The Consumption Law of Vehicle Maintenance Materials

Qianqian Zhu, **Lihui Wang, Wei Zhou**

Air Force Logistics College, Jiangsu China 221000, China

Abstract: This paper proposes a method for classifying vehicle maintenance materials consumption on the basis of defining the concept of vehicle maintenance materials consumption. We systematically analyze the influence of equipment design factors, equipment use factors and equipment maintenance factors on the maintenance materials consumption, then discuss the methods of studying the consumption law of maintenance materials such as empirical inference method, time series model, regression analysis model, combination of maintenance law and life, combination of analysis and data, and finally expound the significance of our study.

1. Introduction

Vehicle maintenance materials is an important part of vehicle maintenance support in our military. It has proved that the vehicle maintenance materials consumption is closely related to maintenance materials support activities. The management of the financing, storing, supplying and other aspects of vehicle maintenance materials support activities must be based on the consumption law of maintenance materials. The purpose of vehicle maintenance materials support is to ensure that the quantity of maintenance materials is appropriate, the quality is good, and the maintenance needs of the general materials of all forces are supported timely and reliably. Only by mastering the consumption law of vehicle maintenance materials, can we realize the efficient support of maintenance materials, and then improve the combat effectiveness of materials. In recent years, with the application of high technology and information technology, there are more and more types of vehicle, and the variety of maintenance materials is increasing rapidly, which makes it difficult to grasp the consumption law of maintenance materials and it is more difficult to predict consumption accurately. Reasonable methods and means are the prerequisites to obtain consumption law of maintenance materials and improve the prediction accuracy of maintenance materials consumption. Therefore, according to the requirements of materials maintenance support and the characteristics of maintenance materials, we study the classification and the influencing factors of maintenance materials consumption、 the study methods of consumption law of maintenance materials and then expound the significance of this work.

2. Definition of Vehicle Maintenance Materials Consumption

Vehicle maintenance materials consumption [1] refers to the variety, quantity and amount of maintenance materials used to maintain or restore a certain number of vehicle materials to a prescribed state within a certain period of time and under certain conditions. Here, the time is "broad", such as mileage and running time; Materials can be one-unit equipment or a single piece of equipment; "a certain number of equipment" can be all equipment of a unit or a single equipment; "condition" refers to the use conditions of equipment, including many aspects, such as the use environment, the use intensity, and so on; "state" refers to the training state, combat state, intact state of equipment and so on.

3. Classification of Vehicle Maintenance Materials Consumption

Vehicle maintenance materials consumption can be divided into different consumption types from different perspectives. As shown in Table 1, the maintenance materials consumption source,

equipment maintenance level, equipment demand timing, equipment use environment, sample data are divided as follows.

Table 1 Classification of maintenance materials consumption

Number	Classification basis	Consumption types
1	Consumption source	Development unit consumption, test range consumption, production unit consumption and military consumption
2	Equipment maintenance level	Overhaul consumption, minor maintenance consumption, medium maintenance consumption, major maintenance consumption
3	Equipment demand timing	Peacetime training consumption, wartime consumption, maintenance consumption, regular maintenance consumption
4	Equipment use environment	Plain materials consumption, plateau materials consumption, island materials consumption, desert materials consumption, mountain materials consumption, jungle materials consumption
5	Sample data	Large sample consumption data and small sample consumption data

4. Analysis of Influencing Factors of Vehicle Maintenance Materials Consumption

The vehicle maintenance materials consumption is affected by various factors. Different types of maintenance materials have different factors affecting their consumption. The influencing factors of maintenance materials consumption can be roughly divided into equipment design factors, equipment use factors and equipment maintenance factors.

4.1 Equipment design factors

(1) Material. To a certain extent, the functional characteristics of the equipment have some requirements for materials used in equipment manufacturing. Generally speaking, materials with single composition and fragile structure (such as rubber parts) are more likely to be damaged in the use of equipment, while metal parts are not easy to be damaged. Therefore, the material of the unit will affect the maintenance materials consumed by the unit.

(2) Function. Functions of different units in the equipment are different, and the frequency of use is also different. Therefore, the function of the unit also affects the maintenance materials consumed by the unit.

(3) Unit life. The life of the equipment unit reflects the design and manufacturing level of the equipment itself, and its length directly affects maintenance materials consumption. The longer the life of the unit, the fewer the number of failures, the less maintenance materials are consumed.

(4) Complexity. Under certain conditions and within a certain period of time, the materials with many parts, components and assemblies, high technical content and complex structure will generate more maintenance materials consumption in variety, quantity and amount than that of simple materials. Therefore, the complexity of equipment will have a significant impact on the maintenance materials consumption.

4.2 Equipment use factors

The maintenance materials consumption during the use and training of vehicle equipment is mainly affected by several factors such as use intensity, operation level and management level [2].

(1) Use intensity. The excessive use and seldom use of equipment have an important impact on the maintenance materials consumption. For example, the impact of excessive use is mainly reflected in two aspects: one is to increase the number of maintenance after equipment failure; the other is to increase the probability of equipment damage, thus increasing the maintenance materials consumption.

(2) Operation level. The operation level includes two aspects: one is whether the equipment users

operate according to the regulations, and the other is whether the operation is proficient. Failure to operate in accordance with the regulations and requirements or unfamiliar with the operation will increase the probability of component damage, thus affecting the maintenance materials consumption.

(3) Management level. Management level includes equipment management level and maintenance materials management level. The level of equipment management affects the service life and failure rate of equipment. The level of maintenance materials management affects the packaging, storage and maintenance status of maintenance materials, and then affects the maintenance materials consumption.

4.3 Equipment maintenance factors

4.3.1 Equipment maintenance cycle

Equipment maintenance cycle is a general term of equipment maintenance interval and maintenance rules [3]. Common equipment maintenance interval units include hour and mileage and so on. The length of the maintenance interval directly affects the variety, quantity and amount of equipment consumed. If the longer the maintenance interval is, the more frequent the maintenance will be after the failure, the more the total maintenance materials consumption will be after the equipment failure, and the less the total maintenance materials consumption will be during level maintenance; if the shorter the maintenance interval is, the more frequent the level maintenance is, the more the total maintenance materials consumption generated during level maintenance, and the less the total maintenance materials consumption produced after the failure. Equipment maintenance rules usually refer to the arrangement and procedures of equipment maintenance activities throughout the entire service life, which mainly specify when equipment is to be maintained and what maintenance depth or level is to be selected during maintenance.

4.3.2 Equipment maintenance level

According to the nature, scope and degree of maintenance, the current equipment maintenance can be divided into three maintenance levels: minor maintenance, medium maintenance and major maintenance [4].

①Minor maintenance

Minor maintenance refers to the adjustment, repair or replacement of simple parts, components and other repair activities for general faults and minor damages in the use of equipment. Its nature belongs to the operational repair of equipment.

②Medium maintenance

Medium maintenance is the repair of partial recovery performance of main system and assembly components of equipment. Its nature belongs to the balanced repair of equipment, that is, to repair some parts of equipment so that it can continue to be used together with its unrepaired parts.

③Major maintenance

Major maintenance is a repair that comprehensively restores equipment performance in accordance with technical standards. Its nature belongs to the comprehensive restorative repair of the equipment, that is, to completely disassemble the equipment, replace or repair all parts and components that do not meet the technical standards and requirements, eliminate defects, and make the equipment reach or approach the new product standards or the specified technical performance indexes.

Since the repair scope of different maintenance levels is different, it directly affects which level the equipment unit should be replaced at.

4.3.3 Unit repair methods

There may be two repair methods of "no replacement" and "visual replacement" in the equipment overhaul of the unit; three repair methods of "must replacement", "visual replacement" and "no replacement" may exist in the regular maintenance of the equipment, as shown in Table 2.

Table 2 Unit repair methods

Number	Maintenance level	Repair methods
1	Overhaul	visual replacement, no replacement
2	Minor maintenance	visual replacement, no replacement, must replacement
3	Medium maintenance	visual replacement, no replacement, must replacement
4	Major maintenance	visual replacement, no replacement, must replacement

No replacement in unit overhaul refers to the strategy that the unit reaches the service life, and cannot be replaced or is replaced without conditions when it is overhauled; visual replacement in unit overhaul refers to the strategy that the unit will be replaced if the unit reaches the service life, otherwise it will not be replaced.

Must replacement in unit regular maintenance refers to the strategy that the equipment repair organization will replace the unit regardless of whether it has reached the service life when performing regular maintenance on the equipment; visual replacement refers to the strategy of replacing the unit if the unit has reached the service life when the equipment repair organization performs regular maintenance on the equipment, otherwise it will not be replaced;　no replacement refers to the strategy that the equipment repair organization does not replace the unit regardless of whether the unit has reached the service life when performing regular maintenance on the equipment.

5. The Study Methods of Consumption Law of Vehicle Maintenance Materials

At present, the study methods involved in the consumption law of vehicle maintenance materials mainly include empirical inference method and mathematical method. Among them, mathematical methods and models are divided into time series model, regression analysis model, combination of maintenance law and life, combination of analysis and data, and so on. The classification of the study methods of consumption law is shown in Figure 1.
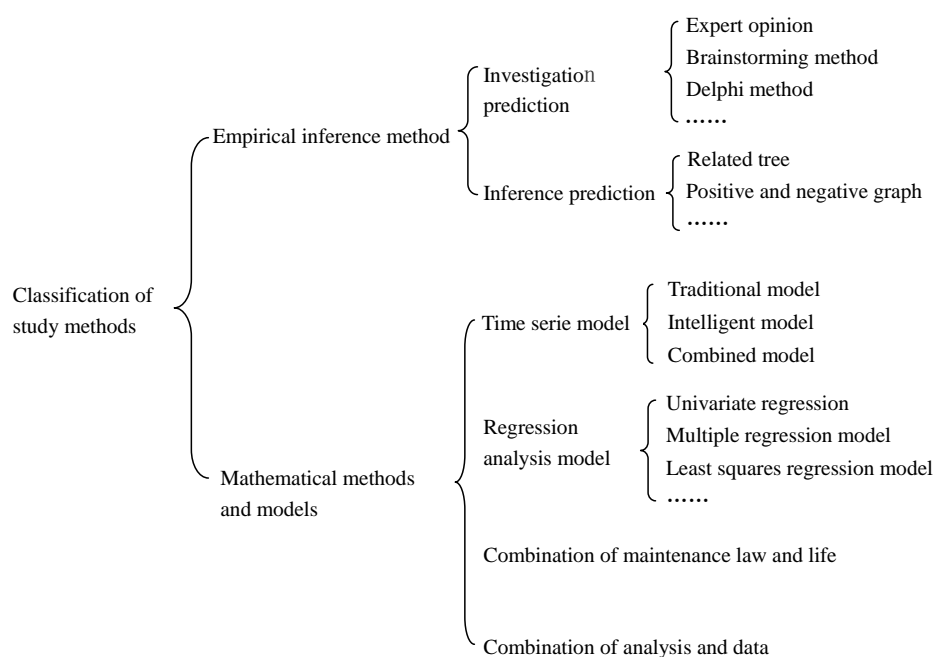

Figure 1 The classification of the study methods of consumption law

5.1 Empirical inference method

Empirical inference method is mainly applicable to the case where the statistical data of vehicle maintenance materials consumption is little, and this method is subjective. The empirical inference

method can be divided into investigation prediction and inference prediction. Experts analyze maintenance materials consumption through the experience and knowledge accumulated from long-term field practice. The advantage of the empirical inference method is that it requires less sample data and is simple to calculate. It is a common method for predicting maintenance materials consumption for new equipment; the disadvantage is that different equipment is used under different conditions and task requirements. Experts describe the maintenance materials consumption of new equipment by statistically analyzing the maintenance materials consumption data of old equipment and multiplying by the corresponding correction coefficient, where the error is often large, and the specific value of the correction coefficient is not easy to determine.

5.2 Time series model

Time series model is based on the objective process and certain regularity of the past development and changes reflected in the time series formed by the historical consumption data of maintenance materials, and establish a time series model to predict the future changes in maintenance materials consumption. The time series model only considers its own historical trends, and does not need to consider other influencing factors. It only needs to extrapolate in time according to the changes in the sequence to realize the prediction of the future.

According to the characteristics of application, time series model can be divided into three categories: traditional prediction model, intelligent prediction model and combined prediction model.

①Traditional prediction model [5-6]. The basis of traditional prediction model is traditional mathematical tools. There are many traditional time series prediction methods, such as moving average method, weighted moving average method, trend extrapolation method, exponential smoothing method, and so on.

② Intelligent prediction model [7-10].The rise of artificial intelligence provides new ideas for the development of prediction technology, and some new intelligent prediction methods appear. The intelligent prediction method takes full account of the knowledge and intelligence possessed by human beings, which is more in line with the reality of prediction and reasoning. It is a very promising method. At present, the commonly used intelligent prediction methods include grey prediction model, artificial neural network method and time series model based on support vector regression machine.

③Combined prediction model [11-13]. Combined prediction model tries to combine different prediction models, comprehensively utilize the information provided by various prediction models, and get the combined prediction model in the form of appropriate weighted average, so as to effectively improve the prediction accuracy. The combined prediction model uses various sample information to a greater extent, so it is more comprehensive and systematic than the single prediction model.

5.3 Regression analysis model

Regression analysis model seeks the correlation between the dependent variable and one or more influencing factors that affect the change of the dependent variable, fits the best fitting curve of these data points based on multiple sets of observation data to determine the relation between the influencing factors and the dependent variable, and establishes the regression equation, mainly including one-way regression, multiple regression and partial least square regression [14-15]. The characteristic of regression analysis is that it is intuitive in meaning. Through the equation, the influence degree of influencing factors on dependent variable can be carefully and accurately examined, and then the dependent variable can be predicted by influencing factors. Theoretically speaking, if we have a clear understanding of the influencing factors, and establish the quantitative relationship between the influencing factors and the dependent variable, then we can achieve better prediction results if we choose this method.

5.4 Combination of maintenance law and life

Different units have different service life. This method is to combine average service life of the unit with maintenance law of the equipment, consider use factors of the equipment and the unit, then infer the later consumption law of maintenance materials, predict the specific consumption value in a certain period of time; It can also combine the life distribution of the unit with the maintenance law of the equipment, consider the use factors of the equipment and the unit, and use the random process theory[16], then predict the later consumption value of maintenance materials.

5.5 Combination of analysis and data

Maintenance materials consumption has the characteristics of randomness and dynamic change, as well as certain regularity. In addition to using probability theory and mathematical statistics to predict the maintenance materials consumption, the method of combining analysis and data can be used to further analyze the dynamic characteristics of maintenance materials consumption and explore the development and changing process of maintenance materials consumption. For example, when studying the maintenance materials consumed by a unit, the distribution function of the same equipment consumed by other units under the same conditions can be used as a prior distribution [16], and it is combined with the maintenance materials consumption data generated by the unit, then the maintenance materials consumption of the unit can be predicted according to Bayes theory [17].

6. The Significance of Studying the Consumption Law of Vehicle Maintenance Materials

6.1 It can solve the prominent contradiction of overstock and shortage in maintenance materials support

Vehicle maintenance materials is an important material basis for vehicle maintenance support work, and an important guarantee for ensuring that equipment is in good condition and improving equipment regeneration capability. Exploring the consumption law of maintenance materials and scientifically predicting the variety, quantity and amount of maintenance materials consumed will help to solve the prominent contradictions in military such as existing co-existence of overstock and shortage, limited funds and shortage of demand in the current maintenance materials support.

6.2 It can provide reference for equipment department to apply for and finance maintenance materials.

Combining the actual situation of vehicle equipment and maintenance materials in military, we analyze the various factors that affect maintenance materials consumption in the use and maintenance activities, use relevant theories and methods to establish a consumption prediction model, then explore the consumption characteristics and consumption law of maintenance materials. We provide a reference for equipment department in military to carry out the application and financing of maintenance materials scientifically and reasonably.

6.3 It can provide a theoretical basis for our military to further revise the standard of maintenance materials

At present, the standard of vehicle maintenance materials is specially formulated for all equipment of the same type in the whole military, it does not distinguish between regions, the usage of various troops, different use stages of equipment, which reflects that the current standard is inaccurate. Therefore, it is necessary to combine the changes in the maintenance materials consumption data of each unit with the use time, conditions, and stages, give corresponding maintenance materials consumption prediction methods, and adjust and revise the standard of maintenance materials accordingly.

7. Conclusion

In this paper, we define the concept of vehicle maintenance materials consumption and give a classification method. We systematically analyze the influence of three main factors on vehicle maintenance materials consumption, discuss the study method of the consumption law of vehicle maintenance materials, and expound the significance of studying the consumption law of vehicle maintenance materials. According to the consumption law of vehicle maintenance materials, the construction unit can accurately predict the variety, quantity and amount of vehicle maintenance materials consumed within a certain period of time. On this basis, it can further optimize reserves of vehicle maintenance materials in construction units，and further improve the level of efficient support of maintenance materials.

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