Research on inventory management method of meteorological spare parts

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Abstract: How to effectively manage and control the inventory of spare parts is the basis of reasonable and effective spare parts support, which is the problem faced by the current meteorological equipment managers. This paper starts from the framework of inventory spare parts management andThe management method of inventory spare parts is described in detail, with emphasis on the prediction method of inventory spare parts, spare parts classification model and spare parts control strategy. The research method in this paper can provide help for meteorological equipment managers and decision makers.

1. Introduction

With the construction and development of comprehensive meteorological observation in China, China has initially established a meteorological observation system with a combination of ground, space and space-based, complete categories and reasonable layout. Meteorological technical equipment is the material basis for the stable operation of the integrated observation system. At present, there are a variety of meteorological technical equipment, including high-altitude, ground, communication, satellite, radar and other meteorological instruments and equipment. These equipment will inevitably fail during operation. It is necessary to set up a spare parts warehouse of meteorological technical equipment, which can replace the failed equipment in time when the meteorological technical equipment fails, Ensure the stable operation of meteorological technology and equipment and provide high-quality meteorological services for the state and society. Too much spare parts inventory will occupy too much funds, and too little spare parts inventory will cause failure, unable to replace in time, affecting the operation of meteorological observation business. How to effectively manage and control the inventory of spare parts is an issue that meteorological equipment managers and decision makers must consider.

2. Inventory spare parts management framework

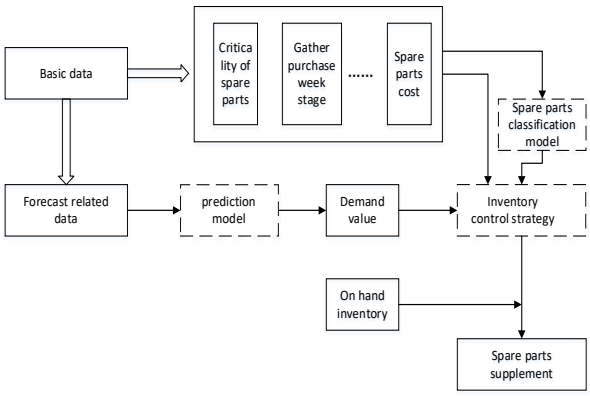

Figure 1. Basic framework and process of spare parts inventory management

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The spare parts inventory management process and framework are shown in Figure 1.

The key process of spare parts inventory management is: spare parts demand forecast, spare parts classification and inventory control strategy. As shown in the dotted box in Figure 1.

3. Inventory spare parts management method

3.1 Spare parts demand forecasting method

Equipment demand forecasting refers to estimating or estimating the demand quantity of spare parts in a certain period of time in the future according to the historical data of spare parts, which is the key premise of effective inventory control.

Continuous spare parts means that the demand for spare parts is continuous or can be regarded as continuous, its demand has certain rules to follow, and the interval between two consecutive demands is short [1]. Generally, some conventional fast flowing spare parts belong to continuous spare parts. Generally, the price of such spare parts is relatively cheap and the demand quantity is large. There are certain statistical laws in the historical data of spare parts demand. The common prediction methods include time series prediction method, regression prediction method and exponential smoothing method. Intermittent spare parts refer to the large zero value in the spare parts demand sequence, and its demand occurs randomly. Usually, this kind of spare parts is expensive and key. Due to equipment failure caused by shortage, it will cause great losses. The commonly used prediction methods include neural network, Bayesian prediction method and support vector machine prediction method. The spare parts demand forecasting method is shown in Figure 2.

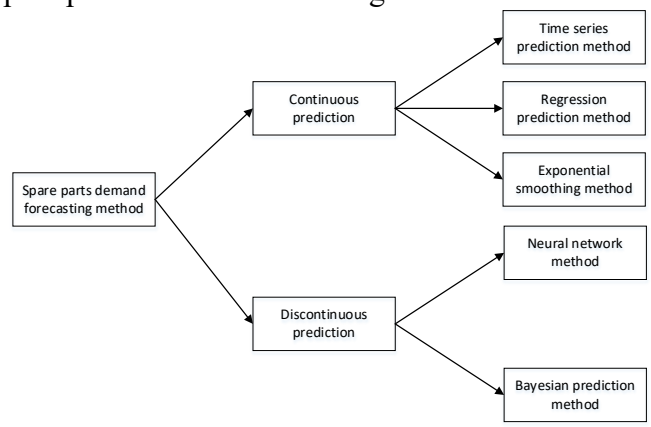

Figure 2. Spare parts demand forecasting method

(1) Demand forecast of continuous spare parts

1) Time series prediction method

Time series forecasting method is to predict the future demand according to the historical change law of variables. According to the historical demand sequence, find out the function form in which the future demand can be represented by the demand of the past several stages. The right side of the function takes the historical demand value from the past t to t-L as the input, and the right side of the function outputs the demand value in the future days. Taking the moving average method as an example, the predicted value takes the average value of several previous demand observations of spare parts as the demand predicted value of the next cycle.

$$\mathrm{F}_t = \frac{A_{t-1} + A_{t-2} + \ldots + A_{t-n}}{n} = \frac{\sum_{i=1}^{n} A_{t-i}}{n} \qquad (1)$$

Where, F_t is the predicted value for the next time, n is the number of cycles of the moving average method, A_{t-1} is the actual value of the previous time, and A_{t-n} is the real data of the previous n time periods.

2) Regression analysis

Regression analysis is a statistical prediction method based on mathematical statistics theory, which is used for continuous demand prediction. Based on the experience of a large number of historical data. By looking for the linear relationship between one or more independent variable factors and demand dependent variables, the least square method is used for the best fitting of multiple groups of observation data points, so as to construct the demand function model affecting demand change.

3) Exponential smoothing method

One finger smoothing method is another mode of weighted moving average method. The principle is that the future predicted value is based on the weighted average of the previous consumption and the predicted value, while the new predicted value is calculated from the predicted value of the previous item plus a part of the difference between the predicted value of the previous item and the real consumption. This incremental adjustment element is called coefficient [2].

The calculation formula of single exponential smoothing is:

$$\mathrm{F}_t = \alpha D_{t-1} + (1-\alpha)\mathrm{F}_{t-1} \tag{2}$$

Where, F_t is the predicted demand in period t, F_{t-1} is the predicted demand in period t-1, D_{t-1} is the actual demand in period t-1, and α is the smoothing coefficient ($0 \le \alpha \le 1$).

Double exponential smoothing is carried out on the basis of single exponential smoothing, and the calculation formula is:

$$F_t^2 = \alpha F_t^1 + (1-\alpha)F_{t-1}^2 \tag{3}$$

$$\hat{y}_{t+T} = \alpha_t + b_t \cdot T \tag{4}$$

$$\begin{cases} \alpha_t = 2F_t^1 - F_t^2 \\ b_t = \dfrac{\alpha}{1-\alpha}(F_t^1 - F_t^2) \end{cases} \tag{5}$$

Where, F_t^2 is the secondary exponential smoothing value at time t, F_t^1 is the primary exponential smoothing value at time t, F_{t-1}^2 is the secondary exponential smoothing value at time t-1, and α is the smoothing coefficient.

(2) Demand forecast of intermittent spare parts

1) Neural network prediction method

Artificial neural network simulates biological nerve based on the action characteristics of neurons. After being abstracted and simplified by mathematical language, it analyzes and simulates the functional structure of each neuron to realize the function of biological neurology. This neural network structure carries out the model modeling of daily complex nonlinear system. By continuously modifying the weights in the network, the sum of squares of output errors is minimized, and the maximum approximation to the model is realized. Because BP neural network has strong self-learning ability and large fault tolerance rate, it can comprehensively consider various factors affecting spare parts demand and simulate the complex relationship of spare parts demand, which has been widely used in practical application.

2) Bayesian prediction method

Bayesian prediction method is a time series prediction method based on dynamic model. Bayesian model not only makes full use of prior information, but also summarizes the experience judgment information of contacts. In each prediction, the positive model of the observed actual value will be used to make the prediction results more credible.

3.2 Spare parts classification method

At present, ABC spare parts classification method is widely used in inventory management. This method is from the perspective of economy

It is mainly based on the well-known "28 law" to divide the key minority and secondary majority of spare parts, distinguish the primary and secondary of many materials in spare parts management, and use the limited resource conditions to focus on the management of a small number of class a important materials that play a key role in meteorological observation, as well as the general management or secondary management of most class B or class C secondary materials with low impact, so as to realize the orderly primary and secondary management, It not only strengthens the management, but also saves the cost.

ABC classification method uses appropriate management strategies for spare parts inventory according to various categories, as shown in Table 1, so that the basic guarantee of meteorological spare parts can be completed by using relatively low cost and effective management methods. It can be seen that class a spare parts have less inventory, but they account for a large proportion of the total value and generally have a relatively high proportion of consumption rate. Therefore, the management method of uninterrupted inventory inspection can be used to increase the turnover rate of spare parts. The criticality of class B spare parts is slightly lower than that of class A, and the inventory quantity can be verified periodically. The quantity of class C spare parts is large, the share of total value is low, and the proportion of consumption rate is relatively low. A relatively simple inventory management method can be used to appropriately increase the amount of safety inventory and reduce the number of spare parts procurement.

Table 1 The Informartion Of Equipment

	Class A	Class B	Class C
Degree of management	Strict management	General management	Simple management
stock	less	More	many
Order quantity	Less	More	Many
Inventory counting frequency	concentrated	commonly	low

3.3 Inventory control strategy

In order to quickly respond to demand changes, spare parts inventory managers usually formulate appropriate inventory control strategies to assist them in making inventory management decisions, mainly involving whether spare parts are in stock, when to order spare parts in stock, and how to determine the quantity of ordered spare parts. Common inventory control strategies include (R, q) [3] strategy, (T, R, q) strategy [4], (s, s) [5] strategy, (T, s, s) [5] strategy and (s-1, s) strategy [6]. (R, q) strategy refers to the continuous inventory of spare parts. When the spare parts inventory is less than the order point R, the order is issued, and the order quantity is a constant Q. (t, R, q) strategy is similar to (R, q) strategy, except that the inventory method is changed from continuous inventory to periodic inventory. (s, s) strategy refers to the continuous inventory of spare parts. When the spare parts inventory level is less than the order point s, the order is started, so that the spare parts inventory level reaches S. at this time, the order batch is a variable. (s-1, s) strategy refers to the continuous inventory of spare parts inventory level. When there is a demand for spare parts, order from the supplier immediately to keep the inventory level constant s.

4. Conclusions

There are many methods for inventory management of meteorological spare parts, and each method has its own characteristics. Appropriate prediction methods, classification methods and

reasonable inventory control strategies should be used for inventory management according to the actual situation. In the follow-up research, we will select typical spare parts according to the actual application scenario to conduct in-depth research on the prediction algorithm, so as to provide guidance for the relevant decision-making of meteorological spare parts management.

References

[1] R. J. Hyndman, G. Athanasopoulos. Forecasting: principles and practice[M]. OTexts, 2018.

[2] J. D. Croston. Forecasting and stock control for intermittent demands[J]. Journal of the Operational Research Society, 1972, 23(3): 289-303.

[3] S. AXSA. Simple evaluation of echelon stock (R, Q) policies for two-level inventory systems[J]. IIE transactions, 1997, 29(8): 661-669.

[4] Z. Little, L. M. Grover, T. J. Teyler. Metabotropic glutamate receptor antagonist,(R, S)-α-methyl 4-carboxyphenyglycine, blocks two distinct forms of long-term potentiation in area CA1 of rat hippocampus[J]. Neuroscience letters, 1995, 201(1): 73-76.

[5] H. Niederreiter. Constructions of (t, m, s)-nets and (t, s)-sequences[J]. Finite Fields and Their Applications, 2005, 11(3): 578-600.

[6] I. Higa, A. M. Feyerherm, A. L. Machado. Waiting time in an (S− 1, S) inventory system[J]. Operations Research, 1975, 23(4): 674-68