

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. 2022-034697 filed on March 7, 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] A large-scale gas turbine system consumes a large
25 amount of fuel. Thus, when ammonia is used as fuel, it is required that a large amount of ammonia be stored. When ammonia is a low-temperature liquid at about -33°C, its vapor

pressure is substantially equal to an atmospheric pressure. Thus, when ammonia is stored in a tank, an internal pressure applied to the tank is reduced, making less liable to cause problems in tank strength and in structure. Meanwhile, when
5 an ammonia liquid at a low temperature is directly supplied to a combustor as fuel for a gas turbine, a quantity of heat for raising a temperature of the ammonia liquid and vaporizing the ammonia liquid is obtained from combustion heat of ammonia. Thus, there arises a problem in that
10 efficiency of the gas turbine system may become lower.

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

Solution to Problem

15 [0006] In order to achieve the above-mentioned object, according to the present disclosure, there is provided a gas turbine system, including: an ammonia tank configured to store ammonia in a liquid state; a combustor, which is connected to the ammonia tank, and to which the ammonia is to
20 be supplied in a liquid state; an exhaust flow passage connected to the combustor; a boiler provided in the exhaust flow passage; and a heat exchanger, which is arranged on a downstream side of the boiler in the exhaust flow passage, and through which an ammonia flow passage connecting the
25 ammonia tank and the combustor to each other passes.

[0007] A heat-medium flow passage may be defined between the exhaust flow passage and the ammonia flow passage in the

heat exchanger.

[0008] The heat exchanger may include a first heat exchanger and a second heat exchanger arranged on a downstream side of the first heat exchanger in the exhaust
5 flow passage, and a switching mechanism configured to switch a path for the ammonia between paths in which the ammonia passes through a different one or ones of the heat exchangers may be provided to the ammonia flow passage.

[0009] The switching mechanism may be configured to
10 switch the path for the ammonia based on a state of the ammonia in the ammonia flow passage.

Effects of Disclosure

[0010] According to the present disclosure, efficiency
15 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
20 embodiment of the present disclosure.

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

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

FIG. 4 is a schematic view for illustrating a

configuration of a gas turbine system according to a third modification example.

Description of Embodiments

5 [0012] 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
10 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
15 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,
20 an ammonia tank 13, a boiler 14, an exhaust stack 15, a heat exchanger 16, a pump 17, and a flow rate control valve 18.

[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.

25 [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. 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-

5 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 10 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.

15 [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. The water flowing through the flow passage 104 is heated with the exhaust gas flowing through the exhaust flow passage 102
20 and is thereby vaporized into gas (that is, steam). The flow passage 104 of the boiler 14 is connected to a steam turbine (not shown). The steam generated in the boiler 14 is sent to the steam turbine. Then, the steam turbine is rotated by the steam to thereby generate rotational power. The rotational
25 power generated by the steam turbine is used for power generation.

[0022] The exhaust flow passage 102 is 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 and is sent to the exhaust stack 15. Then, the exhaust gas is discharged from the exhaust stack 15.

[0023] The heat exchanger 16 is arranged on the downstream side of the boiler 14 in the exhaust flow passage 102. The ammonia flow passage 103 passes through the heat exchanger 16. The pump 17 is provided between the heat exchanger 16 and the ammonia tank 13 in the ammonia flow passage 103. The pump 17 pressurizes the ammonia supplied from the ammonia tank 13 and feeds the pressurized ammonia to the downstream side. The ammonia fed by the pump 17 is sent to the heat exchanger 16.

[0024] In the heat exchanger 16, the exhaust gas flowing through the exhaust flow passage 102 and the ammonia flowing through the ammonia flow passage 103 exchange heat. A temperature of the exhaust gas flowing through the exhaust flow passage 102 is higher than a temperature of the ammonia flowing through the ammonia flow passage 103. Hence, in the heat exchanger 16, the ammonia flowing through the ammonia flow passage 103 is heated with the exhaust gas flowing through the exhaust flow passage 102. Specifically, the ammonia is heated in the heat exchanger 16 to such a degree that the ammonia is not vaporized. Hence, the ammonia is supplied in a liquid state to the combustor 12.

[0025] The flow rate control valve 18 is provided

between the heat exchanger 16 and the combustor 12 in the ammonia flow passage 103. The flow rate control valve 18 adjusts a flow rate of liquid ammonia that is to be sent to the combustor 12 through the ammonia flow passage 103.

5 Specifically, an opening degree of the flow rate control valve 18 is adjusted to thereby adjust the amount of supply of ammonia to the combustor 12.

[0026] As described above, in the gas turbine system 1, the heat exchanger 16 is arranged on the downstream side of
10 the boiler 14 in the exhaust flow passage 102. The ammonia flow passage 103 that connects the ammonia tank 13 and the combustor 12 to each other passes through the heat exchanger 16. In this manner, the ammonia supplied to the combustor 12 can be heated in the heat exchanger 16 with use of heat of
15 the exhaust gas that has passed through the boiler 14. Thus, the heat of the exhaust gas can be used as a part of energy that is required to combust ammonia. Hence, efficiency of the gas turbine system 1 can be improved.

[0027] Further, in the gas turbine system 1, ammonia is
20 heated in the heat exchanger 16 to such a degree that ammonia is not vaporized. That is, the heat of the exhaust gas is used as sensible heat of ammonia in the heat exchanger 16. Thus, the ammonia that is stored in a liquid state in the ammonia tank 13 is supplied in a liquid state to the
25 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 recondensation. Further, a pipe through which gaseous ammonia is to flow is required to be increased in size.

5 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.

[0028] More specifically, in view of effective improvement of the efficiency of the gas turbine system 1, it
10 is preferred that the pump 17 that pressurizes ammonia be provided between the heat exchanger 16 and the ammonia tank 13 in the ammonia flow passage 103, as in the example described above. With the pump 17 provided as described above, the ammonia stored in the ammonia tank 13 is
15 pressurized by the pump 17 and is then sent to the heat exchanger 16. Thus, a boiling point of the ammonia passing through the heat exchanger 16 rises. Hence, a quantity of heat that can be recovered from the exhaust gas (that is, a quantity of heat that can be recovered as sensible heat)
20 without vaporizing the ammonia passing through the heat exchanger 16 is increased. Hence, a proportion of energy obtained from the heat of the exhaust gas in energy required to combust ammonia can be increased. Thus, the efficiency of the gas turbine system 1 can be effectively improved.

25 [0029] Now, gas turbine systems according to modification examples are described with reference to FIG. 2 to FIG. 4.

[0030] 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 a heat-medium flow passage 105 is defined between an exhaust flow passage 102 and an ammonia flow passage 103 in a heat exchanger 16.

[0031] A heat medium such as water flows through the heat-medium flow passage 105. A source of supply of the heat medium flowing through the heat-medium flow passage 105 is not limited to any particular one. For example, the heat-medium flow passage 105 and the flow passage 104 in the boiler 14 may be in communication with each other, and the heat medium flowing through the heat-medium flow passage 105 may be water circulating through the flow passage 104. Further, the heat-medium flow passage 105 and the flow passage 104 in the boiler 14 may be in non-communication with each other, and the heat medium flowing through the heat-medium flow passage 105 may be a heat medium such as water, which is supplied from a source of supply other than the flow passage 104.

[0032] In the gas turbine system 1A, the exhaust flow passage 102 and the ammonia flow passage 103 are opposed to each other across the heat-medium flow passage 105 in the heat exchanger 16. Thus, an exhaust gas flowing through the exhaust flow passage 102 and ammonia flowing through the

ammonia flow passage 103 indirectly exchange heat via the heat medium flowing through the heat-medium flow passage 105. Specifically, the exhaust gas flowing through the exhaust flow passage 102 and the heat medium flowing through the heat-medium flow passage 105 directly exchange heat. Then, the heat medium flowing through the heat-medium flow passage 105 and the ammonia flowing through the ammonia flow passage 103 directly exchange heat.

[0033] As described above, in the gas turbine system 1A, the heat-medium flow passage 105 is defined between the exhaust flow passage 102 and the ammonia flow passage 103 in the heat exchanger 16. Thus, a quantity of heat exchanged between the exhaust gas flowing through the exhaust flow passage 102 and the ammonia flowing through the ammonia flow passage 103 can be adjusted by adjusting a flow rate of the heat medium flowing through the heat-medium flow passage 105. As a result, a quantity of heat that the ammonia passing through the heat exchanger 16 recovers from the exhaust gas can be increased as much as possible while the vaporization of ammonia is suppressed.

[0034] 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, the gas turbine system 1B according to the second modification example differs from the gas turbine system 1 described above in that two heat exchangers 16 are provided.

[0035] In the gas turbine system 1B, a first heat

exchanger 16a and a second heat exchanger 16b are provided as the heat exchangers 16. The first heat exchanger 16a and the second heat exchanger 16b are arranged in an exhaust flow passage 102 in the stated order from an upstream side. That is, the second heat exchanger 16b is arranged on a downstream side of the first heat exchanger 16a in the exhaust flow passage 102. An ammonia flow passage 103 passes through both of the heat exchangers 16, that is, the first heat exchanger 16a and the second heat exchanger 16b.

[0036] A switching mechanism 20-1 is provided to the ammonia flow passage 103. The switching mechanism 20-1 switches a path for ammonia between a plurality of paths in which ammonia passes through a different one or ones of the heat exchangers 16. The switching mechanism 20-1 includes branching portions (specifically, flow passages 103a and 103b described later) of the ammonia flow passage 103, a switching valve 21 that switches the path for ammonia in the ammonia flow passage 103, a temperature sensor 22, and a controller 23.

[0037] In the example illustrated in FIG. 3, the ammonia flow passage 103 passes through the second heat exchanger 16b on a downstream side of a pump 17 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 18. The flow passage 103a passes through the first heat exchanger 16a. Meanwhile, the flow passage 103b does not pass through the

first heat exchanger 16a.

[0038] The switching valve 21 is a three-way valve. The switching valve 21 is provided at a connecting portion between an upstream end of the flow passage 103a and an upstream end of the flow passage 103b. The switching valve 21 switches the path 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. When ammonia passes through the flow passage 103a, ammonia sent from an ammonia tank 13 passes through the second heat exchanger 16b, passes through the first heat exchanger 16a, and is then sent to the combustor 12. Meanwhile, when ammonia passes through the flow passage 103b, ammonia sent from the ammonia tank 13 passes through the second heat exchanger 16b and is then sent to the combustor 12 without passing through the first heat exchanger 16a.

[0039] As described above, the switching mechanism 20-1 switches the path for ammonia in the ammonia flow passage 103 between the path in which ammonia passes through both of the first heat exchanger 16a and the second heat exchanger 16b and the path in which ammonia passes through only the second heat exchanger 16b.

[0040] There has been described above an example in which the switching valve 21 is a three-way valve. However, the switching valve 21 is not required to be a three-way valve. For example, the switching valve 21, which is an on-

off valve, may be provided in each of the flow passage 103a and the flow passage 103b. In this case, when the switching valve 21 provided in the flow passage 103a is set in an open state, and the switching valve 21 provided in the flow
5 passage 103b is set in a closed state, ammonia passes through the flow passage 103a. Meanwhile, when the switching valve 21 provided in the flow passage 103a is set in a closed state, and the switching valve 21 provided in the flow passage 103b is set in an open state, ammonia passes through
10 the flow passage 103b. Further, the number of branching portions from the ammonia flow passage 103 and a position at which branching portions are connected to each other are not limited to any particular number and position. That is, the way in which the ammonia flow passage 103 branches into flow
15 passages in the switching mechanism 20-1 is not limited to any particular one.

[0041] The temperature sensor 22 detects a temperature of the ammonia that has passed through the second heat exchanger 16b and outputs a result of the detection to the
20 controller 23. The temperature sensor 22 is provided, for example, between the second heat exchanger 16b and the switching valve 21 in the ammonia flow passage 103.

[0042] The controller 23 includes a central processing unit (CPU), a ROM stores, for example, a program, and a RAM
25 serves as a work area. In the gas turbine system 1B, the controller 23 controls an operation of the switching valve 21. Thus, the controller 23 can switch the path for ammonia

between the path in which ammonia passes through both of the first heat exchanger 16a and the second heat exchanger 16b and the path in which ammonia passes through only the second heat exchanger 16b.

5 [0043] The controller 23 switches the path for ammonia based on a state of the ammonia in the ammonia flow passage 103. In the example illustrated in FIG. 3, the controller 23 switches the path for ammonia based on, for example, the temperature of the ammonia that has passed through the second
10 heat exchanger 16b.

[0044] For example, when the temperature of the ammonia that has passed through the second heat exchanger 16b is equal to or lower than a reference temperature, the controller 23 controls the switching valve 21 so that the
15 ammonia passes through the flow passage 103a to thereby cause the ammonia to pass through both of the first heat exchanger 16a and the second heat exchanger 16b. Meanwhile, when the temperature of the ammonia that has passed through the second heat exchanger 16b is higher than the reference temperature,
20 the controller 23 controls the switching valve 21 so that the ammonia passes through the flow passage 103b to thereby cause the ammonia to pass through only the second heat exchanger 16b.

[0045] The reference temperature is an index for
25 determining whether or not ammonia is vaporized when ammonia is caused to pass through the first heat exchanger 16a. When the temperature of the ammonia that has passed through the

second heat exchanger 16b is equal to or lower than the reference temperature, it can be determined that the ammonia is not vaporized even with the passage of the ammonia through the first heat exchanger 16a. Meanwhile, when the temperature of the ammonia that has passed through the second heat exchanger 16b is higher than the reference temperature, it can be determined that the ammonia is vaporized with the passage of the ammonia through the first heat exchanger 16a.

[0046] When the path for ammonia is switched as

described above, a quantity of heat that the ammonia passing through the heat exchangers 16 recovers from the exhaust gas can be increased as much as possible while the vaporization of the ammonia is suppressed.

[0047] There has been described above an example in

which the switching mechanism 20-1 switches the path for ammonia based on the temperature of the ammonia that has passed through the second heat exchanger 16b. However, the switching mechanism 20-1 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 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.

[0048] As described above, in the gas turbine system 1B, the heat exchangers 16 include the first heat exchanger 16a and the second heat exchanger 16b. The second heat exchanger 16b is arranged on a downstream side of the first heat

5 exchanger 16a in the exhaust flow passage 102. The switching mechanism 20-1 is provided to the ammonia flow passage 103.

The switching mechanism 20-1 switches the path for ammonia between the plurality of paths in which ammonia passes through a different one or ones of the heat exchangers 16.

10 As a result, the number or the kind of heat exchangers 16 through which ammonia passes in the ammonia flow passage 103 can be changed. In the example illustrated in FIG. 3, the number of heat exchangers 16 through which ammonia passes can be changed. Thus, a degree of increase in temperature of
15 ammonia, which is caused by heat exchange with the exhaust gas, can be adjusted. Hence, a quantity of heat that the ammonia passing through the heat exchangers 16 recovers from the exhaust gas can be increased as much as possible while the vaporization of ammonia is suppressed.

20 [0049] In particular, it is preferred that the switching mechanism 20-1 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 exhaust
25 gas, 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 16 recovers from the exhaust gas can be appropriately achieved while the vaporization of ammonia is suppressed.

[0050] 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, as in the gas turbine system 1B described above, a first heat exchanger 16a and a second heat exchanger 16b are provided as heat exchangers 16 in the gas turbine system 1C according to the third modification example. However, the gas turbine system 1C according to the third modification example differs from the gas turbine system 1B described above in that a switching mechanism 20-2, which is different from the switching mechanism 20-1, is provided.

[0051] Similarly to the switching mechanism 20-1 described above, the switching mechanism 20-2 switches a path for ammonia among a plurality of paths in which ammonia passes through a different one or ones of the heat exchangers 16. In the switching mechanism 20-2, the number of positions at which the ammonia flow passage 103 branches into flow passages is larger than that in the switching mechanism 20-1 described above. Further, the switching mechanism 20-2 differs from the switching mechanism 20-1 in that a switching valve 24 and a flow rate sensor 25 are additionally provided.

[0052] In the example illustrated in FIG. 4, the ammonia flow passage 103 branches into a flow passage 103c and a flow passage 103d on a downstream side of a pump 17. The flow

passage 103c and the flow passage 103d join together on an upstream side of a switching valve 21. The flow passage 103c passes through the second heat exchanger 16b. Meanwhile, the flow passage 103d does not pass through the second heat

5 exchanger 16b. As in the example illustrated in FIG. 3, the ammonia flow passage 103 branches into a flow passage 103a and a flow passage 103b at a position at which the switching valve 21 is installed. The flow passage 103a passes through the first heat exchanger 16a. Meanwhile, the flow passage
10 103b does not pass through the first heat exchanger 16a.

[0053] Similarly to the switching valve 21, the switching valve 24 is a three-way valve. The switching valve 24 is provided at a position at which an upstream end of the flow passage 103c and an upstream end of the flow passage
15 103d are connected to each other. The switching valve 24 switches a path for ammonia in the ammonia flow passage 103 between a path in which ammonia passes through the flow passage 103c and a path in which ammonia passes through the flow passage 103d. When ammonia passes through the flow
20 passage 103c, ammonia sent from an ammonia tank 13 passes through the second heat exchanger 16b and is then sent to the switching valve 21. Meanwhile, when ammonia passes through the flow passage 103d, the ammonia sent from the ammonia tank 13 is sent to the switching valve 21 without passing through
25 the second heat exchanger 16b.

[0054] As in the example illustrated in FIG. 3, the switching valve 21 switches a path 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. When ammonia passes through the flow passage 103a, ammonia that has passed
5 through the switching valve 21 passes through the first heat exchanger 16a and is then sent to the combustor 12.

Meanwhile, when ammonia passes through the flow passage 103b, the ammonia that has passed through the switching valve 21 is sent to the combustor 12 without passing through the first
10 heat exchanger 16a.

[0055] As described above, the switching mechanism 20-2 switches the path for ammonia in the ammonia flow passage 103 between the path in which ammonia passes through the first heat exchanger 16a and the path in which ammonia does not
15 pass through the first heat exchanger 16a. Further, the switching mechanism 20-2 switches the path for ammonia in the ammonia flow passage 103 between the path in which ammonia passes through the second heat exchanger 16b and the path in which ammonia does not pass through the second heat exchanger
20 16b. Thus, the switching mechanism 20-2 can switch the path for ammonia among the path in which ammonia passes through both of the first heat exchanger 16a and the second heat exchanger 16b, the path in which ammonia passes through only the first heat exchanger 16a, the path in which ammonia
25 passes through only the second heat exchanger 16b, and the path in which ammonia does not pass through the first heat exchanger 16a and the second heat exchanger 16b.

[0056] There has been described above an example in which the switching valve 24 is a three-way valve. However, similarly to the switching valve 21 described above, the switching valve 24 is not required to be a three-way valve.

5 For example, the switching valve 24, which is an on-off valve, may be provided in each of the flow passage 103c and the flow passage 103d. In this case, when the switching valve 24 provided in the flow passage 103c is set in an open state, and the switching valve 24 provided in the flow
10 passage 103d is set in a closed state, ammonia passes through the flow passage 103c. Meanwhile, when the switching valve 24 provided in the flow passage 103c is set in a closed state, and the switching valve 24 provided in the flow passage 103d is set in an open state, ammonia passes through
15 the flow passage 103d. Further, the number of branching portions from the ammonia flow passage 103 and a position at which the branching flow passages are connected to each other are not limited to any particular number and position. That is, the way in which the ammonia flow passage 103 branches
20 into flow passages in the switching mechanism 20-2 is not limited to any particular one.

[0057] The flow rate sensor 25 detects a flow rate of ammonia in the ammonia flow passage 103 and outputs a result of the detection to the controller 23. The flow rate sensor
25 25 is provided, for example, between the pump 17 and the switching valve 24 in the ammonia flow passage 103.

[0058] In the gas turbine system 1C, the controller 23

controls operations of the switching valves 21 and 24. In this manner, the controller 23 can switch the path for ammonia among the path in which ammonia passes through both of the first heat exchanger 16a and the second heat exchanger 16b, the path in which ammonia passes through only the first heat exchanger 16a, the path in which ammonia passes through only the second heat exchanger 16b, and the path in which ammonia does not pass through the first heat exchanger 16a and the second heat exchanger 16b.

10 [0059] As in the example illustrated in FIG. 3, the controller 23 switches the path for ammonia based on a state of ammonia in the ammonia flow passage 103. For example, in the example illustrated in FIG. 4, the controller 23 basically keeps ammonia passing through the second heat exchanger 16b and switches the path for ammonia between the path in which ammonia passes through the first heat exchanger 16a and the path in which ammonia does not pass through the first heat exchanger 16a based on a temperature of the ammonia that has passed through the second heat exchanger 16b.

20 [0060] For example, when a temperature of the ammonia that has passed through the second heat exchanger 16b is equal to or lower than a reference temperature, the controller 23 controls the switching valve 21 so that the ammonia passes through the flow passage 103a to thereby cause the ammonia to pass through both of the first heat exchanger 16a and the second heat exchanger 16b. Meanwhile, when the

temperature of the ammonia that has passed through the second heat exchanger 16b is higher than the reference temperature, the controller 23 controls the switching valve 21 so that the ammonia passes through the flow passage 103b to thereby cause
5 the ammonia to pass through only the second heat exchanger 16b.

[0061] For example, when the temperature of the ammonia that has passed through the second heat exchanger 16b is higher than the reference temperature, and the flow rate of
10 the ammonia in the ammonia flow passage 103 exceeds a reference flow rate, the controller 23 controls the switching valve 24 and the switching valve 21 so that the ammonia passes through the flow passage 103d and the flow passage 103b. As a result, the ammonia does not pass through the
15 first heat exchanger 16a and the second heat exchanger 16b.

[0062] The reference flow rate is an index for determining, when the temperature of the ammonia that has passed through the second heat exchanger 16b is higher than the reference temperature, whether or not ammonia is
20 vaporized with the passage of ammonia through only the second heat exchanger 16b. When the temperature of the ammonia that has passed through the second heat exchanger 16b is higher than the reference temperature, and the flow rate of the ammonia in the ammonia flow passage 103 exceeds the reference
25 flow rate, it can be determined that the ammonia is vaporized even with the passage of the ammonia through only the second heat exchanger 16b.

[0063] When the path for ammonia is switched as described above, a quantity of heat that the ammonia passing through the heat exchangers 16 recovers from the exhaust gas can be increased as much as possible while the vaporization of the ammonia is suppressed.

[0064] There has been described above an example in which the switching mechanism 20-2 switches the path for ammonia based on two parameters, which are the temperature of the ammonia that has passed through the second heat exchanger 16b, and the flow rate of the ammonia in the ammonia flow passage 103. However, the switching mechanism 20-2 may switch the path for ammonia based on a parameter other than the above-mentioned two parameters as a parameter indicating a state of the ammonia in the ammonia flow passage 103. For example, only one of the above-mentioned two parameters may be used as a parameter indicating a state of the ammonia in the ammonia flow passage 103. For example, a pressure of the ammonia in the ammonia flow passage 103 may be used alone or in combination with another parameter as a parameter indicating a state of the ammonia in the ammonia flow passage 103.

[0065] There has been described above an example in which the switching mechanism 20-2 switches the path for ammonia among the path in which ammonia passes through both of the first heat exchanger 16a and the second heat exchanger 16b, the path in which ammonia passes through only the second heat exchanger 16b, the path in which ammonia does not pass

through the first heat exchanger 16a and the second heat exchanger 16b. However, the switching mechanism 20-2 may switch the path for ammonia so that ammonia passes through only the first heat exchanger 16a. For example, a degree of increase in temperature of ammonia may be different between the first heat exchanger 16a and the second heat exchanger 16b. In this case, the switching mechanism 20-2 switches the path for ammonia between the path in which ammonia passes through only the first heat exchanger 16a and the path in which ammonia passes through only the second heat exchanger 16b 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 16 recovers from the exhaust gas can be increased as much as possible while the vaporization of ammonia is suppressed.

[0066] As described above, as in the gas turbine system 1B described above, in the gas turbine system 1C, the heat exchangers 16 include the first heat exchanger 16a and the second heat exchanger 16b. The second heat exchanger 16b is arranged on a downstream side of the first heat exchanger 16a in the exhaust flow passage 102. The switching mechanism 20-2 is provided to the ammonia flow passage 103. The switching mechanism 20-2 switches the path for ammonia among the plurality of paths in which ammonia passes through a different one or ones of the heat exchangers 16. Thus, the same effects as those of the gas turbine system 1B described above are obtained.

[0067] There has been described above with reference to FIG. 3 and FIG. 4 an example in which two heat exchangers 16 are provided in the exhaust flow passage 102. However, three or more heat exchangers 16 may be provided in the exhaust flow passage 102. When a plurality of heat exchangers 16 are provided in the exhaust flow passage 102, a heat-medium flow passage 105 may be defined between the exhaust flow passage 102 and the ammonia flow passage 103 in each of the heat exchangers 16, as in the gas turbine system 1A described above.

[0068] The switching mechanism 20-1 and the switching mechanism 20-2 have been described above as examples of the switching mechanism that switches the path for ammonia. However, the switching mechanism is not limited to the examples described above. For example, the flow passage 103b and the switching valve 21 may be omitted from the example illustrated in FIG. 4. In this case, the path for ammonia can be switched between the path in which ammonia passes through both of the first heat exchanger 16a and the second heat exchanger 16b and the path in which ammonia passes through only the first heat exchanger 16a.

[0069] 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.

[0070] 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. However, the rotational power transmitted from the turbine 11b to the compressor 11a in the gas turbine system 1, 1A, 1B, 1C may be used for other purposes of use, for example, in order to drive a movable object such as a ship.

[0071] The present disclosure contributes to the improvement of efficiency of the gas turbine system. Thus, the present disclosure can contribute to, for example, achievement of Goal 7 "ensure access to affordable, reliable, sustainable and modern energy" of the sustainable development goals (SGDs).

Reference Signs List

[0072] 1: gas turbine system, 1A: gas turbine system, 1B: gas turbine system, 1C: gas turbine system, 12: combustor, 13: ammonia tank, 14: boiler, 16: heat exchanger, 16a: first heat exchanger, 16b: second heat exchanger, 20-1: switching mechanism, 20-2: switching mechanism, 102: exhaust flow passage, 103: ammonia flow passage, 105: heat-medium flow passage

Claims

1. A gas turbine system, comprising:

an ammonia tank configured to store ammonia in a liquid state;

5 a combustor, which is connected to the ammonia tank, and to which the ammonia is to be supplied in a liquid state;

an exhaust flow passage connected to the combustor;

a boiler provided in the exhaust flow passage; and

a heat exchanger, which is arranged on a downstream
10 side of the boiler in the exhaust flow passage, and through which an ammonia flow passage connecting the ammonia tank and the combustor to each other passes.

2. The gas turbine system according to claim 1, wherein a
15 heat-medium flow passage is defined between the exhaust flow passage and the ammonia flow passage in the heat exchanger.

3. The gas turbine system according to claim 1 or 2,
wherein the heat exchanger includes a first heat
20 exchanger and a second heat exchanger arranged on a downstream side of the first heat exchanger in the exhaust flow passage, and

wherein a switching mechanism configured to switch a path for the ammonia between paths in which the ammonia
25 passes through a different one or ones of the heat exchangers is provided to the ammonia flow passage.

4. The gas turbine system according to claim 3, wherein the switching mechanism is configured to switch the path for the ammonia based on a state of the ammonia in the ammonia flow passage.