* is not limited thereto, and the burner plate **14***a* may have a shape other than a disk shape. For example, the burner plate **14***a* may have a polygonal shape. Further, the burner plate **14***a* may be formed of a plurality of separate pieces obtained by dividing a circular or polygonal plate. The burner plate **14***a* is formed by metal lamination molding. The fuel supply pipes **14***b* are connected to a surface of the burner plate **14***a* on a side opposite to the combustion chamber **13***c*. In other words, the fuel supply pipes **14***b* are connected to the surface of the burner plate **14***a* facing the space S. The fuel supply pipes **14***b* extend through the casing **13***a* to an outside of the casing **13***a*. In FIG. **1**, three fuel supply pipes **14***b* are illustrated. However, the number of the fuel supply pipes **14***b* is not limited.
(22) As described later with reference to FIGS. **2** to **5**, the burner plate **14***a* has fuel injection holes (specifically, fuel injection holes **31** to be described later) and air injection holes (specifically, first air injection holes **32** and second air injection holes **33** to be described later) formed therein. The fuel injection holes formed in the burner plate **14***a* communicate with the fuel supply pipes **14***b*. Hydrogen is fed as fuel into the fuel supply pipes **14***b* as described later. The hydrogen fed from the fuel supply pipes **14***b* to the burner plate **14***a* passes through the fuel injection holes of the burner plate **14***a*, and is injected into the combustion chamber **13***c*. As indicated by the single-dotted arrows in FIG. **1**, the air fed into the space S passes through the space S, and then reaches the surface of the burner plate **14***a* on the side opposite to the combustion chamber **13***c*. The air fed to the burner plate **14***a* passes through the air injection holes of the burner plate **14***a*, and is injected into the combustion chamber **13***c*.
(23) Hydrogen is stored in the hydrogen tank **15**. In the hydrogen tank **15**, the hydrogen may be liquid or gaseous. The hydrogen tank **15** is connected to the flow rate control valve **16** via a flow passage **23**. The flow rate control valve **16** is connected to each fuel supply pipe **14***b* of the burner **14** via a flow passage **24**. The hydrogen stored in the hydrogen tank **15** is supplied into the fuel supply pipes **14***b* via the flow passage **23**, the flow rate control valve **16**, and the flow passage **24**. The flow rate control valve **16** controls (i.e., adjusts) a flow rate of the hydrogen to be supplied from the hydrogen tank **15** into the fuel supply pipes **14***b*. Through adjustment of an opening degree of the flow rate control valve **16**, a supply amount of hydrogen from the hydrogen tank **15** into the fuel supply pipes **14***b* is adjusted.
(24) In the following, a circumferential direction of the combustion chamber **13***c* is also referred to simply as “circumferential direction”. A radial direction of the combustion chamber **13***c* is also referred to simply as “radial direction”. An axial direction of the combustion chamber **13***c* is also referred to simply as “axial direction”.
(25) FIG. **2** is a view of the burner plate **14***a* as seen from the combustion chamber **13***c* (specifically, from a direction of the arrow A**1** in FIG. **1**). FIG. **3** is a cross-sectional view taken

along the line A**2**-A**2** of FIG. **2**. FIG. **4** is a cross-sectional view taken along the line A**3**-A**3** of FIG. **2**. FIG. **5** is a cross-sectional view taken along the line A**4**-A**4** of FIG. **2**.

(26) As illustrated in FIG. **2**, a plurality of injection hole groups **30** (specifically, a first injection hole group **30-1** and a second injection hole group **30-2**) are formed in the burner plate **14***a*. Each injection hole group **30** includes the plurality of fuel injection holes **31**, the first air injection holes **32**, and the second air injection holes **33**. Each injection hole group **30** extends in the circumferential direction and has an annular shape. The first injection hole group **30-1** is arranged radially outward of the second injection hole group **30-2**. In other words, the second injection hole group **30-2** is arranged radially inward of the first injection hole group **30-1**. Thus, the first injection hole group **30-1** and the second injection hole group **30-2** are formed so as to be spaced apart from each other in the radial direction. However, the number of the injection hole groups **30** formed in the burner plate **14***a* is not limited to this example. For example, the number of the injection hole groups **30** formed in the burner plate **14***a* may be one, or three or more. A configuration of the first injection hole group **30-1** and a configuration of the second injection hole group **30-2** are similar. Accordingly, the configuration of the first injection hole group **30-1** is described in detail below, and a detailed description of the configuration of the second injection hole group **30-2** is omitted.

(27) The fuel injection holes **31** face an interior of the combustion chamber **13***c*. The fuel injection holes **31** are open in the surface of the burner plate **14***a* facing the combustion chamber **13***c*. The fuel injection holes **31** are hydrogen injection holes from which hydrogen is injected as fuel into the combustion chamber **13***c*. In each injection hole group **30**, the plurality of fuel injection holes **31** are formed so as to be spaced apart from each other in the circumferential direction. In each injection hole group **30**, the plurality of fuel injection holes **31** are formed at equal intervals. However, in each injection hole group **30**, the plurality of fuel injection holes **31** may be formed at unequal intervals.

(28) In the burner plate **14***a*, a communication hole **40** is formed for each injection hole group **30**. The communication hole **40** communicates with the plurality of fuel injection holes **31**. The communication hole **40** extends in the circumferential direction. The communication hole **40** is formed into, for example, an annular shape. As illustrated in FIG. **2** and FIG. **3**, the communication hole **40** is aligned in the axial direction with the plurality of fuel injection holes **31** of each injection hole group **30**. The communication hole **40** is arranged on the side opposite to the combustion chamber **13***c* with respect to the plurality of fuel injection holes **31** of each injection hole group **30**. In the example of FIG. **3**, a transverse-sectional shape of the communication hole **40** (specifically, a shape in cross-section orthogonal to an extending direction of the communication hole **40**) is circular. However, the transverse-sectional shape of the communication hole **40** may be a shape other than a circular shape (for example, a polygonal shape).

(29) The fuel supply pipes **14***b* of the burner **14** are connected to the communication holes **40** of the injection hole groups **30**. Hydrogen is supplied from the fuel supply pipes **14***b* to each of the communication holes **40**. As indicated by the arrows C**1** in FIG. **3**, the hydrogen supplied to the communication holes **40** is injected into the combustion chamber **13***c* from each fuel injection hole **31**. The hydrogen supplied to the communication hole **40** of the first injection hole group **30-1** is injected into the combustion chamber **13***c* from the plurality of fuel injection holes **31** of the first injection hole group **30-1**. The hydrogen supplied to the communication hole **40** of the second injection hole group **30-2** is injected into the combustion chamber **13***c* from the plurality of fuel injection holes **31** of the second injection hole group **30-2**.

(30) The first air injection hole **32** faces the interior of the combustion chamber **13***c*. The first air injection hole **32** penetrates the burner plate **14***a* from the surface facing the combustion chamber **13***c* to the surface on the side opposite thereto. In each injection hole group **30**, the first air injection hole **32** is formed on a radially outer side with respect to the plurality of fuel injection holes **31**. The first air injection hole **32** extends in the circumferential direction and is formed into an annular

shape. An outer diameter and an inner diameter of the first air injection hole **32** decrease from the side opposite to the combustion chamber **13***c* toward the combustion chamber **13***c*. A change amount in the inner diameter of the first air injection hole **32** is smaller than a change amount in the outer diameter of the first air injection hole **32**. Accordingly, an opening area of the first air injection hole **32** on the side facing the combustion chamber **13***c* is smaller than an opening area thereof on the side opposite to the combustion chamber **13***c*. Further, a center axis direction of the first air injection hole **32** is inclined toward the fuel injection holes **31** with respect to the axial direction, that is, inward in the radial direction. As indicated by the arrows C**2** in FIG. **3** and FIG. **4**, part of the air fed through the space S in the combustor **13** to the burner plate **14***a* is injected from the first air injection holes **32** into the combustion chamber **13***c*.

(31) First swirling blades **32***a* that are inclined in the circumferential direction with respect to a combustion-chamber-side axial direction Dc are provided in the first air injection hole **32**. In the present disclosure, the combustion-chamber-side axial direction Dc may also be referred to simply as “direction Dc”. The direction Dc is a direction directed to the combustion chamber **13***c* along the axial direction of the combustion chamber **13***c*. To incline in the circumferential direction with respect to the direction Dc means to extend in a direction of a vector obtained by combining a vector of the circumferential direction with a vector of the direction Dc, or to incline so as to advance in the circumferential direction as the first swirling blades **32***a* approach the combustion chamber **13***c*. Each first swirling blade **32***a* has, for example, a substantially flat plate shape. The first swirling blades **32***a* partition the first air injection hole **32** in the circumferential direction. Each first swirling blade **32***a* extends on a plane that intersects the circumferential direction. In each first air injection hole **32**, the plurality of first swirling blades **32***a* are provided so as to be spaced apart from each other in the circumferential direction. In each first air injection hole **32**, the plurality of first swirling blades **32***a* are provided at equal intervals. However, in each first air injection hole **32**, the plurality of first swirling blades **32***a* may be provided at unequal intervals.

(32) For example, as illustrated in FIG. **4**, in the first air injection hole **32** of the first injection hole group **30-1**, the first swirling blades **32***a* are inclined to one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc. Here, the direction of the air to be injected from the first air injection hole **32** is along the first swirling blades **32***a*. Thus, as indicated by the arrows C**2** in FIG. **4**, the direction of the air to be injected from the first air injection hole **32** of the first injection hole group **30-1** is inclined to the one side in the circumferential direction with respect to the direction Dc. Accordingly, as indicated by the arrow B**1** in FIG. **2**, the air injected from the first air injection hole **32** of the first injection hole group **30-1** swirls to the one side in the circumferential direction in the combustion chamber **13***c*.

(33) The second air injection hole **33** faces the interior of the combustion chamber **13***c*. The second air injection hole **33** penetrates the burner plate **14***a* from the surface facing the combustion chamber **13***c* to the surface on the side opposite thereto. In each injection hole group **30**, the second air injection hole **33** is formed on a radially inner side with respect to the plurality of fuel injection holes **31**. The second air injection hole **33** extends in the circumferential direction and is formed into an annular shape. An outer diameter and an inner diameter of the second air injection hole **33** increase from the side opposite to the combustion chamber **13***c* toward the combustion chamber **13***c*. A change amount in the outer diameter of the second air injection hole **33** is smaller than a change amount in the inner diameter of the second air injection hole **33**. Accordingly, an opening area of the second air injection hole **33** on the side facing the combustion chamber **13***c* is smaller than an opening area thereof on the side opposite to the combustion chamber **13***c*. Further, a center axis direction of the second air injection hole **33** is inclined toward the fuel injection holes **31** with respect to the axial direction, that is, outward in the radial direction. As indicated by the arrows C**3** in FIG. **3** and FIG. **5**, part of the air fed through the space S in the combustor **13** to the burner plate **14***a* is injected from the second air injection hole **33** into the combustion chamber **13***c*.

(34) Second swirling blades **33***a* that are inclined to the same side in the circumferential direction

with respect to the direction Dc as the first swirling blades **32***a* (specifically, the first swirling blades **32***a* belonging to the same injection hole group **30**) are provided in the second air injection hole **33**. Each second swirling blade **33***a* has, for example, a substantially flat plate shape. The second swirling blades **33***a* partition the second air injection hole **33** in the circumferential direction. Each second swirling blade **33***a* extends on a plane that intersects the circumferential direction. In each second air injection hole **33**, the plurality of second swirling blades **33***a* are provided so as to be spaced apart from each other in the circumferential direction. In each second air injection hole **33**, the plurality of second swirling blades **33***a* are provided at equal intervals. However, in each second air injection hole **33**, the plurality of second swirling blades **33***a* may be provided at unequal intervals.

(35) For example, as illustrated in FIG. **5**, in the second air injection hole **33** of the first injection hole group **30-1**, the second swirling blades **33***a* are inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc. Here, the direction of the air to be injected from the second air injection hole **33** is along the second swirling blades **33***a*. Thus, as indicated by the arrows C**3** in FIG. **5**, the direction of the air to be injected from the second air injection hole **33** of the first injection hole group **30-1** is inclined to the one side in the circumferential direction with respect to the direction Dc. Accordingly, as indicated by the arrow B**2** in FIG. **2**, the air injected from the second air injection hole **33** of the first injection hole group **30-1** swirls to the one side in the circumferential direction in the combustion chamber **13***c*.

(36) The direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1** with respect to the direction Dc, and the direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the second injection hole group **30-2** with respect to the direction Dc are toward sides different from each other in the circumferential direction. That is, in the first air injection hole **32** of the second injection hole group **30-2**, the first swirling blades **32***a* are inclined to the other side in the circumferential direction (counterclockwise direction in FIG. **2**) with respect to the direction Dc. Accordingly, as indicated by the arrow B**3** in FIG. **2**, the air injected from the first air injection hole **32** of the second injection hole group **30-2** swirls to the other side in the circumferential direction in the combustion chamber **13***c*. In the second air injection hole **33** of the second injection hole group **30-2**, the second swirling blades **33***a* are inclined to the other side in the circumferential direction with respect to the direction Dc. Accordingly, as indicated by the arrow B**4** in FIG. **2**, the air injected from the second air injection hole **33** of the second injection hole group **30-2** swirls to the other side in the circumferential direction in the combustion chamber **13***c*.

(37) The direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1** with respect to the direction Dc, and the direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the second injection hole group **30-2** with respect to the direction Dc may be toward the same side in the circumferential direction. Hereinafter, a case in which the direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1** with respect to the direction Dc, and the direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the second injection hole group **30-2** with respect to the direction Dc are toward the same side in the circumferential direction is referred to as “inclination pattern **1**”. For example, the first swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1** are inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc. At this time, the first swirling blades **32***a* and the second swirling blades **33***a* in the second injection hole group **30-2** are inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc. The first swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1** may be inclined to the other side in the circumferential direction (counterclockwise direction in FIG. **2**) with respect to the direction Dc. At this time, the first swirling blades **32***a* and the second swirling

blades **33***a* in the second injection hole group **30-2** may be inclined to the other side in the circumferential direction (counterclockwise direction in FIG. **2**) with respect to the direction Dc. This enables a strong swirling flow of air to be formed in the entire combustion chamber **13***c*, thereby being capable of ensuring good flame stability.

(38) The direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1** with respect to the direction Dc in the present embodiment is opposite in the circumferential direction to the direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the second injection hole group **30-2** with respect to direction Dc. A case in which the direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1**, and the direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the second injection hole group **30-2** are inclined in directions opposite to each other as described above is referred to as "inclination pattern **2**". For example, the first swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1** are inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc. At this time, the first swirling blades **32***a* and the second swirling blades **33***a* in the second injection hole group **30-2** are inclined to the other side in the circumferential direction (counterclockwise direction in FIG. **2**) with respect to the direction Dc. With this configuration, the swirling flow of air is weakened due to reverse swirling between the injection hole groups **30**, and thus the swirling flow of air in the entire combustion chamber **13***c* is weakened, which can suppress a melt loss of the burner **14**.

(39) As described above, in each injection hole group **30**, in the first air injection hole **32** formed on the radially outer side with respect to the plurality of fuel injection holes **31**, the first swirling blades **32***a* are provided to be inclined in the circumferential direction with respect to the direction Dc. In the second air injection hole **33** formed on the radially inner side with respect to the plurality of fuel injection holes **31**, the second swirling blades **33***a* are provided to be inclined in the same direction as the first swirling blades **32***a* in the circumferential direction with respect to the direction Dc. Thus, the air injected from the first air injection hole **32** and the second air injection hole **33** swirls toward the same side in the circumferential direction in the combustion chamber **13***c*. Hydrogen is injected from the fuel injection holes **31** toward the swirling flow of air thus generated. Accordingly, the hydrogen injected from the fuel injection holes **31** is mixed with the air while being swirled by the swirling flow of air.

(40) As described above, according to the combustion device **10** of the gas turbine system **1**, hydrogen injected from the fuel injection holes **31** is rapidly mixed with the air by the swirling flow of air generated by the air injected from the first air injection hole **32** and the second air injection hole **33** in each injection hole group **30**. Thus, as compared to a case in which hydrogen and air are supplied into the combustion chamber **13***c* in a pre-mixed state, an ignition position is likely to be at a more inner side in the combustion chamber **13***c*. Accordingly, backfires are suppressed. In addition, the melt loss of the burner **14** is suppressed. Accordingly, the burner **14** can be protected from flame. In addition, by adjusting an air supply amount as appropriate and lowering a flame temperature, a reduction in NOx emission amount can be achieved.

(41) In each injection hole group **30**, inclination angles of the first swirling blades **32***a* and the second swirling blades **33***a* (i.e., inclination angles with respect to the direction Dc) may be the same or different from each other.

(42) FIG. **6** is a schematic view for illustrating a flow of gas generated in the combustion chamber **13***c*. In FIG. **6**, the swirling flow of air generated by the air injected from the first air injection holes **32** and the second air injection holes **33** is indicated by the arrow D**1**. When the swirling flow of air is generated, there is generated a circulation flow, as indicated by the arrows D**2**, which is a flow of gas passing near a center axis of the swirling flow (i.e., near a center axis of the combustion chamber **13***c*) toward the burner plate **14***a*.

(43) Here, in the combustion device **10**, as described above, the direction of inclination of the first

swirling blades **32***a* and the second swirling blades **33***a* in the first injection hole group **30-1** with respect to the direction Dc, and the direction of inclination of the first swirling blades **32***a* and the second swirling blades **33***a* in the second injection hole group **30-2** with respect to the direction Dc are toward the sides different from each other in the circumferential direction. Thus, a direction (specifically, clockwise direction in FIG. **2**) of the swirling flow generated by the air injected from the first injection hole group **30-1**, and a direction (specifically, counterclockwise direction in FIG. **2**) of the swirling flow generated by the air injected from the second injection hole group **30-2** are opposite to each other. Accordingly, the swirling flow generated by the air injected from the first injection hole group **30-1**, and the swirling flow generated by the air injected from the second injection hole group **30-2** weaken each other. Thus, the circulation flow (i.e., flow indicated by the arrows D**2** in FIG. **6**) passing near the center axis of the swirling flow toward the burner plate **14***a* is weakened. As a result, approach of flame to the burner plate **14***a* is suppressed. Accordingly, the melt loss of the burner **14** is suppressed.

(44) In the axial direction, at a position where the swirling flow of air generated by the first injection hole group **30-1** and the swirling flow of air generated by the second injection hole group **30-2** interfere with each other, a local vortex is generated, and the gas injected from the first injection hole group **30-1** and the gas injected from the second injection hole group **30-2** are easily mixed with each other. As a result, the NOx emission amount is further reduced.

(45) In the above-mentioned example of the inclination pattern **2**, the first swirling blades **32***a* and the second swirling blades **33***a* of the first injection hole group **30-1** are inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc. However, the first swirling blades **32***a* and the second swirling blades **33***a* of the first injection hole group **30-1** may be inclined to the other side in the circumferential direction (counterclockwise direction in FIG. **2**) with respect to the direction Dc. In this case, the first swirling blades **32***a* and the second swirling blades **33***a* of the second injection hole group **30-2** are inclined to the one side in the circumferential direction with respect to the direction Dc.

(46) The direction of inclination of the first swirling blades **32***a* in the first injection hole group **30-1** with respect to the direction Dc may be toward the same side in the circumferential direction as the direction of inclination of the first swirling blades **32***a* in the second injection hole group **30-2** with respect to the direction Dc. At this time, the direction of inclination of the second swirling blades **33***a* in the first injection hole group **30-1** with respect to the direction Dc may be toward the same side in the circumferential direction as the direction of inclination of the second swirling blades **33***a* in the second injection hole group **30-2** with respect to the direction Dc. The direction of inclination of the first swirling blades **32***a* in the first injection hole group **30-1** and the second injection hole group **30-2** with respect to the direction Dc may be opposite to the direction of inclination of the second swirling blades **33***a* in the first injection hole group **30-1** and the second injection hole group **30-2** with respect to the direction Dc. A case in which the first swirling blades **32***a* in the first injection hole group **30-1** and the second injection hole group **30-2** and the second swirling blades **33***a* in the first injection hole group **30-1** and the second injection hole group **30-2** are thus inclined in directions opposite to each other is referred to as "inclination pattern **3**". For example, the first swirling blades **32***a* of the first injection hole group **30-1** may be inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc, and the second swirling blades **33***a* of the first injection hole group **30-1** may be inclined to the other side in the circumferential direction (counterclockwise in FIG. **2**) with respect to the direction Dc. At this time, the first swirling blades **32***a* of the second injection hole group **30-2** may be inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc, and the second swirling blades **33***a* of the second injection hole group **30-2** may be inclined to the other side in the circumferential direction (counterclockwise direction in FIG. **2**) with respect to the direction Dc. This weakens the swirling flow of air within and outside each injection hole group **30** and between the injection hole groups **30** due to reverse

swirling. Thus, the swirling flow of air is weakened in the entire combustion chamber **13***c* more than in the inclination pattern **2**, thereby being capable of suppressing the melt loss of the burner **14**. In addition, the reverse swirling within and outside each injection hole group **30** enables rapid mixing of hydrogen injected from the fuel injection holes **31** and air.

(47) Further, the direction of inclination of the first swirling blades **32***a* in the first injection hole group **30-1** with respect to the direction Dc may be toward the side in the circumferential direction, which is opposite to the direction of inclination of the first swirling blades **32***a* in the second injection hole group **30-2** with respect to the direction Dc. At this time, the direction of inclination of the second swirling blades **33***a* in the first injection hole group **30-1** with respect to the direction Dc may be toward the side in the circumferential direction, which is opposite to the direction of inclination of the second swirling blades **33***a* in the second injection hole group **30-2** with respect to the direction Dc. The direction of inclination of the first swirling blades **32***a* in the first injection hole group **30-1** and the second swirling blades **33***a* in the second injection hole group **30-2** with respect to the direction Dc may be opposite to the direction of inclination of the second swirling blades **33***a* in the first injection hole group **30-1** and the first swirling blades **32***a* in the second injection hole group **30-2** with respect to the direction Dc. A case in which the first swirling blades **32***a* in the first injection hole group **30-1** and the second swirling blades **33***a* in the second injection hole group **30-2**, and the second swirling blades **33***a* in the first injection hole group **30-1** and the first swirling blades **32***a* in the second injection hole group **30-2** are thus inclined in directions opposite to each other is referred to as "inclination pattern **4**". For example, the first swirling blades **32***a* of the first injection hole group **30-1** may be inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc, and the second swirling blades **33***a* of the first injection hole group **30-1** may be inclined to the other side in the circumferential direction (counterclockwise in FIG. **2**) with respect to the direction Dc. At this time, the first swirling blades **32***a* of the second injection hole group **30-2** may be inclined to the other side in the circumferential direction (counterclockwise direction in FIG. **2**) with respect to the direction Dc, and the second swirling blades **33***a* of the second injection hole group **30-2** may be inclined to the one side in the circumferential direction (clockwise direction in FIG. **2**) with respect to the direction Dc. This strengthens the swirling flow of air due to forward swirling between the injection hole groups **30**, and weakens the swirling flow of air due to reverse swirling within and outside each injection hole group **30**. As a result, the swirling flow of air can be weakened more than in the inclination pattern **1** to be able to further suppress the melt loss of the burner **14**, and the swirling flow of air can be strengthened more than in the inclination pattern **3** to be able to further improve the flame stability. In addition, hydrogen injected from the fuel injection holes **31** and air can be mixed rapidly due to the reverse swirling within and outside each injection hole group **30**. When three or more injection hole groups **30** are provided, the above-mentioned inclination patterns **1** to **4** may be used in combination in the three or more injection hole groups **30**.

(48) In the combustion device **10**, the injection hole groups **30** are formed in the burner plate **14***a* that seals the end portion of the combustion chamber **13***c*. Thus, through integral forming of the burner plate **14***a* by, for example, additive manufacturing technology, the injection hole groups **30** can be easily formed. When the burner plate **14***a* is thus integrally formed, as compared to a case in which a component forming the injection hole groups **30** is provided separately from the burner plate **14***a*, the structure of the burner **14** is simplified, the burner **14** is downsized, and manufacturing cost of the burner **14** is reduced. Further, leakage of hydrogen from joint portions of components is suppressed. In addition, occurrence of cracks in the joint portions due to thermal stress is suppressed.

(49) In the combustion device **10**, the communication hole **40** is formed in the burner plate **14***a*, and communicates with the plurality of fuel injection holes **31**. Thus, through integral forming of the burner plate **14***a* by, for example, additive manufacturing technology, the communication hole **40** can be easily formed. When the burner plate **14***a* is thus integrally formed, as compared to a

case in which a component forming the communication hole **40** is provided separately from the burner plate **14***a*, the structure of the burner **14** is simplified, the burner **14** is downsized, and the manufacturing cost of the burner **14** is reduced. Further, leakage of hydrogen from joint portions of components is suppressed. In addition, occurrence of cracks in the joint portions due to thermal stress is suppressed.
(50) When the burner plate **14***a* is manufactured using the additive manufacturing technology, a metal lamination amount on the surface of the burner plate **14***a* facing the combustion chamber **13***c* is larger than a metal lamination amount on the surface opposite to the combustion chamber **13***c*. This is because the opening areas of the first air injection hole **32** and the second air injection hole **33** in the surface facing the combustion chamber **13***c* are smaller than the opening areas in the surface opposite to the combustion chamber **13***c*. As a temperature of metal laminated during the manufacture of the burner plate **14***a* decreases, the metal shrinks. At this time, a shrinkage force on a side with a larger metal lamination amount may cause the burner plate **14***a* to deform to the combustion chamber side with the larger metal lamination amount.
(51) Accordingly, in the present embodiment, when the burner plate **14***a* is manufactured by the additive manufacturing technology, an annular slit **50** (see FIG. **2** and FIG. **3**) is formed between the plurality of injection hole groups **30** of the burner plate **14***a*. The slit **50** is formed in the surface of the burner plate **14***a* facing the combustion chamber **13***c*. The slit **50** communicates with the combustion chamber **13***c*. That is, the slit **50** is open toward the combustion chamber **13***c*. The slit **50** extends in the axial direction of the combustion chamber **13***c*. However, the slit **50** may extend obliquely to the axial direction of the combustion chamber **13***c*.
(52) A depth of the slit **50** is set so as to maintain a minimum thickness required to maintain strength of the burner plate **14***a* when the burner plate **14***a* is mounted to the liner **13***b*. The depth of the slit **50** is, for example, equal to or larger than a half of the thickness of the burner plate **14***a*. The depth of the slit **50** is, for example, equal to or larger than ⅘ of the thickness of the burner plate **14***a*.
(53) A radial position of the slit **50** is determined so that, for example, a mass of the burner plate **14***a* on a radially outer side with respect to the slit **50** is balanced with a mass of the burner plate **14***a* on a radially inner side with respect to the slit **50**. Thus, the radial position of the slit **50** is set at a position where a radius of the slit **50** is larger than half a radius of the burner plate **14***a*. However, the radial position of the slit **50** may be set at a position where the radius is half the radius of the burner plate **14***a* or a position where the radius is smaller than half the radius of the burner plate **14***a*.
(54) According to the present embodiment, the burner plate **14***a* has the slit **50**, and thus the first injection hole group **30-1** and the second injection hole group **30-2** are divided by the slit **50** in the surface of the burner plate **14***a* facing the combustion chamber **13***c*. Therefore, the shrinkage force of the metal, which is generated as the temperature of the laminated metal decreases during the manufacture of the burner plate **14***a*, is divided between the radially inner side and the radially outer side of the slit **50**. As a result, deformation of the burner plate **14***a* can be suppressed as compared to a case in which the slit **50** is not formed.
(55) FIG. **7** is a schematic cross-sectional view for illustrating a configuration of a burner plate **114***a* in a first modification example. Components substantially equivalent to those of the burner plate **14***a* in the above-mentioned embodiment are denoted by the same reference symbols, and descriptions thereof are omitted. As illustrated in FIG. **7**, the burner plate **114***a* in the first modification example differs from the burner plate of the above-mentioned embodiment in that a plurality of slits **150** are formed.
(56) In the first modification example, the plurality of annular slits **150** are formed between the plurality of injection hole groups **30** of the burner plate **114***a*. The slits **150** are formed in the surface of the burner plate **114***a* facing the combustion chamber **13***c*. The slits **150** extend in the axial direction.

(57) The plurality of slits **150** include a first slit **150***a* and a second slit **150***b*. However, the present disclosure is not limited thereto, and the plurality of slits **150** may include three or more slits. The first slit **150***a* and the second slit **150***b* are formed so as to be spaced apart from each other in the radial direction. The first slit **150***a* is located radially outward of the second slit **150***b*. In other words, the second slit **150***b* is located radially inward of the first slit **150***a*.
(58) Depths of the first slit **150***a* and the second slit **150***b* are the same as those as given in the above-mentioned embodiment. However, the present disclosure is not limited thereto, and the depths of the first slit **150***a* and the second slit **150***b* may be different from those as given in the above-mentioned embodiment. Further, the depths of the first slit **150***a* and the second slit **150***b* may be different from each other.
(59) Radial positions of the first slit **150***a* and the second slit **150***b* are determined so that, for example, a mass of the burner plate **114***a* on a radially outer side of the first slit **150***a* is balanced with a mass of the burner plate **114***a* on a radially inner side of the second slit **150***b*. Thus, the radial position of the first slit **150***a* is set at a position where a radius of the first slit **150***a* is larger than half a radius of the burner plate **114***a*. Further, the radial position of the second slit **150***b* is set at a position where a radius of the second slit **150***b* is smaller than half the radius of the burner plate **114***a*.
(60) According to the first modification example, owing to forming of the plurality of slits **150**, deformation of the burner plate **114***a* can be further suppressed as compared to the above-mentioned embodiment.
(61) FIG. **8** is a schematic cross-sectional view for illustrating a configuration of a burner plate **214***a* in a second modification example. Components substantially equivalent to those of the burner plate **14***a* in the above-mentioned embodiment are denoted by the same reference symbols, and descriptions thereof are omitted. As illustrated in FIG. **8**, the burner plate **214***a* in the second modification example differs from the burner plate of the above-mentioned embodiment in that an annular cavity **250**A is formed.
(62) As illustrated in FIG. **8**, the annular cavity **250**A is formed between the plurality of injection hole groups **30** of the burner plate **214***a*. The cavity **250**A is separated from the injection hole groups **30** in the radial direction. The cavity **250**A is formed in a substantially central position of the burner plate **214***a* in a thickness direction thereof. The cavity **250**A communicates with the slit **50**. The cavity **250**A has a circular transverse-sectional shape (shape in a cross-section including a center axis of the burner plate **214***a*).
(63) FIG. **9** is a schematic cross-sectional view for illustrating a first shape example of a cavity **250**B that is different from the cavity **250**A in the second modification example. FIG. **10** is a schematic cross-sectional view for illustrating a second shape example of a cavity **250**C that is different from the cavity **250**A in the second modification example. As illustrated in FIG. **9**, the cavity **250**B has a triangular transverse-sectional shape. As illustrated in FIG. **10**, the cavity **250**C has a water-drop-like transverse-sectional shape. The transverse-sectional shapes of the cavities **250**A, **250**B, and **250**C are not limited to the shapes as illustrated in FIG. **8** to FIG. **10**, but may be, for example, a semi-circular shape, an elliptical shape, or an ellipsoidal shape.
(64) The cavities **250**A, **250**B, and **250**C each have a curved surface on the side closer to the combustion chamber **13**C, or a surface inclined from a plane perpendicular to the axial direction. In other words, the cavities **250**A, **250**B, and **250**C each have no surface perpendicular to the axial direction on the side closer to the combustion chamber **13***c*. When the cavities **250**A, **250**B, and **250**C each have a surface perpendicular to the axial direction on the side closer to the combustion chamber **13***c*, the burner plate **214***a* cannot be formed because portions corresponding to the cavities **250**A, **250**B, and **250**C collapse during lamination using the additive manufacturing technology. Accordingly, in the second modification example, the cavities **250**A, **250**B, and **250**C each have no surface perpendicular to the axial direction on the side closer to the combustion chamber **13***c*.

(65) According to the second modification example, owing to forming of the cavities **250**A, **250**B, and **250**C, a mass inside the burner plate **214***a* can be reduced. In other words, a metal deposition amount in the burner plate **214***a* can be reduced, and hence a weight of the burner plate **214***a* can be reduced. Accordingly, a degree of shrinkage that occurs when the metal is cooled during the manufacture of the burner plate **214***a* can be reduced. Further, the deposition amount is reduced, and hence a time period required to form the burner plate **214***a* can be reduced. In addition, cost of the burner plate **214***a* can be reduced. Further, owing to the reduction in weight of the burner plate **214***a*, work of mounting the burner plate **214***a* to the liner **13***b* is facilitated.
(66) FIG. **11** is a schematic cross-sectional view for illustrating a configuration of a burner plate **314***a* in a third modification example. Components substantially equivalent to the configurations of the burner plate **214***a* in the above-mentioned second modification example are denoted by the same reference symbols, and descriptions thereof are omitted. As illustrated in FIG. **11**, the burner plate **314***a* in the third modification example differs from the configuration of the above-mentioned second modification example in that through-holes **350** are formed.
(67) In the third modification example, the through-holes **350** are formed between the plurality of injection hole groups **30** of the burner plate **314***a*. The through-holes **350** are formed on a side opposite to the combustion chamber **13***c* with respect to the cavity **250**A. The through-holes **350** are separated from the injection hole groups **30** in the radial direction. The through-holes **350** extend in the axial direction. That is, the through-holes **350** extend in parallel to the slit **50**. However, the present disclosure is not limited thereto, and the through-holes **350** may extend in a direction oblique to the axial direction.
(68) As illustrated in FIG. **11**, the plurality of through-holes **350** are formed in the radial direction. However, the present disclosure is not limited thereto, and only one through-hole **350** may be formed in the radial direction. Further, the plurality of through-holes **350** are formed at equal intervals in the circumferential direction of the burner plate **314***a*. However, the present disclosure is not limited thereto, and the plurality of through-holes **350** may be formed at unequal intervals in the circumferential direction. The plurality of through-holes **350** allow communication between the space S and the cavity **250**A. The plurality of through-holes **350** are displaced in the radial direction with respect to the slit **50**. That is, the plurality of through-holes **350** are formed at positions offset from the slit **50** in the radial direction.
(69) According to the third modification example, the plurality of through-holes **350** can supply the air in the space S into the cavity **250**A. This enables an interior of the cavity **250**A to be cooled and the burner plate **314***a* to be cooled.
(70) Further, the plurality of through-holes **350** are displaced in the radial direction with respect to the slit **50**, and hence the air having passed through the through-holes **350** cannot be easily introduced directly into the slit **50**. Accordingly, the air having passed through the through-holes **350** can be collided with an inner wall surface of the burner plate **314***a* that defines the cavity **250**A. As a result, cooling of the burner plate **314***a* can be accelerated, and hence the melt loss of the burner plate **314***a* can be suppressed.
(71) Further, the air supplied into the cavity **250**A is supplied into the combustion chamber **13***c* via the slit **50**. Accordingly, hydrogen flame formed near the burner plate **314***a* in the combustion chamber **13**C can be prevented from approaching the burner plate **314***a*, and hence the melt loss of the burner plate **314***a* can be suppressed.
(72) An embodiment of the present disclosure has been described above with reference to the attached drawings, but, needless to say, the present disclosure is not limited to the above-mentioned embodiment. It is apparent that those skilled in the art may arrive at various alterations and modifications within the scope of claims, and those examples are construed as naturally falling within the technical scope of the present disclosure.
(73) There has been described above the example in which the rotational power generated by the turbocharger **11** is used as energy for driving the power generator **12** in the gas turbine system **1**.

However, the present disclosure is not limited thereto. For example, the combustion device **10** in the gas turbine system **1** may be applied to other combustion devices, such as a jet engine and an industrial furnace. Further, in the gas turbine system **1**, the rotational power generated by the turbocharger **11** may be used for other purposes (e.g., for driving a moving object such as a ship).
(74) There has been described above the example in which the shape of the combustion chamber **13***c* is a substantially cylindrical shape. However, the shape of the combustion chamber **13***c* is not limited to this example. For example, the combustion chamber **13***c* may be a space having a substantially truncated cone shape. The shapes of the burner plates **14***a*, **114***a*, **214***a*, and **314***a* may be modified as appropriate in accordance with the shape of the combustion chamber **13***c*.
(75) In the example of FIG. **1** described above, the air fed from the compressor **11***a* to the combustor **13** is fed into the combustion chamber **13***c* after passing between an outer peripheral surface of the liner **13***b* and an inner peripheral surface of the casing **13***a*. However, the path of air fed from the compressor **11***a* to the combustor **13** is not limited to this example (i.e., turn-flow type).
(76) There has been described above the example in which the burner plates (plates) **14***a*, **114***a*, **214***a*, and **314***a* are utilized in the gas turbine system **1**. However, the burner plates **14***a*, **114***a*, **214***a*, and **314***a* may be utilized for systems other than the gas turbine system **1**. For example, the burner plates **14***a*, **114***a*, **214***a*, and **314***a* may be used as heat transfer plates in which flow passages for allowing water distribution are formed.
(77) There has been described above the example in which the burner plates **14***a*, **114***a*, **214***a*, and **314***a* supply hydrogen into the combustion chamber **13***c*. However, the fuel to be supplied by the burner plates **14***a*, **114***a*, **214***a*, and **314***a* into the combustion chamber **13***c* is not limited to hydrogen, but may be, for example, natural gas.

Claims

1. A combustion device, comprising: a plate facing a combustion chamber; a plurality of injection hole groups formed in the plate so as to have an annular shape; a slit having an annular shape and formed between the plurality of injection hole groups; an annular cavity that is formed between the plurality of injection hole groups in the plate, and communicates with the slit; and a through-hole that is formed in the plate on a side opposite to the combustion chamber, and communicates with the annular cavity, wherein the plurality of injection hole groups include a first injection hole group and a second injection hole group, wherein each of the first injection hole group and the second injection hole group includes: a plurality of fuel injection holes facing an interior of the combustion chamber and formed so as to be spaced apart from each other in a circumferential direction of the combustion chamber; a first air injection hole having an annular shape, facing the interior of the combustion chamber, and extending in the circumferential direction on a radially outer side with respect to the plurality of fuel injection holes; and a second air injection hole having an annular shape, facing the interior of the combustion chamber, and extending in the circumferential direction on a radially inner side with respect to the plurality of fuel injection holes, and wherein the second injection hole group is located radially inward of the first injection hole group.
2. The combustion device according to claim 1, wherein the through-hole is displaced in a radial direction with respect to the slit.
3. The combustion device according to claim 1, further comprising: a casing; a liner provided in an interior of the casing, the combustion chamber being formed in an interior of the liner; and a space surrounded by the liner, the plate and the casing, wherein the slit is formed on the plate between the plurality of injection hole groups, and wherein the slit faces the combustion chamber, and does not face the space.
4. A gas turbine system, comprising the combustion device of claim 1.
5. A combustion device, comprising: a plate facing a combustion chamber; a plurality of injection

hole groups formed in the plate so as to have an annular shape; a slit having an annular shape and formed between the plurality of injection hole groups; an annular cavity that is formed between the plurality of injection hole groups in the plate, and communicates with the slit; and a through-hole that is formed in the plate on a side opposite to the combustion chamber, and communicates with the annular cavity, wherein the plurality of injection hole groups include a first injection hole group and a second injection hole group, wherein each of the first injection hole group and the second injection hole group includes: a plurality of fuel injection holes facing an interior of the combustion chamber and formed so as to be spaced apart from each other in a circumferential direction of the combustion chamber; and at least one air injection hole having an annular shape, facing the interior of the combustion chamber, and extending in the circumferential direction on at least one of a radially outer side and a radially inner side with respect to the plurality of fuel injection holes, and wherein the at least one air injection hole is inclined, with respect to an axial direction of the combustion chamber, toward the plurality of fuel injection holes in a radial direction.

6. The combustion device according to claim 5, wherein the through-hole is displaced in a radial direction with respect to the slit.

7. The combustion device according to claim 5, further comprising: a casing; a liner provided in an interior of the casing, the combustion chamber being formed in an interior of the liner; and a space surrounded by the liner, the plate and the casing, wherein the slit is formed on the plate between the plurality of injection hole groups, and wherein the slit faces the combustion chamber, and does not face the space.

8. A gas turbine system, comprising the combustion device of claim 5.