

DESCRIPTION

Title of Invention: CARGO SHIP

Technical Field

[0001] The present disclosure relates to a cargo ship on which a fuel cell is mounted.

Background Art

[0002] It has been proposed that a fuel cell is mounted on a ship, and part or all of electric power generated by the fuel cell is utilized as propulsion power or in-ship electric power. For example, PTL 1 discloses a liquefied gas carrier on which an electric power generating apparatus utilizing a fuel cell is mounted. In this liquefied gas carrier, a boil off gas generated in a cargo tank is reformed into a fuel gas, and the fuel gas is supplied to an anode of the fuel cell. An oxidation gas is supplied to a cathode of the fuel cell. Electric power generation is performed by the fuel cell, and the generated electric power is supplied to a propulsion electric motor and a residence area through an electric power feeder.

[0003] In the liquefied gas carrier of PTL 1, the electric power generating apparatus utilizing the fuel cell is located on an exposed deck, and part of the electric power generating apparatus is located above the cargo tank.

Citation List

Patent Literature

[0004] PTL 1: Japanese Laid-Open Patent Application Publication No. 2-109792

Summary of Invention

Technical Problem

[0005] An inside of a cargo tank that stores a liquefied gas, heavy oil, or the like is a section where a hazardous atmosphere continuously exists in a normal state. Such inside of the cargo tank is designated as a hazardous place, and various restrictions regarding the installation of electrical apparatuses and the like are imposed to improve safety. Although a section where a fuel cell is located is not designated as the hazardous place, such section is a section where an explosive fuel-air mixture may be generated. Therefore, it is reasonable to regard such section as the hazardous place. The section as the hazardous place has restrictions regarding devices to be installed. Therefore, it is desirable that the hazardous place in a ship be as small as possible.

[0006] The present disclosure was made under these circumstances, and an object of the present disclosure is to propose, in a cargo ship which carries a cargo such as a liquefied gas or

heavy oil and includes a cargo hold that is a hazardous place due to the cargo, a structure by which a fuel cell is mounted while suppressing expansion of the hazardous place.

Solution to Problem

[0007] A cargo ship according to one aspect of the present disclosure includes: a hull including a cargo hold that includes at least one cargo tank and is a hazardous place due to a cargo and an machinery room located behind the cargo hold; a propulsion electric motor located in the machinery room; a hydrogen fuel tank storing hydrogen fuel; a fuel cell electric power generator including a casing that is sealable and a fuel cell that is located in the casing and generates electric power by using hydrogen supplied from the hydrogen fuel tank and oxygen in air; and an electric power converter that supplies the electric power generated by the fuel cell electric power generator to at least one of the propulsion electric motor and an in-ship electric power load. When a zone having not more than a predetermined first height from a portion of an upper deck of the hull which is located above the cargo hold is defined as an on-deck hazardous place due to the cargo, the hydrogen fuel tank is located between front and rear ends of the cargo hold in the hull in a front-rear direction. The fuel cell electric power generator is located between the front and rear ends of the cargo hold in the front-rear direction and above the upper deck in a state where the fuel cell retreats from the on-deck hazardous place.

Advantageous Effects of Invention

[0008] The present disclosure can propose, in a cargo ship including a cargo hold that is a hazardous place due to a cargo, a structure by which a fuel cell is mounted while suppressing expansion of the hazardous place.

Brief Description of Drawings

[0009] FIG. 1 is a schematic side view showing an entire configuration of a cargo ship according to one embodiment of the present disclosure.

FIG. 2 is a block diagram showing a schematic configuration of a hydrogen electric power generation system.

FIG. 3 is a diagram for explaining an on-deck hazardous place and a cargo region which are defined in the cargo ship.

FIG. 4 is a schematic side view showing an entire configuration of the cargo ship according to Modified Example 1.

FIG. 5 is a schematic side view showing an entire configuration of the cargo ship

according to Modified Example 2.

FIG. 6 is a schematic side view showing an entire configuration of the cargo ship according to Modified Example 3.

Description of Embodiments

[0010] Next, an embodiment of the present disclosure will be described with reference to the drawings.

[0011] Schematic Configuration of Cargo Ship 1

FIG. 1 is a schematic side view showing an entire configuration of a cargo ship 1 according to one embodiment of the present disclosure. The cargo ship 1 shown in FIG. 1 includes: a hull 11; an upper structure 20 located on the hull 11; and a propeller 14 and a rudder 15 which are located at a stern end of the hull 11. A machinery room 13 is located at a stern of the hull 11. A cargo hold 12 is located at a side of the machinery room 13 of the hull 11 at which a bow 17 exists.

[0012] A propulsion electric motor 25 is located in the machinery room 13. The propulsion electric motor 25 rotates the propeller 14. The cargo ship 1 according to the present embodiment is an electric propulsion ship. However, the cargo ship 1 may be a hybrid propulsion ship including a hybrid propulsion system in which a diesel engine, an electric motor, and a storage battery are combined with each other.

[0013] The upper structure 20 projecting upward from the hull 11 is located above the machinery room 13. The upper structure 20 includes a residence area 2 and a bridge 3.

[0014] The cargo hold 12 includes cargo tanks 16. The cargo ship 1 according to the present embodiment is a liquefied gas carrier, and a liquefied gas is stored in the cargo tanks 16. Examples of the liquefied gas include liquefied hydrogen and LNG. However, the cargo is not limited to the liquefied gas. For example, the cargo ship 1 may be an oil tanker, and heavy oil may be stored in the cargo tanks 16. FIG. 1 shows the square cargo tanks 16, but the shape of the cargo tank 16 is not limited to the square shape. Examples of the shape of the cargo tank 16 include a spherical shape, an oval shape, and a cylindrical shape (i.e., a capsule shape) including both ends each closed by a hemisphere.

[0015] The cargo ship 1 includes a hydrogen electric power generation system 6. Electric power generated by the hydrogen electric power generation system 6 is supplied to at least one of the propulsion electric motor 25 and an in-ship electric power load 26. The hydrogen electric power generation system 6 includes a fuel cell electric power generator 61, at least one hydrogen storing module 62, an electric power converter 63, and a storage battery 65.

[0016] FIG. 2 is a block diagram showing a schematic configuration of the hydrogen electric power generation system 6. As shown in FIG. 2, the hydrogen storing module 62 includes: a hydrogen fuel tank 621 storing hydrogen fuel; and a tank valve 622 located at an inlet of the hydrogen fuel tank 621. The hydrogen fuel is a gas or a liquid and is stored in the hydrogen fuel tank 621. The hydrogen fuel tank 621 is connected to the fuel cell electric power generator 61 through a pipe, and the hydrogen stored in the hydrogen fuel tank 621 is supplied to the fuel cell electric power generator 61 through the pipe. The supply of the hydrogen from the hydrogen fuel tank 621 to the fuel cell electric power generator 61 and the stop of this supply are switched by opening and closing of the tank valve 622. The hydrogen storing module 62 may supply the hydrogen to a hydrogen utilizing device other than the hydrogen electric power generation system 6 which is mounted on the cargo ship 1. One example of such hydrogen utilizing device is a hydrogen boiler located in the machinery room 13.

[0017] The fuel cell electric power generator 61 includes a fuel cell 611, a radiator 612, a high pressure hydrogen facility 613, and a system controller 614, and is accommodated in a casing 610 that is sealable. A closed section where the fuel cell 611 is located is formed by the casing 610.

[0018] The fuel cell 611 includes a large number of cells. The fuel cell 611 is supplied with the hydrogen and performs an electrochemical reaction between the hydrogen and oxygen in the air to generate DC power. The radiator 612 adjusts the temperature of the fuel cell 611 to a temperature suitable for electric power generation. For example, a cooling medium circulates in the radiator 612 and the fuel cell 611. The high pressure hydrogen facility 613 adjusts the pressure of the hydrogen supplied from the hydrogen storing module 62 and supplies the hydrogen to the fuel cell 611. The system controller 614 is a device that controls the electric power generation of the fuel cell 611. The system controller 614 controls the high pressure hydrogen facility 613 and the tank valve 622 such that the hydrogen and the oxygen, by which the electric power generation corresponding to a load is performed, are supplied to the fuel cell 611. Moreover, the system controller 614 operates the radiator 612 such that the fuel cell 611 is maintained at an appropriate temperature. Furthermore, the system controller 614 commands the electric power converter 63 to take out the electric power from the fuel cell 611.

[0019] The electric power converter 63 includes input systems and output systems. The electric power converter 63 converts the voltage, current, and frequency of the input electric power and outputs the electric power. For example, the system controller 614 calculates a command to the electric power converter 63 from a load state of a main switchboard 27 and the state of charge of the storage battery 65. The electric power converter 63 takes out the DC

power from the fuel cell 611 in accordance with the command from the system controller 614, converts (or adjusts) the voltage and the like of the DC power, and sends the DC power to the main switchboard 27. The electric power is supplied from the main switchboard 27 to the propulsion electric motor 25 through a wire. Moreover, the electric power is supplied from the main switchboard 27 to the in-ship electric power load 26 through the wire. Herein, the conversion of the voltage and the like may include at least one of conversion from DC to DC, conversion from AC to DC, conversion from DC to AC, conversion from AC to AC, voltage conversion, and electric power adjustment. Moreover, the electric power converter 63 stores the residual of the generated electric power in the storage battery 65. The electric power stored in the storage battery 65 may be suitably taken out by the electric power converter 63 and sent to the main switchboard 27.

[0020] **Arrangement of Hydrogen Electric Power Generation System 6**

The following will describe the arrangement of the hydrogen electric power generation system 6 in the cargo ship 1 in detail. First, an on-deck hazardous place 100 and a cargo region 101 which are defined in the cargo ship 1 will be described. FIG. 3 is a diagram for explaining the on-deck hazardous place 100 and the cargo region 101 which are defined in the cargo ship 1.

[0021] As shown in FIG. 3, an upper deck 18 is an exposed deck covering an upper surface of the hull 11. A zone having not more than a predetermined first height X [m] from a portion of the upper deck 18 which is located above the cargo hold 12 is defined as the “on-deck hazardous place 100” due to the cargo. More specifically, a zone which is surrounded by surfaces S1 and S2 and has not more than the first height X [m] from the upper deck 18 is defined as the on-deck hazardous place 100. The surface S1 is located in front of a front end of the cargo hold 12 by Y [m] and is parallel to a ship width direction, and the surface S2 is located behind a rear end of the cargo hold 12 by Y [m] and is parallel to the ship width direction. When part of an outer surface of the cargo tank 16 projects upward beyond the upper deck 18, the on-deck hazardous place 100 at this projecting portion of the cargo tank 16 is a zone having not more than the first height X [m] from the outer surface of the cargo tank 16. In FIG. 3, the on-deck hazardous place 100 is a region shown by hatching. X and Y are values defined based on a rule or the like. For example, X may be 2.4, and Y may be 3.

[0022] A region surrounded by surfaces S3 and S4 is defined as the “cargo region 101.” The surface S3 is located at the front end of the cargo hold 12 and is parallel to the ship width direction, and the surface S4 is located at the rear end of the cargo hold 12 and is parallel to the ship width direction. In FIG. 3, the cargo region 101 is shown by a thick two-dot chain line.

In addition to the cargo hold 12 of the hull 11, the cargo region 101 includes: a portion of the upper deck 18 which corresponds to an upper side of the cargo hold 12; and a portion of a space above the upper deck 18 which corresponds to the upper side of the cargo hold 12.

[0023] Referring back to FIG. 1, the fuel cell electric power generator 61 is located above the upper deck 18 in the cargo region 101 in a state where the fuel cell 611 substantially retreats from the on-deck hazardous place 100. In the example shown in FIG. 1, the fuel cell electric power generator 61 is supported by at least one support post 71, standing on the upper deck 18, such that the entire fuel cell electric power generator 61 including the fuel cell 611 retreats upward from the on-deck hazardous place 100. In other words, the fuel cell electric power generator 61 is placed on at least one support post 71 standing on the upper deck 18. The support post 71 has a second height H that is the first height X [m] or more. Therefore, the fuel cell electric power generator 61 placed on the support post 71 is located at a position higher than the first height X from the upper deck 18. The fuel cell electric power generator 61 is located in front of the bridge 3. Therefore, it is desirable that the second height H be not less than the first height X [m] and be as small a value as possible such that the field of view from the bridge 3 is not blocked by the fuel cell electric power generator 61.

[0024] When the number of support posts 71 is plural, spaces among the support posts 71 are open such that a space between the fuel cell electric power generator 61 and the upper deck 18 is open. In other words, the support posts 71 are located away from each other in a horizontal direction such that crew members can pass. In addition, a height in an upper-lower direction between the upper deck 18 and the fuel cell electric power generator 61 which are located away from each other by the support post 71 is such a height that the crew member who wears safety shoes and a helmet can adequately pass. Therefore, visibility and mobility are secured in a space under the fuel cell electric power generator 61 and on the upper deck 18. Thus, the crew member can pass through the space under the fuel cell electric power generator 61 and can perform work under the fuel cell electric power generator 61. The configuration of the support post 71 is not limited to this and may have a block shape including a passage tunnel or a frame shape including no walls.

[0025] The hydrogen storing module 62 is located in the cargo region 101. In the example shown in FIG. 1, the hydrogen storing module 62 is located at a side, where the bow 17 is located, of the fuel cell electric power generator 61. The hydrogen fuel tank 621 of the hydrogen storing module 62 includes a lower portion located lower than the upper deck 18 and an upper portion projecting upward from the upper deck 18. Since part of the hydrogen fuel tank 621 is embedded in the upper deck 18, the height of the hydrogen fuel tank 621 projecting

from the upper deck 18 is suppressed while securing such a volume of the hydrogen fuel tank 621 that the amount of hydrogen necessary for sailing can be stored, and forward visibility from the bridge 3 can be secured.

[0026] The electric power converter 63 and the storage battery 65 are located in the machinery room 13. However, the electric power converter 63 may be located in the residence area 2. Or, the electric power converter 63 may be located in the casing 610 of the fuel cell electric power generator 61. When the electric power converter 63 is located in the casing 610, the casing 610 may include two independent spaces therein, the electric power converter 63 may be accommodated in one of the two spaces, and the fuel cell electric power generator 61 may be accommodated in the other space.

[0027] As described above, the cargo ship 1 according to the present disclosure includes:
the hull 11 including

the cargo hold 12 that includes at least one cargo tank 16 and is the hazardous place due to the cargo and

the machinery room 13 located behind the cargo hold 12;

the propulsion electric motor 25 located in the machinery room 13;

the hydrogen fuel tank 621 storing the hydrogen fuel;

the fuel cell electric power generator 61 including

the casing 610 that is sealable and

the fuel cell 611 that is located in the casing 610 and generates the electric power by using the hydrogen supplied from the hydrogen fuel tank 621 and the oxygen in the air; and

the electric power converter 63 that supplies the electric power generated by the fuel cell electric power generator 61 to at least one of the propulsion electric motor 25 and the in-ship electric power load 26, wherein:

when the zone having not more than the predetermined first height X from the portion of the upper deck 18 of the hull 11 which is located above the cargo hold 12 is defined as the on-deck hazardous place 100 due to the cargo, the hydrogen fuel tank 621 is located between the front and rear ends of the cargo hold 12 in the hull 11 in a front-rear direction; and

the fuel cell electric power generator 61 is located between the front and rear ends of the cargo hold 12 in the front-rear direction and above the upper deck 18 in a state where a section where the fuel cell 611 is located retreats from the on-deck hazardous place 100.

[0028] In the cargo ship 1 configured as above, the section where the fuel cell 611 is located retreats from the on-deck hazardous place 100, i.e., an internal space of the casing 610 retreats from the on-deck hazardous place 100. This means that a section of the fuel cell electric power

generator 61 at which an explosive fuel-air mixture may be generated and the on-deck hazardous place 100 due to the cargo do not overlap each other. Thus, safety is secured. Moreover, in the cargo ship 1 configured as above, since the fuel cell electric power generator 61 is located between the front and rear ends of the cargo hold 12 in the front-rear direction (i.e., the fuel cell electric power generator 61 is located in the cargo region 101), the hazardous place due to the fuel cell electric power generator 61 is located in the on-deck hazardous place 100 due to the cargo hold 12 in the front-rear direction. Thus, the fuel cell electric power generator 61 can be located without expanding the hazardous place including the on-deck hazardous place 100 toward the rear side, i.e., toward the stern. Since the hazardous place does not expand toward the stern where the upper structure 20 exists, an existing section that is not the hazardous place does not require safety measures, such as the installation of a dividing wall and reconsideration of peripheral equipment, to expand the hazardous place.

[0029] In the cargo ship 1 according to the present embodiment, the fuel cell electric power generator 61 is supported from below by at least one support post 71 standing on the upper deck 18, and the support post 71 has the second height H higher than the first height X.

[0030] As above, the entire fuel cell electric power generator 61 retreats upward from the on-deck hazardous place 100. Therefore, even when the hydrogen leaks from the fuel cell electric power generator 61, the hydrogen lighter than the air flows upward without staying on the upper deck 18. Thus, a possibility that the hydrogen is ignited in the vicinity of the crew member passing on the upper deck 18 is lowered.

[0031] In the above cargo ship 1, it is desirable that when the number of support posts 71 is plural, the spaces among the support posts 71 be open such that the crew member can pass through the space between the upper deck 18 and the fuel cell electric power generator 61 in the upper-lower direction. Since the spaces among the support posts 71 are open as above, mobility and visibility are secured even when the support posts 71 are located on the upper deck 18.

[0032] Moreover, in the cargo ship 1 according to the present embodiment, the lower portion of the hydrogen fuel tank 621 is located lower than the upper deck 18, and the upper portion of the hydrogen fuel tank 621 projects upward from the upper deck 18.

[0033] Since the hydrogen fuel tank 621 is located such that the lower portion thereof is embedded in the upper deck 18, the amount of upward projection of the hydrogen fuel tank 621 from the upper deck 18 is suppressed while securing an adequate tank volume of the hydrogen fuel tank 621, and front visibility from the bridge 3 can be secured.

[0034] The foregoing has described a preferred embodiment. Modifications of specific

structures and/or functional details of the above embodiment may be included in the present disclosure as long as they are within the scope of the present disclosure. The configuration of the above cargo ship 1 may be changed as in modified examples described below, for example. The following will describe a plurality of modified examples. A combination of features described in one or a plurality of modified examples may be applied to the above embodiment.

[0035] **Modified Example 1**

FIG. 4 is a schematic side view showing an entire configuration of the cargo ship 1 according to Modified Example 1. As shown in FIG. 4, a hydrogen electric power generation system 6A mounted on the cargo ship 1 according to Modified Example 1 is different from the hydrogen electric power generation system 6 according to the above embodiment in that the fuel cell electric power generator 61 is located in a range having not more than the first height X from the upper deck 18 in the cargo region 101.

[0036] In the hydrogen electric power generation system 6A, a casing 610a of the fuel cell electric power generator 61 is placed directly on the upper deck 18 or placed on the upper deck 18 through a jig such that at least a part of the casing 610a overlaps the on-deck hazardous place 100. In the hydrogen electric power generation system 6A, the casing 610a of the fuel cell electric power generator 61 includes an air lock. Specifically, the casing 610a includes: multiple containers including an inner container and an outer container; and airtight doors located at the respective multiple containers. The airtight doors do not open at the same time. According to the casing 610a including the air lock as above, a gas cannot directly flow into the casing 610a from the outside and cannot directly flow out from the casing 610a. Therefore, although the casing 610a is located in the on-deck hazardous place 100, the section of the casing 610a at which the fuel cell 611 is located is a space having an atmosphere independent from the on-deck hazardous place 100. To be specific, in the hydrogen electric power generation system 6A, the section where the fuel cell 611 is located substantially retreats from the on-deck hazardous place 100.

[0037] **Modified Example 2**

FIG. 5 is a schematic side view showing an entire configuration of the cargo ship 1 according to Modified Example 2. As shown in FIG. 5, a hydrogen electric power generation system 6B mounted on the cargo ship 1 according to Modified Example 2 is different from the hydrogen electric power generation system 6 according to the above embodiment in that the hydrogen storing module 62 is located above the upper deck 18 in the cargo region 101. More specifically, in the hydrogen electric power generation system 6B, the hydrogen fuel tank 621 of the hydrogen storing module 62 is supported by the upper deck 18 through a support 72.

[0038] In the cargo ship 1 according to Modified Example 2, the volume of the hydrogen fuel tank 621 is restricted such that the front visibility from the bridge 3 is not blocked by the hydrogen fuel tank 621. In this case, to eliminate the lack of the hydrogen fuel, as will be described in Modified Example 3 below, a boil off gas of the cargo tank 16 may be supplied as fuel to the hydrogen fuel tank 621.

[0039] **Modified Example 3**

FIG. 6 is a schematic side view showing an entire configuration of the cargo ship 1 according to Modified Example 6. As shown in FIG. 6, a hydrogen electric power generation system 6C mounted on the cargo ship 1 according to Modified Example 3 is different from the hydrogen electric power generation system 6 according to the above embodiment in that the cargo tank 16 and the hydrogen fuel tank 621 are connected to each other by a pipe through which the boil off gas in the cargo tank 16 is supplied to the hydrogen fuel tank 621.

[0040] In the hydrogen electric power generation system 6C, a branch pipe 42 of a boil off gas pipe 41 connected to the cargo tank 16 is connected to the hydrogen fuel tank 621 of the hydrogen storing module 62. An on-off valve 43 and a compressor 44 are located on the branch pipe 42. According to this configuration, the boil off gas of the cargo tank 16 is compressed by the compressor 44 and is then supplied to and filled in the hydrogen fuel tank 621. When the liquefied gas stored in the cargo tank 16 is liquefied hydrogen, the hydrogen gas as the boil off gas is supplied to the hydrogen fuel tank 621. When the liquefied gas stored in the cargo tank 16 is LNG, the boil off gas is reformed to the hydrogen gas by a reformer located on the branch pipe 42, and the hydrogen gas is supplied to the hydrogen fuel tank 621. In the hydrogen electric power generation system 6C, the supply of the fuel from a fuel supply facility on land or at sea to the hydrogen fuel tank 621 and the supply of the fuel from the cargo tank 16 to the hydrogen fuel tank 621 are switchable.

CLAIMS

[Claim 1] A cargo ship comprising:

a hull including

a cargo hold that includes at least one cargo tank and is a hazardous place due to a cargo and

an machinery room located behind the cargo hold;

a propulsion electric motor located in the machinery room;

a hydrogen fuel tank storing hydrogen fuel;

a fuel cell electric power generator including

a casing that is sealable and

a fuel cell that is located in the casing and generates electric power by using hydrogen supplied from the hydrogen fuel tank and oxygen in air; and

an electric power converter that supplies the electric power generated by the fuel cell electric power generator to at least one of the propulsion electric motor and an in-ship electric power load, wherein:

when a zone having not more than a predetermined first height from a portion of an upper deck of the hull which is located above the cargo hold is defined as an on-deck hazardous place due to the cargo, the hydrogen fuel tank is located between front and rear ends of the cargo hold in the hull in a front-rear direction; and

the fuel cell electric power generator is located between the front and rear ends of the cargo hold in the front-rear direction and above the upper deck in a state where a section where the fuel cell is located retreats from the on-deck hazardous place.

[Claim 2] The cargo ship according to claim 1, wherein:

the casing is supported from below by at least one support post standing on the upper deck; and

the support post has a second height higher than the first height.

[Claim 3] The cargo ship according to claim 2, wherein:

the at least one support post comprises support posts;

spaces among the support posts are open.

[Claim 4] The cargo ship according to claim 1, wherein:

the casing includes an air lock including

multiple containers and
airtight doors located at respective multiple containers; and
the casing is located such that at least a part thereof overlaps the on-deck hazardous
place.

[Claim 5] The cargo ship according to any one of claims 1 to 4, wherein:
a lower portion of the hydrogen fuel tank is located lower than the upper deck; and
an upper portion of the hydrogen fuel tank projects upward from the upper deck.

[Claim 6] The cargo ship according to any one of claims 1 to 5, wherein the cargo tank and the
hydrogen fuel tank are connected to each other by a pipe through which a boil off gas in the
cargo tank is supplied to the hydrogen fuel tank.