

DESCRIPTION

Title of Invention

GAS REPLACEMENT METHOD

Technical Field

[0001]

The present disclosure relates to a gas replacement method.

The present application claims priority with respect to Japanese Patent Application No. 2019-229388 filed in Japan on December 19, 2019, the content of which is incorporated herein by reference.

Background Art

[0002]

A liquefied gas carrier or the like is provided with a liquefied gas storage tank. Such a tank may be filled with an inert gas and then the inert gas in the tank may be replaced with air or the like such that the liquefied gas remaining in the tank does not come into contact with oxygen when the tank is opened for maintenance or the like (see, for example, PTL 1).

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Publication No.
2013-193653

Summary of Invention

Technical Problem

[0004]

By the way, the type of gas stored in the tank may be switched in the liquefied gas storage tank. At this time, a problem may arise due to contact between the residual gas of a first gas stored in the tank before the switching and a second gas stored in the tank after the switching. Examples of the problem include solid generation resulting from a chemical reaction between the first gas and the second gas. In addition, the first gas may be mixed with the second gas and the first gas may remain in the tank after the switching. Accordingly, in a case where the type of gas stored in the tank is switched, as in the case of the inert gas of PTL 1, the second gas needs to be loaded into the tank after the first gas in the tank is replaced with the inert gas.

However, as for the method described above, it is necessary to sequentially execute the steps of first liquefied gas discharge to the outside of the tank, replacement with the inert gas or the like in the tank, and second liquefied gas loading into the tank in switching the type of gas loaded into the tank. This

entails a problem in that it takes time and effort to switch the type of gas loaded into the tank.

[0005]

The present disclosure has been made in view of the above, and an object of the present disclosure is to provide a gas replacement method by which the type of gas loaded into a tank can be switched with ease and speed.

Solution to Problem

[0006]

In order to achieve the above object, a gas replacement method according to the present disclosure includes: a step of supplying an inert gas higher in specific gravity than a first gas to a tank filled with the first gas to form a separation layer made of the inert gas below the first gas; and a step of supplying a second gas higher in specific gravity than the inert gas to a lower portion of the tank to sequentially discharge the first gas and the separation layer from an upper portion of the tank.

[0007]

A gas replacement method according to the present disclosure includes: a step of supplying an inert gas lower in specific gravity than a second gas to a tank filled with the second gas to form a separation layer made of the inert gas above the second gas; and a step of

supplying a first gas lower in specific gravity than the inert gas to an upper portion of the tank to sequentially discharge the second gas and the separation layer from a lower portion of the tank.

Advantageous Effects of Invention

[0008]

According to the gas replacement method of the present disclosure, the type of gas loaded into the tank can be switched with ease and speed.

Brief Description of Drawings

[0009]

Fig. 1 is a plan view illustrating a schematic configuration of a ship provided with a tank to which a gas replacement method according to an embodiment of the present disclosure is applied.

Fig. 2 is a side cross-sectional view illustrating a state where liquefied carbon dioxide is loaded in the tank to which the gas replacement method according to the embodiment of the present disclosure is applied.

Fig. 3 is a side cross-sectional view illustrating a state where liquefied ammonia is loaded in the tank to which the gas replacement method according to the embodiment of the present disclosure is applied.

Fig. 4 is a flowchart illustrating a procedure of the gas replacement method according to the embodiment of

the present disclosure.

Fig. 5 is a side cross-sectional view illustrating a state where a first gas remains in the tank in the gas replacement method according to the embodiment of the present disclosure.

Fig. 6 is a side cross-sectional view illustrating a state where an inert gas is supplied to the tank and a separation layer is formed in the gas replacement method according to the embodiment of the present disclosure.

Fig. 7 is a side cross-sectional view illustrating a state where a second gas is supplied to the tank and the first gas and the separation layer are pushed up in the gas replacement method according to the embodiment of the present disclosure.

Fig. 8 is a side cross-sectional view illustrating a state where the first gas and the separation layer of the tank are discharged in the gas replacement method according to the embodiment of the present disclosure.

Fig. 9 is a flowchart illustrating a procedure of the gas replacement method according to the embodiment of the present disclosure.

Fig. 10 is a side cross-sectional view illustrating a state where the second gas remains in the tank in the gas replacement method according to the embodiment of the present disclosure.

Fig. 11 is a side cross-sectional view illustrating a state where the inert gas is supplied to the tank and the separation layer is formed in the gas replacement method according to the embodiment of the present disclosure.

Fig. 12 is a side cross-sectional view illustrating a state where the first gas is supplied to the tank and the second gas and the separation layer are pushed down in the gas replacement method according to the embodiment of the present disclosure.

Fig. 13 is a side cross-sectional view illustrating a state where the second gas and the separation layer of the tank are discharged in the gas replacement method according to the embodiment of the present disclosure.

Description of Embodiments

[0010]

Hereinafter, a ship according to an embodiment of the present disclosure will be described with reference to Figs. 1 and 2.

(Configuration of Hull of Ship)

A ship 1 of the embodiment of the present disclosure illustrated in Figs. 1 and 2 is capable of selectively carrying, for example, liquefied carbon dioxide and liquefied ammonia. The ship 1 includes at least a hull 2 and a tank 21.

[0011]

(Hull Configuration)

As illustrated in Fig. 1, the hull 2 has a pair of broadsides 3A and 3B, a ship bottom (not illustrated), and a deck 5, which form the outer shell of the hull 2. The broadsides 3A and 3B are provided with a pair of broadside skins respectively forming the left and right broadsides. The ship bottom (not illustrated) is provided with a ship bottom skin connecting the broadsides 3A and 3B. By the pair of broadsides 3A and 3B and the ship bottom (not illustrated), the outer shell of the hull 2 has a U shape in a cross section orthogonal to a ship stern direction Da. The deck 5 exemplified in this embodiment is a whole deck exposed to the outside. In the hull 2, an upper structure 7 having a living quarter is formed on the deck 5 on a stern 2b side.

[0012]

In the hull 2, a cargo loading section (hold) 8 is formed closer to a bow 2a side than the upper structure 7. The cargo loading section 8 is recessed toward the ship bottom (not illustrated) below the deck 5 and is open upward.

[0013]

(Tank Configuration)

A plurality of the tanks 21 are disposed in the

cargo loading section 8. In this embodiment, for example, a total of seven tanks 21 are disposed in the cargo loading section 8. The tank 21 is not limited in any manner in terms of layout and installation number in the cargo loading section 8. In this embodiment, each tank 21 has, for example, a cylindrical shape extending in the horizontal direction (specifically, ship stern direction). The tank 21 is not limited to a cylindrical tank and may be spherical.

[0014]

As illustrated in Fig. 2, each tank 21 is provided with an upper pipe 32 and a lower pipe 33.

The upper pipe 32 reaches the inside of the tank 21 from the outside of the tank 21. An opening portion 32a opening to the upper portion in the tank 21 is formed at the tip of the upper pipe 32. Here, the upper portion in the tank 21 means the region in the tank 21 that is on the side closer to the upper end of the tank 21 than the center of the tank 21 in an up-down direction Dv. As an example, the portion can be the top of the tank 21. The upper pipe 32 is provided so as to be connectable to another pipe, which will be described later. In addition, the upper pipe 32 is provided with an opening-closing valve (not illustrated). The opening-closing valve (not illustrated) opens and closes the flow path in the upper

pipe 32 as needed when, for example, another pipe is attached to or detached from the upper pipe 32.

[0015]

The lower pipe 33 is provided so as to extend from the outside of the tank 21 to the inside of the tank 21. An opening portion 33a opening to the lower portion in the tank 21 is formed at the tip of the lower pipe 33. Here, the lower portion in the tank 21 means the region in the tank 21 that is on the side closer to the lower end of the tank 21 than the center of the tank 21 in the up-down direction Dv. As an example, the portion can be the bottom portion of the tank 21. The other end of the lower pipe 33 is provided so as to be connectable to another pipe, which will be described later. In addition, the lower pipe 33 is provided with an opening-closing valve (not illustrated). The opening-closing valve (not illustrated) opens and closes the flow path in the lower pipe 33 as needed when, for example, another pipe is attached to or detached from the lower pipe 33.

[0016]

Either liquefied carbon dioxide Lc or liquefied ammonia La can be selectively loaded into the tank 21. In a case where the ship 1 repeatedly carries only one of the liquefied carbon dioxide Lc and the liquefied ammonia La, liquefied carbon dioxide loading and discharge into and

from the tank 21 or liquefied ammonia loading and discharge into and from the tank 21 is performed as follows.

[0017]

(Liquefied Carbon Dioxide Loading and Discharge into and from Tank)

As illustrated in Fig. 2, in order to load the liquefied carbon dioxide Lc into the tank 21, a pipe (not illustrated) for supplying the liquefied carbon dioxide Lc from an outboard liquefied carbon dioxide supply facility or the like is connected to the lower pipe 33. When the liquefied carbon dioxide Lc is sent from the outside of the ship into the lower pipe 33, the liquefied carbon dioxide Lc is loaded into the tank 21 from the opening portion 33a. In this manner, the liquefied carbon dioxide Lc is stored in the tank 21. The liquefied carbon dioxide Lc may be loaded into the tank 21 through the upper pipe 32.

[0018]

When the liquefied carbon dioxide Lc stored in the tank 21 is discharged, the liquefied carbon dioxide Lc is suctioned out of the tank 21 by, for example, a cargo pump (not illustrated). As a result, the liquefied carbon dioxide Lc in the tank 21 is discharged to a liquefied carbon dioxide recovery facility or the like outside the

ship.

[0019]

(Liquefied Ammonia Loading and Discharge into and from Tank)

As illustrated in Fig. 3, in order to load the liquefied ammonia La into the tank 21, a pipe (not illustrated) for supplying the liquefied ammonia La from an outboard liquefied ammonia supply facility or the like is connected to the lower pipe 33. When the liquefied ammonia La is sent from the outside of the ship into the lower pipe 33, the liquefied ammonia La is loaded into the tank 21 from the opening portion 33a. In this manner, the liquefied ammonia La is stored in the tank 21. The liquefied ammonia La may be loaded into the tank 21 through the upper pipe 32.

[0020]

When the liquefied ammonia La stored in the tank 21 is discharged, the liquefied ammonia La is suctioned out of the tank 21 by, for example, a cargo pump (not illustrated). As a result, the liquefied ammonia La in the tank 21 is discharged to a liquefied ammonia recovery facility or the like outside the ship.

[0021]

The following gas replacement method is executed in switching the type of liquefied gas loaded into the tank

21 in the ship 1.

(Method for Gas Replacement from Liquefied Ammonia to Liquefied Carbon Dioxide)

As illustrated in Fig. 4, a method S10 for gas replacement from liquefied ammonia to liquefied carbon dioxide includes a step S11 of forming a separation layer 103 and a step S12 of sequentially discharging ammonia gas G1 and the separation layer 103.

[0022]

(Step of Forming Separation Layer)

After the liquefied ammonia La in the tank 21 is discharged to, for example, a liquefied ammonia recovery facility outside the ship, the tank 21 is filled with the residual gaseous ammonia gas (first gas) G1 as illustrated in Fig. 5. In the step S11 of forming the separation layer 103, as illustrated in Fig. 6, nitrogen gas (inert gas) Gs is sent into the lower pipe 33 from a nitrogen gas supply source such as a nitrogen gas generator provided inside or outside the ship. The nitrogen gas Gs is supplied to the lower portion in the tank 21 from the opening portion 33a of the lower pipe 33. The nitrogen gas Gs is higher in specific gravity than the ammonia gas G1. Accordingly, when the nitrogen gas Gs is supplied to the lower portion in the tank 21, an ammonia gas layer 101 and the separation layer 103 are formed in the tank 21.

The ammonia gas layer 101 is made of the ammonia gas G1 pushed up to the upper portion in the tank 21 by the nitrogen gas Gs. The separation layer 103 is made of the nitrogen gas Gs and is formed below the ammonia gas layer 101.

[0023]

In the step S11 of forming the separation layer 103, as the nitrogen gas Gs forming the separation layer 103, the nitrogen gas Gs that is smaller in amount than the capacity of the tank 21 is supplied to the tank 21. The dew point of the nitrogen gas Gs generated by the nitrogen gas generator is lower than the temperature of the liquefied carbon dioxide Lc (for example, -50°C). In addition, as the nitrogen gas Gs is supplied into the tank 21, a part of the ammonia gas G1 in the upper portion of the tank 21 may be pushed out of the tank 21 through the upper pipe 32. The ammonia gas G1 that is pushed out through the upper pipe 32 is recovered by an outboard gas recovery facility or discharged into the outboard atmosphere. Here, it is assumed that carbon dioxide gas G2 and the inner surface of the tank 21 described above have the same temperature as the liquefied carbon dioxide Lc. Accordingly, by the dew point of the nitrogen gas Gs being lower than the temperature of the liquefied carbon dioxide Lc as described above, it is possible to suppress

the condensation of the moisture contained in the nitrogen gas Gs even if the nitrogen gas Gs comes into contact with the remaining carbon dioxide gas G2 or the inner surface of the tank 21.

[0024]

(Step of Sequentially Discharging Ammonia Gas and Separation Layer)

In the step S12 of sequentially discharging the ammonia gas G1 and the separation layer 103, as illustrated in Fig. 7, the carbon dioxide gas (second gas) G2 higher in specific gravity than the nitrogen gas Gs is supplied to the lower portion of the tank 21. The carbon dioxide gas G2 is supplied from a carbon dioxide gas supply facility or the like to be supplied from the opening portion 33a to the lower portion in the tank 21 through the lower pipe 33. The carbon dioxide gas G2 is higher in specific gravity than the nitrogen gas Gs and the ammonia gas G1. Accordingly, when the carbon dioxide gas G2 is supplied to the lower portion in the tank 21, a carbon dioxide gas layer 102 is formed below the ammonia gas layer 101 and the separation layer 103 in the tank 21. In the step S12 of sequentially discharging the ammonia gas G1 and the separation layer 103, the liquefied carbon dioxide Lc may be supplied to the lower portion in the tank 21 in addition to the carbon dioxide gas G2.

[0025]

In the tank 21 in this state, the separation layer 103 is interposed between the ammonia gas layer 101 in the upper portion and the carbon dioxide gas layer 102 in the lower portion.

When the carbon dioxide gas G2 continues to be supplied to the lower portion of the tank 21, as the amount of the carbon dioxide gas G2 in the tank 21 increases, the ammonia gas G1 forming the ammonia gas layer 101 in the upper portion of the tank 21 and the nitrogen gas Gs forming the separation layer 103 therebelow are pushed up. After the push, the ammonia gas G1 and the nitrogen gas Gs are sequentially discharged to the outside of the tank 21 through the upper pipe 32. The ammonia gas G1 and the nitrogen gas Gs pushed out through the upper pipe 32 are recovered by an outboard gas recovery facility or discharged into the outboard atmosphere.

[0026]

As illustrated in Fig. 8, when the ammonia gas G1 and the nitrogen gas Gs are completely discharged to the outside of the tank 21, only the carbon dioxide gas G2 remains in the tank 21. Subsequently, the liquefied carbon dioxide Lc is loaded into the tank 21 as illustrated in Fig. 2.

[0027]

(Method for Gas Replacement from Liquefied Carbon Dioxide to Liquefied Ammonia)

As illustrated in Fig. 9, a method S20 for gas replacement from liquefied carbon dioxide to liquefied ammonia includes a step S21 of forming the separation layer 103 and a step S22 of sequentially discharging the carbon dioxide gas G2 and the separation layer 103.

[0028]

(Step of Forming Separation Layer)

After the liquefied carbon dioxide Lc in the tank 21 is discharged to, for example, a liquefied carbon dioxide recovery facility outside the ship, the tank 21 is filled with the residual gaseous liquefied carbon dioxide (second gas) G2 as illustrated in Fig. 10. In the step S21 of forming the separation layer 103, as illustrated in Fig. 11, the nitrogen gas (inert gas) Gs is supplied to the tank 21 filled with the carbon dioxide gas G2. The nitrogen gas Gs is supplied to the upper pipe 32 from a nitrogen gas supply source and is supplied to the upper portion in the tank 21 from the opening portion 32a. The nitrogen gas Gs is higher in specific gravity than the carbon dioxide gas G2. Accordingly, when the nitrogen gas Gs is supplied to the upper portion in the tank 21, the carbon dioxide gas layer 102 and the separation layer 103

are formed in the tank 21. The carbon dioxide gas layer 102 is made of the carbon dioxide gas G2 pushed down to the lower portion in the tank 21 by the nitrogen gas Gs. The separation layer 103 is made of the nitrogen gas Gs and is formed above the carbon dioxide gas layer 102.

[0029]

In the step S21 of forming the separation layer 103, as the nitrogen gas Gs forming the separation layer 103, the nitrogen gas Gs that is smaller in amount than the capacity of the tank 21 is supplied to the tank 21. In addition, as the nitrogen gas Gs is supplied into the tank 21, a part of the carbon dioxide gas G2 in the lower portion of the tank 21 may be discharged to the outside of the tank 21 through the lower pipe 33. The carbon dioxide gas G2 that is pushed out through the upper pipe 32 is recovered by an outboard gas recovery facility or discharged into the outboard atmosphere.

[0030]

(Step of Sequentially Discharging Carbon Dioxide Gas and Separation Layer)

In the step S22 of sequentially discharging the carbon dioxide gas G2 and the separation layer 103, as illustrated in Fig. 12, the ammonia gas (first gas) G1 is supplied to the upper portion of the tank 21. The ammonia gas G1 is supplied from an ammonia gas supply facility or

the like to be supplied from the opening portion 32a to the upper portion in the tank 21 through the upper pipe 32. The ammonia gas G1 is lower in specific gravity than the nitrogen gas Gs and the carbon dioxide gas G2. Accordingly, the ammonia gas layer 101 is formed on the carbon dioxide gas layer 102 and the separation layer 103 in the tank 21.

[0031]

In the tank 21 in this state, the separation layer 103 is interposed between the carbon dioxide gas layer 102 in the lower portion and the ammonia gas layer 101 in the upper portion.

When the ammonia gas G1 continues to be supplied to the upper portion of the tank 21, as the amount of the ammonia gas G1 (ammonia gas layer 101) in the tank 21 increases, the carbon dioxide gas G2 in the lower portion of the tank 21 and the nitrogen gas Gs forming the separation layer 103 therebelow are pushed down. As a result, the carbon dioxide gas G2 and the nitrogen gas Gs are sequentially discharged to the outside of the tank 21 through the lower pipe 33. The carbon dioxide gas G2 and the nitrogen gas Gs pushed out through the upper pipe 32 are recovered by an outboard gas recovery facility or discharged into the outboard atmosphere.

[0032]

When the carbon dioxide gas G2 and the nitrogen gas Gs are completely discharged to the outside of the tank 21, only the ammonia gas G1 remains in the tank 21 as illustrated in Fig. 13. Subsequently, the liquefied ammonia La is loaded into the tank 21 as illustrated in Fig. 3.

[0033]

(Action and Effect)

The gas replacement method S10 of the above embodiment includes the step S11 of supplying the nitrogen gas Gs higher in specific gravity than the ammonia gas G1 to the tank 21 filled with the ammonia gas G1 to form the separation layer 103 made of the nitrogen gas Gs below the ammonia gas G1 and the step S12 of supplying the carbon dioxide gas G2 higher in specific gravity than the nitrogen gas Gs to the lower portion of the tank 21 to sequentially discharge the ammonia gas G1 and the separation layer 103 from the upper portion of the tank 21.

In this gas replacement method S10, the separation layer 103 can be interposed between the ammonia gas G1 in the upper portion in the tank 21 and the carbon dioxide gas G2 in the lower portion in the tank 21. Accordingly, contact between the ammonia gas G1 and the carbon dioxide gas G2 can be suppressed. In addition, when the carbon dioxide gas G2 continues to be supplied to the lower

portion of the tank 21, the ammonia gas G1 in the upper portion of the tank 21 and the nitrogen gas Gs forming the separation layer 103 therebelow are sequentially discharged to the outside of the tank 21. In this manner, the inside of the tank 21 filled with the ammonia gas G1 can be replaced with the carbon dioxide gas G2. As a result, it is possible to efficiently switch the type of gas loaded into the tank and gas type switch can be facilitated and expedited.

[0034]

In the gas replacement method S10 of the above embodiment, the nitrogen gas Gs and the carbon dioxide gas G2 are supplied to the tank 21 through the lower pipe 33 opening to the lower portion in the tank 21.

By supplying the nitrogen gas Gs higher in specific gravity than the ammonia gas G1 to the tank 21 through the lower pipe 33 opening to the lower portion in the tank 21 as described above, the separation layer 103 made of the nitrogen gas Gs can be quickly formed below the ammonia gas G1 in the tank 21. Further, by supplying the carbon dioxide gas G2 higher in specific gravity than the nitrogen gas Gs to the tank 21 through the lower pipe 33 opening to the lower portion in the tank 21, the carbon dioxide gas G2 can be supplied below the separation layer 103 in the tank 21.

[0035]

The gas replacement method S20 of the above embodiment includes the step S21 of supplying the nitrogen gas Gs lower in specific gravity than the carbon dioxide gas G2 to the tank 21 filled with the carbon dioxide gas G2 to form the separation layer 103 made of the nitrogen gas Gs above the carbon dioxide gas G2 and the step S22 of supplying the ammonia gas G1 lower in specific gravity than the nitrogen gas Gs to the upper portion of the tank 21 to sequentially discharge the carbon dioxide gas G2 and the separation layer 103 from the lower portion of the tank 21.

[0036]

In this gas replacement method S20, the separation layer 103 can be interposed between the ammonia gas G1 in the upper portion in the tank 21 and the carbon dioxide gas G2 in the lower portion in the tank 21. Accordingly, contact between the ammonia gas G1 and the carbon dioxide gas G2 can be suppressed. In addition, when the ammonia gas G1 continues to be supplied to the upper portion of the tank 21, the carbon dioxide gas G2 in the lower portion of the tank 21 and the nitrogen gas Gs forming the separation layer 103 thereabove are sequentially discharged to the outside of the tank 21. In this manner, the inside of the tank 21 filled with the carbon dioxide

gas G2 can be replaced with the ammonia gas G1. As a result, it is possible to efficiently switch the type of gas loaded into the tank and gas type switch can be facilitated and expedited.

[0037]

In the gas replacement method S20 of the above embodiment, the nitrogen gas Gs and the ammonia gas G1 are supplied into the tank 21 through the upper pipe 32 opening to the upper portion in the tank 21.

By supplying the nitrogen gas Gs lower in specific gravity than the carbon dioxide gas G2 to the tank 21 through the upper pipe 32 opening to the upper portion in the tank 21 as described above, the separation layer 103 made of the nitrogen gas Gs can be formed above the carbon dioxide gas G2 in the tank 21. By supplying the ammonia gas G1 lower in specific gravity than the nitrogen gas Gs to the tank 21 through the upper pipe 32 opening to the upper portion in the tank 21, the ammonia gas G1 can be supplied above the separation layer 103 in the tank 21.

[0038]

In the gas replacement methods S10 and S20 of the above embodiment, in the steps S11 and S21 of forming the separation layer 103 made of the nitrogen gas Gs, the nitrogen gas Gs forming the separation layer 103 is supplied to the tank 21 by an amount smaller than the

capacity of the tank 21.

As a result, the amount by which the nitrogen gas Gs forming the separation layer 103 is supplied into the tank 21 can be suppressed, and the supply of the nitrogen gas Gs into the tank 21 for forming the separation layer 103 can be facilitated and expedited.

[0039]

In the gas replacement methods S10 and S20 of the above embodiment, the tank 21 is provided on the hull 2 of the ship 1.

As a result, it is possible to efficiently switch the type of gas loaded into the tank 21 provided on the hull 2 of the ship 1 and gas type switch can be facilitated and expedited.

[0040]

(Other Embodiments)

Although this embodiment has been described in detail with reference to the drawings, the specific configuration is not limited to this embodiment and also includes, for example, design changes within the gist of the present disclosure.

In the above embodiment, the first gas is the ammonia gas G1, the second gas is the carbon dioxide gas G2, and the inert gas is the nitrogen gas Gs, and yet the present disclosure is not limited thereto. For example,

the first gas may be ammonia and the second gas may be propane or butane.

In addition, although a case where the nitrogen gas Gs is used has been described in the above embodiment, dry air or the like may be used instead of the nitrogen gas Gs.

[0041]

<Additional Notes>

The gas replacement methods S10 and S20 described in the embodiment are, for example, grasped as follows.

[0042]

(1) A gas replacement method S10 according to a first aspect includes: a step S11 of supplying an inert gas Gs higher in specific gravity than a first gas G1 to a tank 21 filled with the first gas G1 to form a separation layer 103 made of the inert gas Gs below the first gas G1; and a step S12 of supplying a second gas G2 higher in specific gravity than the inert gas Gs to a lower portion of the tank 21 to sequentially discharge the first gas G1 and the separation layer 103 from an upper portion of the tank 21.

[0043]

In this gas replacement method S10, since the inert gas Gs forming the separation layer 103 is higher in specific gravity than the first gas G1, the separation layer 103 made of the inert gas Gs is formed below the

first gas G1 in the tank 21 when the inert gas Gs is supplied into the tank 21. The first gas G1 is positioned above the separation layer 103 and in the upper portion of the tank 21. The second gas G2 is higher in specific gravity than the inert gas Gs. Accordingly, when the second gas G2 is supplied to the lower portion of the tank 21, the second gas G2 is sent below the first gas G1 and the separation layer 103 in the tank 21. In this state, in the tank 21, the separation layer 103 is interposed between the first gas G1 in the upper portion and the second gas G2 in the lower portion. As a result, contact between the first gas G1 and the second gas G2 can be suppressed. In addition, when the second gas G2 continues to be supplied to the lower portion of the tank 21, the first gas G1 in the upper portion of the tank 21 and the inert gas Gs forming the separation layer 103 therebelow can be sequentially discharged to the outside of the tank 21. When the first gas G1 and the inert gas Gs are completely discharged to the outside of the tank 21, only the second gas G2 remains in the tank 21. As a result, the inside of the tank 21 filled with the first gas G1 can be replaced with the second gas G2. Accordingly, it is possible to efficiently switch the type of gas loaded into the tank 21 and gas type switch can be facilitated and expedited.

[0044]

(2) In the gas replacement method S10 according to a second aspect, which is the gas replacement method S10 of (1), the inert gas Gs and the second gas G2 are supplied to the tank 21 through a lower pipe 33 opening to the lower portion in the tank 21.

[0045]

As a result, by supplying the inert gas Gs higher in specific gravity than the first gas G1 to the tank 21 through the lower pipe 33 opening to the lower portion in the tank 21, the separation layer 103 made of the inert gas Gs can be quickly formed below the first gas G1 in the tank 21. Further, by supplying the second gas G2 higher in specific gravity than the inert gas Gs to the tank 21 through the lower pipe 33 opening to the lower portion in the tank 21, the second gas G2 can be supplied below the separation layer 103 in the tank 21.

[0046]

(3) A gas replacement method S20 according to a third aspect includes: a step S21 of supplying an inert gas Gs lower in specific gravity than a second gas G2 to a tank 21 filled with the second gas G2 to form a separation layer 103 made of the inert gas Gs above the second gas G2; and a step S22 of supplying a first gas G1 lower in specific gravity than the inert gas Gs to an upper portion

of the tank 21 to sequentially discharge the second gas G2 and the separation layer 103 from a lower portion of the tank 21.

[0047]

In this gas replacement method S20, the inert gas Gs forming the separation layer 103 is lower in specific gravity than the second gas G2. Accordingly, the separation layer 103 made of the inert gas Gs is formed above the second gas G2 in the tank 21 when the inert gas Gs is supplied into the tank 21. In addition, the first gas G1 is lower in specific gravity than the inert gas Gs. Accordingly, when the first gas G1 is supplied to the upper portion of the tank 21, the first gas G1 is accumulated above the second gas G2 and the separation layer 103 in the tank 21. In this state, in the tank 21, the separation layer 103 is interposed between the first gas G1 in the upper portion and the second gas G2 in the lower portion. Accordingly, contact between the first gas G1 and the second gas G2 can be suppressed. In addition, when the first gas G1 continues to be supplied to the upper portion of the tank 21, the second gas G2 in the lower portion of the tank 21 and the inert gas Gs forming the separation layer 103 thereabove are sequentially discharged to the outside of the tank 21. When the second gas G2 and the inert gas Gs are completely discharged to

the outside of the tank 21, only the first gas G1 remains in the tank 21. In this manner, the inside of the tank 21 filled with the second gas G2 can be replaced with the first gas G1. Accordingly, it is possible to efficiently switch the type of gas loaded into the tank 21 and gas type switch can be facilitated and expedited.

[0048]

(4) In the gas replacement method S20 according to a fourth aspect, which is the gas replacement method S20 of (3), the inert gas Gs and the first gas G1 are supplied into the tank 21 through an upper pipe 32 opening to the upper portion in the tank 21.

[0049]

By supplying the inert gas Gs lower in specific gravity than the second gas G2 to the tank 21 through the upper pipe 32 opening to the upper portion in the tank 21 as described above, the separation layer 103 made of the inert gas Gs can be formed above the second gas G2 in the tank 21. Further, by supplying the first gas G1 lower in specific gravity than the inert gas Gs to the tank 21 through the upper pipe 32 opening to the upper portion in the tank 21, the first gas G1 can be supplied above the separation layer 103 in the tank 21.

[0050]

(5) In the gas replacement methods S10 and S20

according to a fifth aspect, which is the gas replacement methods S10 and S20 according to any one of (1) to (4), the inert gas Gs forming the separation layer 103 is supplied to the tank 21 by an amount smaller than a capacity of the tank 21 in the steps S11 and S21 of forming the separation layer 103 made of the inert gas Gs.

[0051]

As a result, the amount by which the inert gas Gs forming the separation layer 103 is supplied into the tank 21 can be suppressed, and the supply of the inert gas Gs into the tank 21 for forming the separation layer 103 can be facilitated and expedited.

[0052]

(6) In the gas replacement methods S10 and S20 according to a sixth aspect, which is the gas replacement methods S10 and S20 according to any one of (1) to (5), the tank 21 is provided on a hull 2 of a ship 1.

[0053]

As a result, it is possible to efficiently switch the type of gas loaded into the tank 21 provided on the hull of the ship and gas type switch can be facilitated and expedited.

[0054]

Examples of the first gas G1 include ammonia gas. Examples of the inert gas Gs include nitrogen gas in a

case where the first gas G1 is ammonia gas. Examples of the second gas G2 include carbon dioxide gas in a case where the inert gas Gs is nitrogen gas.

Industrial Applicability

[0055]

According to the gas replacement method of the present disclosure, the type of gas loaded into the tank can be switched with ease and speed.

Reference Signs List

[0056]

- 1: ship
- 2: hull
- 2a: bow
- 2b: stern
- 3A, 3B: broadside
- 5: deck
- 7: upper structure
- 8: cargo loading section
- 21: tank
- 32: upper pipe
- 32a: opening portion
- 33: lower pipe
- 33a: opening portion
- 101: ammonia gas layer
- 102: carbon dioxide gas layer

103: separation layer

Da: ship stern direction

G1: ammonia gas (first gas)

G2: carbon dioxide gas (second gas)

Gs: nitrogen gas (inert gas)

La: liquefied ammonia

Lc: liquefied carbon dioxide

Claims

[Claim 1]

A gas replacement method comprising:

a step of supplying an inert gas higher in specific gravity than a first gas to a tank filled with the first gas to form a separation layer made of the inert gas below the first gas; and

a step of supplying a second gas higher in specific gravity than the inert gas to a lower portion of the tank to sequentially discharge the first gas and the separation layer from an upper portion of the tank.

[Claim 2]

The gas replacement method according to Claim 1, wherein the inert gas and the second gas are supplied to the tank through a lower pipe opening to the lower portion in the tank.

[Claim 3]

A gas replacement method comprising:

a step of supplying an inert gas lower in specific gravity than a second gas to a tank filled with the second gas to form a separation layer made of the inert gas above the second gas; and

a step of supplying a first gas lower in specific gravity than the inert gas to an upper portion of the tank to sequentially discharge the second gas and the separation layer from a lower portion of the tank.

[Claim 4]

The gas replacement method according to Claim 3, wherein the inert gas and the second gas are supplied into the tank through an upper pipe opening to the upper portion in the tank.

[Claim 5]

The gas replacement method according to any one of Claims 1 to 4, wherein the inert gas forming the separation layer is supplied to the tank by an amount smaller than a capacity of the tank in the step of forming the separation layer made of the inert gas.

[Claim 6]

The gas replacement method according to any one of Claims 1 to 5, wherein the tank is provided on a hull of a ship.