Description

Title of Invention: RECEIVING EQUIPMENT FOR LIQUEFIED NATURAL GAS

Technical Field

[0001] The present invention relates to a technology of utilizing a boil off gas to be generated in a storage tank that stores a liquefied natural gas.

Background Art

[0002] A natural gas produced at a wellhead in a gas field is cooled and liquefied to be stored in a storage tank (LNG tank) as a liquefied natural gas (LNG), and then is gasified again to be supplied to a consumer through a pipe line. In general, the LNG is transported to a distant consuming area by using an LNG tanker.

[0003] A receiving facility for receiving the LNG from the LNG tanker includes an LNG tank (storage tank) configured to store the LNG therein. In the LNG tank, a nitrogen-based or methane-based boil off gas (BOG) is generated due to heat input from an outer wall of the LNG tank, heat input at the time of reception of the LNG, a liquid-level rise in the LNG tank, or the like.

[0004] The BOG generated in the LNG tank is exhausted externally so as to prevent pressurization in the tank. After a pressure is boosted by a gas compressor, the BOG is discharged together with the vaporized LNG to the consumer or is recondensed to be returned to the LNG tank. However, the former technique needs the boosting

of the pressure of the BOG to a relatively high pressure, resulting in high processing costs such as electricity expenses for operating the compressor. On the other hand, the latter technique has a problem in that nitrogen is circulated and condensed due to the recondensation and return of the BOG containing nitrogen to the LNG tank, resulting in a lowered calorific value of the gas discharged from the LNG tank.

[0005] In this regard, in Patent Literature 1, there is described a technology of generating electric power by using the vaporized gas (BOG) generated in a low-temperature tank (LNG tank) as a fuel for a gas turbine generator so as to effectively use the thus generated electric power and exhaust heat from the gas turbine in a storage equipment for the low-temperature liquefied gas (LNG). However, the gas turbine requires equipment for compressing the fuel gas at a high pressure, and therefore requires high equipment costs. Further, energy conversion efficiency is liable to be lowered under the effects of changes in ambient temperature and load changes.

[0006] Further, in Patent Literature 2, there is described a technology of combusting the BOG generated on an LNG base by a gas engine to generate electric power so that exhaust heat of an exhaust gas is used for power generation by a refrigerant turbine and as heat for vaporization of the LNG.

Citation List

Patent Literature

[0007] [PTL 1] JP 10-267197 A: claim 1, paragraphs 0015-0021, FIG. 1 and FIG. 2

[PTL 2] JP 2012-241604 A: paragraphs 0022-0025, FIG. 1

Summary of Invention

Technical Problem

[0008] In general, the gas engine does not need the compression of the fuel gas at a high pressure as compared with the gas turbine, and can also realize stable energy conversion efficiency over wide ambient temperature and load ranges. On the other hand, for example, the amount of generation of the BOG during the reception of the LNG suddenly increases to several times as large as that during normal operation in the receiving facility for receiving the LNG from the LNG tanker. Further, there is observed a phenomenon in which properties of the BOG also greatly change due to property changes of the LNG to be received.

In Patent Literature 2, however, there is not described a technology of coping with the amount of generation of the BOG and the property changes described above.

[0009] The present invention has been made under the circumstances described above, and has an object to provide a receiving facility for a liquefied natural gas, which is capable of stably processing a boil off gas generated in a storage tank for a liquefied natural gas.

Solution to Problem

[0010] According to one embodiment of the present invention, there is provided a receiving facility for a liquefied natural gas, including:

a storage tank configured to store a liquefied natural gas received from outside;

a send out line including a vaporizer configured to vaporize the liquefied natural gas, the send out line being configured to vaporize the liquefied natural gas fed from the storage tank in the vaporizer to discharge the liquefied natural gas in a gas state;

a boil off gas line including a gas compression unit configured to boost a pressure of a boil off gas generated in the storage tank, the boil off gas line being configured to discharge the boil off gas having the boosted pressure;

a gas engine configured to drive a power generator through use of the boil off gas generated in the storage tank as a fuel; and

a fuel gas line configured to supply the boil off gas in the storage tank to the gas engine.

[0011] According to another embodiment of the present invention, there is provided a receiving facility for a liquefied natural gas, including:

a storage tank configured to store a liquefied natural gas received from outside;

a send out line including a vaporizer configured to vaporize

the liquefied natural gas, the send out line being configured to vaporize the liquefied natural gas fed from the storage tank in the vaporizer to discharge the liquefied natural gas in a gas state;

a boil off gas line including a gas compression unit configured to boost a pressure of a boil off gas generated in the storage tank to recondense the boil off gas, the boil off gas line being configured to return the recondensed boil off gas to the storage tank, or to supply the recondensed boil off gas to the vaporizer;

a gas engine configured to drive a power generator through use of the boil off gas generated in the storage tank as a fuel; and

a fuel gas line configured to supply the boil off gas in the storage tank to the gas engine.

[0012] The receiving facility for a liquefied natural gas may have the following features.

(a) The gas compression unit includes a multi-stage gas compressor, and the fuel gas line is connected to a discharge side of an intermediate stage of the multi-stage gas compressor. Alternatively, the fuel gas line branches off from the boil off gas line on an inlet side of the gas compression unit, and the fuel gas line includes a pressure boosting unit configured to boost the pressure of the boil off gas to be supplied to the gas engine to a receiving pressure of the gas engine.

(b) The receiving facility for a liquefied natural gas further includes a feed cut-off unit configured to stop supply of the boil

off gas to the fuel gas line when a property of the boil off gas to be supplied to the gas engine deviates from a preset reference value. Further, the fuel gas line includes a property analyzing unit configured to detect the property of the boil off gas. At this time, the property of the boil off gas is a methane number or a calorific value.

(c) The fuel gas line includes a gas holder provided therein. Further, the gas holder includes a gas mixing unit configured to mix the boil off gas used currently and a boil off gas of a liquefied natural gas newly received from the outside to reduce a property change of the fuel for the gas engine.

(d) The combustion gas line includes a nitrogen removal unit configured to reduce a concentration of nitrogen contained in the boil off gas to be supplied to the gas engine.

(e) The receiving facility for a liquefied natural gas further includes an exhaust gas heat recovery unit configured to recover exhaust heat of cooling water or exhaust heat of an exhaust gas exhausted from the gas engine, and the exhaust gas heat recovery unit is configured to supply a heat source to at least one of the vaporizer, a calorific-value adjusting unit configured to supply a liquefied petroleum gas for calorific-value adjustment to a vaporized gas, or a heater for the storage tank.

(f) The receiving facility for a liquefied natural gas further includes a power supply unit configured to supply electric power generated by the power generator to power consuming equipment inside

the receiving facility for a liquefied natural gas.

Advantageous Effects of Invention

[0013] The present invention provides both the boil off gas line configured to boost the pressure of the boil off gas generated in the storage tank for the liquefied natural gas to discharge the boil off gas, or to recondense the boil off gas to return the recondensed boil off gas to the storage tank or supply the recondensed boil off gas to the vaporizer, and the fuel gas line configured to supply the boil off gas to the gas engine. Therefore, an appropriate processing line can be selected in accordance with the amount of generation or property changes of the boil off gas, thereby enabling stable operation.

Brief Description of Drawings

[0014] FIG. 1 is an explanatory diagram for illustrating a configuration example of an LNG receiving facility according to an embodiment of the present invention.

FIG. 2 is a flowchart for illustrating a flow of determination for interruption of supply of a BOG to a fuel gas line in the LNG receiving facility.

FIG. 3 is an explanatory diagram for illustrating a configuration example of an LNG receiving facility according to another embodiment of the present invention.

FIG. 4 is an explanatory diagram for illustrating a

configuration example of an LNG receiving facility according to a further embodiment of the present invention.

Description of Embodiments

[0015] Now, an embodiment in which the present invention is applied to a receiving facility for receiving an LNG transported by an LNG tanker 1 is described referring to FIG. 1.

The receiving facility includes an LNG tank 2 configured to store the LNG, LNG pumps 21 and 41 configured to feed the LNG from the LNG tank 2 so as to discharge a gas to a consumer 7, an LNG vaporizer 42 configured to vaporize the LNG into a gas state, and a calorific-value adjusting unit 43 configured to mix a liquefied petroleum gas (LPG) for calorific-value adjustment to the vaporized gas.

[0016] The LNG tank 2 is a storage tank configured to store the LNG received from the LNG tanker 1 in a liquid state cooled at about -162°C. A type (such as an aboveground tank, an underground tank, or an in-ground tank) and a capacity thereof are not particularly limited. A heater is provided to the LNG tank so as to prevent ground freezing. For example, heaters are provided to a lateral face and a bottom face in the case of the underground tank, whereas a heater is provided to a bottom face in the case of the aboveground tank. In FIG. 1, an example of the aboveground tank whose upper part of a lateral wall having a cylindrical shape is covered with a dome-like roof is illustrated. A heater 22 configured to circulate a heat

medium for preventing the ground freezing is provided to a bottom face of the LNG tank 2.

[0017] An LNG unloading line 101 configured to receive the LNG unloaded from the LNG tanker 1 through an unloading arm 11 to the LNG tank 2 and an LNG send out line 102a configured to feed the LNG through the LNG pump 21 provided inside the LNG tank 2 are connected to the LNG tank 2. The feed pump 41 for pressure boosting is provided in the LNG send out line 102a, and has a terminal end portion connected to the LNG vaporizer 42.

[0018] The LNG vaporizer 42 is equipment configured to vaporize the LNG fed from the LNG tank 2 in a liquid state so as to discharge the vaporized LNG as a gas having a pressure adjusted to that required at the consumer 7. Hitherto, as the LNG vaporizer 42, there have been used an LNG vaporizer of an open rack type that uses seawater to vaporize the LNG, an LNG vaporizer of a submerged combustion type that bubbles a combustion gas, which is obtained by combusting the gas in a gas burner that is open downward in a water bath, into water contained in the water bath, to thereby vaporize the LNG with heated hot water, and the like. In the receiving facility of this embodiment, exhaust heat of cooling water for a gas engine 6 or exhaust heat of an exhaust gas described later may be used. Therefore, the LNG vaporizer may be constructed as the LNG vaporizer 42 of a system that heats and vaporizes the LNG through direct heat exchange with the exhaust gas or indirect heat exchange through a heat medium heated by the exhaust gas.

[0019] The LNG vaporizer 42 is connected to a vaporized-gas send out line 102b configured to discharge the vaporized gas. A terminal end portion of the vaporized-gas send out line 102b is connected to the calorific-value adjusting unit 43. The calorific-value adjusting unit 43 is equipment configured to mix the LPG for calorific-value adjustment with the vaporized gas to discharge a product gas having a calorific value required by the consumer 7. To the calorific-value adjusting unit 43, the LPG (butane or propane) stored in an LPG tank 8 is fed in a liquid state through an LPG pump 81. The LPG is vaporized by using a heat medium in the calorific-value adjusting unit 43 to be mixed with the vaporized gas fed from the LNG vaporizer 42 side so that a product gas is obtained. The product gas having the calorific value adjusted by the LNG vaporizer 42 is discharged to the consumer 7 through a shipping line 105.

The LNG send out line 102a, the vaporized-gas send out line 102b, and the shipping line 105 located in a site of the receiving facility as described above correspond to a send out line of this embodiment.

[0020] The LNG receiving facility having the basic configuration described above includes equipment for processing a BOG generated in the LNG tank 2. Now, a configuration example of the equipment for processing the BOG is described.

As illustrated in FIG. 1, a BOG exhaust line 103a configured to exhaust the BOG generated inside the LNG tank 2 is connected

to the LNG tank 2. The BOG exhaust line 103a is connected to a BOG compressor 3 that is a compression unit configured to boost a pressure of the BOG.

[0021] The BOG compressor 3 of this embodiment is constructed as a multi-stage gas compressor including, for example, three compression stages 31 to 33. The BOG compressor 3 boosts, for example, a pressure of the BOG of about 12 kPa-G to 22 kPa-G on a suction side of the compression stage 31 to about 2 MPa-G to 7.5 MPa-G. After flowing through a high-pressure BOG line 103b, the BOG whose pressure has been boosted by the BOG compressor 3 merges into the vaporized-gas send out line 102b through which the vaporized gas flows. After the calorific value thereof is adjusted, the BOG is discharged to the consumer 7 as a product gas.

The BOG exhaust line 103a and the high-pressure BOG line 103b constitute a boil off gas line of this embodiment.

[0022] Further, the LNG receiving facility according to this embodiment utilizes the BOG as a fuel gas for the gas engine 6 to use electric power generated by driving a power generator 61 and exhaust heat of cooling water for the gas engine or exhaust heat of a combustion exhaust gas of the fuel gas in each of equipment inside the receiving facility.

As described in the "Background Art" section, the gas engine 6 can use a fuel gas at a low pressure as compared with a gas turbine. On the other hand, the BOG exhausted from the LNG tank 2 does not have a pressure that is high enough to be directly used. Further,

the pressure of the BOG after being boosted by the BOG compressor 3 is excessively high. Therefore, pressure regulation is required, which will result in an energy loss.

[0023] Therefore, in the receiving facility of this embodiment, an intermediate stage of the BOG compressor 3 that boosts the pressure of the BOG in plural stages is used to extract the BOG on a discharge side of the intermediate stage. In this manner, the BOG whose pressure has been boosted to an appropriate pressure (for example, 0.5 MpaG to 1 MpaG) is supplied to the gas engine 6 as the fuel gas. In the example illustrated in FIG. 1, a base end portion of a fuel gas line 104a configured to supply the fuel gas to the gas engine 6 is connected to a discharge side of the first compression stage 31 of the BOG compressor 3.

[0024] Further, various devices for stably operating the gas engine 6 so as to correspond to the amount of generation of the BOG or property changes are provided to fuel gas lines 104a to 104c configured to supply the BOG to the gas engine 6 as the fuel gas.

A shut-off valve 51 is an on-off valve configured to execute supply and stop of the BOG to a downstream side of the send out line 102a. The shut-off valve 51 functions as a feed cut-off unit configured to stop the supply of the BOG to the downstream side of the fuel gas line 104a when properties of the BOG supplied from the LNG tank 2 side deviate from preset reference values.

[0025] As the properties of the BOG, which serve as references of execution of the supply and the stop of the BOG by the shut-off

valve 51, a methane number and a calorific value may be given.

The methane number is an index indicating unlikelihood of occurrence of knocking in the gas engine (anti-knock performance), and corresponds to an octane number of gasoline in a gasoline engine. A fuel gas having a small methane number is likely to cause knocking, whereas a fuel gas having a large methane number is unlikely to cause knocking. As a method of calculating the methane number, there exist a method standardized by AVL LIST GmbH or a reference determined by California Air Resources Board (CARB) (see "Oil & Gas Review" (Japan Oil, Gas and Metals National Corporation), vol. 39, No. 5, page 20), and the like. As the reference of determination of the supply and interruption of the fuel gas by the shut-off valve 51, the methane number that is calculated in accordance with a calculation method adopted for specifications of the gas engine 6 included in the receiving facility is adopted.

[0026] Further, as the calorific value, an index such as a heating value of heat generated when the BOG is combusted or a Wobbe index obtained by dividing the heating value by a 1/2 root of a BOG specific gravity is adopted.

For the methane number and the calorific value required for the BOG supplied as the fuel gas to the gas engine 6, ranges of reference values are preset as the specifications of the gas engine 6.

[0027] Further, in the BOG exhaust line 103a, an analyzer 55 (property analyzing unit) consisting of an online methane-number

analyzer or gas calorimeter is provided. The value of the methane number and the calorific value of the BOG detected by the analyzer 55 are output to a control unit 511 including a distributed control system (DCS) that controls the receiving facility or the like so as to be utilized for the determination of an opening and closing operation of the shut-off valve 51.

[0028] A position at which the analyzer 55 is provided is not limited to the fuel gas line 104a on an outlet side of the BOG compressor 3. For example, the analyzer 55 may be provided in the fuel gas line 104b after nitrogen is removed in a PSA unit 52 described later.

Further, the opening and closing of the shut-off valve 51 may be determined not only by providing the online analyzer 55 in the fuel gas line 104a but also based on a result of periodical sampling and off-line analysis of the BOG supplied to the fuel gas line 104a.

[0029] On a downstream side of the shut-off valve 51, the pressure swing adsorption (PSA) unit 52 that is a nitrogen removal unit configured to reduce a concentration of nitrogen (N_2) contained in the BOG serving as the fuel gas for the gas engine 6 is provided. The PSA unit 52 includes two adsorption columns, each being filled with an adsorbent for adsorbing nitrogen, through one of which the BOG is forced to flow to adsorb and remove nitrogen contained in the BOG. In another adsorption column through which the BOG does not flow, a regenerating operation for lowering a pressure inside the tower to desorb nitrogen from the adsorbent so as to exhaust nitrogen together with air supplied into the tower or the like is

performed.

[0030] Then, by alternately switching the absorption column in which nitrogen is adsorbed and the absorption column in which the regenerating operation for the adsorbent is performed, processing of removing nitrogen from the BOG can be continuously performed.

The nitrogen removal method adopted in the nitrogen removal unit is not limited to the PSA method. For example, a cryogenic distillation method for cooling and liquefying the BOG so as to separate the BOG into nitrogen and a fuel gas component such as methane by distillation may be adopted.

[0031] The BOG from which nitrogen is removed in the PSA unit 52 is introduced into a gas holder 53 through the fuel gas line 104b. The gas holder 53 temporarily stores the BOG to be supplied to the gas engine 6 as the fuel gas. A configuration of the gas holder 53 is not limited to a special form. In this embodiment, a configuration including a piston 532 to be moved up and down in accordance with the amount of BOG stored in the gas holder 53 is exemplified.

[0032] Further, inside the gas holder 53, baffle plates 531 for mixing the BOG in the gas holder 53 and the BOG received from the fuel gas line 104b are arranged. The baffle plates 531 serve as a gas mixing unit configured to sufficiently mix the BOG in the gas holder 53, which has been used currently, and the BOG generated from new LNG to reduce a property change of the fuel gas supplied

to the gas engine 6 when the properties of the BOG greatly change due to the property changes of the LNG received from the LNG tanker 1.

[0033] The BOG in the gas holder 53 described above is supplied to the gas engine 6 through the fuel gas line 104c. The gas engine 6 is an internal combustion engine that can drive the power generator 61 by using the methane-based BOG as the fuel gas to generate electric power. The gas engine 6 can operate within a wide load range of, for example, from 30% to 100%, and has a characteristic of being unsusceptible to the effects of a change in ambient temperature as compared with the gas turbine.

[0034] The electric power generated by driving the power generator 61 by the gas engine 6 is supplied to power consuming equipment such as motors for the BOG compressor 3, the LNG pumps 21 and 41, and 81, and a lighting device provided inside the receiving facility through a power supply unit 62 that is a power supply equipment.

Further, an exhaust gas generated after combusting the BOG in the gas engine 6 and driving internal cylinders is used to vaporize the LNG and LPG in the LNG vaporizer 42 and the calorific-value adjusting unit 43 and to heat the bottom face of the LNG tank 2 and the like. When cooling water is used as a heat source, the cooling water serves as a heat medium to supply heat to the LNG vaporizer 42, the calorific-value adjusting unit 43, and the heater 22. When the cooling water and the exhaust gas themselves are used as the

heat source, the cooling water and the exhaust gas exhausted from the gas engine 6 are directly supplied to the LNG vaporizer 42, the calorific-value adjusting unit 43, and the heater 22. In this case, these equipment 42, 43, and 22 form an exhaust gas heat recovery unit. Further, when a steam or hot water is generated by a boiler (not shown) using heat of the exhaust gas to be used as a heat medium (heat source), the boiler serves as the exhaust gas heat recovery unit.

[0035] A specific example of an operation of processing the BOG generated in the LNG tank 2 in the LNG receiving facility whose configuration has been described above is described. FIG. 2 is a flowchart for illustrating a flow of determination of opening and closing of the shut-off valve 51.

It is assumed that, for example, the BOG at 5 t/h (tons per hour) is generated while the LNG tank 2 illustrated in FIG. 1 is not receiving the LNG from the LNG tanker 1. The gas engine 6 has an output capable of sufficiently generating the electric power to be consumed in the receiving facility, and consumes the BOG at, for example, 1 t/h on power consumption balance.

[0036] Therefore, the amount corresponding to 4 t/h of the BOG supplied to the BOG compressor 3 through the BOG exhaust line 103a is mixed with the vaporized gas to be discharged as a product gas to the consumer 7. The amount of feeding of the LNG to be fed from the LNG tank 2 is increased or decreased in consideration of the above-mentioned amount of mixed BOG.

[0037] On the other hand, the BOG to be supplied to the gas engine 6 as the fuel gas is branched from the intermediate stage of the BOG compressor 3 to the fuel gas line 104a, and is measured by the analyzer 55 for the methane number and the calorific value (START in FIG. 2). When both the methane number and the calorific value of the BOG satisfy the reference values (YES in Step S101 and YES in Step S102 of FIG. 2), the BOG is supplied to the downstream side through the fuel gas line 104a (Step S103 of FIG. 2).

[0038] After nitrogen is removed from the BOG supplied from the fuel gas line 104a in the PSA unit 52, the BOG flows into the gas holder 53 to be temporarily stored therein and is subsequently supplied to the gas engine 6 to be combusted as the fuel gas. The electric power generated by the combustion of the BOG is consumed in the BOG compressor 3, the LNG pumps 21 and 41, and the like. Further, the exhaust heat of the cooling water and the exhaust heat of the combustion exhaust gas exhausted from the gas engine 6 are used in the LNG vaporizer 42, the calorific-value adjusting unit 43, and the heater 22.

[0039] The reception of the LNG from the LNG tanker 1 is carried out once to about several times a month. During the reception, the amount of generation of the BOG in the LNG tank 2 increases to several times, for example, to about four times as large as that during normal operation. In this case, the amount of BOG to be mixed with the vaporized gas through the BOG compressor 3 is increased, while the amount of LNG to be fed from the LNG tank 2 is decreased to

absorb the amount of increased BOG. At this time, the gas engine 6 consumes the BOG in balance with the amount of power consumption in the receiving facility.

Further, when the amount of BOG that exceeds the amount mixable with the vaporized gas is generated, the amount of supply to the fuel gas line 104a may be increased to temporarily increase the amount of BOG stored in the gas holder 53.

[0040] At a timing of reception of the LNG from the LNG tanker 1, the properties of the LNG sometimes greatly change depending on different production areas or wells. In such a case, the properties of the BOG generated in the LNG tank 2 also greatly change to change a combustion condition of the BOG in the gas engine 6. However, the gas holder 53 is provided on the inlet side of the gas engine 6. The BOG that is used currently and the BOG generated from the new LNG are mixed by the baffle plates 531. Therefore, the changes in properties of the BOG to be combusted in the gas engine 6 proceed slowly. As a result, the gas engine 6 can follow the changes in BOG properties well in time, and can continue operation while changing operating conditions such as an air supply amount.

Further, the PSA unit 52 is provided between the fuel gas line 104a and the fuel gas line 104b of this embodiment. Therefore, even when the property change corresponding to an increase in nitrogen concentration of the BOG occurs, nitrogen content is reduced to enable the supply of the fuel gas having a stable calorific value to the gas engine 6.

[0041] On the other hand, when a variation range of the properties of the BOG is large and the value of the methane number or the calorific value deviates from the reference value that allows the use in the gas engine 6 (NO in Step S101 or NO in Step S102 of FIG. 2), the shut-off valve 51 is closed to stop the supply of the BOG from the fuel gas line 104a to the downstream side (Step S104 of FIG. 2). Even when the supply of the BOG from the fuel gas line 104a is stopped, the BOG is stored in the gas holder 53. Therefore, the gas engine 6 can continue operation.

[0042] Further, when the property change of the BOG is likely to occur over a long period of time, the operation of the gas engine 6 is slowed down so as to continue the operation of the gas engine 6 with the BOG stored in the gas holder 53. As a result, when the amount of electric power generated by the power generator 61 is reduced to fail to sufficiently supply the electric power to the power consuming equipment in the receiving facility, electric power only needs to be purchased externally.

[0043] In the above-mentioned example where the supply of the BOG to the downstream side of the fuel gas line 104a is stopped, the BOG that is not sent to the gas engine 6 side is mixed with the vaporized gas through the high-pressure BOG line 103b. At this time, when the amount of BOG that exceeds the amount mixable with the vaporized gas is generated, surplus BOG may be exhausted to a flare stack (not shown) to be combusted therein.

[0044] For example, on the fuel gas line 104a on the upstream

side of the shut-off valve 51, a recycle line (not shown) for returning the BOG recycled from the intermediate stage of the BOG compressor 3 to a suction side of the BOG compressor 3 is provided so as to enable the analysis of the fuel gas by the analyzer 55 even when the supply of the BOG to the downstream side is stopped. Then, when the properties of the BOG detected by the analyzer 55 have values within the reference values, the shut-off valve 51 is opened to supply the BOG to the downstream side of the fuel gas line 104a (YES in Step S101, YES in Step S102, and Step S103 of FIG. 3). At this time, in order to complement for the BOG in the gas holder, which is consumed during a time period in which the shut-off valve 51 is closed, the amount of BOG to be supplied to the gas holder 53 may be temporarily increased to be larger than the amount of consumption of the BOG in the gas engine 6.

[0045] According to the LNG receiving facility of the embodiment of the present invention, the following effects are obtained. The LNG send out line 102a configured to boost the pressure of the BOG generated in the LNG tank 2 to discharge the BOG, the vaporized-gas send out line 102b, the send out line 105, and the fuel gas lines 104a to 104c configured to supply the BOG to the gas engine 6 are all provided. Therefore, an appropriate processing line can be selected in accordance with the amount of generation of the BOG or the property changes to enable the stable operation.

[0046] Next, in FIG. 3, there is illustrated an example where the gas engine 6 is provided in the LNG receiving facility that

recondenses the BOG. The receiving facility of this embodiment differs from the embodiment illustrated in FIG. 1 in that the number of the compression stages 31 and 32 of a BOG compressor 3a is smaller than that of the BOG compressor 3 illustrated in FIG. 1 to provide a lower discharging pressure, that a condenser 44 configured to cool and recondense the BOG through heat exchange with the LNG is provided in a stage subsequent to the BOG compressor 3a, and that the BOG recondensed in the condenser 44 is collected in the LNG tank 2 through the recondensed BOG line 103a or merges into the LNG fed from the LNG tank 2 through a recondensed BOG send out line 107 to be discharged to the consumer 7.

[0047] As described in the "Background Art" section, the receiving facility for recovering the recondensed BOG has a problem in that nitrogen is concentrated through circulation. However, by constantly exhausting the BOG to the gas engine 6, the degree of concentration of nitrogen can be reduced. Further, the BOG from which nitrogen is removed in the PSA unit 52 is supplied as the fuel gas to the gas engine 6. Therefore, even when nitrogen is concentrated due to the recondensation of the BOG, the effects of the increase in nitrogen concentration on the gas engine 6 can be suppressed.

[0048] Here, the BOG flowing through the high-pressure BOG line 103b illustrated in FIG. 1 is not only mixed with the vaporized gas in the vaporized-gas send out line 102b to be discharged. For example, the BOG may be directly discharged to the calorific-value

adjustment without being mixed with the vaporized gas so as to be discharged as a product gas.

[0049] Further, the method of adjusting the pressure of the BOG to be supplied to the gas engine 6 is not limited to a method of extracting the BOG from the intermediate stage of the BOG compressor 3 or 3a having plural stages. For example, as illustrated in FIG. 4, the fuel gas line 104a may branch off on an inlet side of the BOG compressor 3, and a fuel gas compressor 54 (pressure boosting unit) for pressure boosting may be provided in the fuel gas line 104a to boost the pressure of the BOG to a receiving pressure of the gas engine 6 (for example, 0.5 MpaG to 1 MpaG).

[0050] As described above, in FIG. 1, FIG. 3, and FIG. 4, the examples of the receiving facility of type that receives the LNG from the LNG tanker 1 and vaporizes the LNG in the LNG vaporizer 42 to ship the LNG to the consumer 7 have been described. However, a facility to which the present invention is applicable is not limited to the receiving facility of type that receives the LNG from the LNG tanker 1. For example, the present invention is also applicable to a delivery facility on an LNG liquefaction base that receives the LNG obtained by cooling and liquefying a natural gas produced at a wellhead in a gas field. In this case, a base of connection of the LNG unloading line 101 illustrated in each of the above-mentioned figures is the delivery facility on the LNG liquefaction base installed in the gas field in place of the LNG tanker 1.

[0051] Further, in the case of the delivery facility on the LNG liquefaction base that receives the LNG obtained by cooling and liquefying the natural gas produced at the wellhead in the gas field, when the LNG in the LNG tank 2 is to be delivered, the vaporization of the LNG is not indispensable. For example, the present invention is also applicable to delivery facility on an LNG liquefaction base having a configuration of delivering the LNG in the LNG tank 2 still in a liquid state to the LNG tanker 1.

[0052] Further, in the LNG receiving facility according to the present invention, providing all of the shut-off valve 51 (feed cut-off unit), the PSA unit 52 (nitrogen removal unit), and the gas holder 53 to the fuel gas lines 104a to 104c is not an indispensable requirement. Any one of the above-mentioned equipment 51, 52, and 53 may be selected to be provided in accordance with the property changes of the LNG and the BOG stored in the LNG tank 2 and changes in the amount of generation of the BOG.

[0053] Further, for example, in a receiving facility including a plural tanks 2 on the same site, providing the fuel gas lines 104a and 104b and the gas engine 6 to all the LNG tanks 2 is not indispensable. Only the fuel gas lines 104a and 104b (with the installation of the fuel gas compressor 54 illustrated in FIG. 4) may be provided to one of the plural LNG tanks 2 so that the BOG generated in the corresponding LNG tank 2 is entirely used as the fuel gas for the gas engine 6. On the other hand, another LNG tank 2 includes the BOG exhaust line 103a through the BOG compressor

3 to the high-pressure BOG line 103b (FIG. 1) or the BOG exhaust line 103a through the BOG compressor 3a to the recondensed BOG line 103c and the recondensed BOG send out line 107 (FIG. 3) so as not to supply the BOG to the gas engine 6 as in the related art. A line branches off from the fuel gas line 104a of the LNG tank 2 connected to the gas engine 6 to be connected to the BOG exhaust line 103a of the another LNG tank 2.

[0054] As a result, when viewed as the whole receiving facility including the plural LNG tanks 2, the receiving facility has a configuration including all of a system that boosts the pressure of the BOG to discharge the BOG (BOG exhaust line 103a-BOG compressor 3-high-pressure BOG line 103b) or a system that recondenses, recovers, and discharges the BOG (BOG exhaust line 103a-BOG compressor 3a-recondensed BOG line 103c and recondensed BOG send out line 107), and the fuel gas lines 104a to 104c configured to supply the BOG to the gas engine 6.

[0055] In the above-mentioned manner, when a total amount of the BOG generated in one of the LNG tanks 2 is combusted in the gas engine 6 and electric power generated by power generation exceeds the amount of power consumption in the receiving facility, surplus electric power can be sold. When the properties of the BOG deviate from the references that are acceptable in the gas engine 6, the BOG generated in the corresponding LNG tanks 2 only needs to be discharged to the BOG exhaust line 103a of another LNG tank 2 through the above-mentioned branch line so that the supply of the BOG to

the gas engine 6 is stopped.

Reference Signs List

[0056]

1	LNG tanker
102a	LNG send out line
102b	vaporized-gas send out line
103a	BOG exhaust line
103b	high-pressure BOG line
103c	recondensed BOG line
104a-104c	fuel gas line
105	send out line
107	recondensed BOG send out line
2	LNG tank
22	heater
3, 3a	BOG compressor
31-33	compression stage
42	LNG vaporizer
43	calorific-value adjusting unit
51	shut-off valve
52	PSA unit
53	gas holder
531	baffle plate
54	fuel gas compressor
55	analyzer
6	gas engine

61 power generator

62 power supply unit

Claims

[Claim 1] A receiving facility for a liquefied natural gas, comprising:

a storage tank configured to store a liquefied natural gas received from outside;

a send out line comprising a vaporizer configured to vaporize the liquefied natural gas, the send out line being configured to vaporize the liquefied natural gas fed from the storage tank in the vaporizer to discharge the liquefied natural gas in a gas state;

a boil off gas line comprising a gas compression unit configured to boost a pressure of a boil off gas generated in the storage tank, the boil off gas line being configured to discharge the boil off gas having the boosted pressure;

a gas engine configured to drive a power generator through use of the boil off gas generated in the storage tank as a fuel; and

a fuel gas line configured to supply the boil off gas in the storage tank to the gas engine.

[Claim 2] A receiving facility for a liquefied natural gas, comprising:

a storage tank configured to store a liquefied natural gas received from outside;

a send out line comprising a vaporizer configured to vaporize the liquefied natural gas, the send out line being configured to

vaporize the liquefied natural gas fed from the storage tank in the vaporizer to discharge the liquefied natural gas in a gas state;

a boil off gas line comprising a gas compression unit configured to boost a pressure of a boil off gas generated in the storage tank to recondense the boil off gas, the boil off gas line being configured to return the recondensed boil off gas to the storage tank, or to supply the recondensed boil off gas to the vaporizer;

a gas engine configured to drive a power generator through use of the boil off gas generated in the storage tank as a fuel; and

a fuel gas line configured to supply the boil off gas in the storage tank to the gas engine.

[Claim 3] A receiving facility for a liquefied natural gas according to claim 1 or 2, wherein:

the gas compression unit comprises a multi-stage gas compressor; and

the fuel gas line is connected to a discharge side of an intermediate stage of the multi-stage gas compressor.

[Claim 4] A receiving facility for a liquefied natural gas according to claim 1 or 2, wherein:

the fuel gas line branches off from the boil off gas line on an inlet side of the gas compression unit; and

the fuel gas line comprises a pressure boosting unit configured

to boost the pressure of the boil off gas to be supplied to the gas engine to a receiving pressure of the gas engine.

[Claim 5] A receiving facility for a liquefied natural gas according to claim 1 or 2, further comprising a feed cut-off unit configured to stop supply of the boil off gas to the fuel gas line when a property of the boil off gas to be supplied to the gas engine deviates from a preset reference value.

[Claim 6] A receiving facility for a liquefied natural gas according to claim 5, wherein the fuel gas line comprises a property analyzing unit configured to detect the property of the boil off gas.

[Claim 7] A receiving facility for a liquefied natural gas according to claim 5, wherein the property of the boil off gas comprises a methane number.

[Claim 8] A receiving facility for a liquefied natural gas according to claim 5, wherein the property of the boil off gas comprises a calorific value.

[Claim 9] A receiving facility for a liquefied natural gas according to claim 1 or 2, wherein the fuel gas line comprises a gas holder provided therein.

[Claim 10] A receiving facility for a liquefied natural gas according to claim 9, wherein the gas holder comprises a gas mixing unit configured to mix the boil off gas used currently and a boil off gas of a liquefied natural gas newly received from the outside to reduce a property change of the fuel for the gas engine.

[Claim 11] A receiving facility for a liquefied natural gas according to claim 1 or 2, wherein the combustion gas line comprises a nitrogen removal unit configured to reduce a concentration of nitrogen contained in the boil off gas to be supplied to the gas engine.

[Claim 12] A receiving facility for a liquefied natural gas according to claim 1 or 2, further comprising an exhaust gas heat recovery unit configured to recover exhaust heat of cooling water or exhaust heat of an exhaust gas exhausted from the gas engine,

wherein the exhaust gas heat recovery unit is configured to supply a heat source to at least one of the vaporizer, a calorific-value adjusting equipment configured to supply a liquefied petroleum gas for calorific-value adjustment to a vaporized gas, or a heater for the storage tank.

[Claim 13] A receiving facility for a liquefied natural gas according to claim 1 or 2, further comprising a power supply equipment configured to supply electric power generated by the power generator to a power consuming equipment inside the receiving facility for a liquefied

natural gas.