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Forecasting Method of Consumption Spare Parts of Mutual Support System Based on Stochastic Process

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Abstract

Considering the characteristics of mutual support system in which unit fault leads to the failure rate mutation, through the analysis of practical problems, using the theory of stochastic process, the paper gives the procedure and method of consumption forecast model of spare parts to establish the relay board mutual support system of a communication device. The applicability of the model is illustrated by examples.

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Keywords: mutual support system; fault correlation; spare parts consumption

1. Introduction

In recent years, with the application of high-tech and information technology, equipment of formed units has become more and more complex with more and more species. Different maintenance strategies also tend to be applied for different components of equipment, making it difficult to grasp the law of equipment spare parts supply and leading to heavier workload of spare parts consumption forecasting. To meet the needs of equipment maintenance, formed units need to store a certain variety and quantity of spare parts in advance. If the storage capacity of each spare part is too small, the equipment's successful completion of the training mission cannot be guaranteed; if the storage capacity of each spare parts is too much, it will cause overstock which affects economic benefit of the components. To ensure that spare parts stored in the formed units is of reasonable quantity and good

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quality and can timely and reliably guarantee the equipment maintenance needs, a scientific and valid method of equipment spare parts consumption forecasting must be given.

Many scholars at home and abroad have conducted in-depth studies of methods of equipment spare parts consumption forecasting. Xu Ting-xue[1] et al proposed the cruise missile spare parts consumption forecasting method based on rough sets and BP neural network, which gives full play to the advantage of rough set in handling of redundant data and improves the speed and effectiveness of forecasting. Yang Shi-mei[2] et al proposed a combination forecasting method of aviation material spare parts based on least squares support vector machines and information entropy in order to achieve precision support of aviation equipment, which solved the problems of the existing methods in difficulty in accurately predicting the aviation material spare parts under conditions of small samples. Cheung KL[3] et al analyzed the multiple failures of components, studied the component control model based on multi-tier technology, and established such spare parts consumption forecasting models as Mod-METRIC, Vari-METRIC, Dyna-METRIC through improvement. Through the analysis of the previous literature, it can be found there are few undertaken research work of method of equipment spare parts forecasting based on a variety of maintenance strategies.

Mutual support system is a kind of hot backup redundancy system. In the mutual support system, the main standby units at first are all in working condition. When a unit breaks down, the remaining units continue to work. However, due to the reduced number of work units, the fault rate of remaining units will generally change[4][5].

A unit is equipped with dozens of the same type of communication equipment, and the voice channel of each device contains two relay boards, which constitute a redundant structure of mutual support system. The relay board is the key part of the communication equipment to amplify the signal and transmit the signal. The two pieces of the relay board can bear the load of the equipment. When one of the relay boards fails, all the loads can be carried by the other relay board, so that the equipment can continue to run. However, due to the increase of the load, the failure rate of the relay board will suddenly increase. When both relay boards fail, the system fails. A single relay board failure is not repaired until the two relay boards both fail. To meet the needs of the relay board replacement repair, the unit needs to reserve a certain number of relay boards for backup. If the number of relay boards is too small, it will be difficult to ensure the successful completion of the task of such communications equipment; if the relay board reserves too much, that will result in backlog. long standby time of the relay board will reduce the working life, and even during the reserve period a malfunction may occur. It is a key problem to study how to master the consumption rule of spare parts in mutual support system and to estimate the spare parts consumption quantity of the relay board and to determine the reasonable spare parts reserve quantity in a certain period of time.

Through the abstraction of the above-mentioned problems, the following gives a general solution to such problems.

2. Model Construction

Spare parts consumption law is closely related to the failure law of system[6][7].In order to establish the spare parts consumption forecasting model, the working process of the mutual support system is further analyzed. It is found that, according to the order of the relay board failure, the working process of the system can be divided into three types: ① The first relay board works for T_1 before failure, and the second relay board continues to work, but also works for T_4 before failure; ②The second relay board works for T_2 before failure, and the first relay board continues to work, but also works for T_3 before failure; ③Two relay boards fail simultaneously. Since the probability of simultaneous failure of two relay boards approaches zero, the third case is negligible.

According to the first two types of work, the working life T of the system can be expressed :

$$T = \begin{cases} T_2 + T_3, & T_1 > T_2 \\ T_1 + T_4, & T_2 > T_1 \end{cases} \tag{1}$$

System reliability function $R(t)$ is equal to the probability that the working life of the first relay board is greater than the working life of the second relay board under the condition of the system whose total life is more than t and the working life of the second relay board is greater than the working life of the first relay board under the condition of the system whose total life is more than t .