

【DESCRIPTION】**【Invention Title】****APPARATUS AND METHOD FOR SUPPLYING HYBRID POWER OF
OFFSHORE PLANT****【Technical Field】**

[1] The present invention relates to hybrid power supply for an offshore plant, and, more particularly, to a hybrid power supply apparatus and method using regenerative power generated in an offshore plant.

【Background Art】

[2] With rapid industrialization and industrial development, consumption of resources such as petroleum has increased, and stable production and supply of oil have become a crucial global problem.

[3] For this reason, development of smaller marginal fields or deep-sea oil fields, which has been ignored due to lack of economic feasibility, is now emerging. Thus, development of offshore plants provided with oil drilling equipment suitable for use in such oil fields is actively carried out along with development of seabed mining technology.

[4] An offshore plant is provided with various types of drilling-related equipment such as a Derrick crane system, a draw-works, a top drive, a mud pump, a cement pump, a riser, and a drill pipe.

[5] The draw-works performs lifting of the drill pipe, insertion of a casing, and the like, and includes a drum and a motor. The drum is powered by the motor so as to wind or unwind a wire rope for controlling lifting of the drill pipe. The rotational speed of the motor can be adjusted so as to adjust the rotational speed of the drum, thereby enabling adjustment of the speed of the drill pipe.

[6] The top drive provides power for drilling and pipe fastening in drilling operation.

[7] Offshore plants are divided into a stationary platform anchored at one point of nearshore to perform drilling operations and a floating offshore plant capable of

performing drilling operation at ocean depths of 3,000 m or more.

[8] The floating offshore plant is provided with a plurality of thrusters as a main propulsion device or a propulsion device for computer-aided dynamic positioning. The thrusters are located at the bottom of a ship to change an operating direction of a propeller and are commonly used to allow the ship to navigate or to sail in a canal or enter/leave a port under its own power without a tug. The thruster is powered by a thrust motor connected thereto.

[9] FIG. 1 is a diagram of a typical power supply system known in the art.

[10] Referring to FIG. 1, AC power generated by a power generator 110 is supplied to an AC bus, to which a first AC/DC converter 121, a second AC/DC converter 122, and a third AC/DC converter 123 are connected.

[11] The first AC/DC converter 121 converts alternating current supplied from the AC bus into direct current and supplies the direct current to a first DC bus 131, and a DC/AC converter 141 converts direct current supplied from the first DC bus 131 into alternating current and supplies the alternating current to a first thruster motor 151.

[12] The second AC/DC converter 122 converts alternating current supplied from the AC bus into direct current and supplies the direct current to a second DC bus 132, and a DC/AC converter 142 converts direct current supplied from the second DC bus 132 into alternating current and supplies the alternating current to a second thruster motor 152.

[13] The third AC/DC converter 123 converts alternating current supplied from the AC bus into direct current and supplies the direct current to a third DC bus 133, and a plurality of DC/AC converters 143 to 148 are connected to the third DC bus 133. The plurality of DC/AC converters 143 to 148 convert direct current supplied from the third DC bus 133 into alternating current and supply the alternating current to corresponding ones of a plurality of draw-works motors 153, 154, 155, 158, 159 and a plurality of top drive motors 156, 157.

[14] Since the draw-works motors 153, 154, 155, 158, 159 and the top drive motors 156, 157 are configured to repeatedly lift or lower drilling equipment such as a drill pipe, a brake is frequently put on the motors to bring the motors to a sudden

stop or to rotate the motors in a reverse direction during rotation at rated load, and, for the thruster motors 151, 152, a brake is also frequently put on the motors to bring the motors to a sudden stop or to rotate the motors in the reverse direction during rotation at rated load. When a brake is put on the motors, regenerative power is generated in the motors. In addition, when a thruster is rotated due to a disturbance, regenerative power is also generated in the thruster motors.

[15] When regenerative power is generated in the draw-works motors, the top drive motors, or the thruster motors, voltage of a DC bus connected to the draw-works motors, the top drive motors, or the thruster motors is increased, and, when the voltage is increased beyond a degree which the DC bus can accommodate, the DC bus is tripped.

[16] Thus, the typical power supply system is provided with resistors 161 to 166 to consume regenerative power as heat, thereby preventing the DC bus from tripping.

[17] FIG. 2 is a graph showing power consumption of each component of a typical power supply system known in the art.

[18] Referring to FIG. 2, electric power produced by a power generator is supplied to a first load 220 and an AC/DC converter 260 through a distributor. The AC/DC converter 260 converts alternating current into direct current and supplies the direct current to a second load 240 while supplying the direct current to a draw-works 230 through a DC/AC converter. Each of the first load 220 and the second load 240 is a load that consumes a constant level of electric power. On the contrary, power consumption of the draw-works 230 changes continuously, and, in FIG. 2, a negative value of electric power means that regenerative power is generated. Regenerative power generated in the draw-works 230 is consumed by the second load or a resistor 250.

[19] In FIG. 2, it can be seen that abrupt change in power consumption of the draw-works 230 causes abrupt change in power output of the power generator 210. A diesel power generator consumes more fuel and discharges more exhaust gas in the case where power output is abruptly changed than in the case where power output is maintained at a constant level.

[20] In order to supply suitable electric power corresponding to abrupt change in

power consumption of the draw-works motors, the top drive motors, and the thruster motors, it is necessary to rapidly change power output of the power generator. However, the power generator has difficulty providing suitable electric power corresponding to abrupt change in power consumption of the draw-works motors, the top drive motors, and the thruster motors due to low responsiveness thereof. If suitable power supply to the draw-works motors, the top drive motors, and the thruster motors is not achieved, a dangerous situation can occur due to characteristics of drilling operation. Further, when power supply to the draw-works motors or the top drive motors is suddenly interrupted upon loss of power, a dangerous situation can also occur.

[21] In other words, typical power supply systems have problems such as energy waste due to consumption of regenerative power by resistors, increase in fuel consumption and exhaust gas due to abrupt change in power output of a power generator, difficulty in suitable electric power supply to draw-works motors, top drive motors, and thruster motors, and danger upon loss of power.

【Disclosure】

【Technical Problem】

[22] It is an aspect of the present invention to provide a hybrid power supply apparatus and method for an offshore plant which can efficiently utilize regenerative power, maintain power output of a generator at a constant level, supply suitable electric power corresponding to abrupt change in power consumption of electric loads, and supply electric power upon sudden loss of power.

【Technical Solution】

[23] In accordance with one aspect of the present invention, there is provided a hybrid power supply apparatus for an offshore plant, including: a power generator; an AC/DC converter converting alternating current produced by the power generator into direct current and supplying the direct current to a DC bus; an electric power load connected to the DC bus and generating regenerative power; a first DC/DC converter connected to the DC bus; a first power storage unit connected to the first

DC/DC converter and storing electric power; and a first resistor connected to the first DC/DC converter and consuming electric power when the first power storage unit is full, wherein the first DC/DC converter measures voltage of the DC bus, and allows the first power storage unit to store electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time, the first DC/DC converter measures the voltage of the DC bus, and allows the first resistor to consume electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, and wherein the second period of time is longer than the first period of time.

[24] The first DC/DC converter may measure voltage of the DC bus, and may allow the first power storage unit to store electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time.

[25] The first DC/DC converter may measure the voltage of the DC bus, and may allow the first resistor to consume electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, and wherein the second period of time is longer than the first period of time.

[26] The hybrid power supply apparatus may further include: a second power storage unit and a second resistor.

[27] The DC bus may be connected to a second DC/DC converter, and the second power storage unit and the second resistor may be connected to the second DC/DC converter.

[28] The first power storage unit may be an ultracapacitor.

[29] The electric power load may be a draw-works.

[30] The electric power load may be a top drive.

[31] In accordance with another aspect of the present invention, there is provided a hybrid power supply method for an offshore plant, including: measuring, by a DC/DC converter, voltage of a DC bus; storing, by a power storage unit, electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time; and consuming, by a resistor, electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, wherein the DC bus is connected to an electric

power load generating regenerative power and the second period of time is longer than the first period of time.

[32] The DC/DC converter may measure the voltage of the DC bus, and may allow electric power to flow from the DC bus to the power storage unit such that the power storage unit stores electric power, when the voltage of the DC bus is maintained at the first threshold value or higher for the first period of time.

[33] The DC/DC converter may measure the voltage of the DC bus, and may allow electric power to flow from the DC bus to the resistor such that the resistor consumes electric power when the voltage of the DC bus is maintained at the first threshold value or higher for the second period of time.

[34] The power storage unit may be an ultracapacitor.

[35] The electric power load may be a draw-works.

[36] The electric power load may be a top drive.

[37] In accordance with a further aspect of the present invention, there is provided a hybrid power supply apparatus for an offshore plant, including: a power generator; an AC/DC converter converting alternating current produced by the power generator into direct current and supplying the direct current to a DC bus; a first electric power load connected to the DC bus via a first DC/AC converter and generating regenerative power; a first power storage unit storing regenerative power when regenerative power is generated in the first electric power load; a first resistor consuming electric power when the first power storage unit is full; a second electric power load connected to the DC bus via a second DC/AC converter and generating regenerative power; a second power storage unit storing regenerative power when regenerative power is generated in the second electric power load; a second resistor consuming electric power when the second power storage unit is full; and a first DC/DC converter connected to the DC bus; wherein the first power storage unit and the first resistor are connected to the first DC/DC converter, the first DC/DC converter measures voltage of the DC bus, and allows the first power storage unit to store electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time, the first DC/DC converter measures the voltage of the DC bus, and allows the first resistor to consume electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, and wherein the second period of time is longer than the first period of time.

[38] The hybrid power supply apparatus may further include: a first DC/DC converter connected to the DC bus; and a second DC/DC converter connected to the DC bus, wherein the first power storage unit and the first resistor are connected to

the first DC/DC converter, and the second power storage unit and the second resistor are connected to the second DC/DC converter.

[39] The first DC/AC converter may detect whether regenerative power is generated in the first electric power load, and send a control signal to the first DC/DC converter when regenerative power is generated in the first electric power load, and the first DC/DC converter may allow electric power to be supplied from the DC bus to the first power storage unit in response to the control signal such that the first power storage unit stores electric power.

[40] The first DC/DC converter may allow electric power to be supplied from

the DC bus to the first resistor such that the first resistor consumes electric power when detecting that the first power storage unit is full.

[41] The first power storage unit may be an ultracapacitor.

[42] The first electric power load may be a draw-works.

[43] The first electric power load may be a top drive.

[44] In accordance with another aspect of the present invention, there is provided a hybrid power supply apparatus for an offshore plant, comprising: a power generator; an AC/DC converter converting alternating current produced by the power generator into direct current and supplying the direct current to a DC bus; a first electric power load connected to the DC bus via a first DC/AC converter and generating regenerative power; a first power storage unit storing regenerative power when regenerative power is generated in the first electric power load; a first resistor consuming electric power when the first power storage unit is full; a second electric power load connected to the DC bus via a second DC/AC converter and generating regenerative power; a second power storage unit storing regenerative power when regenerative power is generated in the second electric power load; a second resistor consuming electric power when the second power storage unit is full; a first DC/DC converter connected to the DC bus; a second DC/DC converter connected to the DC bus; a third DC/DC converter connected to the DC bus; and a fourth DC/DC converter connected to the DC bus, wherein the first power storage unit may be connected to the first DC/DC converter, the first resistor may be connected to the second DC/DC converter, the second power storage unit may be connected to the third DC/DC converter, and the second resistor may be connected to the fourth DC/DC converter, the first DC/DC converter measures voltage of the DC bus, and allows the first power storage unit to store electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time, the first DC/DC converter measures the voltage of the DC bus, and allows the first resistor to consume electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, and wherein the second period of time is longer than the first period of time.

[45] In accordance with yet another aspect of the present invention, there is provided a hybrid power supply method for an offshore plant, wherein a first DC/AC converter and a second DC/AC converter are connected to a DC bus, a first electric power load is connected to the first DC/AC converter, and a second electric power load is connected to the second DC/AC converter, including: detecting, by the first DC/AC converter, whether regenerative power is generated in the first electric power load; storing, by a first power storage unit, regenerative power generated in the first electric power load when a voltage of the DC bus is maintained at a first threshold value or higher for a first period of time; detecting, by the second DC/AC converter, whether regenerative power is generated in the second electric power load; storing, by a second power storage unit, regenerative power generated in the second electric power load, and consuming, by a first resistor, electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, wherein the second period of time is longer than the first period of time.

[46] The DC bus may be connected to a first DC/DC converter and a second DC/DC converter; the first power storage unit and a first resistor may be connected to the first DC/DC converter; and the second power storage unit and a second resistor may be connected to the second DC/DC converter.

[47] The hybrid power supply method may further include: sending, by the first DC/AC converter, a control signal indicative of generation of regenerative power in the first electric power load to the first DC/DC converter; and allowing, by the first

DC/DC converter, electric power to be supplied from the DC bus to the first power storage unit in response to the control signal such that the first power storage unit stores electric power.

[48] The hybrid power supply method may further include: detecting, by the first DC/DC converter, that the first power storage unit is full; and allowing, by the first DC/DC converter, electric power to be supplied from the DC bus to the first resistor such that the first resistor consumes.

[49] The hybrid power supply method may further include: consuming, by the second resistor, electric power when the second power storage unit is full.

[50] The first power storage unit may be an ultracapacitor.

[51] The first electric power load may be a draw-works.

[52] The first electric power load may be a top drive.

【Advantageous Effects】

[53] According to embodiments of the present invention, it is possible to provide a hybrid power supply apparatus and method which allow regenerative power generated in a draw-works motor, a top drive motor, and a thruster motor to be stored in a power storage unit and supply electric power stored in the power storage unit upon abrupt increase in power consumption of the draw-works motor, the top drive motor, and the thruster motor to efficiently utilize regenerative power while maintaining power output of a power generator at a constant level to reduce exhaust gas.

[54] In addition, it is possible to provide a hybrid power supply apparatus and method which use an ultracapacitor having high responsiveness as a power storage unit, thereby supplying suitable electric power corresponding to abrupt change in power consumption of electric loads.

[55] Further, it is possible to provide a hybrid power supply apparatus and method which can utilize electric power stored in a power storage unit to safely shut down drilling equipment such as a draw-works or a top drive upon transients or loss of power.

[56] Furthermore, it is possible to provide a hybrid power supply apparatus and

method which can reduce the number of DC/DC converters by connecting a power storage unit and a resistor to a single DC/DC converter, thereby reducing equipment size and costs.

[57] Furthermore, it is possible to provide a hybrid power supply apparatus and method which can operate a set of an electric power load, a power storage unit, and a resistor in an individual manner by allocating a dedicated power storage unit and a dedicated resistor to a specific electric power load.

【Description of Drawings】

[58] FIG. 1 is a diagram of a typical power supply system known in the art.

[59] FIG. 2 is a graph showing power consumption of each component of a typical power supply system known in the art.

[60] FIG. 3 is a diagram of a hybrid power supply apparatus for an offshore plant according to a first embodiment of the present invention.

[61] FIG. 4 is a diagram of a hybrid power supply apparatus for an offshore plant according to a second embodiment of the present invention.

[62] FIG. 5 is a diagram of a hybrid power supply apparatus for an offshore plant according to a third embodiment of the present invention.

[63] FIG. 6 is a flowchart of a process of supplying electric power to a power storage unit in a hybrid power supply method for an offshore plant according to an embodiment of the present invention.

[64] FIG. 7 is a flowchart of a process of supplying electric power from the power storage unit to a DC bus upon power shortage in the hybrid power supply method for an offshore plant according to the embodiment of the present invention.

[65] FIG. 8 is a flowchart of a process of supplying electric power from the power storage unit to the DC bus upon loss of power in the hybrid power supply method for an offshore plant according to the embodiment of the present invention.

[66] FIG. 9 is a graph showing power consumption of each component of the power supply apparatus according to the embodiments of the present invention.

【Best Mode】

[67] Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings. It should be noted that like components will be denoted by like reference numerals throughout the specification and the accompanying drawings. In addition, descriptions of details apparent to those skilled in the art will be omitted for clarity.

[68] First, a hybrid power supply apparatus for an offshore plant according to embodiments of the present invention will be described with reference to FIGs. 3 to 5. FIG. 3 is a diagram of a hybrid power supply apparatus for an offshore plant according to a first embodiment of the present invention, FIG. 4 is a diagram of a hybrid power supply apparatus for an offshore plant according to a second embodiment of the present invention, and FIG. 5 is a diagram of a hybrid power supply apparatus for an offshore plant according to a third embodiment of the present invention.

[69] Referring to FIGs. 3 to 5, a hybrid power supply apparatus for an offshore plant according to the first embodiment of the present invention includes a power generator 310, an AC/DC converter 320, a DC bus 321, a variable frequency drive (VFD) controller 330, DC/DC converters 351 to 353, electric power loads 361 to 363, power storage units 371 to 373, resistors 381 to 383, and a sensor 391.

[70] The power generator 310 is a device producing electric power for an offshore plant and is connected to the AC/DC converter 320 via an AC bus. Alternatively, electric power produced by the power generator 310 may be supplied to the AC/DC converter 320 after being altered to a voltage suitable for use in electric power loads. The power generator 310 is an AC Generator and can produce AC power.

[71] The AC/DC converter 320 converts AC power produced by the power generator 310 into direct current and supplies the direct current to the DC bus 321.

[72] The DC bus 321 supplies electric power to electric power loads connected to the DC bus 321. Electric power loads using DC power may be connected directly to the DC bus 321, and electric power loads using AC power may be connected to the DC bus 321 via DC/AC converters (341 to 343).

[73] The electric power loads 361 to 363 of FIG. 3 are electric power loads

using AC power and are connected to the DC bus 321 via the DC/AC converters 341 to 343, respectively. The DC/AC converters 341 to 343 convert direct current supplied from the DC bus 321 into alternating current and supply the alternating current to the electric power loads 361 to 363, respectively.

[74] The electric power loads 361 to 363 may be draw-works motors or top drive motors.

[75] Although, in FIG. 3, three draw-works motors 361 to 363, as the electric power loads, are shown as being connected to the DC bus 321, it should be understood that the present invention is not limited thereto and a varying number of draw-works motors and top drive motors may be connected to the DC bus 321.

[76] Since the draw-works motors 361 to 363 are configured to repeatedly lift or lower drilling equipment such as a drill pipe, a brake is frequently put on the motors to bring the motors to a sudden stop or to rotate the motors in a reverse direction during rotation at rated load.

[77] The power storage units 371 to 373 receive electric power from the DC bus 321 so as to store the electric power when a voltage of the DC bus 321 is maintained at a first threshold value or higher for a first period of time, and the power storage units supply electric power to the DC bus 321 when the voltage of the DC bus 321 is maintained at a second threshold value or less for a second period of time. For example, assuming that the DC bus 321 is a 720 V DC bus and is tripped at 750 V or higher, the first threshold value may be set to 740 V.

[78] The DC/DC converters 351 to 353 measure the voltage of the DC bus 321, and supply electric power from the DC bus 321 to the power storage units 371 to 373 such that the power storage units 371 to 373 store electric power when the voltage of the DC bus is maintained at the first threshold value or higher for the first period of time, whereas the DC/DC converters allow electric power to flow from the power storage units 371 to 373 to the DC bus 321 to supply electric power from the power storage units 371 to 373 to the DC bus 321 when the voltage of the DC bus is maintained at the second threshold value or less for the second period of time.

[79] When regenerative power is generated in the electric power loads 361 to 363, the voltage of the DC bus 321 is increased, and, when power consumption of

the electric power loads 361 to 363 is abruptly increased, the voltage of the DC bus 321 drops.

[80] In other words, when regenerative power is generated in the electric power loads 361 to 363 causing increase in the voltage of the DC bus 321 and the voltage of the DC bus 321 is maintained at the threshold value or higher for the first period of time, the DC/DC converters 351 to 353 supply electric power to the power storage units 371 to 373 such that the power storage units 371 to 373 store electric power, thereby allowing regenerative power generated in the electric power loads 361 to 363 to be stored in the power storage units 371 to 373.

[81] When power consumption of the electric power loads 361 to 363 is abruptly increased causing drop in the voltage of the DC bus 321 and the voltage of the DC bus 321 is maintained at the second threshold value or less for the second period of time, the DC/DC converters 351 to 353 allow electric power to flow from the power storage units 371 to 373 to the DC bus 321 such that the DC bus 321 receives electric power from the power storage units 371 to 373. The power storage units 371 to 373 may be at least of an ultracapacitor, a capacitor, a battery, and a flywheel. Particularly, when the power storage units 371 to 373 are ultracapacitors, it is possible to rapidly supply electric power to the electric power loads 361 to 363 upon a sudden increase in power consumption of the electric power loads 361 to 363 since such an ultracapacitor has higher responsiveness than the power generator 310.

[82] In addition, the power storage units 371 to 373 can supply electric power to the DC bus 321 upon transients or loss of power. When a sensor for detecting transients or loss of power 391 senses a transient or loss of power and sends detection signals to the DC/DC converters 351 to 353, the DC/DC converters 351 to 353 allow electric power to be supplied from the power storage units 371 to 373 to the DC bus 321.

[83] The sensor 391 may be mounted on at least one of a switchboard and the DC bus 321.

[84] Drilling equipment such as a draw-works and a top drive can cause a dangerous situation upon abrupt interruption of power supply. Thus, the power storage units 371 to 373 supply electric power to the DC bus 321 upon transients or

loss of power to safely shut down the drilling equipment.

[85] The resistors 381 to 383 consume electric power when the voltage of the DC bus 321 is maintained at the first threshold value or higher for a third period of time. Here, the third period of time is longer than the first period of time.

[86] When regenerative power is generated in the electric power loads 361 to 363 causing increase in the voltage of the DC bus 321 and the voltage of the DC bus is maintained at the threshold value or higher for the first period of time, the power storage units 371 to 373 store electric power. When the power storage units 371 to 373 are full, the voltage of the DC bus 321 does not drop and is continuously maintained at the first threshold value or higher. Thus, if the voltage of the DC bus 321 is maintained at the first threshold value or higher for the third period of time, it can be determined that the power storage units 371 to 373 are full. When regenerative power is continuously generated even after the power storage units 371 to 373 are full, the voltage of the DC bus 321 continuously increases, thereby causing the DC bus 321 to be tripped. Thus, when the voltage of the DC bus 321 is maintained at the first threshold value or higher for the third period of time, the DC/DC converters 351 to 353 allow the resistors 381 to 383 to consume electric power.

[87] Although FIGs. 3 to 5 show three power storage units 371 to 373 and three resistors 381 to 383, it should be understood that the present invention is not limited thereto and may include varying numbers of power storage units and resistors.

[88] As shown in FIG. 3, the power storage units 371 to 373 and the corresponding resistors 381 to 383 may be connected to the DC bus 321 in pairs. In other words, a first power storage unit 371 and a first resistor 381 are connected to the DC bus 321 via a first DC/DC converter 351; a second power storage unit 372 and a second resistor 382 are connected to the DC bus 321 via a second DC/DC converter 352; and a third power storage unit 373 and a third resistor 383 are connected to the DC bus 321 via a third DC/DC converter 353. When the power storage unit and the resistor are connected to the same DC/DC converter, as in FIG. 3, it is possible to reduce the number of required DC/DC converters and the overall size of the apparatus.

[89] Alternatively, the plural power storage units 371 to 373 and the plural resistors 381 to 383 may be connected to the DC bus 321 via separate DC/DC converters 451 to 456, respectively, as shown in FIG. 4. In other words, a first power storage unit 371 is connected to the DC bus 321 via a first DC/DC converter 451; a second power storage unit 372 is connected to the DC bus 321 via a second DC/DC converter 452; a third power storage unit 373 is connected to the DC bus 321 via a third DC/DC converter 453; a first resistor 381 is connected to the DC bus 321 via a fourth DC/DC converter 454; a second resistor 382 is connected to the DC bus 321 via a fifth DC/DC converter 455; and a third resistor 383 is connected to the DC bus 321 via a sixth DC/DC converter 456. When the plural power storage units 371 to 373 and the plural resistors 381 to 383 are connected to separate DC/DC converters 451 to 456, respectively, as in FIG. 4, it is possible to operate the plural power storage units 371 to 373 and the plural resistors 381 to 383 in an individual manner.

[90] Alternatively, a single power storage unit 371 to 373 and a single resistor 381 to 383 may be dedicated to a single electric power load 361 to 363, as shown in FIG. 5. In other words, when regenerative power is generated in a first electric power load 361, a first power storage unit 371 stores the regenerative power and a first resistor 381 does not consume electric power until the first power storage unit 371 is full. When regenerative power is generated in a second electric power load 362, a second power storage unit 372 stores the regenerative power and a second resistor 382 does not consume electric power until the second power storage unit 372 is full. When regenerative power is generated in a third electric power load 363, a third power storage unit 373 stores the regenerative power and a third resistor 383 does not consume electric power until the third power storage unit 372 is full.

[91] When regenerative power is generated in the first electric power load 361, a first DC/AC converter 341 detects generation of regenerative power in the first electric power load 361 and sends a control signal to the first DC/DC converter 351. In response to the control signal, the first DC/DC converter 351 allows electric power to be supplied from the DC bus 321 to the first power storage unit 371 such that the first power storage unit 371 can store electric power. Then, the first DC/DC converter 351 detects whether the first power storage unit 371 is full, and, when the

first power storage unit 371 is full, the first DC/DC converter allows the first resistor 381 to consume electric power. Although the first power storage unit 371 and the first resistor 381 are shown as being connected to the same DC/DC converter 351, it should be understood that the first power storage unit 371 and the first resistor 381 may be connected to different DC/DC converters.

[92] Next, a hybrid power supply method for an offshore plant according to an embodiment of the present invention will be described with reference to FIGs. 6 to 8. FIG. 6 is a flowchart of a process of supplying electric power to a power storage unit in a hybrid power supply method for an offshore plant according to an embodiment of the present invention, FIG. 7 is a flowchart of a process of supplying electric power from the power storage unit to a DC bus upon power shortage in the hybrid power supply method for an offshore plant according to the embodiment of the present invention, and FIG. 8 is a flowchart of a process of supplying electric power from the power storage unit to the DC bus upon loss of power in the hybrid power supply method for an offshore plant according to the embodiment of the invention.

[93] Referring to FIG. 6, voltage of a DC bus is measured (S610); electric power is stored in a power storage unit when the voltage of the DC bus 321 is maintained at a first threshold value or higher for a first period of time (S620); and electric power is consumed by a resistor when the voltage of the DC bus 321 is maintained at the first threshold value or higher for a second period of time (S630).

[94] Referring to FIG. 7, the voltage of the DC bus is measured (S710); and electric power stored in the power storage unit is supplied to the DC bus when the voltage of the DC bus is maintained at a second threshold value or less for a third period of time (S720).

[95] When a sensor 391 detects loss of power (S810), the sensor 391 sends a control signal to a DC/DC converter (S820), and the DC/DC converter allows the power storage unit to supply electric power to the DC bus in response to the control signal from the sensor 391 (S830).

[96] Next, power consumption of each component of the power supply apparatus according to the embodiments of the invention will be described with reference to FIG. 9. FIG. 9 is a graph showing power consumption of each

component of the power supply apparatus according to the embodiments of the invention.

[97] As shown in FIG. 9, it can be seen that, when regenerative power is generated in the electric power load, the power storage unit stores the generated regenerative power, and, when power consumption of the electric power load is suddenly increased, the power storage unit supplies electric power to the electric power load, thereby maintaining power output of the power generator at a constant level.

[98] Although some embodiments have been described herein, it should be understood by those skilled in the art that these embodiments are given by way of illustration only, and that various modifications, variations and alterations can be made without departing from the spirit and scope of the invention. Therefore, the embodiments disclosed herein should not be construed as limiting the technical scope of the present invention, but should be construed as illustrating the idea of the present invention. The scope of the present invention should be interpreted according to the appended claims as covering all modifications or variations derived from the appended claims and equivalents thereof.

【CLAIMS】**【Claim 1】**

A hybrid power supply apparatus for an offshore plant, comprising:

- a power generator;
- an AC/DC converter converting alternating current produced by the power generator into direct current and supplying the direct current to a DC bus;
- an electric power load connected to the DC bus and generating regenerative power;
- a first DC/DC converter connected to the DC bus;
- a first power storage unit connected to the first DC/DC converter and storing electric power; and
- a first resistor connected to the first DC/DC converter and consuming electric power when the first power storage unit is full,

wherein the first DC/DC converter measures voltage of the DC bus, and allows the first power storage unit to store electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time,

the first DC/DC converter measures the voltage of the DC bus, and allows the first resistor to consume electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, and wherein the second period of time is longer than the first period of time.

【Claim 2】

The hybrid power supply apparatus according to claim 1, further comprising:
a second power storage unit and a second resistor.

【Claim 3】

The hybrid power supply apparatus according to claim 2, wherein the DC bus is connected to a second DC/DC converter, and the second power storage unit and the second resistor are connected to the second DC/DC converter.

【Claim 4】

The hybrid power supply apparatus according to claim 1, wherein the first power storage unit is an ultracapacitor.

【Claim 5】

The hybrid power supply apparatus according to claim 1, wherein the electric power load is a draw-works.

【Claim 6】

The hybrid power supply apparatus according to claim 1, wherein the electric power load is a top drive.

【Claim 7】

A hybrid power supply method for an offshore plant, comprising:
measuring, by a DC/DC converter, voltage of a DC bus;
storing, by a power storage unit, electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time; and
consuming, by a resistor, electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time,
wherein the DC bus is connected to an electric power load generating regenerative power and the second period of time is longer than the first period of time.

【Claim 8】

The hybrid power supply method according to claim 7, wherein the DC/DC converter measures the voltage of the DC bus, and allows electric power to flow

from the DC bus to the power storage unit such that the power storage unit stores electric power, when the voltage of the DC bus is maintained at the first threshold value or higher for the first period of time.

【Claim 9】

The hybrid power supply method according to claim 8, wherein the DC/DC converter measures the voltage of the DC bus, and allows electric power to flow from the DC bus to the resistor such that the resistor consumes electric power when the voltage of the DC bus is maintained at the first threshold value or higher for the second period of time.

【Claim 10】

The hybrid power supply method according to claim 7, wherein the power storage unit is an ultracapacitor.

【Claim 11】

The hybrid power supply method according to claim 7, wherein the electric power load is a draw-works.

【Claim 12】

The hybrid power supply method according to claim 7, wherein the electric power load is a top drive.

【Claim 13】

A hybrid power supply apparatus for an offshore plant, comprising:
a power generator;
an AC/DC converter converting alternating current produced by the power generator into direct current and supplying the direct current to a DC bus;
a first electric power load connected to the DC bus via a first DC/AC converter and generating regenerative power;
a first power storage unit storing regenerative power when regenerative

power is generated in the first electric power load;

a first resistor consuming electric power when the first power storage unit is full;

a second electric power load connected to the DC bus via a second DC/AC converter and generating regenerative power;

a second power storage unit storing regenerative power when regenerative power is generated in the second electric power load;

a second resistor consuming electric power when the second power storage unit is full; and

a first DC/DC converter connected to the DC bus;

wherein the first power storage unit and the first resistor are connected to the first DC/DC converter,

the first DC/DC converter measures voltage of the DC bus, and allows the first power storage unit to store electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time,

the first DC/DC converter measures the voltage of the DC bus, and allows the first resistor to consume electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, and wherein the second period of time is longer than the first period of time.

【Claim 14】

The hybrid power supply apparatus according to claim 13, further comprising:

a second DC/DC converter connected to the DC bus,

wherein the second power storage unit and the second resistor are connected to the second DC/DC converter.

【Claim 15】

The hybrid power supply apparatus according to claim 14, wherein the first

DC/AC converter detects whether regenerative power is generated in the first electric power load, and sends a control signal to the first DC/DC converter when regenerative power is generated in the first electric power load, and the first DC/DC converter allows electric power to be supplied from the DC bus to the first power storage unit in response to the control signal such that the first power storage unit stores electric power.

【Claim 16】

The hybrid power supply apparatus according to claim 15, wherein the first DC/DC converter allows electric power to be supplied from the DC bus to the first

resistor such that the first resistor consumes electric power when detecting that the first power storage unit is full.

【Claim 17】

The hybrid power supply apparatus according to claim 13, wherein the first power storage unit is an ultracapacitor.

【Claim 18】

The hybrid power supply apparatus according to claim 13, wherein the first electric power load is a draw-works.

【Claim 19】

The hybrid power supply apparatus according to claim 13, wherein the first electric power load is a top drive.

【Claim 20】

A hybrid power supply apparatus for an offshore plant, comprising:

a power generator;

an AC/DC converter converting alternating current produced by the power generator into direct current and supplying the direct current to a DC bus;

a first electric power load connected to the DC bus via a first DC/AC converter and generating regenerative power;

a first power storage unit storing regenerative power when regenerative power is generated in the first electric power load;

a first resistor consuming electric power when the first power storage unit is full;

a second electric power load connected to the DC bus via a second DC/AC converter and generating regenerative power;

a second power storage unit storing regenerative power when regenerative power is generated in the second electric power load;

a second resistor consuming electric power when the second power storage

unit is full;

- a first DC/DC converter connected to the DC bus;
- a second DC/DC converter connected to the DC bus;
- a third DC/DC converter connected to the DC bus; and
- a fourth DC/DC converter connected to the DC bus;

wherein the first power storage unit is connected to the first DC/DC converter, the first resistor is connected to the second DC/DC converter, the second power storage unit is connected to the third DC/DC converter, and the second resistor is connected to the fourth DC/DC converter,

the first DC/DC converter measures voltage of the DC bus, and allows the first power storage unit to store electric power when the voltage of the DC bus is maintained at a first threshold value or higher for a first period of time,

the first DC/DC converter measures the voltage of the DC bus, and allows the first resistor to consume electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time, and wherein the second period of time is longer than the first period of time.

【Claim 21】

A hybrid power supply method for an offshore plant, wherein a first DC/AC converter and a second DC/AC converter are connected to a DC bus, a first electric power load is connected to the first DC/AC converter, and a second electric power load is connected to the second DC/AC converter, comprising:

detecting, by the first DC/AC converter, whether regenerative power is generated in the first electric power load;

storing, by a first power storage unit, regenerative power generated in the first electric power load when a voltage of the DC bus is maintained at a first threshold value or higher for a first period of time;

detecting, by the second DC/AC converter, whether regenerative power is generated in the second electric power load;

storing, by a second power storage unit, regenerative power generated in the second electric power load; and

consuming, by a first resistor, electric power when the voltage of the DC bus is maintained at the first threshold value or higher for a second period of time,

wherein the second period of time is longer than the first period of time.

【Claim 22】

The hybrid power supply method according to claim 21, wherein the DC bus is connected to a first DC/DC converter and a second DC/DC converter; the first power storage unit and the first resistor are connected to the first DC/DC converter; and the second power storage unit and a second resistor are connected to the second DC/DC converter.

【Claim 23】

The hybrid power supply method according to claim 22, further comprising:

sending, by the first DC/AC converter, a control signal indicative of generation of regenerative power in the first electric power load to the first DC/DC converter; and

allowing, by the first DC/DC converter, electric power to be supplied from the DC bus to the first power storage unit in response to the control signal such that the first power storage unit stores electric power.

【Claim 24】

The hybrid power supply method according to claim 23, further comprising:

detecting, by the first DC/DC converter, that the first power storage unit is full; and

allowing, by the first DC/DC converter, electric power to be supplied from the DC bus to the first resistor such that the first resistor consumes.

【Claim 25】

The hybrid power supply method according to claim 22, further comprising:
consuming, by the second resistor, electric power when the second power storage unit is full.

【Claim 26】

The hybrid power supply method according to claim 21, wherein the first power storage unit is an ultracapacitor.

【Claim 27】

The hybrid power supply method according to claim 21, wherein the first electric power load is a draw-works.

【Claim 28】

The hybrid power supply method according to claim 21, wherein the first electric power load is a top drive.