Research on Composite Support Mode Based on Fault Phenomena and Maintenance Methods

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Abstract: Faced with the current situation where a single unit is equipped with various types of equipment, but the support capabilities of the personnel are relatively limited, it is crucial to enhance the maintenance support capacity for different types of equipment. Conducting research on support models is therefore of great importance. This paper proposes a composite support mode based on fault phenomena and maintenance methods. This support mode focuses on de-emphasizing equipment attributes, emphasizing functionally similar and structurally analogous aspects, and highlighting fault phenomena. It stresses the importance of key components in the system to study common fault phenomena. The research integrates similar fault phenomena across different systems, developing a composite support mode guided by fault phenomena and led by key components. This research provides guidance for improving maintenance support capabilities for various types of equipment systems.

Keywords: Composite Support Mode; Multiple Types of Equipment; Fault Phenomena; Maintenance Methods

1. Introduction

Currently, a single unit often equips a variety of types of equipment. Enhancing maintenance support capabilities for multiple types of equipment is a key focus in the capability building of a unit [1-4]. Addressing the support issues of various types of equipment, this paper proposes a new support model aimed at dealing with the complexity of equipment types and fault phenomena. By integrating similar fault phenomena across different pieces of equipment, this model facilitates precise and rapid fault diagnosis and efficient equipment repair.

2. The Challenge of Supporting Diverse Equipment: Analysis of Fault Phenomena and Maintenance Challenges

Equipment maintenance support refers to a series of technical and management activities carried out to maintain and restore the technical condition of equipment, ensuring its normal operation and use to fully realize its combat performance. From different perspectives, equipment maintenance tasks can be classified in various ways. Based on the purpose of equipment maintenance support, it can be divided into corrective maintenance, preventive maintenance, and improvement maintenance, as shown in Figure 1. Corrective maintenance refers to the repair work for equipment that has already failed. Also known as repair, it is performed after equipment damage, where the equipment is restored to its original working capacity through relevant handling by the maintenance organization. Preventive maintenance is usually carried out before equipment failure. Its purpose is to anticipate potential faults in the equipment, reduce the likelihood of subsequent failures, and improve the effectiveness and life cycle of the equipment. Improvement maintenance involves the maintenance organization utilizing opportunities during equipment maintenance to make further improvements to the equipment's performance and reliability based on the needs of the user units. It is a functional design modification.

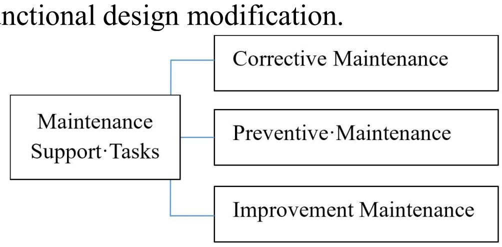

Figure 1 Classification of Maintenance Support Tasks by Purpose

Traditional maintenance support methods usually involve organizing professional technicians specific to a certain type of equipment, based on schematics and repair manuals, to carry out fault repair and support tasks. This requires a high level of professional knowledge and skills from the maintenance personnel. However, with the increasing complexity and diversity of today's equipment systems, maintenance support faces certain challenges due to limitations in the scale and conditions of maintenance support forces. When carrying out maintenance tasks, equipment maintenance support organizations often encounter many new problems. In the absence of repair manuals or technical documents, technicians need to explore and research multiple times, which can significantly affect the efficiency of equipment maintenance and even lead to equipment damage and scrapping. Traditional maintenance methods have certain inadequacies in dealing with faults in various types of equipment [5-7]. These challenges and their underlying causes are analyzed in depth below.

With the advancement of technology, various types of equipment are not only numerous but also more complex in functionality. From simple single systems to comprehensive systems incorporating various sensors, electronic systems, and complex mechanical structures, each type of equipment has its unique structure and operating principles [8]. This diversity poses a primary challenge: maintenance personnel need to master a vast array of professional knowledge and skills for different systems. Given the limitations in training resources and time, accomplishing this task is challenging.

Fault phenomena in different equipment may be similar, but due to differences in their internal structures and working principles, the methods and steps for repairs can vary greatly. This requires maintenance personnel to not only identify fault phenomena but also understand the internal mechanisms of different systems, undoubtedly increasing the difficulty of diagnosis and repair.

As technology rapidly evolves, new types of equipment are introduced at an accelerating pace, while traditional maintenance support systems often fail to update synchronously. The introduction of new equipment often brings new types of faults and maintenance challenges. Without adequate training and practical experience, maintenance personnel find it difficult to effectively address these emerging issues.

Maintenance resources, tools, and processes often vary between different types of equipment. This means that even if maintenance personnel can accurately diagnose a problem, they might be unable to repair it promptly due to the lack of specific tools or parts. This resource mismatch not only increases the cost of maintenance but also reduces its efficiency.

With the ever-changing combat environment, maintenance support work also needs to respond quickly. In battlefield conditions, the rapid and effective repair of equipment faults is crucial. However, traditional maintenance methods often struggle to meet this demand. The prolonged time for fault diagnosis and repair not only affects combat efficiency but also poses risks to the safety of the troops.

3. Core Mechanism of the Composite Support Model: Integration of Fault Phenomena of Functionally Similar Components

In addressing the challenge of supporting various types of equipment, a composite maintenance support model is proposed. Its core lies in integrating the fault phenomena of functionally similar components, aimed at improving repair efficiency and reducing the professional skill requirements for maintenance personnel. The core mechanism of this model is explored in detail below.

The first key aspect of the composite support model is the identification and categorization of functionally similar components. In different equipment systems, despite potentially vast differences in overall structure, there are many core components with similar or identical functions, such as power systems, sensors, guidance devices, etc. [9]. An in-depth study of these components reveals similar fault phenomena across different systems, making cross-system fault diagnosis and repair possible.

The composite support model focuses on integrating the fault phenomena of these functionally similar components. By integrating, organizing, and merging the same or similar fault phenomena across different systems, a cross-system fault database can be formed. This database includes not only fault phenomena but also corresponding diagnostic methods and repair steps. Thus, even if maintenance personnel are not familiar with a specific system, they can quickly locate problems based on fault phenomena and find effective repair methods.

This support model emphasizes the importance of key components. By identifying key components in each system and focusing resources and training on improving the repair capabilities for these components, overall repair efficiency can be effectively enhanced. This approach reduces the dependency on maintenance personnel to have comprehensive knowledge of all systems, making repair work more efficient and flexible.

The composite support model also stresses the importance of information sharing and technical exchange. Establishing an information exchange platform across departments and systems promotes the sharing of experiences and knowledge among different maintenance teams. This not only helps in quickly resolving complex faults but also enhances the skills and knowledge of maintenance personnel.

To adapt to this model, the maintenance process also needs to be optimized. By standardizing the fault diagnosis process and repair steps, the efficiency and accuracy of repairs can be further improved. At the same time, this provides clear guidance for maintenance personnel, reducing the risk of secondary damage due to improper operations.

4. Innovative Strategies and Implementation Suggestions: Exploring Paths to Enhance Maintenance Efficiency of Multi-system Equipment

For the training and skill enhancement of maintenance personnel, a more systematic and comprehensive approach is needed. Traditional maintenance training often focuses on specific equipment, but in a multi-system environment, a more effective approach is to emphasize foundational knowledge and skills across systems. This includes a basic understanding of electronics, mechanics, and systems engineering, as well as a comprehensive grasp of common fault types and maintenance strategies. Through such training, maintenance personnel can more quickly adapt to the repair needs of different equipment.

4.1 Integration of Fault Diagnosis and Information Management Systems

Establishing an integrated fault diagnosis and information management system is crucial. This system should be able to collect and analyze fault data from various systems, providing references for fault diagnosis, historical repair records, and maintenance support plans. When an equipment maintenance support organization encounters challenging problems, problem matching can provide references and guidance for equipment repair, maintenance tasks, and the scheduling of personnel and resources. The integration of maintenance support plans brings the following advantages:

(1) Equipment maintenance support plans can provide technical personnel with fault prediction, task allocation, and recommendations for maintenance resources. Maintenance support organizations can carry out a series of equipment maintenance tasks based on the specific content of the plans.

(2) Equipment maintenance support plans are the primary basis for carrying out equipment repairs. Based on the content of the plans, relevant technical personnel can be organized for effective daily equipment maintenance training and learning.

(3) Equipment maintenance support plans outline the maintenance resources needed for repair tasks. These resources include personnel, facilities, equipment, materials, and technical documents. Through the rational allocation of resources, it is possible to reduce situations where maintenance tasks are difficult to complete due to uneven distribution of resources or insufficient capabilities.

4.2 Resource Sharing and Collaborative Work

With the rapid development of science and technology, technologies such as cloud environments, artificial intelligence, and virtualization have broken the mold of traditional equipment maintenance support models. Utilizing artificial intelligence can make equipment maintenance training systems more intelligent, better assisting technical personnel in completing maintenance tasks. Virtualization technology, on one hand, frees technical personnel's training from the constraints of equipment sites and materials, and on the other hand, allows experts to remotely provide technical support for maintenance tasks. Using cloud environments, data systems and information systems can be integrated, achieving network sharing and intercommunication of maintenance support information.

In a cloud environment, equipment maintenance support organizations are in a highly collaborative setting, with organizational information, personnel information, and resource information being open and transparent. Maintenance personnel can access relevant information based on their management permissions. In the cloud environment, with a vast amount of equipment awaiting maintenance and resources from maintenance organizations, no single factor can affect the overall functioning of the maintenance support. In this environment, equipment and maintenance organizations are recipients, not determiners, of maintenance tasks. Establishing this kind of effective collaboration mechanism between different units or departments ensures the rapid allocation of maintenance resources and professional technicians when needed. This not only improves maintenance efficiency but also increases flexibility in urgent situations.

Adopting new technologies, such as Augmented Reality (AR) and Virtual Reality (VR), it is possible to provide maintenance personnel with more intuitive and efficient repair guidance. Through these technologies, technicians can learn and practice in simulated environments and even receive real-time guidance and support during actual operations.

4.3 Regular Assessment and Data Mining

Regular evaluation and improvement of these strategies are crucial. By regularly collecting feedback, analyzing maintenance data, and conducting performance assessments, maintenance strategies can be continuously optimized to ensure they adapt to the ever-changing technological and operational environments.

Additionally, by applying advanced data analysis techniques, such as machine learning, it is possible to identify failure patterns from historical data and predict potential faults, thus allowing for the implementation of preventative measures in advance. Optimizing the maintenance process is also key to improving efficiency. The adoption of modular and standardized approaches in the design and updating of equipment can make maintenance faster and more straightforward [10]. Modular design enables maintenance personnel to quickly replace damaged parts instead of spending extensive time on complex repairs.

In summary, enhancing the efficiency of multi-system equipment maintenance requires a series of innovative strategies and implementation suggestions. This includes systematic training, integrated information management, optimization of maintenance processes, resource sharing, application of new technologies, and continuous assessment and improvement.

5. Conclusions

This paper delves into the challenges of maintenance support brought about by diversified equipment systems and proposes a composite support model based on fault phenomena and maintenance methods. Through this model, effective integration of cross-system fault phenomena is achieved, significantly improving maintenance efficiency and accuracy. Additionally, the paper presents a series of innovative strategies and implementation suggestions, including systematic training, optimization of information management, modularization of maintenance processes, and the application of new technologies. These provide a foundation for rapid and efficient maintenance support of various types of equipment under complex conditions.

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