【DESCRIPTION】

【Invention Title】

SYSTEM AND METHOD FOR PREVENTING LIQUID CARGO IN SHIP FROM EVAPORATING

【Technical Field】

[1] The present invention relates to a system and method for reducing or preventing evaporation of liquid cargo, and more particularly, to a system and method for preventing evaporation of liquid cargo in a ship, which can reduce or prevent generation of boil-off gas by adjusting the inner pressure of a loading pipe when liquid cargo such as LNG, LPG, and crude oil is loaded into a storage tank in a ship.

【Background Art】

[2] Among ships, cargo ships are classified according to cargo type. Examples of cargo ships for carrying liquid cargo include a crude oil tanker configured to carry crude oil, a product carrier configured to carry petroleum products, and a liquefied gas carrier configured to liquefy gases and carry the liquefied gases, and examples of the liquefied gas carrier include a liquefied natural gas (LNG) carrier, a liquefied petroleum gas (LPG) carrier, and the like. In addition, ships for carrying or storing liquid cargo include an LNG FPSO, an LNG FSRU, an LNG FSU, an LNG bunkering vessel, a chemical tanker, an ethylene carrier, and the like.

[3] Conventionally, liquid cargo such as LNG, LPG, and crude oil is supplied and loaded into a storage tank through a feed pipe extending generally horizontally above the storage tank and a loading pipe extending downwards from the feed pipe toward a bottom of the storage tank.

[4] However, there is a problem in that, during loading of liquid cargo, the inner pressure of an upper end of a loading pipe extending in a vertical direction of a storage tank becomes lower than vapor pressure of liquid cargo due to water head differential within the pipe, thereby causing evaporation or vaporization of a considerable amount of the liquid cargo.

[5] Conventionally, boil-off gas generated by evaporation of the liquid cargo during loading of the liquid cargo is sent back to a liquid cargo source (for example, an onshore LNG or oil plant, a bunkering vessel, top-side LNG production facilities, or the like) or discharged to the atmosphere, instead of being loaded into a storage tank. Boil-off gas discharged to the atmosphere can cause environmental pollution, whereas boil-off gas sent back to the source requires additional reprocessing costs and facilities.

[6] To overcome these problems, the present inventor has proposed a method in which a pressure regulator is provided to a lower end of a loading pipe extending in a vertical direction of a storage tank; the inner pressure of an upper end of the loading pipe is measured; and the pressure regulator is adjusted based on the measured pressure to maintain the inner pressure of the upper end of the loading pipe at a level above the vapor pressure of liquid cargo. This method is disclosed in Korean Patent No. 10-1012643.

【Disclosure】

【Technical Problem】

[7] However, the present inventor has found that, when the pressure in the upper end of the loading pipe is maintained at a level above the vapor pressure of liquid cargo by the pressure regulator provided to the lower end of the loading pipe according to the method proposed by the present inventor, it takes more time than expected to load liquid cargo due to differential pressure caused by the pressure regulator even when the pressure regulator is fully opened.

[8] In addition, the present inventor has found that, if the pressure regulator provided to the lower end of the loading pipe is not operable or causes the loading pipe to be closed due to breakdown, this can cause serious problems.

[9] Embodiments of the present invention seek to solve such problems in the art, and it is an aspect of the present invention to provide a system and method for preventing evaporation of liquid cargo in a ship, in which, in addition to a pressure regulator, a bypass pipe and a bypass valve are provided to a lower end of a loading pipe extending in a vertical direction of a storage tank, whereby liquid cargo can be

loaded through both the bypass pipe and the loading pipe which may increase loading speed when the requirement that the pressure in an upper end of the loading pipe be maintained at a level above the vapor pressure of liquid cargo is satisfied, and liquid cargo can be loaded through the bypass pipe upon malfunction of the pressure regulator.

【Technical Solution】

[10] In accordance with one aspect of the present invention, there is provided a system for preventing evaporation of liquid cargo in a ship, which prevents generation of boil-off gas when liquid cargo is loaded into a storage tank capable of storing liquid cargo, the system including: a pressure regulator provided to a pipe configured to load liquid cargo into the storage tank; a sensing unit placed apart from the pressure regulator; and a bypass pipe branching off from the pipe to allow liquid cargo to bypass the pressure regulator and to be loaded into the storage tank; wherein a degree of opening of the pressure regulator is controlled to maintain pressure in the pipe at a level above a vapor pressure of liquid cargo based on information sensed by the sensing unit, wherein the bypass pipe is provided with a bypass valve controlling flow of liquid cargo through the bypass pipe, and wherein the bypass valve is opened to allow liquid cargo to be loaded through both the bypass pipe and the pipe, when the pressure in the pipe can be maintained at a level above the vapor pressure of liquid cargo even though the pressure regulator is fully opened, as liquid cargo is loaded and a level of liquid cargo in the storage tank thus is raised.

[11] The system may further include a bypass pipe branching off from the pipe to allow the liquid cargo to be loaded into the storage tank after bypassing the pressure regulator.

[12] The bypass pipe may have a smaller diameter than the pipe from which the bypass pipe branches off.

[13] The bypass pipe may be provided with a bypass valve controlling flow of liquid cargo through the bypass pipe.

[14] The bypass valve may be opened to allow liquid cargo to be loaded through

both the bypass pipe and the pipe, when the pressure in the pipe can be maintained at a level above the vapor pressure of liquid cargo even though the pressure regulator is fully opened, as liquid cargo is loaded and a level of liquid cargo in the storage tank thus is raised.

[15] The sensing unit may be a pressure transmitter provided to the pipe at an upstream side of the pressure regulator to measure the pressure in the pipe and controlling the degree of opening of the pressure regulator based on the measured value.

[16] The sensing unit may be a level measurement device provided to the storage tank to measure a level of liquid cargo in the storage tank and controlling the degree of opening of the pressure regulator based on the measured value.

[17] The pipe may include: a feed pipe extending above the storage tank; and a loading pipe extending downwards from the feed pipe towards a bottom of the storage tank, and the pressure regulator may be provided to a lower portion of the loading pipe.

[18] The pipe may further include a dispensing pipe extending horizontally from a lower end of the loading pipe.

[19] The pressure regulator may be a valve or a hydraulic turbine.

[20] In accordance with another aspect of the present invention, there is provided a method for preventing evaporation of liquid cargo in a ship, which prevents generation of boil-off gas when liquid cargo is loaded into a storage tank capable of storing liquid cargo, the method comprising: controlling a degree of opening of a pressure regulator provided to a pipe configured to load liquid cargo into the storage tank based on information measured at a position apart from the position at which the pressure regulator is provided to maintain pressure in the pipe at a level above a vapor pressure of liquid cargo, wherein a bypass pipe branching off from the pipe and a bypass valve opening/closing the bypass pipe are provided, and wherein, upon opening of the bypass valve, liquid cargo can be loaded into the storage tank through the bypass pipe without passing through the pressure regulator while being loaded into the storage tank through the pipe, and wherein the bypass valve is opened to allow liquid cargo to be loaded through both the bypass pipe and the pipe, when the pressure in the pipe can be maintained at a level above the vapor pressure of liquid cargo even though the pressure regulator is fully opened, as liquid cargo is loaded and a level of liquid cargo in the storage tank thus is raised.

[21] A bypass pipe branching off from the pipe and a bypass valve opening/closing the bypass pipe may be provided, and wherein, upon opening of the bypass valve, liquid cargo can be loaded into the storage tank through the bypass pipe without passing through the pressure regulator while being loaded into the storage tank through the pipe.

[22] The bypass valve may be opened to allow liquid cargo to be loaded through both the bypass pipe and the pipe, when the pressure in the pipe can be maintained at a level above the vapor pressure of liquid cargo even though the pressure regulator is fully opened, as liquid cargo is loaded and a level of liquid cargo in the storage tank thus is raised.

[23] Upon malfunction of the pressure regulator, liquid cargo may be loaded without interruption through the bypass pipe by opening the bypass valve, and the bypass pipe may have a smaller diameter than the pipe such that the pressure in the

pipe can be maintained at a level above the vapor pressure of liquid cargo.

[24] The information may be the pressure in the pipe measured by a pressure transmitter provided to the pipe at an upstream side of the pressure regulator.

[25] The information may be the level of liquid cargo in the storage tank measured by a level measurement device provided to the storage tank.

【Advantageous Effects】

[26] Embodiments of the present invention provide a system and method for preventing evaporation of liquid cargo in a ship, in which, in addition to a pressure regulator, a bypass pipe and a bypass valve are provided to a lower end of a loading pipe extending in a vertical direction of a storage tank.

[27] In the system and method for preventing evaporation of liquid cargo in a ship according to embodiments of the present invention, the pressure in the loading pipe, particularly the pressure in an upper end of the loading pipe can be adjusted and maintained at a level above a vapor pressure of liquid cargo by the pressure regulator provided to the loading pipe, thereby reducing or preventing generation of boil-off gas during loading of liquid cargo while allowing loading of liquid cargo to be efficiently performed.

[28] In addition, in the system and method for preventing evaporation of liquid cargo in a ship according to embodiments of the present invention, liquid cargo can be loaded through both the bypass pipe and the loading pipe to prevent reduction in loading speed when the requirement that the pressure in the upper end of the loading pipe be maintained at a level above the vapor pressure of liquid cargo is satisfied.

[29] Actually, when the flow rate of liquid cargo was measured under the requirement that a valve having anti-cavitation ability be used as the pressure regulator, the loading pipe configured to load liquid cargo have a length of 28 m, and the pressure in the loading pipe be maintained at a level above the vapor pressure of liquid cargo, the flow rate of liquid cargo when only the loading pipe was opened was measured to be 7,838 m^3/h, and the flow rate of liquid cargo when both the loading pipe and the bypass pipe were opened was measured to be 9,338 m^3/h. Thus, it could be seen that the flow rate was increased by about 20% when

both the bypass pipe and the loading pipe were used.

[30] Here, increase in flow rate means faster loading speed of liquid cargo and thus reduction in time required to load liquid cargo. Reduction in loading time allows, for example, reduction in mooring charge that should be paid according to the time for which a ship is moored in a port, thereby cutting down operating costs.

[31] Furthermore, in the system and method for preventing evaporation of liquid cargo in a ship according to embodiments of the present invention, loading of liquid cargo can be continuously performed through the bypass pipe even when the pressure regulator suddenly breaks down.

【Description of Drawings】

[32] Fig. 1 is a schematic view of a system for preventing evaporation of liquid cargo according to a first exemplary embodiment of the present invention.

[33] Fig. 2 is a schematic view of a system for preventing evaporation of liquid cargo according to a second exemplary embodiment of the present invention.

[34] Fig. 3 is a schematic view of a system for preventing evaporation of liquid cargo according to a third exemplary embodiment of the present invention.

[35] Fig. 4 is a schematic view of a system for preventing evaporation of liquid cargo according to a fourth exemplary embodiment of the present invention.

【Best Mode】

[36] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[37] A system for preventing evaporation of liquid cargo in a ship according to the present invention may be used in any ship so long as the ship is equipped with a storage tank for storing liquid cargo. A storage tank employing the system for preventing evaporation of liquid cargo according to the present invention is not necessarily limited to a storage tank intended to be loaded with liquid cargo and must be considered to also include storage tanks (i.e. fuel tanks) carrying oil used as an engine fuel, liquefied gas, and the like.

[38] In other words, the system for preventing evaporation of liquid cargo

according to the present invention may be used in all kinds of ships carrying liquid cargo as cargo or using liquid cargo as a fuel, i.e. a crude oil tanker, a product oil carrier, an LNG carrier, an LPG carrier, a PC, a liquefied carbon dioxide carrier, an LNG RV, an oil FPSO, an LNG FPSO, an LNG FSRU, an LNG FSU, an LNG bunkering vessel, a chemical tanker, an ethylene carrier, and the like. Here, although FPSOs, FSRUs, and the like are classified as offshore plants, the term "ship" as used herein must be considered to include a variety of offshore plants floating in the sea as well as ships in the ordinary sense.

[39] In addition, the system for preventing evaporation of liquid cargo according to the present invention may be used in an onshore storage tank storing liquefied gas such as LNG, LPG, liquefied nitrogen, and liquefied carbon dioxide or oil such as crude oil and refined oil, as well as in an offshore storage tank.

[40]

[41] Fig. 1 is a schematic view of a system for preventing evaporation of liquid cargo according to a first exemplary embodiment of the present invention. Referring to Fig. 1, liquid cargo is supplied and loaded into a storage tank 1 from a supply source such as an onshore plant and an FPSO through a feed pipe 11 extending generally horizontally above the storage tank 1, a loading pipe 12 extending downwards from the feed pipe 11 toward a bottom of the storage tank 1, and a dispensing pipe 13 communicating with a lower end of the loading pipe 12 and extending generally horizontally.

[42] The system for preventing evaporation of liquid cargo according to the first exemplary embodiment includes a pressure regulator 22 provided to a lower portion of the loading pipe 12, a pressure transmitter 21, as a sensing unit, measuring pressure in an upper end of the loading pipe 12 and controlling the pressure regulator 22 based on the measured value, a bypass pipe 14 branching off from the loading pipe 12 to bypass the pressure regulator 22, and a bypass valve 24 provided to the bypass pipe 14 to control flow of liquid cargo through the bypass pipe 14.

[43] As the sensing unit, the pressure transmitter 21 is placed apart from the pressure regulator 22.

[44] The dispensing pipe 13 is provided with a dispensing valve 23 and at least

one dispensing valve 23 may be provided to each storage tank 1. When liquid cargo is stored at room temperature as in a crude oil storage tank, the dispensing pipe 13 may extend through a bulkhead 3. In this embodiment, a single dispensing pipe 13 may be connected to a plurality of storage tanks.

[45] The pressure regulator 22 is preferably placed at the lower end of the loading pipe 12 to maintain pressure in the loading pipe 12 at a level above a vapor pressure of liquid cargo in response to electrical signals from the pressure transmitter 21. In other words, the pressure regulator 22 regulates the degree of opening/closing of a lower end opening of the loading pipe 12 based on the pressure in the loading pipe, thereby allowing the pressure in the loading pipe, particularly the pressure in the upper end of the loading pipe to be maintained at a level above the vapor pressure of liquid cargo. Thus, the pressure regulator 22 can prevent creation of a vacuum within the upper end (portion A) of the loading pipe 12, which is a main cause of generation of boil-off gas during loading of liquid cargo.

[46] According to this exemplary embodiment, the pressure regulator 22 regulates the degree of opening/closing of the lower end opening of the loading pipe in response to signals from the pressure transmitter 21, thereby adjusting the pressure in the loading pipe 12, particularly, the pressure in the upper end of the loading pipe 12 indicated by A in the drawing. As the pressure regulator 22, a control valve, a hydraulic turbine, or the like may be used.

[47] As the pressure regulator, the control valve may be a valve operable by hydraulic pressure or pneumatic pressure when submerged under liquid cargo. The control valve is configured to operate in a full-open state upon failure of a signal or failure of hydraulic pressure or pneumatic pressure, has anti-cavitation ability in a normal operation state, and preferably has explosion-proof characteristics.

[48] Theoretically, a valve allows only a pressure drop by providing isenthalpic expansion, whereas a hydraulic turbine used as the pressure regulator can theoretically provide isentropic expansion by producing a work output to allow reduction in enthalpy of liquid cargo, for example, LNG along with a pressure drop, thereby obtaining liquid cargo at a relatively low temperature at a downstream side, as compared with a valve, and thus can be more efficient. Such a hydraulic turbine

used as the pressure regulator 22 has already been used in a variety of fields and may include any suitable hydraulic turbine generally used in the art depending on design requirements.

[49] According to this exemplary embodiment, a simple arrangement such as a valve or a hydraulic turbine is added to the system, whereby unnecessary generation of boil-off gas can be effectively suppressed during loading of liquid cargo without high equipment costs, thereby enabling efficient loading liquid cargo into the storage tank 10.

[50] According to this exemplary embodiment, the bypass pipe 14 branching off from the loading pipe 12 at an upstream side of the pressure regulator 22 to bypass the pressure regulator 22 is connected to the dispensing pipe 13 such that liquid cargo loaded through the feed pipe 11 and the loading pipe 12 can be directly supplied to the dispensing pipe 13 without passing through the pressure regulator 22.

[51] When the loading pipe 12 is closed due to malfunction of the pressure regulator 22, loading of liquid cargo can be performed without interruption by opening the bypass valve 24 provided to the bypass pipe 14. Here, since abrupt opening of the bypass valve 24 can cause the pressure in the upper end of the loading pipe 12 to be reduced and create a vacuum within the loading pipe 12, it is desirable that the bypass pipe 14 have a smaller diameter than the loading pipe 12.

[52] In addition, when the level of liquid cargo in the storage tank 1 is raised as liquid cargo is loaded into the storage tank 1, the bypass valve 24 may be opened such that liquid cargo can be loaded through both the bypass pipe 14 and the loading pipe 12. Here, opening of the bypass valve 24 must not be performed until the pressure in the upper end of the loading pipe 12 can be maintained at a level above the vapor pressure of liquid cargo despite opening of the bypass valve 24. According to this exemplary embodiment, even when the pressure regulator 22 is fully opened during loading of liquid cargo, it is possible to overcome the problem of reduction in loading speed due to differential pressure caused by the pressure regulator using the bypass pipe 12, thereby reducing the time required to complete loading of liquid cargo.

[53]

[54] Next, operation of the system for preventing generation of boil-off gas of liquid cargo in a ship according to the first exemplary embodiment will be described.

[55] When liquid cargo such as LNG, LPG, and crude oil is loaded into the storage tank 1 through the feed pipe 11, the loading pipe 12, and the dispensing pipe 13, the pressure transmitter 21 measures pressure in the upper end of the loading pipe 12. The pressure regulator 22 is opened/closed or regulated in the degree of opening based on the pressure value measured by the pressure transmitter 21 to regulate loading speed of liquid cargo, thereby maintaining the pressure in the upper end of the loading pipe 12 at a level above a vapor pressure of liquid cargo.

[56] According to this exemplary embodiment, when the pressure regulator 22 accidentally breaks down during loading of liquid cargo, liquid cargo can be loaded without interruption through the bypass pipe by opening the bypass valve 24 provided to the bypass pipe 14. In addition, it is possible to reduce the risk of creation of a cavity within the upper end of the loading pipe, since the bypass pipe 14 has a smaller diameter than the loading pipe 12.

[57] On the other hand, if the pressure in the upper end of the loading pipe 12 can be maintained above the vapor pressure of liquid cargo even when the pressure regulator 22 is fully opened as loading of liquid cargo is normally achieved and the level of liquid cargo in the storage tank 1 thus is raised, the bypass valve 24 is opened such that liquid cargo can be loaded through both the bypass pipe 14 and the loading pipe 12, thereby offsetting the pressure differential caused by the pressure regulator 22. Thus, it is possible to prevent reduction in loading speed due to the pressure differential, thereby allowing loading of liquid cargo to be completed as quickly as possible.

[58] Accordingly, it is possible to minimize adverse influence on loading speed and cargo capacity while reducing generation of boil-off gas (i.e. flash gas) or volatile organic compounds (VOCs) during loading of liquid cargo.

[59]

[60] Fig. 2 is a schematic view of a system for preventing evaporation of liquid cargo according to a second exemplary embodiment of the present invention. Referring to Fig. 2, liquid cargo is supplied and loaded into a storage tank 1 from a

supply source such as an onshore plant and an FPSO through a feed pipe 11 extending generally horizontally above the storage tank 1, a loading pipe 12 extending downwards from the feed pipe 11 toward a bottom of the storage tank 1, and a dispensing pipe 13 communicating with a lower end of the loading pipe 12 and extending generally horizontally.

[61] The system for preventing evaporation of liquid cargo according to the second exemplary embodiment includes a pressure regulator 22 provided to a lower portion of the loading pipe 12, a level measurement device 31, as a sensing unit, provided to the storage tank 1 and measuring the level of liquid cargo in the storage tank 1 to control the pressure regulator 22 based on the measured value, a bypass pipe 14 branching off from the loading pipe 12 to bypass the pressure regulator 22, and a bypass valve 24 provided to the bypass pipe 14 to control flow of liquid cargo through the bypass pipe 14.

[62] As the sensing unit, the level measurement device 31 is placed apart from the pressure regulator 22, and, for example, may be mounted at an upper end of the storage tank 1.

[63] Since the system for preventing evaporation of liquid cargo according to the second exemplary embodiment is substantially the same as the system for preventing evaporation of liquid cargo according to the first exemplary embodiment except for the level measurement device 31 measuring the level of liquid cargo in the storage tank 1 as the sensing unit, the same components as the first exemplary embodiment are denoted by the same reference numerals and detailed descriptions thereof are omitted.

[64]

[65] Fig. 3 is a schematic view of a system for preventing evaporation of liquid cargo according to a third exemplary embodiment of the present invention. Referring to Fig. 3, liquid cargo is supplied and loaded into a storage tank 1 from a supply source such as an onshore plant and an FPSO through a feed pipe 11 extending generally horizontally above the storage tank 1 and a loading pipe 12 extending downwards from the feed pipe 11 toward a bottom of the storage tank 1.

[66] The system for preventing evaporation of liquid cargo according to the third

exemplary embodiment includes a pressure regulator 22 provided to a lower portion of the loading pipe 12, a pressure transmitter 21, as a sensing unit, measuring pressure in an upper end of the loading pipe 12 and controlling the pressure regulator 22 based on the measured value, a bypass pipe 14 branching off from the loading pipe 12 to bypass the pressure regulator 22, and a bypass valve 24 provided to the bypass pipe 14 to control flow of liquid cargo through the bypass pipe 14.

[67] As the sensing unit, the pressure transmitter 21 is placed apart from the pressure regulator 22.

[68] One loading pipe 12 may be provided to each storage tank 1. Generally, the lower end of the loading pipe 12 is located near a bottom of the storage tank 1 without being secured to the bottom.

[69] The pressure regulator 22 is preferably placed at a lower end of the loading pipe 12 to maintain pressure in the loading pipe 12 at a level above a vapor pressure of liquid cargo in response to electrical signals from the pressure transmitter 21. In other words, the pressure regulator 22 regulates the degree of opening/closing of a lower end opening of the loading pipe 12 based on the pressure in the loading pipe, thereby allowing the pressure in the loading pipe, particularly the pressure in the upper end of the loading pipe to be maintained at a level above the vapor pressure of liquid cargo. Thus, the pressure regulator 22 can prevent creation of a vacuum within the upper end (portion A) of the loading pipe 12, which is a main cause of generation of boil-off gas during loading of liquid cargo.

[70] According to this exemplary embodiment, the pressure regulator 22 regulates the degree of opening/closing of the lower end opening of the loading pipe in response to signals from the pressure transmitter 21, thereby adjusting the pressure in the loading pipe 12, particularly, the pressure in the upper end of the loading pipe 12 indicated by A in the drawing. As the pressure regulator 22, a control valve, a hydraulic turbine, or the like may be used.

[71] As the pressure regulator, the control valve may be a valve operable by hydraulic pressure or pneumatic pressure when submerged under liquid cargo. The control valve is configured to operate in a full-open state upon failure of a signal or failure of hydraulic pressure or pneumatic pressure, has anti-cavitation ability in a

normal operation state, and preferably has explosion-proof characteristics.

[72] Theoretically, a valve allows only a pressure drop by providing isenthalpic expansion, whereas a hydraulic turbine when used as the pressure regulator can theoretically provide isentropic expansion by producing a work output to allow reduction in enthalpy of liquid cargo, for example, LNG along with a pressure drop, thereby obtaining liquid cargo at a relatively low temperature at the downstream side as compared with a valve, and thus can be more efficient. Such a hydraulic turbine used as the pressure regulator 22 has already been used in a variety of fields and may include any suitable hydraulic turbine generally used in the art depending on design conditions.

[73] According to this exemplary embodiment, a simple arrangement such as a valve or hydraulic turbine is added to the system, whereby unnecessary generation of boil-off gas can be effectively suppressed during loading of liquid cargo without high equipment costs, thereby enabling efficient loading of liquid cargo into the storage tank 10.

[74] According to this exemplary embodiment, the bypass pipe 14 branching off from the loading pipe 12 to bypass the pressure regulator 22 branches off from the loading pipe 12 at the upstream side of the pressure regulator 22 and then extends generally parallel to the loading pipe 12 such that liquid cargo loaded through the feed pipe 11 and the loading pipe 12 can be directly supplied to the storage tank 1 through the bypass pipe 14 without passing through the pressure regulator 22.

[75] When the loading pipe 12 is closed due to malfunction of the pressure regulator 22, loading of liquid cargo can be performed without interruption by opening the bypass valve 24 provided to the bypass pipe 14. Here, since abrupt opening of the bypass valve 24 can cause the pressure in the upper end of the loading pipe 12 to be lower, thereby creating a vacuum within the loading pipe 12, it is desirable that the bypass pipe 14 have a smaller diameter than the loading pipe 12.

[76] In addition, when the level of liquid cargo in the storage tank 1 is raised as liquid cargo is loaded into the storage tank 1, the bypass valve 24 may be opened such that liquid cargo can be loaded through both the bypass pipe 14 and the loading pipe 12. Here, opening of the bypass valve 24 must not be performed until the

pressure in the upper end of the loading pipe 12 can be maintained at a level above the vapor pressure of liquid cargo despite opening of the bypass valve 24. According to this exemplary embodiment, even when the pressure regulator 22 is fully opened during loading of liquid cargo, it is possible to overcome the problem of reduction in loading speed due to differential pressure caused by the pressure regulator using the bypass pipe 14, thereby reducing the time required to complete loading of liquid cargo.

[77]

[78] Next, operation of the system for preventing generation of boil-off gas of liquid cargo in a ship according to the third exemplary embodiment will be described.

[79] When liquid cargo such as LNG, LPG, and crude oil is loaded into the storage tank 1 through the feed pipe 11 and the loading pipe 12, the pressure transmitter 21 measures pressure in the upper end of the loading pipe 12. The pressure regulator 22 is opened/closed or regulated in the degree of opening based on the pressure value measured by the pressure transmitter 21 to regulate loading speed of liquid cargo, thereby maintaining the pressure in the upper end of the loading pipe 12 at a level above a vapor pressure of liquid cargo.

[80] According to this exemplary embodiment, when the pressure regulator 22 accidentally breaks down during loading of liquid cargo, liquid cargo can be loaded without interruption through the bypass pipe 14 by opening the bypass valve 24 provided to the bypass pipe 14. In addition, it is possible to reduce the risk of creation of a cavity within the upper end of the loading pipe, since the bypass pipe 14 has a smaller diameter than the loading pipe 12.

[81] On the other hand, if the pressure in the upper end of the loading pipe 12 can be maintained above the vapor pressure of liquid cargo even when the pressure regulator 22 is fully opened as loading of liquid cargo is normally achieved and the level of liquid cargo in the storage tank 1 thus is raised, the bypass valve 24 is opened such that liquid cargo can be loaded through both the bypass pipe 14 and the loading pipe 12, thereby offsetting the pressure differential caused by the pressure regulator 22. Thus, it is possible to prevent reduction in loading speed due to the

pressure differential, thereby allowing loading of liquid cargo to be completed as quickly as possible.

[82] Accordingly, it is possible to minimize adverse influence on loading speed and cargo capacity while reducing generation of boil-off gas (i.e. flash gas) or volatile organic compounds (VOCs) during loading of liquid cargo.

[83]

[84] Fig. 4 is a schematic view of a system for preventing evaporation of a liquid cargo according to a fourth exemplary embodiment of the present invention. Referring to Fig. 4, liquid cargo is supplied and loaded into a storage tank 1 from a supply source such as an onshore plant and an FPSO through a feed pipe 11 extending generally horizontally above the storage tank 1 and a loading pipe 12 extending downwards from the feed pipe 11 toward a bottom of the storage tank 1.

[85] The system for preventing evaporation of liquid cargo according to the fourth exemplary embodiment includes a pressure regulator 22 provided to a lower portion of the loading pipe 12, a level measurement device 31, as a sensing unit, provided to the storage tank 1 and measuring the level of liquid cargo in the storage tank 1 to control the pressure regulator 22 based on the measured value, a bypass pipe 14 branching off from the loading pipe 12 to bypass the pressure regulator 22, and a bypass valve 24 provided to the bypass pipe 14 to control flow of liquid cargo through the bypass pipe 14.

[86] As the sensing unit, the level measurement device 31 is placed apart from the pressure regulator 22, and, for example, may be mounted at an upper end of the storage tank 1.

[87] Since the system for preventing evaporation of liquid cargo according to the fourth exemplary embodiment is substantially the same as the system for preventing evaporation of liquid cargo according to the third exemplary embodiment except for including the level measurement device 31 measuring the level of liquid cargo in the storage tank 1 as the sensing unit, the same components as the third exemplary embodiment are denoted by the same reference numerals and detailed descriptions thereof are omitted.

[88]

[89] The system according to the exemplary embodiments of the present invention may be modified to include a separate valve (not shown) provided to the loading pipe 12 at the upstream side of the pressure regulator 22, wherein the valve is closed during maintenance of the pressure regulator 22 to facilitate maintenance work. The separate valve may be a manual valve.

[90] Although some exemplary embodiments have been described with reference to the accompanying drawings, it should be understood that these embodiments are given by way of illustration only, and that various modifications, variations, and alterations can be made without departing from the spirit and scope of the present invention.

【CLAIMS】

【Claim 1】

A system for preventing evaporation of liquid cargo in a ship, which prevents generation of boil-off gas when liquid cargo is loaded into a storage tank capable of storing liquid cargo, the system comprising:

a pressure regulator provided to a pipe configured to load liquid cargo into the storage tank;

a sensing unit placed apart from the pressure regulator; and

a bypass pipe branching off from the pipe to allow liquid cargo to bypass the pressure regulator and to be loaded into the storage tank;

wherein a degree of opening of the pressure regulator is controlled to maintain pressure in the pipe at a level above a vapor pressure of liquid cargo based on information sensed by the sensing unit,

wherein the bypass pipe is provided with a bypass valve controlling flow of liquid cargo through the bypass pipe, and

wherein the bypass valve is opened to allow liquid cargo to be loaded through both the bypass pipe and the pipe, when the pressure in the pipe can be maintained at a level above the vapor pressure of liquid cargo even though the pressure regulator is fully opened, as liquid cargo is loaded and a level of liquid cargo in the storage tank thus is raised.

【Claim 2】

The system according to claim 1, wherein the bypass pipe has a smaller diameter than the pipe from which the bypass pipe branches off.

【Claim 3】

The system according to claim 1, wherein the sensing unit is a pressure transmitter provided to the pipe at an upstream side of the pressure regulator to measure the pressure in the pipe and controlling the degree of opening of the pressure regulator based on a sensed value.

【Claim 4】

The system according to claim 1, wherein the sensing unit is a level measurement device provided to the storage tank to measure a level of liquid cargo in the storage tank and controlling the degree of opening of the pressure regulator based on a sensed value.

【Claim 5】

The system according to claim 1, wherein the pipe comprises a feed pipe extending above the storage tank; and a loading pipe extending downwards from the feed pipe towards a bottom of the storage tank, and wherein the pressure regulator is provided to a lower portion of the loading pipe.

【Claim 6】

The system according to claim 5, wherein the pipe further comprises a dispensing pipe extending horizontally from a lower end of the loading pipe.

【Claim 7】

The system according to claim 1, wherein the pressure regulator is a valve or a hydraulic turbine.

【Claim 8】

A method for preventing evaporation of liquid cargo in a ship, which prevents generation of boil-off gas when liquid cargo is loaded into a storage tank

capable of storing liquid cargo, the method comprising:

controlling a degree of opening of a pressure regulator provided to a pipe configured to load liquid cargo into the storage tank based on information measured at a position apart from the position at which the pressure regulator is provided to maintain pressure in the pipe at a level above a vapor pressure of liquid cargo,

wherein a bypass pipe branching off from the pipe and a bypass valve opening/closing the bypass pipe are provided, and wherein, upon opening of the bypass valve, liquid cargo can be loaded into the storage tank through the bypass pipe without passing through the pressure regulator while being loaded into the storage tank through the pipe, and

wherein the bypass valve is opened to allow liquid cargo to be loaded through both the bypass pipe and the pipe, when the pressure in the pipe can be maintained at a level above the vapor pressure of liquid cargo even though the pressure regulator is fully opened, as liquid cargo is loaded and a level of liquid cargo in the storage tank thus is raised.

【Claim 9】

The method according to claim 8, wherein, upon malfunction of the pressure regulator, liquid cargo can be loaded without interruption through the bypass pipe by opening the bypass valve, and wherein the bypass pipe has a smaller diameter than the pipe such that the pressure in the pipe can be maintained at a level above the vapor pressure of liquid cargo.

【Claim 10】

The method according to claim 8, wherein the information is the pressure in the pipe measured by a pressure transmitter provided to the pipe at an upstream side of the pressure regulator.

【Claim 11】

The method according to claim 8, wherein the information is a level of liquid cargo in the storage tank measured by a level measurement device provided to the storage tank.