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Research Status and Development Prospect of Intelligent Ship System

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ABSTRACT: With the advent of the intelligent era, the world shipping industry and the ship industry have gradually focused on the development of intelligent ships, among which the intelligent ship system has become one of its research focuses. This paper introduces intelligent ships and intelligent ship systems, sorts out the development status of intelligent ship systems abroad, summarizes the development characteristics of intelligent ship systems outside China, looks forward to the development prospects of intelligent ship systems, and proposes that the research and development of key core technologies and key system equipment should be accelerated through the guidance of national key intelligent ship projects, andthe development of intelligent ship systems of various ship types should be promoted in an orderly manner.

Keywords: intelligent ships; intelligent ship systems; network maintenance; ship-to-shore communication equipment; development status; Development prospects

I. INTRODUCTION

Since China put forward the "Made in China 2025" strategy in 2015, high-end manufacturing has become a new highland for the world's scientific and technological revolution and industrial transformation.

Among them, in the "Made in China 2025" power strategy, the research of marine engineering equipment and high-tech ship-related technologies is listed as one of the top ten fields, and the development of intelligent ships has a new historical opportunity [1].

In the field of traditional vehicles, the intelligent start of ships is not late, and there are some relatively mature technologies in the early days, but due to the low degree of standardization of the ship itself, the uneven level of digitalization, and the variety of supporting equipment, it is difficult for ships to form standard data analysis methods and theories, and the level of data collection is low. In addition, the enthusiasm of shipowners to invest in the development of smart ships is gradually decreasing due to the high investment in communication bandwidth and network security construction.

Factors such as the slow recovery of the world shipping industry, the current relative scarcity of satellite broadband resources and the high investment in intelligent ship research have limited the development of intelligent ships in the early stage. However, as intelligent ship technology is widely regarded as the next generation of shipbuilding industry technology revolution, the world's major shipbuilding countries have begun to make efforts to invest heavily in intelligent ship research. At the same time, with the launch and operation of low-orbit broadband satellites in recent years, large-scale cloud computing services are expected to be realized on future intelligent ship systems. Throughout the development of intelligent ship systems in recent years, the supporting software of intelligent systems has been gradually improved, the intelligent equipment of ships has been continuously enriched, the cross-border cooperation of enterprises in the field of Internet communications, and the cooperation between industry, university and research have increased, all of which have promoted the rapid development of intelligent ships.

II. THE DEVELOPMENT STATUS OF INTELLIGENT SHIPS

In May 2006, the International Maritime Organization (IMO) adopted the E-Navigation related work project, that is, the use of electronic information technology to coordinate ship-shore communication and navigation information, to achieve information exchange between ships, ship-to-shore and shore-to-shore, and to promote marine environmental protection and efficient and safe navigation of ships. Intelligent ships have been listed as important topics by IMO and the International Organization for Standardization, and

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the world's major classification societies have also issued relevant specifications and guidance documents for intelligent ships, and the international ship and shipping industry is bound to develop in the direction of intelligent ships.

In recent years, China has vigorously developed intelligent ship technology. In 2017, the Ministry of Industry and Information Technology set up a special high-tech ship research project "Smart Ship 1.0"; In 2018, the Ministry of Industry and Information Technology, the Ministry of Transport and the Bureau of Science, Technology and Industry for National Defense jointly compiled the Action Plan for the Development of Intelligent Ships (2019-2021). In 2019, the Ministry of Transport and other seven departments jointly issued the "Opinions on the Development of Intelligent Shipping".

III. INTELLIGENT SHIP SYSTEM

3.1 Overview

The intelligent level of intelligent ships is mainly reflected in the intelligent systems that have been configured on the ship. According to the relevant guidelines issued by the China Classification Society, the functions of the intelligent ship system can be divided into 8 parts, namely intelligent navigation, intelligent energy efficiency management, intelligent cargo management, intelligent hull, intelligent integrated platform, intelligent engine room, remote control and autonomous operation, and these functions have gradually developed into corresponding subsystems. However, due to the different operational tasks of different types of ships, the functions of the intelligent systems required will also vary greatly [2]. Taking large ocean transport ships as an example, such ships mainly include liquefied natural gas carriers, large oil tankers, large bulk carriers and container ships, etc., and the common characteristics are mainly manifested as: high added value of ships and goods, large tonnage of ships, and greater consequences or harm caused by accidents, and the demand for remote control and autonomous operation functions of such ships is not strong in the short term. Despite this, all types of ships still have common requirements for intelligent ship system functions. It mainly includes intelligent navigation system, intelligent cabin system, intelligent energy efficiency system and intelligent integrated platform system.

3.2 Intelligent ship system equipment

Before constructing the overall scheme of the intelligent ship system, it is necessary to configure each intelligent system according to the actual operation task requirements of the ship, and clarify the equipment of each intelligent system in combination with factors such as ship structure, mechanical equipment layout, intelligent equipment configuration, crew operation specifications and habits. The main equipment of the intelligent integrated platform system includes integrated platform switches, communication gateways, servers, firewalls, multi-computer switches and integrated display workstations. The main equipment of the intelligent nacelle system includes nacelle status monitoring system software, equipment operation and maintenance software, sensors of main mechanical equipment in the nacelle, shafting vibration data acquisition box and shafting oil monitoring box, etc.; The main equipment of the intelligent energy efficiency system includes intelligent energy efficiency server, alarm monitoring system, communication and conduction, liquid level telemetry, power distribution board, flow meter and shaft power meter, etc.; The main equipment of the intelligent navigation system includes firewalls, uninterruptible power supplies, meteorological industrial computers, communication switches, en-route servers, en-route system switches, video graphics array transmitters/receivers, image acquisition cards, image servers, DC12V and 24V power supplies, navigation system related sensors and displays, etc. The installation of intelligent ship system equipment should reasonably adjust the ship structure and optimize the equipment layout according to the technical requirements of each intelligent system under the premise of meeting the installation specifications of ship electrical equipment.

IV. RESEARCH STATUS OF INTELLIGENT SHIP SYSTEM

The intelligent ship system is a large-scale comprehensive dynamic system, which has the characteristics of good safety, environmental protection and economy. Integrating new technologies such as artificial intelligence and modern information technology, the following is a brief description of China's international research status from the aspects of intelligent energy efficiency system, intelligent integrated station system, and intelligent navigation system.

4.1 Current status of international research

The development of global intelligent ships and intelligent ship systems has shown an overall trend of rapid development. However, due to the differences in the focus and technical advantages of international parties, the research

directions and paths of intelligent ship systems in various countries are different.

4.1.1 Intelligent energy efficiency systems

In 2009, Future Ship, a maritime consulting company owned by Deutsche Lloyd's Register, developed the "ECO-Assistant" software system for marine energy efficiency. The system calculates the optimal trim angle [3] for a particular vessel based on the ship's operating parameters, thereby reducing fuel consumption and CO2 emissions by up to 6% and increasing efficiency by up to 6% with a payback period of just a few months. In 2011, South Korea's Samsung Heavy Industries developed a ship energy efficiency management system, which can improve the integration of energy efficiency management systems by using data acquisition technology, long-distance data transmission technology, database and computer software, and can save at least 15% of energy consumption.

4.1.2 Intelligent integrated platform system

At present, the integrated platform management systems of major international ship automation equipment suppliers are relatively mature and have occupied most of the market share. SAM's integrated platform management system is an open system, in which the equipment is integrated into a system according to different functions within the framework of the ship network. The integrated platform management system follows a unified operation and design mode, uses a common hardware platform, provides a good human-computer interaction interface, reduces the difficulty of equipment installation and maintenance, the number of spare parts and the cost of personnel training, so as to reduce costs and increase efficiency. In 2012, the relevant units in Japan launched the research project of "Intelligent Ship Application Platform". The project has developed one set of intelligent information and control systems, which realize the functions of intelligent navigation, intelligent engine room, intelligent energy efficiency and remote maintenance management through traditional shipborne monitoring systems such as ballast water management, ship power management, electronic charts, and integrated host remote control.

4.1.3 Intelligent navigation systems

In 2017, the International Maritime Organization (IMO) added the topic of "Autonomous Unmanned Ships" and approved the Interim Guidance for Sea Trials of Autonomous Surface Ships in 2019 by circular. At present, due to the limitations of international legal conventions and the applicability of intelligent navigation technology, most of the research on foreign intelligent navigation systems tends to carry out technical research such as ship situational awareness, remote control driving, autonomous route optimization and auxiliary collision avoidance in open water on small ships. In 2017, Norway's YARA and Kongsberg partnered to build the first self-driving electric container ship, the YARA Birkeland. The vessel can achieve automatic avoidance in the channel through equipment such as global positioning system, radar, cameras and sensors, and the supporting automatic berthing system can complete the autonomous ship berthing and sailing. The hull was launched in February 2020, but further development was suspended due to the coronavirus pandemic and changing global outlook. In 2018, the Wärtsilä Group of Finland successfully tested the automatic berthing system of the ship, and in the presence of the Norwegian Maritime Authority, the ship operated autonomously and achieved uninterrupted operation of three port routes. This is the first attempt at fully automated shore-to-shore navigation for a vessel of this size in fully unmanned mode.

4.2 Current status of research in China

4.2.1 Intelligent energy efficiency system

At present, China's intelligent energy efficiency control system technology research is still in its infancy, and the intelligent energy efficiency management system still needs to be continuously improved. In China, COSCO Container Lines Co., Ltd. cooperated with Shanghai Maritime University to develop a ship fuel monitoring system. The system can monitor fuel consumption, provide energy efficiency optimization schemes, and analyze the causes of abnormal fuel consumption, effectively realizing energy saving, environmental protection, cost reduction and efficiency improvement in the process of ship operation. COSCO SHIPPING Kilimanjaro – the first CCS-certified intelligent energy efficiency management vessel designed and built by Hudong-Zhonghua Shipbuilding (Group) Co., Ltd. for COSCO SHIPPING Group. The vessel's intelligent energy efficiency system not only monitors the energy consumption level of the ship, but also provides the crew and the shipowner with energy efficiency optimization decisions.

4.2.2 Intelligent integrated platform system

At present, China's ship intelligent integrated platform system is mainly used in

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China's self-developed intelligent ships, and the development is still in its infancy. In China, Changshu Ruiter Electric Co., Ltd. has developed an intelligent ship integrated information platform. The platform realizes the reliable interaction and information visualization of system data, and unifies the information model of the data of various intelligent systems of the ship. China Ship and Ocean Engineering Design and Research Institute has developed and installed an intelligent engine room integrated platform system for China's polar research vessels. The implementation of the integrated platform system project has brought China's polar research icebreaker to the world's advanced level.

V. PREDICTION OF THE DEVELOPMENT PROSPECT OF INTELLIGENT SHIP SYSTEM

5.1 New intelligent systems

With the continuous development and application of technologies such as artificial intelligence and modern information technology in the field of intelligent ships,breakthroughs will be made in key technologies such as network and communication systems, ship intelligent perception systems, and intelligent navigation systems [4]. Different types of ships can be subdivided into their own intelligent system development routes according to their different tasks, and a new type of specialized and customized intelligent system can be generated, and the intelligent level of ship equipment, the degree of ship-shore collaborative interaction, and the integration of 54 equipment will be further improved.

5.2 Intelligent system network security

With the gradual improvement of ship networking, ship network security has begun to face threats, and the network security of ship intelligent systems has attracted close attention in the international maritime field. At present, the key tasks of China's intelligent ship development mainly include the intelligent ship system requirements to realize the ship's network and link security, ship data security, system hardware and software security, and improve the network and information security protection capabilities of intelligent ships.

5.3 Ship-to-shore communication system upgrade

The development of maritime satellite communication technology will promote the development and progress of ship-shore communication system and ensure the reliability of intelligent ship ship-to-shore communication system under high throughput and low latency conditions.

VI. CONCLUSION

At present, the world's intelligent ship research is still exploring and developing, the overall design of the ship intelligent system is not perfect, at present, the development of China's intelligent ship is facing challenges at the right time, so it should be based on the needs of intelligent navigation technology, and actively develop related technologies. Looking forward to the development of China's intelligent ships, it is also necessary to accelerate the research and development of key core technologies and key systems and equipment through the guidance of key national intelligent ship projects, accelerate the integration of intelligent ship technology, a new generation of information technology and artificial intelligence technology, tailor intelligent development strategies for various types of ships, promote the development of intelligent ship systems of various ship types in an orderly manner, and strive to improve the relevant performance of intelligent ships.

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