

DESCRIPTION

TITLE OF INVENTION: AMMONIA RECEIVING FACILITY

TECHNICAL FIELD

5 [0001]

The present disclosure relates to an ammonia receiving facility.

Priority is claimed on Japanese Patent Application No. 2024-006364, filed January 18, 2024, the content of which is incorporated herein by reference.

BACKGROUND ART

10 [0002]

For example, Patent Document 1 discloses a combustion device capable of burning ammonia as a fuel. The combustion device disclosed in Patent Document 1 is installed in a boiler, and ammonia supplied from an ammonia supply source is mixed and burned together with pulverized coal.

15 Citation List

Patent Document

[0003]

Patent Document 1: Japanese Unexamined Patent Application, First Publication No. 2019-86189

20 SUMMARY OF INVENTION

Technical Problem

[0004]

A large-scale boiler for power generation using liquefied natural gas (LNG) or liquefied petroleum gas (LPG) as a fuel is provided with a receiving facility for storing
25 LNG or the like. The receiving facility vaporizes a fuel such as LNG and supplies a

required amount of vaporized gas to a boiler or a gas turbine. The receiving facility is provided with apparatuses that use nitrogen gas for maintenance, shaft sealing of rotating equipment, replacement work of a process fluid, or the like. Since the nitrogen gas used for such work includes vaporized gas such as LNG, the nitrogen gas is often returned to a process pipe and is ultimately delivered to a power generation facility as a part of a fuel gas. However, ammonia gas is less likely to burn than fossil fuels such as LNG or LPG. Therefore, when a large amount of nitrogen gas, which is an inert gas, is supplied to the boiler, stable combustion may be hindered. On the other hand, since ammonia gas is toxic, it is necessary to detoxify the ammonia gas using a detoxification facility such as a ground flare before being released to the atmosphere. In a case where the entire amount of nitrogen gas mixed with ammonia is treated by a detoxification facility such as a ground flare, the detoxification facility has to be large in size. In addition, in a case where a large amount of fossil fuel is required for the detoxification facility, the detoxification facility does not meet the demand of the times for decarbonization.

[0005]

The present disclosure has been made in view of the above-described problems, and an object of the present disclosure is, in an ammonia receiving facility that vaporizes liquid ammonia for supply to a supply destination, to suppress the supply amount of nitrogen gas recovered from a nitrogen gas-using apparatus to a detoxification facility.

20 Solution to Problem

[0006]

The present disclosure adopts the following configurations to solve the above problems.

[0007]

According to a first aspect of the present disclosure, an ammonia receiving facility includes an ammonia tank that stores liquid ammonia, an ammonia gas delivery portion that vaporizes the liquid ammonia and delivers vaporized ammonia to a supply destination, a boil-off gas supply portion that is capable of supplying boil-off gas

5 generated in the ammonia tank to the ammonia gas delivery portion, a nitrogen gas recovery portion that supplies nitrogen gas recovered from a nitrogen gas-using apparatus to the boil-off gas supply portion and mixes the nitrogen gas with the boil-off gas, a gas calorific value detection portion that detects a gas calorific value of ammonia gas delivered from the ammonia gas delivery portion, a treatment facility that is capable of
10 separating the nitrogen gas from the boil-off gas and supplying the separated nitrogen gas to a detoxification facility, and a control unit configured to cause the boil-off gas supply portion to supply the boil-off gas to the treatment facility in a case where the gas calorific value is lower than a predetermined threshold.

Advantageous Effects of Invention

15 [0008]

According to the present disclosure, the nitrogen gas recovered in the nitrogen gas recovery portion is mixed with the boil-off gas and further mixed with the ammonia gas (vaporized gas) to be delivered to the supply destination. In a case where the calorific value of the ammonia gas delivered to the supply destination is higher than the
20 predetermined threshold, the boil-off gas is supplied to the supply destination. On the other hand, in a case where the calorific value of the ammonia gas supplied to the supply destination is lower than the predetermined threshold, the boil-off gas is supplied to the treatment facility without being delivered to, for example, a gas delivery pipe. In a case where the boil-off gas is supplied to the treatment facility, for example, a gas containing a
25 large amount of nitrogen that is not re-liquefied in a condenser is separated from the boil-

off gas and supplied to the detoxification facility. In this manner, in the present disclosure, the nitrogen gas is supplied to the detoxification facility only in a case where the concentration of the nitrogen gas contained in the ammonia gas supplied to the supply destination is high and the calorific value of the mixed gas is lower than the predetermined threshold. Therefore, according to the present disclosure, in the ammonia receiving facility that vaporizes the liquid ammonia for supply to the supply destination, it is possible to suppress the supply amount of the nitrogen gas recovered from the nitrogen gas-using apparatus to the detoxification facility.

BRIEF DESCRIPTION OF DRAWINGS

10 [0009]

[FIG. 1] A flow diagram showing a schematic configuration of an ammonia receiving facility according to a first embodiment of the present disclosure.

[FIG. 2] A flowchart for describing an operation of a control unit provided in the ammonia receiving facility according to the first embodiment of the present disclosure.

15 [FIG. 3] A flow diagram showing a schematic configuration of an ammonia receiving facility according to a second embodiment of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0010]

Hereinafter, embodiments of an ammonia receiving facility according to the present disclosure will be described with reference to the drawings.

[0011]

(First Embodiment)

FIG. 1 is a flow diagram showing a schematic configuration of an ammonia receiving facility 1 of the present embodiment. The ammonia receiving facility 1 of the present embodiment stores liquid ammonia X. In addition, the ammonia receiving

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facility 1 of the present embodiment vaporizes the stored liquid ammonia X to produce ammonia gas Y. In addition, the ammonia receiving facility 1 of the present embodiment supplies a required amount of the ammonia gas Y to a boiler B (supply destination). The supply destination of the ammonia gas Y of the ammonia receiving facility 1 is not limited to the boiler B, and may be a gas turbine or the like.

[0012]

As shown in FIG. 1, the ammonia receiving facility 1 of the present embodiment includes an ammonia tank 2, an ammonia gas delivery portion 3, a boil-off gas supply portion 4, a nitrogen gas recovery portion 5, a treatment facility 6, a gas analyzer 7 (gas calorific value detection portion), and a control unit 8.

[0013]

The ammonia tank 2 is a tank that stores the liquid ammonia X. The ammonia tank 2 stores the liquid ammonia X supplied from the outside in a state of being held at a low temperature. The ammonia tank 2 is, for example, a PC concrete double-shell tank including a metal inner shell and a PC concrete containment dike. The ammonia tank 2 includes, for example, a heat insulating material filled between the containment dike and the inner shell, and stores the liquid ammonia X inside the inner shell in a low temperature state. However, the structure of the ammonia tank 2 is not particularly limited.

[0014]

The ammonia gas delivery portion 3 vaporizes the liquid ammonia X and delivers the vaporized ammonia to the boiler B. As shown in FIG. 1, the ammonia gas delivery portion 3 includes a discharge pump 3a, a discharge pipe 3b, a vaporization facility 3c, and a gas delivery pipe 3d.

[0015]

The discharge pump 3a is disposed inside the ammonia tank 2 and pressure-feeds the liquid ammonia X stored in the ammonia tank 2 to the outside of the ammonia tank 2. The discharge pump 3a is connected to, for example, the control unit 8, and discharges a designated amount of the liquid ammonia X to the outside of the ammonia tank 2 based on control of the control unit 8.

[0016]

The discharge pipe 3b is a pipe that connects the ammonia tank 2 and the vaporization facility 3c. An upstream end of the discharge pipe 3b is connected to the ammonia tank 2, and a downstream end of the discharge pipe 3b is connected to the vaporization facility 3c. The discharge pipe 3b guides the liquid ammonia X discharged by the discharge pump 3a from the ammonia tank 2 to the vaporization facility 3c.

[0017]

The vaporization facility 3c heats and vaporizes the liquid ammonia X. The vaporization facility 3c vaporizes the liquid ammonia X supplied from the ammonia tank 2 via the discharge pipe 3b. For example, a heating fluid supply unit (not shown) is connected to the vaporization facility 3c, and a heating fluid such as seawater is supplied to the vaporization facility 3c. The vaporization facility 3c vaporizes the liquid ammonia X through heat exchange between the liquid ammonia X and the heating fluid such as seawater.

[0018]

The gas delivery pipe 3d is a pipe that connects the vaporization facility 3c and the boiler B. An upstream end of the gas delivery pipe 3d is connected to the vaporization facility 3c, and a downstream end of the gas delivery pipe 3d is connected to the boiler B. The downstream end of the gas delivery pipe 3d may not be directly connected to the boiler B. That is, the downstream end of the gas delivery pipe 3d may

be connected to the boiler B via another device or the like. The gas delivery pipe 3d guides the ammonia gas Y discharged from the vaporization facility 3c to the boiler B.

[0019]

The vaporization facility 3c may include a superheater at an intermediate portion
5 of the gas delivery pipe 3d. The superheater vaporizes the mist-like liquid ammonia X contained in the ammonia gas Y flowing through the gas delivery pipe 3d.

[0020]

The boil-off gas supply portion 4 can supply boil-off gas G generated in the ammonia tank 2 to the ammonia gas delivery portion 3. As shown in FIG. 1, the boil-
10 off gas supply portion 4 includes a boil-off gas main pipe 4a (first pipe), a first on-off valve 4b, a boil-off gas treatment facility connection pipe 4c (second pipe), a second on-off valve 4d, a boil-off gas compressor 4e, and an emergency exhaust pipe 4f.

[0021]

The boil-off gas main pipe 4a is a pipe connected to the ammonia gas delivery
15 portion 3. An upstream end of the boil-off gas main pipe 4a is connected to the ammonia tank 2, and a downstream end of the boil-off gas main pipe 4a is connected to the ammonia gas delivery portion 3. The downstream end of the boil-off gas main pipe 4a is connected to the gas delivery pipe 3d of the ammonia gas delivery portion 3. The boil-off gas main pipe 4a guides the boil-off gas G generated inside the ammonia tank 2
20 from the ammonia tank 2 to the gas delivery pipe 3d.

[0022]

The first on-off valve 4b is an on-off valve installed at an intermediate portion of the boil-off gas main pipe 4a. The first on-off valve 4b is opened and closed under the control of the control unit 8. The first on-off valve 4b is disposed at the intermediate
25 portion of the boil-off gas main pipe 4a, near the downstream end of the boil-off gas

main pipe 4a. The first on-off valve 4b is located downstream of a portion of the boil-off gas main pipe 4a to which the boil-off gas treatment facility connection pipe 4c is connected. The boil-off gas G is supplied to the gas delivery pipe 3d in a state where the first on-off valve 4b is open. In addition, the supply of the boil-off gas G to the gas delivery pipe 3d is stopped by closing the first on-off valve 4b.

[0023]

The boil-off gas treatment facility connection pipe 4c is a pipe that connects the boil-off gas main pipe 4a and the treatment facility 6. An upstream end of the boil-off gas treatment facility connection pipe 4c is connected to the boil-off gas main pipe 4a, and a downstream end of the boil-off gas treatment facility connection pipe 4c is connected to the treatment facility 6. The upstream end of the boil-off gas treatment facility connection pipe 4c is connected to the boil-off gas main pipe 4a at an upstream position located upstream of the first on-off valve 4b. That is, the boil-off gas treatment facility connection pipe 4c connects the upstream position of the boil-off gas main pipe 4a located upstream of the first on-off valve 4b and the treatment facility 6. The boil-off gas treatment facility connection pipe 4c guides the boil-off gas G from the boil-off gas main pipe 4a to the treatment facility 6. The downstream end of the boil-off gas treatment facility connection pipe 4c is connected to a condenser 6a of the treatment facility 6, which will be described later.

[0024]

The second on-off valve 4d is an on-off valve installed at an intermediate portion of the boil-off gas treatment facility connection pipe 4c. The second on-off valve 4d is opened and closed under the control of the control unit 8. The boil-off gas G is supplied to the treatment facility 6 in a state where the second on-off valve 4d is open.

In addition, the supply of the boil-off gas G to the treatment facility 6 is stopped by closing the second on-off valve 4d.

[0025]

The boil-off gas compressor 4e is a compressor that increases the pressure of the
5 boil-off gas G flowing through the boil-off gas main pipe 4a, and is installed at an intermediate portion of the boil-off gas main pipe 4a. The boil-off gas compressor 4e is disposed upstream of the portion of the boil-off gas main pipe 4a to which the boil-off gas treatment facility connection pipe 4c is connected. The boil-off gas compressor 4e compresses the boil-off gas G to increase the pressure of the boil-off gas G to a pressure
10 at which the boil-off gas G can be supplied to the gas delivery pipe 3d or the treatment facility 6.

[0026]

The emergency exhaust pipe 4f is a pipe for supplying the boil-off gas G to a ground flare F (detoxification facility) in a case where the pressure of the boil-off gas G
15 becomes excessively high. An upstream end of the emergency exhaust pipe 4f is connected to the boil-off gas main pipe 4a, and a downstream end of the emergency exhaust pipe 4f is connected to a boil-off gas release valve 6d of the treatment facility 6, which will be described later. The upstream end of the emergency exhaust pipe 4f is connected to the boil-off gas main pipe 4a at a position upstream of the boil-off gas
20 compressor 4e.

[0027]

In addition, in the present embodiment, the emergency exhaust pipe 4f functions as a pipe that guides nitrogen gas N recovered by the nitrogen gas recovery portion 5 during normal operation. The nitrogen gas recovery portion 5 is connected to an
25 intermediate portion of the emergency exhaust pipe 4f. The emergency exhaust pipe 4f

causes the nitrogen gas N supplied from the nitrogen gas recovery portion 5 to flow to the boil-off gas main pipe 4a during normal operation (when the boil-off gas release valve 6d is closed). That is, the nitrogen gas N recovered by the nitrogen gas recovery portion 5 flows through the emergency exhaust pipe 4f toward the boil-off gas main pipe 4a and is supplied to the boil-off gas main pipe 4a.

[0028]

The nitrogen gas recovery portion 5 supplies the nitrogen gas N recovered from the nitrogen gas-using apparatus to the boil-off gas supply portion 4 and mixes the nitrogen gas N with the boil-off gas G. As shown in FIG. 1, the nitrogen gas recovery portion 5 includes a pipe that guides the nitrogen gas N from the nitrogen gas recovery portion 5 to the boil-off gas main pipe 4a of the boil-off gas supply portion 4. An upstream portion of the nitrogen gas recovery portion 5 is branched into a plurality of pipes. An upstream end of each of the branched pipes is connected to the nitrogen gas-using apparatus.

[0029]

In the present embodiment, the ammonia tank 2, the vaporization facility 3c, and the gas analyzer 7 are nitrogen gas-using apparatuses. For example, the ammonia tank 2 uses the nitrogen gas N as a purge gas. In addition, the vaporization facility 3c uses the nitrogen gas N as a purge gas or a seal gas. In addition, the gas analyzer 7 takes in the boil-off gas G containing the nitrogen gas N, analyzes the boil-off gas G, and then discharges the boil-off gas G. That is, the nitrogen gas N used in the ammonia tank 2, the vaporization facility 3c, and the gas analyzer 7 is supplied to the boil-off gas main pipe 4a of the boil-off gas supply portion 4 via the nitrogen gas recovery portion 5.

[0030]

The treatment facility 6 can separate the nitrogen gas N from the boil-off gas G and supply the nitrogen gas N to the ground flare F. In addition, in a case where the pressure of the ammonia tank 2 rises excessively, the treatment facility 6 can receive the boil-off gas G via the emergency exhaust pipe 4f and supply the boil-off gas G received from the emergency exhaust pipe 4f to the ground flare F. As shown in FIG. 1, the treatment facility 6 includes the condenser 6a, a nitrogen gas discharge portion 6b (discharge portion), a boil-off gas receiving pipe 6c, and the boil-off gas release valve 6d.

[0031]

The condenser 6a condenses the boil-off gas G in a case where the boil-off gas G is supplied from the boil-off gas supply portion 4. When the second on-off valve 4d is opened, the boil-off gas G is supplied from the boil-off gas supply portion 4 to the condenser 6a. The boil-off gas G is condensed and liquefied inside the condenser 6a to become the liquid ammonia X. In a case where the boil-off gas G supplied to the condenser 6a contains the nitrogen gas N, the nitrogen gas N contained in the boil-off gas G is not liquefied inside the condenser 6a and remains accumulated inside the condenser 6a in a gaseous state.

[0032]

The nitrogen gas discharge portion 6b supplies the nitrogen gas N accumulated inside the condenser 6a to the ground flare F. The nitrogen gas discharge portion 6b includes a nitrogen gas pipe 6b1 and a nitrogen gas release valve 6b2.

[0033]

The nitrogen gas pipe 6b1 is a pipe that connects the condenser 6a and the ground flare F. An upstream end of the nitrogen gas pipe 6b1 is connected to the condenser 6a, and a downstream end of the nitrogen gas pipe 6b1 is connected to the

ground flare F. The nitrogen gas pipe 6b1 guides the nitrogen gas N from the condenser 6a to the ground flare F.

[0034]

The nitrogen gas release valve 6b2 is a release valve installed at an intermediate
5 portion of the nitrogen gas pipe 6b1. The nitrogen gas release valve 6b2 is opened in a case where the internal pressure of the condenser 6a exceeds a predetermined threshold. The internal pressure of the condenser 6a rises as the nitrogen gas N accumulates. In a case where the internal pressure of the condenser 6a exceeds the predetermined threshold and the nitrogen gas release valve 6b2 is opened, the nitrogen gas N inside the condenser
10 6a flows into the nitrogen gas pipe 6b1.

[0035]

When the nitrogen gas release valve 6b2 is opened, a portion of the boil-off gas G inside the condenser 6a flows into the nitrogen gas pipe 6b1 along the flow of the nitrogen gas N. The boil-off gas G that has flowed into the nitrogen gas pipe 6b1 is
15 incinerated and detoxified by the ground flare F.

[0036]

The ground flare F incinerates the boil-off gas G contained in the supplied nitrogen gas N. In a case where the amount of the boil-off gas G contained in the supplied nitrogen gas N is small, the ground flare F injects fossil fuel such as LPG to
20 burn ammonia. That is, the ground flare F burns ammonia together with the fuel. The ground flare F is also supplied with boil-off gas G received by the treatment facility 6 via the emergency exhaust pipe 4f. The ground flare F also incinerates such boil-off gas G. The ground flare F may be replaced by a flare facility such as a flare stack.

[0037]

The gas analyzer 7 is a gas calorific value detection portion that detects the gas calorific value of the ammonia gas Y delivered from the ammonia gas delivery portion 3 to the boiler B. In the present embodiment, two gas analyzers 7, that is, a first gas analyzer 7a (first gas calorific value detection portion) and a second gas analyzer 7b (second gas calorific value detection portion), are provided.

[0038]

As shown in FIG. 1, the first gas analyzer 7a is provided at an intermediate portion of the gas delivery pipe 3d of the ammonia gas delivery portion 3. The first gas analyzer 7a is disposed downstream of a position of the gas delivery pipe 3d to which the boil-off gas main pipe 4a is connected. The first gas analyzer 7a detects the gas calorific value of the ammonia gas Y supplied from the gas delivery pipe 3d to the boiler B. In addition, the first gas analyzer 7a inputs the detected gas calorific value to the control unit 8.

[0039]

As shown in FIG. 1, the second gas analyzer 7b is provided at an intermediate portion of the boil-off gas main pipe 4a of the boil-off gas supply portion 4. The second gas analyzer 7b is disposed upstream of the position of the boil-off gas main pipe 4a to which the boil-off gas treatment facility connection pipe 4c is connected. The second gas analyzer 7b detects the gas calorific value of the boil-off gas G flowing through the boil-off gas main pipe 4a. The second gas analyzer 7b may be omitted.

[0040]

The second gas analyzer 7b obtains, for example, via the control unit 8, flow rate information of the ammonia gas Y supplied from the ammonia gas delivery portion 3 to the boiler B. The second gas analyzer 7b calculates the gas calorific value of the ammonia gas Y in a case where the boil-off gas G flowing through the boil-off gas main

pipe 4a is mixed with the ammonia gas Y, based on the obtained flow rate information of the ammonia gas Y. The second gas analyzer 7b inputs the gas calorific value of the ammonia gas Y calculated in this manner to the control unit 8.

[0041]

5 The gas calorific value of the ammonia gas Y may be calculated by the control unit 8. In this case, the second gas analyzer 7b detects the gas calorific value of the boil-off gas G flowing through the boil-off gas main pipe 4a, and inputs the detected gas calorific value to the control unit 8. As described above, the detection of the gas calorific value of the ammonia gas Y in the gas analyzer 7 is not limited to directly
10 detecting the gas calorific value of the delivered ammonia gas Y, and includes detecting a value from which the gas calorific value of the ammonia gas Y delivered to the boiler B can be calculated.

[0042]

 The control unit 8 is connected to each of the gas analyzers 7 (the first gas
15 analyzer 7a and the second gas analyzer 7b), and can acquire the gas calorific value of the ammonia gas Y supplied to the boiler B. In addition, the control unit 8 is connected to each of the first on-off valve 4b and the second on-off valve 4d, and can control opening and closing of each of the first on-off valve 4b and the second on-off valve 4d.

[0043]

20 The control unit 8 causes the boil-off gas supply portion 4 to supply the boil-off gas G to the treatment facility 6 in a case where the gas calorific value of the ammonia gas Y delivered to the boiler B is lower than a predetermined threshold. Furthermore, the control unit 8 causes the boil-off gas supply portion 4 to supply the boil-off gas G to the ammonia gas delivery portion 3 in a case where the gas calorific value of the
25 ammonia gas Y delivered to the boiler B is higher than the predetermined threshold.

[0044]

Specifically, in a case where the gas calorific value of the ammonia gas Y delivered to the boiler B is lower than the predetermined threshold, the control unit 8 closes the first on-off valve 4b and opens the second on-off valve 4d. As a result, the
5 boil-off gas G is supplied from the boil-off gas supply portion 4 to the treatment facility 6.

[0045]

In addition, in a case where the gas calorific value of the ammonia gas Y delivered to the boiler B is higher than the predetermined threshold, the control unit 8
10 opens the first on-off valve 4b and closes the second on-off valve 4d. As a result, the boil-off gas G is supplied from the boil-off gas supply portion 4 to the ammonia gas delivery portion 3.

[0046]

Subsequently, an operation of the ammonia receiving facility 1 of the present
15 embodiment will be described. As shown in FIG. 1, the liquid ammonia X stored in the ammonia tank 2 is discharged from the ammonia tank 2 by the discharge pump 3a and supplied to the vaporization facility 3c. The liquid ammonia X supplied to the vaporization facility 3c is vaporized into ammonia gas Y. The ammonia gas Y discharged from the vaporization facility 3c is delivered to the boiler B.

20 [0047]

On the other hand, the boil-off gas G generated inside the ammonia tank 2 is discharged from the ammonia tank 2 and is then pressurized by being compressed by the boil-off gas compressor 4e. In a case where the gas calorific value of the ammonia gas Y delivered to the boiler B is higher than a predetermined threshold, the pressurized boil-
25 off gas G is supplied to the ammonia gas delivery portion 3 and mixed with the ammonia

gas Y. In addition, in a case where the gas calorific value of the ammonia gas Y delivered to the boiler B is lower than the predetermined threshold, the pressurized boil-off gas G is supplied to the treatment facility 6.

[0048]

5 The boil-off gas G supplied to the treatment facility 6 is condensed by the condenser 6a to become liquid ammonia X. The liquid ammonia X produced in the condenser 6a is discharged from the condenser 6a and returned to the ammonia tank 2 via, for example, an economizer (not shown). On the other hand, the nitrogen gas N accumulated inside the condenser 6a is supplied to the ground flare F, and the ammonia
10 contained therein is incinerated.

[0049]

FIG. 2 is a flowchart for describing an example of the control of the control unit 8. As shown in FIG. 2, the control unit 8 acquires the gas calorific value of the ammonia gas Y delivered to the boiler B based on signals input from the first gas
15 analyzer 7a and the second gas analyzer 7b (step S1).

[0050]

Subsequently, the control unit 8 determines whether or not the gas calorific value of the ammonia gas Y acquired in step S1 exceeds a predetermined threshold (step S2). The threshold here is set based on the gas calorific value that can be received by
20 the boiler B. In a case where the gas calorific value does not exceed the predetermined threshold, the control unit 8 closes the first on-off valve 4b and opens the second on-off valve 4d (step S3), and causes the boil-off gas supply portion 4 to supply the boil-off gas G to the treatment facility 6. On the other hand, in a case where the gas calorific value exceeds the predetermined threshold, the control unit 8 opens the first on-off valve 4b
25 and closes the second on-off valve 4d (step S4), and causes the boil-off gas supply

portion 4 to supply the boil-off gas G to the ammonia gas delivery portion 3. After step S3 and step S4, the control unit 8 returns to step S1.

[0051]

The ammonia receiving facility 1 of the present embodiment includes the ammonia tank 2 and the ammonia gas delivery portion 3. The ammonia tank 2 stores the liquid ammonia X. The ammonia gas delivery portion 3 vaporizes the liquid ammonia X and delivers the vaporized ammonia to the boiler B. In addition, the ammonia receiving facility 1 of the present embodiment includes the boil-off gas supply portion 4, the nitrogen gas recovery portion 5, the gas analyzer 7, the treatment facility 6, and the control unit 8. The boil-off gas supply portion 4 is capable of supplying the boil-off gas G generated in the ammonia tank 2 to the ammonia gas delivery portion 3. The nitrogen gas recovery portion 5 supplies the nitrogen gas N recovered from the nitrogen gas-using apparatus to the boil-off gas supply portion 4 and mixes the nitrogen gas N with the boil-off gas G. The gas analyzer 7 detects the gas calorific value of the ammonia gas delivered from the ammonia gas delivery portion 3. The treatment facility 6 is capable of separating the nitrogen gas N from the boil-off gas and supplying the separated nitrogen gas N to the ground flare F. The control unit 8 causes the boil-off gas supply portion 4 to supply the boil-off gas G to the treatment facility 6 in a case where the gas calorific value is lower than the predetermined threshold.

[0052]

According to the ammonia receiving facility 1 of the present embodiment, the nitrogen gas N recovered in the nitrogen gas recovery portion 5 is mixed with the boil-off gas G and further mixed with the ammonia gas Y to be delivered to the boiler B. In a case where the gas calorific value of the ammonia gas Y delivered to the boiler B is higher than the predetermined threshold, the boil-off gas G is supplied to the boiler B.

On the other hand, in a case where the gas calorific value of the ammonia gas Y delivered to the boiler B is lower than the predetermined threshold, the boil-off gas G is supplied to the treatment facility 6. In the case where the boil-off gas G is supplied to the treatment facility 6, the nitrogen gas N is separated from the boil-off gas G and supplied to the ground flare F. As described above, the ammonia receiving facility 1 of the present embodiment supplies the nitrogen gas N to the ground flare F only in a case where the gas calorific value of the ammonia gas Y delivered to the boiler B is lower than the predetermined threshold. Therefore, according to the ammonia receiving facility 1 of the present embodiment, in the ammonia receiving facility 1 that vaporizes the liquid ammonia X for supply to the boiler B, it is possible to suppress the supply amount of the nitrogen gas N recovered from the nitrogen gas-using apparatus to the ground flare F.

[0053]

In addition, in the ammonia receiving facility 1 of the present embodiment, the boil-off gas supply portion 4 includes the boil-off gas main pipe 4a, the first on-off valve 4b, the boil-off gas treatment facility connection pipe 4c, and the second on-off valve 4d. The boil-off gas main pipe 4a is connected to the ammonia gas delivery portion 3. The first on-off valve 4b is installed at an intermediate portion of the boil-off gas main pipe 4a. The boil-off gas treatment facility connection pipe 4c connects the upstream position of the boil-off gas main pipe 4a located upstream of the first on-off valve 4b and the treatment facility 6. The second on-off valve 4d is installed at an intermediate portion of the boil-off gas treatment facility connection pipe 4c. In addition, the control unit 8 closes the first on-off valve 4b and opens the second on-off valve 4d in a case where the gas calorific value is lower than the threshold. In addition, the control unit 8 opens the first on-off valve 4b and closes the second on-off valve 4d in a case where the gas calorific value is higher than the threshold.

[0054]

In the ammonia receiving facility 1 of the present embodiment, the control unit 8 can open and close the first on-off valve 4b and the second on-off valve 4d. Therefore, the ammonia receiving facility 1 of the present embodiment can automatically change the supply destination of the boil-off gas G.

[0055]

In addition, the ammonia receiving facility 1 of the present embodiment includes the first gas analyzer 7a and the second gas analyzer 7b. The first gas analyzer 7a detects the gas calorific value at a downstream position located downstream of the first on-off valve 4b. The second gas analyzer 7b detects the gas calorific value at an upstream position located upstream of the connection position of the boil-off gas treatment facility connection pipe 4c.

[0056]

The ammonia receiving facility 1 of the present embodiment can determine, using the first gas analyzer 7a, that the gas calorific value of the ammonia gas Y has fallen below the threshold. In addition, the second gas analyzer 7b can be used to determine that the gas calorific value of the ammonia gas Y has exceeded the threshold.

[0057]

Note that the second gas analyzer 7b can be used to determine that the gas calorific value of the ammonia gas Y has fallen below the threshold. Therefore, the first gas analyzer 7a may be omitted. However, by installing the first gas analyzer 7a, the gas calorific value can be detected immediately before the boiler B, and thus it is possible to more accurately measure the gas calorific value of the ammonia gas Y to be supplied to the boiler B.

[0058]

In addition, in the ammonia receiving facility 1 of the present embodiment, the treatment facility 6 includes the condenser 6a and the nitrogen gas discharge portion 6b. The condenser 6a condenses the boil-off gas G. The nitrogen gas discharge portion 6b supplies the nitrogen gas N accumulated inside the condenser 6a to the ground flare F that detoxifies ammonia.

[0059]

According to the ammonia receiving facility 1 of the present embodiment, the nitrogen gas N can be separated from the boil-off gas G by condensing the boil-off gas G in the condenser 6a. Therefore, the ammonia receiving facility 1 of the present embodiment can separate the nitrogen gas N from the boil-off gas G with a simple configuration.

[0060]

In addition, in the ammonia receiving facility 1 of the present embodiment, the detoxification facility is the ground flare F that burns ammonia together with the fuel.

In the ammonia receiving facility 1 of the present embodiment, the supply amount of the nitrogen gas N recovered from the nitrogen gas-using apparatus to the ground flare F can be suppressed, and thus the amount of fossil fuel consumed by the ground flare F can be reduced.

[0061]

In addition, in the ammonia receiving facility 1 of the present embodiment, the ammonia tank 2, the ammonia gas delivery portion 3, and the gas analyzer 7 are the nitrogen gas-using apparatuses. Therefore, the ammonia receiving facility 1 of the present embodiment can appropriately treat the nitrogen gas N discharged from the ammonia tank 2, the ammonia gas delivery portion 3, and the gas analyzer 7.

[0062]

(Second Embodiment)

Next, a second embodiment of the present disclosure will be described with reference to FIG. 3. In the description of the present embodiment, the description of the same parts as in the first embodiment will be omitted or simplified.

5 [0063]

FIG. 3 is a flow diagram showing a schematic configuration of an ammonia receiving facility 1A of the present embodiment. As shown in FIG. 3, the ammonia receiving facility 1A of the present embodiment includes a loading arm 10 and a return gas blower 11.

10 [0064]

The loading arm 10 is a facility for delivering the liquid ammonia X and the boil-off gas G between an ammonia ship that transports the liquid ammonia X and the ammonia receiving facility 1A of the present embodiment. The loading arm 10 receives the liquid ammonia X from the ammonia ship and supplies the liquid ammonia X to the ammonia tank 2 via a pipe. In addition, the loading arm 10 supplies the boil-off gas G pressure-fed by the return gas blower 11 to the ammonia ship. The return gas blower 11 is connected to the boil-off gas main pipe 4a of the boil-off gas supply portion 4 and supplies the boil-off gas G supplied from the boil-off gas main pipe 4a to the loading arm 10.

20 [0065]

The loading arm 10 and the return gas blower 11 are nitrogen gas-using apparatuses that use nitrogen gas N as a purge gas or a seal gas. The nitrogen gas N used in the loading arm 10 and the return gas blower 11 may contain ammonia. Therefore, in the ammonia receiving facility 1A of the present embodiment, the nitrogen

gas recovery portion 5 also recovers the nitrogen gas N from the loading arm 10 and the return gas blower 11.

[0066]

According to the ammonia receiving facility 1A of the present embodiment, it is possible to recover the nitrogen gas N from the loading arm 10 and the return gas blower 11 and to appropriately treat the recovered nitrogen gas N.

[0067]

Although the preferred embodiments of the present disclosure have been described above with reference to the accompanying drawings, it goes without saying that the present disclosure is not limited to the above-described embodiments. The various shapes, combinations, and the like of each constituent member shown in the embodiments described above are merely examples, and can be variously changed on the basis of design requirements and the like without departing from the gist of the present disclosure.

15 [0068]

Meanwhile, the embodiments described above can also be described as, for example, the following supplementary notes.

[0069]

(Supplementary Note 1)

20 An ammonia receiving facility including:

an ammonia tank that stores liquid ammonia;

an ammonia gas delivery portion that vaporizes the liquid ammonia and delivers vaporized ammonia to a supply destination;

a boil-off gas supply portion that is capable of supplying boil-off gas generated in the ammonia tank to the ammonia gas delivery portion;

25

a nitrogen gas recovery portion that supplies nitrogen gas recovered from a nitrogen gas-using apparatus to the boil-off gas supply portion and mixes the nitrogen gas with the boil-off gas;

5 a gas calorific value detection portion that detects a gas calorific value of ammonia gas delivered from the ammonia gas delivery portion;

a treatment facility that is capable of separating the nitrogen gas from the boil-off gas and supplying the separated nitrogen gas to a detoxification facility; and

a control unit configured to cause the boil-off gas supply portion to supply the boil-off gas to the treatment facility in a case where the gas calorific value is lower than a
10 predetermined threshold.

[0070]

(Supplementary Note 2)

The ammonia receiving facility according to Supplementary Note 1, in which the boil-off gas supply portion includes:

15 a first pipe connected to the ammonia gas delivery portion;

a first on-off valve installed at an intermediate portion of the first pipe;

a second pipe connecting an upstream position of the first pipe located upstream of the first on-off valve and the treatment facility; and

a second on-off valve installed at an intermediate portion of the second pipe, and
20 the control unit is configured to:

close the first on-off valve and open the second on-off valve in a case where the gas calorific value is lower than the threshold; and

open the first on-off valve and close the second on-off valve in a case where the gas calorific value is higher than the threshold.

25 [0071]

(Supplementary Note 3)

The ammonia receiving facility according to Supplementary Note 2, in which the gas calorific value detection portion includes:

5 a first gas calorific value detection portion that detects the gas calorific value at a downstream position located downstream of the first on-off valve; and

a second gas calorific value detection portion that detects the gas calorific value at an upstream position located upstream of a connection position of the second pipe.

[0072]

(Supplementary Note 4)

10 The ammonia receiving facility according to any one of Supplementary Notes 1 to 3, in which

the treatment facility includes:

a condenser that condenses the boil-off gas; and

15 a discharge portion that supplies the nitrogen gas accumulated inside the condenser to a detoxification facility that detoxifies ammonia.

[0073]

(Supplementary Note 5)

The ammonia receiving facility according to Supplementary Note 4, in which the detoxification facility is a flare facility that burns ammonia together with a fuel.

20 [0074]

(Supplementary Note 6)

The ammonia receiving facility according to any one of Supplementary Notes 1 to 5, in which at least one of the ammonia tank, the ammonia gas delivery portion, and the gas calorific value detection portion is the nitrogen gas-using apparatus.

25 INDUSTRIAL APPLICABILITY

[0075]

According to the present disclosure, in an ammonia receiving facility that vaporizes liquid ammonia for supply to a supply destination, it is possible to suppress the supply amount of nitrogen gas recovered from a nitrogen gas-using apparatus to a

5 detoxification facility.

REFERENCE SIGNS LIST

[0076]

- 1 Ammonia receiving facility
- 1A Ammonia receiving facility
- 10 2 Ammonia tank
- 3 Ammonia gas delivery portion
- 3a Discharge pump
- 3b Discharge pipe
- 3c Vaporization facility
- 15 3d Gas delivery pipe
- 4 Boil-off gas supply portion
- 4a Boil-off gas main pipe (first pipe)
- 4b First on-off valve
- 4c Boil-off gas treatment facility connection pipe (second pipe)
- 20 4d Second on-off valve
- 4e Boil-off gas compressor
- 4f Emergency exhaust pipe
- 5 Nitrogen gas recovery portion
- 6 Treatment facility
- 25 6a Condenser

	6b Nitrogen gas discharge portion
	6b1 Nitrogen gas pipe
	6b2 Nitrogen gas release valve
	6c Boil-off gas receiving pipe
5	6d Boil-off gas release valve
	7 Gas analyzer (gas calorific value detection portion)
	7a First gas analyzer (first gas calorific value detection portion)
	7b Second gas analyzer (second gas calorific value detection portion)
	8 Control unit
10	10 Loading arm
	11 Return gas blower
	B Boiler (supply destination)
	F Ground flare (detoxification facility flare facility)
	G Boil-off gas
15	N Nitrogen gas
	X Liquid ammonia
	Y Ammonia gas

CLAIMS

[Claim 1] An ammonia receiving facility comprising:

an ammonia tank that stores liquid ammonia;

an ammonia gas delivery portion that vaporizes the liquid ammonia and delivers
5 vaporized ammonia to a supply destination;

a boil-off gas supply portion that is capable of supplying boil-off gas generated
in the ammonia tank to the ammonia gas delivery portion;

a nitrogen gas recovery portion that supplies nitrogen gas recovered from a
nitrogen gas-using apparatus to the boil-off gas supply portion and mixes the nitrogen gas
10 with the boil-off gas;

a gas calorific value detection portion that detects a gas calorific value of
ammonia gas delivered from the ammonia gas delivery portion;

a treatment facility that is capable of separating the nitrogen gas from the boil-
off gas and supplying the separated nitrogen gas to a detoxification facility; and

15 a control unit configured to cause the boil-off gas supply portion to supply the
boil-off gas to the treatment facility in a case where the gas calorific value is lower than a
predetermined threshold.

[Claim 2] The ammonia receiving facility according to Claim 1,

wherein the boil-off gas supply portion includes:

20 a first pipe connected to the ammonia gas delivery portion;

a first on-off valve installed at an intermediate portion of the first pipe;

a second pipe connecting an upstream position of the first pipe located upstream
of the first on-off valve and the treatment facility; and

a second on-off valve installed at an intermediate portion of the second pipe, and

25 the control unit is configured to:

close the first on-off valve and open the second on-off valve in a case where the gas calorific value is lower than the threshold; and

open the first on-off valve and close the second on-off valve in a case where the gas calorific value is higher than the threshold.

5 [Claim 3] The ammonia receiving facility according to Claim 2,

wherein the gas calorific value detection portion includes:

a first gas calorific value detection portion that detects the gas calorific value at a downstream position located downstream of the first on-off valve; and

a second gas calorific value detection portion that detects the gas calorific value
10 at an upstream position located upstream of a connection position of the second pipe.

[Claim 4] The ammonia receiving facility according to any one of Claims 1 to 3,

wherein the treatment facility includes:

a condenser that condenses the boil-off gas; and

a discharge portion that supplies the nitrogen gas accumulated inside the
15 condenser to a detoxification facility that detoxifies ammonia.

[Claim 5] The ammonia receiving facility according to Claim 4,

wherein the detoxification facility is a flare facility that burns ammonia together with a fuel.

[Claim 6] The ammonia receiving facility according to any one of Claims 1 to 3,

20 wherein at least one of the ammonia tank, the ammonia gas delivery portion, and the gas calorific value detection portion is the nitrogen gas-using apparatus.