Design and Implementation of Charging and Discharging Device for Electric Inland River Cruise ship

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Abstract. This paper designs a charging and discharging device for electric ships. The electric ships’ battery is very large, when performing charge and discharge control of the battery system, it is necessary to manage the charge and discharge current of the battery system reasonably. The battery charging and discharging device can convert the voltage of the energy storage system with a large variation range into a stable DC output voltage, which can control the charge and discharge current of each cluster, and complete the charge and discharge management of each battery cluster. The battery charging and discharging device can be quickly and dynamically adjusted to adapt to changes in the load, and has high operating efficiency and power density. This charging and discharging device has been successfully applied to a certain type of inland river pure electric cruise ship, which will significantly improve the reliability of large-capacity lithium battery ships, and significantly improve the environment of the Yangtze River and other inland river economic zones, and has good applicability in the field of new energy ships.

1. Introduction

At present, “low-carbon economy” has become a global hot spot, and the concept of green ships based on new technologies and new energy has gradually attracted the attention of the shipbuilding and shipping industries. With the International Maritime Organization (IMO) promulgating a series of new standards and new rules for energy conservation and emission reduction of ships, major shipping countries and regions attach great importance to the development of safe, environmentally friendly and energy-saving green ships. The "green revolution" of energy saving and environmental protection equipment is taking place.

Because of the large battery capacity of electric ships, the design of the battery system and its charging and discharging devices is more complicated when the battery system is controlled for charging and discharging. It needs to manage the charging and discharging of the battery system. The ship's charging and discharging device can manage the charging and discharging of the battery system of the electric ship.

2. System Topology of All electric inland river cruise

The new energy ships adopt clean and quiet green energy, which does not pollute the environment during use, full electric propulsion, which has high efficiency, low vibration and noise, good ride comfort, and high flexibility. Due to its relatively limited endurance, all electric ships are mainly suitable for ships in fixed navigation areas and fixed flight segments, which has broad application prospects in river basins such as inland rivers, lakes, reservoirs, and ports.

According to the definition of China Classification Society (CCS), "Green ships are designed, built, operated and dismantled throughout the life cycle, through the application of green technology to
maximize the realization of low energy consumption, low emissions, low pollution, high energy efficiency, safety and health. The realization of this goal is reflected in the entire life cycle of the ship, including green elements in the design, production, use, recycling and other links [1].

Green ship power has the following characteristics:

1) High energy efficiency and low emissions: The use of low-pollution, low-emission or even zero-emission power sources; the heat engine works in the best fuel consumption area; the operating efficiency of the system is improved, and the required operating time is shortened.

2) Quiet and comfortable, easy to use: Reduce the noise and vibration level of the ship's power plant; increase the power density of the ship's power plant, reduce the occupancy rate of the equipment compartment, and improve the comfort of the ship's personnel; improve the automation of equipment and improve the convenience of maneuvering.

3) Flexible access and power quality assurance: The ship power system is open, the ship power system has strong safety protection and fault tolerance, and the power quality of the power grid of the ship power system is high.

Electric ship power system includes power battery system, DC power distribution system, propulsion system, automation system, and battery charging system. The power battery system supplies power to the ship through the DC switchboard, and the busbar voltage is DC600V. The propulsion motor is driven by the propulsion inverter. The daily load of the whole ship is provided with AC400V alternating current by the power inverter.

1) Lithium battery charging and discharging are completed through the energy management system (EMS) and charging and discharging control cabinet together;

2) The battery charge and discharge control cabinet can control the discharge current of each cluster, and complete the discharge management and charging management of each cluster;

3) Energy management system (EMS) reasonably manages the battery cluster current in the battery charge and discharge control cabinet[2];

4) When the ship is at anchor, the power supply of shore power is similar to that of traditional ships, the shore-based shore power box directly supplies power to the ship. At this time, the inverter power supply will not supply power to the ship’s AC load, and there is an electrical interlock between the shore power switch and the secondary side switch of the isolation transformer;

5) The energy management system not only has the functions of monitoring, control and protection of the ship power station, but also realizes the coordinated operation of the propulsion system, ship power station, and battery system. The energy management system monitors the battery system, propulsion system, and daily load according to the real-time demand for power, and coordinates the work of the battery system and the propulsion system, and can alarm and deal with faults in the power supply system for the propulsion system and other electrical equipment. Provide reliable, stable and optimally configured electric energy. When the power supply system fails, the energy management system will take various measures to ensure continuous power supply to the load as much as possible, avoid power outages in the power station, and ensure the safety of the ship[3].

3. Design of charging and discharging device
The charging and discharging device consists of two parts: a bidirectional DCDC converter and a filter. The charging and discharging device has the following basic functions:
Figure 1 Schematic diagram of DCDC converter

Figure 2 Schematic diagram of the filter

1) The battery charging and discharging device has a bus communication interface, which can upload the operating state parameters to the monitoring system;

2) The battery charging and discharging device has a hard-wired interface for control and monitoring, which can perform local operations near the machine and indicate the running status;

3) When powered by shore power, the battery charging and discharging device can charge the battery pack in constant current mode or constant voltage mode;

4) When powered by the battery pack, the battery charging and discharging device can operate in a voltage stabilization mode to keep the bus side voltage stable and the power can flow in both directions;

5) The battery charging and discharging device has the function of monitoring input DC voltage, output DC voltage, output DC current and other parameters;

The system control principle is mainly to independently adjust the duty cycle of the PWM signal of each bridge arm through feedback control of the respective output currents of the three bridge arms. When the two-way DC converter is running on the ship, there are the following working conditions: First, when the ship is charging at the port, each bridge arm adopts an independent constant current limiting voltage control strategy and a constant voltage limiting current control strategy to charge the battery; Second, when the ship leaves the port for discharge, the bidirectional DC converter switches the mode to reverse output power. At this time, the converter control strategy is switched to constant voltage current limiting control to provide real-time power demand for the DC network side; third, when the ship is parked, the switching mode of the two-way DC converter needs to provide or absorb the corresponding power demand in real time according to the requirements of the ship's power system to ensure the normal operation of the entire ship[4].

The control system adopts a DSP28335-based controller, including 1 control board, 1 interface board, and 3 drive boards. The main control board contains functions such as analog sampling processing, switching input status detection, switching output status control, temperature sampling detection processing, PWM drive signal generation and fault information collection processing; the interface board is the external interface extension of the control board, including All the interface circuits of the corresponding functional unit of the main control board are provided, and the power supply of the external hall can be provided at the same time to provide power for the drive board.

The sampling signal of the charging and discharging device includes 1 DC input voltage signal, 1 DC output voltage signal, 3 input current signals, 1 temperature signal, a total of 6 sampling signals; a total of 4 passive input signals and a total of active output signals 4 channels (to be defined by the user).
4. Implementation Of the Charging and Discharging Device

The charging and discharging device has been successfully applied to a certain type of all electric inland river cruise. When the ship is sailing normally, it controls the discharge current of the battery cluster of the battery system. Ensure that during normal navigation and when a single battery cluster fails, the charging and discharging device controls the current of the battery cluster, and the discharge current of the battery system is balanced and does not exceed the discharge capacity of the battery system;

When the ship berths and docks, the shore-based charging pile is used to charge the ship’s battery system. When the ship berths and docks, the shore-based charging pile is used to charge the ship’s battery system. The charging and discharging device ensures that the charging current meets the requirements of the lithium battery system, and the ship battery system is charged within the specified time. The successful application of charging and discharging devices will significantly improve the reliability of large-capacity lithium battery ships, and will significantly improve the environment in the Yangtze River and other inland river economic zones, and has good applicability in the field of new energy ships.

5. Conclusion
This paper designs a charging and discharging device for electric ships. Because of the large battery capacity of electric ships, when controlling the charge and discharge of the battery system, it is necessary to manage the charge and discharge current of the battery system reasonably. The device can convert a large range of energy storage system voltage into a stable DC output voltage, which can control the charge and discharge current of each cluster, and complete the charge management and discharge management of each cluster. The battery charging and discharging device should be able to adjust quickly and dynamically to adapt to changes in the load, with high operating efficiency, high power density and compact structure.

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