

Description

Title of Invention: GAS TURBINE SYSTEM

Technical Field

5 [0001] The present disclosure relates to a gas turbine system. The present application claims the benefit of priority based on Japanese Patent Application No. 2022-174057 filed on October 31, 2022, the contents of which are incorporated herein by reference.

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Background Art

[0002] Ammonia is known as a fuel that does not emit CO₂. For example, Patent Literature 1 discloses a gas turbine system that uses ammonia as fuel. The system
15 includes a tank for ammonia and a first combustion chamber. Ammonia in the tank passes through a first mass flow separator, a part of which is directly sent to the first combustion chamber and the rest of which is sent to a first cracker chamber. In the first cracker chamber, ammonia is
20 decomposed into a hydrogen-rich gas mixture including nitrogen, hydrogen and other constituents. The ammonia and the hydrogen-rich gas mixture are injected into the first combustion chamber and combusted. Exhaust gas from the first combustion chamber contains high levels of NO_x. Furthermore,
25 the system includes a second combustion chamber. The exhaust gas from the first combustion chamber is routed to the second combustion chamber. The ammonia in the tank passes through a

second mass flow separator, a part of which is directly sent to the second combustion chamber and the rest of which is sent to a second cracker chamber. In the second cracker chamber, ammonia is decomposed into the hydrogen-rich gas mixture including nitrogen, hydrogen, and other constituents. The ammonia and the hydrogen-rich gas mixture are injected into the second combustion chamber and combusted. In the second combustion chamber, fuel is combusted at a high equivalent ratio of 1.0 to 1.2. This removes NO_x from the exhaust gas from the first combustion chamber.

Citation List

Patent Literature

[0003] Patent Literature 1: JP 2018-535355 A

Summary

Technical Problem

[0004] Ammonia is a fuel that is hard to combust. Accordingly, when starting a gas turbine, it is difficult to increase pressure in a combustor from atmospheric pressure to a pressure at a rated speed with using only ammonia as fuel. As such, preparing another fuel that is easy to combust such as natural gas is conceivable in order to start a gas turbine. However, this would lead to an increase in fuel costs.

[0005] The purpose of the present disclosure is to provide a gas turbine system that uses ammonia as fuel and

that can facilitate starting of a gas turbine.

Solution to Problem

[0006] A gas turbine system according to an aspect of
5 the present disclosure includes an ammonia supply source, a
gas turbine including a combustor that is connected to the
ammonia supply source and that combusts ammonia from the
ammonia supply source, a water electrolyzer that is operated
by electricity generated by an output of the gas turbine and
10 that decomposes water into hydrogen and oxygen, a hydrogen
tank that stores hydrogen generated by the water electrolyzer
and that is fluidly connected to the combustor, and a
controller that controls supply of hydrogen from the hydrogen
tank to the combustor, wherein the controller starts
15 supplying hydrogen to the combustor when the gas turbine is
started.

[0007] The gas turbine system may include a cracker that
is connected to the ammonia supply source and the gas
turbine, the cracker decomposing ammonia from the ammonia
20 supply source to hydrogen and nitrogen and sending gas
including the generated hydrogen to the gas turbine, and an
oxygen tank that stores oxygen generated by the water
electrolyzer and that is fluidly connected to the cracker,
wherein the controller may control supply of oxygen from the
25 oxygen tank to the cracker and may start supplying oxygen to
the cracker when the gas turbine is started.

[0008] A gas turbine system according to another aspect

of the present disclosure includes an ammonia supply source,
a cracker that is connected to the ammonia supply source and
that decomposes ammonia into hydrogen and nitrogen, a gas
turbine including a combustor that is connected to the
5 ammonia supply source and the cracker and that combusts
ammonia from the ammonia supply source and gas including
hydrogen from the cracker, a water electrolyzer that is
operated by electricity generated by an output of the gas
turbine and that decomposes water into hydrogen and oxygen,
10 an oxygen tank that stores oxygen generated by the water
electrolyzer and that is fluidly connected to the cracker,
and a controller that controls supply of oxygen from the
oxygen tank to the cracker, wherein the controller starts
supplying oxygen to the cracker when the gas turbine is
15 started.

[0009] The gas turbine system may include a hydrogen
tank that stores hydrogen generated by the water electrolyzer
and that is fluidly connected to the combustor, wherein the
controller may control supply of hydrogen from the hydrogen
20 tank to the combustor, and may start supplying hydrogen to
the combustor when the gas turbine is started.

Advantageous Effects of Invention

[0010] According to the present disclosure, starting of
25 a gas turbine can be facilitated in a gas turbine system that
uses ammonia as fuel.

Brief Description of Drawings

[0011] Fig. 1 is a schematic diagram of a gas turbine system according to a first embodiment.

Fig. 2 is a schematic diagram of a gas turbine system according to a second embodiment.

Fig. 3 is a schematic diagram of a gas turbine system according to a third embodiment.

Description of Embodiments

[0012] Embodiments of the present disclosure will be described in detail below with reference to the accompanying drawings. Specific dimensions, materials, and numerical values described in the embodiments are merely examples for a better understanding, and do not limit the present disclosure unless otherwise specified. In this specification and the drawings, duplicate explanations are omitted for elements having substantially the same functions and configurations by assigning the same sign. Furthermore, elements not directly related to the present disclosure are omitted from the figures.

[0013] Fig. 1 is a schematic diagram of a gas turbine system 100 according to a first embodiment. In the present disclosure, the gas turbine system 100 may also be referred to simply as "system 100." For example, the system 100 includes an ammonia tank (ammonia supply source) 1, a pressurizer 2, a cracker 3, a gas turbine 4, a generator 5, a water electrolyzer 6, a hydrogen tank 7, an oxygen tank 8,

and a controller 90. The system 100 may further include other components. Furthermore, the system 100 may not include one or more of the above components.

[0014] The ammonia tank 1 stores ammonia. Specifically,
5 the ammonia tank 1 stores liquid ammonia. The ammonia tank 1 is connected to the pressurizer 2 by piping P1. Liquid ammonia stored in the ammonia tank 1 is supplied to the pressurizer 2 via the piping P1. In another embodiment, for example, an ammonia production device may be used as an
10 ammonia supply source, instead of the ammonia tank 1.

[0015] The pressurizer 2 pressurizes ammonia from the ammonia tank 1. The pressurizer 2 is communicatively connected to the controller 90 by wire or wirelessly, and controlled by the controller 90. Piping P2 is connected to
15 the pressurizer 2. Pressurized ammonia flows out of the pressurizer 2 to the piping P2.

[0016] In the present embodiment, ammonia is supplied in a liquid state to the cracker 3 and the gas turbine 4. In this case, for example, the pressurizer 2 may be a pump. In
20 another embodiment, for example, the system 100 may include a vaporizer in at least one of the piping P1, the piping P2 and piping 21, and ammonia may be supplied in a gaseous state to the cracker 3 and the gas turbine 4. When the pressurizer 2 pressurizes gaseous ammonia, for example, the pressurizer 2
25 may be a compressor.

[0017] A valve V1 is provided in the piping P2. The valve V1 is communicatively connected to the controller 90 by

wire or wirelessly, and controlled by the controller 90. For example, the controller 90 adjusts a flow rate of ammonia flowing through the piping P2 by controlling a degree of opening of the valve V1 based on power demand and an amount of electricity generated in the generator 5. The piping P2 is branched into piping P21 and piping P22. The piping P21 is connected to the cracker 3, and the piping P22 is connected to the gas turbine 4.

[0018] At least a part of the pressurized ammonia is supplied to the gas turbine 4 via the piping P22.

[0019] The rest of pressurized ammonia is supplied to the cracker 3 via the piping P21. A valve V2 is provided in the piping P21. The valve V2 is communicatively connected to the controller 90 by wire or wirelessly, and controlled by the controller 90. For example, the controller 90 adjusts a flow rate of ammonia supplied to the cracker 3 by controlling a degree of opening of the valve V2.

[0020] The cracker 3 decomposes ammonia into hydrogen and nitrogen. The cracker 3 includes a catalyst that decomposes ammonia into hydrogen and nitrogen. Such a catalyst includes, for example, at least one of Ru, Rh, Pt, and Pd. The cracker 3 is connected to the gas turbine 4 by piping P23. Gas including hydrogen and nitrogen (which may also be referred to as "hydrogen-rich gas" in the present disclosure) is supplied from the cracker 3 to the gas turbine 4 via the piping P23.

[0021] The gas turbine 4 includes a compressor 41, a

combustor 42, and a turbine 43. The gas turbine 4 may further include other components. The compressor 41 pressurizes air, and sends the pressurized air to the combustor 42.

5 [0022] The combustor 42 receives the pressurized air from the compressor 41. Furthermore, the combustor 42 is fluidly connected to the ammonia tank 1 via the above-described piping P1, P2, and P22. The combustor 42 receives ammonia from the ammonia tank 1. Additionally, the combustor
10 42 is fluidly connected to the cracker 3 via the above-described piping P23. The combustor 42 receives the hydrogen-rich gas from the cracker 3. In the present embodiment, the combustor 42 combusts ammonia and the hydrogen-rich gas. The combustor 42 may combust other fuels
15 depending on situations.

[0023] Exhaust gas generated by the combustion is supplied from the combustor 42 to the turbine 43. The turbine 43 is rotated by the exhaust gas. The exhaust gas is supplied to other facilities located downstream of the
20 turbine 43, such as a heat recovery steam generator and a denitrification device (not shown). In the present embodiment, rotational power of the turbine 43 is used to operate the generator 5. In another embodiment, the rotational power of the turbine 43 may be used in another
25 equipment. Electricity generated by the generator 5 is supplied to other devices in the system 100 (not shown), or to an outside. Furthermore, a part of the electricity

generated by the generator 5 is supplied to the water electrolyzer 6.

[0024] In general, the combustion rate of ammonia is slow. Accordingly, when only ammonia is combusted in the combustor 42, the combustion is likely to be unstable.

However, in the present embodiment, a part of ammonia from the ammonia tank 1 is decomposed into hydrogen and nitrogen in the cracker 3, and supplied to the combustor 42. Since the combustion rate of hydrogen is faster, the combustion in the combustor 42 is stabilized, and an amount of ammonia that can be combusted also increases. Accordingly, ammonia remaining in the exhaust gas from the combustor 42 due to various factors (e.g., unreacted ammonia in the cracker 3 and unburned ammonia in the combustor 42) is reduced. As a result, for example, the operating cost of the denitrification device is reduced.

[0025] Furthermore, as mentioned above, a part of ammonia from the ammonia tank 1 is decomposed into hydrogen and nitrogen in the cracker 3, and supplied to the combustor 42, in the present embodiment. In this case, nitrogen atoms N combine to form nitrogen molecules N_2 in an environment in the section from the cracker 3 to the combustor 42 where there are no or few oxygen atoms O. Nitrogen molecule N_2 is stable and is less likely to combine with oxygen atom O, compared to nitrogen atom N. Accordingly, the formation of NO_x , especially the formation of fuel NO_x , is curbed.

[0026] The water electrolyzer 6 decomposes water into

hydrogen and oxygen by electrolysis. The water electrolyzer 6 includes an electrolysis tank including a cathode and an anode. The water electrolyzer 6 receives water (e.g., alkaline pure water) from piping P3. Water can be supplied from various supply sources (not shown), such as, for example, a feed water line of a steam turbine. The water electrolyzer 6 receives electricity from the generator 5, and applies a voltage between the cathode and the anode placed in the water. Hydrogen is generated at the cathode and oxygen is generated at the anode.

[0027] The water electrolyzer 6 is connected to the hydrogen tank 7 by piping P4. Furthermore, the water electrolyzer 6 is connected to the oxygen tank 8 by piping P5. Hydrogen is sent to the hydrogen tank 7 by the piping P4, and oxygen is sent to the oxygen tank 8 by the piping P5.

[0028] The hydrogen tank 7 stores hydrogen generated by the water electrolyzer 6. The hydrogen tank 7 is fluidly connected to the combustor 42. Specifically, in the present embodiment, the hydrogen tank 7 is connected to the piping P22 by piping P6, and connected to the combustor 42 via the piping P6 and P22.

[0029] The hydrogen tank 7 supplies hydrogen to the combustor 42. Specifically, for example, a valve V3 is provided in the piping P6. The valve V3 is communicatively connected to the controller 90 by wire or wirelessly, and controlled by the controller 90. The controller 90 adjusts a flow rate of hydrogen supplied from the hydrogen tank 7 to

the combustor 42 by controlling a degree of opening of the valve V3.

[0030] The oxygen tank 8 stores oxygen generated by the water electrolyzer 6. The oxygen tank 8 is fluidly connected to the cracker 3. Specifically, in the present embodiment, the oxygen tank 8 is connected to the cracker 3 by piping P7.

[0031] The oxygen tank 8 supplies oxygen to the cracker 3. Specifically, for example, a valve V4 is provided in the piping P7. The valve V4 is communicatively connected to the controller 90 by wire or wirelessly, and controlled by the controller 90. The controller 90 adjusts a flow rate of oxygen supplied to the cracker 3 by controlling a degree of opening of the valve V4.

[0032] The controller 90 controls the system 100 in whole or in part. For example, the controller 90 may include one or more PCs. For example, the controller 90 includes components such as a processor 90a, a memory 90b, and a connector 90c, and these components are connected to each other via buses. For example, the processor 90a includes a CPU (Central Processing Unit) or the like. For example, the memory 90b includes a hard disk, a ROM in which programs and the like are stored, and a RAM as a work area. The controller 90 is communicatively connected to each component of the system 100 by wire or wirelessly via the connector 90c. For example, the controller 90 may further include other components, such as a display such as an LCD display or a touch panel, and an input device such as a keyboard, a

button or a touch panel, etc. For example, the following operations of the controller 90 may be realized by executing programs stored in the memory 90b on the processor 90a.

[0033] Next, operations of the system 100 will be
5 described.

[0034] At some point during the operation of the gas turbine 4, the water electrolyzer 6 decomposes water into hydrogen and oxygen with electricity generated by the generator 5, i.e., electricity generated by the output of the
10 gas turbine 4. Hydrogen is stored in the hydrogen tank 7, and oxygen is stored in the oxygen tank 8. For example, the water electrolyzer 6 may stop the operation when both of or at least one of the hydrogen tank 7 and the oxygen tank 8 is filled with gas.

15 [0035] When the controller 90 receives a command to restart the gas turbine 4 after the gas turbine 4 stops the operation, the processor 90a opens the valve V1 and the valve V2 and starts the pressurizer 2, and controls the pressurizer 2 to supply ammonia from the ammonia tank 1 to the combustor
20 42 and the cracker 3.

[0036] Furthermore, the processor 90a opens the valve V3 to supply hydrogen from the hydrogen tank 7 to the piping P22. In the piping P22, ammonia from the ammonia tank 1 and hydrogen from the hydrogen tank 7 are mixed. Accordingly, a
25 mixture of ammonia and hydrogen is supplied to the combustor 42. After the gas turbine 4 stops the operation, pressure in the combustor 42 and the piping P22 drops to atmospheric

pressure. Accordingly, for example, hydrogen may be automatically supplied from the hydrogen tank 7 to the piping P22 by a pressure difference between pressure in the hydrogen tank 7 and pressure in the piping P22.

5 [0037] The combustor 42 receives the mixture of ammonia and hydrogen from the piping P22 as described above.

Accordingly, when the gas turbine 4 is started, the mixture of ammonia and hydrogen is combusted in the combustor 42.

Hydrogen is easy to combust compared to ammonia.

10 Accordingly, the combustion in the combustor 42 is accelerated, compared to a case in which only ammonia is used as fuel.

[0038] Furthermore, the processor 90a opens the valve V4 to supply oxygen from the oxygen tank 8 to the cracker 3.

15 For example, when the gas turbine 4 stops the operation, the cracker 3 also stops the operation. Furthermore, when these are stopped, the valve V4 is closed, so oxygen does not flow. Accordingly, pressure in the cracker 3 also drops to atmospheric pressure after the gas turbine 4 stops the

20 operation. As such, for example, oxygen may be automatically supplied from the oxygen tank 8 to the cracker 3 by a pressure difference between pressure in the oxygen tank 8 and pressure in the cracker 3.

[0039] The cracker 3 receives ammonia from the ammonia
25 tank 1 and oxygen from the oxygen tank 8 as described above. Cracking of ammonia to nitrogen and hydrogen is an endothermic reaction, and therefore the cracker 3 requires

energy. However, in the present embodiment, the cracker 3 receives oxygen from the oxygen tank 8. Accordingly, both ammonia and oxygen are present in the cracker 3 when the gas turbine 4 is started. The catalyst in the cracker 3 is oxidized by oxygen from the oxygen tank 8 and heated. As such, the cracker 3 can obtain energy required for cracking by self-heating of the catalyst, without receiving energy from an outside. The generated hydrogen-rich gas including nitrogen and hydrogen is supplied from the cracker 3 to the combustor 42. Accordingly, the combustor 42 also receives hydrogen from the cracker 3. As such, the combustion in the combustor 42 is further accelerated.

[0040] As an amount of hydrogen in the hydrogen tank 7 decreases, the pressure in the hydrogen tank 7 decreases. Furthermore, as the starting (sequence) of the gas turbine 4 proceeds, the pressure in the combustor 42 and the piping P22 increases. Accordingly, the pressure difference between the pressure in the hydrogen tank 7 and the pressure in the piping P22 decreases. As such, for example, the supply of hydrogen may automatically stop when the pressure difference sufficiently decreases. Alternatively or additionally, for example, when the gas turbine 4 reaches its rated speed, the processor 90a may close the valve V3 to stop supplying hydrogen from the hydrogen tank 7 to the piping P22.

[0041] Similarly, as an amount of oxygen in the oxygen tank 8 decreases, the pressure in the oxygen tank 8 decreases. Furthermore, as cracking proceeds, the pressure

in the cracker 3 increases. Accordingly, the pressure difference between the pressure in the oxygen tank 8 and the pressure in the cracker 3 decreases. As such, for example, the supply of oxygen may automatically stop when the pressure difference sufficiently decreases. Alternatively or additionally, for example, when the gas turbine 4 reaches its rated speed, the processor 90a may close the valve V4 to stop supplying oxygen from the oxygen tank 8 to the cracker 3.

[0042] The system 100 as described above includes the ammonia tank 1, the gas turbine 4 including the combustor 42 that is connected to the ammonia tank 1 and that combusts ammonia from the ammonia tank 1, the water electrolyzer 6 that is operated by electricity generated by the output of the gas turbine 4 and that decomposes water into hydrogen and oxygen, the hydrogen tank 7 that stores hydrogen generated by the water electrolyzer 6 and that is fluidly connected to the combustor 42, and the controller 90 that controls the supply of hydrogen from the hydrogen tank 7 to the combustor 42, wherein the controller 90 starts supplying hydrogen to the combustor 42 when the gas turbine 4 is started. According to such a configuration, when the gas turbine 4 is started, the mixture of ammonia and hydrogen is combusted in the combustor 42. Hydrogen is easy to combust compared to ammonia. As such, the combustion in the combustor 42 can be accelerated, compared to a case in which only ammonia is used as fuel. Thus, starting of the gas turbine 4 can be facilitated.

[0043] Furthermore, the system 100 includes the cracker

3 that is connected to the ammonia tank 1 and the gas turbine 4, the cracker 3 decomposing ammonia from the ammonia tank 1 into hydrogen and nitrogen and sending the generated hydrogen-rich gas to the gas turbine 4, and the oxygen tank 8 that stores oxygen generated by the water electrolyzer 6 and that is fluidly connected to the cracker 3, wherein the controller 90 controls the supply of oxygen from the oxygen tank 8 to the cracker 3, and starts supplying oxygen to the cracker 3 when the gas turbine 4 is started. According to such a configuration, both ammonia and oxygen are present in the cracker 3 when the gas turbine 4 is started. The catalyst in the cracker 3 is oxidized by oxygen from the oxygen tank 8 and heated. Accordingly, the cracker 3 can obtain energy required for cracking by self-heating of the catalyst, without receiving energy from an outside. The generated hydrogen-rich gas is supplied from the cracker 3 to the combustor 42. Accordingly, the combustor 42 also receives hydrogen from the cracker 3. As such, the starting of the gas turbine 4 can be further facilitated.

[0044] In another aspect, the system 100 includes the ammonia tank 1, the cracker 3 that is connected to the ammonia tank 1 and that decomposes ammonia into hydrogen and nitrogen, the gas turbine 4 including the combustor 42 that is connected to the ammonia tank 1 and the cracker 3 and that combusts ammonia from the ammonia tank 1 and the gas including hydrogen from the cracker 3, the water electrolyzer 6 that is operated by electricity generated by the output of

the gas turbine 4 and that decomposes water into hydrogen and oxygen, the oxygen tank 8 that stores oxygen generated by the water electrolyzer 6 and that is fluidly connected to the cracker 3, and the controller 90 that controls the supply of oxygen from the oxygen tank 8 to the cracker 3, wherein the controller 90 starts supplying oxygen to the cracker 3 when the gas turbine 4 is started. According to such a configuration, both ammonia and oxygen are present in the cracker 3 when the gas turbine 4 is started. The catalyst in the cracker 3 is oxidized by oxygen from the oxygen tank 8 and heated. Accordingly, the cracker 3 can obtain energy required for cracking by self-heating of the catalyst, without receiving energy from an outside. The generated hydrogen-rich gas is supplied from the cracker 3 to the combustor 42. Accordingly, when the gas turbine 4 is started, the mixture of ammonia and hydrogen is combusted in the combustor 42. Hydrogen is easy to combust compared to ammonia. Accordingly, the combustion in the combustor 42 can be accelerated, compared to a case in which only ammonia is used as fuel. As such, the starting of the gas turbine 4 can be facilitated.

[0045] Furthermore, the system 100 includes the hydrogen tank 7 that stores hydrogen generated by the water electrolyzer 6 and that is fluidly connected to the combustor 42, wherein the controller 90 controls the supply of hydrogen from the hydrogen tank 7 to the combustor 42, and starts supplying hydrogen to the combustor 42 when the gas turbine 4

is started. According to such a configuration, when the gas turbine 4 is started, the combustor 42 also receives hydrogen from the hydrogen tank 7. As such, the starting of the gas turbine 4 can be further facilitated.

5 [0046] Next, a gas turbine system according to another embodiment will be described.

[0047] Fig. 2 is a schematic diagram of a gas turbine system 200 according to a second embodiment. The system 200 differs from the system 100 of the first embodiment in that,
10 in the oxygen tank 8, oxygen is mixed with ambient air and stored. In other configurations, the system 200 may be the same as the system 100.

[0048] Specifically, the oxygen tank 8 is provided with piping P8 for drawing ambient air into the oxygen tank 8.
15 The piping P8 is provided with a valve V5 and a compressor 9. The valve V5 and the compressor 9 are communicatively connected to the controller 90 by wire or wirelessly, and controlled by the controller 90.

[0049] Furthermore, the oxygen tank 8 is provided with a
20 sensor Se. The sensor Se detects a concentration of oxygen in the gas in the oxygen tank 8. The sensor Se can be, for example, an oxygen analyzer. The sensor Se is communicatively connected to the controller 90 by wire or wirelessly, and transmits detection data to the controller
25 90.

[0050] For example, the controller 90 controls a degree of opening of the valve V5 and an output of the compressor 9

to adjust an amount of air drawn into the oxygen tank 8 so that the concentration of oxygen detected by the sensor Se is within a predetermined range. For example, a lower limit of the predetermined range can be determined so that the gas in the oxygen tank 8 sufficiently facilitates heat generation in the cracker 3, and is higher than 21% which is the concentration of oxygen in a typical environment.

Furthermore, oxygen is a gas that highly supports combustion. Accordingly, for example, an upper limit of the predetermined range can be determined so as to prevent ignition in the oxygen tank 8. For example, the predetermined range may be stored in the memory 90b.

[0051] Such system 200 of the second embodiment has similar effects to those of the system 100. Furthermore, the system 200 includes the sensor Se that detects the concentration of the oxygen in the gas in the oxygen tank 8, and the compressor 9 and the valve V5 that draw ambient air into the oxygen tank 8. According to such a configuration, the concentration of oxygen in the gas in the oxygen tank 8 can be maintained within a range that sufficiently facilitates heat generation in the cracker 3 and that prevents ignition in the oxygen tank 8.

[0052] Next, a gas turbine system according to yet another embodiment will be described.

[0053] Fig. 3 is a schematic diagram of a gas turbine system 300 according to a third embodiment. The system 300 differs from the system 100 of the first embodiment in that

the piping P6 from the hydrogen tank 7 is directly connected to the combustor 42. In other configurations, the system 300 may be the same as the system 100.

[0054] For example, the piping P6 may supply hydrogen to a vicinity of an igniter (not shown) in the combustor 42. According to such a configuration, a flame can be quickly formed in the combustor 42 when the gas turbine 4 is started. Such system 300 of the third embodiment has similar effects to those of the system 100.

10 [0055] Although the embodiments of the present disclosure have been described above with reference to the accompanying drawings, the present disclosure is not limited thereto. It is obvious that a person skilled in the art can conceive of various examples of variations or modifications within the scope of the claims, which are also understood to belong to the technical scope of the present disclosure.

[0056] For example, in the above embodiments, the systems 100, 200 and 300 have both the hydrogen tank 7 and the oxygen tank 8, and both hydrogen and oxygen generated by the water electrolyzer 6 are used to start the gas turbine 4. In another embodiment, the system may use only one of hydrogen and oxygen generated by the water electrolyzer 6 to start the gas turbine 4. For example, in another embodiment, the system may not include the oxygen tank 8, and oxygen generated by the water electrolyzer 6 may not be used to start the gas turbine 4. In this case, the system may include or may not include the cracker 3. In still another

embodiment, for example, the system may not include the hydrogen tank 7, and hydrogen generated by the water electrolyzer 6 may not be used to start the gas turbine 4.

[0057] Furthermore, in the system 300 of the third embodiment, the piping P6 from the hydrogen tank 7 is directly connected to the combustor 42. In another embodiment, for example, the piping P6 may be connected to the piping P23 that connects the cracker 3 and the combustor 42.

10 [0058] The present disclosure can promote the use of ammonia to reduce CO₂ emissions, thus contributing to Sustainable Development Goals (SDGs), Goal 7 "Ensure access to affordable, reliable, sustainable and modern energy," and Goal 13 "Take urgent action to combat climate change and its
15 impacts," for example.

Reference Signs List

[0059] 1: ammonia tank (ammonia supply source)
3: cracker
20 4: gas turbine
6: water electrolyzer
7: hydrogen tank
8: oxygen tank
42: combustor
25 90: controller
100: gas turbine system
200: gas turbine system

300: gas turbine system

Claims

[Claim 1] A gas turbine system comprising:

an ammonia supply source;

5 a gas turbine including a combustor that is connected to the ammonia supply source and that combusts ammonia from the ammonia supply source;

a water electrolyzer that is operated by electricity generated by an output of the gas turbine and that decomposes
10 water into hydrogen and oxygen;

a hydrogen tank that stores hydrogen generated by the water electrolyzer and that is fluidly connected to the combustor; and

a controller that controls supply of hydrogen from the
15 hydrogen tank to the combustor, wherein the controller starts supplying hydrogen to the combustor when the gas turbine is started.

[Claim 2] The gas turbine system according to claim 1,
20 comprising:

a cracker that is connected to the ammonia supply source and the gas turbine, the cracker decomposing ammonia from the ammonia supply source into hydrogen and nitrogen and sending gas that includes the generated hydrogen to the gas
25 turbine; and

an oxygen tank that stores oxygen generated by the water electrolyzer and that is fluidly connected to the

cracker,

wherein the controller controls supply of oxygen from the oxygen tank to the cracker, and starts supplying oxygen to the cracker when the gas turbine is started.

5

[Claim 3] A gas turbine system comprising:

an ammonia supply source;

a cracker that is connected to the ammonia supply source and that decomposes ammonia into hydrogen and

10 nitrogen;

a gas turbine including a combustor that is connected to the ammonia supply source and the cracker and that combusts ammonia from the ammonia supply source and gas including hydrogen from the cracker;

15 a water electrolyzer that is operated by electricity generated by an output of the gas turbine and that decomposes water into hydrogen and oxygen;

an oxygen tank that stores oxygen generated by the water electrolyzer and that is fluidly connected to the

20 cracker; and

a controller that controls supply of oxygen from the oxygen tank to the cracker, wherein the controller starts supplying oxygen to the cracker when the gas turbine is started.

25

[Claim 4] The gas turbine system according to claim 3, comprising:

a hydrogen tank that stores hydrogen generated by the water electrolyzer and that is fluidly connected to the combustor,

wherein the controller controls supply of hydrogen from
5 the hydrogen tank to the combustor, and starts supplying hydrogen to the combustor when the gas turbine is started.