Analysis on the power system of photovoltaic diesel power storage ships

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Abstract—Aiming at the problems that current ships can only use traditional non-renewable energy sources such as petroleum as the source of power, and they would cause high energy consumption, and large pollution, a centralized control system for the power system of photovoltaic diesel power storage ships is designed. With the development of society, the concept of green economy and sustainable development is deeply rooted in the people's mind. Green ship has become the main theme of shipbuilding. At present, internal combustion engines are used as the power source for ships, with limited endurance, high operation and maintenance costs, and accompanied by a large amount of exhaust emissions, which are not conducive to environmental friendliness. This problem does not exist in the photovoltaic diesel storage ship power system. The system integrates photovoltaic power generation and diesel power generation, and cooperates with the energy storage unit to allow the ship to adapt to various weather conditions to work normally, achieve the purpose of energy saving and environmental protection and extend battery life. It is an innovative energy saving and environmental protection system.

1. INTRODUCTION

Nowadays, traditional ships can no longer meet the current requirements of society for energy saving and environmental protection. In this context, the photovoltaic diesel storage ship power system emerged at the historic moment. This system can supply ships with photovoltaic power and diesel power. When the light is sufficient, photovoltaic power supplies all the ships' needs, and the excess electricity is stored; when the light is insufficient, the photovoltaic power generation unit and the energy storage unit are used to power the ship; when the light is insufficient for a long time, the diesel engine is started Machine power\textsuperscript{[1]}. The centralized controller can well reduce the use of diesel and reduce the emission of polluting gas. At the same time, the components of this system are modularly integrated, which has the advantages of simple structure, small size, small mass, and easy assembly and maintenance. It will be easy to apply to various types of ships in large quantities in the future.

2. SYSTEM COMPOSITION AND WORKING PRINCIPLE

2.1. System composition

The system is a centralized controller composed of photovoltaic power generation modules, MPPT (Maximum Power Point Tracking) control systems, energy storage modules, energy storage control systems, and inverter control system\textsuperscript{[2]}. 

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2.2. System working principle
The system uses the MPPT algorithm for maximum power tracking of photovoltaic power generation units, studies the working principles of energy storage units and inverter units, and studies the centralized control targets under a reasonable configuration scheme for photovoltaic diesel energy storage systems.

First of all, it is known that the essence of MPPT is that the controller can detect the power generation voltage and current of the solar panel in real time and track its maximum value[3], so that the system always outputs to the outside with the highest efficiency. Secondly, the energy storage control unit can store and release electrical energy by controlling the energy storage elements, so that the electrical energy generated by photovoltaic power generation can be used reasonably. Finally, the DC power generated by the photovoltaic power generation unit and the energy storage unit is converted into AC power through the inverter system to power the ship system.

3. Technical routes

3.1. Topological structure of photovoltaic diesel energy storage ship power system and its centralized controller
The solar panel in this system realizes the conversion of light energy into electrical energy for use by the load[4]. As an energy storage unit, on the one hand, the electric energy generated by solar cells is stored, and on the other hand, it is used as the energy source of the entire ship under specific needs. The power and battery can be seamlessly switched. Diesel generators are generally not used as auxiliary devices. Activated only when encountering severe weather or in an emergency[5]. Figure 1 shows the topology of a photovoltaic diesel storage ship power system and its centralized controller.

3.2. Control Strategy of Photovoltaic Diesel Energy Storage Ship Power System
3.2.1. Maximum Power Tracking MPPT Control for Photovoltaic Units
The MPPT module simulates its control strategy by changing the local shadow area. Figure 2[6] is a schematic diagram of the maximum power tracking circuit. When factors such as temperature and light intensity change, their corresponding voltages and currents will also change[7], resulting in changes in photovoltaic power generation efficiency and corresponding maximum power points. In the process of tracking the maximum power point, the real-time voltage and current data is fed back to the detection unit, and the corresponding maximum power point is obtained through the ABFOA algorithm, so that the photovoltaic module always maintains the maximum power output.
3.2.2. Energy storage system control

Figure 3 is a dual full-bridge bidirectional DC converter[8], which is a simple circuit model consisting of two bridge arms, each of which contains four IGFETs, which are connected to The energy storage unit and the photovoltaic power generation unit can adjust the ratio of the intermediate coil to stably deliver the DC power generated by photovoltaic power generation to the energy storage unit or the inverter unit. At the same time, it can also transfer the direct current After being transformed, it is delivered to the inverter unit and finally delivered to the ship for use. The converter can well connect the energy storage unit, photovoltaic power generation unit and inverter unit, and through the reasonable distribution of electrical energy, the ship can reduce the use of fuel.

3.2.3. Contravariant strategy

Since direct current cannot directly increase and decrease voltage, and alternating current can, the system needs to use an inverter to convert direct current to alternating current. The direct current is converted into alternating current by the modulation circuit, and the obtained alternating current is then boosted by the coil to supply power to the ship system[9]. The inverter of this system is composed of a three-phase bridge PWM inverter circuit[10]. As shown in Figure 4, the drive signals of its two upper and lower bridge arms are complementary. The modulation circuit controls the on and off of the six triodes to turn the device on and off six times throughout the cycle, thereby obtaining three-phase alternating current and direct current. The inverter is converted into AC power for use by the marine system.
3.2.4. Coordinated control strategy

When the photovoltaic array power output is greater than the load power, the photovoltaic controller directly transmits power to the photovoltaic inverter unit, and the excess energy is charged to the energy storage unit through the energy storage unit control module BMS and the energy coordination control module, as shown in Figure 5.

When the output of the photovoltaic array is less than the load power, seamlessly switch to the photovoltaic controller and energy storage unit (via the BMS module and the energy coordination control module) to supply power to the photovoltaic inverter unit, as shown in Figure 6.

In the case of long-term rainy days, if the power output of the photovoltaic power generation unit is insufficient and the energy storage unit energy cannot support the normal operation of the electrical load, the diesel engine unit is powered on[11] and the energy storage unit is charged, as shown in Figure 7.
4. **SYSTEM CHARACTERISTICS**

Photovoltaic power generation and diesel power generation work in coordination and complement each other to save energy.

- Each control module can be centralized to form a centralized controller, which makes the system simple and reduces the failure rate.
- The system can reduce carbon emissions, reduce energy consumption, and help protect the environment.
- The system has a high degree of automation, which can reduce labor costs.

5. **CONCLUSION**

The photovoltaic diesel energy storage ship power system designed by this system realizes the organic combination of photovoltaic power generation and diesel power generation, so that it can reflect the characteristics of energy saving and consumption reduction and increase the system's smooth operation throughout the life cycle. The design is conducive to saving shipping costs and extending battery life, and now realizes green shipping.

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