

Description

Title: GAS TURBINE SYSTEM

Technical Field

5 [0001] The present disclosure relates to a gas turbine system. This application claims the benefit of priority to Japanese Patent Application No. 2022-041292 filed on March 16, 2022, and contents thereof are incorporated herein.

10 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 ammonia as fuel, as disclosed in Patent Literature 1.

15 Emission of carbon dioxide is suppressed by using ammonia as fuel.

Citation List

Patent Literature

20 [0003] Patent Literature 1: JP 2016-191507 A

Summary

Technical Problem

[0004] As the gas turbine system, there exists a system

25 that generates steam in a boiler by using heat of an exhaust gas discharged from a combustor and drives a steam turbine with the steam. The steam that has passed through the steam

turbine is liquefied in a condenser through heat exchange with a heat medium such as seawater. It is required that a temperature of the heat medium such as seawater, which is discharged after the heat exchange with the steam, be
5 prevented from becoming excessively high so as not to adversely affect an ecosystem. Thus, it is required that a large amount of heat medium such as seawater be sucked by a pump and supplied to the condenser. Along with an increase in the amount of sucked heat medium such as seawater,
10 required power also increases, which may result in lower efficiency of the gas turbine system.

[0005] An object of the present disclosure is to provide a gas turbine system with improved efficiency.
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Solution to Problem

[0006] In order to solve the above-mentioned problem, according to the present disclosure, there is provided a gas turbine system including: an ammonia tank configured to store
20 ammonia; a combustor connected to the ammonia tank; an exhaust flow passage connected to the combustor; a boiler provided in the exhaust flow passage; a steam turbine connected to the boiler; a condenser connected to the steam turbine; a heat-medium flow passage passing through the
25 condenser; and a heat exchanger, which is arranged on an upstream side of the condenser in the heat-medium flow passage, on a downstream side of the condenser in the heat-

medium flow passage, or in a flow passage that connects the steam turbine, the condenser, and the boiler, the heat exchanger through which an ammonia flow passage that connects the ammonia tank and the combustor to each other passes.

5 [0007] The ammonia may be stored in a liquid state in the ammonia tank, and the ammonia may be supplied in a liquid state to the combustor.

[0008] The heat exchanger may include: a first heat exchanger arranged on an upstream side of the condenser in
10 the heat-medium flow passage; and a second heat exchanger arranged on a downstream side of the condenser in the heat-medium flow passage, and the ammonia flow passage may be provided with a switching mechanism configured to switch a path for the ammonia between a plurality of paths in which
15 the ammonia passes through a different one or ones of the heat exchangers.

[0009] The switching mechanism may switch the path for the ammonia based on at least one of a state of the ammonia in the ammonia flow passage or a state of a heat medium in
20 the heat-medium flow passage.

Effects of Disclosure

[0010] According to the present disclosure, efficiency
25 of a gas turbine system can be improved.

Brief Description of Drawings

[0011] FIG. 1 is a schematic view for illustrating a

configuration of a gas turbine system according to an embodiment of the present disclosure.

FIG. 2 is a schematic view for illustrating a configuration of a gas turbine system according to a first
5 modification example.

FIG. 3 is a schematic view for illustrating a configuration of a gas turbine system according to a second modification example.

FIG. 4 is a schematic view for illustrating a
10 configuration of a gas turbine system according to a third modification example.

FIG. 5 is a schematic view for illustrating a configuration of a gas turbine system according to a fourth modification example.

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Description of Embodiments

[0012] Now, with reference to the attached drawings, an embodiment of the present disclosure is described. The dimensions, materials, and other specific numerical values
20 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
25 same reference symbols to omit redundant description thereof. Further, illustration of elements with no direct relationship to the present disclosure is omitted.

[0013] FIG. 1 is a schematic view for illustrating a configuration of a gas turbine system 1 according to this embodiment. As illustrated in FIG. 1, the gas turbine system 1 includes a compressor 11a, a turbine 11b, a combustor 12, an ammonia tank 13, a boiler 14, an exhaust stack 15, a steam turbine 16, a condenser 17, a pump 18, a pump 19, a heat exchanger 20, a pump 21, and a flow rate control valve 22.

[0014] The compressor 11a and the turbine 11b rotate integrally. The compressor 11a and the turbine 11b are coupled to each other through intermediation of a shaft.

[0015] The compressor 11a is provided in an intake flow passage 101 connected to the combustor 12. Air to be supplied to the combustor 12 flows through the intake flow passage 101. An intake port (not shown) is formed at an upstream-side end portion of the intake flow passage 101. 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 12. The compressor 11a compresses the air and discharges the compressed air to a downstream side.

[0016] The turbine 11b is provided in an exhaust flow passage 102 connected to the combustor 12. An exhaust gas discharged from the combustor 12 flows through the exhaust flow passage 102. The exhaust gas discharged from the combustor 12 passes through the turbine 11b and is sent to a downstream side of the exhaust flow passage 102 from the turbine 11b. When the turbine 11b is rotated by the exhaust

gas, rotational power is generated.

[0017] A power generator (not shown) is connected to the compressor 11a. The rotational power that has been transmitted from the turbine 11b to the compressor 11a is used by the power generator for power generation.

[0018] The air, which has been compressed by the compressor 11a, is supplied to the combustor 12 through the intake flow passage 101, while ammonia is supplied in a liquid state as fuel from the ammonia tank 13 to the

combustor 12. However, ammonia may be supplied in a gaseous state to the combustor 12 as described later. Combustion is performed in the combustor 12 with use of ammonia as fuel.

The exhaust gas generated in the combustor 12 is discharged to the exhaust flow passage 102.

[0019] Ammonia is stored in a liquid state in the ammonia tank 13. In the ammonia tank 13, ammonia is maintained in a liquid state at, for example, an atmospheric pressure and -33°C . The storage of ammonia in a low-temperature liquid state in the ammonia tank 13 suppresses an increase in vapor pressure in the ammonia tank 13. Thus, the occurrence of problems in tank strength and in structure is suppressed.

[0020] The ammonia tank 13 is connected to the combustor 12 through intermediation of an ammonia flow passage 103.

Ammonia flows through the ammonia flow passage 103. Ammonia is supplied from the ammonia tank 13 to the combustor 12 through the ammonia flow passage 103. Details of the ammonia

flow passage 103 are described later.

[0021] The boiler 14 is provided on a downstream side of the turbine 11b in the exhaust flow passage 102. The boiler 14 includes a flow passage 104 through which water flows.

5 The water flowing through the flow passage 104 is heated with the exhaust gas flowing through the exhaust flow passage 102 and is thereby vaporized into gas (that is, steam). The steam generated in the boiler 14 is used for power generation as described later. The exhaust flow passage 102 is
10 connected to the exhaust stack 15 at a position on a downstream side of the boiler 14. The exhaust gas discharged from the combustor 12 passes through the turbine 11b and the boiler 14, is sent to the exhaust stack 15, and is then discharged from the exhaust stack 15.

15 [0022] The boiler 14 is connected to the steam turbine 16. Specifically, an outlet of the flow passage 104 of the boiler 14 is connected to an inlet of the steam turbine 16 through intermediation of a flow passage 105. The steam generated in the boiler 14 is sent to the steam turbine 16
20 through the flow passage 105. Then, the steam turbine 16 is rotated with the steam to thereby generate rotational power. The rotational power generated by the steam turbine 16 is used for power generation.

[0023] The steam turbine 16 is connected to the
25 condenser 17. Specifically, an outlet of the steam turbine 16 is connected to an inlet of the flow passage 104 of the boiler 14 through intermediation of a flow passage 106. The

condenser 17 is arranged in the flow passage 106. A seawater flow passage 107 passes through the condenser 17. Seawater flows through the seawater flow passage 107. The seawater flow passage 107 corresponds to one example of a heat-medium flow passage through which a heat medium flows. That is, the seawater corresponds to one example of the heat medium flowing through the heat-medium flow passage. Examples of the heat medium include, besides seawater, river water, groundwater, and air.

[0024] In the condenser 17, the steam flowing through the flow passage 106 and the seawater flowing through the seawater flow passage 107 exchange heat. A temperature of the steam flowing through the flow passage 106 is higher than a temperature of the seawater flowing through the seawater flow passage 107. Thus, in the condenser 17, the steam flowing through the flow passage 106 is cooled with the seawater flowing through the seawater flow passage 107 and is thereby liquified into water. Details of the seawater flow passage 107 are described later.

[0025] The pump 18 is provided on a downstream side of the condenser 17 in the flow passage 106. The pump 18 pressurizes the water generated in the condenser 17 and feeds the water to a downstream side. The water fed by the pump 18 is sent to the flow passage 104 of the boiler 14.

[0026] The seawater sucked from the sea flows through the seawater flow passage 107. The seawater that has passed through the seawater flow passage 107 is discharged back into

the sea. The pump 19 is provided on an upstream side of the condenser 17 in the seawater flow passage 107. The pump 19 pressurizes seawater and feeds the seawater to a downstream side. In this manner, seawater is sucked from the sea into
5 the seawater flow passage 107.

[0027] The heat exchanger 20 is arranged between the pump 19 and the condenser 17 in the seawater flow passage 107. The ammonia flow passage 103 passes through the heat exchanger 20. The pump 21 is provided between the heat
10 exchanger 20 and the ammonia tank 13 in the ammonia flow passage 103. The pump 21 pressurizes the ammonia supplied from the ammonia tank 13 and feeds the pressurized ammonia to the downstream side. The ammonia fed by the pump 21 is sent to the heat exchanger 20.

15 [0028] In the heat exchanger 20, the seawater flowing through the seawater flow passage 107 and the ammonia flowing through the ammonia flow passage 103 exchange heat. A temperature of the seawater flowing through the seawater flow passage 107 is higher than a temperature of the ammonia
20 flowing through the ammonia flow passage 103. Thus, in the heat exchanger 20, the seawater flowing through the seawater flow passage 107 is cooled with the ammonia flowing through the ammonia flow passage 103. Meanwhile, the ammonia flowing through the ammonia flow passage 103 is heated with the
25 seawater flowing through the seawater flow passage 107. The ammonia is heated in the heat exchanger 20 to such a degree that the ammonia is not vaporized. Thus, the ammonia is

supplied in a liquid state to the combustor 12.

[0029] The flow rate control valve 22 is provided between the heat exchanger 20 and the combustor 12 in the ammonia flow passage 103. The flow rate control valve 22
5 adjusts a flow rate of liquid ammonia that is to be sent to the combustor 12 through the ammonia flow passage 103. Specifically, an opening degree of the flow rate control valve 22 is adjusted to thereby adjust the amount of supply of ammonia to the combustor 12.

10 [0030] As described above, in the gas turbine system 1, the heat exchanger 20 is arranged on the upstream side of the condenser 17 in the seawater flow passage 107. The ammonia flow passage 103 that connects the ammonia tank 13 and the combustor 12 to each other passes through the heat exchanger
15 20. With this arrangement, the seawater flowing through the seawater flow passage 107 can be cooled with use of the ammonia flowing through the ammonia flow passage 103 in the heat exchanger 20. Thus, the seawater and the steam in the condenser 17 can have a large difference in temperature.

20 Hence, even when a suction amount of seawater is reduced, a cooling effect of seawater for steam can be maintained. Accordingly, power of the pump 19 can be reduced, and thus efficiency of the gas turbine system 1 can be improved.

[0031] Further, in the gas turbine system 1, the ammonia
25 to be supplied to the combustor 12 can be heated in the heat exchanger 20 with use of the seawater flowing through the seawater flow passage 107. Thus, the heat of the seawater

can be used as a part of energy that is required to combust ammonia. With this configuration, efficiency of the gas turbine system 1 can also be improved.

[0032] In particular, in the gas turbine system 1,

5 ammonia is heated in the heat exchanger 20 to such a degree that ammonia is not vaporized. That is, the heat of the seawater is used as sensible heat of ammonia in the heat exchanger 20. Thus, the ammonia that is stored in a liquid state in the ammonia tank 13 is supplied in a liquid state to
10 the combustor 12 without being vaporized in the ammonia flow passage 103. In a case in which the ammonia is vaporized in the ammonia flow passage 103, an additional facility and complicated control are required in order to suppress a fluctuation in pressure of the vaporized ammonia and prevent
15 recondensation. Further, a pipe through which gaseous ammonia is to flow is required to be increased in size. Meanwhile, in the gas turbine system 1, ammonia is not vaporized in the ammonia flow passage 103. Thus, the above-mentioned problems do not occur in the gas turbine system 1.

20 [0033] More specifically, in view of effective improvement of the efficiency of the gas turbine system 1, it is preferred that the pump 21 that pressurizes ammonia be provided between the heat exchanger 20 and the ammonia tank 13 in the ammonia flow passage 103, as in the example
25 described above. With the pump 21 provided as described above, the ammonia stored in the ammonia tank 13 is pressurized by the pump 21 and is then sent to the heat

exchanger 20. Thus, sensible heat that is required to vaporize the ammonia passing through the heat exchanger 20 increases. Hence, a quantity of heat that can be recovered from the seawater (that is, a quantity of heat that can be recovered as sensible heat) without vaporizing the ammonia passing through the heat exchanger 20 is increased. Hence, a proportion of energy obtained from the heat of the seawater in energy required to combust ammonia can be increased. Thus, the efficiency of the gas turbine system 1 can be effectively improved.

[0034] Further, in the gas turbine system 1, the seawater flowing through the seawater flow passage 107 can be cooled in the heat exchanger 20 with use of the ammonia flowing through the ammonia flow passage 103. Thus, the seawater and the steam in the condenser 17 can have a large difference in temperature. Hence, a temperature of the water generated in the condenser 17 can be decreased with a smaller suction amount of seawater (that is, power consumption by the pump 19 can be reduced). A reduction in temperature of condensate also reduces a pressure on an outlet side of the steam turbine 16. Thus, energy that can be obtained through a thermal cycle of water passing through the boiler 14, the steam turbine 16, and the condenser 17 can be increased. This increase in energy can also improve the efficiency of the gas turbine system 1.

[0035] Further, in the gas turbine system 1, even when the steam turbine 16 is not activated, ammonia, which is

flame-retardant and stored at a low temperature in the ammonia tank 13, can be heated by actuating the pump 19. Thus, stable combustion can be achieved promptly in the combustor 12, and in turn, the gas turbine system 1 can be
5 activated promptly.

[0036] There has been described an example in which the heat exchanger 20 is arranged on the upstream side of the condenser 17 in the seawater flow passage 107. However, similarly to a second heat exchanger 20b of a gas turbine
10 system 1A illustrated in FIG. 2 or a gas turbine system 1B illustrated in FIG. 3, which are described later, the heat exchanger 20 may be arranged on a downstream side of the condenser 17 in the seawater flow passage 107. With this arrangement, the seawater flowing through the seawater flow
15 passage 107 can also be cooled in the heat exchanger 20 with use of the ammonia flowing through the ammonia flow passage 103. Thus, the same effects as those of the gas turbine system 1 described above are obtained. Further, as in a gas turbine system 1C illustrated in FIG. 4 or a gas turbine
20 system 1D illustrated in FIG. 5, which are described later, the heat exchanger 20 may be arranged in the flow passage 106 that connects the steam turbine 16, the condenser 17, and the boiler 14. Also in this case, the suction amount of seawater can be reduced as in the gas turbine system 1 described
25 above. Thus, the efficiency of the gas turbine system 1 can be improved.

[0037] Now, gas turbine systems according to

modification examples are described with reference to FIG. 2 to FIG. 5.

[0038] FIG. 2 is a schematic view for illustrating a configuration of a gas turbine system 1A according to a first modification example. As illustrated in FIG. 2, the gas turbine system 1A according to the first modification example differs from the gas turbine system 1 described above in that two heat exchangers 20 are provided. The gas turbine system 1A corresponds to an embodiment that is particularly effective mainly in a region where a seawater temperature is high, such as a low-latitude region.

[0039] In the gas turbine system 1A, a first heat exchanger 20a and a second heat exchanger 20b are provided as the heat exchangers 20. The first heat exchanger 20a is arranged on an upstream side of a condenser 17 in a seawater flow passage 107. The second heat exchanger 20b is arranged on a downstream side of the condenser 17 in the seawater flow passage 107. An ammonia flow passage 103 passes through both of the heat exchangers 20, that is, the first heat exchanger 20a and the second heat exchanger 20b.

[0040] A switching mechanism 30-1 is provided to the ammonia flow passage 103. The switching mechanism 30-1 switches a path for ammonia between a plurality of paths in which ammonia passes through a different one or ones of the heat exchangers 20. The switching mechanism 30-1 includes branching portions (specifically, flow passages 103a and 103b described later) of the ammonia flow passage 103, switching

valves 31 and 32 switch the path for ammonia in the ammonia flow passage 103, temperature sensors 33 and 34, and a controller 35.

[0041] In the example illustrated in FIG. 2, the ammonia
5 flow passage 103 passes through the first heat exchanger 20a on a downstream side of a pump 21 and then branches into the flow passage 103a and the flow passage 103b. The flow passage 103a and the flow passage 103b join together on an upstream side of a flow rate control valve 22. The flow
10 passage 103b passes through the second heat exchanger 20b. Meanwhile, the flow passage 103a does not pass through the second heat exchanger 20b.

[0042] The switching valves 31 and 32 are on-off valves. Each of the switching valves opens and closes a flow passage
15 at its installation position. The switching valve 31 is provided in the flow passage 103a. When the switching valve 31 is in an open state, ammonia that has passed through the first heat exchanger 20a passes through the flow passage 103a and is sent to a combustor 12. Meanwhile, when the switching
20 valve 31 is in a closed state, the ammonia that has passed through the first heat exchanger 20a cannot pass through the flow passage 103a. The switching valve 32 is provided on an upstream side of the second heat exchanger 20b in the flow passage 103b. When the switching valve 32 is in an open
25 state, the ammonia that has passed through the first heat exchanger 20a passes through the second heat exchanger 20b and is sent to the combustor 12. Meanwhile, when the

switching valve 32 is in a closed state, the ammonia that has passed through the first heat exchanger 20a is not sent to the second heat exchanger 20b.

[0043] For example, when the switching mechanism 30-1

5 sets the switching valve 31 in an open state and the switching valve 32 in a closed state, ammonia can be sent to the combustor 12 through only the first heat exchanger 20a. Further, when the switching mechanism 30-1 sets the switching valve 31 in a closed state and the switching valve 32 in an
10 open state, the ammonia can be sent to the combustor 12 through both of the first heat exchanger 20a and the second heat exchanger 20b. As described above, the switching mechanism 30-1 switches a path for ammonia between a path in which ammonia passes through only the first heat exchanger
15 20a and a path in which ammonia passes through both of the first heat exchanger 20a and the second heat exchanger 20b.

[0044] There has been described an example in which the switching valves 31 and 32 are on-off valves. However, a switching valve provided in the switching mechanism 30-1 is
20 not required to be an on-off valve. For example, a switching valve, which is a three-way valve, may be provided at a connecting portion between an upstream end of the flow passage 103a and an upstream end of the flow passage 103b. When the switching valve described above switches the path
25 for ammonia in the ammonia flow passage 103 between a path in which ammonia passes through the flow passage 103a and a path in which ammonia passes through the flow passage 103b, the

heat exchangers 20 through which ammonia passes can be switched, as in the example described above. Further, the number of branching portions from the ammonia flow passage 103 and a position at which the branching portions are

5 connected in the switching mechanism 30-1 are not limited to any particular number and position. That is, the way in which the ammonia flow passage 103 branches into flow passages in the switching mechanism 30-1 is not limited to any particular way. The switching valves 31 and 32 may be
10 flow rate control valves, each having a function to adjust a flow rate. In this case, a flow rate of ammonia to be sent to each of the heat exchangers 20, that is, the first heat exchanger 20a and the second heat exchanger 20b, can be more finely adjusted.

15 [0045] The temperature sensor 33 detects a temperature of the ammonia that has passed through the first heat exchanger 20a and outputs a result of detection to the controller 35. The temperature sensor 33 is provided, for example, between the connecting portion between the upstream
20 end of the flow passage 103a and the upstream end of the flow passage 103b and the first heat exchanger 20a.

[0046] The temperature sensor 34 detects a temperature of seawater discharged into the sea and outputs a result of detection to the controller 35. The temperature sensor 34 is
25 provided, for example, on a downstream side of the second heat exchanger 20b in the seawater flow passage 107.

[0047] The controller 35 includes, for example, a

central processing unit (CPU), a ROM stores, for example, a program, and a RAM serves as a work area. In the gas turbine system 1A, the controller 35 controls operation of the switching valves 31 and 32. Through the control described
5 above, the controller 35 can switch the path for ammonia between the path in which ammonia passes through only the first heat exchanger 20a and the path in which ammonia passes through both of the first heat exchanger 20a and the second heat exchanger 20b.

10 [0048] For example, the controller 35 may switch the path for ammonia based on a state of the ammonia in the ammonia flow passage 103. In the example illustrated in FIG. 2, the controller 35 switches the path for ammonia based on, for example, the temperature of the ammonia that has passed
15 through the first heat exchanger 20a.

[0049] For example, when the temperature of the ammonia that has passed through the first heat exchanger 20a is equal to or lower than a target temperature, the controller 35 controls the switching valve 31 and 32 so that the ammonia
20 passes through the flow passage 103b to thereby cause the ammonia to pass through both of the first heat exchanger 20a and the second heat exchanger 20b. Meanwhile, when the temperature of the ammonia that has passed through the second heat exchanger 20a is higher than the target temperature, the
25 controller 35 controls the switching valves 31 and 32 so that the ammonia passes through the flow passage 103a to thereby cause the ammonia to pass through only the first heat

exchanger 20a.

[0050] The target temperature is a target to which ammonia is to reach through heating with seawater. For example, the target temperature is set as high as possible
5 without causing vaporization of ammonia.

[0051] When the path for ammonia is switched as described above, a quantity of heat that the seawater passing through the heat exchangers 20 recovers from the seawater can be increased as much as possible while the vaporization of
10 the ammonia is suppressed.

[0052] There has been described above an example in which the switching mechanism 30-1 switches the path for ammonia based on the temperature of the ammonia that has passed through the first heat exchanger 20a. However, the
15 switching mechanism 30-1 may switch the path for ammonia based on a parameter other than the above-mentioned temperature as a parameter indicating a state of the ammonia in the ammonia flow passage 103. For example, a flow rate of the ammonia in the ammonia flow passage 103 may be used as a
20 parameter indicating a state of ammonia in the ammonia flow passage 103. For example, a pressure of the ammonia in the ammonia flow passage 103 may be used as a parameter indicating a state of ammonia in the ammonia flow passage 103.

25 [0053] Further, the controller 35 may switch the path for ammonia based on, for example, a state of seawater in the seawater flow passage 107. In the example illustrated in

FIG. 2, the controller 35 switches the path for ammonia based on, for example, the temperature of the seawater discharged into the sea.

[0054] For example, when the temperature of the seawater
5 discharged into the sea is equal to or lower than a reference temperature, the controller 35 controls the switching valves 31 and 32 so that ammonia passes through the flow passage 103a to thereby cause the ammonia to pass through only the first heat exchanger 20a. Meanwhile, when the temperature of
10 the seawater discharged into the sea is higher than the reference temperature, the controller 35 controls the switching valves 31 and 32 so that ammonia flows through the flow passage 103b to thereby cause the ammonia to pass through both of the first heat exchanger 20a and the second
15 heat exchanger 20b.

[0055] The reference temperature is an index for determining whether or not the temperature of the seawater discharged into the sea is excessively high (for example, whether or not the temperature of the seawater is such high
20 that an ecosystem is adversely affected). When the temperature of the seawater discharged into the sea is equal to or lower than the reference temperature, it is determined that the temperature of the seawater discharged into the sea is not excessively high. Meanwhile, when the temperature of
25 the seawater discharged into the sea is higher than the reference temperature, it is determined that the temperature of the seawater discharged into the sea is excessively high.

[0056] The switching of the path for ammonia as described above can suppress excessive cooling and solidification of the seawater in the seawater flow passage 107 while suppressing an excessive increase in temperature of the seawater discharged into the sea.

[0057] There has been described an example in which the switching mechanism 30-1 switches the path for ammonia based on the temperature of the seawater discharged into the sea. However, the switching mechanism 30-1 may switch the path for ammonia based on a parameter other than the above-mentioned temperature as a parameter indicating a state of the seawater in the seawater flow passage 107. For example, a flow rate of the seawater in the seawater flow passage 107 may be used as a parameter indicating a state of the seawater in the seawater flow passage 107. For example, a pressure of the seawater in the seawater flow passage 107 may be used as a parameter indicating a state of the seawater in the seawater flow passage 107.

[0058] As described above, in the gas turbine system 1A, the heat exchangers 20 include the first heat exchanger 20a and the second heat exchanger 20b. The first heat exchanger 20a is arranged on the upstream side of the condenser 17 in the seawater flow passage 107. The second heat exchanger 20b is arranged on the downstream side of the condenser 17 in the seawater flow passage 107. The switching mechanism 30-1 that switches the path for ammonia between a plurality of paths in which ammonia passes through a different one or ones of the

heat exchangers 20 is provided to the ammonia flow passage 103. As a result, the number or the kind of heat exchangers 20 through which ammonia passes can be changed in the ammonia flow passage 103. In the example illustrated in FIG. 2, the number of heat exchangers 20 through which ammonia passes can be changed. Thus, not only the above-mentioned effects of the gas turbine system 1 are obtained, but also a degree of increase in temperature of ammonia and a degree of decrease in temperature of seawater, which are caused through heat exchange between seawater and ammonia, can be adjusted. Hence, efficiency of the gas turbine system 1A can be improved while the temperature of the seawater is appropriately adjusted.

[0059] In particular, it is preferred that the switching mechanism 30-1 switch the path for ammonia based on a state of ammonia in the ammonia flow passage 103 as described above. As a result, a degree of increase in temperature of ammonia, which is caused by heat exchange with the seawater, can be appropriately adjusted based on a state of ammonia in the ammonia flow passage 103. Hence, a maximum increase in quantity of heat that the ammonia passing through the heat exchangers 20 recovers from the seawater can be appropriately achieved while the vaporization of seawater is suppressed.

[0060] In particular, it is preferred that the switching mechanism 30-1 switch the path for ammonia based on a state of the seawater in the seawater flow passage 107 as described above. As a result, the degree of decrease in temperature of

seawater through heat exchange with ammonia can be appropriately adjusted based on a state of the seawater in the seawater flow passage 107. Thus, for example, the suppression of excessive cooling and solidification of the seawater in the seawater flow passage 107 is appropriately achieved while an excessive increase in temperature of the seawater discharged into the sea is suppressed.

[0061] The switching mechanism 30-1 may switch the path for ammonia based on one of a state of the ammonia in the ammonia flow passage 103 and a state of the seawater in the seawater flow passage 107. The switching mechanism 30-1 may switch the path for ammonia based on both of a state of the ammonia in the ammonia flow passage 103 and a state of the seawater in the seawater flow passage 107. That is, the switching mechanism 30-1 may switch the path for ammonia based on at least one of a state of the ammonia in the ammonia flow passage 103 or a state of the seawater in the seawater flow passage 107.

[0062] FIG. 3 is a schematic view for illustrating a configuration of a gas turbine system 1B according to a second modification example. As illustrated in FIG. 3, as in the gas turbine system 1A described above, a first heat exchanger 20a and a second heat exchanger 20b are provided as heat exchangers 20 in the gas turbine system 1B according to the second modification example. However, the gas turbine system 1B according to the second modification example differs from the gas turbine system 1A described above in

that a switching mechanism 30-2, which is different from the switching mechanism 30-1, is provided. The gas turbine system 1B corresponds to an embodiment that is particularly effective mainly in a region where a seawater temperature is low, such as a high-latitude region.

[0063] Similarly to the switching mechanism 30-1 described above, the switching mechanism 30-2 switches a path for ammonia among a plurality of paths in which ammonia passes through a different one or ones of the heat exchangers 20. In the switching mechanism 30-2, the number of positions at which the ammonia flow passage 103 branches into flow passages is different from that in the switching mechanism 30-1 described above. Further, the switching mechanism 30-2 includes switching valves 36 and 37 in place of the switching valves 31 and 32 of the switching mechanism 30-1 described above. Further, the switching mechanism 30-2 includes a temperature sensor 38 in place of the temperature sensor 33 of the switching mechanism 30-1 described above. Similarly to the switching mechanism 30-1 described above, the switching mechanism 30-2 includes a temperature sensor 34 and a controller 35.

[0064] In the example illustrated in FIG. 3, the ammonia flow passage 103 branches into a flow passage 103c and a flow passage 103d on a downstream side of a pump 21. The flow passage 103c and the flow passage 103d join together on an upstream side of a flow rate control valve 22. The flow passage 103c passes through the first heat exchanger 20a.

Meanwhile, the flow passage 103d passes through the second heat exchanger 20b.

[0065] The switching valves 36 and 37 are on-off valves. Each of the switching valves opens and closes a flow passage at its installation position. The switching valve 36 is provided on an upstream side of the first heat exchanger 20a in the flow passage 103c. When the switching valve 36 is in an open state, ammonia supplied from an ammonia tank 13 passes through the first heat exchanger 20a and is sent to a combustor 12. Meanwhile, when the switching valve 36 is in a closed state, the ammonia supplied from the ammonia tank 13 is not sent to the first heat exchanger 20a. The switching valve 37 is provided on an upstream side of the second heat exchanger 20b in the flow passage 103d. When the switching valve 37 is in an open state, the ammonia supplied from the ammonia tank 13 passes through the second heat exchanger 20b and is sent to the combustor 12. Meanwhile, when the switching valve 37 is in a closed state, the ammonia supplied from the ammonia tank 13 is not sent to the second heat exchanger 20b.

[0066] For example, when the switching mechanism 30-2 sets the switching valve 36 in a closed state and the switching valve 37 in an open state, the ammonia can be sent to the combustor 12 through only the second heat exchanger 20b. Further, when the switching mechanism 30-2 sets both of the switching valve 36 and the switching valve 37 in an open state, the ammonia can be sent to the combustor 12 through

both of the first heat exchanger 20a and the second heat exchanger 20b. As described above, the switching mechanism 30-2 switches the path for ammonia between a path in which ammonia passes through only the second heat exchanger 20b and a path in which ammonia passes through both of the first heat exchanger 20a and the second heat exchanger 20b.

[0067] There has been described an example in which the switching valves 36 and 37 are on-off valves. However, similarly to the switching valves 31 and 32 described above, the switching valves 36 and 37 are not required to be on-off valves. For example, one or each of the switching valves 36 and 37 may be replaced by a switching valve, which is a three-way valve. Further, as in the switching mechanism 30-1 described above, the number of branching portions from the ammonia flow passage 103 and a position at which the branching portions are connected are not limited to any particular number and position in the switching mechanism 30-2. That is, the way in which the ammonia flow passage 103 branches into flow passages in the switching mechanism 30-2 is not limited to any particular way. The switching valves 36 and 37 may be flow rate control valves, each having a function to adjust a flow rate. In this case, a flow rate of ammonia to be sent to each of the heat exchangers 20, that is, the first heat exchanger 20a and the second heat exchanger 20b, can be more finely adjusted.

[0068] The temperature sensor 38 detects a temperature of the ammonia that has passed through the second heat

exchanger 20b and outputs a result of detection to the controller 35. The temperature sensor 38 is provided, for example, on a downstream side of the second heat exchanger 20b in the flow passage 103d.

5 [0069] In the gas turbine system 1B, the controller 35 controls operations of the switching valves 36 and 37. Through the control described above, the controller 35 can switch the path for ammonia between the path in which ammonia passes through only the second heat exchanger 20b and the
10 path in which ammonia passes through both of the first heat exchanger 20a and the second heat exchanger 20b.

[0070] As in the example illustrated in FIG. 2, the controller 35 may switch the path for ammonia based on, for example, a state of ammonia in the ammonia flow passage 103.
15 In the example illustrated in FIG. 3, the controller 35 switches the path for ammonia based on, for example, a temperature of the ammonia that has passed through the second heat exchanger 20b.

[0071] For example, when the temperature of the ammonia
20 that has passed through the second heat exchanger 20b is higher than a target temperature, the controller 35 controls the switching valves 36 and 37 so that the ammonia passes through only the flow passage 103d of the flow passages 103c and 103d to cause the ammonia to pass through only the second
25 heat exchanger 20b. Meanwhile, when the temperature of the ammonia that has passed through the second heat exchanger 20b is equal to or lower than the target temperature, the

controller 35 controls the switching vales 36 and 37 so that the ammonia passes through both of the flow passage 103c and the flow passage 103d to cause the ammonia to pass through both of the first heat exchanger 20a and the second heat
5 exchanger 20b.

[0072] When the path for ammonia is switched as described above, a quantity of heat that the ammonia passing through the heat exchangers 20 recovers from seawater can be increased as much as possible while the vaporization of
10 ammonia is suppressed.

[0073] Similarly to the switching mechanism 30-1, the switching mechanism 30-2 may switch the path for ammonia based on a parameter other than the above-mentioned temperature as a parameter indicating a state of the ammonia
15 in the ammonia flow passage 103.

[0074] Further, for example, as in the example illustrated in FIG. 2, the controller 35 may switch the path for ammonia based on a state of seawater in a seawater flow passage 107. In the example illustrated in FIG. 3, the
20 controller 35 switches the path for ammonia based on, for example, a temperature of seawater discharged into the sea.

[0075] For example, when the temperature of the seawater discharged into the sea is equal to or lower than a reference temperature, the controller 35 controls the switching valves
25 36 and 37 so that the ammonia passes through only the flow passage 103d of the flow passages 103c and 103d to cause the ammonia to pass through only the second heat exchanger 20b.

Meanwhile, when the temperature of the seawater discharged into the sea is higher than the reference temperature, the controller 35 controls the switching valves 36 and 37 so that the ammonia passes through both of the flow passage 103c and the flow passage 103d to cause the ammonia to pass through both of the first heat exchanger 20a and the second heat exchanger 20b.

[0076] When the path for ammonia is switched as described above, excessive cooling and solidification of the seawater in the seawater flow passage 107 can be suppressed while an excessive increase in temperature of the seawater discharged into the sea is suppressed.

[0077] Similarly to the switching mechanism 30-1, the switching mechanism 30-2 may switch the path for ammonia based on a parameter other than the above-mentioned temperature as a parameter indicating a state of the seawater in the seawater flow passage 107.

[0078] There has been described an example in which the switching mechanism 30-2 switches the path for ammonia between the path in which ammonia passes through only the second heat exchanger 20b and the path in which ammonia passes through both of the first heat exchanger 20a and the second heat exchanger 20b. However, the switching mechanism 30-2 may switch the path for ammonia so that ammonia passes through only the first heat exchanger 20a. For example, a degree of increase in temperature of ammonia may be different between the first heat exchanger 20a and the second heat

exchanger 20b. In this case, the switching mechanism 30-2 switches the path for ammonia between the path in which ammonia passes through only the first heat exchanger 20a and the path in which ammonia passes through only the second heat exchanger 20b based on, for example, the flow rate of the ammonia in the ammonia flow passage 103. As a result, a quantity of heat that the ammonia passing through the heat exchangers 20 recovers from the seawater can be increased as much as possible while the vaporization of ammonia is suppressed.

[0079] As described above, similarly to the gas turbine system 1A described above, the gas turbine system 1B includes the first heat exchanger 20a and the second heat exchanger 20b. The first heat exchanger 20a is arranged on the upstream side of the condenser 17 in the seawater flow passage 107. The second heat exchanger 20b is arranged on the downstream side of the condenser 17 in the seawater flow passage 107. Further, the ammonia flow passage 103 is provided with the switching mechanism 30-2. The switching mechanism 30-2 switches the path for ammonia among the plurality of paths in which ammonia passes through a different one or ones of the heat exchangers 20. Thus, the same effects as those of the gas turbine system 1A described above are obtained.

[0080] There has been described above with reference to FIG. 2 and FIG. 3 an example in which two heat exchangers 20 are provided in the seawater flow passage 107. However,

three or more heat exchangers 20 may be provided in the seawater flow passage 107.

[0081] FIG. 4 is a schematic view for illustrating a configuration of a gas turbine system 1C according to a third modification example. As illustrated in FIG. 4, the gas turbine system 1C according to the third modification example differs from the gas turbine system 1 described above in that a heat exchanger 20 is arranged in a flow passage 106 that connects a steam turbine 16, a condenser 17, and a boiler 14.

[0082] In the example illustrated in FIG. 4, the heat exchanger 20 is arranged between the steam turbine 16 and the condenser 17 in the flow passage 106. An ammonia flow passage 103 passes through the heat exchanger 20. In the heat exchanger 20, steam that is discharged from the steam turbine 16 and flows through the flow passage 106 and ammonia flowing through the ammonia flow passage 103 exchange heat. A temperature of the steam flowing through the flow passage 106 is higher than a temperature of the ammonia flowing through the ammonia flow passage 103. Thus, the steam flowing through the flow passage 106 is cooled with the ammonia flowing through the ammonia flow passage 103 in the heat exchanger 20. Meanwhile, the ammonia flowing through the ammonia flow passage 103 is heated with the steam flowing through the flow passage 106.

[0083] As described above, in the gas turbine system 1C, the heat exchanger 20 is arranged on an upstream side of the condenser 17 in the flow passage 106 that connects the steam

turbine 16, the condenser 17, and the boiler 14. The ammonia flow passage 103 that connects an ammonia tank 13 and a combustor 12 to each other passes through the heat exchanger 20. Thus, steam sent to the condenser 17 can be cooled with use of the ammonia flowing through the ammonia flow passage 103 in the heat exchanger 20. Hence, a quantity of heat that is required to be recovered from steam with the seawater in the condenser 17 can be reduced, and thus a suction amount of seawater can be reduced. Accordingly, power of a pump 19 can be reduced, and thus efficiency of the gas turbine system 1C can be improved.

[0084] Further, ammonia can be heated with use of steam having a higher temperature than a temperature of seawater in the gas turbine system 1C. Hence, ammonia can be more effectively heated than in a case in which ammonia is heated with use of seawater. Also in this regard, the efficiency of the gas turbine system 1 can be improved.

[0085] FIG. 5 is a schematic view for illustrating a configuration of a gas turbine system 1D according to a fourth modification example. As illustrated in FIG. 5, as in the gas turbine system 1C described above, a heat exchanger 20 is arranged in a flow passage 106 that connects a steam turbine 16, a condenser 17, and a boiler 14 in the gas turbine system 1D according to the fourth modification example. However, the gas turbine system 1D according to the fourth modification example differs from the above-mentioned gas turbine system 1C in that the heat exchanger 20 is

arranged on a downstream side of the condenser 17 in the flow passage 106 that connects the steam turbine 16, the condenser 17, and the boiler 14.

[0086] In the example illustrated in FIG. 5, the heat exchanger 20 is arranged between the condenser 17 and a pump 18 in the flow passage 106. An ammonia flow passage 103 passes through the heat exchanger 20. In the heat exchanger 20, water that is generated in the condenser 17 and flows through the flow passage 106 and ammonia flowing through the ammonia flow passage 103 exchange heat. A temperature of the water flowing through the flow passage 106 is higher than a temperature of the ammonia flowing through the ammonia flow passage 103. Thus, the water flowing through the flow passage 106 is cooled with the ammonia flowing through the ammonia flow passage 103 in the heat exchanger 20. Meanwhile, the ammonia flowing through the ammonia flow passage 103 is heated with the water flowing through the flow passage 106.

[0087] As described above, in the gas turbine system 1D, the heat exchanger 20 is arranged on the downstream side of the condenser 17 in the flow passage 106 that connects the steam turbine 16, the condenser 17, and the boiler 14. The ammonia flow passage 103 that connects an ammonia tank 13 and a condenser 12 to each other passes through the heat exchanger 20. Thus, the water sent from the condenser 17 to the downstream side can be cooled in the heat exchanger 20 with use of the ammonia flowing through the ammonia flow

passage 103. Hence, as in the gas turbine system 1C described above, a quantity of heat that is required to be recovered from steam with use of seawater in the condenser 17 can be reduced, and thus a suction amount of seawater can be reduced. Accordingly, power of a pump 19 can be reduced, and thus efficiency of the gas turbine system 1D can be improved.

[0088] A temperature of the water sent from the condenser 17 to the downstream side is lower than a temperature of steam sent to the condenser 17. Thus, a degree of increase in temperature of ammonia is lower in the gas turbine system 1D than in the gas turbine system 1C described above. Hence, the vaporization of ammonia can be suppressed. Thus, a fluctuation in pressure of vaporized ammonia, an additional facility and complicated control for prevention of recondensation, and an increase in size of a pipe through which gaseous ammonia is to flow can be suppressed.

[0089] 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.

[0090] There has been described above an example in which the rotational power transmitted from the turbine 11b

to the compressor 11a is used as energy for driving the power generator in the gas turbine system 1, 1A, 1B, 1C, 1D.

However, the rotational power transmitted from the turbine 11b to the compressor 11a in the gas turbine system 1, 1A,

5 1B, 1C, 1D may be used for other purposes of use, for example, in order to drive a movable object such as a ship.

[0091] There have been described examples in which ammonia is supplied in a liquid state to the combustor 12.

However, ammonia may be supplied in a gaseous state to the
10 combustor 12. In this case, a vaporizer is provided in the ammonia flow passage 103, and ammonia is vaporized by the vaporizer.

[0092] The condenser 17 and the heat exchanger(s) 20 have been described with reference to the drawings. However,
15 a relationship between a direction of flow of a high-temperature fluid and a direction of flow of a low-temperature fluid through the condenser 17 and the heat exchanger(s) 20 is not limited to those in the examples illustrated in the drawings. For example, the condenser 17
20 and the heat exchanger(s) 20 may be of counterflow type, of parallel flow type, or of cross flow type.

[0093] The present disclosure contributes to the improvement of efficiency of the gas turbine system. Thus, the present disclosure can contribute to, for example,
25 achievement of Goal 7 "ensure access to affordable, reliable, sustainable and modern energy" of the sustainable development goals (SGDs).

Reference Signs List

[0094] 1: gas turbine system, 1A: gas turbine system,
1B: gas turbine system, 1C: gas turbine system, 1D: gas
5 turbine system, 12: combustor, 13: ammonia tank, 14: boiler,
16: steam turbine, 17: condenser, 20: heat exchanger, 20a:
first heat exchanger, 20b: second heat exchanger, 30-1:
switching mechanism, 30-2: switching mechanism, 102: exhaust
flow passage, 103: ammonia flow passage, 106: flow passage,
10 107: seawater flow passage (heat-medium flow passage)

Claims

1. A gas turbine system, comprising:
 - an ammonia tank configured to store ammonia;
 - a combustor connected to the ammonia tank;
 - 5 an exhaust flow passage connected to the combustor;
 - a boiler provided in the exhaust flow passage;
 - a steam turbine connected to the boiler;
 - a condenser connected to the steam turbine;
 - a heat-medium flow passage passing through the
 - 10 condenser; and
 - a heat exchanger, which is arranged on an upstream side of the condenser in the heat-medium flow passage, on a downstream side of the condenser in the heat-medium flow passage, or in a flow passage that connects the steam
 - 15 turbine, the condenser, and the boiler, the heat exchanger through which an ammonia flow passage that connects the ammonia tank and the combustor to each other passes.
2. The gas turbine system according to claim 1,
 - 20 wherein the ammonia is stored in a liquid state in the ammonia tank, and
 - wherein the ammonia is supplied in a liquid state to the combustor.
- 25 3. The gas turbine system according to claim 1 or 2,
 - wherein the heat exchanger comprises:
 - a first heat exchanger arranged on an upstream

side of the condenser in the heat-medium flow passage; and
a second heat exchanger arranged on a downstream
side of the condenser in the heat-medium flow passage, and
wherein the ammonia flow passage is provided with a
5 switching mechanism configured to switch a path for the
ammonia between a plurality of paths in which the ammonia
passes through a different one or ones of the heat
exchangers.

10 4. The gas turbine system according to claim 3, wherein
the switching mechanism switches the path for the ammonia
based on at least one of a state of the ammonia in the
ammonia flow passage or a state of a heat medium in the heat-
medium flow passage.

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