(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 477 953 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
18.12.2024 Bulletin 2024/51

(21) Application number: **22926058.3**

(22) Date of filing: **18.11.2022**

(51) International Patent Classification (IPC):
F23R 3/28 *(2006.01)* ***F23K 5/00*** *(2006.01)*
F23R 3/14 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F23K 5/00; F23R 3/14; F23R 3/28

(86) International application number:
PCT/JP2022/042902

(87) International publication number:
WO 2023/153042 (17.08.2023 Gazette 2023/33)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **08.02.2022 JP 2022017901**

(71) Applicant: **IHI Corporation**
Tokyo 135-8710 (JP)

(72) Inventors:
- **ITO, Shintaro**
  Tokyo 135-8710 (JP)
- **UCHIDA, Masahiro**
  Tokyo 135-8710 (JP)

(74) Representative: **Marks & Clerk LLP**
15 Fetter Lane
London EC4A 1BW (GB)

(54) **INJECTION NOZZLE AND COMBUSTION DEVICE**

(57) An injection nozzle 100 includes: an inner wall 101 having a cylindrical shape; a first outer wall 102 having a cylindrical shape and being formed integrally with the inner wall 101 through intermediation of a connection portion 107; a fuel passage 108 having an annular shape and being formed between the inner wall 101 and the first outer wall 102; and an inner air passage 104 formed on an inner side of the inner wall 101.

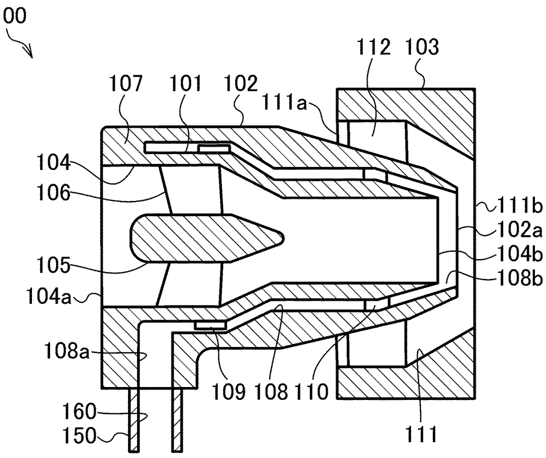

FIG. 2

Description

Technical Field

[0001] The present disclosure relates to an injection nozzle and a combustion device. This application claims the benefit of priority to Japanese Patent Application No. 2022-17901 filed on February 8, 2022, and contents thereof are incorporated herein.

Background Art

[0002] 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 a fuel injection nozzle configured to premix fuel with air and inject it into a combustor, as disclosed in Patent Literature 1. Through premixing of the fuel with sufficient air to perform lean combustion, emission of NOx is suppressed.

Citation List

Patent Literature

[0003] Patent Literature 1 JP 5472863 B2

Summary of Invention

Technical Problem

[0004] In a fuel injection nozzle described in Patent Literature 1, a fuel passage for allowing fuel to flow therethrough and an air passage for allowing air to flow therethrough are formed by assembling a plurality of members. However, for example, when the plurality of members are assembled to form the fuel passage, due to machining accuracy, assembly errors, or the like, the fuel sometimes flows through the fuel passage unevenly, resulting in deteriorated combustibility in a combustor.

[0005] An object of the present disclosure is to provide an injection nozzle and a combustion device capable of improving combustibility.

Solution to Problem

[0006] In order to achieve the above-mentioned object, according to the present disclosure, there is provided an injection nozzle, including: an inner wall having a cylindrical shape; an outer wall having a cylindrical shape and being formed integrally with the inner wall through intermediation of a connection portion; a fuel passage having an annular shape and being formed between the inner wall and the outer wall; and an inner air passage formed on an inner side of the inner wall.

[0007] The injection nozzle may include a swirling portion that is formed integrally with at least one of the inner wall and the outer wall and arranged in the fuel passage obliquely to a circumferential direction of the inner wall and the outer wall.

[0008] The injection nozzle may include a swirling blade that is formed integrally with the inner wall and arranged in the inner air passage obliquely to the circumferential direction of the inner wall.

[0009] The injection nozzle may include: a shaft portion arranged on a center axis of the inner air passage and formed integrally with the swirling blade; a distribution portion formed inside the shaft portion; and a fuel communication passage formed inside the swirling blade and allowing communication between the distribution portion and the fuel passage.

[0010] The injection nozzle may include: an air supply passage connected to the inner air passage and extending tangentially to the inner air passage; and a fuel communication passage that is formed so as to separate from the air supply passage in the circumferential direction, and communicates with the fuel passage.

[0011] In order to achieve the above-mentioned object, according to the present disclosure, the combustion device includes the above-mentioned injection nozzle.

Advantageous Effects of Invention

[0012] According to the present disclosure, combustibility can be improved.

Brief Description of Drawings

[0013]

FIG. 1 is a schematic view for illustrating a configuration of a gas turbine system according to an embodiment.

FIG. 2 is a schematic cross-sectional view for illustrating a configuration of an injection nozzle according to the embodiment.

FIG. 3 is a schematic cross-sectional view for illustrating a configuration of an injection nozzle according to a first modification example.

FIG. 4 is a schematic cross-sectional view for illustrating a configuration of an injection nozzle according to a second modification example.

FIG. 5 is a schematic cross-sectional view of a plurality of air supply passages.

Summary of Invention

Description of Embodiments

[0014] 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 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 description thereof. Further, illustration of elements with no direct relationship to the present disclosure is omitted.

[0015] 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, an injection nozzle mechanism 14, a fuel tank 15, and a flow rate control valve 16.

[0016] Of the gas turbine system 1, the combustor 13, the injection nozzle mechanism 14, the fuel tank 15, and the flow rate control valve 16 are included in a combustion device 10.

[0017] The turbocharger 11 includes a compressor 11a and a turbine 11b. The compressor 11a and the turbine 11b rotate integrally. The compressor 11a and the turbine 11b are coupled by a shaft.

[0018] The compressor 11a 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 11a and is sent to the combustor 13. The compressor 11a compresses the air and discharges the compressed air to a downstream side.

[0019] The turbine 11b 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 11b and is sent to the exhaust port. The turbine 11b is rotated by the exhaust gas to generate rotational power.

[0020] 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.

[0021] The combustor 13 includes a casing 13a, a liner 13b, and a combustion chamber 13c. The casing 13a has a substantially cylindrical shape. The liner 13b is provided inside the casing 13a. The liner 13b has a substantially cylindrical shape. The liner 13b is arranged coaxially with the casing 13a. The combustion chamber 13c is formed inside the liner 13b. That is, an interior space of the liner 13b corresponds to the combustion chamber 13c. The combustion chamber 13c is a space having a substantially cylindrical shape. The exhaust flow passage 22 is connected to the combustion chamber 13c.

[0022] As described later, fuel and air are supplied into the combustion chamber 13c. In the combustion chamber 13c, a gas mixture of fuel and air is subjected to combustion. An exhaust gas generated as a result of combustion in the combustion chamber 13c is discharged to the exhaust flow passage 22. A space S is defined between an inner surface of the casing 13a and an outer surface of the liner 13b. The intake flow passage 21 is connected to the space S. Air is fed into the space S from the compressor 11a via the intake flow passage 21. An opening is formed in an end portion (left end portion in FIG. 1) of the liner 13b on a side that air is fed from the compressor 11a. A plate P is provided in the vicinity of the opening in the end portion of the liner 13b.

[0023] The injection nozzle mechanism 14 is provided on the plate P. The plate P retains the injection nozzle mechanism 14. An opening is formed in a center of the plate P. A gas mixture of fuel and air to be injected from the injection nozzle mechanism 14 is introduced into the combustion chamber 13c through the opening of the plate P. The injection nozzle mechanism 14 includes an injection nozzle 100 and a fuel supply pipe 150.

[0024] FIG. 2 is a schematic cross-sectional view for illustrating a configuration of the injection nozzle 100 according to the present embodiment. As illustrated in FIG. 2, the injection nozzle 100 includes an inner wall 101, a first outer wall 102, a second outer wall 103, an inner air passage 104, a shaft portion 105, inner swirling blades 106, a connection portion 107, a fuel passage 108, a resistance portion 109, a swirling portion 110, an outer air passage 111, and outer swirling blades 112.

[0025] The inner wall 101, the first outer wall 102, and the second outer wall 103 are each formed into a cylindrical shape. However, the present disclosure is not limited thereto, and the inner wall 101, the first outer wall 102, and the second outer wall 103 may be formed into, for example, a truncated cone shape. Further, the inner wall 101, the first outer wall 102, and the second outer wall 103 may have an inclined shape inclined in a direction in which a part of the cylinder comes close to or separates away from a center axis. Thus, the inner wall 101, the first outer wall 102, and the second outer wall 103 may have such an inclined shape that at least a part of the cylinder is inclined along a center axis direction. The inner wall 101, the first outer wall 102, and the second outer wall 103 separate from each other in a radial direction. The inner wall 101 is arranged radially inward of the first outer wall 102 and the second outer wall 103. The first outer wall 102 is arranged between the inner wall 101 and the second outer wall 103, and is arranged radially outward of the inner wall 101 and radially inward of the second outer wall 103. The second outer wall 103 is arranged radially outward of the inner wall 101 and the first outer wall 102. The second outer wall 103 is connected to the plate P (see FIG. 1).

[0026] The inner air passage 104 is formed by an inner peripheral surface of the inner wall 101. An air inlet 104a is formed at one end of the inner air passage 104, and an air outlet 104b is formed at another end thereof. The air inlet 104a communicates with the space S (see FIG. 1) into which the air is fed from the compressor 11a. The air flows through the inner air passage 104 from the air inlet 104a toward the air outlet 104b. The shaft portion 105 and the inner swirling blades 106 are provided in the inner air passage 104.

[0027] The shaft portion 105 is formed into a substantially cylindrical shape. The shaft portion 105 is arranged on the center axis of the inner air passage 104. The plurality of inner swirling blades 106 are provided on an outer peripheral surface of the shaft portion 105 so as to separate from each other in a circumferential direction. The plurality of inner swirling blades 106 are arranged at equal intervals in the circumferential direction of the shaft portion 105. The inner swirling blades 106 are connected to the outer peripheral surface of the shaft portion 105 and the inner peripheral surface of the inner wall 101. The inner swirling blades 106 are arranged in the inner air passage 104 obliquely to the circumferential direction of the inner wall 101 and the shaft portion 105. The inner swirling blades 106 swirl the air in a clockwise or counterclockwise direction about the center axis of the inner air passage 104.

[0028] The connection portion 107 connects the inner wall 101 and the first outer wall 102 to each other. The connection portion 107 is provided on a side of the inner wall 101 including the air inlet 104a, and connects the inner wall 101 and the first outer wall 102 to each other.

[0029] The fuel passage 108 is formed between the inner wall 101 and the first outer wall 102. The fuel passage 108 is formed into an annular shape. At one end of the fuel passage 108, a fuel communication passage 108a is connected to a part of the fuel passage 108 in the circumferential direction, and at another end thereof, a fuel discharge port 108b is formed. The fuel flows through the fuel passage 108 from the fuel communication passage 108a toward the fuel discharge port 108b. The resistance portion 109 and the swirling portion 110 are provided in the fuel passage 108.

[0030] The resistance portion 109 is provided upstream of the swirling portion 110. However, the present disclosure is not limited thereto, and the resistance portion 109 may be provided downstream of the swirling portion 110. The resistance portion 109 is, for example, a protrusion formed over an entire circumference of an outer peripheral surface of the inner wall 101 and protruding radially from the outer peripheral surface of the inner wall 101 toward an inner peripheral surface of the first outer wall 102. A gap is defined between the resistance portion 109 and the inner peripheral surface of the first outer wall 102 so as to allow the fuel to flow therethrough. Owing to the resistance portion 109, a flow rate of the fuel flowing in the fuel passage 108 can be made uniform in the circumferential direction.

[0031] However, the present disclosure is not limited thereto, and the resistance portion 109 may be a protrusion formed over the entire circumference of the inner peripheral surface of the first outer wall 102 and protruding radially from the inner peripheral surface of the first outer wall 102 toward the outer peripheral surface of the inner wall 101. Further, a pair of resistance portions 109 may be formed over the entire circumference of the outer peripheral surface of the inner wall 101 and the entire circumference of the inner peripheral surface of the first outer wall 102. The pair of resistance portions 109 are, for example, protrusions that are arranged to be opposed to each other in the radial direction and protrude in directions of approaching to each other. Thus, the resistance portion 109 is the protrusion that is formed on at least one of the inner wall 101 and the first outer wall 102 and reduces a cross-sectional area of the flow passage of the fuel passage 108. The resistance portion 109 is not limited to a protrusion, and may be, for example, a slit formed in at least one of the outer peripheral surface of the inner wall 101 and the inner peripheral surface of the first outer wall 102. A plurality of slits may be formed so as to separate from each other in the circumferential direction. Further, the resistance portion 109 may be a hole, such as an orifice, formed between the inner wall 101 and the first outer wall 102. A plurality of holes may be formed so as to separate from each other in the circumferential direction.

[0032] The swirling portion 110 is formed on, for example, the inner wall 101, and at least a part of the swirling portion 110 is arranged obliquely to the circumferential direction of the inner wall 101. Owing to oblique arrangement of the swirling portion 110, the fuel can be swirled in a clockwise or counterclockwise direction about the center axis of the inner air passage 104. However, the present disclosure is not limited thereto, and the swirling portion 110 may be formed on the first outer wall 102 or on both the inner wall 101 and the first outer wall 102. That is, the swirling portion 110 may be formed on at least one of the inner wall 101 and the first outer wall 102, and may be arranged in the fuel passage 108 obliquely to the circumferential direction of the inner wall 101 and the first outer wall 102.

[0033] The outer air passage 111 is formed between an inner peripheral surface of the second outer wall 103 and an outer peripheral surface of the first outer wall 102. The outer air passage 111 has an annular shape. An air inlet 111a is formed at one end of the outer air passage 111, and an injection port 111b is formed at another end thereof. The air inlet 111a communicates with the space S into which the air is fed from the compressor 11a. The air flows through the outer air passage 111 from the air inlet 111a toward the injection port 111b. In the outer air passage 111, the outer swirling blades 112 are provided.

[0034] The plurality of outer swirling blades 112 are provided on the outer peripheral surface of the first outer wall 102 so as to separate from each other in the circumferential direction. The plurality of outer swirling blades 112 are arranged at equal intervals in the circumferential direction of the first outer wall 102. The outer swirling blades 112 are connected to the outer peripheral surface of the first outer wall 102 and the inner peripheral surface of the second outer wall 103. The outer swirling blades 112 swirl the air in a clockwise or counterclockwise direction about the center axis of the outer air passage 111.

[0035] The fuel supply pipe 150 is connected at one end to the connection portion 107 and the outer peripheral surface of the first outer wall 102, and connected at another end to a flow passage 24 (see FIG. 1) to be described later. The fuel supply pipe 150 supplies the fuel from the flow passage 24 to the injection nozzle 100. A fuel supply passage 160 is formed in the fuel supply pipe 150. The fuel supply passage 160 communicates with the fuel passage 108 via the fuel communication passage 108a.

[0036] Returning to FIG. 1, the fuel is stored in the fuel tank 15. The fuel is, for example, natural gas or hydrogen. The hydrogen may be liquid or gaseous in the fuel tank 15. The fuel 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 the fuel supply pipe 150 via the flow passage 24. The fuel stored in the fuel tank 15 is supplied into the fuel supply pipe 150 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 fuel to be supplied from the fuel tank 15 into the fuel supply pipe 150. Through adjustment of an opening degree of the flow rate control valve 16, a supply amount of the fuel from the fuel tank 15 into the fuel supply pipe 150 is adjusted.

[0037] Returning to FIG. 2, the fuel supply passage 160 of the fuel supply pipe 150 is connected to the fuel communication passage 108a. The fuel is supplied from the fuel supply pipe 150 into the fuel passage 108 via the fuel communication passage 108a. The fuel supplied into the fuel passage 108 merges with the air having flowed through the inner air passage 104, and is mixed therewith, when the fuel is injected from the fuel discharge port 108b.

[0038] Here, the air flowing through the inner air passage 104 is swirled by the inner swirling blades 106, and the fuel flowing through the fuel passage 108 is swirled by the swirling portion 110. When the swirling air and fuel merge with each other, a shear force atomizes the fuel and accelerates mixing of the air and the fuel. In the present embodiment, a swirling direction of the air caused by the inner swirling blades 106 and a swirling direction of the fuel caused by the swirling portion 110 are the same direction. However, the present disclosure is not limited thereto, and the swirling direction of the air caused by the inner swirling blades 106 and the swirling direction of the fuel caused by the swirling portion 110 may be directions opposite to each other.

[0039] The gas mixture of air and fuel is discharged from a gas mixture injection port 102a of the first outer wall 102 and flows into the outer air passage 111 of the second outer wall 103. The gas mixture discharged from the gas mixture injection port 102a merges with the air having flowed through the outer air passage 111, and is mixed therewith.

[0040] Here, the air flowing through the outer air passage 111 is swirled by the outer swirling blades 112. When the swirling air and the gas mixture merge with each other, a shear force atomizes the fuel and accelerates mixing of the air and the gas mixture. In the present embodiment, the swirling direction of the air caused by the outer swirling blades 112 and the swirling direction of the fuel caused by the inner swirling blades 106 and the swirling portion 110 are the same direction. However, the present disclosure is not limited thereto, and the swirling direction of the air caused by the outer swirling blades 112 and the swirling direction of the air caused by the inner swirling blades 106 or the swirling direction of the fuel caused by the swirling portion 110 may be directions opposite to each other. The gas mixture mixed in the second outer wall 103 is injected from the injection port 111b into the combustion chamber 13c.

[0041] When the inner wall, the outer walls, the connection portion, and the like, which form the injection nozzle, are formed of separate members and each member is assembled to form the injection nozzle, the fuel may flow through the fuel passage unevenly or the fuel may leak from gaps between the plurality of members due to machining accuracy, assembly errors, or the like. When the fuel flows through the fuel passage unevenly, combustibility in the combustor may deteriorate.

[0042] Accordingly, in the present embodiment, parts forming the injection nozzle 100 are integrally formed. Specifically, the inner wall 101, the first outer wall 102, the second outer wall 103, the shaft portion 105, the inner swirling blades 106, the connection portion 107, the resistance portion 109, the swirling portion 110, and the outer swirling blades 112 are integrally formed by additive manufacturing technology.

[0043] Through integral forming of parts forming the injection nozzle 100 by the additive manufacturing technology, it is possible to prevent the fuel from flowing through the fuel passage unevenly and the fuel from leaking from gaps between the plurality of members due to machining accuracy, assembly errors, or the like.

[0044] Specifically, the inner wall 101 and the first outer wall 102 are integrally formed. Thus, a gap between the inner wall 101 and the first outer wall 102 can be eliminated, thereby being capable of preventing fuel leakage. Further, no machining or assembly is required. Thus, a radial width of the fuel passage 108 can be made uniform over the entire circumference. That is, it is possible to reduce eccentricity between the center axis of the inner wall 101 having a cylindrical shape and the center axis of the first outer wall 102 having a cylindrical shape, which is caused by assembly. As a result, the flow rate of the fuel in the circumferential direction of the fuel passage 108 can be made uniform, thereby being capable of improving the combustibility in the combustion chamber 13c.

[0045] Further, the resistance portion 109 is formed integrally with the inner wall 101 or the first outer wall 102. Thus, influences of machining accuracy and assembly errors are eliminated, thereby being capable of making the flow rate of the fuel flowing through the fuel passage 108 uniform in the circumferential direction. In addition, the swirling portion 110 is formed integrally with the inner wall 101 or the first outer wall 102. Thus, influences of machining accuracy and assembly errors are eliminated, thereby being capable of making the swirling flow of the fuel uniform in the circumferential direction. Similarly, the inner swirling blades 106 are formed integrally with the inner wall 101, and the outer swirling blades 112 are formed integrally with the first outer wall 102. Thus, influences of machining accuracy and assembly errors are eliminated, thereby being capable of making the swirling flow of the air uniform in the circumferential direction.

[0046] FIG. 3 is a schematic cross-sectional view for illustrating a configuration of an injection nozzle 200 according to a first modification example. Components that are substantially the same as those of the injection nozzle 100 according to the above-mentioned embodiment are denoted by the same reference symbols, and descriptions thereof are omitted. As illustrated in FIG. 3, the injection nozzle 200 according to the first modification example differs from the above-mentioned embodiment in that fuel communication passages 208a are formed in the inner swirling blades 106 and a distribution portion 210 is formed in the shaft portion 105.

[0047] In the first modification example, the inner wall 101, the first outer wall 102, the second outer wall 103, the shaft portion 105, the inner swirling blades 106, the connection portion 107, the resistance portion 109, the swirling portion 110, and the outer swirling blades 112 are integrally formed by the additive manufacturing technology. At this time, the fuel communication passages 208a and the distribution portion 210 are formed in the inner swirling blades 106 and the shaft portion 105, respectively.

[0048] The distribution portion 210 is formed inside the shaft portion 105, and is an internal space into which the fuel is supplied. The fuel supply pipe 150 is connected to the shaft portion 105. The fuel supply passage 160 of the fuel supply pipe 150 is connected to the distribution portion 210. The distribution portion 210 communicates with the fuel supply passage 160. The plurality of fuel communication passages 208a are connected to the distribution portion 210. The fuel communication passages 208a each have the same shape and size. One fuel communication passage 208a is formed inside one inner swirling blade 106. Each fuel communication passage 208a is connected at one end to the distribution portion 210, and connected at another end to the fuel passage 108.

[0049] The fuel having passed through the fuel supply passage 160 of the fuel supply pipe 150 is supplied to the distribution portion 210. The distribution portion 210 evenly distributes the fuel that is supplied from the fuel supply passage 160 to each of the fuel communication passages 208a. The fuel communication passages 208a supply the fuel that is distributed by the distribution portion 210 to the fuel passage 108. The plurality of inner swirling blades 106 are arranged at equal intervals in the circumferential direction of the shaft portion 105, and thus the plurality of fuel communication passages 208a can supply the fuel evenly over the entire circumference of the fuel passage 108.

[0050] According to the first modification example, the fuel communication passages 208a are formed in the inner swirling blades 106. Thus, the injection nozzle 200 can be downsized as compared to that according to the above-mentioned embodiment. Further, the fuel supply pipe 150 is connected to the shaft portion 105 but is not connected to the outer peripheral surface of the first outer wall 102. Thus, for example, inhibition of air flow into the outer air passage 111 by the fuel supply pipe 150 can be reduced.

[0051] FIG. 4 is a schematic cross-sectional view for illustrating a configuration of an injection nozzle 300 according to a second modification example. Components that are substantially the same as those of the injection nozzle 100 according to the above-mentioned embodiment are denoted by the same reference symbols, and descriptions thereof are omitted. As illustrated in FIG. 4, the injection nozzle 300 according to the second modification example differs from the above-mentioned embodiment in that a plurality of air supply passages 310 are provided instead of the inner swirling blades 106. A configuration in which the inner swirling blades 106 cause the air to swirl is hereinafter also referred to as an axial swirler, and a configuration in which the air supply passages 310, which are described later, cause the air to swirl is hereinafter also referred to as a tangential swirler. Further, the injection nozzle 300 differs from the above-mentioned embodiment in that a distribution portion 320 and a plurality of fuel communication passages 308a are formed in the connection portion 107.

[0052] In the second modification example, the inner wall 101, the first outer wall 102, the second outer wall 103, the shaft portion 105, the connection portion 107, the resistance portion 109, the swirling portion 110, and the outer swirling blades 112 are integrally formed by the additive manufacturing technology. At this time, the plurality of air supply passages 310, the plurality of fuel communication passages 308a, and the distribution portion 320 are formed in the connection portion 107.

[0053] FIG. 5 is a schematic cross-sectional view of the plurality of air supply passages 310. As illustrated in FIG. 5, the plurality of air supply passages 310 are formed in the connection portion 107 so as to be connected to the inner air passage 104 and separate from each other in the circumferential direction. In the second modification example, four air supply passages 310 are formed at equal intervals in the circumferential direction of the inner air passage 104. However, the present disclosure is not limited thereto, and the plurality of air supply passages 310 may be formed at unequal intervals in the circumferential direction of the inner air passage 104. Further, the number of the air supply passages 310 may be one, two, or three, or five or more air supply passages 310 may be formed.

[0054] Each air supply passage 310 is connected at one end to an outer edge portion of the inner air passage 104, and is opened at another end in an outer peripheral surface of the connection portion 107 or the first outer wall 102. The air supply passages 310 communicate with the space S (see FIG. 1) into which the air is fed from the compressor 11a. The air supply passages 310 extend tangentially to an outer periphery of the inner air passage 104. This can cause the air supplied into the inner air passage 104 to swirl even when the inner swirling blades 106 are not provided. With reference to FIG. 4, the injection nozzle 300 according to the second modification example may include air supply passages similar to the plurality of air supply passages 310 described above instead of the outer swirling blades 112.

[0055] The distribution portion 320 is formed inside the connection portion 107, and is an internal space into which the fuel is supplied. The fuel supply pipe 150 is connected to the connection portion 107. The fuel supply passage 160 of the fuel supply pipe 150 is connected to the distribution portion 320. The distribution portion 320 communicates with the fuel supply passage 160. The plurality of fuel communication passages 308a are connected to the distribution portion 320. The plurality of fuel communication passages 308a are formed in the connection portion 107, and are formed so as to separate from each other in the circumferential direction of the inner air passage 104 as illustrated in FIG. 5. The plurality of fuel communication passages 308a are formed, for example, at equal intervals in the circumferential direction of the inner air passage 104. However, the present disclosure is not limited thereto, and the plurality of fuel communication passages 308a may be formed at unequal intervals in the circumferential direction of the inner air passage 104. The fuel communication passages 308a each have the same shape and size.

[0056] Each fuel communication passage 308a is connected at one end to the distribution portion 320, and connected at another end to the fuel passage 108. Each fuel communication passage 308a extends along the center axis direction of the inner wall 101 and the first outer wall 102 from the distribution portion 210 toward the fuel passage 108. As illustrated in FIG. 5, the fuel communication passages 308a are formed in the connection portion 107 so as to separate from the air supply passages 310 in the circumferential direction. Thus, without communication with the air supply passages 310, the fuel communication passages 308a can prevent the fuel flowing through the fuel communication passages 308a from leaking into the air supply passages 310.

[0057] The fuel having passed through the fuel supply passage 160 of the fuel supply pipe 150 is supplied to the distribution portion 320. The distribution portion 320 evenly distributes the fuel that is supplied from the fuel supply passage 160 to each of the fuel communication passages 308a. The fuel communication passages 308a supply the fuel that is distributed by the distribution portion 320 to the fuel passage 108. The plurality of fuel communication passages 308a are arranged at equal intervals in the circumferential direction of the inner air passage 104, and thus the plurality of fuel communication passages 308a can supply the fuel evenly over the entire circumference of the fuel passage 108.

[0058] According to the second modification example, the plurality of air supply passages 310 extending tangentially to the inner air passage 104 are provided, and thus a swirl angle of the swirling flow of the air can be increased as compared to the case in which the inner swirling blades 106 are provided as in the above-mentioned embodiment and the first modification example. This is because in additive manufacturing, there is a limit to an inclination angle of the inner swirling blades 106 with respect to the center axis direction of the shaft portion 105 in the above-mentioned embodiment, and it is difficult to increase the inclination angle of the inner swirling blades 106 beyond a predetermined angle or more. In the second modification example, the air supply passages 310 extending tangentially to the inner air passage 104 are formed in parallel to the center axis direction of the shaft portion 105, and hence the swirl angle of the swirling flow of the air in the inner air passage 104 can be increased as compared to that in the above-mentioned embodiment.

[0059] Further, the fuel supply pipe 150 is not connected to the outer peripheral surface of the first outer wall 102. Thus, for example, inhibition of air flow into the outer air passage 111 by the fuel supply pipe 150 can be reduced.

[0060] The 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 alternations and modifications within the scope of claims, and those examples are construed as naturally falling within the technical scope of the present disclosure.

[0061] 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).

[0062] In the embodiment, the first modification example, and the second modification example described above, description has been given of the example of providing the resistance portion 109 and the swirling portion 110 in the fuel passage 108. However, the resistance portion 109 and the swirling portion 110 are not essential components, and it is not always required that the resistance portion 109 and the swirling portion 110 be provided in the fuel passage 108.

[0063] In the above-mentioned embodiment, description has been given of the example of providing the shaft portion 105 and the inner swirling blades 106 in the inner air passage 104. However, in the above-mentioned embodiment, the shaft portion 105 and the inner swirling blades 106 are not essential components, and it is not always required that the shaft portion 105 and the inner swirling blades 106 be provided in the inner air passage 104.

[0064] In the embodiment, the first modification example, and the second modification example described above, description has been given of the example of providing the outer swirling blades 112 in the outer air passage 111. However, the outer swirling blades 112 are not essential components, and it is not always required that the outer swirling blades 112 be provided in the outer air passage 111.

Reference Signs List

[0065]

1: gas turbine system
10: combustion device
100: injection nozzle
101: inner wall
102: first outer wall
103: second outer wall
104: inner air passage
105: shaft portion
106: inner swirling blade
107: connection portion
108: fuel passage
108a: fuel communication passage
109: resistance portion
110: swirling portion
111: outer air passage
112: outer swirling blade
200: injection nozzle
208a: fuel communication passage
210: distribution portion
300: injection nozzle
308a: fuel communication passage
310: air supply passage
320: distribution portion

Claims

1. An injection nozzle, comprising:

an inner wall having a cylindrical shape;
an outer wall having a cylindrical shape and being formed integrally with the inner wall through intermediation of a connection portion;
a fuel passage having an annular shape and being formed between the inner wall and the outer wall; and
an inner air passage formed on an inner side of the inner wall.

2. The injection nozzle according to claim 1, comprising a swirling portion that is formed integrally with at least one of the inner wall and the outer wall and arranged in the fuel passage obliquely to a circumferential direction of the inner wall and the outer wall.

3. The injection nozzle according to claim 1 or 2, comprising a swirling blade that is formed integrally with the inner wall and arranged in the inner air passage obliquely to the circumferential direction of the inner wall.

4. The injection nozzle according to claim 3, comprising:

a shaft portion arranged on a center axis of the inner air passage and formed integrally with the swirling blade;
a distribution portion formed inside the shaft portion; and
a fuel communication passage formed inside the swirling blade and allowing communication between the distribution portion and the fuel passage.

5. The injection nozzle according to claim 1 or 2, comprising:

an air supply passage connected to the inner air passage and extending tangentially to the inner air passage; and
a fuel communication passage that is formed so as to separate from the air supply passage in the circumferential direction, and communicates with the fuel passage.

6. A combustion device, comprising the injection nozzle of claim 1 or 2.

7. A combustion device, comprising the injection nozzle of claim 3.

8. A combustion device, comprising the injection nozzle of claim 4.

9. A combustion device, comprising the injection nozzle of claim 5.

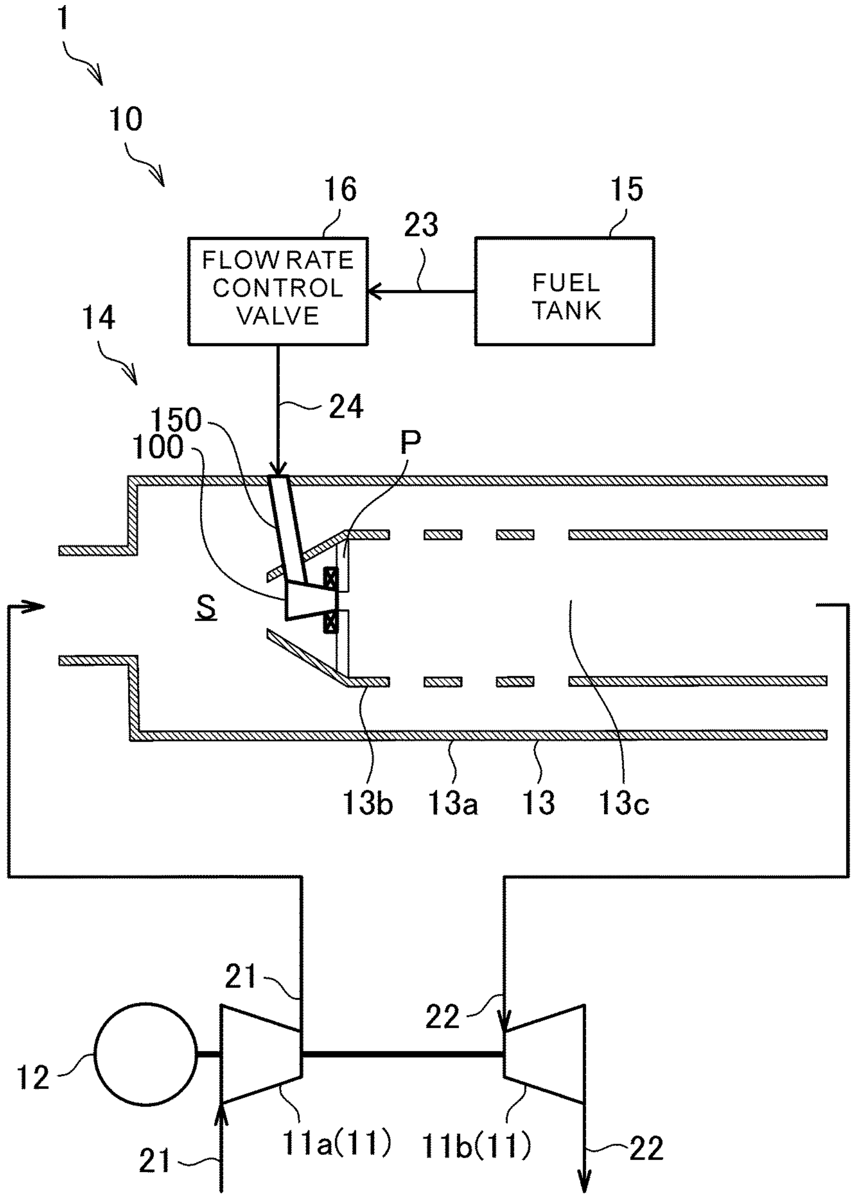
1
10
16
15
23
FLOW RATE
CONTROL
VALVE
FUEL
TANK
14
24
150
100
P
S
13b
13a
13
13c
21
22
12
21
11a(11)
11b(11)
22

FIG. 1

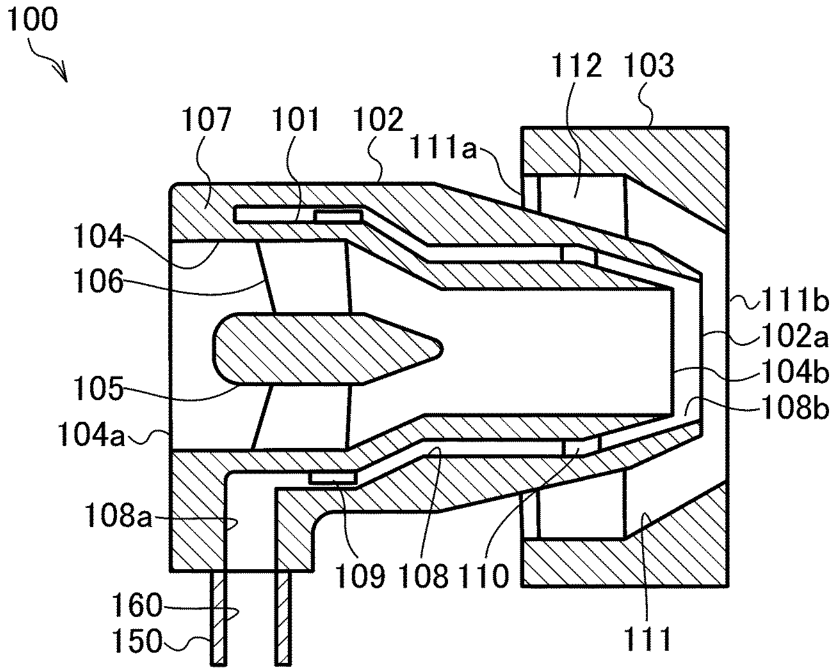
100
112
103
107
101
102
111a
104
106
111b
102a
105
104b
108b
104a
108a
109
108
110
160
150
111

FIG. 2

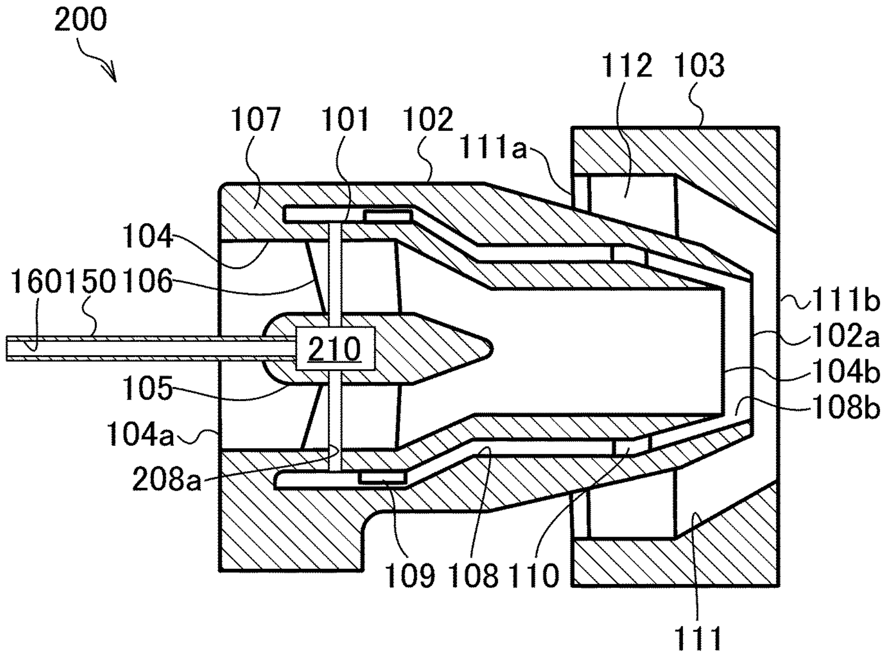
200
112
103
107
101
102
111a
104
160
150
106
111b
210
102a
104b
105
108b
104a
208a
109
108
110
111

FIG. 3

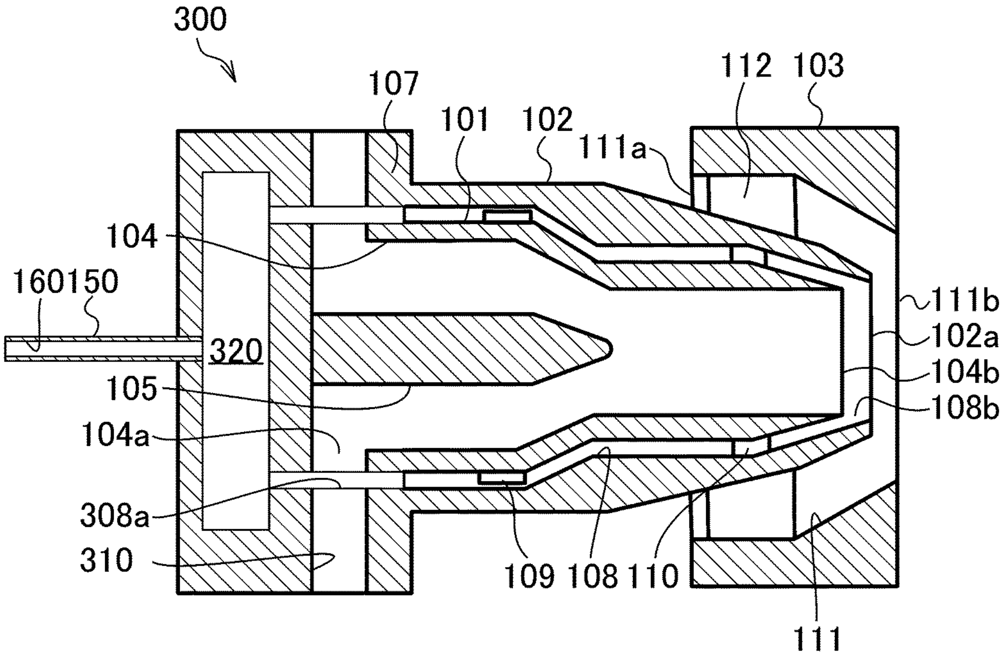
300
107
101
102
111a
112
103
104
160150
320
105
104a
308a
310
109
108
110
111
111b
102a
104b
108b

FIG. 4

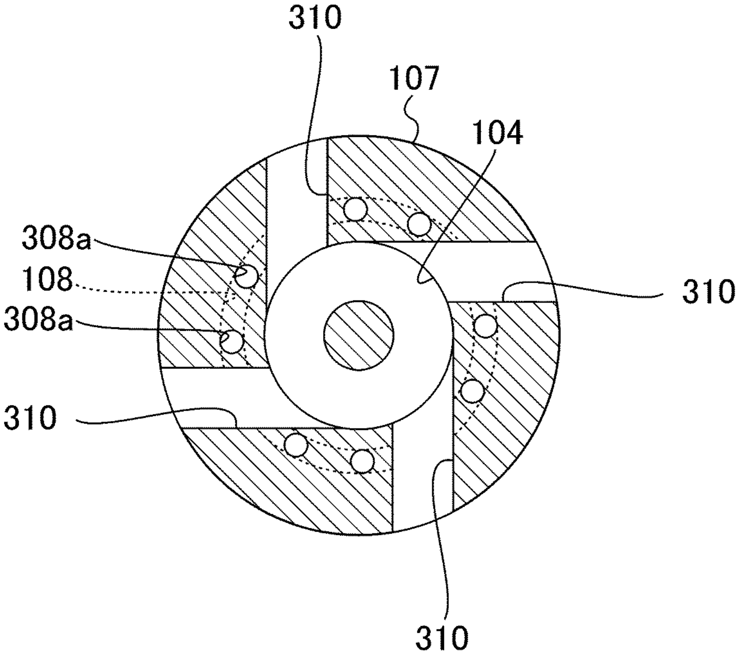

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No. **PCT/JP2022/042902**

A. CLASSIFICATION OF SUBJECT MATTER

F23R 3/28(2006.01)i; ***F23K 5/00***(2006.01)i; ***F23R 3/14***(2006.01)i
FI: F23R3/28 B; F23R3/14; F23K5/00 301Z

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F23R3/28; F23K5/00; F23R3/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 6-94218 A (MITSUBISHI HEAVY IND LTD) 05 April 1994 (1994-04-05) paragraphs [0001]-[0002], fig. 4	1-2, 6
Y		3, 7
A		4–5, 8–9
Y	JP 2003-47892 A (NATIONAL AEROSPACE LABORATORY OF JAPAN) 18 February 2003 (2003-02-18) paragraph [0004], fig. 7	3, 7
A	JP 2003-214604 A (NATIONAL AEROSPACE LABORATORY OF JAPAN) 30 July 2003 (2003-07-30) fig. 1-4	1-9
A	US 2007/0137207 A1 (MANCINI, Alfred Albert) 21 June 2007 (2007-06-21) fig. 2-4	1-9

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 December 2022	**27 December 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/042902

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 6-94218 A	05 April 1994	(Family: none)	
JP 2003-47892 A	18 February 2003	(Family: none)	
JP 2003-214604 A	30 July 2003	US 2003/0141383 A1 fig. 1-4 EP 1331441 A1	
US 2007/0137207 A1	21 June 2007	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2022017901 A **[0001]**
- JP 5472863 B **[0003]**