

DESCRIPTION

Title of the Invention: SHIP PROPULSION DEVICE

Technical Field

[0001]

The present invention relates to an electric-propulsion-type ship propulsion device which uses a motor (electric motor) as a drive source, and particularly relates to an inexpensive ship propulsion device which includes two sets of motors which drive propellers by way of a planetary gear mechanism, and can perform drive control efficiently.

Background Art

[0002]

The following Patent Literature 1 discloses an invention relating to a ship propulsion device. The ship propulsion device according to this invention includes: an internal combustion engine and a motor generator which function as ship-use propulsion devices having input shafts respectively; and propellers which are mounted on an output shaft of the internal combustion engine and an output shaft of the motor generator respectively. The ship propulsion device also includes a gear box formed of a planetary gear mechanism which connects these two input and output shafts. According to this invention, a load torque and a reference value are compared to each other, and a power generation amount generated

by the generator motor is controlled according to a result of the comparison, or an assist output of the generator motor is controlled. According to this invention, it is possible to acquire an effect that fuel consumption can be improved while maintaining an output torque of the internal combustion engine which propels a ship at a fixed value.

[0003]

The following Patent Literature 2 discloses an invention relating to a variable speed device. The variable speed device according to this invention is a variable speed device deployed in a general-purpose industrial machine such as a pump. Patent literature 2 discloses a configuration example which uses a planetary gear and has two input shafts and one output shaft, and a configuration example which uses a planetary gear and has one input shaft and two output shafts. Rotational speeds of the respective shafts are variable, and a fluid coupling is adopted as a speed change mechanism. Efficiency of the variable speed device can be enhanced by combining the planetary gear with the fluid coupling. Further, the variable speed device includes a clutch capable of controlling a slip ratio for changing a rotational speed range. According to this invention, an optimum design can be performed easily, and efficiency of the variable speed device can be enhanced compared to the

prior art.

[0004]

Patent literature 3 discloses an invention relating to a ship propulsion device. The ship propulsion device according to this invention includes two electric motors including a sub electric motor which is rotationally controlled by an inverter for driving a propeller, and an electric motor which is rotationally controlled by a slip clutch. In a case where a rotational speed of the propeller is less than a predetermined rotational speed, the propeller is rotated by controlling the small-output sub electric motor using a general-purpose inverter having a small capacity. At the time of rotating the propeller, by disconnecting an on-off clutch in a main electric motor driving system, the rotation is not transmitted to a slip clutch input shaft. When the rotational speed of the propeller becomes equal to or more than the predetermined rotational speed, a drive source is switched from the sub electric motor to the main electric motor, and the on-off clutch is connected thus rotating the propeller by controlling a rotational speed by the slip clutch.

[0005]

Further, with respect to conventional ship propulsion devices, in the case where an inexpensive fixed-pitch propeller which does not require control

compared to a variable-pitch propeller is adopted, as a technique for changing a propulsion force by controlling a rotational speed of a propeller in a whole region ranging from 0 to a rated rotational speed, there has been known the electric propulsion by the electric motor drive as disclosed in the abovementioned Patent Literature 3. In the electric propulsion by the electric motor drive, it is necessary to perform variable speed control of the electric motor for changing a rotational speed of the propeller. Accordingly, an inverter becomes necessary. To acquire a large output capable of driving a propeller of a ship and to stabilize an inboard power source of a ship, a harmonic wave suppressor such as a filter is necessary. An inverter having such a harmonic wave suppressor is not available as a general-purpose product and hence, there is no choice but to acquire such an inverter as a specially ordered product whereby such an inverter is expensive. Accordingly, the present situation is that a demand for electric propulsion is low compared to a ship propulsion device where a propeller and an internal combustion engine are directly connected to each other.

Citation List

Patent Literature

[0006]

Patent Literature 1: Japanese Patent No.
5830309

Patent Literature 2: Japanese Patent No.
5778844

Patent Literature 3: Japanese Patent No.
5942061

Summary of Invention

Technical Problem

[0007]

The ship propulsion device disclosed in Patent Literature 1 uses an internal combustion engine, and a speed of this internal combustion engine can be arbitrarily changed. However, a planetary gear mechanism is interposed between the internal combustion engine and the propeller and hence, efficiency of the ship propulsion device is deteriorated by an amount corresponding to the provision of the gears. No description is made with respect to a technique capable of efficiently controlling within a whole region of a rotational speed of the propeller by using the planetary gear mechanism in the internal combustion engine and in the motor.

[0008]

According to the variable speed device disclosed in Patent Literature 2, in the case where only the planetary gear mechanism is adopted as the

transmission mechanism, when a rotational speed of an input shaft is set to a fixed speed, a rotational speed of the propeller cannot be efficiently controlled within a whole region ranging from 0 to a rated rotational speed. Accordingly, a fluid coupling or a slip clutch which can control a slip ratio is adopted as a transmission mechanism. However, a slip loss occurs in both the fluid coupling and the slip clutch and hence, efficient control of a rotational speed of the propeller cannot be performed.

[0009]

According to the ship propulsion device disclosed in Patent Literature 3, although the ship propulsion device adopts the electric propulsion obtained by the electric motor drive, an inverter which is a specially ordered product as described above is unnecessary. However, the ship propulsion device adopts the structure where a rotational speed of a main electric motor is transmitted to a propeller by controlling a rotational speed using a slip clutch in a high load region at the time of operating the ship propulsion device and hence, there has been a drawback that a slip loss occurs so that efficiency of the ship propulsion device is lowered.

[0010]

The present invention has been made to overcome

the abovementioned drawbacks of the prior art, and it is an object of the present invention to provide an inexpensive ship propulsion device which can perform more efficient drive control by adopting the structure where two sets of motors each do not require an expensive inverter which is a specially ordered product are adopted as a drive source, and a propeller is driven by way of a planetary gear mechanism.

Solution to Problem

[0011]

The ship propulsion device described in claim 1 includes:

a planetary gear mechanism having a ring gear, a sun gear, and planet gears mounted on a carrier, the ring gear, the sun gear and planet gears engaging with each other;

a first motor connected to any one of the ring gear, the sun gear, and the carrier, the first motor being driven by an inverter;

a second motor connected to one of the ring gear, the sun gear, and the carrier excluding the one connected to the first motor, the second motor being driven at a fixed speed; and

a propeller connected to one of the ring gear, the sun gear, and the carrier excluding the one connected to the first motor and the one connected to

the second motor.

[0012]

The ship propulsion device described in claim 2 is characterized in that, in the ship propulsion device according to claim 1, the first motor is connected to the ring gear, the second motor is connected to the sun gear, and the propeller is connected to the carrier.

[0013]

The ship propulsion device described in claim 3 is characterized in that, the ship propulsion device according to claim 2, the ship propulsion device further includes a clutch mounted on the second motor, and a brake disposed between the clutch and the sun gear.

[0014]

The ship propulsion device described in claim 4 is characterized in that, in the ship propulsion device according to claim 1, the ship propulsion device further includes a clutch mounted on the second motor, and a reverse rotation preventing mechanism disposed between the clutch and the sun gear.

[0015]

The ship propulsion device described in claim 5 is characterized in that, in the ship propulsion device according to any one of claims 1 to 4, the

ship propulsion device further includes a controller which performs control such that the propeller is driven only by the first motor in a small-output region where an output of the propeller is relatively small, and the propeller is driven by the first motor and the second motor in a large-output region where an output of the propeller is relatively large.

Effects of Invention

[0016]

According to the ship propulsion device described in claim 1 and claim 2, the following advantageous effects can be acquired. That is, an inverter which is a specially ordered product having a harmonic wave suppressor such as a filter has a large size, and it is necessary to ensure a relatively large space for installing such an inverter. However, it is unnecessary to provide an inverter which is a specially ordered product with respect to the second motor which is driven at a fixed speed and hence, it is unnecessary to ensure a space for installing such an inverter. Accordingly, the space can be used for other purposes (for example, a space for placing a cargo or the like on a work ship). Further, by performing efficient control corresponding to an output of the propeller using two sets of motors, a fuel consumption amount of a power generating engine for driving the electric motor can

be reduced.

[0017]

According to the ship propulsion device described in claim 3, the clutch is mounted on the second motor, and the brake is disposed between the clutch and the sun gear and hence, a driving force for driving the propeller is not interrupted so that the ship can sail in a stable manner.

[0018]

According to the ship propulsion device described in Claim 4, the clutch is mounted on the second motor, and the reverse rotation preventing mechanism is disposed between the clutch and the sun gear and hence, a driving force for driving the propeller is not interrupted so that the ship can sail in a stable manner, and the propeller can be driven only in a normal rotation direction.

[0019]

According to the ship propulsion device described in Claim 5, the propeller is driven by only the first motor in a small-output region, and the propeller is driven by the first motor and the second motor in a large-output region and hence, efficient control can be performed corresponding to a propeller output thus further reducing a fuel consumption amount of the power generating engine which drives the electric motor.

Brief Description of Drawings

[0020]

[FIG. 1] A schematic constitutional view of a ship propulsion device according to an embodiment of the present invention.

[FIG. 2] A schematic constitutional view of a drive system of the ship propulsion device of the embodiment, and is also a view showing a transmission state of a driving force during low-speed sailing.

[FIG. 3] A schematic constitutional view of the drive system of the ship propulsion device of the embodiment, and is also a view showing a transmission state of a driving force during high-speed sailing.

[FIG. 4] A schematic view showing the structure of a solar-type planetary gear mechanism, the structure of a planet-type planetary gear mechanism, and the structure of a differential-type planetary gear mechanism formed by combining the solar-type planetary gear mechanism and the planet-type planetary gear mechanism with each other.

[FIG. 5] A table showing a calculation example where power or the like which is allocated to a ring gear of the solar-type planetary gear mechanism and power or the like which is allocated to a sun gear of the planet-type planetary gear mechanism in the form of a numerical value example as an example for indicating a ratio of power allocated to the ring gear and a

ratio of power allocated to the sun gear in the differential-type planetary gear mechanism.

[FIG. 6] A graph showing a relationship between a propeller output and a shaft rotational speed in the ship propulsion device of the embodiment.

[FIG. 7] A graph showing a relationship between a propeller rotational speed and a propeller output and the like in the ship propulsion device of the embodiment.

[FIG. 8] A graph showing a relationship between a propeller rotational speed and a power generation amount of a power generator in the ship propulsion device of the embodiment and a ship propulsion device of a comparison example.

[FIG. 9] A schematic constitutional view of a ship propulsion device according to a second embodiment of the present invention.

[FIG. 10] A schematic constitutional view of a drive system of a ship propulsion device according to a third embodiment of the present invention, and is also a view showing a transmission state of a driving force during low-speed sailing.

Mode for Carrying out Invention

[0021]

The embodiments of the present invention are described with reference to FIG. 1 to FIG. 10.

As shown in FIG. 1, a ship propulsion device 1

of this embodiment relates to a so-called azimuth thruster where a propulsion direction is set by rotating a horizontal propeller shaft 3 about a vertical shaft 2 for transmitting power.

Particularly, the ship propulsion device 1 is configured such that two sets of motors (electric motors) A, B are connected to the propeller shaft 3 by way of a planetary gear mechanism 5 housed in a gear box 4, and efficient control of the ship propulsion device 1 can be performed by switching the motors A, B corresponding to an output of the propeller 6.

[0022]

The configuration of the ship propulsion device 1 of this embodiment is described mainly with reference to FIG. 1 to FIG. 5.

As shown in FIG. 1, a speed reduction unit 8 is mounted on an upper surface of a platform 7 on a stern of a ship. In the speed reduction unit 8, a horizontal transmission shaft 9, a vertical shaft disposed below an approximately center portion of the transmission shaft 9, and a speed reduction gear 10 which connects one end side (upper end side) of the vertical shaft 2 and the transmission shaft 9 to each other in an interlocking manner are disposed.

[0023]

As shown in FIG. 1, a strut 11 and a casing 12

are mounted on a lower surface side of the platform 7 such that the strut 11 and the casing 12 are turnable on a lower side of the ship. The strut 11 and the casing 12 can be turned by a turn driving mechanism (not shown).

[0024]

As shown in FIG. 1, the vertical shaft 2 penetrates the platform 7 and a ship bottom of the ship, and is disposed in the strut 11 and the casing 12. One end side of the horizontal propeller shaft 3 is connected to the other end side (lower end side) of the vertical shaft 2 by way of a direction changing mechanism 13. The other end side of the propeller shaft 3 protrudes to the outside of the casing 12, and a propeller 6 is mounted on the other end side of the propeller shaft 3. The propeller 6 is a fixed-pitch propeller. A duct 14 having an approximately circular cylindrical shape which surrounds the propeller 6 is mounted on the casing 12.

[0025]

As shown in FIG. 1, the gear box 4 from which a first input shaft 21, a second input shaft 22, and an output shaft 23 protrude to the outside is disposed in the ship. The output shaft 23 is connected to an end portion of the transmission shaft 9 of the speed reduction unit 8.

[0026]

The planetary gear mechanism 5 shown in FIG. 2 and FIG. 3 is housed in the gear box 4 shown in FIG. 1. The planetary gear mechanism 5 includes a ring gear R, a sun gear S, and planet gears P which are mounted on a carrier C. These three kinds of gears mesh with each other. Further, external teeth are formed on the ring gear R, and a drive gear D meshes with the external teeth.

[0027]

As shown in FIG. 2 and FIG. 3, one end of the first input shaft 21 is connected to the drive gear D. One end of the second input shaft 22 is connected to the sun gear S. Further, one end of the output shaft 23 is connected to the carrier C on which the planet gears P are mounted. The other end of the first input shaft 21 is connected to the motor A which forms a first motor. The other end of the second input shaft 22 is connected to the motor B which forms a second motor by way of a clutch 15. On the second input shaft 22, a brake 16 is disposed between the clutch 15 and the sun gear S. The clutch 15 and the brake 16 shown in FIG. 2 and FIG. 3 are disposed in the gear box 4 shown in FIG. 1.

[0028]

As shown in FIG. 2 and FIG. 3, the planetary gear mechanism 5 is a differential type planetary gear mechanism where all of the ring gear R, the sun

gear S, the planet gears P, and the carrier C are operable. As shown in FIG. 2, in the case where the sun gear S is fixed by turning off the clutch 15 and by turning on the brake 16, when the motor A rotates the ring gear R by way of the drive gear D, the planet gears P and the carrier C rotate and the output shaft 23 on which the propeller 6 is mounted rotates. As shown in FIG. 3, in a state where the clutch 15 is turned on and the brake 16 is turned off, when the motor A rotates the ring gear R by way of the drive gear D and the motor B rotates the sun gear S, the planet gears P and the carrier C rotate so that the output shaft 23 on which the propeller 6 is mounted rotates. Although the operation the planetary gear mechanism 5 is described later in detail, as shown in FIG. 2, the ship propulsion device is operated using only the motor A during low-speed sailing. During high-speed sailing, a rotational speed of the motor A is lowered, the brake 16 is released, and the clutch 15 is connected. Accordingly, the motor B is operated at a fixed speed, and an operation speed is adjusted by the motor A.

[0029]

As shown in FIG. 1, the motor A is connected to the first input shaft 21 of the gear box 4. The motor A is an inverter motor which is controlled by a general-purpose inverter 17 including a filter which

is provided for suppressing harmonic waves. In this embodiment, the general-purpose inverter 17 is an inverter supplied from an inverter manufacturer as a standard product. As such an inverter, an inverter having a capacity within a generally-available capacity range can be used. In this manner, although the motor A is an inverter-controlled motor, the motor A adopts the general-purpose inverter 17 and hence, a cost can be suppressed. Further, a filter of the inverter 17 is small and hence, an inverter panel size can be made relatively small, and the installation space for the inverter 17 can also be made small.

[0030]

As shown in FIG. 1, a resistor 18 is connected to the inverter 17. When the propeller 6 functions as the brake 16 so that the motor A generates electric power, generated energy is absorbed by the resistor 18.

[0031]

As shown in FIG. 1, the inverter 17 is connected to a distribution board 19, and the distribution board 19 is connected to a power supply system to which one or more main power generating engines 20 are connected.

[0032]

As shown in FIG. 1, the motor B is connected to

the second input shaft 22 of the gear box 4. As shown in FIG. 2 and FIG. 3, the motor B includes a starter 25 (starter switch). The motor B is an alternate current (AC) motor. When an operation of the motor B is started by the starter 25, the motor B is driven at a fixed speed by a three-phase alternating current.

[0033]

As shown in FIG. 2 and FIG. 3, the ship propulsion device 1 of this embodiment includes a controller 30. The controller 30 is connected to a rotational speed sensor (not shown) which directly or indirectly measures a propeller rotational speed. The controller 30 is configured to acquire a measurement value of the propeller rotational speed from the rotational speed sensor.

[0034]

As shown in FIG. 2 and FIG. 3, the controller 30 is connected to the inverter 17 of the motor A, the starter 25 of the motor B, the brake 16, and the clutch 15, and can control these elements based on an acquired propeller rotational speed.

[0035]

FIG. 4 is a schematic view showing the configuration of a solar-type planetary gear mechanism 5a, the configuration of a planet-type planetary gear mechanism 5b, and the configuration of

a differential-type planetary gear mechanism 5. Particularly, Fig. 4 shows, using an addition formula metaphorically, that the differential-type planetary gear mechanism 5 is the combination of the solar-type planetary gear mechanism 5a and the planet-type planetary gear mechanism 5b. In FIG. 4, although only one planet gear P is shown, usually, a plurality of, for example, three to four planet gears P are used. In FIG. 4, arrows indicate operating directions. The carrier C on which the planet gears P are mounted is not shown in FIG. 4. However, the revolution (rotation of the carrier C) is indicated by the arrow extending from the center of the planet gear P.

[0036]

As indicated by a left term of the formula shown in FIG. 4, in the solar-type planetary gear mechanism 5a, the sun gear S is fixed, and the ring gear R, the planet gears P, and the carrier C (see FIG. 2 and FIG. 3) are operable. This state is a state where only the motor A drives the ring gear R, the second input shaft 22 connected to the sun gear S is fixed by the brake 16, and the clutch 15 is disconnected so that the motor B is stopped. In this embodiment, this state corresponds to a low-speed sailing state where only the motor A is driven.

[0037]

Further, as indicated by the left term of the formula shown in FIG. 4, in the planet-type planetary gear mechanism 5b, the ring gear R is fixed, and the sun gear S, the planet gears P, and the carrier C (see FIG. 2 and FIG. 3) are operable. This state is a state where the motor A is stopped so that the ring gear R is fixed, and the motor B intends to drive the planet gears P and the carrier C (see FIG. 2 and FIG. 3) by driving the sun gear S. In this embodiment, this state corresponds to a state taken at the time of switching a speed from low-speed sailing to high-speed sailing where driving of the motor B is started.

[0038]

As indicated by the right term of the formula shown in FIG. 4, in the differential-type planetary gear mechanism 5 of this embodiment, all of the ring gear R, the sun gear S, the planet gears P, and the carrier C are operable. This state is a state where the ring gear R is driven by the motor A, the sun gear S is driven by the motor B, and the output shaft 23 is rotated due to the rotation of the carrier C (see FIG. 2 and FIG. 3). This state corresponds to a high-speed sailing state where the motor B is driven at a fixed speed, and the speed is regulated by the motor A.

[0039]

FIG. 5 is a table exemplifying the numbers of

teeth of the solar-type planetary gear mechanisms 5a and 5b respectively in the differential-type planetary gear mechanism 5 of this embodiment. Fig. 5 also shows a calculation example of ratios of powers which are respectively allocated to the ring gear R connected to the motor A and the sun gear S connected to the motor B based on the abovementioned number-of-teeth examples.

[0040]

As shown in FIG. 5, as one example, the numbers of teeth of the respective gears of the solar-type planetary gear mechanism and the numbers of teeth of the respective gears of the planet-type planetary gear mechanism are set such that the number of teeth of the sun gear S is 70, the number of teeth of the planet gear P is 30, and the number of teeth of the ring gear R is 130. To calculate speeds of the respective members based on these numbers of teeth, in the case of the solar-type, the speed of the sun gear S is 0, the speed of the carrier C on which the planet gears P are mounted is 588 min⁻¹, and the speed of the ring gear R is 904 min⁻¹. In the case of the planet-type, the speed of the sun gear S is 1750 min⁻¹, the speed of the carrier C on which the planet gears P are mounted is 612 min⁻¹, and the speed of the ring gear R is 0. Accordingly, in the differential-type planetary gear mechanism 5 of the

embodiment which is formed by combining the solar-type and the planet-type with each other, the speed of the carrier C on which the planet gears P are mounted and forms the output shaft 23 is the sum of speeds of the carriers C of the solar-type planetary gear mechanism 5a and the planet-type planetary gear mechanism 5b on each of which the planet gears P are mounted. That is, the speed of the carrier C in the differential-type planetary gear mechanism 5 of the embodiment is expressed by the formula $588 \text{ min}^{-1} + 612 \text{ min}^{-1} = 1200 \text{ min}^{-1}$. Assume the case where a desired output is set to 100 kW. In this case, power of the ring gear R of the solar-type planetary gear mechanism 5a is 49 kW, and power of the sun gear S of the planet-type planetary gear mechanism 5b is 51 kW. Accordingly, in the differential-type planetary gear mechanism 5 of the embodiment, power of the motor A which drives the ring gear R is 49 kW, and power of the motor B which drives the sun gear S is 51 kW. Accordingly, power of the motor B which drives the sun gear S is slightly larger than power of the motor A.

[0041]

The manner of operation of the ship propulsion device 1 of this embodiment is described with reference to FIG. 6 to FIG. 8.

FIG. 6 is a graph showing the relationship

between a propeller output and a shaft rotational speed in the ship propulsion device of the embodiment. As shown in FIG. 6, in the ship propulsion device of the embodiment, when the propeller output is in a small-output region ranging from 0 kW at the time of starting, as indicated by a bold solid line in FIG. 6, the controller 30 propels the ship by driving the motor A by the inverter. During such a period, the clutch 15 is disconnected and the motor B is stopped. The brake 16 is operated so as to fix the second input shaft 22 and hence, the sun gear S is not rotated.

[0042]

As shown in FIG. 6, when the propeller output reaches a boundary between a small-output region and a high-output region, the controller 30 perform control such that a rotational speed and an output of the motor A are dropped to predetermined values, and the motor B which is started by the starter 25 is driven at a predetermined fixed rotational speed (in the embodiment, 1750 min⁻¹) as indicated by a narrow solid line in FIG. 6, thus making the motor B bear a reduction amount of the output of the motor A. On the other hand, in the high-output region, the controller 30 adjusts the propeller output as indicated by a bold broken line by controlling the motor A using the inverter as indicated by a bold

solid line.

[0043]

According to this embodiment, there is no possibility that the motor A acts as the brake 16 against driving of the motor B after the motor B starts driving. According to the differential-type planetary gear mechanism 5 adopted in this embodiment, depending on an output of the propeller or a shaft rotational speed, there may be the case where a region where the propeller cannot increase a rotational speed in a normal direction is generated unless the motor A is driven in a direction opposite to a direction of the motor B. According to this embodiment, driving is performed by properly switching the kind of the in-use motor and the combination of in-use motors between the small-output region and the high-output region and hence, the sum of an output of the motor A and an output of the motor B can be obtained as an output of the propeller in the whole rotational region.

[0044]

As described hereinafter, the switching of the motors A, B in the transition from the small-output region to the high-output region can be performed in a stable manner by properly controlling the brake 16 and the clutch 15. That is, assuming the case where clutch 15 is not provided, the motor B is constantly

connected to the sun gear S. In this case, in the transition from the small-output region to the high-output region, the motor B which is connected to the stopped sun gear S has to start its operation against a large inertial force. Accordingly, compared to a state where a load is not connected to the output shaft 22 of the motor B, a larger electric power is necessary to increase a rotational speed of the motor B connected to the sun gear S to a predetermined fixed rotational speed. According to this embodiment, the clutch 15 is disposed between the output shaft 23 of the motor B and the sun gear S. Accordingly, in the transition from the small-output region to the high-output region, before such transition is performed, the motor B can be started at a minimum necessary power in a state where the clutch 15 is disconnected, and a rotational speed of the motor B can be increased to a necessary rotational speed. Further, by releasing the brake 16 at a timing of such transition and by connecting the clutch 15, the power can be smoothly transmitted from the motors A, B to the propeller.

[0045]

FIG. 7 is a graph showing the relationship between a propeller rotational speed and a propeller output and the like in the ship propulsion device of the embodiment. Fig. 7 shows a graph of the

propeller output with respect to the propeller rotational speed, outputs of the motors A, B, and efficiency of the ship propulsion device. When the propeller output is in a small-output region from 0 kW at the time of starting, the controller 30 controls the propeller output by driving the motor A using the inverter. When the propeller output reaches a boundary between the small-output region and a high-output region, the controller 30 controls the propeller output by driving the motor B at a fixed rotational speed and by regulating a speed of the motor A using the inverter. As a result, the propeller output has a so-called cubic characteristic with respect to the propeller rotational speed and hence, the efficiency of the planetary gear acquires a high value of 98% in the whole region where the propeller rotational speed reaches a rated rotational speed from 0 whereby a fuel consumption rate is enhanced.

[0046]

FIG. 8 is a graph showing the relationship between a propeller rotational speed and an amount of power generated by the power generator in the ship propulsion device of the embodiment and a ship propulsion device of a comparison example. In this case, the comparison example corresponds to the ship propulsion device disclosed in "Patent Literature 3"

described in the Background Art. This ship propulsion device is a device of a type which includes two electric motors, that is, a sub electric motor whose rotation is controlled by an inverter, and an electric motor whose rotation is controlled by a slip clutch. As can be understood from the graph shown in FIG. 8, in the case of the comparison example, an amount of a slip loss is increased along with an increase of a load applied to the propeller and hence, a power generation amount is increased. Further, a discontinuous region exists where the power generation amount is rapidly increased at an intermediate rotational speed and hence, the comparison example lacks smoothness in operation control. However, in this embodiment, a slip loss is small and hence, operation efficiency of the ship propulsion device of this embodiment is superior to operation efficiency of the comparison example whereby a fuel consumption amount of the power generating engine which generates power for driving the motor can be made reduced.

[0047]

FIG. 9 is a view showing the schematic configuration of a ship propulsion device according to a second embodiment of the present invention. In the second embodiment, in place of the speed reduction unit 8 in the first embodiment, a gear box

4 which incorporates a differential-type planetary gear mechanism 5 therein is mounted on a platform 7, and an output shaft 23 of the differential-type planetary gear mechanism 5 is connected to a vertical shaft 2. Other configurations are substantially equal to the first embodiment. According to the second embodiment, the drive mechanism is disposed in a vertical posture and hence, it is possible to realize space saving with respect to equipment and the like disposed in the ship.

[0048]

FIG. 10 is a constitutional view showing the schematic constitution of a drive system of a ship propulsion device according to a third embodiment of the present invention. FIG. 10 is a view showing a transmission state a driving force during low-speed sailing. This view corresponds to FIG. 2 described in the first embodiment. In the third embodiment, in place of the brake 16 of the first embodiment, a one-way clutch 40 which forms a reverse rotation preventing mechanism is provided. An outer ring of the one-way clutch 40 is fixed, and an inner ring of the one-way clutch 40 is formed as a drive shaft. With such a configuration, the drive shaft is rotatable only in the normal rotational direction of a propeller 6.

[0049]

As has been described heretofore, according to this embodiment, in the ship propulsion device 1 which propels a ship using two sets of motors (electric motors) A, B, one motor B is formed of a general-purpose AC electric motor and is driven at a fixed speed, and the other motor A is formed of an AC electric motor which is driven by a small general-purpose inverter 17 and controls a speed. Further, the planetary gear mechanism 5 which includes the brake 16 and the clutch 15 is used for connecting both motors A, B and the propeller 6 to each other and hence, an expensive inverter which is a specially ordered product is unnecessary whereby an installation space for such an inverter can be reduced. Still further, a fuel consumption amount of the power generating engine which drives the motors A, B can be reduced due to a stable operation where drive power of the propeller 6 is not interrupted and efficient control of the motors A, B corresponding to a propeller output.

[0050]

In the embodiment described heretofore, the motor A is connected to the ring gear R, the motor B is connected to the sun gear S, and the propeller 6 is connected to the carrier C. However, such a configuration is not always indispensable. In the planetary gear mechanism 5, any one of the ring gear

R, the sun gear S, and the carrier C on which the planet gears P are mounted may be connected to the propeller, and remaining two elements may be connected to the motor A and the motor B respectively.

List of Reference Signs

[0051]

1: ship propulsion device

5: planetary gear mechanism

6: propeller

15: clutch

16: brake

17: inverter

30: controller

40: one-way clutch which forms reverse rotation preventing mechanism

S: sun gear

P: planet gear

R: ring gear

C: carrier

A: first motor

B: second motor

Claims

[Claim 1]

A ship propulsion device comprising:

- a planetary gear mechanism having a ring gear, a sun gear, and planet gears mounted on a carrier, the ring gear, the sun gear, and planet gears engaging with each other;
- a first motor connected to any one of the ring gear, the sun gear, and the carrier, the first motor being driven by an inverter;
- a second motor connected to one of the ring gear, the sun gear, and the carrier excluding the one connected to the first motor, the second motor being driven at a fixed speed; and
- a propeller connected to one of the ring gear, the sun gear, and the carrier excluding the one connected to the first motor and the one connected to the second motor.

[Claim 2]

The ship propulsion device according to claim 1, wherein the first motor is connected to the ring gear, the second motor is connected to the sun gear, and the propeller is connected to the carrier.

[Claim 3]

The ship propulsion device according to claim 2, further comprising: a clutch mounted on the second motor; and a brake disposed between the clutch and

the sun gear.

[Claim 4]

The ship propulsion device according to claim 2, further comprising: a clutch mounted on the second motor; and a reverse rotation preventing mechanism disposed between the clutch and the sun gear.

[Claim 5]

The ship propulsion device according to any one of claims 1 to 4, further comprising a controller which performs control such that the propeller is driven only by the first motor in a small-output region where an output of the propeller is relatively small, and the propeller is driven by the first motor and the second motor in a large-output region where an output of the propeller is relatively large.