

D E S C R I P T I O N

CARGO TANK

5 Technical Field

The present invention relates generally to a cargo tank containing cargo.

Background Art

10 In general, ships that transport liquefied gases such as liquefied natural gas (LNG) loaded in cargo tanks are known. For example, an LNG ship capable of efficiently cooling cargo tanks by reducing a heel amount has been disclosed (see Patent Literature 1).

15 However, the temperature to be managed is different depending on the type of the liquefied gas. For this reason, problems may arise when the contents of the cargo tank are replaced with the other substance whose temperature to be managed is different. For example, in a case of replacing LNG whose temperature to be managed is low with liquefied carbon dioxide (carbon dioxide) whose temperature to be managed is high, if the liquefied carbon dioxide is injected into the cargo tank too quickly, the liquefied carbon dioxide may solidify (become dry ice). To avoid this problem, the cargo tank needs to be warmed up before replacement of the cargo. However, since the tank body has a large heat capacity, warming up takes time.

Citation List

Patent Literature

30 Patent Literature 1: JP 2019-34665 A

Summary of Invention

35 An object of embodiments of the present invention is to provide a cargo tank suitable for replacing two types of liquefied gases different in temperature to be managed in a short time.

A cargo tank according to an aspect of the present invention includes an outer shell containing two types

of liquefied gases different in temperature to be managed while replacing the liquefied gases, and including an inner wall having a curved shape in which a central portion in a vertical direction is formed to be most expanded in a horizontal direction, a first filling line which is provided to inject at least one liquefied gas of the two types of liquefied gases into an inside of the outer shell and on which a first ejection hole is provided at a height greater than or equal to an intermediate height between a height of the central portion and a height of a deepest portion in inner space of the outer shell such that the injected liquefied gas flows along the curved shape of the inner wall, and a second filling line which is provided to inject at least one liquefied gas of the two types of liquefied gases into the inside of the outer shell and on which a second ejection hole is provided such that liquefied gas is ejected to a bottom surface of the outer shell.

Brief Description of Drawings

FIG. 1 is a configuration diagram showing a configuration of a cargo tank according to an embodiment of the present invention.

FIG. 2 is a cross-sectional view simply showing a position of a pipe of a first filling line according to the embodiment.

FIG. 3 is a configuration diagram showing a configuration of a ship to which the cargo tank according to the embodiment is applied.

Mode for Carrying Out the Invention

(Embodiment)

FIG. 1 is a configuration diagram showing a configuration of a cargo tank 1 according to an embodiment of the present invention. The same portions in the drawings are denoted by the same reference numerals and redundant descriptions are omitted as appropriate.

The cargo tank 1 is mounted on a ship for loading cargo. At least two types of liquefied gases with different temperatures to be managed are replaced and contained in the cargo tank 1. Therefore, the temperature to be managed, inside the cargo tank 1, is changed depending on the type of liquefied gas contained therein.

The cargo tank 1 is a bilobe tank of type C. FIG. 1 shows a state in which the inside of one side of the bilobe tank can be seen. The other side of the bilobe tank is also configured symmetrically to that shown in FIG. 1. Therefore, the same configuration as that shown in FIG. 1 is also provided on the opposite side (not shown) of the cargo tank 1. Incidentally, the configuration shown in FIG. 1 may be provided on only one side of the cargo tank 1 and only one piece of any device or the like may be provided in the cargo tank 1.

Incidentally, the cargo tank 1 may be of any type and may have any shape. For example, the cargo tank 1 may be a monolobe (cylindrical) cargo tank. In this case, the cargo tank 1 is configured symmetrically, but only one piece of device may be provided in the vicinity of the center of the cargo tank 1. For example, one second filling line 14 may be provided at the deepest portion of a bottom surface, and one third filling line 15 may be provided at the uppermost part.

For example, the cargo is LNG and liquefied carbon dioxide (carbon dioxide). The temperature at which the LNG is managed is, for example, -162°C , and the temperature at which the liquefied carbon dioxide is managed is, for example, -50°C . The cargo may be liquefied petroleum gas (LPG) or any other liquefied gas. In addition, three or more types of liquefied gases including two or more types of liquefied gases whose temperatures to be managed are the same, may be replaced in the cargo tank 1.

The cargo tank 1 includes an outer shell 11, frame members 12, a first filling line 13, a second filling line 14, a third filling line 15, three valves 16a, 16b, and 16c, and a hatch portion 17. Incidentally, the cargo tank 1 may include any configuration or devices not described here. For example, a pump for loading and unloading, a temperature sensor for managing the temperature inside the cargo tank 1, and the like may be provided in the cargo tank 1.

The outer shell 11 is a portion serving as a shell which covers the outside of the cargo tank 1. An internal space of the outer shell 11 is the space containing the liquefied gas that is the cargo of the cargo tank 1. The outer shell 11 has a shape suitable for containing the liquefied gas compressed at high pressure. For example, the outer shell 11 has a curved shape formed such that its central portion in the vertical direction is most expanded in the horizontal direction. For example, a cross-sectional shape of the outer shell 11 is a circle, an ellipse, or a combination of these shapes. More specifically, the outer shell 11 has a bilobe shape or a monolobe shape.

The frame members 12 are supporting members that strengthen the outer shell 11. The frame members 12 are provided on the inner wall of the outer shell 11 at regular intervals in the longitudinal direction of the outer shell 11. Each frame member 12 is provided so as to go around the inner circumference in a direction perpendicular to the longitudinal direction of the outer shell 11.

The first filling line 13 is a pipe for injecting the liquefied gas (containing the gas in its gaseous state), which is the cargo, into the cargo tank 1. The first filling line 13 is used when replacing a low-density liquefied gas (for example, LNG) to a high-density liquefied gas (for example, liquefied carbon dioxide).

The first filling line 13 includes a pipe 131 extending vertically from the hatch portion 17 of the cargo tank 1 to be inserted into the inside of the cargo tank 1, and a pipe 132 which has a plurality of ejection holes H13 for spraying liquefied gas, which is provided on each of both sides (left and right sides) located in a direction perpendicular to the longitudinal direction, of the outer shell 11, and which extends horizontally in the vicinity of an equator of the inner wall of the outer shell 11. In this case, the equator is a part of the outer shell 11 which is most expanded in the horizontal direction. The ejection holes H13 are provided in the pipe 132 at regular intervals in the longitudinal direction of the outer shell 11. The ejection holes H13 are provided such that the sprayed liquefied gas flows from the vicinity of the equator to the bottom surface along the inner wall of the outer shell 11. As a result, the liquefied gas sprayed from the ejection holes H13 flows while heating the inner wall of the outer shell 11 from the vicinity of the equator to the bottom surface. All the pipes 132 in which the ejection holes H13 are provided may be connected together. For example, the pipes 132 are provided symmetrically on the left and right sides of the inner wall of the outer shell 11, but the pipes 132 provided on the left and right sides may be connected to each other or the pipes 132 may be configured to go around the inner wall.

For example, the first filling line 13 is fixed to the frame members 12. Incidentally, the first filling line 13 may be fixed to the inner wall of the outer shell 11 in any manner and may be fixed to parts other than the frame members 12. For example, the first filling line 13 may be fixed directly to the outer shell 11 or additional members for fixing the first filling line 13 may be provided.

The second filling line 14 is a pipe for injecting

the liquefied gas (containing the gas in its gaseous state), which is the cargo, into the cargo tank 1. The second filling line 14 is used when replacing a low-density liquefied gas (for example, LNG) with a high-density liquefied gas (for example, liquefied carbon dioxide) and when replacing a high-density liquefied gas (for example, liquefied carbon dioxide) with a low-density liquefied gas (for example, LNG). The second filling line 14 is used to perform gas replacement in the cargo tank 1 in layers and improve the replacement efficiency. More specifically, the two gases to be replaced form layers and, while the two layers are separated into upper and lower parts, one gas is injected into the cargo tank 1 while the other gas is discharged from the cargo tank 1. In addition, the second filling line 14 is also used when discharging the liquefied gas (containing the gas in its gaseous state) that accumulates on the bottom surface from the cargo tank 1.

The second filling line 14 includes a pipe 141 extending vertically from the hatch portion 17 to be inserted into the interior of the cargo tank 1, and a pipe 142 which has a plurality of ejection holes H14 for spraying the liquefied gas and which extends in the longitudinal direction of the outer shell 11 in the vicinity of the deepest portion of the bottom surface. The ejection holes H14 are provided in the pipe 142 at regular intervals in the longitudinal direction of the outer shell 11. The ejection holes H14 are provided such that the liquefied gas is sprayed toward the deepest portion of the outer shell 11. The liquefied gas sprayed from the ejection holes H14 gradually starts accumulating from the deepest portion of the bottom surface of the outer shell 11.

The vertically extending pipe 141 of the second filling line 14 is connected to the vertically extending pipe 131 of the first filling line 13 in the

vicinity of the hatch portion 17 inside the outer shell 11 to form a single pipe. Incidentally, the two vertically extending pipes 131 and 141 may be connected outside the outer shell 11 or may remain separate without being connected.

For example, the second filling line 14 is fixed to the frame members 12. Incidentally, the second filling line 14 may be fixed to the vicinity of the bottom surface of the outer shell 11 in any manner or may be fixed to parts other than the frame members 12. For example, the second filling line 14 may be fixed directly to the bottom surface of the outer shell 11 or additional members for fixing the second filling line 14 may be provided. Furthermore, the second filling line 14 may be configured similarly to a filling line provided in a known cargo tank (for example, an LNG tank) containing liquefied gas.

The third filling line 15 is used to spray liquid to cool the cargo tank 1 and the cargo. For example, the third filling line 15 is used when replacing a high-density liquefied gas (for example, liquefied carbon dioxide) with a low-density liquefied gas (for example, LNG). In addition, similarly to the second filling line 14, the third filling line 15 may be used to perform gas replacement in the cargo tank 1 in layers to improve replacement efficiency.

The third filling line 15 includes a pipe which is inserted into the cargo tank 1 from the hatch portion 17 and which extends in the longitudinal direction of the outer shell 11 in the vicinity of the uppermost part. Ejection holes are provided in the pipe at regular intervals in the longitudinal direction of the outer shell 11. The ejection holes are provided such that liquefied gas is ejected downwardly from the upper part of the outer shell 11. The pipe inserted into the cargo tank 1 from the hatch portion 17 of the third filling line 15 is provided separately from the first

filling line 13 and the second filling line 14, but may be configured to be connected to at least one of the first filling line 13 and the second filling line 14.

For example, the third filling line 15 is fixed to
5 the frame members 12. Incidentally, the third filling line 15 may be fixed to the vicinity of the upper surface of the outer shell 11 in any manner or may be fixed to parts other than the frame members 12. For example, the third filling line 15 may be fixed
10 directly to the upper surface of the outer shell 11 or additional members for fixing the third filling line 15 may be provided. Furthermore, the third filling line 15 may be configured similarly to a filling line provided at an upper part of a known cargo tank (for
15 example, an LNG tank) containing liquefied gas. Incidentally, the third filling line 15 does not need to be provided in the cargo tank 1.

The hatch portion 17 is a portion which serves as an entrance and exit of the cargo tank 1. The first
20 filling line 13, the second filling line 14, and the third filling line 15 are connected to a pipe outside the cargo tank 1 via the hatch section 17.

The first valve 16a and the second valve 16b are provided at positions located immediately after the
25 first filling line 13 and the second filling line 14 are branched into two pipes 131 and 141 from a part where the filling lines are joined as one body. The first valve 16a is provided in the first filling line 13. The second valve 16b is provided in the second
30 filling line 14. The third valve 16c is provided in the pipe located immediately before branching after the third filling line 15 is inserted through the hatch portion 17.

By opening each of the valves 16a, 16b, and 16c,
35 each of the filling lines 13, 14, and 15 can be used individually. In addition, by closing each of the valves 16a, 16b, and 16c, each of the filling lines 13,

14, and 15 can be made individually unavailable.

Incidentally, the valves 16a, 16b, and 16c may be opened and closed by remote control, by computers, or manually by an operator. In addition, if each of the filling lines 13, 14, and 15 is configured to be able to be used individually, the valves 16a, 16b, and 16c do not need to be provided in the cargo tank 1.

FIG. 2 is a cross-sectional view simply showing a position of the pipe 132 of the first filling line 13 according to the embodiment. The positions of the ejection holes H13 provided in the pipe 132 of the first filling line 13 will be described with reference to FIG. 2. Incidentally, the configuration described here is not limited but, if the ejected liquefied gas flows to the bottom surface along the inner wall, the ejection holes H13 may be provided in any manner.

The ejection holes H13 are provided on the surface of the cylindrical pipe 132. For example, the orientation of the ejection holes H13 is set such that, when assuming that the horizontal direction in the direction of the inner wall is 0 degrees and the vertically downward direction is 90 degrees, the liquefied gas is ejected in a direction within the range of 0 degrees to 90 degrees. By providing the ejection holes H13 in this manner, the liquefied gas ejected from the ejection holes H13 flows to the bottom surface along the inner wall.

Next, the height of the ejection holes H13 will be described. It is assumed that, in the internal space of the outer shell 11, the height of the uppermost part is 100%, the height of the equator is 0%, and the height of the deepest portion is -100%. Incidentally, it is assumed that the internal space of the outer shell 11 has a cross-sectional shape occupying most part of the outer shell 11 as shown in FIG. 2 and does not include space having a special cross-sectional shape, which is a part of the outer shell 11, such as

the hatch portion 17.

The height of the ejection holes H13 is desirably set in the range from -20% to 20%, and more desirably set at 0% (height of equator) or higher. By setting the ejection holes H13 at a height of 0% or higher, the inner wall lower than the vicinity of the equator can be heated by the ejected liquefied gas. By setting the ejection holes H13 at a height of 20% or lower, the ejected liquefied gas can easily flow to the bottom surface along the inner wall. By setting the height of the ejection holes H13 at -20% or higher, a sufficient area for the ejected liquefied gas to flow can be secured in order to obtain the effect of heating the inner wall with the liquefied gas. Furthermore, if the height of the ejection holes H13 is below -50% (if the height of the ejection holes H13 is below an intermediate height between the height of the equator and the height of the deepest portion), the effect of heating the inner wall with the liquefied gas may not be able to be obtained.

Next, a method of replacing the contents of the cargo tank 1 from LNG to liquefied carbon dioxide will be described. Incidentally, if a low-density liquefied gas (i.e., a liquefied gas whose temperature to be managed is low) is to be replaced with a high-density liquefied gas (i.e., a liquefied gas whose temperature to be managed is high), the replacement can be performed in a similar manner to a method described below. In addition, the replacement method described here is only one example, and the contents of the cargo tank 1 may be replaced in any manner.

The first filling line 13 is used when the contents of the cargo tank 1 are replaced from a liquefied gas whose temperature to be managed is low (for example, LNG) to a liquefied gas whose temperature for management is high (for example, liquefied carbon dioxide).

First, all the LNG in the cargo tank 1 is discharged (unloading). However, even after all the LNG is discharged, the cargo tank 1 is still filled with methane gas.

5 Next, the first valve 16a provided on the first filling line 13 is opened and, at the same time, the second valve 16b provided on the second filling line 14 is opened. As a result, the first filling line 13 and the second filling line 14 can be used.

10 Preheated carbon dioxide gas (for example, carbon dioxide at approximately 40°C) is injected into the cargo tank 1 by using the first filling line 13. The injected carbon dioxide gas is ejected from the ejection holes H13 provided in the vicinity of the
15 equator of the inner wall. The carbon dioxide ejected from the ejection holes H13 flows from the vicinity of the equator toward the deepest portion of the bottom surface along the inner wall. As a result, the inner
20 wall is heated, and the methane gas which fills the cargo tank 1 is discharged. By continuing injection of carbon dioxide gas, all of the methane gas is
25 discharged from the cargo tank 1, and the inside of the cargo tank 1 becomes filled with carbon dioxide gas.

 In addition, the internal temperature of the cargo
25 tank 1 is heated to a temperature at which liquefied carbon dioxide can be injected. At the same time, the internal pressure of the cargo tank 1 is increased to a pressure at which liquefied carbon dioxide can be
30 injected. For example, the temperature and pressure at which liquefied carbon dioxide can be injected are the temperature and pressure at which the injection of
35 liquefied carbon dioxide does not cause any problems and, more specifically, the temperature and pressure at which the injected liquefied carbon dioxide does not
 solidify (the temperature and pressure at which liquefied carbon dioxide does not turn into dry ice).

 When all the methane gas is discharged from the

cargo tank 1 and the temperature and pressure inside the cargo tank 1 reach a predetermined level at which it is determined that liquefied carbon dioxide can be injected, the injection of liquefied carbon dioxide is started. Liquefied carbon dioxide is injected until the cargo tank is full of liquefied carbon dioxide. Thus, the contents of the cargo tank 1 are replaced from LNG to liquefied carbon dioxide.

Next, a method of replacing the contents of the cargo tank 1 from liquefied carbon dioxide to LNG will be described. Incidentally, if a high-density liquefied gas (i.e., liquefied gas whose temperature to be managed is high) is to be replaced with a low-density liquefied gas (i.e., a liquefied gas whose temperature to be managed is low), the replacement can be performed in a similar manner to a method described below. In addition, the replacement method described here is only one example, and the contents of the cargo tank 1 may be replaced in any manner.

First, all the liquefied carbon dioxide in the cargo tank 1 is discharged (unloading). However, even if all the liquefied carbon dioxide is discharged, carbon dioxide gas (carbon dioxide) remains.

Next, the second valve 16b provided on the second filling line 14 is opened. At this time, the first valve 16a provided on the first filling line 13 is closed. As a result, the second filling line 14 can be used.

Methane gas is injected using the second filling line 14. The injected methane gas is ejected from the ejection holes H14 located in the vicinity of the deepest portion of the bottom surface. The methane gas ejected from the ejection holes H14 starts to accumulate from the deepest portion. As the methane gas is injected, all of the carbon dioxide gas remaining on the bottom surface is discharged from the upper part of the cargo tank 1 (for example, the hatch

portion 17). For this reason, the inside of the cargo tank 1 becomes filled with methane gas.

When all the carbon dioxide gas is discharged from the cargo tank 1, injection of LNG starts. LNG is
5 injected until the cargo tank is full of LNG. Thus, the contents of the cargo tank 1 are replaced from liquefied carbon dioxide to LNG.

FIG. 3 is a configuration diagram showing a configuration of a ship 20 to which the cargo tank 1
10 according to the embodiment is applied.

For example, the ship 20 is a tanker which replaces and transports LNG and liquefied carbon dioxide. The ship 20 transports LNG on its outward voyage to a destination and transports liquefied carbon
15 dioxide on its return voyage from the destination. As a result, it is possible to transport LNG from its production site to the destination and to return carbon dioxide emitted from the use of LNG back to the LNG production site.

20 In the ship 20, a plurality of cargo tanks 1 are mounted inside the hull. For example, three cargo tanks 1 are arranged in a line along the longitudinal direction of the hull. All of the filling lines 13, 14, and 15 provided in each of the cargo tanks 1 are
25 connected to a manifold 21 by a pipe 22 provided in the hull. The manifold 21 is a connection part for connecting to pipes outside the ship such as those on land. For example, the manifold 21 is connected to pipelines provided on land during loading and
30 unloading. Any number of manifolds 21 may be provided on the ship 20.

The pipe 22 connecting each of the filling lines 13, 14, and 15 with the manifold 21 may have any path. For example, the pipe 22 may be branched or joined at
35 any point. In addition, various valves, pumps, and the like may be provided on the pipe 22.

According to this embodiment, by providing the

first filling line 13 whose ejection holes H13 are provided in the vicinity of the equator of the inner wall, and the second filling line 14 whose ejection holes H14 are provided in the vicinity of the bottom surface, in the cargo tank 1, two types of liquefied gases whose temperatures to be managed are different can be replaced efficiently.

More specifically, as the injected liquefied gas or gas in its gaseous state (liquefied carbon dioxide or the like) is sprayed from the ejection holes H13 of the first filling line 13, the inner wall of the cargo tank 1 can be heated from the equator to the bottom surface. As a result, the inside of the cargo tank 1 can be heated efficiently.

Incidentally, additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

C L A I M S

1. A cargo tank characterized by comprising:

an outer shell containing two types of liquefied gases different in temperature to be managed while replacing the liquefied gases, and including an inner wall having a curved shape in which a central portion in a vertical direction is formed to be most expanded in a horizontal direction;

a first filling line which is provided to inject at least one liquefied gas of the two types of liquefied gases into an inside of the outer shell and on which a first ejection hole is provided at a height greater than or equal to an intermediate height between a height of the central portion and a height of a deepest portion in inner space of the outer shell such that the injected liquefied gas flows along the curved shape of the inner wall; and

a second filling line which is provided to inject at least one liquefied gas of the two types of liquefied gases into the inside of the outer shell and on which a second ejection hole is provided such that liquefied gas is ejected to a bottom surface of the outer shell.

2. The cargo tank of claim 1, characterized in that the first ejection hole is provided at a height in a range from -20% to 20% when it is assumed that a height of a highest part is 100%, a height of the central is 0%, and a height of the deepest portion is -100% in the inner space of the outer shell.

3. The cargo tank of claim 1, characterized by further comprising:

a third filling line in which a third ejection hole is provided so as to spray at least one liquefied gas of the two types of liquefied gases downwardly from an upper part of the outer shell.

4. The cargo tank of claim 3, characterized by further comprising:

valves provided on the first filling line, the second filling line, and the third filling line, respectively.

5 5. A ship characterized by comprising:
 a hull; and,
 a cargo tank installed in the hull,
 the cargo tank including:

 an outer shell containing two types of liquefied
 gases different in temperature to be managed while
10 replacing the liquefied gases, and including an inner
 wall having a curved shape in which a central portion
 in a vertical direction is formed to be most expanded
 in a horizontal direction;

 a first filling line which is provided to inject at
15 least one liquefied gas of the two types of liquefied
 gases into an inside of the outer shell and on which a
 first ejection hole is provided at a height greater
 than or equal to an intermediate height between a
 height of the central portion and a height of a deepest
20 portion in inner space of the outer shell such that
 injected liquefied gas flows along the curved shape of
 the inner wall; and

 a second filling line which is provided to inject
 at least one liquefied gas of the two types of
25 liquefied gases into the inside of the outer shell and
 on which a second ejection hole is provided such that
 liquefied gas is ejected to a bottom surface of the
 outer shell.