Communication Equipment Condition Based Maintenance Decision

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Abstract. In order to develop a scientific and cost reasonable maintenance strategy to solve the current high cost problem of running and maintenance management for communication equipment, introduce the same type set which has the similar running condition with the object set as the reference set and propose a life prediction method for communication equipment. The method solves the similarity factor of life evaluation parameters (running time, times of starting and stopping) in actual and benchmark running condition by using experience running data. In order to accurately calculate the running life of the object set under the actual running conditions and overcome the shortcomings of the traditional artificial statistics, the calculation method of real time and historical life is presented. Then based on the product of the maintenance factor and service factor of running time and the times of starting and stopping, the concept of the key parameters of the decision of condition-based maintenance-equivalent service factor is put forward; According to the relationship between the equivalent service factor in running time and to predict period, four kinds of decision models of condition-based maintenance are established. The historical data of communication equipment running were perioded to predict when given equivalent service factor.

1 Introduction

Condition-based Maintenance (CBM) monitors equipment’s running status by using the mature state monitoring technology and then implements corresponding maintenance decisions accordingly to the monitoring data $^{[1, 2]}$. CBM can reduce maintenance surplus and power outages thus ensures the safety and economy of equipment’s operation $^{[3]}$. CBM has been widely used in the maintenance of large equipment at home and abroad. Verma et al. proposed a maintenance strategy based on the combination of time and state according to the complex running state of large power generation equipment $^{[4]}$; NIU et al. Built maintenance strategy CBM system based on reliability $^{[5]}$; Tian et al. successfully applied the wind power generator’s running data which was obtained by the real-time monitoring system to the Condition-based Maintenance; Based on the actual running state of electrical equipment $^{[6]}$. Pan Lezhen et al. Calculated electrical equipment failure rate in state maintenance decision and then determined the actual age of electrical equipment $^{[7]}$; Yao Jiangang et al. built a fuzzy comprehensive evaluation model and relatively complete
Li Gang et al. used the integrated development tools JBuilder and Oracle Database to design and develop a very practical maintenance and optimization system for power generation and transmission equipment in primary electricity market environment \cite{9}. In addition, CBM has been used in the maintenance of communication equipment in a certain degree. Rao et al. Realized the online and off-line water washing of the compressor by applying the state maintenance strategy to dirt washing of communication equipment’s compressor blade \cite{10}; Zhao et al. recommended that the communication equipment state maintenance plan should be drawn up according to the comprehensive consideration on factors of power plant cost, profit and power market \cite{11}; Mao Dan, et al. qualitatively introduced the method of calculating the relevant parts’ maintenance interval which was realized by using communication equipment’s running data \cite{12}; Gong Wenqiang et al. used equivalent running time analysis to establish the equivalent running time equation of communication equipment, and based on EOH analysis they put forward a manual statistical method for life evaluation of communication equipment \cite{13}.

Based on the discussion above, this paper proposes a new method to solve the current high cost problem of running and maintenance management for communication equipment. According to the relationship between the equivalent service factor in running time and to predict period, four kinds of decision models of condition-based maintenance are established. The historical data of communication equipment running were periodized to predict when given equivalent service factor.

### 2 Key parameters of the decision model

According to equality of equivalent Service Factor of running time PH\textsubscript{1} and to predict time PH\textsubscript{2} (investigate whether the maintenance factors of PH\textsubscript{1} and PH\textsubscript{2} are equal, whether the service factors of PH\textsubscript{1} and PH\textsubscript{2} are equal, then arrange and combine these results), four kinds of decision models of condition-based maintenance are established, thus taking the historical data of communication equipment running time as the basis or combining with the actual operation plan in the period to predict, the power generation enterprise can decide specific maintenance time in the period to predict if given equivalent service factor. CBM decision analysis for communication equipment parts is shown in figure 1.

![Figure 1. Decision model of CBM for communication equipment parts.](image)

In the literature, the ratio of equivalent running time (equivalent starting times) to actual running time (actual starting times) of relevant parts of the communication equipment is defined as Maintenance Factor (MF), shown as following:

\[
MF = \frac{F}{A}
\]

(1)
At the same time, the ratio of actual running time (actual starting times) to all hours during the statistics period is defined as service factor (SF), that is:

$$SF_H = \frac{A_H}{PH}$$  \hspace{1cm} (3)

$$SF_S = \frac{A_S}{PH}$$  \hspace{1cm} (4)

In above 4 formulas, the subscripts H and S respectively represent the running time and starting times. The main factors that affect the maintenance factor are fuel type, load change, starting mode (normal, urgent and fast lifting load) and whether there are water injection or steam ratio, peak load running, tripping, starting mode and so on. The service factor is affected only by actual running time (actual starting times) in unit statistics time.

From the definition of equivalent service factor in to predict time $PH_2$, it can be concluded as following:

$$FSF_{PH_2} = \frac{F_{PH_2}}{PH_2} = \frac{IF_H - IF_{P1}}{PH_2}$$  \hspace{1cm} (5)

In the formula, IFH is ideal maintenance interval of running time of parts of the communication equipment, that is total equivalent running time. Thus, the value of $PH_2$ can be obtained:

$$PH_2 = \frac{IF_H - IF_{P1}}{FSF_{PH_2}}$$  \hspace{1cm} (6)

From formula (6), it can be known that: the value of $PH_2$ is only related to equivalent service factor of $PH_2$ and they are in an inverse relationship. So if given the value of the key parameter of equivalent service factor $PH_2$ in to predict time, we can get four decision models (investigate whether the maintenance factors of $PH_1$ and $PH_2$ are equal, whether the service factors of $PH_1$ and $PH_2$ are equal, then arrange and combine these results.) of Condition-based Maintenance of running time and starting times of communication equipment’s related parts.

### 3 Calculation and discussion

If the enterprise chooses the second kind of maintenance decision model, that is, the maintenance factor of running time (starting times) in $PH_2$ period is calculated as the maintenance factor 1.154(1.248) of running time (starting times) in $PH_1$ period, while the service factor of running time (starting times) in $PH_2$ period is given by enterprise according to the actual running plan. Through formula (5) and formula (6), the relationship curve between annual running time (annual starting times) and $PH_2$ maintenance interval time is draw, shown as figure3 and figure4. With the increase of annual running time and annual starting times, the $PH_2$ maintenance interval time decreases, that is, the maintenance cycle is shortened. From figure3: when annual running time is less than 2000h, the maintenance cycle reduces obviously and when more than 2000h, reduces slowly. From figure4: when annual starting times is less than 100, the maintenance cycle decreases sharply and when more than 100, decreases gently. Therefore, in the choice of the second kind of maintenance decision model, the annual running time is 2000h and annual starting times 100 given by enterprise according to the actual running plan. They are very important key values which have very large impact on the length of the maintenance cycle.
4 Conclusion

This paper proposes a new method of life prediction for communication equipment. The new method solves the similarity factor of life evaluation parameters (running time, times of starting and stopping) in actual and benchmark running condition by using experience running data. In order to accurately calculate the running life of the object set under the actual running conditions and overcome the shortcomings of the traditional artificial statistics, the calculation method of real time and historical life is presented. Then based on the product of the maintenance factor and service factor of running time and the times of starting and stopping, the concept of the key parameters of the decision of condition-based maintenance-equivalent service factor is put forward; According to the relationship between the equivalent service factor in running time and to predict period, four kinds of decision models of condition-based maintenance are established. The historical data of communication equipment running were perioded to predict when given equivalent service factor.

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