

**【DESCRIPTION】****【Invention Title】****SHIP POWER GENERATION SYSTEM AND METHOD****【Technical Field】**

[1] The present invention relates to a power generation system and method for ships, and more particularly, to a power generation system for ships which provides increased power generation capacity to allow a ship designed as an LNG carrier to be converted into a ship usable as an FSRU, and to a power generation method using the same.

**【Background Art】**

[2] Recently, consumption of natural gas is rapidly increasing worldwide. Natural gas is transported in a gaseous state via onshore or offshore gas pipelines, or is transported in a liquid state to a distant destination by an LNG ship (particularly, an LNG carrier). Liquefied natural gas (LNG) is obtained by cooling natural gas to a cryogenic temperature (about -163°C) and has a volume of about 1/600 that of natural gas in a gaseous state. Thus, LNG is suited to long distance transport by sea.

[3] An LNG carrier is a ship designed to carry LNG by sea to an onshore source of demand and thus includes an LNG storage tank that can withstand cryogenic temperatures of LNG (commonly called "LNG cargo hold"). Generally, such an LNG carrier unloads LNG in a liquid state from the LNG storage tank to the land, and the unloaded LNG is regasified by an onshore LNG regasification facility prior to being delivered to natural gas demand sites via gas pipelines.

[4] Such an onshore LNG regasification facility is known to be economically feasible when installed in a place where there is a stable demand for natural gas due to existence of a well-developed natural gas market.

[5] However, for a source of demand where there is only a seasonal, short-term, or cyclical demand for natural gas, installation of the onshore LNG regasification facility is economically infeasible due to high installation and management costs.

[6] In particular, if the onshore LNG regasification facility is destroyed due to a

natural disaster or the like, it is impossible to regasify LNG transported to a source of demand by an LNG carrier. Therefore, a typical method of transporting natural gas using an LNG carrier has a limitation.

[7] Accordingly, there has been developed, for example, an offshore LNG regasification system in which an offshore plant or an LNG carrier is provided with an LNG regasification facility to regasify LNG at sea and to supply the regasified LNG to an onshore source of demand.

[8] Examples of a floating structure provided with a storage tank capable of storing cryogenic liquefied gas and a liquefied gas regasification facility may include ships, such as LNG regasification vessels (RVs), or plants such as LNG floating storage and regasification units (FSRUs).

[9] In particular, an LNG FSRU is a floating structure that stores LNG unloaded from an LNG carrier at sea far from land in a storage tank and, if necessary, regasifies LNG to supply the regasified LNG to an onshore source of demand. For regasification, such a floating structure requires about 12MW of electricity, which is not covered by a small capacity generator.

[10] Recently, as an LNG carrier, a ship that is propelled using a propeller and a shaft generator directly driven by a large two-stroke propulsion engine, such as an MEGI engine, is mainly used. Such a large two-stroke propulsion engine is effective in improvement of energy efficiency and fuel economy when used to generate propulsive force while at sea. Accordingly, a typical LNG carrier is provided with one or two large two-stroke propulsion engines and three or four separate power generation engines. Here, the power generation engine is a four-stroke engine that uses LNG and fuel oil as a fuel.

[11] However, a ship provided with the propulsion engine cannot use the propulsion engine while loading or unloading LNG cargo at quay level or while lying at anchor to be switched into an FSRU mode to regasify LNG and deliver the regasified LNG to an onshore source of demand. That is, when in the FSRU mode, the ship has difficulty in producing sufficient electricity to operate a regasification facility using a shaft generator and a small-capacity power generation engine.

[12] In particular, for a ship designed as an LNG carrier provided with an MEGI

engine, an additional power generation engine must be provided due to shortage of power generation capacity. In this case, since the MEGI engine and the additional power generation engine are not operated at the same time, a considerable amount of equipment is required to operate the additional power generation engine, a space for installation of the equipment is needed, and system complexity is increased due to pipes connected to each of an additional system for operating the MEGI engine and an additional system for operating the additional power generation engine.

**【Disclosure】**

**【Technical Problem】**

[13] It is an aspect of the present invention to provide a power generation system for ships, which provides increased power generation capacity to allow a ship designed as an LNG carrier to be converted into a ship usable as an FSRU, and a power generation method using the same.

**【Technical Solution】**

[14] In accordance with one aspect of the present invention, a power generation system for ships includes: a propulsion engine driving a propeller while at sea; a power generation engine producing electricity required for a regasification facility during regasification; and an additional system provided to operate the propulsion engine, wherein the propulsion engine and the power generation engine are alternatively operated, and the additional system is connected to each of the propulsion engine and the power generation engine to be shared by the propulsion engine and the power generation engine.

[15] The additional system may include at least one selected from the group of a cooling system, a fuel supply system, and a lubrication system.

[16] The power generation system may further include a shaft generator driven by the propulsion engine to produce electricity.

[17] The power generation system may further include a clutch disposed between the shaft generator and the propeller to block or allow power transmission to the propeller.

[18] The power generation engine may include a plurality of power generation engines, and, among the plurality of power generation engines, a power generation engine sharing the additional system may be disposed at an upper side of a steering gear room at a stern side.

[19] Another power generation engine among the plurality of power generation engines may be operated along with the propulsion engine.

[20] The power generation system may further include: a switchover valve disposed between the propulsion engine and the power generation engine to alternatively supply a coolant to the propulsion engine and the power generation engine; a circulation pump supplying the coolant at a flow rate and pressure predetermined based on size of the propulsion engine; a recirculation line recirculating a part of the coolant passing through the circulation pump upon supplying the coolant to the power generation engine; and a control valve disposed on the recirculation line to be switched between open and closed positions.

[21] The power generation system may further include a switchboard connected to each of the power generation engine and a shaft generator driven by the propulsion engine to produce electricity, wherein the switchboard may collect electricity produced by the power generation engine and the shaft generator to distribute the collected electricity to on-board electricity demand sites.

[22] The cooling system may include a fresh water generator generating fresh water while at sea or during regasification.

[23] In accordance with another aspect of the present invention, there is provided a power generation method using a power generation system for ships, the power generation system including a propulsion engine driving a propeller while at sea and a power generation engine producing electricity required for a regasification facility during regasification, wherein: an additional system provided to operate the propulsion engine is connected to each of the propulsion engine and the power generation engine to be shared by the propulsion engine and the power generation engine; and the propulsion engine and the power generation engine are alternatively operated to produce electricity.

[24] While at sea, the additional system may be associated only with the

propulsion engine, and electricity may be produced by a shaft generator driven by the propulsion engine with the power generation engine shut down.

[25] During regasification, the additional system may be associated only with the power generation engine, and electricity may be produced by the power generation engine with the propulsion engine shut down.

[26] Electricity produced by the power generation engine or a shaft generator driven by the propulsion engine to produce electricity may be collected and distributed to on-board electricity demand sites.

[27] The power generation system may further include: a switchover valve disposed between the propulsion engine and the power generation engine to alternatively supply a coolant to the propulsion engine and the power generation engine; a circulation pump supplying the coolant at a flow rate and pressure predetermined based on size of the propulsion engine; a recirculation line recirculating some of the coolant passing through the circulation pump upon supplying the coolant to the power generation engine; and a control valve disposed on the recirculation line to be switched between open and closed positions, wherein the control valve may be opened upon supplying the coolant to the power generation engine.

[28] The power generation engine may include a plurality of power generation engines and any one of the plurality of power generation engines may be operated along with the propulsion engine to produce electricity.

#### **【Advantageous Effects】**

[29] The present invention provides a power generation system for ships, which provides increased power generation capacity to allow a ship designed as an LNG carrier to be converted into a ship usable as an FSRU, and a power generation method using the same.

[30] In addition, according to the present invention, a propulsion engine and a power generation engine are alternatively operated and the power generation engine shares an additional system provided to operate the propulsion engine, whereby: the ship can be propelled through the propulsion engine while at sea; sufficient

electricity to operate a regasification facility can be secured through operation of the power generation engine during regasification; and a separate additional system for operating the power generation engine is not required, thereby allowing considerable savings on equipment cost, reduction in space for equipment installation, and simplification of the system.

**【Description of Drawings】**

[31] FIG. 1 is a diagram of a power generation system for ships according to one embodiment of the present invention.

[32] FIG. 2 is a diagram illustrating an installation position of a first power generation engine.

**【Best Mode】**

[33] Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings.

[34] FIG. 1 is a diagram of a power generation system for ships according to one embodiment of the present invention.

[35] Referring to FIG. 1, a power generation system for ships according to this embodiment includes a propulsion engine 1 driving a propeller P while at sea, power generation engines 5, 8 producing electricity required for a regasification facility during regasification, and an additional system provided to operate the propulsion engine 1, wherein the additional system is connected to one power generation engine 5 among the power generation engines to be alternatively shared by the propulsion engine 1 and the one power generation engine 5.

[36] The additional system includes at least one selected from the group of a cooling system A cooling a heated coolant, a fuel supply system B fueling the propulsion engine 1 or the power generation engine 5, and a lubrication system C facilitating operation of the propulsion engine 1 or the power generation engine 5.

[37] Here, the power generation engine 5 is an additional engine, and is separately disposed at an upper side of a steering gear room at a stern side of the ship. Since the additional power generation engine 5 shares the additional system

provided to operate the propulsion engine 1, there is no need to install additional equipment for operating the power generation engine 5, thereby allowing considerable savings on equipment cost.

[38] In particular, upon converting a ship designed as an LNG carrier equipped with the propulsion engine 1, for example, an MEGI engine, into a ship usable as an FSRU, the additional power generation engine 5 is separately disposed on the upper side of the steering gear room at the stern side and is then connected to the additional system A, B, or C provided to operate the propulsion engine 1. Accordingly, while at sea, the ship can be propelled by the propulsion engine 1 and, during regasification, electricity required for the regasification facility can be secured through the additional power generation engine 5 along with the power generation engine 8 and a shaft generator 3, which are already provided to the LNG carrier, thereby allowing the LNG carrier equipped with an MEGI engine to be converted into an FSRU. As a result, the ship according to present invention can be used in an FSRU mode through operation of the additional power generation engine 5 while at anchor, while retaining the benefit of the propulsion engine 1 having high efficiency while at sea.

[39] The propulsion engine 1 is a high-efficiency engine that is used in an LNG carrier to directly transmit power using a shaft upon propelling the LNG carrier. Here, the propulsion engine 1 may be an MEGI engine.

[40] While at sea, the propulsion engine 1 drives the propeller P. The shaft generator 3 connected to the propulsion engine 1 is driven by the propulsion engine 1 to produce electricity and delivers the produced electricity to a switchboard 12.

[41] A clutch 4 is disposed between the propeller P and the shaft generator 3. The clutch 4 prevents the propeller P from being rotated during use of the shaft generator 3. That is, with the clutch 4, the propeller P is separated from the shaft generator 3 and thus can be prevented from being rotated during operation of the shaft generator 3. As a result, while at anchor, the ship can produce electricity through the shaft generator 3 without rotation of the propeller P.

[42] Among the power generation engines 5, 8, the additional power generation engine 5 (hereinafter referred to as "first power generation engine") shares the

additional system A, B, or C with the propulsion engine and is disposed on the upper side of the steering gear room at the stern side. When in the FSRU mode (that is, in a regasification mode), the ship requires lots of electricity, which is not covered by the power generation engine 8 (hereinafter referred to as "second power generation engine"), which is already provided to the LNG carrier. Accordingly, the first power generation engine 5 is added to the ship to produce electricity.

[43] The second power generation engine 8 is operated along with the propulsion engine 1.

[44] Among the aforementioned additional systems, the fuel supply system B includes a fuel tank 16 storing a fuel (for example, fuel oil or fuel gas), a first fuel supply unit 2 supplying the fuel from the fuel tank 16 to the propulsion engine 1 or the first power generation engine 5, and seventh and eighth switchover valves B7, B8 disposed between the propulsion engine 1 or the first power generation engine 5 and the first fuel supply unit 2. The seventh and eighth switchover valves B7, B8 are valves that are switched depending upon whether the propulsion engine 1 is operated or the first power generation engine 5 is operated.

[45] A second fuel supply unit 9 is provided to supply the fuel from the fuel tank 16 to the second power generation engine 8 to operate the second power generation engine 8.

[46] Upon operating the propulsion engine 1 or the first power generation engine 5, the second power generation engine 8 may also be operated to produce electricity required for on-board electricity demand sites while at sea or during regasification. The first power generation engine 5 may be a DF engine and the second power generation engine 8 may also be a DF engine.

[47] The first fuel supply unit 2 supplies the fuel to the propulsion engine 1 and the second fuel supply unit 9 supplies the fuel to the second power generation engine 8. Each of the first fuel supply unit 2 and the second fuel supply unit 9 includes a fuel supply pump, a fuel circulation pump, a filter, a cooler, a heater, a viscosity regulator, and the like. In each of the first and second fuel supply units 2, 9, among the fuel supplied from the fuel supply pump, a fuel surplus in excess of the amount consumed by being circulated by the fuel circulation pump is returned to the fuel

supply pump.

[48] Among the aforementioned additional systems, the cooling system A supplies a coolant heated through operation of the propulsion engine 1 while at sea to a first cooler 6 via a first switchover valve B1 and supplies the coolant cooled by the first cooler 6 to the propulsion engine 1 via a first circulation pump 7 and a fourth switchover valve B4. In addition, the cooling system A supplies a coolant heated through operation of the first power generation engine 5 during regasification to the first cooler 6 via the first switchover valve B1 and supplies the coolant cooled by the first cooler 6 to the first power generation engine 5 via the first circulation pump 7 and the fourth switchover valve B4. Here, the first and fourth switchover valves B1, B4 are valves that are switched depending upon whether the propulsion engine 1 is operated or the first power generation engine 5 is operated.

[49] In particular, the first circulation pump 7 supplies the coolant at a flow rate and pressure predetermined based on the size of the propulsion engine 1. Accordingly, a recirculation line RL is provided to recirculate a part of the coolant passing through the first circulation pump 7 upon supplying the coolant to the first power generation engine 5. For this purpose, the recirculation line RL is provided with a reclosable control valve B3. A coolant flow rate and pressure required for the first power generation engine 5 may be lower than those required for the propulsion engine 1. Thus, the control valve B3 serves to adjust the flow rate and pressure of the coolant to levels required for the first power generation engine 5 by returning the coolant to the first circulation pump 7.

[50] The cooling system A includes a fresh water generator 15. The fresh water generator 15 may generate fresh water while at sea, during regasification, or while docked.

[51] The fresh water generator 15 is a device that generates fresh water by heating seawater using a coolant returned from an engine as a heat source. Although the fresh water generator is generally associated with the propulsion engine 1, the fresh water generator may also generate fresh water while at anchor using a coolant recovered from the first power generation engine 5.

[52] The power generation system according to the present invention may

further include a cooling system including a second cooler 10 cooling a coolant heated through operation of the second power generation engine 8 and a second circulation pump 11 circulating the cooled coolant.

[53] Among the aforementioned additional systems, the lubrication system C includes an L.O. purifier 14 and a pump delivering lubricating oil used during operation of the propulsion engine 1 or the first power generation engine 5 to the L.O. purifier 14.

[54] The L.O. purifier 14 serves to purify lubricating oil used in the propulsion engine 1 or the first power generation engine 5. More specifically, the L.O. purifier 14 purifies lubricating oil used in the propulsion engine 1 while at sea and purifies lubricating oil used in the first power generation engine 5 during regasification.

[55] Although the first power generation engine 5 is shown as supplied with the lubricating oil purified through an external lubrication system C in FIG. 1, it will be understood that the present invention is not limited thereto and the first power generation engine may be provided therein with a lubrication system.

[56] The propulsion engine 1 includes a cooling unit 1a cooling the propulsion engine and a lubrication unit 1b facilitating operation of the propulsion engine. Likewise, the first power generation engine 5 includes a cooling unit 5a cooling the first power generation engine and a lubrication unit 5b facilitating operation of the first power generation engine.

[57] The second power generation engine 8 includes a cooling unit 8a and a lubrication unit (not shown) disposed therein to facilitate operation of the second power generation engine 8.

[58] The switchboard 12 is connected to the shaft generator 3 as well as to the second power generation engine 8 and the first power generation engine 5, which produce electricity using the fuel received from the fuel tank 16.

[59] The switchboard 12 collects electricity produced by at least one of the shaft generator 3, the first power generation engines 5, and the second power generation engine 8, and distributes the collected electricity to on-board electricity demand sites.

[60] According to the present invention, while at sea, the ship can be propelled by the propeller P driven by the propulsion engine 1, and, during regasification, the

regasification facility can perform regasification by being supplied with electricity produced by the first power generation engine 5. Since the propulsion engine 1 and the first power generation engine 5 are alternatively operated, the additional system used to operate the propulsion engine 1 can be shared by the first power generation engine 5, thereby allowing considerable savings on equipment cost, reduction in space for equipment installation, and simplification of the system.

[61] Next, a power generation method using the power generation system for the ship set forth above will be described.

[62] In a power generation method for a ship according to one embodiment of the present invention, while at sea, the ship produces electricity through a shaft generator 3 driven by a propulsion engine 1 operated to drive a propeller P and through a second power generation engine 8 operated along with the propulsion engine 1. At this time, a first power generation engine 5 is shut down, and required electricity while at sea is thus produced by the shaft generator 3 and the second power generation engine 8.

[63] The propulsion engine 1 and the second power generation engine 8 are operated by an additional system. More specifically, the propulsion engine 1 is connected to each of the cooling system A, the fuel supply system B, and the lubrication system C set forth above, and the second power generation engine 8 is connected to each of a fuel supply system including a second fuel supply unit 9 separately connected to a fuel tank 16 and a cooling system including a second cooler cooling a coolant heated by the second power generation engine. In addition, the second power generation engine 8 is provided therein with a lubrication system facilitating operation of the second power generation engine.

[64] Electricity produced by both the second power generation engine 8 and the shaft generator 3 connected to the propulsion engine 1 operated by the additional system is delivered to a switchboard 12. The switchboard 12 distributes electricity collected from the shaft generator 3 and the second power generation engine 8 to on-board electricity demand sites.

[65] While at sea, the ship can produce sufficient electricity to meet the needs of the on-board power demand sites only using the shaft generator 3 connected to the

propulsion engine 1 and the second power generation engine 8, which has a small capacity.

[66] On the other hand, electricity required for the regasification facility during regasification cannot be secured by the shaft generator 3 and the second power generation engine 8, which has a small capacity. Accordingly, during regasification, the first power generation engine 5 disposed at an upper side of a steering gear room at the stern is operated to produce electricity with the propulsion engine 1 shut down. In addition to the first power generation engine 5, the second power generation engine 8 may also be operated to produce electricity.

[67] Although it has been described that electricity is produced by operating the additional first power generation engine 5 with the propulsion engine 1 shut down during regasification, it will be understood that the present invention is not limited thereto and the regasification facility may be operated only using the shaft generator 3, which is driven by the propulsion engine 1 to produce electricity.

[68] That is, although electricity needs of the regasification system may be met by the shaft generator 3 alone, the first and second power generation engines 5, 8 may be optionally operated depending upon fuel consumption and power demand.

[69] The additional first power generation engine 5 is connected to each additional system connected to the propulsion engine 1 and thus can share the additional systems with the propulsion engine.

[70] Upon operation of the first power generation engine 5, the opening degree of a control valve B3 disposed on a recirculation line RL to supply a coolant at a flow rate and pressure predetermined based on the size of the propulsion engine 1 may be regulated to recirculate some of a coolant passing through a first circulation pump 7 so as to adjust a coolant flow rate and pressure to levels appropriate to the size of the first power generation engine 5.

[71] According to the present invention, the additional first power generation engine 5 can share the additional system provided to operate the propulsion engine 1 of the LNG carrier, for example, an MEGI engine, thereby allowing considerable savings on equipment cost, and electricity required for the regasification facility can be secured by the second power generation engine 8, which is already provided to

the LNG carrier, and the first power generation engine 5, which is additionally provided to the LNG carrier, thereby allowing the LNG carrier to be used as an offshore plant such as an FSRU.

[72] Although it has been described that electricity required for the regasification facility during regasification is secured by the first and second power generation engines 5, 8 in this embodiment, it will be understood that the present invention is not limited thereto and the propulsion engine 1 may also be operated such that the regasification facility is further supplied with electricity produced by the shaft generator 3 driven by the propulsion engine 1.

[73] It will be apparent to those skilled in the art that the present invention is not limited to the embodiments described above and various modifications, changes, alterations, and equivalent embodiments can be made without departing from the spirit and scope of the present invention.

**【CLAIMS】****【Claim 1】**

A power generation system for ships, comprising:  
a propulsion engine driving a propeller while at sea;  
a power generation engine producing electricity required for a regasification facility during regasification; and  
an additional system provided to operate the propulsion engine,  
wherein the propulsion engine and the power generation engine are alternatively operated, and  
the additional system is connected to each of the propulsion engine and the power generation engine to be shared by the propulsion engine and the power generation engine.

**【Claim 2】**

The power generation system according to claim 1, wherein the additional system comprises at least one selected from the group of a cooling system, a fuel supply system, and a lubrication system.

**【Claim 3】**

The power generation system according to claim 1, further comprising:  
a shaft generator driven by the propulsion engine to produce electricity.

**【Claim 4】**

The power generation system according to claim 3, further comprising:  
a clutch disposed between the shaft generator and the propeller to block or allow power transmission to the propeller.

**【Claim 5】**

The power generation system according to claim 1, wherein the power

generation engine comprises a plurality of power generation engines, and, among the plurality of power generation engines, a power generation engine sharing the additional system is disposed at an upper side of a steering gear room at a stern side.

**【Claim 6】**

The power generation system according to claim 5, wherein another power generation engine among the plurality of power generation engines is operated along with the propulsion engine.

**【Claim 7】**

The power generation system according to claim 1, further comprising:

a switchover valve disposed between the propulsion engine and the power generation engine to alternatively supply a coolant to the propulsion engine and the power generation engine;

a circulation pump supplying the coolant at a flow rate and pressure predetermined based on size of the propulsion engine;

a recirculation line recirculating some of the coolant passing through the circulation pump upon supplying the coolant to the power generation engine; and

a control valve disposed on the recirculation line to be switched between open and closed positions.

**【Claim 8】**

The power generation system according to claim 1, further comprising:

a switchboard connected to each of the power generation engine and a shaft generator driven by the propulsion engine to produce electricity,

wherein the switchboard collects electricity produced by the power generation engine and the shaft generator and distributes the collected electricity to on-board electricity demand sites.

**【Claim 9】**

The power generation system according to claim 2, wherein the cooling system comprises a fresh water generator generating fresh water while at sea or during regasification.

**【Claim 10】**

A power generation method using a power generation system for ships, the power generation system comprising a propulsion engine driving a propeller while at sea and a power generation engine producing electricity required for a regasification facility during regasification, wherein:

an additional system provided to operate the propulsion engine is connected to each of the propulsion engine and the power generation engine to be shared by the propulsion engine and the power generation engine; and

the propulsion engine and the power generation engine are alternatively operated to produce electricity.

**【Claim 11】**

The power generation method according to claim 10, wherein, while at sea, the additional system is associated only with the propulsion engine and electricity is produced by a shaft generator driven by the propulsion engine with the power generation engine shut down.

**【Claim 12】**

The power generation method according to claim 10, wherein, during regasification, the additional system is associated only with the power generation engine and electricity is produced by the power generation engine with the propulsion engine shut down.

**【Claim 13】**

The power generation method according to claim 10, wherein electricity produced by the power generation engine or a shaft generator driven by the

propulsion engine to produce electricity is collected and distributed to on-board electricity demand sites.

**【Claim 14】**

The power generation method according to claim 10, wherein the power generation system further comprises:

a switchover valve disposed between the propulsion engine and the power generation engine to alternatively supply a coolant to the propulsion engine and the power generation engine;

a circulation pump supplying the coolant at a flow rate and pressure predetermined based on size of the propulsion engine;

a recirculation line recirculating some of the coolant passing through the circulation pump upon supplying the coolant to the power generation engine; and

a control valve disposed on the recirculation line to be switched between open and closed positions,

wherein the control valve is opened upon supplying the coolant to the power generation engine.

**【Claim 15】**

The power generation method according to claim 10, wherein the power generation engine comprises a plurality of power generation engines and any one of the plurality of power generation engines is operated along with the propulsion engine to produce electricity.