

MANUFACTURING METHOD OF

FLOATING LIQUEFIED HYDROCARBON GAS PLANT

TECHNICAL FIELD

[0001]

- 5 The present invention relates to a manufacturing method of a floating liquefied hydrocarbon gas plant that reuses liquefied hydrocarbon gas tanks of a ship for transporting liquefied hydrocarbon gas.

BACKGROUND ART

[0002]

- 10 Conventionally, it is known that in a ship (LNG ship) for transporting liquefied natural gas (LNG), even after the hull of the ship has aged to a significant extent, the liquefied natural gas tanks (LNG tanks) still have not aged so much. Therefore, it has been proposed to remove LNG tanks from a ship which has been in service for a long period of time, and reuse the LNG tanks in other LNG ships.

- 15 [0003]

For instance, a conventionally known technology includes the step of removing LNG tanks from the hull of a first LNG ship by using a first crane, and the step of mounting the LNG tanks on the hull of a second ship which is different from the first ship by using the same crane or a different second crane. See Patent Document 1.

- 20 PRIOR ART DOCUMENT(S)

PATENT DOCUMENT(S)

[0004]

Patent Document 1: JP2012-086768A

SUMMARY OF THE INVENTION

- 25 TASK TO BE ACCOMPLISHED BY THE INVENTION

[0005]

According to the prior art disclosed in Patent Documents 1, the LNG tanks of an existing LNG ship can be reused in a newly constructed LNG ship. However, the entire hull of the newly constructed LNG ship is required to be newly constructed so
5 that a high construction cost is required.

In the case of a small LNG plant which requires a relatively small storage capacity of LNG, all of the LNG tanks of an existing LNG ship are not required to be reused. An excessive tank storage capacity means a lower facility utilization efficiency, and increases the maintenance cost.

10 [0006]

Based on such considerations, the inventors of this patent application have realized that when reusing the LNG tanks of an existing LNG ship for a floating liquefied natural gas plant, by reducing the fore and aft length of the floating liquefied natural gas plant as compared to the fore and aft length of the existing LNG ship, the
15 required mechanical strength of the hull for supporting a floating liquefied natural gas plant is reduced, and a part of the hull of the existing LNG ship can be reused.

[0007]

Also, by using a part of the LNG tanks of the existing LNG ship, a relatively small plant for utilizing LNG can be constructed in a convenient manner (for the
20 purpose of supplying electric power generated by using LNG to small or medium sized power users). Furthermore, as an additional advantage, the BOG (boil off gas) processing facility associated with the LNG tanks can be reused.

[0008]

The technology for reusing existing ships proposed by the inventors of this
25 application can be applied not only to LNG ships but also to ships for transporting other

types of hydrocarbon gases such as LPG. Therefore, such liquefied hydrocarbon gas plants, including liquefied natural gas plants, will be collectively referred to as "liquefied hydrocarbon gas plants" in the following disclosure.

[0009]

5 The present invention was made in view of such problems of the prior art, and has a primary object to provide a method of manufacturing a floating liquefied hydrocarbon gas plant that efficiently reutilizes an existing liquefied hydrocarbon gas transport ship.

MEANS FOR ACCOMPLISHING THE TASK

10 [0010]

 To achieve such an object, a first aspect of the present invention provides a method of manufacturing a floating liquefied hydrocarbon gas plant that reuses liquefied hydrocarbon gas tanks of a ship for transporting liquefied hydrocarbon gas, comprising the steps of: cutting the ship into a plurality of blocks each containing at least one of the liquefied hydrocarbon gas tanks; and building a new floating structure portion including a liquefied hydrocarbon gas plant connected to a front end or a rear end of at least one of the blocks; wherein a combined length of the at least one of the blocks and the floating structure portion connected thereto is smaller than a length of the ship.

20 [0011]

 By thus making the fore and aft length of the floating liquefied hydrocarbon gas plant smaller than that of the existing ship, the required mechanical strength and the required thickness of the structural plates of the hull forming the floating liquefied hydrocarbon gas plant can be reduced so that the existing ship (including a part of the hull thereof) can be efficiently utilized.

[0012]

According to a second aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant further comprises the step of installing at least a part of a plant facility in the floating structure portion.

5 [0013]

Thereby, the freedom in the layout of the devices and appliances of the plant facility can be improved, and the manufacture of the floating liquefied hydrocarbon gas plant can be facilitated.

[0014]

10 According to a third aspect of the present invention, the floating structure portion is provided with a plurality of vertically arranged decks each containing a part of the plant facility.

[0015]

15 Thereby, the space within the floating liquefied hydrocarbon gas plant can be efficiently utilized so that the fore and aft dimension of the floating liquefied hydrocarbon gas plant can be minimized even when the plant facility is installed in the floating liquefied hydrocarbon gas plant.

[0016]

20 According to a fourth aspect of the present invention, the plant facility comprises at least one of a facility for regasification of liquefied hydrocarbon gas stored in the liquefied hydrocarbon gas tank, a facility for liquefying hydrocarbon gas to be stored in the liquefied hydrocarbon gas tank, a facility for liquefying hydrocarbon gas obtained from a gas field or an associated gas to be stored in the liquefied hydrocarbon gas tank, a power transmission facility for transmitting electric power generated by the
25 floating liquefied hydrocarbon gas plant which is moored to a coast to an existing power

grid, and a facility for supplying hydrocarbon gas from the floating liquefied hydrocarbon gas plant which is moored to a coast directly to a hydrocarbon gas user.

[0017]

The facility for regasification of liquefied hydrocarbon gas stored in the liquefied hydrocarbon gas tank allows the gasified hydrocarbon gas to be used as fuel or the like. The facility for liquefying hydrocarbon gas to be stored in the liquefied hydrocarbon gas tank allows the liquefied hydrocarbon gas to be stored as fuel or the like. The facility for liquefying hydrocarbon gas obtained from a gas field or an associated gas to be stored in the liquefied hydrocarbon gas tank allows the liquefied hydrocarbon gas to be transported to a user site by using an LNG ship or the like. The power transmission facility for transmitting electric power generated by the floating liquefied hydrocarbon gas plant which is moored to a coast allows the generated electric power to be transmitted to an existing power grid. The facility for supplying hydrocarbon gas from the floating liquefied hydrocarbon gas plant which is moored to a coast allows the hydrocarbon gas to be supplied directly to a hydrocarbon gas user.

[0018]

According to a fifth aspect of the present invention, the block to which the floating structure portion is connected includes a propulsion facility for the ship.

[0019]

By thus reutilizing the propulsion facility for the existing ship, the existing ship for transporting liquefied hydrocarbon gas can be efficiently reutilized.

[0020]

According to a sixth aspect of the present invention, the plant facility includes at least one of a gas engine and a gas turbine that uses hydrocarbon gas regasified from the liquefied hydrocarbon gas stored in the liquefied hydrocarbon gas tank and/or boil

off gas.

[0021]

Thereby, the output and the exhaust heat of the gas engine and/or the gas turbine can be utilized within and without the floating liquefied hydrocarbon gas plant.

5 [0022]

In this case, by using a gas engine generator combining a gas engine and a power generator, or a gas turbine generator combining a gas turbine and a power generator, the electric power generated by using the hydrocarbon gas can be used within or without the floating liquefied hydrocarbon gas plant. Also, a device utilizing the cold
10 heat of the liquefied hydrocarbon gas may be provided in association with the gas engine. The plant facility may include a gas turbine combine cycle power generation facility.

[0023]

According to a seventh aspect of the present invention, the at least one of the
15 gas engine and the gas turbine is used for generating a propelling power.

[0024]

Thereby, the floating liquefied hydrocarbon gas plant can travel over the sea without requiring a tugboat or the like.

[0025]

20 According to an eighth aspect of the present invention, the plant facility comprises: a gas engine using hydrocarbon gas stored in the liquefied hydrocarbon gas tank as a fuel; a refrigerant turbine using a refrigerant consisting of a hydrocarbon or carbon dioxide as a working fluid; an electric power generator driven by the refrigerant turbine; a refrigerant heater for heating the refrigerant using a cooling liquid for cooling
25 the gas engine as a heat source; a heat exchanger for further heating the refrigerant

heated by the refrigerant heater by using exhaust gas of the gas engine as a heat source; and a condenser for condensing the refrigerant expelled from the refrigerant turbine by exchanging heat with hydrocarbon gas discharged from the liquefied hydrocarbon gas tank.

5 [0026]

By thus utilizing the waste heat (the heat from the exhaust gas and the cooling liquid) from the gas engine for the refrigerant turbine using hydro carbon or carbon dioxide as a working fluid, the heat recovery ratio of the gas engine can be improved, and hence, the power generation efficiency of the plant facility can be improved.

10 [0027]

According to a ninth aspect of the present invention, the plant facility comprises: a gas turbine using hydrocarbon gas stored in the liquefied hydrocarbon gas tank as a fuel; a refrigerant turbine using a refrigerant consisting of a hydrocarbon or carbon dioxide as a working fluid; an electric power generator driven by the refrigerant turbine; a heat recovery boiler for recovering waste heat from the gas turbine; a heater for heating a cooling liquid for cooling the gas turbine with a heat medium heated by the heat recovery boiler; a refrigerant heater for heating the refrigerant by using the cooling liquid heated by the heater as a heat source; and a condenser for condensing the refrigerant expelled from the refrigerant turbine by exchanging heat with hydrocarbon gas discharged from the liquefied hydrocarbon gas tank.

[0028]

By thus utilizing the waste heat (the heat from the cooling liquid) from the gas turbine for the refrigerant turbine using hydro carbon or carbon dioxide as a working fluid, the heat recovery ratio of the gas turbine can be improved, and hence, the power generation efficiency of the plant facility can be improved.

25

[0029]

According to a tenth aspect of the present invention, the plant facility is configured to supply regasified hydrocarbon gas simultaneously as the electric power generator generates electric power by being driven by the gas engine.

5 [0030]

Thereby, simultaneously as electric power is generated by the power generator driven by the gas engine, the hydrocarbon gas can be supplied to the gas engine as a fuel.

[0031]

10 According to an eleventh aspect of the present invention, the plant facility is configured to supply regasified hydrocarbon gas simultaneously as the electric power generator generates electric power by being driven by the gas turbine.

[0032]

15 Thereby, simultaneously as electric power is generated by the power generator driven by the gas engine, the hydrocarbon gas can be supplied to the gas turbine as a fuel.

[0033]

20 According to a twelfth aspect of the present invention, the liquefied hydrocarbon gas consists of at least one of liquefied natural gas and liquefied petroleum gas.

[0034]

Thereby, the existing ship for transporting liquefied hydrocarbon gas can be efficiently reutilized as a floating liquefied hydrocarbon gas plant that uses at least one of liquefied natural gas and liquefied petroleum gas.

25 [0035]

According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is a same width as the block connected thereto.

[0036]

5 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is provided with an upper deck at a same level as an upper deck of the block.

[0037]

10 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the block and the floating structure portion connected to the block are formed into a single floating structure by welding.

[0038]

15 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that a section accommodating the plant facility is separated from the seawater by at least a pair of longitudinal bulkheads.

[0039]

20 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that a section accommodating the plant facility is separated from the seawater by at least a pair of bottom walls.

[0040]

25 According to another aspect of the present invention, the method of

manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is provided with a tank or tanks for storing at least one of plant waste water, plant medium liquid (refrigerant, heat medium or the like), fuel oil, and lubricating oil.

5 [0041]

According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is provided with a longitudinal bulkhead extending continuously from the block.

10 [0042]

According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is not closed by an upper deck.

[0043]

15 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is provided with a plurality of compartments separated by at least one bulkhead.

[0044]

20 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the block and the floating structure portion connect to the block are provided with a buoyancy.

[0045]

25 According to another aspect of the present invention, the method of

manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the block and the floating structure portion connect to the block are provided with a ballast tank for controlling the attitude of the hull (trim and heel adjustment).

[0046]

5 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is provided with a mooring facility for mooring to a pier or a seabed.

[0047]

10 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the block and the floating structure portion are provided with a mooring facility for mooring to a pier or a seabed.

[0048]

15 According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that a floating body consisting of the block and the floating structure portion connected to the block is provided with a mooring facility for mooring the floating body to another ship such as an LNG ship and a loading facility for loading and unloading liquefied
20 hydrocarbon gas (such as LNG) to and from the other ship so that liquefied hydrocarbon gas can be accepted from a liquefied hydrocarbon gas tank of the block to the other ship.

[0049]

 According to another aspect of the present invention, the method of
25 manufacturing a floating liquefied hydrocarbon gas plant is characterized by that a

floating body consisting of the block and the floating structure portion connected to the block is provided with a mooring facility for mooring the floating body to another ship such as an LNG ship and a loading facility for loading and unloading liquefied hydrocarbon gas (such as LNG) to and from the other ship so that liquefied hydrocarbon gas can be accepted from the other ship to a liquefied hydrocarbon gas tank of the block.

[0050]

According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is provided with a superstructure for accommodating living quarters or working areas

[0051]

According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the plant facility includes a facility for liquefying liquefied natural gas stored in the liquefied natural gas tank.

[0052]

According to another aspect of the present invention, the method of manufacturing a floating liquefied hydrocarbon gas plant is characterized by that the floating structure portion is provided with a propulsion facility.

EFFECT OF THE INVENTION

[0053]

Thus, the present invention provides an advantage in that an existing liquefied hydrocarbon gas transportation ship such as an existing LNG ship can be efficiently reutilized.

BRIEF DESCRIPTION OF THE DRAWING(S)

[0054]

Figure 1 shows a side view and a plan view of an LNG ship provided with LNG tanks to be reutilized according to an embodiment of the present invention;

5 Figures 2A to 2D are diagrams illustrating a method of manufacturing floating liquefied hydrocarbon gas plants by reutilizing the LNG ship shown in Figure 1;

Figure 3 is a sectional view of the LNG tank and a surrounding part of one of the floating liquefied hydrocarbon gas plants shown in Figure 2;

10 Figure 4 is a sectional view showing the layout of a plant facility installed in the floating structure portion shown in Figure 2B;

Figure 5 shows plan views of the layout of the plant facility installed on different decks of the floating structure portion shown in Figure 2B;

Figure 6 is a diagram showing a first example of a plant facility provided in a floating liquefied hydrocarbon gas plant; and

15 Figure 7 is a diagram showing a second example of a plant facility provided in a floating liquefied hydrocarbon gas plant.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0055]

20 Preferred embodiments of the present invention are described in the following with reference to the appended drawings.

[0056]

Figure 1 shows a side view and a top view of an example of an LNG ship 1 having LNG tanks 2A to 2D to be reused in an embodiment of the present invention.

25 The terms (such as front, rear, left, right, up and down) denoting directions used in the following description are defined with regard to the LNG ship 1 shown in Figure 1. For

example, the bow direction (on the right hand side in the drawing) is defined as "front", and the stern direction (on the left hand side in the drawing) is defined as "rear".

[0057]

As shown in Figure 1, the LNG ship 1 is an existing ship used for marine transportation of LNG, and includes a plurality (four in this case) of LNG tanks 2A to 2D (which may hereinafter be referred to collectively as the "LNG tank 2" wherever appropriate), a propulsion unit 3, and a hull 4 on which these components are mounted. In the present embodiment, the existing vessel to be reused may consist of a ship whose hull 4 (including the outer shell of the ship but excluding at least the LNG tank 2) is coming close to an end of a service life owing to a long time period of use. Alternatively, the ship 1 may have become redundant for any other reasons.

[0058]

In this disclosure, the LNG ship 1 is given as an example of a liquefied hydrocarbon gas transport ship to be reused, but the present invention is not limited to this, but may be applied to any ship such as an LPG ship fitted at least with a storage tank for liquefied hydrocarbon gas similar to the LNG tank 2.

According to the present invention, it is also possible to reuse an LNG ship as a floating liquefied natural gas plant or a floating liquefied petroleum gas plant, and reuse an LPG ship as a floating liquefied petroleum gas plant.

20 [0059]

Figure 2 includes diagrams illustrating a method of building floating liquefied hydrocarbon gas plants of the present embodiment based on the reuse of the LNG ship 1 shown in Figure 1.

[0060]

25 As shown in (A) to (D) of Figures 2, in the method of building the floating

liquefied hydrocarbon gas plant 5 according to the present embodiment, by reusing the LNG tank 2 of the LNG ship 1 and a part of the surrounding structural members such as the hull 4, a new floating liquefied hydrocarbon gas plant 5 is built.

[0061]

5 In building the floating liquefied hydrocarbon gas plant 5, first of all, as shown in Figure 1, the LNG ship 1 is cut into a plurality of blocks (a first block 11, a second block 12, a third block 13, and a fourth block 14) in a construction dock (not shown in the drawings) for ships. Each block 11, 12, 13, 14 contains the corresponding one of the LNG tanks 2A to 2D and an associated part of the structural members such as the hull 4
10 which has been cut. In this case, the LNG ship 1 is cut along cut planes 16, 17 and 18 extending vertically and arranged along the fore and aft direction of the LNG ship 1 (see Figure 1 also).

[0062]

 In the case of the floating liquefied hydrocarbon gas plant 5 shown in Figure
15 2(A), the first block 11 is utilized, and a newly constructed floating structure portion 21 is connected to the front end of the first block 11. In the newly constructed floating structure portion 21, major structural members corresponding to the outer shell and other major structural members (deck, bottom plate, outer plate, etc.) of the hull 4 extend in the longitudinal direction in the first block 11 in continuation with the counter
20 parts of the first block 11. The major parts of the first block 11 and the floating structure portion 21 are integrally joined to one another by welding or the like so as to form a single new floating structure. The floating structure portion 21 may have a same width as the first block 11. The first block 11 is provided with a per se known propulsion unit 3 (which may include a diesel engine, a generator, a motor, etc.) in addition to the first
25 LNG tank 2A. By using this existing propulsion unit 3, the floating structure portion 21

can function as a smaller ship than the original LNG ship 1 while conveniently reusing the existing facilities of the LNG ship 1. Furthermore, the floating structure portion 21 serves as a platform for installing a plant facility utilizing the liquefied hydrocarbon gas stored in the first LNG tank 2A. Therefore, this plant is newly fitted with a plant facility
5 including various appliances and devices for using the liquefied hydrocarbon gas. It is not essential that all the appliances and devices of the plant facility 30 are placed on the floating structure portion 21, and a part of appliances and devices of the plant facility 30 may be installed on the side of the existing first block 11.

[0063]

10 In the case of the floating liquefied hydrocarbon gas plant 5 shown in Figure 2(B), a newly constructed floating structure portion 22 is connected to the front end of the second block 12, and another newly built floating structure portion 23 is connected to the rear end of the second block 12. The newly constructed floating structure portions 22 and 23 are provided with structural members corresponding to the outer shell and
15 other major structural members of the hull extending in the fore and aft direction in the second block 12 so as to be continuous in the fore and aft direction. The front floating structure portion 22 is a protective structure for protecting the front of the second block 12 (the LNG tank 2B), and the rear floating structure portion 23 is a floating structure serving as a platform for a plant facility 30 similarly as the floating structure portion 21
20 shown in Figure 2(A). However, in this case, the rear floating structure portion 23 may be provided with a cabin 31 that can be used as an operation room or the like for the plant facility 30. Since the floating liquefied hydrocarbon gas plant 5 shown in Figure 2 (B) does not have any existing propulsion equipment, it may be transported on the sea to a desired place using a per se known tugboat or the like. However, it is also possible
25 to install a propulsion unit in the floating structure portion 23.

[0064]

The floating liquefied hydrocarbon gas plant 5 shown in Figure 2(C) is similar to that shown in Figure 2(B) except that the third block 13 is used in place of the second block 12.

5 [0065]

In the case of the floating liquefied hydrocarbon gas plant 5 shown in Figure 2(D), a newly constructed floating structure portion 24 is connected to the rear end of the fourth block 14. The new floating structure portion 24 is provided with structural members corresponding to the outer shell of the hull extending in the longitudinal
10 direction in the fourth block 14 and other major structural members of the fourth block so as to be continuous in the fore and aft direction. Similarly as the floating structure portion 23 of Figure 2(B), the floating structure portion 24 serves as a platform for a plant facility 30.

[0066]

15 In the present embodiment, the LNG ship 1 having the four LNG tanks 2A to 2D is divided into the four blocks, the first to fourth blocks 11, 12, 13 and 14, and all of the four blocks are utilized to produce the four floating liquefied hydrocarbon gas plants 5. Thus, in the present embodiment, the floating liquefied hydrocarbon gas plants 5 are constructed by reusing the entire existing LNG ship 1. However, the present invention is
20 not limited to this, but it is also possible to build the floating liquefied hydrocarbon gas plants 5 by reusing only a part of the separated multiple blocks of the existing LNG ship 1.

[0067]

Further, in regard to the floating liquefied hydrocarbon gas plants 5 according
25 to the present embodiment, various changes can be made on the number of the LNG

tanks provided in the LNG ship 1 to be reused, and the number of blocks the LNG ship 1 is cut into. For example, one floating liquefied hydrocarbon gas plant 5 (or a block separated from the LNG ship 1) may include two or more of the LNG tanks originally provided in the existing LNG ship 1.

5 [0068]

The fore and aft dimension of the floating liquefied hydrocarbon gas plant 5 to be constructed is required to be smaller than that of the LGN ship 1 to be reused. Therefore, even if the existing LNG ship 1 may not be fit to be continued to be used from the viewpoint of the required strength (the longitudinal strength requirement, for
10 example) of the structural members (in particular, the hull), because the floating liquefied hydrocarbon gas plant 5 to be constructed has a smaller fore and aft dimension, the required strength of the structural members associated with each block 11, 12, 13, 14 that is to be reused will be less, and the mechanical strength of the existing structure members may well be adequate. As a result, in the floating liquefied hydrocarbon gas
15 plants 5, it is possible to reuse not only the LNG tanks 2 but also the structural members (at least a part thereof) of the hull 4 and the like located in the vicinity of the LNG tanks 2. Therefore, the floating liquefied hydrocarbon gas plants 5 can be constructed by efficiently reutilizing the existing ship (including a part of the hull in addition to the LNG tanks 2).

20 [0069]

The foregoing embodiment pertained to the plant facilities 30 using hydrocarbon gases, but the plant facilities 30 may use LPG or any other liquefied hydrocarbon gases. For instance, when an LNG ship 1 (with LNG tanks 2) is to be reused, it is possible to install a plant facility 30 using LNG or LPG. When an LPG ship
25 (with LPG tanks 2) is to be reused, it is possible to install a plant facility 30 using LPG.

[0070]

Figure 3 is a cross sectional view of an LNG tank 2 of a floating liquefied hydrocarbon gas plant 5 and a peripheral part thereof.

[0071]

5 As shown in Figure 3, in the illustrated embodiment, the LNG tank 2 consists of a Moss tank (spherical independent tank), and includes a spherical tank main body 41, a skirt 42 forming a cylindrical support structure and fixedly supported by a hull 4 (a base deck), and a tank cover 43 in a per se known manner. In the floating liquefied hydrocarbon gas plant 5 described above, not only the tank main body 41 but also the
10 surrounding structural members including a part of the hull 4 supporting the tank main body 41 are reused. However, in the floating liquefied hydrocarbon gas plant 5 according to the present invention, depending on the degree of aging or damage sustained by the tank main body 41 and the surrounding structural members, such parts may be partly repaired or replaced before reusing them.

15 [0072]

Although not shown in Figure 3, as a structural member surrounding the LNG tank 2, bulkheads 45 (see Figure 1) separate the installation spaces of the LNG tanks 2 from the remaining part of the hull 4 with respect to the fore and aft direction. When cutting the LNG ship 1 into a plurality of blocks 11, 12, 13 and 14, the cut planes 16, 17
20 and 18 may be selected so as not to coincide with the bulkheads 45 (by offsetting in the forward or rearward direction). Thereby, the bulkheads 45 can be reused as parts of the blocks 11, 12, 13 and 14.

[0073]

The LNG tanks 2 are not limited to Moss tanks, but may consist of tanks
25 (membrane tanks, for example) which can be formed into a group of independent tanks.

[0074]

Figures 4 and 5 are a cross-sectional view and plan views of the arrangement of the plant facility 30 in the floating structure portion 23 shown in Figure 2(B).

[0075]

5 As shown in Figures 4 and 5, the floating structure portion 23 may be provided with a plurality of layers arranged on top of one another. Here, the floating structure portion 23 is provided with an upper deck 51 located at an uppermost part, an intermediate deck 52 positioned below the upper deck 51, and a base deck 53 located at a lowermost part. Although details of the plant facility 30 will be described later, for
10 example, a BOG compressor, a vertically placed LNG storage tank, a heat exchanger for regasifying the LNG, a heater, and the like can be arranged in the upper deck 51. Further, for example, a gas turbine for power generation using LNG as fuel can be arranged in the intermediate deck 52. Further, for example, a steam turbine, a generator, and the like can be disposed in the base deck 53. Such a structure of the floating
15 structure portion 23 can be similarly adopted also in the other floating structure portions 21, 24, etc. provided with the corresponding plant facility 30.

[0076]

 The number of decks (floors for placing appliances, devices, etc.) provided in the floating structure portion 23, and the arrangement of the specific devices and
20 appliances can be variously changed. The plant facility 30 provided in the floating liquefied hydrocarbon gas plant 5 may consist of a liquefied natural gas plant, a gas treatment plant, an acidic gas injection plant, a regasification plant, a power generation plant, a liquefied petroleum gas plant, or a part of any of such plants. The floating structure portion 23 may also be provided with tanks for storing plant wastewater, plant
25 medium liquid, fuel oil, lubricating oil or the like. For example, it is possible to provide

a tank or the like for holding amine that may be used for absorbing acidic components in the natural gas associated with the plant facility 30, produced water (water contaminated with oil), diesel oil or the like.

[0077]

- 5 The liquefied natural gas plant may include a liquefaction facility (such as a heat exchanger) for liquefying natural gas mined from a gas field.

[0078]

- The gas treatment plant may include facilities for treating or processing the gas obtained from gas fields such as a slag catcher, facilities for removing acid gases (CO₂,
10 H₂S, mercaptan, etc.), dehydration facilities, mercury removal facilities and the like.

[0079]

 Further, the acidic gas removal plant may include a plant for injecting acidic gases into a geological layer other than a gas layer in the gas field when the treatment of acidic gases such as H₂S is not practical.

- 15 [0080]

 The regasification plant may include a heat exchanger as a part of a regasification facility, and a hydrocarbon gas delivery facility, etc. for forwarding a hydrocarbon gas obtained from a moored floating liquefied hydrocarbon gas plant to a hydrocarbon gas user facility, etc.

- 20 [0081]

 The power generation plant may include a turbine generator and a gas engine generator using a liquefied hydrocarbon gas as a fuel, and a power transmission facility that transmits electric power generated by a moored power plant to an existing power grid. It is also possible to deliver hydrocarbon gas regasified by the regasification plant

- 25 while performing power generation by the gas engine generator or the gas turbine

generator in the power plant at the same time.

[0082]

The liquefied petroleum gas plant may include a liquefaction facility (compressor or the like) for liquefying the gas.

5 [0083]

In addition, it is preferable that the installation area (installation space) of the plant facility in the floating structure portion 23 is separated from the seawater by at least two longitudinally extending bulkheads. Furthermore, the installation area of the plant facility should be separated from the seawater by a double bottom structure.

- 10 Further, in addition to the block 12, the floating structure portion 23 is preferably provided with a longitudinally extending bulkhead which is structurally continuous with the block 12. Further, the floating structure portion 23 may be configured not to be closed by the upper deck or the like. The floating structure portion 23 may be provided with a plurality of compartments separated by at least one bulkhead having a similar
- 15 configuration as the bulkhead 45. Also, the block 12 and the floating structure portion 23 connected to the block 12 may have a sufficient buoyancy to keep the entire structure afloat on the sea. At least one of the block 12 and the floating structure portion 23 connected to the block 12 may be provided with a ballast tank so that a hull attitude control (trim and heel adjustment) can be made. Further, at least one of the block 12 and
- 20 the floating structure portion 23 connected to the block 12 may be provided with a mooring facility to be thereby moored or anchored to a pier or a seabed. The floating body (the floating liquefied hydrocarbon gas plant 5) constituted by the block 12 and the floating structure portion 23 connected to the block 12 may be equipped with a facility for mooring the floating body to a liquefied hydrocarbon gas transport ship and
- 25 a loading facility for loading liquefied hydrocarbon gas (such as LNG) and boil-off gas

from a liquefied hydrocarbon gas transport ship so that liquefied hydrocarbon gas may be accepted from the liquefied hydrocarbon gas transport ship to the liquefied hydrocarbon gas tank situated in the block 12. The floating body (the floating liquefied hydrocarbon gas plant 5) constituted by the block 12 and the floating structure portion 23 connected to the block 12 may be equipped with a facility for mooring the floating body to a liquefied hydrocarbon gas transport ship and an unloading facility for unloading liquefied hydrocarbon gas (such as LNG) and boil-off gas to the liquefied hydrocarbon gas transport ship so that liquefied hydrocarbon gas may be accepted from the liquefied hydrocarbon gas tank situated in the block 12 to the liquefied hydrocarbon gas transport ship. The floating structure portion 23 may also be provided with a superstructure for accommodating living quarters or working areas. In the plant facility 30, facilities for liquefying hydrocarbon gas to be stored in the liquefied hydrocarbon gas tank may be provided. The floating structure portion 23 may also be provided with facilities for the propulsion of the floating body.

15 [0084]

By installing at least a part of the plant facility 30 in the floating structure portion 23 in this manner, the degree of freedom in laying out the appliances and devices constituting the plant facility 30 is increased, and the manufacturing of the floating liquefied hydrocarbon gas plant is facilitated. In particular, by providing a plurality of decks 51 to 53 arranged in the vertical direction to accommodate different parts of the facilities 30, the space available for installing the plant facility 30 can be effectively utilized so that the length in the fore and aft direction of the liquefied hydrocarbon gas plant 5 can be minimized.

[0085]

25 Figure 6 is a structural diagram showing a first example of the plant facility 30

provided in the floating liquefied hydrocarbon gas plant 5. Here, as a preferred example, the plant facility 30 is configured as a gas engine combined cycle power generation plant.

[0086]

5 As shown in Figure 6, the gas engine combined cycle power generation plant includes a gas engine (reciprocating engine) 61, which may consist of an internal combustion engine using LNG as a fuel, and a refrigerant turbine 62 using a hydrocarbon refrigerant having a lower boiling point than water as a working fluid. The gas engine 61 and the refrigerant turbine 62 are used for driving a generator 64 and a
10 generator 65, respectively, for generating electric power. In this case, the gas engine 61 and the generator 64 can be configured as an integral gas engine generation unit. At least a part of the generated electric power may be supplied from the floating liquefied hydrocarbon gas plant 5 which is moored to a harbor to the outside.

[0087]

15 The natural gas obtained by regasifying the LNG stored in the LNG tank 2 and the boil off gas (hereinafter referred to as BOG) generated in the LNG tank 2 are supplied to the gas engine 61 as fuel, and the exhaust gas of the gas engine 61 at a relatively high temperature (410 °C, in this case) is discharged toward a heat exchanger 71 for recovering the exhaust heat. The gas engine 61 is provided with a cooling water
20 jacket (not shown), and the jacket cooling water at a relatively low temperature (88°C, in this case) is expelled from the cooling water jacket, and is recirculated back to the cooling water jacket via a water circulation line 73 provided with a water circulation pump 72 in the direction indicated by arrows in Figure 6. The natural gas and boil off gas can also be used as engine fuel for the propulsion of the floating body.

25 [0088]

The output of the gas engine 61 is converted into electric power by the generator 64, and at least a part of the generated electric power is used for the rotation of the propeller 10 for the propulsion of the floating body via a motor or the like (not shown). When the floating liquefied hydrocarbon gas plant 5 does not require a propulsion facility, it is also possible to supply all the electric power generated by the generator 64 to the outside of the floating liquefied hydrocarbon gas plant 5. If desired, the generator 64 may be omitted while the output shaft of the gas engine 61 is connected to the propeller 10 via a per se known gear mechanism or the like so that the output of the gas engine 61 may be directly used for the propulsion of the floating liquefied hydrocarbon gas plant 5.

[0089]

The refrigerant turbine 62 uses a mixed refrigerant consisting of methane and propane (50 to 55 wt% of methane, and 45 to 50 wt% of propane, for example) as a working fluid. This working fluid is heated by the gas engine exhaust gas in the heat exchanger 71 before being introduced into the refrigerant turbine 62. The heat exchanger 71 is provided with a plurality of heating units including bundles of heat transfer tubes so that an efficient exchange of heat between the gas engine exhaust gas and the working fluid is enabled. As a result, a working fluid (gas) having a predetermined temperature and pressure (103 °C, and 4.9 MPaG, for example) is introduced into the refrigerant turbine 62 to cause the turbine blades (not shown) to rotate by the kinetic energy of the working fluid. The output of the refrigerant turbine 62 is converted into electric power by the generator 65. In the refrigerant turbine 62, not only the hydrocarbon gas but also carbon dioxide may be used as the working fluid. The carbon dioxide for this purpose may be obtained from a gas treatment plant in the plant facility 30 or may be recovered from the exhaust gas of a gas engine or a gas turbine.

[0090]

The working fluid (gas having a temperature of -5 °C and a pressure of 0.4 MPaG, in this case) discharged from the refrigerant turbine 62 is sent to a condenser 82 via a refrigerant circulation line 81 in the direction indicated by arrows in Figure 6. A
5 discharge line 83 of the LNG tank 2 is connected to the condenser 82, and the cold heat of the LNG (temperature: -160 °C, pressure: 7.0 MPaG, in this case) at a temperature equal to or lower than the freezing point that is supplied to the condenser 82 is used for cooling the working fluid. Meanwhile, the condenser 82 functions as a regasification device that vaporizes LNG by using the heat of the working fluid.

10 [0091]

The LNG stored in the LNG tank 2 is temporarily stored in the LNG storage tank 66 and then sent to the side of the condenser 82 via the discharge line 83 by a discharge pump 67. The BOG generated in the LNG tank 2 is mixed with the LNG in the LNG storage tank 66 via the BOG compressor 68.

15 [0092]

The working fluid condensed in the condenser 82 is temporarily stored in a circulating refrigerant storage tank 85 provided in the refrigerant circulation line 81. Thereafter, the working fluid (- 128 °C, 5.0 MPaG, 99.4 t / hr, in this case) pressurized by a refrigerant pump 86 provided in the refrigerant circulation line 81 is sent to a
20 refrigerant evaporator 87. A seawater inlet pipe 88 for introducing seawater (15 °C, in this case) existing around the floating liquefied hydrocarbon gas plant 5 is connected to the refrigerant evaporator 87, and the working fluid is subjected to heat exchange with the seawater to be preheated to a temperature (5 °C, in this case) at which the jacket cooling water does not freeze.

25 [0093]

The working fluid exiting from the refrigerant evaporator 87 is sent to a refrigerant heater 91 to be heated (29 °C, in this case) by heat exchange with the jacket cooling water (88 °C, 270 t / hr, in this case). Meanwhile, the jacket cooling water is cooled by the refrigerant heater 91 to a temperature (50 to 80 °C, in this case) that is
5 suitable for cooling the gas engine 61. The working fluid from the refrigerant heater 91 is sent to the heat exchanger 71, and the heated working fluid (103 °C, 4.9 MPaG) is supplied to the refrigerant turbine 62. However, it is also possible to omit the heat exchanger 71 and supply the working fluid from the refrigerant heater 91 to the refrigerant turbine 62 without passing through the heat exchanger 71.

10 [0094]

The LNG from the LNG tank 2 is discharged from the condenser 82, and then sent to the LNG heater 92 via the discharge line 83. A seawater introduction pipe 93 for introducing seawater (15 °C, in this case) existing around the floating liquefied hydrocarbon gas plant 5 is connected to the LNG heater 92, and the working fluid is
15 heated (to be turned into gas at a temperature of 5 °C) by heat exchange with the seawater, and is sent to the gas engine 61 as fuel.

[0095]

In this gas engine combined cycle power generation plant, electric power is generated by the refrigerant turbine 62 using a mixed refrigerant consisting of methane
20 and propane as the working fluid and operated under a binary Rankin cycle using the gas engine exhaust gas and the jacket cooling water as a high temperature heat source and the cold heat obtained at the time of gasification of the LNG as a low temperature heat source. Thereby, the power generation efficiency of the gas engine combined cycle power plant can be maximized by improving the exhaust heat recovery ratio or by
25 efficiently utilizing the heat of the gas engine exhaust gas and the jacket cooling water

which account for a large part of heat emission from the gas engine 61. In place of the jacket cooling water, a per se known coolant other than water may be used. In addition, since the mixed refrigerant is flammable, the heating temperature in the heat exchanger 71 is preferably set to a relatively low temperature (130 °C or lower, for example) from the viewpoint of safety of the system.

[0096]

Further, the working fluid is condensed in the condenser 82 by using the LNG so that the cold heat of the LNG supplied from the LNG tank 2 can be effectively utilized in the cooling process of the refrigerant. Furthermore, the BOG is used as a part of the fuel gas of the gas engine 61 so that the BOG generated from the LNG tank 2 can be effectively utilized, and further, the cold heat of the LNG can be effectively utilized in the cooling process of the working fluid.

[0097]

As described above, in this gas engine combined cycle power generation plant, the waste heat of the gas engine 61 (the heat of the exhaust gas and the cooling liquid) is utilized in the refrigerant turbine 62 using the hydrocarbon-based or carbon dioxide refrigerant as the working fluid so that the exhaust heat recovery ratio of the engine 61 is increased, and the power generation efficiency of the plant facility 30 can be improved.

[0098]

The gas engine combined cycle power generation plant shown in Figure 6 is not limited to the floating liquefied hydrocarbon gas plant 5 that reuses an existing LNG ship 1, but may also be installed in a newly constructed floating liquefied hydrocarbon gas plant or a similar floating structure such as a ship. The gas engine combined cycle power generation plant shown in Figure 6 may also be constructed on land, instead of a

platform floating in a body of water. In such a case, the LNG may be supplied to the gas engine 61 from an LNG tank constructed on land.

[0099]

Figure 7 is a structural diagram showing a second example of the plant facility 30 provided in a floating liquefied hydrocarbon gas plant 5. Here, as a preferred example, the plant facility 30 is applied to a gas turbine combined cycle power generation plant. In Figure 7, the parts corresponding to those of the plant facility 30 shown in Figure 6 are denoted with like numerals, and detailed description of such parts may be omitted in the following disclosure. Further, the parts which are not specifically referred to in the following disclosure may be similar to the corresponding parts of the plant facility 30 shown in Figure 6 described above.

[0100]

As shown in Figure 7, the gas turbine combined cycle power generation plant comprises a gas turbine 161 using LNG as a fuel and a refrigerant turbine 62 using a hydrocarbon-based refrigerant having a relatively low boiling (lower than water) as a working fluid. Electric power is generated by a generator 164 and a generator 65 driven by a gas turbine 161 and a refrigerant turbine 62, respectively. In this case, the gas turbine 161 and the generator 164 may be configured as an integrally combined gas turbine generator. At least a part of the generated electric power is supplied from the floating liquefied hydrocarbon gas plant 5 which is moored to the shore to the outside.

[0101]

LNG stored in the LNG tank 2 and boil off gas (hereinafter referred to as BOG) generated in the LNG tank 2 are supplied as fuel to the gas turbine 161, and the relatively high-temperature exhaust gas produced by combustion is forwarded to a exhaust heat recovery boiler 101. In the exhaust heat recovery boiler 101, a part of the

steam heated by the exhaust gas is introduced into a steam turbine 103 via a steam circulation line 102, and electric power is generated by a generator 104 driven by the steam turbine 103. Here, at least a part of the generated electric power is supplied to the outside in the same way as in the above case. The steam discharged from the steam turbine 103 is sent to a condenser 106. A seawater inlet pipe 107 for introducing seawater existing around the floating liquefied hydrocarbon gas plant 5 is connected to the condenser 106, and the steam from the steam turbine 103 is condensed by heat exchange with the seawater, and is again supplied to the exhaust heat recovery boiler 101 by a condensate pump 108.

10 [0102]

In the exhaust heat recovery boiler 101, a part of the steam heated by the exhaust gas is introduced into a heater 202 via a steam circulation line 201. The steam discharged from the heater 202 is condensed in a condensate drum 203 and then introduced into the steam circulation line 102 on the downstream side of the steam turbine 103 by a condensed water pump 204. Further, a water circulation line 73 is connected to the heater 202, and the water introduced into the heater 202 from the water circulation line 73 is heated by heat exchange with the steam from the exhaust heat recovery boiler 101.

[0103]

20 In the gas turbine combined cycle power generation plant shown in Figure 7, the heat exchanger 71 shown in Figure 6 is omitted, and the working fluid from the refrigerant heater 91 is supplied to the refrigerant turbine 62 without passing through the heat exchanger 71.

[0104]

25 As described above, in the gas turbine combined cycle power generation plant,

the exhaust heat of the gas turbine 161 (the heat of the coolant) is utilized in the refrigerant turbine 62 using the hydrocarbon-based or carbon dioxide refrigerant as the working fluid so that the exhaust heat recovery ratio of the gas turbine 161 is improved, and hence the power generation efficiency of the plant facility 30 can be improved.

5 [0105]

The gas turbine combined cycle power generation plant shown in Figure 7 is not limited to the floating liquefied hydrocarbon gas plant 5 that reuses an existing LNG ship 1, but may also be installed in a newly constructed floating liquefied hydrocarbon gas plant or a similar floating structure such as a ship. The gas turbine combined cycle
10 power generation plant shown in Figure 7 may also be constructed on land, instead of a platform floating in a body of water. In such a case, the LNG may be supplied to the gas turbine 161 from an LNG tank constructed on land.

[0106]

Further, in the gas turbine combined cycle power generation plant shown in
15 Figure 7, it is also possible to install the gas engine 61 shown in Figure 6 together with the heater 202 in the water circulation line 73. When the liquefied hydrocarbon gas tank is opened up for inspection, it is thus possible to continue power generation by using diesel oil as the fuel of the gas engine or gas turbine.

[0107]

20 Although the present invention has been described based on specific embodiments, these embodiments are merely examples, and the present invention is not limited by these embodiments. For example, the recycling of an existing ship by the method of manufacturing a floating liquefied hydrocarbon gas plant according to the present invention is not limited to the case where a part of an existing ship in a floating
25 liquefied hydrocarbon gas plant is used as it is, but also to the cases where a part of the

structural members are repaired or replaced before reutilizing such parts. In addition, the above described method of manufacturing a floating liquefied hydrocarbon gas plant can be used as a method of manufacturing a floating liquefied hydrocarbon gas plant that reuses liquefied hydrocarbon gas tanks of all types of ships for transporting liquefied hydrocarbon gases. It is to be noted that all the constituent elements of the method of manufacturing the floating liquefied natural gas plant according to the present invention shown in the above embodiments are not necessarily essential, and it is possible to omit or substitute the constituent elements without departing from the spirit of the present invention.

10 GLOSSARY OF TERMS

[0108]

- | | |
|----------|--|
| 1 | LNG ship (liquefied hydrocarbon gas transportation ship) |
| 2A-2D | first to fourth LNG tanks |
| 3 | propulsion facility |
| 15 4 | hull |
| 5 | floating liquefied hydrocarbon gas plant |
| 10 | propeller |
| 11-14 | first to fourth blocks |
| 16-18 | cut planes |
| 20 21-24 | floating structure portion |
| 30 | plant facility |
| 31 | cabin |
| 51 | upper deck |
| 52 | intermediate deck |
| 25 53 | base deck |

	61	gas engine
	62	refrigerant turbine
	64, 65	generator
	66	LNG storage tank
5	67	discharge pump
	68	BOG compressor
	71	heat exchanger
	72	water circulation line
	73	water circulation line
10	81	refrigerant circulation line
	82	condenser
	83	discharge line
	85	circulating refrigerant storage tank
	86	refrigerant pump
15	87	refrigerant evaporator
	88	seawater inlet pipe
	91	refrigerant heater
	92	LNG heater
	93	seawater inlet pipe
20	101	heat recovery boiler
	102	steam circulation line
	103	steam turbine
	104	generator
	106	condenser
25	107	seawater inlet pipe

	108	condensate pump
	161	gas turbine
	164	generator
	201	steam circulation line
5	202	heater
	203	condensate drum
	204	condensate water pump

CLAIMS

1. A method of manufacturing a floating liquefied hydrocarbon gas plant that reuses liquefied hydrocarbon gas tanks of a ship for transporting liquefied hydrocarbon
5 gas, comprising the steps of:

cutting the ship into a plurality of blocks each containing at least one of the liquefied hydrocarbon gas tanks; and

building a new floating structure portion(s) for each of the plurality of blocks, the new floating structure portion(s) including a liquefied hydrocarbon gas plant and
10 connected to at least one of a front end and a rear end of each block;

wherein in the step of building a new floating structure portion(s), the floating structure portion(s) is provided such that a fore and aft length of each newly manufactured floating liquefied hydrocarbon gas plant formed by combining one of the blocks and the floating structure portion(s) connected thereto is smaller than a fore and
15 aft length of the ship.
2. The method of manufacturing a floating liquefied hydrocarbon gas plant according to claim 1, further comprising the step of installing at least a part of a plant facility in the floating structure portion(s).
- 20 3. The method of manufacturing a floating liquefied hydrocarbon gas plant according to claim 2, wherein the floating structure portion(s) is provided with a plurality of vertically arranged decks each containing a part of the plant facility.
- 25 4. The method of manufacturing a floating liquefied hydrocarbon gas plant

according to claim 2, wherein the plant facility comprises at least one of a facility for regasification of liquefied hydrocarbon gas stored in the liquefied hydrocarbon gas tank, a facility for liquefying hydrocarbon gas to be stored in the liquefied hydrocarbon gas tank, a facility for liquefying hydrocarbon gas obtained from a gas field or an associated gas to be stored in the liquefied hydrocarbon gas tank, a power transmission facility for transmitting electric power generated by the floating liquefied hydrocarbon gas plant which is moored to a coast to an existing power grid, and a facility for supplying hydrocarbon gas from the floating liquefied hydrocarbon gas plant which is moored to a coast directly to a hydrocarbon gas user.

10

5. The method of manufacturing a floating liquefied hydrocarbon gas plant according to claim 1, wherein the block to which the floating structure portion(s) is connected includes a propulsion facility for the ship.

15 6. The method of manufacturing a floating liquefied hydrocarbon gas plant according to any one of claims 2 to 4, wherein the plant facility includes at least one of a gas engine and a gas turbine that uses hydrocarbon gas regasified from the liquefied hydrocarbon gas stored in the liquefied hydrocarbon gas tank and/or boil off gas.

20 7. The method of manufacturing a floating liquefied hydrocarbon gas plant according to claim 6, wherein the at least one of the gas engine and the gas turbine is used for generating a propelling power.

8. The method of manufacturing a floating liquefied hydrocarbon gas plant
25 according to claim 1, wherein the liquefied hydrocarbon gas consists of at least one of

liquefied natural gas and liquefied petroleum gas.