Research on the Combination Method of Spare Parts Consumption Data

Shenyang Liu, Qian Zhu, Xiaopei Shi, Yongliang Zhang, Chen Zhu
Department of Air Material and Four Stations, Air Force Logistics College, Xuzhou 221000, China

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Abstract: Through an analysis of the problem of lacking of spare parts consumption data in some environments, this paper combines spare parts consumption data in different environments, applies equipment reliability theory and probability theory to establish spare parts consumption combination models. The calculation method could be used to solve the difficult problem of developing a reserve program of spare parts since it is not easy to find out spare parts consumption rule. The models provide a theoretical basis for calculating reserves of spare parts scientifically and have an important guiding significance.

1. INTRODUCTION

Many scholars have made scientific researches on spare parts consumption (Li, 2003). However, under many circumstances, the sample of spare parts consumption in a unit is small (Xu, 2013), so expanding the spare parts consumption data is an effective method to increase the fitting precision (Yang, 2012). In order to expand spare parts consumption data, this unit could draw on the experience of the pare parts consumption data in other units. It is essential to do research on the combination method of the pare parts consumption data (Mu, 2011).

Through analyzing the scientific researches on spare parts consumption, we could find that few papers have been published as of now regarding the combination of spare parts consumption data, which is formulated by combining spare parts consumption rules under both corrective maintenance and condition-based maintenance.

Based on the abstraction of above problems, a general solution is given to such kind of problems.

2. COMBINATION OF SPARE PARTS CONSUMPTION DATA WITH TIME VARIATION

At first, it is necessary to educe the reasonable environmental factor. Then according to the reasonable environmental factor, the spare parts consumption data in different environments can be transformed into the equivalent spare parts consumption data in the same environment. So the combination method of spare parts consumption data could be obtained in different environments.

2.1 Environmental Factor

Suppose the spare parts consumption rule of equipment unit is a distribution function concerning the parameter t , and the probability of spare parts consumption at the t_1 time is $F_1(t_1)$ in the first environment; the probability of spare parts consumption at the t_1 time is $F_2(t_2)$ in the second environment; the type of distribution function in the first environment is the same with that in the second environment; the probability of spare parts consumption at the t_1 time in the first environment is the same with that at the t_1 time in the second environment. The formula is (Liu, 2012)

$$F_1(t_1) = F_2(t_2) \qquad (1)$$

If the type of distribution function of the spare parts consumption rule of equipment unit is normal distribution, i.e. $T_1 \sim N(u_1, \sigma_1^2)$; $T_2 \sim N(u_2, \sigma_2^2)$, $u_1, \sigma_1^2, u_2, \sigma_2^2$ are respectively the average values and variances of T_1 and T_2 . According to the formula (1),

$$\Phi\left(\frac{t_1 - u_1}{\sigma_1}\right) = \Phi\left(\frac{t_2 - u_2}{\sigma_2}\right) \qquad (2)$$

According to the stochastic values t_1 and t_2 , it is not hard to educe the relation between T_1 and T_2 (He, 2013),

$$T_1 = K_N T_2 + B_N \qquad (3)$$

In the formula (3), $K_N = \frac{\sigma_1}{\sigma_2}$, and it is name is flex factor; $B_N = u_1 - K_N u_2$, and it is name is translation factor. According to the formula (3), the conversion of the spare parts consumption data in the two different environments, is called the environmental factor method.

When the parameters of normal distribution in the two different environments are known, the environmental factor could be solved and it is a certain value. When the parameters of normal distribution in the two different environments are unknown, the estimation value of the environmental factor could be solved via the spare parts consumption data, then the estimation value of the environmental factor could be used to transform spare parts consumption data.

The distribution function of the environmental factor is also suitable for other types of distribution function of the spare parts consumption rule, for example, uniform distribution and triangle distribution. K_N and B_N are certain values via the parameters of distribution, and they are not stochastic values; K_N and B_N are all have functions of expression, and they are not hard to be calculated and used .

2.2 Combination of Data

Suppose the spare parts consumption data of equipment unit in the two different environments has been obtained.

The sample of spare parts consumption in the first environment is z_1 , and the sample of spare parts consumption in the second environment is z_2 .

When the parameters of the distribution in the two different environments are unknown, the conversion and combination of the spare parts consumption data are as follows:

(1) The maximum likelihood estimate method could be used to calculate the parameters of the distribution, then the point estimation values K_N and B_N could be calculated.

(2) According to the point estimation values K_N and B_N , the spare parts consumption data in one environment can be transformed into the equivalent spare parts consumption data in another environment.

When the spare parts consumption data in the second environment is transformed into the data in the first environment, the formula is (Sheng, 2013)

$$t'_{1j} = \hat{K}_N t_{2j} + \hat{B}_N \qquad j = 1,2,\cdots,z_2 \tag{4}$$

(3) Composite the spare parts consumption data in the two different environments, the combination of the spare parts consumption data are

$$t_{11}, t_{12}, \cdots, t_{1z_1},\ t'_{11}, t'_{12}, \cdots, t'_{1z_2}$$

In this way, the sample of the spare parts consumption data of equipment unit could be expanded into $z_1 + z_2$.

3. COMBINATION OF SPARE PARTS CONSUMPTION DATA WITH YEARLY VARIATION

3.1 Combination of Homology Equipment Annual Consumption Data

Composing the same variety of spare parts consumption data in many different environments could expand the sample of the spare parts consumption data of equipment unit and increase the forecasting precision of the spare parts consumption rule.

Suppose the spare parts consumption data comes from the same variety of equipment in l environments, and the using conditions are the same, the number of the same variety of equipment units is N .

Suppose the number of the same variety of equipment is n_i （$i = 1,2,\cdots,l$）, the number of spare parts consumption in the i th environment in the j th year is x_{ij} (j =1,2,…, m).

Statistics on homology equipment annual consumption in different environments is shown in Table 1.

Table 1: Statistics on homology equipment annual consumption in different environments

Environment \ Year	1	2	…	m
1	x_{11}	x_{12}	…	x_{1m}
2	x_{21}	x_{22}	…	x_{2m}
…	…	…	…	…
l	x_{l1}	x_{l2}	…	x_{lm}
Combination	$\frac{\sum_{i=1}^{l} x_{i1}}{\sum_{i=1}^{l} n_i N}$	$\frac{\sum_{i=1}^{l} x_{i2}}{\sum_{i=1}^{l} n_i N}$	…	$\frac{\sum_{i=1}^{l} x_{im}}{\sum_{i=1}^{l} n_i N}$

3.2 Combination of Different Equipment Annual Consumption Data

If the number of environments is very big, with regard to all the environments, it is essential to select the typical environments to do research on the combination of different equipment annual consumption data, then the spare parts consumption rule could be found.

Suppose the spare parts consumption data comes from the same variety of equipment in l environments, and the using conditions are the same, the number of the units in the k th equipment is N_k ; the number of the k th equipment in the i th environment is n_{ki} (i =1,2,…, l , k =1,2,…, q), the number of spare parts consumption in the i th environment in the j th year is x_{ij} (j =1,2,…, m).

Statistics on different equipment annual consumption in different environments is shown in Table 2.

Table 2: Statistics on different equipment annual consumption in different environments

Environment \ Year	1	2	…	m
1	x_{11}	x_{12}	…	x_{1m}
2	x_{21}	x_{22}	…	x_{2m}
…	…	…	…	…
l	x_{l1}	x_{l2}	…	x_{lm}
Combination	$\frac{\sum_{i=1}^{l} x_{i1}}{\sum_{i=1}^{l}\sum_{k=1}^{q} n_{ki} N_k}$	$\frac{\sum_{i=1}^{l} x_{i2}}{\sum_{i=1}^{l}\sum_{k=1}^{q} n_{ki} N_k}$	…	$\frac{\sum_{i=1}^{l} x_{im}}{\sum_{i=1}^{l}\sum_{k=1}^{q} n_{ki} N_k}$

4. CONCLUSIONS

Nearly all the segments about aviation ammunition equipment maintenance materials include acquisition, storage, supplying and management have close connections with the aviation ammunition equipment maintenance materials consumption information.

The application of the aviation ammunition equipment maintenance materials consumption models based on the reliability of the units under condition-based maintenance could be extended and the aviation ammunition equipment maintenance materials consumption models could also be improved aiming at solving different problems.

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