

DESCRIPTION

Title of the Invention

POWER SYSTEM FOR VESSEL

5

Technical Field

[0001]

The present invention relates to a power system for vessel which is equipped with an engine capable of using both of a fuel gas and a liquid fuel as a main fuel and is served as an engine for a propulsion device, and is capable of using output of the engine for a working device in addition to propulsion of the vessel.

Background Art

[0002]

As an example of a power system for vessel, a power device of a working ship equipped with a firefighting device disclosed in Patent Document 1 has been proposed. The power device disclosed in Patent Document 1 uses a diesel engine as a main engine. The power device of the working ship is provided with a firefighting device that is attached to a propulsion shaft system connected to a propeller of the working ship having a main engine such as a diesel engine, and extracts power from the propulsion shaft system via wheels such that a fire pump provided as an auxiliary device is driven to discharge seawater.

This power system detects an overload on the main engine with a load detection device during the firefighting work, and suppresses the overload on the main engine by reducing a blade angle of a propulsion device. During idling of the fire pump,

transmission of the power is intercepted by releasing a clutch provided in a pump drive shaft system from the power system of the main engine.

[0003]

From the viewpoint of reduction in the amount of exhaust gas and
5 environmental protection, instead of a diesel engine using a liquid fuel as a main fuel, gas engines that can mainly use a fuel gas as a main fuel have been attempted to be used.

The gas engines are generally used as a main engine of a large ship such as an LNG carrier or tanker, and can be operated only within a narrow range of combustible air-fuel ratio, and therefore it is difficult to rapidly cope with a sudden load fluctuation. Thus,
10 the gas engines are not suitable for a working ship provided with a working device such as the firefighting device, and in the power device of the working ship disclosed in Patent Document 1, power is extracted from the diesel engine and is used as a power source.

Document of Related Art

15 Patent Document

[0004]

Patent Document 1: Japanese Examined Utility Model Application, Second
Publication No. S62-23359

20 Summary of Invention

Technical Problem

[0005]

In recent years, regulations on emissions of air pollutants emitted from vessels have become stricter in accordance with international treaties. For example, in some
25 sea areas called ECA, stricter regulations are imposed on the emission of sulfur oxides

and nitrogen oxides.

[0006]

However, the power device of the working ship disclosed in Patent Document 1
uses a diesel engine as a main engine, and thus is not sufficiently appropriate for the need
5 for these regulations on emissions of air pollutants.

[0007]

The present invention has been made in light of the above-described problem,
and an object thereof is to provide a power system for vessel using a fuel gas as a main
fuel, using as a drive source of not only a propulsion device but also a working device,
10 and capable of performing accurate combustion control while coping with a load
fluctuation.

Another object of the present invention is to provide a power system for vessel
using a fuel gas as a main fuel, and capable of quickly coping with a sudden load
fluctuation or a great load fluctuation and driving a working device.

15

Solution to Problem

[0008]

According to the present invention, there is provided a power system for vessel
including: an engine capable of using a fuel gas as a main fuel; a propulsion device
20 connected to the engine via a first clutch and driven by the engine; a propulsion-device-
side output sensor provided between the engine and the first clutch; a working device
connected to the engine via a second clutch and driven by the engine; and a working-
device-side output sensor provided between the engine and the second clutch.

According to the present invention, the propulsion device is driven by closing
25 the first clutch and opening the second clutch, and the output of the engine driving the

propulsion device is measured by the propulsion-device-side output sensor. The working device is driven by opening the first clutch and closing the second clutch, and the output of the engine driving the working device is measured by the working-device-side output sensor. In the engine using the fuel gas, since a fuel gas is an elastic

5 medium, and therefore it is relatively difficult to accurately obtain a supply amount of fuel compared with a liquid fuel, an actual output of the engine is measured by the output sensor, and the engine is controlled on the basis of the measurement value. In either of a case where the propulsion device is driven and a case where the working device is driven, it is possible to accurately measure, with the propulsion-device-side output sensor
10 and the working-device-side output sensor, an actual output of the engine in consideration of a loss caused by resistance of a transmission system, a clutch, or the like, and thus to accurately control the engine using the fuel gas as a main fuel.

[0009]

The working device is a firefighting device that is configured to discharge water.

15 It is possible to accurately measure an actual output of the engine with the working-device-side output sensor and thus to accurately control the engine.

[0010]

The power system for vessel further includes a control device configured to cause the propulsion device to drive by closing the first clutch and opening the second
20 clutch, and cause the working device to drive by opening the first clutch and closing the second clutch.

The control device can perform switching between driving of the propulsion device and driving of the working device by performing switching between opening and closing of the first clutch and the second clutch.

25 [0011]

The engine may be controlled according to a sum of an output measurement value from the propulsion-device-side output sensor and an output measurement value from the working-device-side output sensor.

A more accurate output value of the engine can be obtained by summing the
5 output measurement value from the propulsion-device-side output sensor and the output measurement value from the working-device-side output sensor. For example, in a state where the propulsion device is driven, most of the output of the engine is measured by the propulsion-device-side output sensor, but some extent of the output value is also detected by the working-device-side output sensor due to drag resistance or a mechanical
10 loss of the clutch in an opened state. Thus, it is possible to measure a more accurate output value of the engine by summing the output values from both of the output sensors.
[0012]

When at least one of an output measurement value from the propulsion-device-side output sensor and an output measurement value from the working-device-side output
15 sensor exceeds an upper limit value, the engine may be controlled such that a rotational speed of the engine is reduced.

In an operation mode (also referred to as “gas mode”) in which the fuel gas is used as a main fuel, when the output value from the propulsion-device-side output sensor or the output value from the working-device-side output sensor exceeds an upper limit
20 value for a predetermined time, automatic slow-down control is performed such that the rotational speed of the engine is forced to be reduced. When the output of the engine is excessive in the gas mode, knocking or misfire may occur. Therefore, when the output value from the output sensor exceeds the upper limit value, the output of the engine is reduced by performing control such that the rotational speed of the engine is forced to be
25 reduced, and thus knocking, misfire, and the like is prevented.

As the upper limit value, one or both of an upper limit value of power that is output from the engine and an upper limit value of torque may be set. A single upper limit value may be set, and an upper limit value of torque that changes depending on the rotational speed of the engine may be set as the upper limit value.

5 [0013]

The propulsion-device-side output sensor and the working-device-side output sensor may be torque sensors configured to measure a torque that is actually applied to a propulsion shaft of the engine.

Torque sensors are used as the propulsion-device-side output sensor and the
10 working-device-side output sensor to measure a torque that is actually applied to the propulsion shaft of the engine. The output (power) of the engine can be obtained by using a product between the torque values obtained by the torque sensors and a rotational speed of the engine obtained by a rotational speed sensor.

[0014]

15 In the power system for vessel according to the present invention, when transition from a state of driving the propulsion device to a state of driving the working device occurs during an operation of the engine in an operation mode in which the fuel gas is used as a main fuel, temporary switching from the operation mode in which the fuel gas is used as a main fuel to an operation mode (also referred to as “diesel mode”) in
20 which a liquid fuel is used as a main fuel is performed, at least one of the first clutch and the second clutch is operated, and then returning from the operation mode in which the liquid fuel is used as a main fuel to the operation mode in which the fuel gas is used as a main fuel is performed.

According to the present invention, when transition from the state of driving the
25 propulsion device to the state of driving the working device occurs during the operation

mode of the engine in which the fuel gas is used as a main fuel, temporary switching from the operation mode using the fuel gas to the operation mode using the liquid fuel is performed, and then opening/closing operations of the first clutch and the second clutch are performed. In the operation mode of the engine using the fuel gas, there is a

5 possibility that the operation of the engine may be easily influenced by a load fluctuation, and a smooth operation of the engine may be hindered by a disturbance of the load due to opening/closing operations of the clutches. However, temporary switching to the diesel mode, which is resistant to the load fluctuation, is performed, and then opening and closing of the clutches are performed, so that it is possible to perform a stable switching
10 operation without being influenced by the load fluctuation.

[0015]

In the power system for vessel according to the present invention, when transition from a state of driving the working device to a state of driving the propulsion device occurs during an operation of the engine in an operation mode in which the fuel
15 gas is used as a main fuel, temporary switching from the operation mode in which the fuel gas is used as a main fuel to an operation mode in which a liquid fuel is used as a main fuel is performed, at least one of the second clutch and the first clutch is operated, and then returning from the operation mode in which the liquid fuel is used as a main fuel to the operation mode in which the fuel gas is used as a main fuel is performed.

20 According to the present invention, when returning from the state of driving the working device to the state of driving the propulsion device occurs during the operation mode of the engine in which the fuel gas is used as a main fuel, temporary switching to the diesel mode in which the liquid fuel is used as a main fuel is performed, and the opening/closing operations of the first and second clutches are performed in the diesel
25 mode. Since the activate of the first clutch on the propulsion device side causes a

relatively large disturbance of the load, switching to the diesel mode is performed and then the first clutch is closed, so that it is possible to perform a stable switching operation without being influenced by the load fluctuation.

[0016]

5 The control device may include a diesel mode transition unit configured to perform transition from a gas mode in which the fuel gas is used as a main fuel to a diesel mode in which a liquid fuel is used as a main fuel in order to perform an operation of opening one of the first clutch and the second clutch and closing the other clutch, and a gas mode transition unit configured to perform transition from the diesel mode to the gas
10 mode after the operation of opening one of the first clutch and the second clutch and closing the other clutch is finished.

 In the operation mode of the engine using the fuel gas, since there is possibility that the operation of the engine may be easily influenced by a load fluctuation, and a smooth operation of the engine may be hindered by a disturbance of the load due to
15 opening and closing of the first clutch and the second clutch, temporary transition to the diesel mode, which is resistant to the load fluctuation, is performed, and then opening and closing of the first clutch and the second clutch are performed, so that it is possible to perform a stable switching operation without being influenced by the load fluctuation. Thereafter, transition to the gas mode is performed, and thus it is possible to perform an
20 operation in which the influence on an environment is reduced.

[0017]

 According to the present invention, there is provided a power system for vessel including a plurality of engines capable of using a fuel gas as a main fuel, the power system including, on a first engine side, a first propulsion device connected to the first
25 engine via a first clutch and driven by the first engine, a first propulsion-device-side

output sensor provided between the first engine and the first clutch, a working device connected to the first engine via a second clutch and driven by the first engine, a working-device-side output sensor provided between the first engine and the second clutch, and a control device configured to cause the first propulsion device to drive by closing the first clutch and opening the second clutch, and cause the working device to drive by opening the first clutch and closing the second clutch, and on a second engine side, a second propulsion device connected to the second engine via a third clutch and driven by the second engine, and a second propulsion-device-side output sensor provided between the second engine and the third clutch, in which the control device is configured to cause the second propulsion device to drive by closing the third clutch.

According to the present invention, when the working device is driven by the first engine, the second propulsion device is driven by the second engine on the basis of the second propulsion-device-side output sensor to continuously propel the vessel. Particularly, in a case where a firefighting device configured to discharge water is provided as the working device, the vessel receives reaction force due to the water discharge, but the reaction force is canceled out by continuously propelling the vessel, and thus water discharge work can be performed in a stable state.

Advantageous Effects of Invention

[0018]

According to the power system for vessel of the present invention, since the propulsion-device-side output sensor is provided between the engine and the first clutch and the working-device-side output sensor is provided between the engine and the second clutch on the propulsion shaft of the engine that can be operated by using a fuel gas as a main fuel, it is possible to measure the output value of the engine by the sensors to

control the engine, and thus it is possible to drive not only the propulsion device but also the working device.

It is possible to more accurately measure an actual output of the engine in consideration of a loss caused by resistance of a transmission system, a clutch, or the like, and even when the clutch is opened, it is possible to measure the output in consideration of the resistance.

Brief Description of Drawings

[0019]

Fig. 1 is an explanatory diagram illustrating the overall configuration of a vessel provided with a firefighting device according to an embodiment of the present invention.

Fig. 2 is an explanatory diagram illustrating configurations of an engine, a propulsion device, and the firefighting device in the vessel according to the embodiment.

Fig. 3 is an explanatory diagram illustrating the overall configuration of the engine illustrated in Fig. 2.

Fig. 4A is an explanatory diagram of the engine illustrating a diesel mode.

Fig. 4B is an explanatory diagram of the engine illustrating a gas mode.

Fig. 5 is a flowchart illustrating steps of switching from driving of the propulsion device to driving of the firefighting device in First Example.

Fig. 6 is a flowchart illustrating steps of switching from driving of the firefighting device to driving of the propulsion device.

Fig. 7 is a flowchart illustrating steps of switching from driving of the firefighting device to driving of the propulsion device in Second Example.

Fig. 8 is a flowchart illustrating automatic slow-down control.

Description of Embodiments

[0020]

Hereinafter, a power system of a vessel 1 according to an embodiment of the present invention will be described with reference to Figs. 1 to 8.

5 Fig. 1 illustrates a fundamental configuration of a marine propulsion device of a working ship such as a tugboat as the vessel 1. The vessel 1 includes a dual fuel engine 3 as a main engine, and can be operated to switch between two modes of a gas mode in which a fuel gas is used as a main fuel and a diesel mode in which a liquid fuel is used as a main fuel.

10 [0021]

The vessel 1 can switch a transmission direction of a drive force by the dual fuel engine 3 as a main engine such that the vessel 1 can selectively drive a propulsion device 5 provided with a propeller 5a and a firefighting device 6 configured to discharge, from a discharge nozzle 6a, seawater pumped up from the sea.

15 The vessel 1 illustrated in Fig. 1 has, for example, an azimuth thruster (clutch separate type azimuth thruster) 8 as a marine propulsion device. The vessel 1 according to the present embodiment may not have the azimuth thruster 8.

[0022]

The vessel 1 illustrated in Fig. 1 is equipped with a first clutch 9 serving as a
20 main clutch and disposed between the azimuth thruster 8 and a rear end side in terms of driving of the dual fuel engine 3 as a main engine. The propulsion device 5 provided with the propeller 5a is connected to a rear end side of the azimuth thruster 8. The first clutch 9 is a slip clutch, performs slip-control to reduce the maximum rotational speed of the dual fuel engines 3 to a required rotational speed, and drives the propeller 5a of the
25 propulsion device 5 at the required rotational speed.

An accelerating gear 10 may be connected to the firefighting device 6 provided on a front end side of the dual fuel engines 3. Seawater is discharged from the discharge nozzle 6a via a fire pump 11 provided in the firefighting device 6.

[0023]

5 Next, with reference to Fig. 2, a configuration of the marine propulsion device of the vessel 1 illustrated in Fig. 1 will be described in more detail. The same configuration as the fundamental configuration of the marine propulsion device of the vessel 1 illustrated in Fig. 1 will be described on the basis of a detailed disposition configuration illustrated in Fig. 2. In Fig. 2, some members of the vessel 1 illustrated in
10 Fig. 1 are provided in a pair, and the pair of members will be denoted in detail by adding A and B to the same reference numeral.

In the vessel 1 illustrated in Fig. 2, for example, two dual fuel engines (hereinafter, simply referred to as engines in some cases) 3 are provided in parallel, and one thereof will be referred to as a dual fuel engine 3A, and the other will be referred to
15 as a dual fuel engine 3B. Each of the dual fuel engines 3A and 3B includes an ECU. A propulsion mechanism including the dual fuel engine 3A on the port side will be referred to as a first marine propulsion device 20A, and a propulsion mechanism including the dual fuel engine 3B on the starboard side will be referred to as a second marine propulsion device 20B.

20 [0024]

The vessel 1 such as a tugboat or a working ship having a firefighting function generally has a configuration in which a total of two engines 3A and 3B are provided in parallel on the port and starboard. When the fire pump 11 of the firefighting device 6 is driven by one dual fuel engine 3A to discharge seawater, and the vessel 1 is propelled by
25 the other dual fuel engine 3B, thereby a fire extinguishing activity can be performed

while preventing the vessel 1 from being retreated due to reaction force of a driving load of the fire pump 11.

[0025]

In the first marine propulsion device 20A on the port side, a propulsion shaft 13A is provided to the dual fuel engine 3A, and a propulsion device 5A is provided to the propulsion shaft 13A via a first clutch 9A as a main clutch. The first clutch 9A is a slip clutch, and can freely change and switch a load transmission ratio in the range of slipping of 100% to 0%. The propulsion shaft 13A is connected to the propulsion device 5A having the propeller 5a.

A propulsion-device-side output sensor 14A is provided between the dual fuel engine 3A and the first clutch 9A. A rotational speed sensor 15A that measures a rotational speed of the propulsion shaft 13A is provided between the dual fuel engine 3A and the propulsion-device-side output sensor 14A. The propulsion-device-side output sensor 14A is a torque sensor that measures a torque, and an output can be calculated by a product of the rotational speed measured by the rotational speed sensor 15A and the torque. The propulsion-device-side output sensor 14A may measure both of a rotational speed and a torque.

[0026]

The fire pump 11 of the firefighting device 6 is connected to a drive shaft 17 provided on an opposite side to the propulsion device 5A with respect to the dual fuel engine 3A, and a second clutch 18 is attached to the fire pump 11 on the dual fuel engine 3A side. The second clutch 18 is a power take-off (PTO) clutch.

A working-device-side output sensor 19 is provided between the second clutch 18 and the dual fuel engine 3A. In the same manner as the propulsion-device-side output sensor 14A, the working-device-side output sensor 19 is a torque sensor that

measures a torque, and an output can be calculated by a product of the rotational speed measured by the rotational speed sensor 15A and the torque. The working-device-side output sensor 19 may measure both of a rotational speed and a torque.

[0027]

5 Each constituent of the first marine propulsion device 20A on the port side is electrically connected to a control device 22. When the propulsion device 5A is driven, the first clutch 9A is closed and the second clutch 18 on the firefighting device 6 side is opened by the control device 22, and, when the firefighting device 6 is driven, the first clutch 9A is opened and the second clutch 18 on the firefighting device 6 side is closed.

10 During driving of the propulsion device 5A or the firefighting device 6, the operation of the dual fuel engine 3A is controlled by the control device 22 on the basis of the output value of the dual fuel engine 3A measured by the rotational speed sensor 15A and the propulsion-device-side output sensor 14A or the working-device-side output sensor 19.

[0028]

15 In the second marine propulsion device 20B on the starboard side illustrated in Fig. 2, a propulsion shaft 13B is provided to the dual fuel engine 3B, and a propulsion device 5B is provided to the propulsion shaft 13B via a third clutch 9B as a main clutch. The third clutch 9B is the same slip clutch as the first clutch 9A, and can freely change and switch a load transmission ratio. The propulsion shaft 13B is connected to the

20 propulsion device 5B having a propeller 5b.

 A propulsion-device-side output sensor 14B is provided between the dual fuel engine 3B and the third clutch 9B. A rotational speed sensor 15B is provided between the dual fuel engine 3B and the propulsion-device-side output sensor 14B. The propulsion-device-side output sensor 14B is a torque sensor that measures a torque, and

25 an output can be calculated by a product of the rotational speed measured by the

rotational speed sensor 15B and the torque. The propulsion-device-side output sensor 14B may measure both of a rotational speed and a torque.

[0029]

Each constituent of the second marine propulsion device 20B on the starboard
5 side is electrically connected to the control device 22 in the same manner as that of the first marine propulsion device 20A. When the propulsion device 5B is driven, the third clutch 9B is closed by the control device 22. The operation of the dual fuel engine 3B is controlled by the control device 22 on the basis of the output value of the dual fuel engine 3B measured by the rotational speed sensor 15B and the propulsion-device-side
10 output sensor 14B.

[0030]

Next, a configuration and a function of the dual fuel engine 3 will be described with reference to Figs. 3, 4A, and 4B using an exemplary example of a four-stroke engine.

15 The marine dual fuel engine (hereinafter, simply referred to as the engine in some cases) 3 illustrated in Figs. 3, 4A, and 4B is switchable between a diesel mode and a gas mode during the operation of the engine 3. The dual fuel engine 3 illustrated in Fig. 3 includes a mechanism of a crank shaft 24 as the propulsion shaft 13A or 13B connected to the propeller 5a or 5b, and the crank shaft 24 is connected to a piston 26
20 provided in a cylinder block 25. A combustion chamber 28 is formed by the piston 26 provided in the cylinder block 25 and an engine head 27.

[0031]

The combustion chamber 28 is closed by an intake valve 29 and an exhaust valve 30 installed at the engine head 27, and a fuel injection valve 31 used in the diesel
25 mode. The engine head 27 is provided with a micro-pilot oil injection valve 32 used in

the gas mode. A fuel injection pump 33 is connected to the fuel injection valve 31.

An intake pipe 34 is connected to an intake port in which the intake valve 29 of the engine head 27 is provided, and an exhaust pipe 35 is installed in an exhaust port in which the exhaust valve 30 is provided. A fuel gas supply valve 36 formed of a

5 solenoid valve and configured to control gas injection is provided in the intake pipe 34, and an air cooler 37 and a supercharger 38 communicating with the exhaust pipe 35 are provided on the upstream side of the fuel gas supply valve 36.

[0032]

The dual fuel engines 3 according to the present embodiment can be switched
10 between and operated in the diesel mode and the gas mode as illustrated in Figs. 4A and 4B. In the diesel mode illustrated in Fig. 4A, for example, A-type heavy oil as a fuel oil is supplied from a fuel tank (not illustrated) to the fuel injection pump 33, and is mechanically injected into compressed air in the combustion chamber 28 from the fuel injection valve 31 to be ignited and combusted.

15 [0033]

In the gas mode illustrated in Fig. 4B, a fuel gas such as a natural gas is supplied to the intake pipe 34 via the fuel gas supply valve 36 and is premixed with an air flow, the fuel-air mixture is supplied into the combustion chamber 28, and the fuel-air mixture in a compressed state is ignited by an ignition device. In this example, a pilot fuel is
20 injected from the micro-pilot oil injection valve 32 to be ignited and combusted. For example, the micro-pilot oil injection valve 32 is electronically controlled to inject a small amount of the pilot fuel as a powerful ignition source. The fuel gas supply valve 36 is a solenoid valve that can form a large opening with a small stroke and cause a large amount of gas to flow in a short period of time.

25 [0034]

The gas mode includes both of an operation method in which only a fuel gas is used as a fuel and ignition is performed by using an ignition plug, and an operation method in which a small amount of a liquid fuel (pilot oil) is injected and used to ignite a fuel gas that occupies a major portion of a heat source. In the latter operation method, the ratio of the liquid fuel in total fuel is typically about 1% to 10% of a total calorific value relative to a calorific value of the rated output. From the viewpoint of achieving environmental regulations on emissions of gases, the ratio is preferably equal to or less than 3%.

The diesel mode is an operation method in which only a liquid fuel is used as a fuel, and is generally used during starting and stopping of the engine, and during occurrence of a load fluctuation such as switching between opening and closing of the first clutch 9A and the third clutch 9B and the second clutch 18 when mode transition between a normal operation mode and a firefighting mode occurs.

[0035]

The engine 3 is started in the diesel mode in which liquid fuel is injected into the combustion chamber 28 by the fuel injection valve 31. After it is confirmed that a gas under the pressure higher than a reference value is supplied to the engine 3, operation is performed in the gas mode in which the fuel gas is supplied to the intake pipe 34 via the fuel gas supply valve 36 to be mixed with air and then is flowed into the combustion chamber 28, and the fuel gas is combusted.

The operation mode is changed to the diesel mode again upon stopping, and then the engine is stopped. The diesel mode and the gas mode can be switched other than upon starting and stopping.

[0036]

During a steady operation, the engine 3 is operated in the gas mode theoretically

according to a vessel cube characteristic line on the basis of the relationship between the rotational speed and the output. The vessel cube characteristics indicate characteristics of a vessel main engine (engine 3) in a vessel using the propeller 5a with a fixed pitch, in which the output is proportional to the cube of the rotational speed. Upon operations
5 other than the steady operation, for example when the vessel is operated in stormy weather or is maneuvered due to a rapid change of a course, since an output equal to or more than a normal operation range and greatly exceeding the vessel cube characteristics is required and an operation in the gas mode may be difficult due to insufficient output, the liquid fuel is temporarily supplied into the combustion chamber 28 and an operation
10 is performed using the liquid fuel together with the gas fuel.

[0037]

In the operation system of the vessel 1 according to the present embodiment, in order to cope with exhaust gas regulations, fundamentally, both the normal operation (normal operation mode) using the propulsion device 5 and fire extinguishing work
15 (firefighting mode) using the firefighting device 6 are performed in the gas mode. In this case, the output value of the gas engine is not measured from the amount of the supplied fuel gas since the amount of the supplied fuel gas is difficult to be measured accurately, but the propulsion-device-side output sensors 14A and 14B and the working-device-side output sensor 19 are provided in the first marine propulsion device 20A and
20 the second marine propulsion device 20B, and the output value is measured in a timely manner by the propulsion-device-side output sensors 14A and 14B and the working-device-side output sensor 19. Shaft horsepower meters are preferably used as the propulsion-device-side output sensors 14A and 14B and the working-device-side output sensor 19.

25 [0038]

Since the load fluctuation is great when transition between the normal operation mode and the firefighting mode occurs upon load driving in the gas mode, temporary transition from the gas mode to the diesel mode is performed in this case. Accordingly, it is possible to rapidly cope with the load fluctuation due to switching between opening and closing of the first clutch 9A, the third clutch 9B, and the second clutch 18. Thus, the control device 22 is provided with a diesel mode transition unit 63 which detects an instruction signal of transition to the firefighting mode and performs temporary transition from the gas mode to the diesel mode. The control device 22 is also provided with a gas mode transition unit 64 which performs transition from the diesel mode to the gas mode after the load fluctuation due to switching between opening and closing of the first clutch 9A, the third clutch 9B, and the second clutch 18 is stabilized.

In a case where the load fluctuation when transition from the propulsion mode to the firefighting mode occurs is relatively small, transition to the firefighting mode may be performed in a state where the gas mode is maintained without transition to the diesel mode.

[0039]

In the power system of the vessel 1 according to the present embodiment, a more accurate output value of the engine 3A may be obtained by summing the output measurement value from the propulsion-device-side output sensor 14A of the first marine propulsion device 20A and the output measurement value from the working-device-side output sensor 19 and the operation of the engine 3A may be controlled on the basis of the obtained output value.

For example, in a state where the first marine propulsion device 20A is driven, most of the output of the engine 3A is measured by the propulsion-device-side output sensor 14A, but some extent of the output value is also detected by the working-device-

side output sensor 19. This is because some extent of mechanical loss in the firefighting device 6 is generated even when the second clutch 18 on the firefighting device 6 side is opened. Similarly, some extent of the output value is detected by the working-device-side output sensor 19 even when the first clutch 9A is opened and the fire pump 11 of the firefighting device 6 is driven.

Therefore, by summing the output values from the propulsion-device-side output sensor 14A and the working-device-side output sensor 19, it is possible to obtain a more accurate output value of the engine 3A.

[0040]

The dual fuel engine 3 according to the present embodiment includes a gas engine system configured to control an output upon power-up in the gas mode. A structure of the gas engine system will be described.

In Fig. 3, the rotational speed sensor 15 (15A or 15B) and the propulsion-device-side output sensor 14 (14A or 14B) are attached to the crank shaft 24, and the rotational speed sensor 15 measures a rotational speed of the crank shaft 24, and the propulsion-device-side output sensor 14 measures an engine torque. For example, as the propulsion-device-side output sensor 14, a strain sensor configured to detect a torque applied to a shaft through strain may be used. Measurement data measured by each of the rotational speed sensor 15 and the propulsion-device-side output sensor 14 is output as a signal to the control device 22 configured to control the engine 3.

[0041]

The control device 22 detects an operation state of the engine 3 on the basis of the signals from the rotational speed sensor 15, the propulsion-device-side output sensor 14, and the like. That is, when the rotational speed of the crank shaft 24 measured by the rotational speed sensor 15 is indicated by n , and the torque measured by the

propulsion-device-side output sensor 14 is indicated by T, the output (load) A of the engine 3 is calculated according to the following Equations (1) and (2). Here, L_t indicates a rated output of the engine 3.

$$\text{Output } L_o = 2\pi Tn/60 \quad (1)$$

$$\text{Output (load) } A = L_o/L_t \times 100 \quad (2)$$

[0042]

As a method of obtaining the output (load) of the engine 3, there are a method of estimating the output of the engine 3 from information regarding an operation state of the engine 3 such as a supply amount of fuel or other, and a method of obtaining the output of the engine 3 by actually measuring a torque using the propulsion-device-side output sensor 14 provided in the power transmission system of the propulsion shaft 13 (13A or 13B) of the engine 3. In the gas fuel engine, since a fuel gas is an elastic medium, it is relatively difficult to accurately obtain a supply amount of fuel compared with a liquid fuel. Therefore, it is preferable to calculate output by actually measuring a torque using the propulsion-device-side output sensor 14.

When the rotational speed n is constant, the output A and the torque measurement value T have a direct proportional relationship. Under a condition in which the rotational speed n is constant, it is desirable to set advance amount of the closing timing of the intake valve 29 at a larger ratio as the output A is increased, i.e., as the torque data T is increased.

[0043]

A first map 40 for determining a first electric signal of an intake valve opening/closing timing and a second map 41 for determining a second electric signal on the basis of the first electric signal and the opening/closing timing are previously created and stored in the control device 22. The control device 22 calculates the output A of the

engine 3 using the above Equations (1) and (2) on the basis of the rotational speed data n and the torque data T corresponding to the output A of the engine 3 and measured by the rotational speed sensor 15 and the propulsion-device-side output sensor 14. The first electric signal corresponding to the opening/closing timing of the intake valve 29 is
5 selected from the first map 40 according to the rotational speed n and the output A . The opening/closing timing of the intake valve 29 corresponding to the first electric signal is determined in the second map 41 on the basis of the first electric signal.

[0044]

The second electric signal of the opening/closing timing set in the control device
10 22 is transmitted to an electropneumatic converter 42, and a signal of the opening/closing timing is converted into an air pressure by the electropneumatic converter 42. The air pressure is sent to an actuator 43 to control driving of a variable intake valve timing mechanism 44. Air pressure $P1$ for driving and air pressure $P2$ for controlling are supplied to the actuator 43 from a first pressure reducing regulator 45 and the
15 electropneumatic converter 42.

[0045]

The air pressure supplied to the actuator 43 is compressed by an air compressor 46 and stored in an air tank 47. The air pressure in the air tank 47 is decompressed to a required pressure by the first pressure reducing regulator 45. The pressure at this time
20 is adjusted by changing a valve opening of the first pressure reducing regulator 45, and supplied as the air pressure $P1$ for driving to the actuator 43. When the pressure $P1$ measured by a pressure gauge 48 is equal to or less than a prescribed value, the engine 3 cannot be started.

[0046]

25 The air pressure for driving the electropneumatic converter 42 is supplied from

the first pressure reducing regulator 45 and further decompressed by a second pressure reducing regulator 49. The electropneumatic converter 42 supplies the air pressure corresponding to the input second electric signal of the opening/closing timing to the actuator 43 as the air pressure P2 for adjusting operation of the actuator 43. A rod 43a
5 of the actuator 43 is operated to actuate the variable intake valve timing mechanism 44 on the basis of the air pressures P1 and P2.

[0047]

The actuator 43 is, for example, a known P cylinder (a cylinder with a positioner), and controls advancing and retreating of the rod 43a on the basis of the
10 pressures P1 and P2 input from the first pressure reducing regulator 45 and the electropneumatic converter 42. As a movement length of the rod 43a of the actuator 43 is changed, driving of the variable intake valve timing mechanism 44 is controlled to advance or retard the closing timing of the intake valve 29 from intake bottom dead center, thereby a compression ratio is reduced, and thus control is performed.

15 [0048]

Since a period between the valve opening timing and the valve closing timing of the intake valve 29 is not changed, when the valve opening timing advances from the intake bottom dead center, the valve closing timing also advances by the same time from the intake top dead center. In the present embodiment, the valve opening/closing timing
20 is changed according to the output of the engine 3 such that knocking is suppressed, and the power-up time is shortened. The opening/closing timing of the intake valve 29 is set by using the first map 40 and the second map 41 in the control device 22 on the basis of the output A and the rotational speed n of the engine 3, and the valve opening/closing timing of the intake valve 29 is adjusted by the actuator 43 and the variable intake valve
25 timing mechanism 44 such that knocking can be suppressed.

[0049]

The configuration of the variable intake valve timing mechanism 44 is known in the related art. That is, in the variable intake valve timing mechanism 44 is provided with, for example, a link shaft of which a rotation angle range is set by a movement
5 length of the rod 43a of the actuator 43 and a cam shaft having an eccentric cam, the link shaft and the cam shaft being disposed parallel to each other. An exhaust swing arm is connected to the link shaft, and an intake swing arm is connected to a tappet shaft provided at an eccentric position of the link shaft. The intake valve 29 is connected to the intake swing arm, and the exhaust valve 30 is connected to the exhaust swing arm.

10 [0050]

The distance between the cam shaft and the intake swing arm is changed depending on a rotation angle of the tappet shaft according to rotation of the link shaft, and thus a timing at which the eccentric cam of the cam shaft starts to come into contact with the intake swing arm is changed. Accordingly, the valve closing timing can be
15 changed to be advanced (or to be retarded). As a distance between the tappet shaft and a center of the cam shaft increases, the valve closing timing of the intake valve 29 becomes earlier. A rotation angle of the tappet shaft is changed according to the movement length of the rod 43a of the actuator 43. The movement length of the rod 43a is arbitrarily changed by the air pressures P1 and P2 for controlling supplied to the
20 actuator 43.

The magnitude of the advance corresponding to the closing/opening timing of the intake valve 29 is determined by the timing at which the eccentric cam of the cam shaft starts to come into contact with the intake swing arm connected to the tappet shaft of the link shaft.

25 [0051]

As a rotary device of the tappet shaft in the variable intake valve timing mechanism 44, a servo motor (not illustrated) may be used instead of the actuator 43.

In this case, a signal of the opening/closing timing transmitted from the second map 41 in the control device 22 is input to the servo motor. The servo motor can rotate the link shaft by an amount corresponding to the received signal, and thus turn the tappet shaft to come closer to or become more distant from the cam shaft, so that the opening/closing timing of the intake valve 29 can be changed. When the servo motor is used, a configuration of the actuator 43 and the first pressure reducing regulator 45 to a pressure gauge 50 is not necessary. The servo motor is driven by the controller instead of the electropneumatic converter 42.

[0052]

A description will be made of a mechanism configured to a fuel gas to the fuel gas supply valve 36 that controls gas injection into the intake pipe 34. In Fig. 3, a fuel gas such as natural gas is supplied to a gas vaporizer 53 from an LNG gas tank 52 in which the fuel gas is stored, and a gas pressure is decompressed to a required gas pressure by a gas regulator 54.

The gas pressure is displayed on a fuel gas pressure gauge 55, adjusted by changing a valve opening of the gas regulator 54, and supplied from the fuel gas supply valve 36 into the intake pipe 34 as a fuel gas for combustion. The fuel gas is mixed with turbocharged air cooled by the air cooler 37 in the intake pipe 34, and the fuel-air mixture is supplied to the combustion chamber 28. Upon power-up, a supply amount of the fuel gas is increased through the operation of the fuel gas supply valve 36.

[0053]

The second electric signal for the opening/closing timing set by the control device 22 is transmitted to the fuel gas supply valve 36 via a gas governor 57 separately

from the electropneumatic converter 42. The gas governor 57 performs speed governing control (governor control) on a supply amount of the fuel gas in the gas mode. The gas governor 57 controls the opening timing of the fuel gas supply valve 36, at which the fuel gas supply valve 36 is opened to supply the fuel gas into the intake pipe 5 34, to be advanced according to the advance of the closing timing of the intake valve 29. The gas regulator 54 that adjusts the gas pressure and the gas governor 57 that advances the opening timing of the fuel gas supply valve 36 and performs speed governing control are included in a fuel gas supply valve timing mechanism 60.

The gas governor 57 may be provided outside the control device 22. The fuel 10 gas supply valve timing mechanism 60 may be configured to receive the second electric signal from the second map 41 and advance the opening timing of the fuel gas supply valve 36 according to the advance of the closing timing of the intake valve 29.

[0054]

During operation of the vessel 1 in the gas mode, when transition from the 15 normal operation mode to the firefighting mode occurs or transition from the firefighting mode to the normal operation mode occurs, temporary switching from the gas mode to the diesel mode is performed, and then switching between opening and closing of the first clutch 9A and the second clutch 18 is performed in the diesel mode. There is a possibility that the operation of the engine 3A in the gas mode may be easily influenced 20 by the load fluctuation, and a smooth operation of the engine 3A may be hindered by a disturbance of the load due to opening/closing operations of the first clutch 9A and the second clutch 18. Therefore, during transition between the normal operation mode and the firefighting mode, temporary switching from the gas mode to the diesel mode, which is resistant to a load fluctuation, is performed, and then opening/closing operations of the 25 first clutch 9A and the second clutch 18 are performed, so that influence on the engine 3A

due to the load fluctuation can be suppressed.

When a load caused by the fire pump 11 is relatively small, the disturbance of the load due to closing of the second clutch 18 on the fire pump 11 side is also relatively small, and therefore the above operation may be omitted depending on conditions.

5 [0055]

In the power system of the vessel 1 according to the present embodiment, when the normal operation of the vessel 1 is performed in the gas mode and transition from the normal operation mode to the firefighting mode occurs in the gas mode, there are a case where a load fluctuation is great and a case where a load fluctuation is small. Thus, in
 10 the present embodiment, separate description will be made of (A) First Example in which switching to the diesel mode is performed during bidirectional transition between the time of normal operation and the time of firefighting, and (B) Second Example in which the gas mode is maintained during transition from the time of normal operation to the time of firefighting operation, and switching to the diesel mode is performed during only
 15 transition from the time of firefighting to the normal operation mode.

[0056]

(A) First Example

With reference to a flowchart of Fig. 5, a description will be made of procedures in a case where switching to the diesel mode is performed during bidirectional transition
 20 between the normal operation mode and the firefighting mode.

This is appropriate for a case where the load of the fire pump 11 of the firefighting device 6 is relatively large.

a) Switching procedure from normal operation mode to firefighting mode

During the normal mode operation of the dual fuel engines 3A and 3B of the
 25 vessel 1, the first marine propulsion device 20A and the second marine propulsion device

20B on both of the port and the starboard sides are operated in the gas mode in which the first clutch 9A and the third clutch 9B are closed and the second clutch 18 is opened (S100). The propellers 5a and 5b on both of the port and the starboard sides are driven to propel the vessel 1. When switching from this state to the firefighting mode is to be performed, the rotational speeds of the engines 3A and 3B on both of the port and the starboard sides are slowed down to perform an idle operation (S101).

[0057]

Next, the first clutch 9A and the third clutch 9B on both of the port and the starboard sides are opened. An instruction signal of switching to the firefighting mode is output to the control device 22 (S102), and the first marine propulsion device 20A on the port side is switched from the gas mode operation to the diesel mode operation (S103). Thereafter, the third clutch 9B of the second marine propulsion device 20B on the starboard side is closed, and the second clutch 18 of the firefighting device 6 on the port side is closed (S104).

There is possibility that the operation of the engine 3A in the gas mode may be easily influenced by the load fluctuation, and a smooth operation of the engine 3A may be hindered by a disturbance of the load due to opening/closing operations of the first clutch 9A and the second clutch 18. Therefore, during transition from the normal operation mode to the firefighting mode, temporary switching from the gas mode to the diesel mode, which is resistant to the load fluctuation, is performed, and then the clutch operation is performed. In the present example, since the first clutch 9A and the third clutch 9B are slip clutches and are capable of being gradually switched from a closing state to an opening state, the operation of opening the clutches is performed in the gas mode, but switching to the diesel mode may be performed first such that the clutch operation is performed in the diesel mode.

[0058]

Next, the first marine propulsion device 20A on the port side is switched from the diesel mode to the gas mode operation (S105), and then switching to the firefighting mode is performed (S106). The rotational speeds of the engines 3A and 3B on both of the port and the starboard sides are increased. Then, in the firefighting mode, the fire pump 11 of the firefighting device 6 is driven by the engine 3A on the port side, and seawater pumped up from the sea is discharged from the discharge nozzle 6a.

Simultaneously therewith, the propeller 5b on the starboard side is driven by the engine 3B on the starboard side to propel the vessel 1.

Here, the vessel 1 receives reaction force in a retreat direction due to the water discharge from the fire pump 11, but is advanced by driving the propulsion device 5B with the second marine propulsion device 20B on the starboard side, and thus the reaction force is canceled out such that the vessel 1 stays at a standstill position. In the above-described way, a fire extinguishing activity in the firefighting mode is performed. The engine 3B on the starboard side does not switch to a fire pump, but the third clutch 9B on the starboard side is opened/closed together with the operation on the port side in order to balance propulsion force on both of the port and the starboard. The opening/closing operation of the third clutch 9B may be omitted.

[0059]

b) Switching procedure from firefighting mode to normal operation mode

In a flowchart of Fig. 6, when the fire extinguishing activity in the firefighting mode is finished (S107), the vessel 1 is switched from the firefighting mode to the normal operation mode. In this case, the rotational speeds of the engines 3A and 3B on both of the port and the starboard sides are slowed down to perform an idle operation (S108). The third clutch 9B of the second marine propulsion device 20B on the

starboard side is opened. An instruction of switching to the normal operation mode is output (S109).

When switching from the firefighting device 6 to the propulsion device 5A is performed in the gas mode, there is a possibility that the load may suddenly vary, and thus misfire, knocking, or the like may occur. Thus, temporary switching to the diesel mode is performed, and then the operation of switching between opening and closing of the first clutch 9A and the second clutch 18 is performed, so that it is possible to cope with the load fluctuation.

[0060]

Next, the control device 22 causes the engine 3A of the first marine propulsion device 20A on the port side to switch from the gas mode operation to the diesel mode operation (S110). The second clutch 18 on the port side is opened, and the first clutch 9A and the third clutch 9B on both of the port and the starboard sides are closed (S111). The first marine propulsion device 20A on the port side is switched from the diesel mode operation to the gas mode operation (S112), and then is switched to the normal operation mode along with the second marine propulsion device 20B on the starboard side (S113).

[0061]

There is a possibility that the operation of the engine 3A in the gas mode may be easily influenced by the load fluctuation, and a smooth operation of the engine 3A may be hindered by a disturbance of the load due to opening/closing operations of the first clutch 9A and the second clutch 18. Therefore, during transition from the firefighting mode to the normal operation mode, temporary switching from the gas mode to the diesel mode, which is resistant to the load fluctuation, is performed, and then the clutches are opened or closed.

The rotational speeds of the engines 3A and 3B of the first and second marine

propulsion devices 20A and 20B on both of the port and the starboard sides are increased, and the propellers 5a and 5b of the propulsion devices 5A and 5B on both of the port and the starboard sides are driven to propel the vessel 1, so that the vessel 1 is operated in the normal operation mode.

5 [0062]

B) Second Example

With reference to Fig. 7, a description will be made of procedures in a case where switching to the diesel mode is performed in only unidirectional transition in the vessel 1. This is appropriate for a case where the load of the fire pump 11 of the
 10 firefighting device 6 is relatively small. In other words, in Second Example, switching to the diesel mode is not performed during transition from the normal operation mode of the vessel 1 to the firefighting mode, and switching to the diesel mode is performed during transition from the firefighting mode to the normal operation mode.

[0063]

15 a) Switching procedure from normal operation mode to firefighting mode

In the normal operation mode of the vessel 1, the first clutch 9A and the third clutch 9B of the first and second marine propulsion devices 20A and 20B on both of the port and the starboard sides are closed, the second clutch 18 on the port side is opened, and the engines 3A and 3B on both of the port and the starboard sides are operated in the
 20 gas mode (S200).

In this state, the rotational speeds of the engines 3A and 3B of the first and second marine propulsion devices 20A and 20B on both of the port and the starboard sides are slowed down to perform an idle operation (S201). The first clutch 9A and the third clutch 9B of the first and second marine propulsion devices 20A and 20B on both of
 25 the port and the starboard sides are opened.

[0064]

Next, an instruction of switching from the normal operation mode to the firefighting mode is output to the control device 22 (S202). In this case, since the load of the fire pump 11 (or other working device driven by the engine 3A) is small, the engine 3A of the first marine propulsion device 20A on the port side is maintained in the gas mode operation without switching to the diesel mode operation by the control device 22.

The third clutch 9B of the second marine propulsion device 20B on the starboard side is closed, and the second clutch 18 on the port side is closed (S203). In the above-described way, switching from the normal operation mode to the firefighting mode is performed in the gas mode (S204). Then, the rotational speeds of the engines 3A and 3B on both of the port and the starboard sides are increased.

[0065]

In the firefighting mode, the fire pump 11 of the firefighting device 6 is driven by the engine 3A of the first marine propulsion device 20A on the port side to discharge seawater. In the second marine propulsion device 20B on the starboard side, the propeller 5b of the propulsion device 5B on the starboard side is driven by the engine 3B to propel the vessel 1.

Although the vessel 1 receives reaction force due to the water discharge from the fire pump 11 and thus receives a load in a retreat direction, the vessel 1 is advanced by driving the propulsion device 5B with the second marine propulsion device 20B on the starboard side, and thus the reaction force is canceled out such that the vessel 1 stays at a standstill position. In the above-described way, the fire extinguishing activity in the firefighting mode is performed.

[0066]

b) Switching procedure from firefighting mode to normal operation mode

An operation method in this state is the same as that described in the above b) in A), and will be described with reference to the flowchart of Fig. 6.

In the vessel 1, in the firefighting mode (S107), the first clutch 9A of the first
 5 marine propulsion device 20A on the port side is opened, and the second clutch 18 is closed. The third clutch 9B of the second marine propulsion device 20B on the starboard side is closed. In this state, the fire pump 11 of the firefighting device 6 is driven by the engine 3A on the port side to discharge water. The propeller 5b of the second marine propulsion device 20B is driven by the engine 3B on the starboard side to
 10 propel the vessel 1.

During switching to the firefighting mode, the rotational speeds of the engines 3A and 3B of the first and second marine propulsion devices 20A and 20B on both of the port and the starboard sides are slowed down to perform an idle operation (S108).

[0067]

15 Next, the third clutch 9B on the starboard side is opened. An instruction of causing the vessel 1 to switch from the firefighting mode to the normal operation mode is output to the control device 22 (S109). Then, in the first marine propulsion device 20A on the port side, the engine 3A is switched from the gas mode operation to the diesel mode operation (S110).

20 In the first marine propulsion device 20A on the port side, the second clutch 18 is opened. In the first and second marine propulsion devices 20A and 20B on both of the port and the starboard sides, the first clutch 9A and the third clutch 9B are closed (S111). The first marine propulsion device 20A on the port side is switched from the diesel mode operation to the gas mode operation (S112).

25 Next, the rotational speeds of the engines 3A and 3B of the first and second

marine propulsion devices 20A and 20B on both of the port and the starboard sides are increased. In the normal operation mode, the propellers 5a and 5b of the propulsion devices 5A and 5B on both of the port and the starboard sides are driven to propel the vessel 1 (S113).

5 In the above-described way, switching between the gas mode and the diesel mode is controlled in both cases where the load of the firefighting device 6 is large and small.

[0068]

C) Automatic Slow-down Control

10 In a normal operation state of the vessel 1 or a working device driving state such as the firefighting mode, it is necessary that the output values from the propulsion-device-side output sensors 14A and 14B and the working-device-side output sensor 19 for the dual fuel engines 3A and 3B do not indicate overloads, and thus a ship class rule is defined by each ship class engine. For example, when the output measurement value
15 from either of the propulsion-device-side output sensors 14A and 14B for the engines 3A and 3B is equal to or more than 80%, a warning is issued from the control device 22, and, when the output measurement value is equal to or more than 100% and thereafter is not reduced to 95% for 30 seconds, it is assumed that the output measurement value remains in a state of 100%. For example in the ship class rule defined in the ABS (U.S.A.),
20 when a state in which the output of the engine 3A is equal to or more than 95% lasts for 30 seconds, the rotational speeds of the engines 3A and 3B are forced to be slowed down unless an override button is pressed within five seconds therefrom. The rotational speeds of the engines 3A and 3B are forced to be slowed down to X rpm which is a preset slow-down value.

25 [0069]

Generally, the output measurement value from the working-device-side output sensor 19 on the firefighting device 6 side is small and is less than 100%, but on the propulsion devices 5A and 5B sides, there is a possibility that excessive outputs may be applied to the engines 3A and 3B as unreasonable maneuvering or propulsion is performed in order to avoid danger during the operation of the vessel 1. In this case, automatic slow-down control is performed to protect the engines 3.

[0070]

Next, with reference to Fig. 8, a description will be made of an example of the automatic slow-down control based on the ship class rule.

In the normal operation mode (S300), during propulsion of the vessel by the propulsion devices 5A and 5B, for example, in order to avoid danger, it may happen that the output measurement values from the propulsion-device-side output sensors 14A and 14B for the dual fuel engines 3A and 3B exceed a predetermined upper limit value (reference value) (S301). In this case, the rotational speed is slowed down at a predetermined rate such that the output measurement value for the engine 3A is reduced to equal to or smaller than the upper limit value (S302).

The upper limit value in the automatic slow-down control may be set to an output value of only the engine 3A of the first marine propulsion device 20A on the port side provided with the firefighting device 6 or an output value of only the engine 3B of the second marine propulsion device 20B not provided with a fire pump. Alternatively, the upper limit value may be set to a sum of the output values of both of the engines 3A and 3B on the port and the starboard side. The output value may be appropriately selected as necessary.

[0071]

The power system of the vessel 1 of the present embodiment uses the dual fuel

engines 3A and 3B that can be operated to switch between the gas mode and the diesel mode. In the gas mode, it is necessary to more accurately control the mass ratio of air to fuel gas in order to prevent knocking, misfire and the like, and it is effective to control the engines 3A and 3B according to outputs of the engines 3A and 3B measured in real time by the propulsion-device-side output sensors 14A and 14B.

[0072]

As described above, according to the power system for vessel of the present embodiment, the propulsion-device-side output sensors 14A and 14B of the propulsion devices 5A and 5B and the working-device-side output sensor 19 are respectively provided between the engine 3A and the first clutch 9A, between the engine 3B and the third clutch 9B, and between the engine 3A and the second clutch 18, and thus it is possible to more accurately measure an actual output of the engine 3A in consideration of a loss caused by resistance of the transmission system, the clutch, or the like. Further, even when the first clutch 9A or the second clutch 18 is opened, it is possible to measure the output in consideration of the resistance.

Thus, even in the gas engine mode using the fuel gas, the output measurement values of the engines 3A and 3B are measured by the propulsion-device-side output sensors 14A and 14B and the working-device-side output sensor 19, and thus the engines 3A and 3B can be accurately controlled.

[0073]

When transition between a state of driving the propulsion device 5A and a state of driving the fire pump 11 occurs upon the operation of the vessel 1 in the gas mode, temporary switching from the gas mode to the diesel mode, which is resistant to the load fluctuation, is performed, and then switching between opening and closing of the first clutch 9A and the second clutch 18 is performed, thereby it is possible to suppress a

disturbance of the load caused by opening and closing of the first clutch 9A and the second clutch 18 and to perform a smooth operation of the engine 3A without being influenced by the load fluctuation.

When the load caused by the fire pump is relatively small, the disturbance of the load due to closing of the second clutch 18 on the fire pump 11 side is also relatively small, and thus transition to the firefighting device 6 may be omitted depending on conditions.

[0074]

Upon the automatic slow-down control, when the output measurement values from the propulsion-device-side output sensors 14A and 14B or the output measurement value from the working-device-side output sensor 19 exceed the predetermined upper limit value, control is performed such that the rotational speeds of both of the engines 3A and 3B are forced to be reduced, and thus it is possible to prevent knocking, misfire, and the like.

[0075]

In the dual fuel engine 3A on the port side, when the second clutch 18 on the firefighting device 6 side is opened or the first clutch 9A on the propulsion device 5A is opened, some extent of mechanical loss is generated in the fire pump 11 or the propulsion device 5A. Therefore, a more accurate output value of the engine 3A can be obtained by summing the output value from the propulsion-device-side output sensor 14A and the output value from the working-device-side output sensor 19 on the firefighting device 6 side, and thus it is possible to control the engine 3A with high accuracy.

Further, it is possible to perform the automatic slow-down control of reducing the rotational speed of the engine 3A on the basis of the sum of the output values from the propulsion-device-side output sensor 14A and the working-device-side output sensor

19.

[0076]

According to the vessel 1 having the firefighting device 6 of the present embodiment, two devices of the first marine propulsion device 20A including the engine 3A and the second marine propulsion device 20B including the engine 3B are provided in parallel on both of the port and the starboard. Therefore, when the fire pump 11 of the firefighting device 6 is driven by one dual fuel engine 3A to discharge water, the vessel 1 is advanced by the other dual fuel engine 3B to prevent the vessel 1 from being retreated due to reaction force of the driving load of the fire pump 11, and a fire extinguishing activity can be performed.

[0077]

The power system of the vessel 1 according to the present invention is not limited to the above-described embodiment, and may be changed or replaced within the scope without departing from the spirit of the present invention. Hereinafter, modification examples or the like of the present invention will be described, but a component, a member, or the like similar or identical to that described in the embodiment will be given the same reference numeral, and description thereof will not be repeated.

[0078]

In the power system of the vessel 1 of the embodiment of the present invention, the first marine propulsion device 20A and the second marine propulsion device 20B are respectively disposed in parallel on the port and the starboard of the vessel 1, the firefighting device 6 as a working device is provided in the first marine propulsion device 20A, and one of the gas mode and the diesel mode is selectively operable.

However, the above configuration only represents one embodiment of the present invention, and the present invention is not limited to such a configuration. The

concept of the present invention is applicable as long as output of the dual fuel engine 3 is used for driving a working device in addition to driving of the propulsion device 5.

[0079]

For example, a working device is not limited to the firefighting device 6 having the fire pump 11, and a working device including a pump for other applications, a cargo handling machine such as a crane, or various machines equipped on the vessel 1 and driven by a main engine for propelling the vessel 1 may be employed.

[0080]

The power system of the vessel 1 according to the present invention may control the dual fuel engine 3A according to one or the sum of the output measurement value from the propulsion-device-side output sensor 14A and the output measurement value from the working-device-side output sensor 19.

Alternatively, the dual fuel engine 3A may be controlled according to the output measurement value from the propulsion-device-side output sensor 14A in a state in which the first clutch 9A is closed, or the dual fuel engine 3A may be controlled according to the output measurement value from the working-device-side output sensor 19 in a state in which the second clutch 18 is closed.

[0081]

The power system of the vessel 1 according to the present invention is not limited to the configuration in which two devices of the propulsion devices 5A and 5B are respectively provided on the port and the starboard, and the working device such as the firefighting device 6 is provided on one of the propulsion devices 5A and 5B. For example, a single propulsion device 5 may be provided, and a working device such as the firefighting device 6 may be installed to the drive shaft 17 provided to the dual fuel engine 3 for the single propulsion device 5. Alternatively, three or more propulsion

devices 5 may be provided, and a working device such as a firefighting device may be attached to one or two or more engines 3 for one or two or more propulsion devices 5.

Industrial Applicability

5 [0082]

According to the present invention, a propulsion device is connected to an engine that can use at least a fuel gas as a main fuel via a first clutch, and a working device such as a firefighting device is connected to the engine via a second clutch, and a propulsion-device-side output sensor is provided between the engine and the first clutch,
 10 and a working-device-side output sensor is provided between the engine and the second clutch. The propulsion device is driven by closing the first clutch and opening the second clutch, and the working device is driven by opening the first clutch and closing the second clutch. There is provided a vessel power system that can drive and control the working device in a gas mode by measuring an output of the engine using a fuel gas
 15 as a main fuel with the propulsion-device-side output sensor and the working-device-side output sensor and controlling driving of the engine.

Reference Signs List

[0083]

20	1 Vessel
	3, 3A, 3B Dual fuel engine (engine)
	5, 5A, 5B Propulsion device
	6 Firefighting device
	9A First clutch
25	9B Third clutch

- 11 Fire pump
- 13A, 13B Propulsion shaft
- 14, 14A, 14B Propulsion-device-side output sensor
- 15, 15A, 15B Rotational speed sensor
- 5 17 Drive shaft
- 18 Second clutch
- 19 Working-device-side output sensor
- 22 Control device

CLAIMS

1. A power system for vessel comprising:

an engine capable of using a fuel gas as a main fuel;

5 a propulsion device connected to the engine via a first clutch and driven by the engine;

a propulsion-device-side output sensor provided between the engine and the first clutch;

10 a working device connected to the engine via a second clutch and driven by the engine; and

a working-device-side output sensor provided between the engine and the second clutch;

wherein, when transition from a state of driving the propulsion device to a state of driving the working device occurs during an operation of the engine in an operation

15 mode in which the fuel gas is used as a main fuel,

temporary switching from the operation mode in which the fuel gas is used as a main fuel to an operation mode in which a liquid fuel is used as a main fuel is performed, at least one of the first clutch and the second clutch is operated, and then returning from the operation mode in which the liquid fuel is used as a main fuel to the operation mode

20 in which the fuel gas is used as a main fuel is performed.

2. The power system for vessel according to claim 1,

wherein the working device is a firefighting device that is configured to discharge water.

3. The power system for vessel according to claim 1 or 2, further comprising:

a control device configured to cause the propulsion device to drive by closing the first clutch and opening the second clutch, and cause the working device to drive by opening the first clutch and closing the second clutch.

5

4. The power system for vessel according to any one of claims 1 to 3,

wherein the engine is controlled according to a sum of an output measurement value from the propulsion-device-side output sensor and an output measurement value from the working-device-side output sensor.

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5. The power system for vessel according to any one of claims 1 to 4,

wherein, when at least one of an output measurement value from the propulsion-device-side output sensor and an output measurement value from the working-device-side output sensor exceeds an upper limit value, the engine is controlled such that a rotational speed of the engine is reduced.

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6. The power system for vessel according to any one of claims 1 to 5,

wherein the propulsion-device-side output sensor and the working-device-side output sensor are torque sensors configured to measure a torque that is actually applied to a propulsion shaft of the engine.

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7. A power system for vessel comprising:

an engine capable of using a fuel gas as a main fuel;

a propulsion device connected to the engine via a first clutch and driven by the engine;

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a propulsion-device-side output sensor provided between the engine and the first clutch;

a working device connected to the engine via a second clutch and driven by the engine; and

5 a working-device-side output sensor provided between the engine and the second clutch;

wherein, when transition from a state of driving the working device to a state of driving the propulsion device occurs during an operation of the engine in an operation mode in which the fuel gas is used as a main fuel,

10 temporary switching from the operation mode in which the fuel gas is used as a main fuel to an operation mode in which a liquid fuel is used as a main fuel is performed, at least one of the second clutch and the first clutch is operated, and then returning from the operation mode in which the liquid fuel is used as a main fuel to the operation mode in which the fuel gas is used as a main fuel is performed.

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8. A power system for vessel comprising:

an engine capable of using a fuel gas as a main fuel;

a propulsion device connected to the engine via a first clutch and driven by the engine;

20 a propulsion-device-side output sensor provided between the engine and the first clutch;

a working device connected to the engine via a second clutch and driven by the engine;

25 a working-device-side output sensor provided between the engine and the second clutch; and

a control device configured to cause the propulsion device to drive by closing the first clutch and opening the second clutch, and cause the working device to drive by opening the first clutch and closing the second clutch;

wherein the control device includes:

5 a diesel mode transition unit configured to perform transition from a gas mode in which the fuel gas is used as a main fuel to a diesel mode in which a liquid fuel is used as a main fuel in order to perform an operation of opening one of the first clutch and the second clutch and closing the other clutch; and

 a gas mode transition unit configured to perform transition from the
10 diesel mode to the gas mode after the operation of opening one of the first clutch and the second clutch and closing the other clutch is finished.

9. A power system for vessel including a plurality of engines capable of using a fuel gas as a main fuel, the power system comprising:

15 on a first engine side,

 a first propulsion device connected to the first engine via a first clutch and driven by the first engine;

 a first propulsion-device-side output sensor provided between the first engine and the first clutch;

20 a working device connected to the first engine via a second clutch and driven by the first engine;

 a working-device-side output sensor provided between the first engine and the second clutch; and

 a control device configured to cause the first propulsion device to drive by
25 closing the first clutch and opening the second clutch, and cause the working device to

drive by opening the first clutch and closing the second clutch, and

on a second engine side,

a second propulsion device connected to the second engine via a third clutch and
driven by the second engine; and

5 a second propulsion-device-side output sensor provided between the second
engine and the third clutch,

wherein the control device is configured to cause the second propulsion device
to drive by closing the third clutch when the control device causes the working device to
drive by opening the first clutch and closing the second clutch of the first engine.