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Research on Power Management of Ship Power System

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Abstract

Modern shipbuilding technology is developing day by day, and the stability and energy-saving requirements of ship power system power management are getting higher and higher, so the importance of ship power stations is increasing in control, detection and management. According to the characteristics of electric oil hybrid power as the electric power management system of electric ship, the structural and functional requirements of the ship's power system are analyzed, and the ship electric energy management system is designed. The ship power system is composed of Siemens S7-1200 model PLC and Danish DEIF PPM300 as the core controller, and the function design and software flow of the dual fuel generator set and the shaft generator set are elaborated. The ship power system has been put into use. The actual effect is good.

Keywords

Ship power management; shaft power generation; dual fuel power generation.

1. PREFACE

At present, China's ship power system is mainly based on a power system composed of a radiating structure, AC motors and other marine equipment. The electrical energy of the electrical load is transmitted by the marine distribution cable through the centralized distribution board on the ship. Therefore, thousands of marine cables on the ship are interspersed in various parts of the ship, which results in a large number of marine cables being placed in the various compartments of the ship. With the increasing power load of ships, the power distribution system has become huge and complicated. It also needs the ship power management system to improve the ship's power system by concentrating, controlling, and distributing the power generated by the generator set and managing the ship's electrical equipment. Scientific and rational.

The dual-fuel power generation system uses a dual-fuel unit as the prime mover, and uses diesel and natural gas as fuel. The dual-fuel unit drives the generator to generate electricity, converts mechanical energy into electrical energy, and then transmits electricity to the ship's power grid. This is a gas supply with high emission level, long-term stable and safe operation, no carbon deposition of natural gas, no PM2.5 emission, low wear resistance to cylinder liner and piston ring, simple maintenance, and perfect adaptation to instability. Marine power generation equipment that automatically switches diesel fuel and dual fuel modes.

The shaft power generation system drives the ship's generator through the main engine, and uses the rich power of the main engine to achieve energy saving. The shaft power generation system has many advantages such as reducing fuel consumption, reducing light diesel consumption, reducing maintenance costs, improving the working environment, reducing oil consumption, and facilitating the layout of the engine room. This has led to the application of more and more shaft power generation systems in modern shipbuilding technology and experimental academic research.

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2. OVERVIEW

This paper introduces the ship electric power comprehensive energy-saving and emission reduction training platform newly established by Shanghai Maritime University. The power management system of the platform consists of one dual-fuel generator set (G1), two diesel generator sets (G2, G3) and one set. The shaft generator set (SG) is composed, as shown in Figure 1. The system has several modes of operation:

1) Co-generation, that is, dual-fuel generator sets, two diesel generator sets and shaft generator sets are simultaneously operated in the network, and the common phase ship power supply;

2) Dual-fuel power generation, that is, diesel generators and shaft generators are shut down, and only dual-fuel generators operate on the grid to supply power to the ship's power grid;

3) Shaft-band power generation, that is, diesel generators and dual-fuel generators are shut down, and only the shaft generator runs on the grid to supply power to the ship's power grid;

4) Diesel power generation, that is, dual-fuel generators and shaft generators are shut down, and only diesel generators operate on the grid to supply power to the ship's power grid;

5) Dual fuel power generation and shaft power generation, that is, diesel generators are shut down, dual fuel generators and shaft power generation are operated in the network to supply power to the ship's power grid;

6) Dual-fuel power generation and diesel power generation, that is, the shaft generators are shut down, and the dual-fuel generators and diesel generators are operated in the network to supply power to the ship's power grid;

7) Diesel power generation and shaft power generation, that is, the dual-fuel generator set is shut down, and the diesel generator and the shaft generator run on the network to supply power to the ship's power grid;

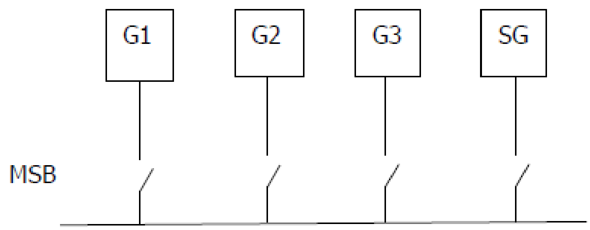

Figure 1. The platform power management system topology

In general, the ship power system power management system is in a dual fuel power generation mode, a diesel power generation mode, or a shaft power generation mode. A short co-generation mode is required only when load transfer is required, or when the shaft power generation system and the dual fuel power generation system are started.

3. STRUCTURE AND FUNCTION

3.1. Structure

As shown in Figure 2, the energy management system (PMS) of this experimental system consists of four PPM 300s and one Siemens S7-1200 PLC. The PPM300 includes dual fuel units (G1), diesel generator sets (G2, G3) and shaft belts. The generator (SG) and PPM300 control and protect each unit. The Energy Management System (PMS) system provides G1, G2, G3 start, stop, synchronization, desequencing, power distribution, and C4, C5/C51, C6 start and stop functions.

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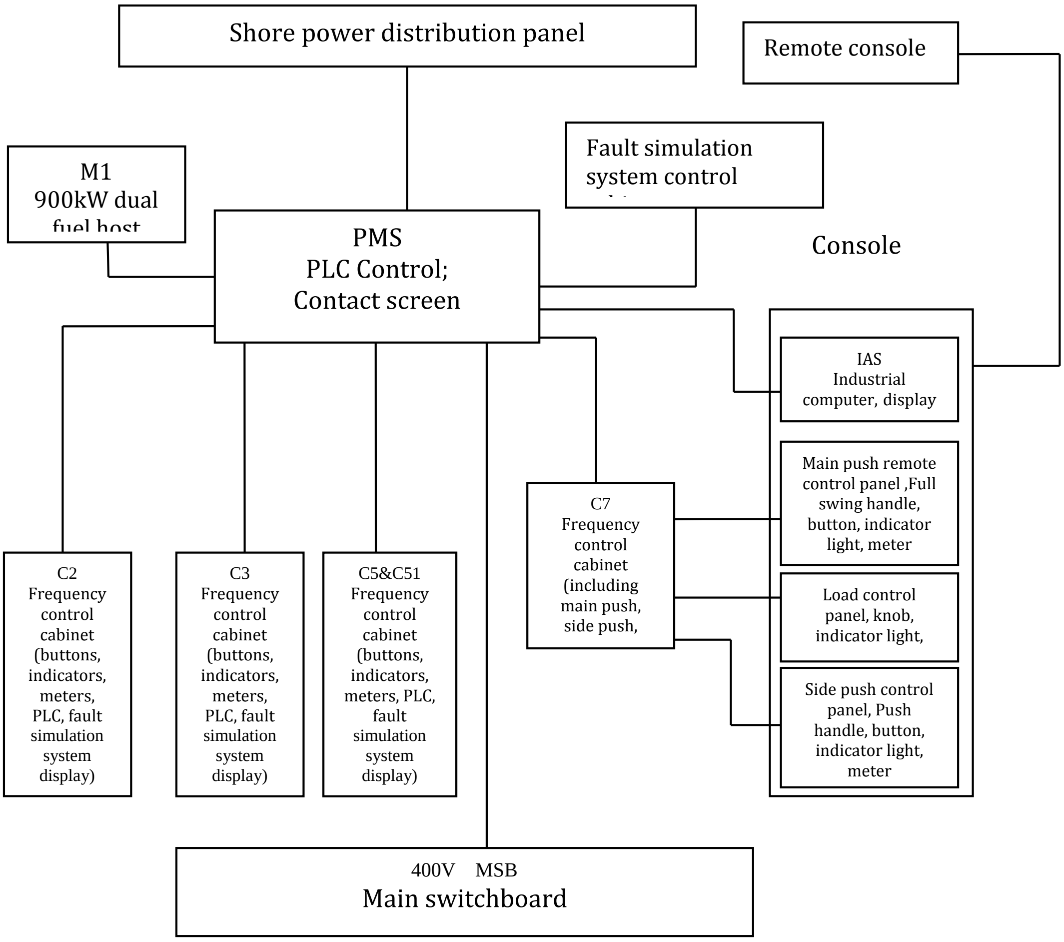

Figure 2. Energy management system structure

3.2. Main Function

The single line of the experimental platform is shown in Figure 3.

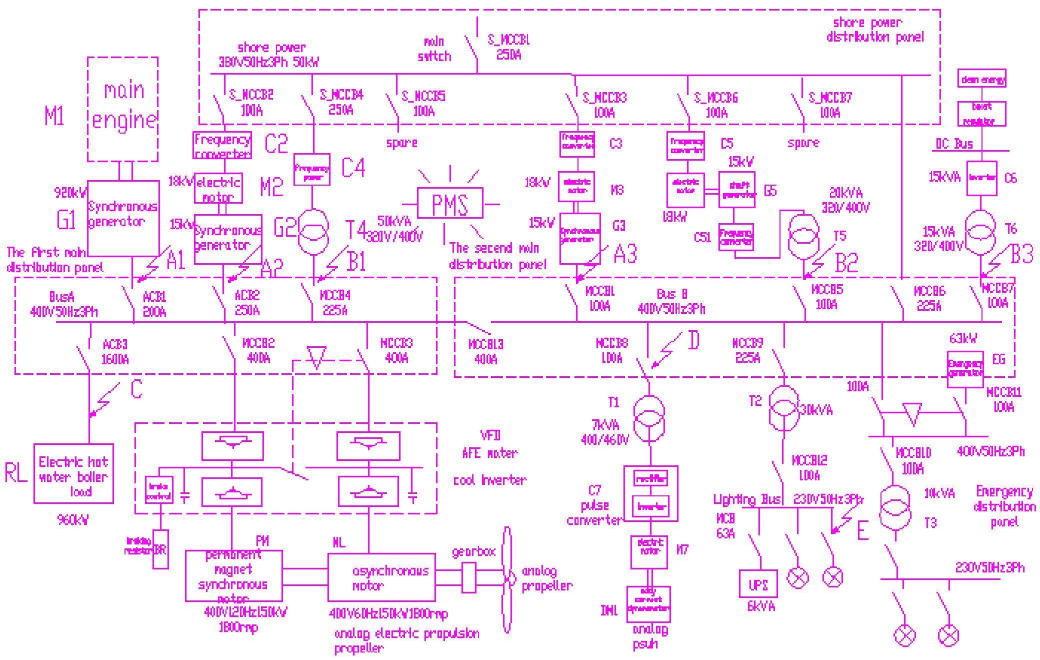

Figure 3. Experimental platform single line diagram

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3.2.1 Control mode

The modes of the energy management system include: manual parallel, semi-automatic and full-automatic control. Manual parallel driving refers to manually controlling the start and stop of the generator set through the switchboard knob, and the generator is connected to the grid and disconnected. The semi-automatic parallel mode is semi-automatic control of G2 and G3 through the PPM 300 display unit button. The automatic control refers to the PMS automatic control of the generator set related functions. Automatic/semi-automatic switching is performed on the PPM 300 display unit.

3.2.2 Unit standby / priority selection

The user can set the order of priority of the unit through the PPM panel. The start/stop sequence of the PMS for the G2 and G3 generator sets is based on priority and the priority order of the units can be modified online.

3.2.3 Working mode selection

PMS working mode: Conventional power station mode: Only G2/G3 units operate on the network and start/stop according to grid load. Shaft generator mode: C51 shaft with generator set alone in the net. Shore power mode: C4 variable frequency power supply is in the network alone. Large unit mode: Unit G1 is on the net. Wind power mode: C6 variable frequency power supply is in the network alone.

Mode switching is triggered by soft keys on the AMS's PC screen. Among them, only the conventional power station mode can be switched with other modes, and the shaft generator mode, the shore power mode, the large unit mode, and the wind power mode are not switched. It is necessary to ensure that G2 and G3 work in automatic mode before mode switching.

3.2.4 Integrated Faulty Machine Fault Monitoring

For the G2 and G3 generator sets, when the system detects that there is a comprehensive fault in one generator set, the standby unit is immediately started to be put into the grid to prevent the impact of the failure of a single generator set on the grid, and the standby unit is successfully connected to the grid ,parking.

3.2.5 Calculation of automatic increase and decrease machine and residual power

In the conventional power plant mode, the number of generators in the network should be dynamically adjusted according to the load. According to the actual grid load, it can automatically start and synchronize the grid-connected standby units, or automatically ungroup and stop one unit in the network.

The PMS will send the remaining power signal 4-20 mA to the propulsion system in real time through the PPM 300 in the large unit mode, the conventional power station mode and the shaft generator mode. In other modes, the residual power signal 4~20mA is sent to the propulsion system in real time through the PLC.

3.2.6 Automatic control of power-changing operation in axis-on mode

In the axis sending mode, when the host car command changes, the system determines whether the command speed needs to be executed. If the system is running, the system will automatically start the standby unit. After the car is operated as soon as possible and the load is switched, the host maneuver command is switched. Instead of using a shaft generator when entering or leaving the port and leaving the terminal, the ship uses an auxiliary diesel generator. The shaft generator must be operated in parallel with the auxiliary diesel generator for a long period of time. The control circuit of the frequency converter in the shaft generator system is required to have the same characteristics as the governor. Therefore, when the shaft generator set is selected, continuous operation is generally not considered. Requirements for parallel operation. However, the ship needs to be temporarily parked during the voyage, or when entering or leaving the port, it must consider the electrification conversion with the auxiliary

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diesel generator set. The electrification conversion must be carried out within the range of 60% to 110% of the rated speed of the main engine. When the host is in emergency stop and emergency reversing, two conversion methods can be used: one is that the main engine speed drops below 60%, and the power is converted; the other is that the main engine speed is maintained at 60% of the rated speed, and the power supply is converted to After the auxiliary diesel generator is activated, the main engine speed is drastically reduced. If there is no time to convert the power, the host is required to stop. At this time, only the emergency power supply can be used.

The start-up grid-connected process in the axis-running mode has mode one (same as C4, called fixed-frequency): the PMS will first judge the state of C5 and C51 and after detecting that S_MCCB_6 is closed, it will send a C5 start signal to the running signal of C5. After the occurrence, the C51 start command is issued with a delay of 5s. After receiving the running feedback of C51, load transfer is performed. Then G2/G3 will automatically open the barrier and then stop. Mode 2 (called frequency conversion): As with the general parallel operation, the PMS will first judge the status of C5 and C51 and after detecting that S_MCCB_6 is closed, it will send a C5 start signal. After the running signal of C5 appears, the delay is 5s and C51 is issued. Start command. After the C51 running feedback is detected, the PMS triggers the shaft generator closing command, and the PPM 300 SG will control the diesel generator speed control via Ethernet to complete the synchronization. After MCCB_5 is closed, G2/G3 will automatically open the barrier and then stop.

3.2.7 Inverter C4 is connected to the grid and disconnected

When the working mode is selected to the shore power mode, the PMS first judges the state of C4 and receives the S_MCCB_4 closing feedback. The PMS sends a C4 start signal, and the C4 is automatically turned on and then started. After the PMS detects the running feedback of C4, the PPM 300 of G2 and G3 will automatically open the barrier and then stop.

When the shore power mode is switched to the normal power station mode, the PMS will automatically control G2 or G3 to start the grid connection. After G2 or G3 is closed, the PMS sends a power-down signal to C4. When the load is to be transferred below 5%, the PMS sends a stop signal to C4. C4 needs to send a 4-20 mA power signal to the PMS.

When the PMS receives a startup failure and a comprehensive alarm of C4, the handover process is interrupted.

3.2.8 Grid and Disconnect of Other Power Supply C6

When the operating mode is selected to the wind power mode, the PMS first determines the state of C6 and receives the S_MCCB_70 closing feedback. The PMS sends a C6 start signal, and the C6 automatically turns on and starts. After the PMS detects the running feedback of C6, the PPM 300 of G2 and G3 will automatically open the barrier and then stop.

When the wind power mode is switched to the normal power station mode, the PMS will automatically control the G2 or G3 to start the grid connection. After G2 or G3 is closed, the PMS sends a power-down signal to C6. When the load is to be transferred below 5%, the PMS sends a stop signal to C6. C6 needs to send a 4-20 mA power signal to the PMS. When the PMS receives the startup failure of C6 and the integrated alarm, the handover process is interrupted.

4. SYSTEM DESIGN

4.1. Hardware Design

Considering the harsh working environment in which the ship power station is actually operating, the hardware equipment must have the characteristics of strong environmental adaptability and high reliability. SIEMENS PLC has excellent logic control function and superior anti-interference ability, which is the best choice for the ship's power management system

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hardware. Therefore, the power management system of this experimental platform uses SIEMENS S7-1200 PLC and PPM300 as the core controller, and cooperates with the digital input/output module and the analog input and output module to complete the management function of the power generation system of the power station. The S7-1200 PLC is reliable, affordable, flexible and expandable, representing the future direction of small PLCs and leading the new trend of automation. The PPM300 power management system combines a variety of control, protection and detection functions, including dual fuel units (G1), diesel generator sets (G2, G3) and shaft generators (SG). PPM300 controls and protects each unit.

4.2. Software Design

The SIEMENS S7-1200 PLC is configured and programmed with engineering software. The configuration software supports the ladder diagram and the SCL programming language. The SCL language is similar to the C language, and the PLC program of this system mainly uses the SCL programming language. The software of the ship's power management system controller is modular in design.

When the power generation mode is diesel generator power generation or shaft motor power generation, the power management system only needs to meet the power supply requirements of the power grid according to the basic functions, reasonably distribute the power, and manage the power equipment. The situation becomes somewhat complicated when the grid generation mode is switched between diesel motor generation and shaft motor generation. In order to ensure a smooth transition between the power grid and the power equipment during the power generation mode conversion process, the system adopts a better engineering effect.

5. CONCLUSION

The energy management system (PMS) system of the experimental system described in this paper can provide the functions of starting, stopping, synchronizing, decoupling and power distribution of dual fuel generator sets, diesel generator sets and shaft generator sets, as well as various frequency converters and inverses. Start and stop function of the transformer.

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