Applied Science and Innovative Research
ISSN 2474-4972 (Print) ISSN 2474-4980 (Online)
Vol. 7, No. 3, 2023
www.scholink.org/ojs/index.php/asir

Original Paper

Exploring the Current Status and Development of Condition Monitoring and Fault Diagnosis for Power Machinery of Engineering Ships

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Received: July 25, 2023 Accepted: August 12, 2023 Online Published: August 15, 2023

doi:10.22158/asir.v7n3p62 URL: http://doi.org/10.22158/asir.v7n3p62

Abstract

With the continuous progress of science and technology, modern engineering ships are also moving towards large-scale and high-speed development. Due to the fact that the power propulsion system is one of the most important parts of the entire ship, its operational status will directly affect navigation safety and operational efficiency, etc. Therefore, real-time monitoring of it is of great significance. Based on this, this article mainly explores the current status and development trends of condition monitoring and fault diagnosis of engineering ship power machinery, aiming to enable technical personnel to quickly and better grasp and apply these advanced technologies, and promote the healthy and sustainable development of China's shipbuilding industry.

Keywords

Engineering ships, Power machinery, Status monitoring, Fault diagnosis

1. Introduction

The state detection and diagnosis technology of engineering ship power machinery has been widely applied on ships, not only improving work efficiency, but also reducing the occurrence of accidents caused by human factors, and saving a lot of funds for ship owners. However, currently in China, there are many and complex faults in the power machinery of engineering ships, which are difficult to detect and eliminate in a timely manner. Therefore, it is necessary to further study how to achieve online status monitoring and fault diagnosis of power machinery through scientific and effective methods, in order to continuously improve the reliability and safety of the operation of engineering ship power devices. This has very important practical significance for ensuring the stability of ship navigation and extending the service life.

2. The Significance of Conducting CMFD Research on Engineering Ship Power Machinery

2.1 Promote the Reform of Ship Maintenance System

The research on CMFD (Condition Monitoring and Fault Diagnosis) of engineering ship power machinery is of great significance for promoting the reform of ship maintenance system. By continuously monitoring key parameters such as vibration, temperature, and pressure, abnormal situations can be detected and fault diagnosis can be carried out as soon as possible, avoiding potential mechanical failures that may cause ship operation interruption or accidents. In addition, CMFD technology has transformed ship maintenance from regular maintenance to conditional maintenance. Based on the actual operating status of power machinery, more reasonable and effective maintenance plans can be developed to avoid unnecessary maintenance and downtime. This reform will significantly improve the operational efficiency and safety performance of ships, and promote the progress of ship maintenance systems and management systems.

2.2 Reduce Maintenance Costs and Improve Economic Benefits

In the research of CMFD for engineering ship power machinery, it plays an important role in reducing maintenance costs and improving economic benefits. CMFD technology can monitor and diagnose the status and faults of power machinery in real-time during ship operation. By promptly detecting faults or abnormal situations, the downtime and maintenance time caused by faults can be reduced, and the economic losses caused by ship operation interruption can be reduced. In addition, CMFD technology can develop maintenance plans based on the actual operating status of power machinery, avoid unnecessary maintenance and replacement of parts, effectively reduce maintenance costs and material consumption, improve maintenance accuracy and economic benefits, and contribute to the sustainable development and competitiveness of the shipbuilding industry.

2.3 Improve Fault Prediction Ability to Ensure System Safety and Reliability

Conducting CMFD research on engineering ship power machinery is of great significance in improving fault prediction capabilities, ensuring system safety and reliability, and other aspects. CMFD technology can provide real-time operational status information and fault diagnosis results for ship operations, helping to formulate reasonable maintenance plans and decisions. By monitoring and predicting faults in real-time, ship managers can arrange maintenance work in a timely manner to avoid system failures and unnecessary downtime caused by faults. In addition, CMFD technology can also improve the ability to identify and understand the cause of faults by analyzing and interpreting fault data and patterns. By establishing models and algorithms, fault diagnosis and prediction can be carried out, and in-depth analysis of the causes and mechanisms of faults can help improve design, maintenance strategies, and system safety and reliability.

3. The Current Status of CMFD Technology for Engineering Ship Power Machinery

3.1 Backward Fault Detection and Diagnosis Methods

The current status of CMFD technology for engineering ship power machinery is that the methods of fault detection and diagnosis are relatively backward, mainly manifested in the following two aspects. On the one hand, traditional fault detection methods are relatively lagging and mainly rely on manual inspections and regular maintenance. This method has problems such as waste of human resources, subjectivity and inaccuracy of diagnostic results. The development of CMFD technology in engineering ship power machinery has enabled real-time monitoring and sensor technology to be widely applied in the field of ship power machinery. However, currently, fault detection methods still lag behind in terms of accuracy and reliability, and there is a lack of an effective online state detection technology to quickly and accurately diagnose them. On the other hand, the CMFD technology of engineering ship power machinery also faces some challenges in fault diagnosis. Due to the complexity and diversity of ship power machinery, research on fault modes and fault diagnosis methods is still insufficient. At present, fault diagnosis algorithms mainly focus on pattern recognition, statistical analysis, etc. However, in complex ship environments, the applicability and accuracy of these methods still need to be improved. Therefore, it is necessary to strengthen research work in this area.

3.2 Insufficient Evaluation and Optimization of Operational Status

In the current research on CMFD technology for engineering ship power machinery, insufficient evaluation and optimization of operating conditions remains an important issue. On the one hand, the indicators and methods for evaluating operational status need to be improved. At present, the evaluation of operational status mainly relies on real-time monitoring of key parameters and comparison with reference values to determine the operational status of mechanical equipment. However, this parameter based evaluation method cannot comprehensively and accurately reflect the actual operational status of mechanical equipment, making it difficult to meet the configuration and usage management needs of engineering ship power mechanical systems; On the other hand, research on optimizing operational status urgently needs to be strengthened. The CMFD technology for engineering ship power machinery can monitor and diagnose the status and faults of mechanical equipment in real time, thus providing a foundation for optimizing system operation. At present, there is relatively little research on the optimization of the operational status of ship power machinery systems, and there is a lack of systematic optimization methods and strategies. This poses some challenges for the CMFD technology of engineering ship power machinery in terms of operational status evaluation and optimization. It is necessary to accelerate the development of targeted optimization algorithms and strategies, optimize the operational status of the system, and improve the safety and economy of the ship system.

3.3 Poor Effectiveness in Efficiency Monitoring and Energy Conservation and Consumption Reduction

Efficiency monitoring and energy conservation and consumption reduction are the two most concerned issues in the research and application of CMFD technology for engineering ship power machinery. However, due to the complexity of the configuration of engineering ship power machinery systems and

the uncertainty of operating conditions, the energy-saving and consumption reduction effects of engineering ship power machinery are not satisfactory. On the one hand, the current CMFD technology has some limitations in the performance monitoring of engineering ship power mechanical systems. Although the efficiency of mechanical systems can be evaluated by monitoring key parameters, for complex ship power mechanical systems such as multivariable and multimodal systems, relying solely on parameter monitoring cannot comprehensively and accurately evaluate the energy efficiency status of the system; On the other hand, although CMFD technology can monitor the operating status of power machinery in real-time and provide energy-saving suggestions through fault diagnosis and optimization algorithms, the current energy-saving and consumption reduction effect is not significant enough. This is mainly because existing energy-saving optimization methods focus on the energy-saving details of a single device, lacking global optimization and collaborative control of the entire system, resulting in significant energy waste and high energy consumption, making it difficult to meet the efficient and low consumption operation needs of modern ships.

3.4 Insufficient Intelligence in Monitoring and Early Warning Functions

The current situation of CMFD technology for engineering ship power machinery is that the monitoring and warning functions are not intelligent enough to detect abnormal phenomena during the operation of the power machinery in a timely manner. The reason for this is that, on the one hand, the intelligence level of monitoring functions is limited. The current CMFD technology usually relies on set thresholds to trigger alarms or alarms in the monitoring of ship power mechanical systems. However, this static threshold setting cannot adapt to dynamic changes in different operating states, nor can it determine whether the fault is a natural fluctuation of system operation, which can easily lead to certain false alarms or missed alarms; On the other hand, current CMFD technology usually establishes static warning rules based on historical data and models in fault warning. Due to the complexity and variability of ship power mechanical systems, warning systems based solely on static models are difficult to meet practical application needs, and cannot ensure timely detection of potential faults and abnormal situations, resulting in significant deviations or even errors in warning results, thereby reducing the safety and reliability of the entire ship power system.

4. Development Trends and Research Hotspots of CMFD Technology for Engineering Ship Power Machinery

4.1 Data-driven Fault Detection and Diagnosis

With the complexity of ship power mechanical systems and the improvement of data acquisition capabilities, traditional rule-based and experiential fault detection and diagnosis methods are no longer able to meet the requirements. Data driven fault detection and diagnosis utilizes technologies such as big data, machine learning, and data mining to automatically learn features and patterns from complex operational data, and perform fault detection and diagnosis of power mechanical systems based on models. Among them, fault feature extraction and pattern recognition are research hotspots in

data-driven fault detection and diagnosis. By extracting features from a large amount of operational data, feature indicators for different fault modes and abnormal situations can be identified for subsequent fault detection and diagnosis. At the same time, using machine learning and pattern recognition algorithms, a large amount of feature data can be analyzed and modeled to achieve automatic recognition and classification of different fault modes. The research on fault feature extraction and pattern recognition provides important support for data-driven fault detection and diagnosis, helping to more accurately diagnose faults and predict potential faults, and improving the accuracy and efficiency of system fault detection and diagnosis [3].

4.2 Intelligent Operation Status Evaluation and Optimization

One of the development trends and research hotspots of CMFD technology for engineering ship power machinery is intelligent operation status evaluation and optimization. Traditional operational status evaluation mainly relies on parameter monitoring and rule setting, often unable to comprehensively and accurately reflect the actual operational status of mechanical equipment. The future development trend is to introduce advanced technologies such as machine learning. By collecting a large amount of real-time monitoring data and analyzing it, intelligent algorithms can learn the operating characteristics and modes of power machinery equipment, and conduct real-time and accurate operation status evaluation. This will enable ship managers to better understand the health status of equipment, provide early warning of potential faults, and take corresponding maintenance measures. At the same time, intelligent operation state optimization will focus on system level optimization, combining machine learning and optimization algorithms to achieve intelligent control and optimization of power mechanical systems. By analyzing real-time monitoring data and predicting models, equipment operating parameters can be adjusted in real-time to maximize the reliability and safety of power system operation, optimize ship navigation performance, and contribute to the sustainable development of the shipbuilding industry.

4.3 Comprehensive Innovation in Energy Management and Energy Conservation and Consumption Reduction

In the development trend and research of CMFD technology for engineering ship power machinery, the comprehensive innovation of energy management and energy conservation is an important direction for future research and development of power propulsion technology. Firstly, the research and application of a comprehensive energy management system. The comprehensive energy management system integrates various energy sources, including traditional and new energy sources such as fuel, natural gas, and electricity, by comprehensively considering the supply, consumption, and utilization of different energy sources. Through intelligent control and optimization algorithms, it achieves efficient energy utilization and collaborative work. In addition, intelligent energy-saving technology in the field of ship power machinery CMFD automatically identifies energy-saving potential through real-time monitoring and analysis of environmental and equipment operation data, and proposes corresponding optimization measures. For example, intelligent energy-saving technology can improve the energy efficiency of

power mechanical systems and effectively reduce operating costs by optimizing equipment operating parameters, adjusting the matching and coordination of power systems. In addition, intelligent energy-saving technology can also be applied to optimize and manage the energy supply chain, achieve dynamic matching between supply and demand, reduce energy waste and losses, and help improve ship energy efficiency and navigation economy.

4.4 Intelligent Monitoring and Early Warning Based on Artificial Intelligence

Intelligent monitoring and early warning based on artificial intelligence is currently one of the development trends and research hotspots of CMFD technology for engineering ship power machinery. Traditional monitoring devices mainly rely on set thresholds to trigger alarms or alarms, which are difficult to adapt to dynamic changes in different operating states and can easily cause false alarms or missed alarms. And intelligent monitoring based on artificial intelligence technology can continuously optimize monitoring strategies through machine learning and deep learning algorithms based on real-time monitoring data and historical data, through automatic learning and adaptive adjustment. This can achieve accurate and real-time perception of the state changes of the power mechanical system, and improve the intelligent level of monitoring functions. In addition, the intelligent warning of artificial intelligence technology can utilize real-time monitoring data and machine learning technology to establish dynamic warning models. Through real-time analysis and pattern recognition, potential faults can be predicted in real time and accurately, and warning signals can be sent. An intelligent early warning system can adapt to real-time perception of system state changes, improve the intelligence of early warning functions, and provide support for the sustainable development of the shipbuilding industry.

5. Epilogue

In summary, the status monitoring and fault diagnosis of power machinery in engineering ships are of great significance in the shipbuilding industry. At present, although some progress has been made, there are still some challenges and room for improvement. Traditional monitoring methods and early warning systems generally suffer from insufficient accuracy and timeliness, and fault diagnosis methods need to be more intelligent and accurate. The future development direction is to introduce technologies such as artificial intelligence and big data analysis for data-driven fault detection and diagnosis, and achieve intelligent operational status evaluation and optimization. In addition, the application of comprehensive energy management and intelligent energy-saving technology is also a research hotspot, which helps to reduce energy consumption and improve energy efficiency. Through continuous research and innovation, the condition monitoring and fault diagnosis technology of engineering ship power machinery will provide safer, more reliable and efficient services for the shipbuilding industry.

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