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

[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

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

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

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

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.

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.

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 fuel 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

[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 calorific-value adjusting unit 43 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

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 fuel gas line 104a. 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

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 the LPG pump 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

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. 2). 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

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.

Claims

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

a storage tank configured to store a liquefied natural gas;

an unloading line configured to receive the liquefied natural gas from an external liquefied natural gas tanker to the storage tank;

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 to the send out line;

a gas engine configured to drive a power generator;

a fuel gas line provided so as to branch off from the boil off gas line, the fuel gas line being configured to supply the boil off gas generated in the storage tank as a fuel to the gas engine; and

a gas holder provided in the fuel gas line, the gas holder comprising a gas mixing unit configured to absorb a change in amount of supply of the boil off gas to be supplied to the fuel gas line and to reduce a property change of the boil off gas to be supplied to the gas engine during reception of the liquefied natural gas through the unloading line.

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

a storage tank configured to store a liquefied natural gas;

an unloading line configured to receive the liquefied natural gas from an external liquefied natural gas tanker to the storage tank;

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;

a fuel gas line provided so as to branch off from the boil off gas line, the fuel gas line being configured to supply the boil off gas generated in the storage tank as a fuel to the gas engine; and

a gas holder provided in the fuel gas line, the gas holder comprising a gas mixing unit configured to absorb a change in amount of supply of the boil off gas to be supplied to the fuel gas line and to reduce a property change of the boil off gas to be supplied to the gas engine during reception of the liquefied natural gas through the unloading line.

[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 a stage on an inlet side of a final stage of the multi-stage gas compressor to branch off from the boil off gas line so that the boil off gas having the pressure boosted to a receiving pressure of the gas engine is supplied to the gas engine.

[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 nitrogen removal unit configured to reduce a concentration of nitrogen contained in the boil off gas to be supplied to the gas engine.

[Claim 10] 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 11] 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.