Research on the Maintenance and Common Failures of the Marine Machinery and Equipment of the Scientific Investigation Ship

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Abstract. The reliability, maintainability and effectiveness Ships, machinery and equipment, maintenance, failure of various mechanical equipment is essentially the reflection of the state of this type of repairable system at different stages in the same random process. Scientific investigation of ship machinery and equipment maintenance is an important part of ship maintenance, which has a greater impact on the entire ship’s running quality and service life. This article analyses the common problems in the maintenance of marine machinery and equipment through the explanation of the significance of the maintenance of marine machinery and equipment, and takes the gas turbine as the research object, and specifically analyses its failure repair measures. It is hoped that the safety and quality of ship operations can be further improved, while ensuring the safety of the lives of the ship’s passengers, it also provides assistance for follow-up research on relevant content.

Keywords: Smart electric energy meter, RFID, data acquisition.

1. Introduction
In fact, many external factors can affect the daily operation of ships. For example, humid air, underwater factors, and strong sea breeze. Because these factors are uncontrollable factors, relevant personnel need to pay more attention to the repair and maintenance of ship machinery and equipment, so as to enhance the ship's anti-interference ability and reduce the restriction of external factors at sea. In daily life, workers need to pay attention to the common faults of ship machinery and equipment, and be able to eliminate these fault factors to the greatest extent, so that the ship can operate normally.

In the actual maintenance process, because the ship cannot be moored for a long time, the maintenance effect cannot reach the expected goal, and even the loss of mechanical equipment will be increased \cite{1}. Therefore, it is necessary to strengthen the application of repair and maintenance technology, improve the diagnosis and maintenance of common faults, and ensure that the ship can be dealt with in time when a ship fails, to a certain extent, to avoid the further expansion of the accident, and to ensure the safety of ship operation. With the development of the shipping industry, the number of large, medium and small ships in my country has always been increasing, but some ships lack...
maintenance management, and their equipment is aging but not replaced in time, which can easily cause shipping accidents. In the operation management and maintenance of marine machinery and equipment, there is a lack of a systematic maintenance system, and excessive attention is paid to the replacement and procurement of faulty equipment, but the quality of the safety guarantee of the equipment performance for the entire ship system is ignored. In the routine maintenance and operation of machinery and equipment, objective factors, such as the insufficient technical level of operators, often lead to aggravation of ship safety problems.

2. Failure types of ship machinery and equipment

2.1. Failure of the oil pump unit
For companies, they are very concerned about sailing costs. Therefore, many companies only allocate one oil pump unit for ships. In fact, oil pumping units can easily increase navigation accidents. Because the ship is in the process of sailing, it will be difficult to achieve emergency steering. In addition, since one motor is equipped with only one oil pump set, once the oil pump set fails, it will directly affect the ship's operation.

2.2. Propeller failure problem
Because the underwater environment is relatively complex, it often affects the propeller. For example, the propeller is separated or broken. The propeller is the main mechanism of ship operation. Therefore, the failure of the propeller will directly affect the operating efficiency and stability of the ship.

2.3. The problem of ship bottom water pipeline failure
Since the operating environment of ships is often affected by external factors, the bottom water pipelines of ships are also easily affected. The bottom water pipeline of a ship will also have a significant impact on the ship. Because it will not only affect people's inspection work on the bottom of the ship, but also directly affect the mechanical system of the bottom of the ship.

2.4. The problem of ship watertight wall failure
In fact, the watertight wall function of ships is also prone to failure. Because in the process of shipbuilding, people used many poor materials with poor quality. These materials are prone to deformation and breakage. In addition, because many people lack certain professional skills, this has a certain adverse effect on their performance.

2.5. Failure of ship's water-breaking and holding tank
As ship equipment has special shipping conditions, people need to conduct strict inspections on it. For example, in the process of the occurrence of flywheel obstacles, it is necessary to strictly inspect components such as fuel injection pumps, propellers, and intake pipes. If it is blocked, it is prone to "break water and hold the tank".

3. Gas turbine failure and maintenance

3.1. Working principle of gas turbine
The rotary terminal servo drive station includes a servo motor driver, a rotary servo motor and a motor rotary encoder [3]. The communication between the servo drive station and the PLC is realized through the RS-485 protocol. Since the ship uses a total of 5 rudder propellers for propulsion, it is necessary to calibrate the station numbers of the 5 servo drive stations in the RS-485 protocol. The PLC calculates the speed ratio of the rotary servo motor shaft end gear and the inner gear ring of the slewing bearing, recursively returns the number of the rotary encoder to obtain the rudder position angle, and realizes digital control of the rudder position. The rudder position angle calculation formula is:
In the formula: \( A \) is the actual rudder position angle; \( E \) is the motor rotary code value; \( I_1 \) is the two-stage planetary speed ratio; \( I_2 \) is the rotary bearing speed ratio. MOD \([\text{number1}, \text{number2}]\) is the remainder of \text{number1} for \text{number2}. The variable control system of the pump station includes a bus expansion module, a stepper motor driver, a numerically controlled variable pump (independently designed) and a hydraulic pressure monitoring system. In this design, the manual variable pump was innovatively modified in hardware. After contacting the manufacturer of the "Huade" variable pump, the original handwheel bearing seat of the variable pump was designed to be suitable for stepper motor installation. Flange base; connect the motor shaft and the screw shaft through a gear coupling, change the original variable pump manual control to the PLC bus communication port to receive the throttle handle angle, perform equal calculations on the variable screw stroke \( L_1 \), and correspond to the station number. The control value is sent to the stepper motor, and the pressure feedback monitoring of the hydraulic circuit is performed. The progress bar is used in the configuration system to simulate the hydraulic change value to realize the full digital control of the pump station variables. The calculation formula of variable screw stroke \( L_1 \) is:

\[
L_1 = \text{MOD} \left[ \frac{F \times I_1}{I_2} \right] / 150' \times L \times K
\]

In the formula: \( F \) is the handle code value; \( L \) is the total length of the screw rod; \( K \) is the effective coefficient of the screw rod. The hydraulic circuit control system is the core control system for circuit on-off or switching. The PLC performs logic processing on real-time operating data, and outputs 24V DC high-level digital signals through the PLC’s 20 output extension ports. The DC high-level digital signals drive solenoid valves, repeaters and other actuators to achieve hydraulic circuit control.

### 3.2. Statistical analysis of actual monitoring data of gas turbine

In order to study the vibration monitoring threshold of gas turbines in a targeted manner, the most direct method is to perform statistical analysis on the actual monitoring data. After a long-term investigation of the vibration monitoring of multiple gas turbines of this type, a large amount of vibration intensity monitoring data has been obtained. After preliminary sorting and eliminating some erroneous data caused by instrument and personnel factors and some unrepresentative data, we have obtained Vibration monitoring waveform data of 263 units. The measurement points of these sample data are unified, and the measuring instruments are all the EMT690B equipment fault diagnosis instrument [4]. The measurement of vibration intensity is marked as the effective value of vibration velocity, so the following indicators are calculated for each waveform data for analysis: A. 35-400Hz interval vibration velocity effective value, mm/s; B. 10-1000Hz interval vibration velocity effective value, mm/s. Among them, the effective value of the vibration velocity in the range of 35-400Hz corresponds to the measurement frequency range of the vibration test device equipped with the GT25000 gas turbine, and the effective value of the vibration velocity in the range of 10-1000Hz corresponds to the evaluation frequency range of the vibration degree specified in the international standard. The sample distributions of the effective values of the vibration velocity in the 35-400Hz and 10-1000Hz intervals are shown in Figure 1. The figure includes 2 subgraphs. The upper subgraph is a sample distribution pattern. The abscissa is the sample number, and the ordinate is the effective value of the sample's corresponding vibration velocity. The samples that are smaller than the sample mean plus 1 time the sample standard deviation is indicated by "∗", the sample between the sample mean plus 1 time the sample standard deviation and the sample mean plus twice the sample standard deviation is indicated by "#". The samples between the sample mean plus 2 times the sample standard deviation and the sample mean plus 3 times the sample standard deviation is used "&" means; no samples exceeding the mean value plus 3 times the standard deviation was found during the analysis. The following subgraph is a sample distribution...
histogram, the abscissa is the effective value of the corresponding vibration velocity, and the ordinate is the number of samples falling within the interval of the abscissa.

![Histogram of vibration speed](image)

**Figure 1.** Distribution of effective value of vibration velocity in the 35-400Hz interval

It can be seen that the distribution of vibration intensity basically conforms to the law of normal distribution. The monitoring threshold can be calculated according to the three-line method commonly used at home and abroad, that is, the average value plus 2 times the standard deviation as the warning threshold, and the average value plus 3 times the standard deviation is the abnormal threshold. The calculated mean, standard deviation, warning threshold, and abnormal threshold are shown in Table 1.

| Indicator name       | Effective value of vibration speed in the range of 35-400Hz | Effective value of vibration speed in the range of 10-1000Hz |
|----------------------|------------------------------------------------------------|------------------------------------------------------------|
| Mean                 | 5.4117                                                     | 6.2070                                                     |
| Standard deviation   | 2.3894                                                     | 2.0844                                                     |
| Warning threshold    | 10.1904                                                    | 10.3758                                                    |
| Abnormal threshold   | 12.5797                                                    | 12.4602                                                    |

**Table 1.** Calculated mean value, standard deviation and monitoring threshold of vibration intensity (mm/s)

3.3. **Optimization design of fault detection method**

According to the analysis of the requirements, a remote detection program that can accurately determine the failure of the ship's machinery is designed. The flow chart of the detection and judgment is shown in Figure 2.
It can be seen from Figure 2 that the diesel engine sensors, shafting thruster sensors, generator set sensors, automation system sensors, transmission sensors, and marine pump and piping system sensors installed on the ship are all controlled by a programmable logic controller (PLC) The system is directly connected. The sensors in each mechanism of the mechanical transmission can collect data of various parts of the body, such as displacement, vibration frequency, vibration amplitude, and angle deviation. The PLC control system receives the collected information from each sensor, performs analogy-to-digital conversion processing, and transmits these data to the acquisition end of the PLC control system. To collect and process the information from the sensors at the collecting end, the PLC control system is directly connected with the working host, which has the function of feedback and adjustment. The work host packs and compresses the sensor information processed by the PLC control system, and then performs data editing and transfer with the remote logic server. The remote logic server is connected with the transmitting terminal communication device. The transmitting terminal communication device uses the GPRS transceiver communication module to send out information [5]. The receiving terminal communication device receives the information sent by the transmitting terminal through the GPRS transceiver communication module and transmits the information to the remote host. The processor of the remote host analyses, integrates, summarizes and summarizes information, and monitors, records, stores, and compares the above data.

4. Discussion on common maintenance methods

4.1. Oil analysis method
The oil analysis method is to analyse the loss of ship machinery and equipment, determine the oil condition in the ship, perform data analysis on the use of equipment lubricants, and detect the quality of lubricants and the content of abrasive particles. As far as the current level of technological development is concerned, oil analysis methods are often used to analyse ship pollution indicators and spectral trends.
4.2. Vibration analysis method

Vibration detection and analysis method is mainly used in the detection of vibration amplitude during diesel engine operation. It has the characteristics of strong operability, high accuracy, and good detection effect [6]. It is often used in the fault diagnosis of various marine machinery and equipment detection work. Taking the air valve as an example, the vibration analysis method is used to perform heuristic air leakage vibration monitoring. According to the fluctuation of the vibration time difference and the regularity of the valve change, it can be detected whether there is air leakage, and corresponding measures can be taken to repair the equipment.

4.3. Thermal analysis method

The principle of using thermal analysis method for ship machinery maintenance is to use thermal parameter analysis to realize real-time monitoring of the exhaust temperature during the internal operation of the ship’s diesel engine, and to use the pressure indicator to understand the actual working conditions of the ship’s main and auxiliary engines. In addition, the thermal analysis method also emphasizes the dynamic effect of equipment monitoring, and the monitoring range is relatively comprehensive. The cylinder power and compression pressure related data parameters can be understood through the indicator diagram, so it is used in the maintenance of most marine machinery and equipment. The online PMI system of modern intelligent diesel engines more intuitively displays the working conditions of each cylinder of the main engine, allowing managers to monitor the operation status of the main engine at any time, and can make fine adjustments to make the main engine work under better working conditions. Work has played a huge role.

5. Conclusion

In the process of common failures and maintenance analysis in the maintenance of marine machinery and equipment, shipping companies should combine their own development layout and economic conditions to formulate feasible mechanical equipment maintenance and management measures to truly prevent failures before they occur. The staff shall clarify the operation process of mechanical equipment maintenance, adopt scientific operation concepts, divide labour and cooperate to ensure the safe driving of ships.

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