

Description

Title of Invention

NATURAL GAS FIRED COMBINED-CYCLE POWER GENERATION SYSTEM
AND NATURAL GAS FIRED COMBINED-CYCLE POWER GENERATION
METHOD

Technical Field

[0001] The present invention relates to a natural gas fired combined-cycle power generation system.

Background Art

[0002] A conventionally known natural gas fired combined-cycle power generation system uses cold heat energy recovered from liquefied natural gas (LNG) in a vaporizer, which vaporizes LNG, to cool the air to be supplied to a gas-turbine combined power generation apparatus.

[0003] For example, Patent Literature 1 discloses an LNG-fired combined-cycle power generation plant including an LNG vaporizer, a gas-turbine suction cooler, a gas-turbine suction cooling water circulation path, a gas-turbine suction cooling water circulation pump, and a gas-turbine power generation apparatus. The LNG vaporizer includes a heat transfer tube in which LNG flows. In the LNG vaporizer, heat is exchanged between the LNG flowing in the heat transfer tube and water in contact with the surface of the heat transfer tube, and thereby LNG is vaporized. In the gas-turbine suction cooler, the water (cooling water) flowing out of the LNG vaporizer exchanges heat with air, and thereby the air is cooled. The gas-turbine suction cooling water circulation path interconnects the LNG vaporizer and the gas-turbine suction cooler. Water circulates in the gas-turbine suction cooling water circulation path, flowing through the LNG vaporizer and the gas-turbine suction cooler in this order. The gas-turbine suction cooling water circulation pump is provided in a section, in the downstream of the gas-turbine suction cooler, of the gas-turbine suction cooling water circulation path. The gas-turbine power generation apparatus includes a gas-turbine compressor that compresses the air flowing out of the cooler, a gas-turbine driven by a mixed gas of air discharged from the gas-turbine compressor and combustion gas resulting from burning natural gas (NG), and a power generator connected to the gas-turbine. In this plant, the cold heat energy that the water recovers from LNG in the LNG vaporizer cools the air to be supplied to the gas-turbine compressor of the gas-turbine power generation apparatus.

[0004] In the vaporizer of the LNG-fired combined-cycle power generation plant disclosed in Patent Literature 1, icing may occur on the surface of the heat transfer tube in which LNG flows.

Citation List

Patent Literature

[0005] Patent Literature 1: JP H06-213001 A

Summary of Invention

[0006] An object of the present invention is to provide a natural gas fired combined-cycle power generation system and a natural gas fired combined-cycle power generation method that can suppress icing in the vaporizer.

[0007] A natural gas fired combined-cycle power generation system according to an aspect of the present invention includes a vaporizer configured to heat liquefied natural gas (LNG) with water to vaporize at least a portion of the LNG, a cooler configured to exchange heat between water flowing out of the vaporizer and air to cool the air, a circulation passage that interconnects the vaporizer and the cooler so as to cause water to flow through the vaporizer and then through the cooler, a pump provided on the circulation passage, and a gas-turbine combined power generation apparatus including a gas-turbine driven by gas including air flowing out of the cooler, and a gas-turbine power generator connected to the gas-turbine. The vaporizer includes an intermediate fluid evaporator configured to exchange heat between an intermediate fluid and water flowing out of the cooler to evaporate at least a portion of the intermediate fluid, the intermediate fluid having a freezing point lower than the freezing point of water, and a liquefied natural gas vaporizing unit configured to exchange heat between the intermediate fluid and LNG to vaporize at least a portion of the LNG.

[0008] A natural gas fired combined-cycle power generation method according to an aspect of the present invention uses cold heat energy recovered from LNG in a vaporizer for vaporizing the LNG to cool air to be supplied to a gas-turbine combined power generation apparatus including a gas-turbine and a gas-turbine power generator connected to the gas-turbine. The method includes a vaporizing step of heating the LNG with water to vaporize at least a portion of the LNG, and a cooling step of cooling air to be supplied to the gas-turbine combined power generation apparatus by cold heat energy that water recovers from the LNG in the vaporizing step. In the vaporizing step, heat recovered from air by water by cooling the air in the vaporizer in the cooling step is supplied to an intermediate fluid to evaporate at least a portion of the intermediate fluid, and the LNG is heated by the intermediate fluid to vaporize at least a portion of the LNG, the intermediate fluid having a freezing point lower than the freezing point of water.

Brief Description of Drawings

[0009] FIG. 1 illustrates a schematic configuration of a natural gas fired combined-cycle power generation system according to a first embodiment of the present invention.

FIG. 2 is an enlarged view of a region including a vaporizer and a heater of

the first embodiment.

FIG. 3 illustrates a modification of the natural gas fired combined-cycle power generation system illustrated in FIG. 1.

FIG. 4 illustrates a schematic configuration of a natural gas fired combined-cycle power generation system according to a second embodiment of the present invention.

FIG. 5 is an enlarged view of a region including a vaporizer and a heater of the second embodiment.

Description of Embodiments

[0010] Preferable embodiments of the present invention will now be described with reference to the drawings.

[0011] (First Embodiment)

A natural gas fired combined-cycle power generation system 1 according to a first embodiment of the present invention will be described with reference to FIGS. 1 and 2. The natural gas fired combined-cycle power generation system 1 uses cold heat energy recovered from LNG via water in a vaporizer 10, which vaporizes LNG, to cool the air to be supplied to a gas-turbine combined power generation apparatus 50 and generates power by the gas-turbine combined power generation apparatus 50. Specifically, the natural gas fired combined-cycle power generation system 1 includes the vaporizer 10, a cooler 20, a circulation passage 30, a pump 40, and the gas-turbine combined power generation apparatus 50. The circulation passage 30 interconnects the vaporizer 10 and the cooler 20 in this order.

[0012] The vaporizer 10 is an intermediate fluid type vaporizer (IFV) in which heat is exchanged between water and LNG via an intermediate fluid (such as propane) having a freezing point lower than the freezing point of water, and thereby the LNG is vaporized. In the vaporizer 10, not brine or the like but the water heats the intermediate fluid, and the intermediate fluid heats LNG. Details on the vaporizer 10 will be described later.

[0013] The cooler 20 exchanges heat between the water flowing out of the vaporizer 10 and air to cool the air.

[0014] The pump 40 is provided in a section, in the downstream of the vaporizer 10, of the circulation passage 30. The pump 40 sends water (cooling water) flowing out of the vaporizer 10 to the cooler 20. In the present embodiment, a pump 41 is provided in a section, in the downstream of the cooler 20, of the circulation passage 30. The pump 41 sends water (hot water) flowing out of the cooler 20 to the vaporizer 10. A cold heat storage tank 42 configured to store cold heat energy may be provided in a section, between the vaporizer 10 and the pump 40, of the circulation passage 30. Likewise, a hot heat storage tank 43 configured to store hot heat energy may be provided in a section, between the cooler 20 and the pump 41, of the circulation passage 30. Moreover, in a section of the circulation passage

30 between the cooler 20 and the hot heat storage tank 43, a backup heating unit 44 that heats water by a heat source (such as sea water) may be provided.

[0015] The gas-turbine combined power generation apparatus 50 includes an air compressor 51, a gas-turbine 52, an exhaust heat recovery boiler 53, a steam turbine 54, and a gas-turbine power generator 55. The air compressor 51 compresses the air flowing out of the cooler 20. The gas-turbine 52 is driven by a mixture gas of the compressed air discharged from the air compressor 51 and the combustion gas resulting from burning NG. The exhaust heat recovery boiler 53 exchanges heat between the exhaust gas exhausted from the gas-turbine 52 and water to evaporate the water. The steam turbine 54 is driven by the steam flowing out of the exhaust heat recovery boiler 53. The gas-turbine power generator 55 is connected to the gas-turbine 52 and the steam turbine 54 and generates power by rotation in the gas-turbine 52 and the steam turbine 54.

[0016] The natural gas fired combined-cycle power generation system 1 may further include a heating unit 60 provided in a section, between the cooler 20 and the vaporizer 10, of the circulation passage 30.

[0017] The vaporizer 10 and the heating unit 60 will be described with reference to FIG. 2.

[0018] The vaporizer 10 includes an intermediate fluid evaporator E1, a liquefied natural gas vaporizing unit E2, and a shell 11 that can contain the intermediate fluid evaporator E1, the liquefied natural gas vaporizing unit E2, and the intermediate fluid M.

[0019] The intermediate fluid evaporator E1 exchanges heat between the intermediate fluid M in the liquid phase and water (hot water) flowing out of the cooler 20 to evaporate at least a portion of the intermediate fluid M. In the present embodiment, the intermediate fluid evaporator E1 includes a heat transfer tube. The intermediate fluid evaporator E1 is disposed in a lower portion inside the shell 11 (a portion inside the shell 11 filled with the intermediate fluid M in the liquid phase). That is, the water flowing inside the intermediate fluid evaporator E1 heats the intermediate fluid M in contact with the intermediate fluid evaporator E1.

[0020] The liquefied natural gas vaporizing unit E2 exchanges heat between LNG and the intermediate fluid M in the gas phase to vaporize at least a portion of the LNG. In the present embodiment, the liquefied natural gas vaporizing unit E2 includes a heat transfer tube having a form of a U-shape. The liquefied natural gas vaporizing unit E2 is disposed in the upper portion inside the shell 11 (a region inside the shell 11 above the surface of the intermediate fluid M in the liquid phase). That is, LNG flowing inside the liquefied natural gas vaporizing unit E2 is heated by the intermediate fluid M in the gas phase in contact with the surface of the liquefied natural gas vaporizing unit E2.

[0021] An inlet chamber 12 and an outlet chamber 13 that are partitioned from each

other by a partitioning plate 14 are joined to the shell 11. The inlet chamber 12 is joined to an end of the liquefied natural gas vaporizing unit E2 so as the inside of the inlet chamber 12 to communicate with the inside of the liquefied natural gas vaporizing unit E2. The outlet chamber 13 is joined to the other end of the liquefied natural gas vaporizing unit E2 so as the inside of the outlet chamber 13 to communicate with the inside of the liquefied natural gas vaporizing unit E2. That is, LNG flown into the liquefied natural gas vaporizing unit E2 from the inlet chamber 12 is heated by the intermediate fluid M in the gas phase while passing through the inside of the liquefied natural gas vaporizing unit E2. At least a portion of the LNG is thereby vaporized, and LNG and the vaporized NG flow into the outlet chamber 13.

[0022] A water inlet chamber 15 and a water outlet chamber 16 are joined to the shell 11. The water inlet chamber 15 is joined to a side portion of the shell 11 so as the inside of the water inlet chamber 15 to communicate with the inside of the intermediate fluid evaporator E1. The water outlet chamber 16 is joined to the other side portion of the shell 11 so as the inside of the water outlet chamber 16 to communicate with the inside of the intermediate fluid evaporator E1. That is, the water flown into the intermediate fluid evaporator E1 from the water inlet chamber 15 recovers cold heat energy from the intermediate fluid M in the liquid phase while passing through the intermediate fluid evaporator E1 and flows into the circulation passage 30 through the water outlet chamber 16.

[0023] The heating unit 60 is provided in a section, in the upstream of the vaporizer 10, of the circulation passage 30. The heating unit 60 heats NG flowing out of the vaporizer 10. The heating unit 60 includes a heater E3, and a casing 61 that contains the heater E3.

[0024] The heater E3 exchanges heat between NG flowing out of the liquefied natural gas vaporizing unit E2 and water flowing out of the cooler 20 to heat the NG. In the present embodiment, the heater E3 includes a heat transfer tube having a form of a U-shape.

[0025] An inlet chamber 62 and an outlet chamber 63 that are partitioned from each other by a partitioning plate 64 are joined to the casing 61 via a flange 65. The inlet chamber 62 and the outlet chamber 63 are respectively configured the same as the inlet chamber 12 and the outlet chamber 13 joined to the shell 11. The NG flowing out of the outlet chamber 13 of the vaporizer 10 flows into the inlet chamber 62. The NG is then heated by the water inside the casing 61 while passing through the heater E3, and flows into the outlet chamber 63. The flange 65 is detachably joined to the casing 61. That is, the heater E3, the inlet chamber 62, the outlet chamber 63, and the partitioning plate 64 can be detached from the casing 61.

[0026] As illustrated in FIG. 1, the natural gas fired combined-cycle power

generation system 1 includes a heat amount adjusting passage 31. The heat amount adjusting passage 31 is connected to the circulation passage 30 and bypasses the heating unit 60. The water flown out of the cooler 20 and has passed through the heating unit 60 and the water flown out of the cooler 20 and has passed through the heat amount adjusting passage 31 flow into the intermediate fluid evaporator E1.

[0027] As described above, in the natural gas fired combined-cycle power generation system 1 according to the present embodiment, heat is exchanged between water and LNG via the intermediate fluid (such as propane) having a freezing point lower than the freezing point of water, so that icing in the intermediate fluid evaporator E1 is suppressed compared to a configuration in which heat is directly exchanged between water and LNG. Moreover, it is not necessary to use expensive brine water (such as ethylene glycol water) as a cold heat fluid in order to prevent troubles due to icing.

[0028] Furthermore, the heating unit 60 for heating NG with water flowing out of the cooler 20 is provided in the upstream of the vaporizer 10. Thus, NG can be heated using a structure simpler than that in a configuration in which NG flowing out of the liquefied natural gas vaporizing unit E2 is heated with a heating fluid other than the water flowing out of the cooler 20.

[0029] Furthermore, the heating unit 60 is configured such that the heater E3, the inlet chamber 62, the outlet chamber 63, and the partitioning plate 64 can be detached from the casing 61. Thus, the inside of the heater E3 and the casing 61 can be cleaned (cleansed) easily.

[0030] As illustrated in FIG. 3 the natural gas fired combined-cycle power generation system 1 may further include a cooler bypass passage 32 and a cold heat recovery unit 45. The cooler bypass passage 32 is connected to the circulation passage 30 and bypasses the cooler 20. The cold heat recovery unit 45 recovers cold heat energy of the water flowing out of the vaporizer 10. The cold heat recovery unit 45 may be a cooling apparatus for cooling the inside of a room or a cable pit. In the embodiment, the cold heat energy is used for cooling the air in the cooler 20 and a surplus cold heat is effectively recovered by the cold heat recovery unit 45.

[0031] (Second Embodiment)

A natural gas fired combined-cycle power generation system 1 according to a second embodiment of the present invention will be described with reference to FIGS. 4 and 5. The second embodiment will be described only for portions different from the first embodiment. Description on structures and effects which are the same as the first embodiment will be omitted.

[0032] The natural gas fired combined-cycle power generation system 1 according to the present embodiment further includes a direct expansion turbine 80, an

expansion turbine power generator 90, a heater bypass passage 33, and an additional heater E4.

[0033] The direct expansion turbine 80 is driven by NG flowing out of the heater E3. The expansion turbine power generator 90 is connected to the direct expansion turbine 80.

[0034] The heater bypass passage 33 is connected to the circulation passage 30 and bypasses the heater E3.

[0035] The additional heater E4 is provided on the heater bypass passage 33. The additional heater E4 exchanges heat between the water that flows through the heater bypass passage 33 and the NG flowing out of the direct expansion turbine 80 to heat the NG. The additional heater E4 includes a heat transfer tube having a form of a U-shape. In the present embodiment, the additional heater E4 is contained in the casing 61. In other words, the casing 61 of the present embodiment has a shape that can contain the heater E3 and the additional heater E4 all together. An inlet chamber 72 and an outlet chamber 73 that are partitioned from each other by a partitioning plate 74 are joined to the casing 61 via a flange 75. The inlet chamber 72 and the outlet chamber 73 communicate with the inside of the additional heater E4. The NG flowing out of the direct expansion turbine 80 flows into the inlet chamber 72. The NG is then heated by the water flown, via the heater bypass passage 33, into the casing 61 while passing through the additional heater E4, and flows into the outlet chamber 73. The additional heater E4 can also be detached, together with the inlet chamber 72, the outlet chamber 73, and the partitioning plate 74, from the casing 61. Thus, the additional heater E4 can also be cleaned (cleansed) easily.

[0036] Furthermore, in the present embodiment, the expansion turbine power generator 90 recovers the energy of the NG flowing out of the heater E3 as an electric power, and thereby the power generated in the total system increases.

[0037] Furthermore, the NG flowing out of the direct expansion turbine 80 is heated not by a dedicated heating fluid but by water flowing out of the cooler 20. This heating raises the NG temperature that has decreased by the NG passing through the direct expansion turbine 80. Specifically, the NG temperature decreases by the NG passing through the direct expansion turbine 80, but a portion of the water flowing out of the cooler 20 flows into the additional heater E4 via the heater bypass passage 33 instead of flowing into the heater E3, and the heat amount of the water flown into the additional heater E4 effectively raises the temperature of NG flowing out of the direct expansion turbine 80. The water that has heated the NG in the additional heater E4 still has a sufficient heat amount, so that the water effectively heats the intermediate fluid M in the intermediate fluid evaporator E1.

[0038] Note that the present embodiments disclosed herein should be considered as illustrative in all aspects and not limiting. The scope of the present invention is

defined by the claims, not by the description on the present embodiments, and includes all alterations within the scope of the meanings equivalent to the claims and within the scope of the claims.

[0039] For example, the heater E3 and the additional heater E4 may be contained in different casings. In this case, the water flowing out of the additional heater E4 is preferably supplied to the intermediate fluid evaporator E1.

[0040] The embodiments will now schematically be described.

[0041] A natural gas fired combined-cycle power generation system according to the embodiments includes a vaporizer that heats liquefied natural gas (LNG) with water to vaporize at least a portion of the LNG, a cooler that exchanges heat between water flowing out of the vaporizer and air to cool the air, a circulation passage that interconnects the vaporizer and the cooler so as to cause water to flow through the vaporizer and then through the cooler, a pump provided on the circulation passage, and a gas-turbine combined power generation apparatus including a gas-turbine driven by gas including air flowing out of the cooler, and a gas-turbine power generator connected to the gas-turbine. The vaporizer includes an intermediate fluid evaporator that exchanges heat between an intermediate fluid and water flowing out of the cooler to evaporate at least a portion of the intermediate fluid, the intermediate fluid having a freezing point lower than a freezing point of water, and a liquefied natural gas vaporizing unit that exchanges heat between the intermediate fluid and the LNG to vaporize at least a portion of the LNG.

[0042] In the natural gas fired combined-cycle power generation system, heat is exchanged between water and LNG via an intermediate fluid (such as propane) having a freezing point lower than the freezing point of water, so that icing in an intermediate fluid evaporator is suppressed.

[0043] Preferably, the natural gas fired combined-cycle power generation system further includes a heater provided in a section, between the cooler and the vaporizer, of the circulation passage and exchanges heat between natural gas (NG) flowing out of the liquefied natural gas vaporizing unit and water flowing out of the cooler to heat the NG.

[0044] This allows the structure to be made simple compared to a configuration in which NG flowing out of the liquefied natural gas vaporizing unit is heated with a heating fluid other than the water flowing out of the cooler.

[0045] Preferably, the natural gas fired combined-cycle power generation system further includes a direct expansion turbine driven by NG flowing out of the heater, and an expansion turbine power generator connected to the direct expansion turbine.

[0046] With such a configuration, the expansion turbine power generator recovers the energy of the NG flowing out of the heater as an electric power, and thereby the

power generated in the total system increases.

[0047] In addition, it is preferable that the natural gas fired combined-cycle power generation system further includes a heating unit bypass passage that is connected to the circulation passage and bypasses the heater, and an additional heater that exchanges heat between water that flows through the heater bypass passage and NG flowing out of the direct expansion turbine to heat the NG.

[0048] With such a configuration, the NG flowing out of the direct expansion turbine is heated not by a dedicated heating fluid but by water flowing out of the cooler. This heating raises the NG temperature that has decreased by the NG passing through the direct expansion turbine. Specifically, the NG temperature decreases by the NG passing through the direct expansion turbine, but a portion of the water flowing out of the cooler flows into the additional heater via the heater bypass passage instead of flowing into the heater, and the heat amount of the water flown into the additional heater effectively raises the NG temperature. The water that has heated the NG in the additional heater still has a sufficient heat amount, so that the water effectively heats the intermediate fluid in the intermediate fluid evaporator.

[0049] It is preferable that the natural gas fired combined-cycle power generation system further includes a casing that contains the heater and the additional heater all together.

[0050] This simplifies and downsizes the structures of the heater and the additional heater compared to a configuration in which the heater and the additional heater are contained in different casings.

[0051] It is further preferable that the heater is detachable from the casing.

[0052] Thus, the inside of the heater and the casing can be cleaned (cleansed) easily.

[0053] It is preferable that, in the natural gas fired combined-cycle power generation system, the additional heater is detachable from the casing.

[0054] Thus, the inside of the additional heater and the casing can be cleaned (cleansed) easily.

[0055] It is preferable that the natural gas fired combined-cycle power generation system further includes a cooler bypass passage that is connected to the circulation passage and bypasses the cooler, and a cold heat recovery unit provided on the cooler bypass passage.

[0056] In such a configuration, cold heat is used for cooling the air in the cooler and a surplus cold heat is effectively recovered by the cold heat recovery unit.

[0057] A natural gas fired combined-cycle power generation method according to the embodiments uses cold heat recovered from liquefied natural gas (LNG) in a vaporizer for vaporizing the LNG to cool air to be supplied to a gas-turbine combined power generation apparatus including a gas-turbine and a gas-turbine power generator connected to the gas-turbine. The method includes a vaporizing

step of heating the LNG with water to vaporize at least a portion of the LNG, and a cooling step of cooling air to be supplied to the gas-turbine combined power generation apparatus by cold heat that water recovers from the LNG in the vaporizing step. In the vaporizing step, heat recovered from air by water by cooling the air in the vaporizer in the cooling step is supplied to an intermediate fluid to evaporate at least a portion of the intermediate fluid, and the LNG is heated by the intermediate fluid to vaporize at least a portion of the LNG, the intermediate fluid having a freezing point lower than a freezing point of water.

[0058] In the vaporizing step of the natural gas fired combined-cycle power generation method, in the vaporizer, LNG is vaporized via the intermediate fluid (such as propane) having a freezing point lower than the freezing point of water, so that icing in the vaporizer is suppressed.

Claims

1. A natural gas fired combined-cycle power generation system comprising:

- a vaporizer configured to heat liquefied natural gas (LNG) with water to vaporize at least a portion of the LNG;

- a cooler configured to exchange heat between water flowing out of the vaporizer and air to cool the air;

- a circulation passage that interconnects the vaporizer and the cooler so as to cause water to flow through the vaporizer and then through the cooler;

- a pump provided on the circulation passage;

- a gas-turbine combined power generation apparatus including a gas-turbine driven by gas including air flowing out of the cooler, and a gas-turbine power generator connected to the gas-turbine,

- a heater provided in a section, between the cooler and the vaporizer, of the circulation passage; and

- a heat amount adjusting passage connected to the circulation passage so that the water flowing from the cooler toward the vaporizer bypasses the heater; wherein

- the vaporizer includes

- an intermediate fluid evaporator configured to exchange heat between an intermediate fluid and water flowing out of the cooler to evaporate at least a portion of the intermediate fluid, the intermediate fluid having a freezing point lower than a freezing point of water, and

- a liquefied natural gas vaporizing unit configured to exchange heat between the intermediate fluid and the LNG to vaporize at least a portion of the LNG, and

- the heater is configured to exchange heat between natural gas (NG) flowing out of the liquefied natural gas vaporizing unit and water flowing out of the cooler to heat the NG.

2. The natural gas fired combined-cycle power generation system according to claim 1, further comprising:

- a direct expansion turbine driven by NG flowing out of the heater; and

- an expansion turbine power generator connected to the direct expansion turbine.

3. A natural gas fired combined-cycle power generation system comprising:

- a vaporizer configured to heat liquefied natural gas (LNG) with water to vaporize at least a portion of the LNG;

- a cooler configured to exchange heat between water flowing out of the vaporizer and air to cool the air;

- a circulation passage that interconnects the vaporizer and the cooler so as to cause water to flow through the vaporizer and then through the cooler;

- a pump provided on the circulation passage;

- a gas-turbine combined power generation apparatus including a gas-turbine driven by gas including air flowing out of the cooler, and a gas-turbine power generator connected to the gas-turbine;

- a heater provided in a section, between the cooler and the vaporizer, of the circulation passage;

- a direct expansion turbine driven by NG flowing out of the heater;

- an expansion turbine power generator connected to the direct expansion turbine;

- a heater bypass passage that is connected to the circulation passage and bypasses the heater; and

- an additional heater configured to exchange heat between water that flows through the heater bypass passage and NG flowing out of the direct expansion turbine to heat the NG, wherein

- the vaporizer includes

- an intermediate fluid evaporator configured to exchange heat between an intermediate fluid and water flowing out of the cooler to evaporate at least a portion of the intermediate fluid, the intermediate fluid having a freezing point lower than a freezing point of water, and

- a liquefied natural gas vaporizing unit configured to exchange heat between the intermediate fluid and the LNG to vaporize at least a portion of the LNG, and

- the heater is configured to exchange heat between natural gas (NG) flowing out of the liquefied natural gas vaporizing unit and water flowing out of the cooler to heat the NG.

4. The natural gas fired combined-cycle power generation system according to claim 3, further comprising

- a casing that contains the heater and the additional heater all together.

5. The natural gas fired combined-cycle power generation system according to claim 4, wherein
the heater is detachable from the casing.

6. The natural gas fired combined-cycle power generation system according to claim 4, wherein
the additional heater is detachable from the casing.

7. The natural gas fired combined-cycle power generation system according to claim 1, further comprising:
a cooler bypass passage that is connected to the circulation passage and bypasses the cooler; and
a cold heat recovery unit provided on the cooler bypass passage.

8. A natural gas fired combined-cycle power generation method that uses cold heat energy recovered from liquefied natural gas (LNG) in a vaporizer for vaporizing the LNG to cool air to be supplied to a gas-turbine combined power generation apparatus including a gas-turbine and a gas-turbine power generator connected to the gas-turbine, the method comprising:

a vaporizing step of heating the LNG with water to vaporize at least a portion of the LNG; and

a cooling step of cooling air to be supplied to the gas-turbine combined power generation apparatus by cold heat energy that water recovers from the LNG in the vaporizing step,

a step of heating a natural gas, in a heater, by exchanging heat between the natural gas obtained in the vaporizing step and a part of the water used in the cooling step, wherein

in the vaporizing step, heat recovered from air by water by cooling the air in the vaporizer in the cooling step is supplied to an intermediate fluid to evaporate at least a portion of the intermediate fluid, and the LNG is heated by the intermediate fluid to vaporize at least a portion of the LNG, the intermediate fluid having a freezing point lower than a freezing point of water, and

the remaining part of the water used in the cooling step flows into the vaporizer without flowing in the heater.