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Research on Intelligent Ship Navigation Dispatching Based on Equipment Support

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ABSTRACT. *Ship equipment support is an important factor to maintain and restore the ship's navigation capability. Compared with traditional ships, intelligent ships have lower human interference factors, higher autonomous navigation, complex equipment structure and a large number of equipment. How to ensure the safe navigation of intelligent ships and smoothly implement dispatching operation plans is an urgent problem to be solved in the development of intelligent ships. In this paper, the relationship between equipment support and navigation dispatching is discussed for the purpose of ensuring navigation dispatching, which leads to the demand of equipment support. Taking the maintenance technology as an example, the technical difficulties of equipment support are expounded, and the future research emphasis of equipment support is prospected.*

KEYWORDS: *intelligent,equipment support, maintenance,technical difficulties*

1. Introduction

As the development direction of future ships, intelligent ships integrate modern information technology, artificial intelligence technology and other new technologies with traditional ship industry technology to achieve the goals of safety, reliability, energy conservation, environmental protection, economy and high efficiency [1], which has been paid close attention by shipping industry. In order to seize the market of intelligent ships, major classification societies have issued standards for the identification of intelligent ships. For example, China Classification Society has issued "Code for Intelligent Ships", which includes domestic and foreign experience in the applications of intelligent ships and the development direction of intelligent ships in the future. Ship manufacturing enterprises jointly carry out research and development, and operation of intelligent ships with ship management companies and scientific research institutions. For example, Rolls-Royce Company has reached strategic cooperation and signed a memorandum of understanding with Singapore Marine Engineering and Ship Center (TCOMS), which is committed to developing the world's top basic technical framework for intelligent ships. However, the development of intelligent ships is

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still in the primary exploration stage, and there are still many key technologies to be broken through, such as equipment control theory, algorithm, high-speed and real-time communication, data acquisition, processing and analysis technology, etc. These key technologies play an inseparable role in ensuring the normal navigation and dispatching of ships. From the perspective of equipment support control, in order to implement the normal dispatching plan of ships and reduce the disorder of dispatching plan caused by equipment failure, this paper analyzes how to ensure the reasonable allocation of ship equipment support resources, with the minimum consumption of resources, to ensure the technical condition of ship equipment is in good condition and has the ability to continue sailing tasks, and to give full play to the efficiency of ship equipment [2].

2.Correlation Analysis of Equipment Support and NavigationDispatching

2.1 Characteristics of Ship Equipment Support

For intelligent ships, due to their complicated system and less manual intervention, more accurate dispatching plan is needed to ensure orderly dispatching. Therefore, the navigation guarantee needed by intelligent ships in various dispatching work during navigation should be safer, more reliable and more stable. For example, due to the reduction of personnel on the ship, the monitoring of the ship itself will be moved from the ship to the shore to realize remote monitoring. Compared with traditional ships, intelligent ships are more closely monitored, requiring faster communication speed and lower delay. Improving the emergency maintenance capability and increasing the redundancy guarantee of key equipment will ensure the timely response in case of ship failure, the safety of ship navigation and avoid the increase of ship losses caused by lack of manual intervention.

2.2 Correlation between Ship Equipment Support and Navigation Dispatching

Generally speaking, ships will make preparations for equipment support before dispatching, such as spare parts management, including spare parts inventory, spare parts application, spare parts procurement, etc. Preventive maintenance mainly inspects the main engine, generator and other equipment in marine engine room in advance to eliminate faults. During the voyage, the daily condition of the main engine is detected by using the working condition report form, and the daily maintenance work of the marine engine and deck department is done regularly according to the maintenance plan.

There is an significant correlation between ship equipment support and ship dispatching. If there is a potential failure of the ship's equipmentwhich may lead to functional failure, and at this time the key spare parts are in short supply, then the ship will have to change the original ship navigation plan, usually berthing at anchorage, and immediately carry out spare parts replenishment to ensure the subsequent safe navigation of the ship. If the maintenance means cannot accurately

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evaluate the maintenance time of the ship, it is difficult for maintenance personnel to timely and accurately implement the maintenance at the time when the ship needs to be maintained, and if the ship needs to be stopped at the dock for repair and maintenance in case of ship failure, it will also affect the ship dispatching plan.

Therefore, in order to ensure that the ship equipment support resources play their role, the ship should do a good job in spare parts management and maintenance, and reduce the possibility of ship equipment failure disrupting the normal ship dispatching plan.

3. Requirement Analysis of Ship Equipment Support

3.1 Management Requirements for Spare Parts of Ship Equipment

Ship spare parts are an important guarantee for the normal operation of ship equipment, and the cost of spare parts accounts for about one fifth of the cost of ship repair. The management of spare parts, which is one of the important basic management links of ships, will directly affect the safe navigation, operation rate and repair cost of ships. Therefore, it is vital to manage ship spare parts [3]. The purpose of ship spare parts management is to quickly find the required spare parts in the inventory when the ship needs to replace them, and to carry out replacement and upgrade efficiently and normatively, as well as to realize quality tracking. In order to achieve this goal, it is necessary to carry out spare parts list management, spare parts purchase plan management, spare parts inventory management, etc.

At present, ship spare parts mainly involve main engine propulsion, engine room auxiliaries, purification equipment, outfitting and anchoring, deck machinery,electrical automation, communication navigation, etc. The procurement cycle of spare parts shall be based on the average time interval of failure consumption, etc. Generally, the procurement plan shall be formulated on a monthly, quarterly or annual basis. For the spare parts with higher importance, if the equipment inventory is lower than the safety level, emergency stock will be prepared.

3.2 Management Requirements for Ship Equipment Maintenance

Maintenance management of ship equipment has a critical impact on the overall structure of the ship and the service life of internal mechanical and electrical equipment. The safety and reliability of ship navigation can be effectively guaranteed through ship repair and maintenance management. ship repair refers to the repair or replacement of parts and components to eliminate potential safety hazards through inspection of ship equipment. Ship maintenance is to master the abrasion of ship equipment, and then clean up dirt and filth in strict accordance with technical specifications. At the same time, lubricating oil is added to the ship for adjustment so as to eliminate hidden troubles of equipment components and replace equipment or components with serious abrasion in time. Moreover, ship

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maintenance has different grades and maintenance periods according to the degree of equipment maintenance and dismantling and the operation of equipment. The actual overhaul cycle of main components such as main engines, generators, shafting, boilers, etc. is generally based on the equipment specifications and determined according to the actual operation conditions of different ships. Different types of components are overhauled according to the operation duration, month, quarter, year or voyage. In addition, in order to urge ship maintenance, government departments also carry out inspections on ship equipment, mainly including whether the equipment can operate normally and whether the maintenance is carried out according to the cycle plan.

4. Research on Maintenance Technology

4.1 Condition-based maintenance and dynamic maintenance planning

1. Condition Based Maintenance (CBM)

CBM is to diagnose and predict the future effective working cycle of the equipment through real-time monitoring of the working state and working environment of the equipment and with the aid of advanced calculation methods such as artificial intelligence, so as to reasonably arrange the future maintenance time of the equipment [4]. The concept of CBM originated in the United States and is a maintenance method that has been widely applied and researched in recent years. CBM is based on the analysis of failure mechanism. According to the results of non-disintegration test, when the maintenance object has "potential failure", it will be adjusted, repaired or replaced, thus avoiding the occurrence of "functional failure". [5].

The theoretical basis is the P-F curve, which depicts the process of equipment state deterioration. In the figure 1, point A is the starting point of the fault. Point P is a potential failure point that can be detected, and point F is a functional failure point. T is the time course from potential fault to functional fault, called P-F interval. In order to prevent the occurrence of functional failure, the time for maintenance should be before point F. In order to accurately predict the probability of failure, real-time state data, historical failure data and key spare parts data of ship equipment should be collected, a failure prediction model should be established for calculation, the possibility of successful functional failure development of equipment from predictive failure should be judged, the calculation results should be uploaded to professional ship management personnel, and finally the ship dispatching decision-making arrangement should be executed according to expert conclusions.

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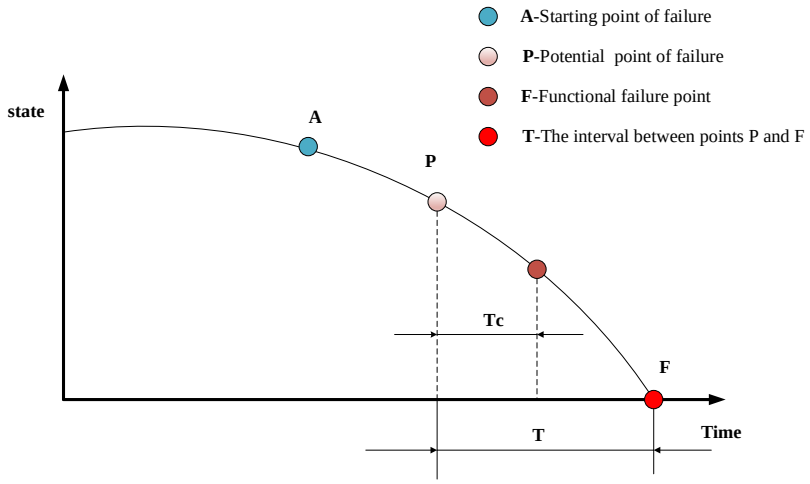

Figure. 1 P-F curve

2. Dynamic Maintenance Planning (DMP)

DMP improves the availability, reliability and effectiveness of equipment by fine-tuning the operating parameters of ship equipment components and adjusting the maintenance intervals of major equipment components (as shown in figure 2). DMP consists of remote condition monitoring service,Site audits and intermediate/opening inspections ,Maintenance planning service.

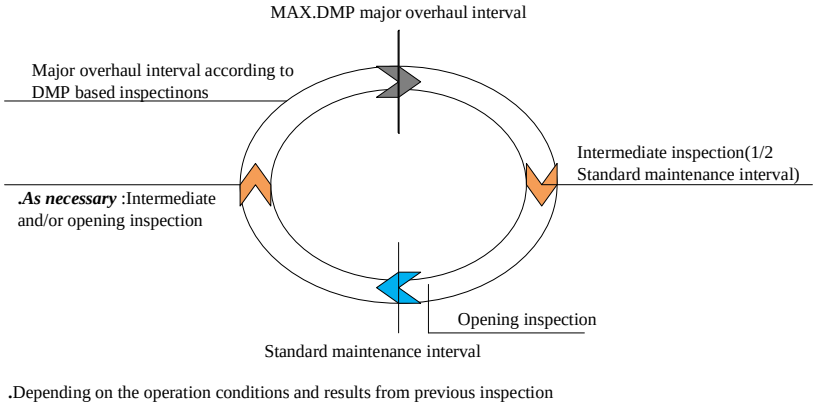

Figure. 2 intervals of major equipment components

The workflow of DMP is that customers can install systems around the world, upload the operation data of ship equipment to the database of the data center

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through the network for expert team analysis, and issue periodic reports to guide customers to implement equipment maintenance decisions. The expert team can directly and remotely access the ship equipment data after being authorized by the enterprise.

CBM and DMP can improve the reliability of ship equipment and reduce unexpected downtime to improve availability. minimize operation interruption caused by ship overhaul and operation plan; improve the level of engine efficiency and reduce fuel consumption.

4.2 Technical route

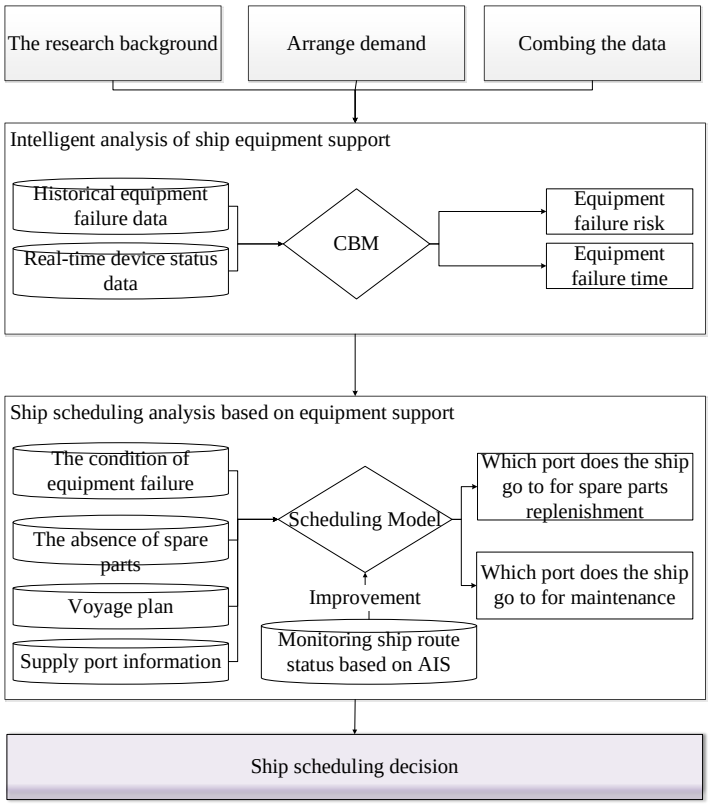

Figure. 3 The specific technical route

In order to study ship dispatching based on equipment support, it is necessary to synthesize various data information for modeling and analysis. The specific technical route is as shown in the following figure 3. Firstly, sensors installed on the ship's main equipment collect relevant equipment state data to establish a failure

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occurrence prediction model to predict equipment failure risk and occurrence time. Then, the ship dispatching plan model is built based on the equipment failure prediction, ship basic file information, spare parts information, local supplier information of the corresponding replenishment port and navigation plan, and the ship dispatching plan model is automatically analyzed which port the ship needs to go to for spare parts replenishment and which port to go to for maintenance. At the same time, the current navigation state of the ship is monitored by combining the Automatic Identification System(AIS) of the ship to judge whether the ship is carried out according to the navigation plan , whether deviation occurs in route or time, andwhether the ship dispatching plan model is corrected in real time. Finally, the ship dispatching decision can be obtained by intelligent calculation.

5. Difficulties and Directions of Equipment Support Research

5.1 Difficulties of Equipment Support Research

1. Data acquisition problem

The improvement of ship intelligence level is based on the high-density monitoring of ship equipment [6]. As the most densely populated place of ship equipment, the cabin of the ship has a very large amount of internal information, which requires a lot of work to collect. There are many types of data collected, which inevitably leads to data collection gaps. The main reasons are:

(1) Difficulties in data acquisition due to differences in cabin equipment architecture

The diversity and density of engine room equipment determine that there are many kinds of implementation forms for the bottom network of each subsystem in the engine room, which makes it difficult to collect and exchange the operating state data of engine equipment. In addition to the main engines ,such as generators and shafting, the data acquisition equipment suppliers of other equipment are scattered and have different specifications. In addition, it is difficult to install data acquisition devices on the periphery of some ship's own equipment systems, resulting in difficulties in data acquisition.

(2) Compatibility Limitation of Engine Room Data Acquisition Technical Scheme

At present, the bottom data acquisition card, which is the basis of the marine engine room data acquisition and monitoring system, has various implementation forms. Because the data acquisition cards provided by different companies are designed for the general development of the entire marine market, their communication methods and the number of data acquisition points are usually far from the actual engineering needs.

(3) The problem of communication charges restricts the scale and timeliness of data collection.

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There is a huge amount of data generated by marine machinery and equipment. The collection and transmission of these data need powerful communication techniques to ensure timely and reliable data. However, the cost of advanced communication technology is relatively high, and its high cost makes it impossible for shipping companies to apply it to ships on a large scale.

2. Data processing problems

The data collected by the ship collector should meet the needs of ship management personnel for equipment failure analysis. Therefore, how to ensure the quality of data is the difficulty of research. Data quality should ensure that data is comprehensive and accurate, consistent in format and semantics, easy to access, traceable and operable. At present, the following problems still exist in data processing:

(1) Effective Organization and Extraction

The data collected by the collector is delayed from being uploaded to the onshore database due to problems of lines, signals or delay, thus real-time data transmission cannot be realized; There are many suppliers of marine data collection products, many of which have their own data standards. Different data standards or the collected data cannot be converted into formats, which will result in the collected data being unusable.

(2) Cleaning and Analysis Modeling

Due to various quality problems such as errors, missing, inconsistent, inaccurate and incomplete data, effective data cleaning methods are needed to make it suitable for the needs of data analysis models [7]. At the same time, the analysis and modeling of ship data needs knowledge from machinery, automation, navigation, information science and other aspects to cross, and the modeling is also difficult.

(3) Problems of verifying the prediction effect.

Although we can estimate the probability of ship failure by establishing a ship failure prediction model and using the existing data, the accuracy of the results cannot be verified. In addition, the decision-making suggestions formed by the final fault diagnosis results still need people to decide whether to implement them or not, which is bound to be interfered by human factors.

5.2 Future Research Direction of Equipment Support

The realization of intelligent ship navigation support in the future requires the cooperation of all parties, extensive use of information technology, in-depth mining and use of ship, port, maritime and other data, construction of intelligent ship navigation support monitoring system, use of big data, artificial intelligence and other technologies, analysis of ship machinery and equipment operation, dynamic behavior characteristics of navigation and ship navigation risk prediction, giving navigation dispatching decision-making recommendations, effectively improving the ability of ship fault recovery, distress research and judgment, etc. In the aspect of

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intelligence of ship equipment support, the future research direction will mainly focus on how to continue to optimize ship equipment maintenance, equipment support demand forecast in advance, independent data collection and processing, maritime information sharing platform, etc.

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