

[DESCRIPTION]

[Invention Title]

SYSTEM AND METHOD FOR BUNKERING LIQUEFIED GAS TO SHIP

[Technical Field]

The present invention relates to a system and method for bunkering liquefied gas to a ship.

[Background Art]

As the International Maritime Organization (IMO) strengthens regulations on emission of greenhouse gases and various air pollutants, the shipbuilding and shipping industries are increasingly using natural gas that is a clean energy source as fuel gas for ships instead of using existing fuels such as heavy oil and diesel oil.

Natural gas, which is widely used among fuel gases, contains methane as its main component and is usually converted into a liquefied gas state whose volume is reduced to 1/600. The liquefied gas is stored and transported in an insulated tank installed on a hull.

Meanwhile, during a bunkering process of injecting liquefied gas (e.g., liquefied natural gas (LNG)) into the tank, the pressure inside the tank may rapidly increase. Specifically, gas may be generated as a pipe is cooled down by transporting the liquefied gas, and gas may be generated as the tank is cooled by LNG. Since boil-off gas accumulated inside the tank may increase the internal pressure of the tank, causing deformation and damage to the tank, it is necessary to reduce the amount of boil-off gas generated.

In the related art, the gas (boil-off gas) generated during the bunkering process is compressed by a compressor and returned to a supply side of the liquefied gas to be re-liquefied, burned, or discharged to the outside.

Therefore, there is a need to improve the bunkering process in the related art, such as to minimizing the amount of evaporated gas generated, minimizing an increase in tank pressure, and so on, by efficiently conducting bunkering.

[Disclosure]

[Technical Problem]

Embodiments of the present invention are directed to providing a system and method for bunkering liquefied gas to a ship, capable of supplying a large amount of liquefied gas in a short period of time while minimizing an increase in pressure in a tank that receives the liquefied gas during bunkering.

[Technical Solution]

According to one aspect of the present invention, a system for bunkering liquefied gas to a ship includes a tank provided in a ship and configured to store liquefied gas, a top filling line configured to supply the liquefied gas to an inner upper part of the tank, a bottom filling line configured to supply the liquefied gas to an inner lower part of the tank, a level sensor configured to measure a level of the liquefied gas supplied to the tank, and a controller configured to adjust a supply amount of the liquefied gas supplied through the top filling line and a supply amount of the liquefied gas supplied through the bottom filling line according to a value measured by the level sensor.

The top filling line may be connected to an upper part of the tank, and the bottom filling line may be formed to branch off from the top filling line to extend to the inner lower part of the tank.

The top filling line may be connected to an upper part of the tank, and the bottom filling line may be connected to a bottom part of the tank.

The system may further include a first valve provided on the top filling line and configured to adjust the supply amount of the liquefied gas supplied through the top filling line and a second valve provided on the bottom filling line and configured to adjust the supply amount of the liquefied gas supplied through the bottom filling line.

The top filling line may include an injection line provided to inject the liquefied gas into the inside of the tank.

The injection line may include multi-holes disposed at regular intervals to directly inject fluid onto a liquefied gas interface.

The system may further include an ejector provided on at least one of the top filling line and the bottom filling line and configured to suck some of boil-off gas of the tank and condense the sucked gas into the liquefied gas to be supplied to the injection line.

The system may further include a vapor line configured to supply some of the boil-off gas of the tank to the ejector, and the vapor line may include a check valve and a control valve provided on the vapor line and configured to adjust a flow rate or pressure of the boil-off gas.

The system may further include a first temperature sensor configured to measure a temperature of the top filling line and a second temperature sensor configured to measure a temperature inside the tank.

The second temperature sensor may include a third temperature sensor configured to measure a temperature of a lower part of the tank and a fourth temperature sensor configured to measure a temperature of an upper part of the tank.

The system may further include a flow sensor provided on the top filling line and configured to measure a flow rate of the liquefied gas supplied through the top filling line.

The system may further include a first pressure sensor provided on the top filling line and configured to measure a pressure of the top filling line and a second pressure sensor provided on the tank and configured to measure a pressure inside the tank.

According to another aspect of the present invention, a method of bunkering liquefied gas to a ship includes a step (a) of supplying liquefied gas to the inside of a tank through a top filling line connected to an upper part of the tank of a ship during bunkering, and a step (b) of supplying the liquefied gas to the inside of the tank through a bottom filling line connected to a bottom part of the tank when a level of the liquefied gas supplied to the tank through the top filling line reaches a first set value, in which a supply amount of the liquefied gas through the top filling line is greater than a supply amount of the liquefied gas through the bottom filling line at an early stage of a bunkering process at which the tank is filled with the liquefied gas to reach the first set value and at a late stage of the bunkering process at which the tank is filled with the liquefied gas to an upper level of the tank to reach a second set value.

In the step (a), a temperature of the top filling line and a temperature inside the tank may be measured while flowing the liquefied gas into the tank through the top filling line at the early stage of the bunkering process, and an opening ratio of a first valve provided on the top filling line may be expanded to increase the supply amount of the liquefied gas when a temperature difference between the top filling line and the inside of the tank is reduced to a set value.

In the step (b), the level of the liquefied gas supplied to the tank may be measured, and an opening ratio of a first valve of the top filling line may be reduced and an opening ratio of the second valve of the bottom filling line may be expanded when the measured level reaches the first set value.

The method may further include, when the liquefied gas is supplied simultaneously using the top filling line and the bottom filling line, a process of measuring each temperature of the lower and upper parts of the tank, and a process of expanding an opening ratio of a first valve provided on the top filling line so that a supply amount of the liquefied gas through the top filling line is greater than a supply amount of the liquefied gas through the bottom filling line when a temperature difference between the lower and upper parts of the tank exceeds a set value.

The method may further include a process of connecting the top filling line to an injection line forming multi-holes provided on an inner upper parts of the tank and a process of controlling a flow rate to be uniformly discharged through the multi-holes of the injection line by controlling an opening ratio of a first valve of the top filling line based on a pressure difference between the top filling line and the inside of the tank.

The opening ratio of the first valve of the top filling line may be controlled so that a C_d value of the multi-holes increases in an equation below,

<Equation >

$$Q = C_d A \sqrt{\frac{2\Delta P}{\rho}}$$

in the equation, Q is a flow rate of the liquefied gas supplied through the top filling line, C_d is injection efficiency of the multi-holes, A is a cross-sectional area of all multi-holes, ΔP is a difference between a pressure of the top filling line and a pressure inside the tank, and ρ is a fluid density of the top filling line.

The Q value may be controlled using the first valve so that the C_d value is 0.6 or more.

[Advantageous Effects]

According to an embodiment of the present invention, a system and method for bunkering liquefied gas to a ship can supply a large amount of liquefied gas in a short period of time while minimizing the pressure increase in a tank that receives the liquefied gas during bunkering.

In addition, by increasing the supply amount of liquefied gas through a top filling line at early and late stages of bunkering, the pressure increase in the tank can be suppressed, and when the top filling line and a bottom filling line are simultaneously used, by determining a flow rate ratio between the two lines, effective bunkering can be performed while minimizing the pressure increase in the tank.

Effects of the present invention are not limited to those mentioned above, and other effects not mentioned will be clearly understood by those skilled in the art from the description of claims.

[Description of Drawings]

FIG. 1 illustrates a state in which bunkering is performed based on a temperature of a top filling line and a temperature inside a tank at an early stage of bunkering in a process of bunkering liquefied gas to a ship according to a first embodiment of the present invention.

FIG. 2 illustrates a state in which a flow rate is determined by controlling an opening ratio of a valve on the top filling line based on a level of the tank in the process of bunkering liquefied gas to a ship according to the first embodiment of the present invention.

FIG. 3 illustrates a state in which a flow rate of liquefied gas supplied through the top filling line is controlled based on the temperatures on a lower part and an upper part of the tank in the process of bunkering liquefied gas to a ship according to the first embodiment of the present invention.

FIG. 4 illustrates a state in which the flow rate of the liquefied gas supplied through the top filling line is controlled based on a pressure of the top filling line and a pressure value inside the tank in the process of bunkering liquefied gas to a ship according to the first embodiment of the present invention.

FIG. 5 is a graph showing a state of flow rate supply according to a level of the liquefied gas in the tank according to the first embodiment of the present invention.

FIG. 6 illustrates a system for bunkering liquefied gas to a ship according to a second embodiment of the present invention.

FIG. 7 illustrates a system for bunkering liquefied gas to a ship according to a third embodiment of the present invention.

[Modes of the Invention]

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings. The embodiments introduced below are provided as examples to ensure that the spirit of the present invention can be sufficiently conveyed to those skilled in the art to which the present invention pertains. The present invention is not limited to the embodiments described below and may be embodied in other forms. In order to clearly describe the present invention, parts that are not related to the description are omitted from the drawings, and in the drawings, the width, length, thickness, etc. of components may be exaggerated for convenience. Like reference numerals refer to like elements throughout the specification.

FIG. 1 illustrates a state in which bunkering is performed based on a temperature of a top filling line and a temperature inside a tank at an early stage of bunkering in a process of bunkering liquefied gas to a ship according to a first embodiment of the present invention, and FIG. 2 illustrates a state in which a flow rate is determined by controlling an opening ratio ~~degree~~ of the top filling line –based on a

level of the tank in the process of bunkering liquefied gas to a ship according to the first embodiment of the present invention.

The process of bunkering liquefied gas to a ship according to the first embodiment of the present invention may be applied to various liquefied fuel propulsion ships, liquefied fuel regasification vessels (RVs), container ships, general merchant ships, LNG-Floating Production Storage and Off-loading (FPSO), LNG-Floating Storage and Regasification Units (FSRUs), or the like.

In addition, the liquefied gas stored in a tank 101 may be any one of liquefied natural gas (LNG), liquefied petroleum gas (LPG), dimethylether (DME), and Ethane that may be stored in a liquid state, but is not limited thereto. In the first embodiment of the present invention, LNG is used as an example of the liquefied gas.

The tank 101 may include a membrane-type tank, type A and type B tank, or the like that stores fuel in a liquefied state while maintaining an insulating state.

A top filling line 110 supplies the liquefied gas to an inner upper part of the tank 101 of the ship. The top filling line 110 is connected to the upper part of the tank 101 of the ship, and an injection line 112 connected to the top filling line 110 is provided on the inner upper part of the tank 101. During the process of bunkering, the liquefied gas supplied through the top filling line 110 may be injected to the inside of the tank 101 through the injection line 112.

Multi-holes H may be formed in the injection line 112, and each hole H may be arranged at a certain interval to inject the liquefied gas into the tank 101. Fluid may be directly injected into a liquefied gas interface through the multi-holes H, and droplets generated by the collision of a water surface and the injected liquefied gas may effectively promote cooling of the tank 101. In this case, as a diameter of the hole H decreases, the pressure loss occurring in the hole H increases, but a flow rate

deviation between the holes H decreases. Therefore, the supplied flow rate reflects a loss coefficient of the multi-holes H according to the flow rate, and the design of the multi-holes H may be different depending on the size and type of the tank 101.

The bottom filling line 120 supplies the liquefied gas to an inner lower part of the tank 101. The bottom filling line 120 is connected to a bottom part of the tank 101 and supplies the liquefied gas to the inside of the tank 101. A diameter of the bottom filling line 120 may be manufactured to be larger than that of the top filling line 110.

Hereinafter, the process of bunkering liquefied gas to a ship according to the first embodiment of the present invention will be described.

As shown in FIG. 1, at the early stage of the bunkering process, the liquefied gas is supplied to the inside of the tank 101 through the top filling line 110 connected to the upper part of the tank 101 of the ship. For example, bunkering may be performed toward the tank 101 in a liquefied gas tanker, a land-based fixed liquefied gas storage tank, a liquefied gas terminal, or an offshore floating liquefied gas storage vessel.

In this case, while flowing a minimum amount of liquefied gas into the tank 101 through the top filling line 110, the temperature of the top filling line 110 and the temperature inside the tank 101 are measured by first and second temperature sensors T1 and T2, respectively. The flow rate of liquefied gas supplied through the top filling line 110 is measured by a flow sensor F1.

A controller 150 performs control operations in conjunction with various means to ensure that the process of bunkering liquefied gas is effectively performed. When a temperature difference between the top filling line 110 and the inside of the tank 101 described above is reduced to a set value, the controller 150 expands an

opening ratio of a first valve V11 provided on the top filling line 110 based on the flow rate of the liquefied gas measured by the flow sensor F1 to increase the flow rate of the liquefied gas supplied through the top filling line 110.

When the liquefied gas is supplied through the top filling line 110 at the early stage of bunkering, boil-off gas is generated in a pipe through which the liquefied gas flows, and the boil-off gas causes a pressure increase of the tank 101. Accordingly, the first embodiment of the present invention allows full-scale bunkering by determining a point in time when pipe cooling is completed based on the temperature difference between the top filling line 110 and the inside of the tank 101 to increase the flow rate of the top filling line 110.

When the flow rate of the top filling line 110 increases, the gas may be condensed to suppress the pressure increase in the tank 101. The increased flow rate of the top filling line 110 at the early stage of bunkering condenses the gas generated during a pipe cooling process, and the increased flow rate of the top filling line 110 at the late stage controls the sensitive pressure behavior of gas having a small volume inside the tank.

An ejector 140 may be provided in at least one of the top filling line 110 and the bottom filling line 120. The ejector 140 may be installed on the top filling line 110 close to the injection line 112. The ejector 140 is provided for the purpose of sucking in some of the boil-off gas from the tank 101 and condensing the sucked gas into liquefied gas to be supplied to the injection line 112. For this purpose, a vapor line 130 is provided to supply some of the boil-off gas of the tank 101 to the ejector 140.

The ejector 140 uses the Bernoulli principle of the ejector to suction high-pressure liquid fuel and the boil-off gas inside the tank 101 into the vapor line 130, so

that the boil-off gas and the liquid fuel are mixed together and supplied to the injection line 112.

Therefore, by introducing the boil-off gas of the tank 101 into the ejector 140, the first embodiment of the present invention may have the effect of inducing depressurization of the tank 101. In addition, since the boil-off gas of the tank 101 is condensed into the liquid fuel supplied through the top filling line 110, the boil-off gas of the tank 101 may be continuously supplied to the ejector 140.

In addition, a check valve 132 and a control valve 131 for adjusting a flow rate or pressure of the boil-off gas supplied to the ejector 140 may be provided on the vapor line 130, and as a flow rate control valve or a pressure control valve, the control valve 131 may allow the boil-off gas passing through the vapor line 130 to be supplied to the ejector 140 at a constant pressure or flow rate.

Next, referring to FIG. 2, when the level of the liquefied gas supplied to the tank 101 through the top filling line 110 reaches a first set value, the liquefied gas is supplied to the inside of the tank 101 through the bottom filling line 120 connected to the bottom part of the tank 101.

In this way, by simultaneously supplying the liquefied gas through the top filling line 110 and the bottom filling line 120, a greater flow rate may be efficiently supplied to the tank 101.

The level of the liquefied gas supplied to the tank 101 may be measured by a level sensor L1, and the controller 150 may control the opening ratio ~~degree~~ of the first valve V11 of the top filling line 110 and a second valve V12 of the bottom filling line 120 based on the value measured by the level sensor L1.

Specifically describing the control, for example, the opening ratio ~~degree~~ of the first valve V11 of the top filling line 110 is expanded to increase the flow rate of the

liquefied gas supplied to the tank 101, thereby cooling the upper part of the tank 101 up to 20% level (first set value) of the tank 101.

In addition, when the level of the tank 101 is 20% to 80%, the second valve V12 of the bottom filling line 120 is fully opened and the opening ratio of the first valve V11 of the top filling line 110 is adjusted so that the supply amount of the liquefied gas supplied through the top filling line 110 is less than the supply amount of the liquefied gas supplied through the bottom filling line 120.

Further, when the level of the tank 101 exceeds 80% (second set value), the opening ratio of the first valve V11 of the top filling line 110 is expanded again compared to the opening ratio of the second valve V12 of the bottom filling line 120, thereby adjusting the supply amount of the liquefied gas supplied through the top filling line 110 to be greater than the supply amount of the liquefied gas supplied through the bottom filling line 120.

In this way, it is possible to increase the flow rate of the liquefied gas supplied to the tank 101 through the top filling line 110 at the early and late stages of bunkering and it is possible to minimize the increase in pressure in the tank 101 by promoting cooling and condensation of the gas.

FIG. 3 illustrates a state in which the flow rate of the liquefied gas supplied through the top filling line is controlled based on the temperatures on the upper part and a lower part of the tank in the process of bunkering liquefied gas to a ship according to the first embodiment of the present invention.

Meanwhile, referring to FIG. 3, in the process of bunkering liquefied gas through the top filling line 110 and the bottom filling line 120 described above, the temperatures of the lower and upper parts of the tank 101 may be measured by third and fourth temperature sensors T3 and T4, respectively, and when a temperature

difference between the lower and upper parts of the tank 101 exceeds a set value, the controller 150 may expand the opening ratio of a first valve V11 provided on the top filling line 110 so that an injection amount of the liquefied gas through the top filling line 110 is greater than that through the bottom filling line 120.

That is, by expanding the opening ratio of the first valve V11 on the top filling line 110 to increase the flow rate of the liquefied gas supplied to the tank 101, the pressure increase in the tank 101 may be suppressed, and as a result, the temperature difference between the lower and upper parts of the tank 101 may be reduced. The temperature difference between the upper and lower parts of the tank 101 may be used as a basis for determining a flow rate ratio of between the top filling line 110 and the bottom filling line 120.

The third and the fourth temperature sensors T3 and T4 are attached to upper and lower sides of a wall surface of the tank 101 to measure the temperature, and the temperature of the wall surface of the tank 101 rises as the pressure of the boil-off gas rises. In order to suppress the pressure in the tank 101 during the bunkering process, the temperature of the upper part of the tank 101 has to be lowered. Since when the temperature difference between the upper and lower parts of the wall surface of the tank 101 increases, the increase is indirect evidence that temperature stratification has occurred in a liquid region, in this case, the opening ratio of the first valve V11 of the top filling line 110 is expanded to increase the supply amount of the liquefied gas supplied to the upper part of the tank 101.

In this way, a process of controlling the temperature difference between the upper and lower parts of the tank 101 may be used at a middle stage of the bunkering process that simultaneously uses the top filling line 110 and the bottom filling line 120,

and through the process, the flow rate ratio between the top filling line 110 and the bottom filling line 120 may be determined.

FIG. 4 illustrates a state in which the flow rate of the liquefied gas supplied through the top filling line is controlled based on a pressure of the top filling line and a pressure value inside the tank in the process of bunkering liquefied gas to a ship according to the first embodiment of the present invention.

Referring to FIG. 4, in the process of bunkering liquefied gas through the top filling line 110 and the bottom filling line 120 described above, the pressure of the top filling line 110 and the pressure inside the tank 101 are measured by pressure gauges P1 and P2, respectively, and the controller 150 controls the opening ratio of the first valve V11 of the top filling line 110 based on the measured pressure values, so that the flow rate may be uniformly discharged through the multi-holes H of the injection line 112.

Efficient cooling and condensation of the gas may be achieved by supplying the uniform flow rate through the multi-holes H.

In this case, the controller 150 may control the opening ratio of the first valve V11 of the top filling line 110 so that a C_d value of the multi-holes increases in an equation below.

<Equation>

$$Q = C_d A \sqrt{\frac{2\Delta P}{\rho}}$$

In the equation, Q represents a flow rate of the liquefied gas supplied through the top filling line, C_d represents an injection efficiency of the multi-holes H, A represents a cross-sectional area of all the multi-holes H, ΔP represents a difference between a pressure of the top filling line and a pressure inside the tank, and ρ

represents a fluid density of the top filling line. At this time, the Q value may be controlled using the first valve so that the C_d value is preferably 0.6 or higher.

As the flow rate of liquefied natural gas passing through the multi-holes H increases, the resistance coefficient of the multi-holes H decreases. As the flow rate of the liquefied gas increases, the resistance coefficient of the multi-holes H rapidly decreases and then becomes stable, which means that the flow rate is uniformly output through the multi-holes H . Accordingly, an operating condition in which the resistance coefficient of the multi-holes H gradually decreases may be maintained based on the equation and through the operating condition, a large flow rate may be supplied with a small pressure drop, thereby making possible to perform efficient bunkering.

The performance of the injection line 112 in which the multi-holes H are formed varies depending on the flow rate. By injecting the uniform flow rate of the liquefied gas to the inside of the tank 101 through each hole H , pressure loss may be effectively reduced, and the bunkering process may proceed quickly and efficiently.

FIG. 5 is a graph showing a state of flow rate supply according to a level of the liquefied gas in the tank according to the first embodiment of the present invention.

Referring to FIG. 5, as described above, at the early stage of the bunkering process, the liquefied gas is supplied to the inside of the tank 101 through the top filling line 110 until the level of the liquefied gas supplied to the tank 101 reaches a first set value.

In addition, after reaching the first set value, the second valve $V12$ of the bottom filling line 120 is fully opened, and the first valve $V11$ of the top filling line 110 is adjusted so that the amount of the liquefied gas supplied through the bottom filling line 120 is greater than the amount supplied through the top filling line 110.

In addition, at the late stage of the bunkering process when the tank 101 is filled with the liquefied gas to its upper level to reach a second set value, the first valve V11 of the top filling line 110 and the second valve V12 of the bottom filling line 120 are adjusted so that the amount of the liquefied gas supplied through the top filling line 110 is greater than that of the bottom filling line 120.

When the first valve V11 of the top filling line 110 and the bottom filling line 120 are simultaneously used, as described in FIGS. 3 and 4, the amount of the liquefied gas supplied through the top filling line 110 is adjusted based on the temperature difference between the upper and lower parts of the tank 101 and the pressure difference between the top filling line 110 and the inside of the tank 101, so that the amount of boil-off gas generated is suppressed, the pressure inside the tank 101 is controlled, and effective liquefied gas injection is achieved, thereby making it possible to perform efficient bunkering.

FIG. 6 illustrates a system for bunkering liquefied gas to a ship according to a second embodiment of the present invention.

Referring to FIG. 6, the system for bunkering liquefied gas to a ship according to the second embodiment of the present invention has a difference in a connection configuration of a bottom filling line 120 compared to the first embodiment, and the other components and operating manners of the components are the same as the first embodiment.

Specifically, the bottom filling line 120 of the second embodiment branches off from a top filling line 110 and extends to an inner lower part of a tank 101. In the second embodiment, an ejector 140 is provided on the top filling line 110, and the bottom filling line 120 branches off from a section past the ejector 140 on the top

filling line 110, but the connection configuration of the bottom filling line 120 is not limited thereto, and may branch off from a section before passing the ejector 140.

FIG. 7 illustrates a system for bunkering liquefied gas to a ship according to a third embodiment of the present invention.

Referring to FIG. 7, the system for bunkering liquefied gas to a ship according to the third embodiment of the present invention has a difference in a deployment configuration of an ejector 140 compared to the second embodiment, and the other components and operating manners of the components are the same as the second embodiment.

Specifically, the ejector 140 of the third embodiment is provided on a bottom filling line 120.

In the above, specific embodiments have been illustrated and described. However, the present invention is not limited to the above-described embodiments, and it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the technical spirit of the present invention defined in the claims.

[CLAIMS]

[Claim 1]

A system for bunkering liquefied gas to a ship, comprising:

a tank provided in a ship and configured to store liquefied gas;

a top filling line configured to supply the liquefied gas to an inner upper part of the tank;

a bottom filling line configured to supply the liquefied gas to an inner lower part of the tank;

a level sensor configured to measure a level of the liquefied gas supplied to the tank; and

a controller configured to adjust a supply amount of the liquefied gas supplied through the top filling line and a supply amount of the liquefied gas supplied through the bottom filling line according to a value measured by the level sensor.

[Claim 2]

The system of claim 1, wherein the top filling line is connected to an upper part of the tank, and

the bottom filling line is formed to branch off from the top filling line to extend to the inner lower part of the tank.

[Claim 3]

The system of claim 1, wherein the top filling line is connected to an upper part of the tank, and

the bottom filling line is connected to a bottom part of the tank.

[Claim 4]

The system of claim 1, further comprising:

a first valve provided on the top filling line and configured to adjust the supply amount of the liquefied gas supplied through the top filling line; and

a second valve provided on the bottom filling line and configured to adjust the supply amount of the liquefied gas supplied through the bottom filling line.

[Claim 5]

The system of claim 1, wherein the top filling line includes an injection line provided to inject the liquefied gas to the inside of the tank.

[Claim 6]

The system of claim 5, wherein the injection line includes multi-holes disposed at regular intervals to directly inject fluid onto a liquefied gas interface.

[Claim 7]

The system of claim 1, further comprising an ejector provided on at least one of the top filling line and the bottom filling line and configured to suck some of boil-off gas of the tank and condense the sucked gas into the liquefied gas to be supplied to the injection line.

[Claim 8]

The system of claim 7, further comprising a vapor line configured to supply some of the boil-off gas of the tank to the ejector,

wherein the vapor line includes a check valve and a control valve provided on the vapor line and configured to adjust a flow rate or pressure of the boil-off gas.

[Claim 9]

The system of claim 1, further comprising:

a first temperature sensor configured to measure a temperature of the top filling line; and

a second temperature sensor configured to measure a temperature inside the tank.

[Claim 10]

The system of claim 9, wherein the second temperature sensor includes a third temperature sensor configured to measure a temperature of a lower part of the tank and a fourth temperature sensor configured to measure a temperature of an upper part of the tank.

[Claim 11]

The system of claim 1, further comprising a flow sensor provided on the top filling line and configured to measure a flow rate of the liquefied gas supplied through the top filling line.

[Claim 12]

The system of claim 1, further comprising:

a first pressure sensor provided on the top filling line and configured to measure a pressure of the top filling line; and

a second pressure sensor provided on the tank and configured to measure a pressure inside the tank.

[Claim 13]

A method of bunkering liquefied gas to a ship, comprising:

a step (a) of supplying liquefied gas to the inside of a tank through a top filling line connected to an upper part of the tank of a ship during bunkering; and

a step (b) of supplying the liquefied gas to the inside of the tank through a bottom filling line connected to a bottom part of the tank when a level of the liquefied gas supplied to the tank through the top filling line reaches a first set value,

wherein a supply amount of the liquefied gas through the top filling line is greater than a supply amount of the liquefied gas through the bottom filling line at an early stage of a bunkering process at which the tank is filled with the liquefied gas to reach the first set value and at a late stage of the bunkering process at which the tank is filled with the liquefied gas to an upper level of the tank to reach a second set value.

[Claim 14]

The method of claim 13, wherein in the step (a),
a temperature of the top filling line and a temperature inside the tank are measured while flowing the liquefied gas into the tank through the top filling line at the early stage of the bunkering process, and
an opening ratio of a first valve provided on the top filling line is expanded to increase the supply amount of the liquefied gas when a temperature difference between the top filling line and the inside of the tank is reduced to a set value.

[Claim 15]

The method of claim 13, wherein in the step (b),
the level of the liquefied gas supplied to the tank is measured, and
an opening ratio of a first valve of the top filling line is reduced and an opening ratio of a second valve of the bottom filling line is expanded when the measured level reaches the first set value.

[Claim 16]

The method of claim 13, further comprising, when the liquefied gas is supplied simultaneously using the top filling line and the bottom filling line:
a step of measuring each temperature of lower and upper parts of the tank; and
a step of expanding an opening ratio of a first valve provided on the top filling line so that a supply amount of the liquefied gas through the top filling line is greater

than a supply amount of the liquefied gas through the bottom filling line when a temperature difference between the lower and upper parts of the tank exceeds a set value.

[Claim 17]

The method of claim 13, further comprising:

a step of connecting the top filling line to an injection line forming multi-holes provided on an inner upper part of the tank; and

a step of controlling a flow rate to be uniformly discharged through the multi-holes of the injection line by controlling an opening ratio of a first valve of the top filling line based on a pressure difference between the top filling line and the inside of the tank.

[Claim 18]

The method of claim 17, wherein the opening ratio of the first valve of the top filling line is controlled so that a C_d value of the multi-holes increases in an equation below,

<Equation>

$$Q = C_d A \sqrt{\frac{2\Delta P}{\rho}}$$

in the equation, Q is a flow rate of the liquefied gas supplied through the top filling line, C_d is injection efficiency of the multi-holes, A is a cross-sectional area of all multi-holes, ΔP is a difference between a pressure of the top filling line and a pressure inside the tank, and ρ is a fluid density of the top filling line.

[Claim 19]

The method of claim 18, wherein the Q value is controlled using the first valve so that the C_d value is 0.6 or more.