

# IDENTIFICATION OF IMPROVEMENT WAYS OF ESTIMATION METHOD FOR NOMENCLATURE AND QUANTITY OF SPARE PARTS

**Poliakov A.P.<sup>1</sup>, Antonyuk O.P.<sup>2</sup>, Ratsyborynskiy V.V.<sup>3</sup>**

<sup>1</sup>*Vinnytsia National Technical University, farv@inmt.vntu.edu.ua*

<sup>2,3</sup>*Vinnytsia National Technical University, ASP\_Antonuk@ukr.net*

**Abstract:** *The article is dedicated to scientific - practical problem of improving the efficiency of the motor transport enterprise, due to calculation of rational number of spare parts.*

**Keywords:** *prognostication, a spare part, nomenclature, resource, need.*

## 1. Introduction

Currently great attention is paid to supply of spare parts for vehicles. This is explained by the fact that it is impossible to create a totally reliable object and to support it in working condition, you always need spare parts, which are used for removing random failures and replacement of worn parts and parts which reached the end of their service life.

It is known that the quality of provision of motor transport enterprise with spare parts depends essentially on the level of technical readiness of the rolling stock and the duration of downtime during repairs due to lack of necessary spare parts. Efficient operation of the rolling stock at the motor transport enterprise is possible only upon condition of timely supply of spare parts. Therefore the problem to which this article is dedicated is to determine the method that would allow determining the rational quantity of spare parts required for motor transport enterprises at a given time, provided failure-free reconditioning of vehicles.

## 2. Main part

To solve the problem formulated above is necessary to consider the methods used to determine the rational quantity of spare parts that are a part of the inventory of motor transport enterprise and identify their advantages and disadvantages, establish the possibility of their use at this time.

To determine the rational quantity of spare parts at present time there are many different methods. Let's consider the most used ones in details.

The most common method for determining the required quantity of spare parts is the application of nomenclature standards which establish the required average annual quantity of specific nomenclature name of parts for 100 cars per year [1]. The basis of this method is data on reliability of parts by means of:

- the use of approximate estimation of the life before the first parts replacement:

$$H_2 = \frac{L_r}{\eta \cdot L_1} 100,$$

where,  $L_r$  – annual mileage;

$L_1$  – the life before the first parts replacement;

$\eta$  – life restoring coefficient;

- determination of the average number of parts replacements for the service life period of a car:

$$H = \frac{100}{\eta} \cdot \left( \frac{L_r}{L_1} - \frac{1}{t_a} \right),$$

where,  $t_a$  – the useful life of a car.

- Additional consideration of variations of component life. For parts, life of which corresponds to the average annual mileage of a car  $L_r$  average rate of spare parts use should be determined by a full lifetime, taking into account

the variations of component life according to the formula:

$$H = \frac{100}{t_a} \left[ \frac{L_r \cdot t_a - L_1}{\eta \cdot L_1} + 0.5 \left( \frac{\nu^2}{\eta} + 1 \right) \right],$$

where  $\nu$  – coefficient of variation of component life.

Taking into account formulas (1 – 3) using the nomenclature standards, large and medium-sized motor transport enterprises can determine the need for spare parts, when using the following formula:

$$\Pi_{3\text{ч}} = \frac{H \cdot A}{100} \cdot k_{\Pi} \cdot k_1 \cdot k_2 \cdot k_3,$$

where  $A$  – available branded car park, pcs.;

$k_{\Pi}$  – coefficient which allows to take into account the average annual mileage deviation from the mileage given in the corresponding standard;

$k_1 = 1 \dots 1,65$  – coefficient which takes into account the operational environment (five categories);

$k_2 = 1 \dots 1,3$  – coefficient which takes into account modification and car working conditions (eight modifications);

$k_3 = 0,8 \dots 1,4$  – coefficient which takes into account weather conditions (seven climatic regions).

The work [2] provides a method for determining the current stock of spare parts, according to which the required number of spare parts is determined by the following formula:

$$3_{\Pi} = \frac{A \cdot N \cdot t_{cp}}{36000},$$

where,  $A$  – quantity of cars;

$N$  – rate of spare parts use, pcs./100 cars per year;

$t_{cp}$  – average time gap between deliveries.

Insurance warranty stock level is determined according to the formula:

$$3_{\Pi} = \frac{A \cdot N \cdot \sigma}{36000},$$

where,  $\sigma$  – root-mean-square deviation of time gap between deliveries.

$$\sigma = \sqrt{\frac{\sum (t_i - t_{cp})^2}{n-1}},$$

where,  $t_i$  – time gap between two neighbouring deliveries;

$n$  – number of deliveries for the determined previous time period. (3)

Stock level is calculated in the form of maximum  $3_{\max}$  and minimum  $3_{\min}$  levels:

$$3_{\max} = 3_{\Pi} + 3_{cmp} = \frac{A \cdot N}{36000} (t_{cp} + \sigma),$$

$$3_{\min} = 3_{cmp} = \frac{A \cdot N}{3600} \sigma.$$

The method of determination of spare parts stock  $Z_p$  at the (4) the house of motor transport enterprise, to maintain the probability of car failure-free operation at a given level is described by dependence:

$$Z_p \geq \frac{L}{T_0} + X_a \cdot \frac{\delta \cdot \sqrt{L}}{T_0^{3/2}},$$

where,  $L$  – mileage thousands;

$T_0$  – component average lifetime;

$X_a$  – quantile of life normal distribution;

$\delta$  – root-mean-square deviation of component life.

In the work [3] the number of spare parts required for the operation of one car with a given probability of failure-free operation during the scheduled period of time is determined by applying the following equations:

$$n = n_2 - n_1,$$

where,  $n$  – number of required spare parts;

$n_2$  – number of required spare parts at the end of the scheduled period; (5)

$n_1$  – number of required spare parts at the beginning of the scheduled period.

$$n_2 = \frac{T_2 - \tau \cdot \delta}{\mu},$$

where,  $T_2$  – car operating time at the end of the scheduled period;

$\tau$  – accuracy level of mathematical calculations;

$\mu$  – expectation (6) value of component life allocation;

$\delta$  – root-mean-square deviation of component life allocation.

$$n_1 = \frac{(T_1) - \tau \cdot \delta}{\mu},$$

where,  $T_1$  – car operating time at the beginning of the scheduled period.

In due time the author of this method [4] identified the need for spare parts, having tested once a group of cars with different operating time. The author collected and analyzed data on the failures of vehicles and units, determined a parameter of replacement flow. By this a failure of separate component of the car system was equal to the failure of the entire system and all parameters of component replacement flow formed one total parameter of replacement flow for the entire system. With the known value of individual components, you can determine unit costs for spare parts for car units and systems  $C_{3q}^S(L)$  according to the formula:

$$C_{3q}^S(L) = \sum_{J=1}^M C_{3q,J}^S(L) = \sum_{J=1}^M \omega_J^S(L) \cdot C_J,$$

For the whole car:

$$C_{3q}^A(L) = \sum_{S=1}^N C_{3q,J}^S(L) = \sum_{S=1}^N \sum_{J=1}^M \omega_J^S(L) \cdot C_J,$$

where,  $\omega_J^S(L)$  – s parameter of replacement flow J – its components, which relates to S – my a car unit or system;

$C_J$  – unit cost J – components depending on the car operating time;

$N$  – quantity of car units and systems;

$M$  – number of components and elements in car units.

The method of need prognostication in spare parts, developed by the author, [5] takes into consideration operating conditions and car maintenance:

$$\Pi_{3q} = N \cdot \lambda \cdot L \cdot K_j \cdot \sqrt{N_\delta \cdot \lambda \cdot L},$$

where,  $N_\delta$  – quantity of components, installed in cars;

$\lambda$  – rate of failures;

$L$  – car mileage;

$K_j$  – gamma – percentage quantile of standard normal allocation.

The disadvantage of the given method is that determination of a necessary quantity of spare parts does not take into account a range of important in our opinion factors such as operating conditions and vehicle operation rate.

The author in his work [6] describes the method of determination of average spare parts use for a certain item, where rating formula takes

into account parameters characterizing car technical condition, road conditions and weather conditions:

$$Z_{CP} = K_H \cdot K_V \cdot K_3 \cdot \lambda_{\max} \cdot \sum L,$$

where,  $\lambda_{\max}$  – rate of failures;

$L$  – average mileage of all cars;

$K_H$ ,  $K_V$ ,  $K_3$  – coefficients which take into account road and weather conditions (seasonal prevalence), spare parts stock.

The work [7] describes the method according to which it is offered to determine a quantity of components replacement for any mileage from 0 to  $L$ , using the method of renewal theory, according to the formula:

$$N = \frac{(L_{am} - L_{nog}) \cdot 100 \cdot n}{t_{am} \cdot R_{3q}} + 100 \cdot X_a \frac{\delta \cdot \sqrt{L_{am}}}{t_{am} \cdot \sqrt{R_{3q}^3}},$$

where,  $N$  – rate of spare parts use;

$L_{am}$  – car mileage for a depreciation period;

$L_{nog}$  – lifetime of a new component, car unit before the first replacement;

$t_{am}$  – car lifetime;

$X_a$  – quantile of normal life allocation of a primary component;

$\delta$  – average root-mean-square deviation of component life;

$R_{3q}$  – average lifetime of spare parts between replacements.

Shchetina V.A. and Lukinski V.S. in their work [8] mentioned that for need prognostication in spare parts during car operating conditions should be used the extrapolation method. By this actual use of spare parts for a certain item of nomenclature for a given make of a car is presented in the form of short time series and in this connection the prognostication of necessary quantity of spare parts using the most developed extrapolation methods makes a certain complication. Structural scheme of prognostication of necessary quantity of spare parts using extrapolation is given in pic. 1.

In general view a prognostication model includes three components (pic.2) and is given in the following form:

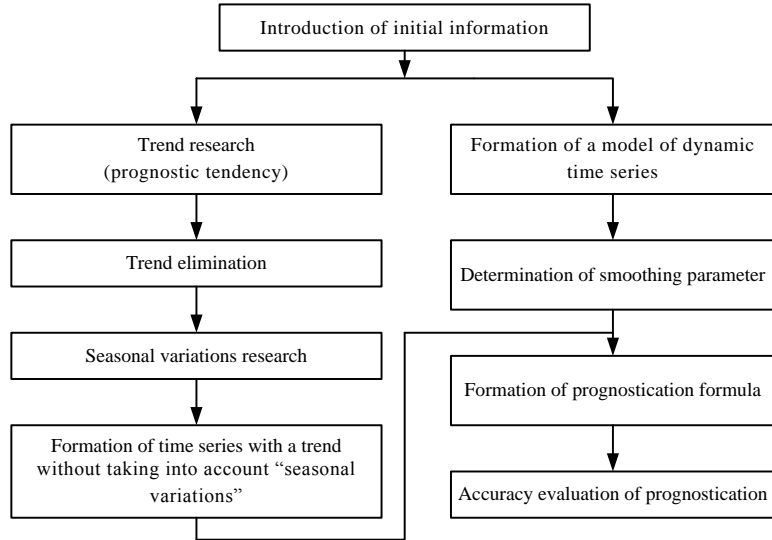
$$y_t = \bar{y}_t + U_t + \varepsilon_t,$$

where,  $y_t$  – prognosticated value of time series;

$\bar{y}_t$  – average prognostication value (trend);

$\varepsilon_t$  – random value of prognosis deviation (white noise).

$v_t$  – a prognostication component, that describes seasonal variations;

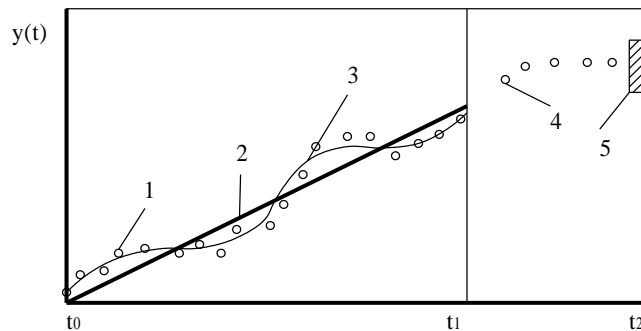


**Figure 1:** Structural scheme of prognostication of necessary quantity of spare parts, using extrapolation of time series

Using the formula (19) to predict the need for spare parts involves the following operations: by values in the pre-predictive period the least square method define coefficients of trend  $\bar{y}$ , the kind of which is specified (by polynomials of different orders), using seasonal wave it is necessary to eliminate a trend from the original series. If there is an evident seasonal wave, determined by the coefficients of equations which are approximated  $v_t$ ; random component  $\varepsilon_t$  is determined after the elimination from series trend values and seasonal waves at the pre-predictive period. For descriptions of white noise  $\varepsilon_t$  we use the normal law of distribution with zero expectation value

and unknown dispersion  $\sigma^2$ ; the accuracy of prognostication is increased by methods of discounting, adaptation.

The method of exponential smoothing has got a practical use, this method increases the importance of the last values of series comparing with the first ones. Prognostication increase is achieved by using multifactor models, by choosing the best dependencies for a trend and seasonal component. Methods based on extrapolation can be realized on the basis of computers as a non-tidal prognostication system.



**Figure 2:** Prognostication of necessary quantity of spare parts using extrapolation of time series:  
 1 – experimental data at the observation interval; 2- trend; 3 – trend and seasonal wave;  
 4- single-value prediction; 5 – interval prediction

Despite the variety of prognostication methods of need for spare parts at present the method for determining the needs for actual demand for spare parts is widely used in practice. The main advantage of this method is the reliability of information on the use of spare parts and efficiency of use that is explained by the ease of use. However, a significant disadvantage is that demand fluctuations for spare parts is compensated by the creation of additional reserves in the storehouses of spare parts, which in turn is connected with additional risk of illiquid stocks of spare parts.

### 3. Conclusion

As a result of analysis for the works dedicated to the determination of rational quantity of spare parts used for repair of vehicles, we can make a conclusion that the complex process of vehicle operation is simplified to obtain a compact easy-to-use functional dependencies. It is obvious that the application of these methods at certain stages of economic development was appropriate. So in the conditions of centralized economy, the use of standard methods for determining the required quantity of spare parts became very popular. However, at this time, under the conditions of market economy, motor transport enterprises operate in production environment, characterized by intense competition from both domestic and foreign enterprises. In these conditions, motor transport enterprises for "survival" at the market and keeping competitive ability should timely and efficiently make decisions to supply spare parts for personal vehicles. Therefore, in this situation any deviations from the calculated rational quantity of spare parts cause additional financial costs arising due to additional downtimes of rolling stock that could cause breakings in the performance of contracts.

Therefore, for motor transport enterprises there is an urgent problem of timely and reliable determination of the required quantity of spare parts that at present time is impossible without the improved method for determining the rational quantity of spare parts that make up the inventory of motor transport enterprises.

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