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Application and Development Trend of Ship Electrical Automation Technology

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ABSTRACT
Ship electrical automation plays a crucial role in the operation of ships. From an application perspective, power electronics technology provides power support and stable operation for equipment through the power electronics platform, while also monitoring power transmission. Positioning technology, utilizing GPS and PLC, achieves precise positioning, optimizes routes, controls headings, and enhances navigation safety. Anti-interference technology ensures the stable operation of automatic control systems by implementing electromagnetic compatibility measures. Future trends include: intelligence, which involves the integration of various technologies to promote ship integration; digital energy conservation, which uses information transmission to manage energy efficiency; and the core of integration lies in the modularization and intelligence of equipment, which can enhance the system's control and monitoring capabilities. The application and development of ship electrical automation are crucial for improving operational efficiency, ensuring navigation safety, and promoting the growth of the shipbuilding industry.

KEYWORDS
Marine electrical automation technology; Power electronics technology; Positioning technology; Intelligence

1 Introduction

As the world economy continues to expand at an unprecedented pace, the importance of international trade cannot be overstated. Within this context, the safe and efficient operation of ships, serving as the backbone of maritime transport, plays a pivotal role in sustaining the prosperity and stability of the global economy. The advent of ship electrical automation, which employs intelligent control systems to manage a ship's power systems, navigation systems, and a myriad of onboard equipment, has emerged as a critical element in elevating the overall operational capabilities of ships. This technological evolution has transformed from its early iterations of simple electrical control mechanisms to today's sophisticated integrated systems that amalgamate power electronics, advanced navigation and positioning technologies, and robust anti-interference capabilities. Each significant leap forward in the realm of ship electrical automation is not only redefining the trajectory of the shipbuilding industry but is also setting new benchmarks for efficiency, safety, and environmental sustainability. By delving into these applications and the ongoing development trends, we gain invaluable insights into the latest advancements in shipbuilding technology. Furthermore, this exploration illuminates the path towards a more intelligent and environmentally friendly future for the maritime industry, aligning with global efforts to foster sustainable development and reduce the ecological footprint of shipping operations.

2 Application of ship electrical automation technology

2.1 Application of power electronics technology

The application of power electronic devices in marine machinery systems primarily focuses on the purposeful and distributed transmission of power energy, ensuring the overall operation of system devices powered by internal power energy. For instance, in shaft-driven power generation units, which are constrained by engine quality characteristics, the energy consumption during the current operation of the ship system is defined as the speed change of the main drive shaft, ensuring the continuous operation of the related equipment powered by power energy, with the overall operation being confined to the intrinsic parameter measurements of the equipment. Regarding the implementation of power electronic devices, an electronic information platform can intuitively display the current operational status of the equipment. When the power energy transmission exceeds a reference value, the system automatically triggers an alarm to alert the operator, who then performs maintenance and repairs on the corresponding equipment based on any errors detected during power transmission, ensuring the normal operation of the internal machinery.

Moreover, the integration of these advanced electronic devices in marine engineering has revolutionized the way power is managed and distributed across various systems on board. This sophisticated approach to power management not only enhances the efficiency of energy usage but also contributes to the longevity and reliability of the machinery. By closely monitoring and controlling the power flow, these devices help in maintaining the optimal performance of the machinery, thereby reducing the likelihood of breakdowns and extending the operational lifespan of the equipment. The

electronic information platform, equipped with real-time data analysis capabilities, provides a comprehensive overview of the machinery's health, allowing for predictive maintenance and reducing downtime. This proactive approach to maintenance ensures that any potential issues are addressed before they escalate into major problems, thus maintaining the smooth operation of the vessel and enhancing safety at sea.

2.2 Application of positioning technology

Most ships navigate in the ocean, where the environment is highly variable and unpredictable, posing significant risks to ship operations. By applying navigation and positioning technologies, vehicles can achieve automatic positioning and optimal route adjustments, thereby reducing safety hazards and minimizing driving risks. GPS technology uses satellite communication to accurately determine a ship's position at sea. The satellite communication signals provided by the International Maritime Satellite Organization (IMSO) can cover most maritime routes, seamlessly integrating with various communication devices on ships to provide accurate location information. Ships can transmit their position information to connected devices via GPS receivers, enabling operations such as coordinate changes on maps, and then sending the results to the driver's handheld mobile terminal and navigation system to plan and generate the optimal route, thereby reducing potential operational risks caused by unknown factors. When navigating in a channel, PLC technology is used for automatic control, allowing for real-time monitoring and confirmation of the ship's navigation status. By comparing the ship's dynamic position information with channel information, the system can issue warnings for situations such as deviation from the channel, alerting the driver to take appropriate actions. In complex navigation environments, such as dense fog or low visibility conditions, the system can perform complex calculations, analyze navigation information such as wind speed and speed, accumulate useful data, predict dangerous events scientifically, and help operators correct their routes in a timely manner, improving operational efficiency and safety.

2.3 Application of anti-interference technology

To ensure the stable operation of ship automation systems, electromagnetic compatibility technology must be employed to enhance the equipment's resistance to interference. For inductive loads, transformer isolation technology is used to shield against electromagnetic interference and electrically isolate circuits, effectively suppressing coil current interference. To effectively suppress electromagnetic interference, a separate insulated transformer should be installed for monitoring and alarm equipment in the ship's power system, and an AC transformer should be set up for the power network. Construction vessels are equipped with slurry pumps and drilling rigs, which require variable frequency speed control. The high-order harmonics generated during this process can interfere with instruments and equipment, leading to operational errors on the construction vessel. Using rectifier transformers for harmonic suppression and filters to remove interference signals can ensure the safety of the automatic control system. Additionally, many power cables are installed on ships. When these cables are close to communication lines, they can easily cause EMI issues, leading to interruptions in equipment communication. To suppress electromagnetic interference, armored power cables and those with shared or independent shielding should be selected based on the strength of the monitoring signals. For cables and signal lines of different voltage levels, the distance between cables should be at least 50 millimeters, and long-distance parallel laying should be preferred. For variable frequency speed control motors, the conductivity of the shielding layer must reach more than 1/10 of the conductivity of the cable's phase core wires to ensure reliable grounding. Furthermore, it is essential to ensure that both the power supply inlet and the busbar are reliably grounded. This includes ensuring all equipment in the control cabinet is properly grounded and isolating the interference source grounding terminal from other equipment grounding terminals. The start and stop of equipment can also cause voltage fluctuations in the ship's power grid. The power supply for the automatic control system must be an independent DC regulated power supply or an UPS uninterruptible power supply. Additionally, isolation devices against electromagnetic interference must be installed at both the signal acquisition box and the signal output terminal to ensure the system's communication functions properly.

3 Development trend of ship electrical automation technology

3.1 Intelligence

As a network communication system that connects the ship to the outside world, the future competition in the global shipbuilding industry will increasingly revolve around the concept of intelligent ships, with the advent of new high-power semiconductor power electronic components and the widespread adoption of information technology. This trend signifies a transformative shift in the industry, where the integration of modern information technology and artificial intelligence with traditional shipbuilding techniques becomes paramount. The aim is to achieve scientific management

and control strategies for mechatronics, which is the synergistic integration of mechanical, electrical, and computer systems. The industry is poised to advance in several key areas, including satellite navigation, intelligent control systems, direct communication channels between ships and shore facilities, and the utilization of GPS technology. The trajectory of ship automation technology development is clear: it is geared towards the full automation of ships, encompassing all aspects of a vessel's operation, from the engine room and navigation systems to machinery and cargo handling. This comprehensive approach also includes the collection, analysis, maintenance, diagnosis, and management of ship information, with the goal of enabling big data processing, analysis, and automatic control functions within the navigation command center. By leveraging these advanced capabilities, the industry aims to provide robust support for the safety, efficiency, and secure navigation of ships, ensuring that they can operate optimally in a variety of maritime environments.

3.2 Digitization

The energy conservation of ships has become a significant research topic in the shipbuilding and navigation sectors, as the demand for more efficient and environmentally friendly maritime transportation continues to grow. In the future, the energy efficiency of ships will be guided by information sensing and communication navigation technologies, which transmit data on navigation conditions, energy consumption, monitoring and alarms, power management, fuel systems, and the control of pumps and valves in ballast systems. This will help analyze and aggregate energy efficiency indices to reduce emissions and enhance energy efficiency. As computer technology continues to evolve, applying advanced electrical automation technology to ships represents a new technological approach and development trend. The various components of ship electrical equipment communicate through signal channels, working in conjunction with the new ship integrated automation system to connect control and execution systems, enabling them to perform corresponding operations according to instructions, thus achieving ship automation. This integration not only optimizes the operational efficiency of the ship but also ensures the safety and reliability of the vessel. The implementation of these technologies is expected to revolutionize the way ships are operated and managed, paving the way for a new era of intelligent and eco-friendly maritime transportation.

3.3 Integration

The advancement of intelligent ship technology represents a significant leap forward in the realm of maritime engineering. This cutting-edge development is poised to greatly enhance the modularity and intelligence of ship electrical automation equipment. As a result, we will witness a substantial improvement in the automation levels of power supply, distribution, electric drive, and electrical systems. The sophisticated monitoring and alarm systems, which are crucial for the power devices in the engine room—such as the main engine, side thruster, and rudder motor—will be extended to the bridge. This extension will enable remote, visual monitoring, granting the crew the ability to oversee these critical systems from a distance. Real-time collection and automatic monitoring and alarms of relevant electrical parameters and operational data will be made possible, thereby improving detection accuracy and the timeliness of information transmission. Consequently, the ship's electrical system will largely achieve remote operation from the bridge, marking a new era of efficiency and safety in maritime operations.

4 Conclusion

In summary, the application of power electronics, positioning, and anti-interference technologies in ship electrical automation has made ship operations more stable, safe, and precise, thereby enhancing the overall performance of ships. Power electronics ensure stable power supply and high efficiency, GPS technology ensures safe navigation and real-time tracking, and anti-electromagnetic interference technology ensures reliable operation of the automation system in complex electromagnetic environments. These technologies have effectively enhanced the international trade and transportation capabilities of ships. Looking ahead, the trends in ship electrical automation are moving towards intelligence, digitalization, and integration. The intelligent integration of multiple cutting-edge technologies is driving a transformation in ship automation; digitalization focuses on energy conservation and efficiency, providing strong support for the sustainable green development of ships; integration improves system control and monitoring, laying the foundation for intelligent ship management. As technological innovation and breakthroughs continue to deepen, ship electronic automation will further enhance ship performance, promoting the industry's shift towards intelligence and sustainability. This will play an increasingly important role in maintaining the smooth flow of international maritime trade and driving global economic development, while also providing a strong impetus for the technological advancement and industrial upgrading of China's shipbuilding industry.

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