TECHNICAL SCIENCES

IMPROVED METHODOLOGY OF DETERMINING THE NOMENCLATURE OF SPARE PARTS FOR MILITARY EQUIPMENT OPERATION

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Abstract

The task of ensuring the necessary nomenclature of spare parts (SP) in operating and repair units of the Armed Forces (AF) of Ukraine is one of the most urgent, since the timely provision or availability of the required number of SP allows them to quickly carry out maintenance and repair of military equipment (ME) and, accordingly, ensure their effective use as intended.

The article is prepared on a topical issue related to increasing the level of failure-free operation of ME by adjusting the nomenclature and number of SP, taking into account the reliability of units and systems of ME, as well as their operating time and service life.

Keywords: military equipment; maintenance; technical condition.

1. INTRODUCTION.

One of the main conditions for the successful conduct of combat operations in modern conditions is maintenance of combat capability of units in the Armed Forces of Ukraine according to the level of their staffing with serviceable ME. Therefore, significant attention has been paid to the problems of determining and maintaining the required level of technical condition (TC) of the Armed Forces of Ukraine ME samples in the conditions of carrying out CO. ME failure occurs both as a result of combat damage and for operational and technical reasons associated with the increased intensity of ME operation under these conditions [1].

Formulation of the problem. The transition of the Armed Forces of Ukraine to a qualitatively new level caused significant changes in the organizational and staffing structures, capabilities and fundamentals of the employment of support units in modern conditions. Despite this, the majority of ME samples remain morally and physically obsolete, that requires the rational use of the necessary SP while performing the assigned tasks both in peacetime and in the conditions of carrying out CO.

Analysis of recent research and publications. When conducting a search for scientific publications in this subject area, the scientific works of well-known scientists, such as O. Vorobiov [2], O. Volokh [3], P. Openko [4] and others, cannot be ignored. The researchers consider the impact of the need for spare parts on the trouble-free operation of ME.

However, taking into account the results of the above-mentioned scientific studies and conducting of the Joint Forces Operations (JFO), as well as during a full-scale invasion of the Russian Federation troops [5; 6], there is an urgent need to increase the level of trouble-free operation of ME by adjusting the nomenclature and number of ME, taking into account the reliability of units and systems of ME, as well as their operating time and service life.

The purpose of the article. Improvement of the methodology for determining the nomenclature of SP

for ME for the planned period of operation, taking into account changes in their TC.

2. RESEARCH RESULTS.

The proposed methodology of determining the nomenclature of SP for ME for the planned period of operation consists of two stages:

the stage of forecasting the change of ME TC for the planned period of operation;

the stage of determining SP for ME for the planned period of operation.

2.1. Forecasting changes in the technical condition of military equipment for the planned period of operation.

The prerequisite for the development of the stage of forecasting the change of ME TC for the planned period of operation, taking into account the operating time and service life, is a justified choice of the evaluation criterion of ME TC. Based on the analysis of the nature, types and ways of eliminating failures of ME systems, the parameters of the flow of failures and the probability of failure-free operation were chosen as the criteria for evaluating performance [7-9].

The process of carrying out maintenance and repair of ME systems largely depends on the availability of SP, which will allow to restore ME operability within the time limit established by regulatory documents. Establishing the necessary moment of replacement of a part that has exhausted its resource, for the recovery of one or another ME system, involves determining its performance. The forecasting of the serviceability of the ME system is carried out on the basis of statistical information about the change of its TC, depending on the operating time and service life of ME.

The essence of the stage of forecasting the change of ME TC for the planned period of operation is to perform the following steps [10]:

Step 1. ME of the same brand is divided into operating groups according to the operating time and service life.

Step 2. Based on the collected statistical data on the failures of ME systems, the parameter of the flow of failures is calculated, and its graphical dependence on the operating time and service life of ME is constructed.

Step 3. The appropriate analytical dependencies are developed to determine the most necessary SP.

The failure flow parameter is the most optimal indicator for evaluating the serviceability of recoverable ME samples, because compared to the operating time to failure, it has no limitations in application. The assessment of the operational efficiency of ME systems based on the operating time to failure provides correct results only for ME with a well-tested design.

Therefore, it is proposed to evaluate the performance of ME systems by the reliability indicator - the parameter of the flow of failures. In addition, the failure flow parameter is quite simply determined from a statistical sample.

In order to calculate the failure flow parameter of ME systems and build it on the basis of the calculated values of its dependence on the operating time and service life of ME, it is necessary to have data on system failures, namely: the nature (type) of the failure, the operating time and the age of ME at the time of the failure. The operating range and the time ME is in operation, during which data on failures are collected, is established depending on the purpose of the study. After that, the distribution of system failures by groups is carried out depending on the operating time and service life of ME.

Based on the calculated values of the parameters of the flow of failures for each operational group of ME, graphic dependences of the parameter of the flow of failures on the operating time and service life of ME are built. The values of the parameters of the flow of failures are placed in the middle of the operating time intervals of each group.

Based on the research of the features of the structure, functioning and loss of performance of ME systems, the law of distribution of the probability of their trouble-free operation is established, after which the nomenclature of parts that fail most often is determined. The criterion for determining the operational efficiency of ME systems is the permissible level of probability of its fault-free operation, which, according to the recommendations, is considered to be equal to 0.85. When achieving the probability of failure-free operation of ME systems of an acceptable value, it is necessary to take into account the inclusion of the most unreliable elements of ME systems.

Forecasting of the change in ME TC for the planned period of operation, in contrast to the existing ones, is carried out using the mathematical apparatus inherent in homogeneous Markov chains with the composition of the system of Kolmogorov differential equations [10].

2.2. Determination of spare parts for military equipment for the planned period of operation.

In the work, this task was solved applying regression models. Currently, regression models are widely used in demand modeling and forecasting, as they most adequately reflect the influence of factors on the process of demand formation. Regression models are based on the application of the apparatus of correlation and regression analyzes and are built in the form of regression equations, in which the studied parameter acts as a function, and the factors that influence this parameter act as independent variables.

In order to take into account the complex influence of factors on the need for SP and establish the degree of relationship between the factors themselves, it is advisable to build a one-factor regression model. In order to apply a one-factor regression model in forecasting the number of SP under the conditions of tasks execution by units of the Armed Forces of Ukraine, it is necessary to consistently implement a number of the following steps.

The first step at the stage of determining the number of SP for carrying out ME maintenance and repair is their division into groups and subgroups according to the period of the operating time and service life. To determine the approximate number of groups, the Sturges formula will be applied.

The register of factors for each specific unit of the Armed Forces of Ukraine can be extended depending

on the specifics of its activity and the geographical conditions of its functioning. However, only those factors that can be taken into account and predicted to change in the conditions of a specific unit of the Armed Forces of Ukraine should be included in the model for forecasting the required number of SP for ME.

2.2.1. Mathematical model of forecasting changes in the technical condition of military equipment depending on the terms of the service life.

In order to take into account the complex influence of factors on the need for SP and to establish the closeness of the relationship between the factors themselves, it is advisable to build a regression model.

For this, the ME is considered as a system that can acquire different states during operation (the ME sample is fully functional; one system of the ME sample has failed, the others are functional; several systems of the ME sample have failed; all systems have failed) that differ among themselves in the quality of the system's performance of its functions. At the same time, the criterion for evaluating efficiency will be the maximum finding of such a system in states when its parameters are within the limits of permissible values: the probability of trouble-free operation is 0.85-0.95; the coefficient of technical use is 0.8.

Thus, the dependence of the total number of failures of ME systems on the period of service life is described by an ordinary homogeneous Markov chain, in which ME can exist in 4 states [10].

At the same time, a linear form of the relationship between the number of failures and the period of service life is assumed, which can be determined using a linear pairwise regression equation, applying the generally accepted method of least squares.

Taking into account the developed mathematical model, the scheme of the methodology for forecasting the need in SP for ME for the planned period of operation is shown in Fig. 1.

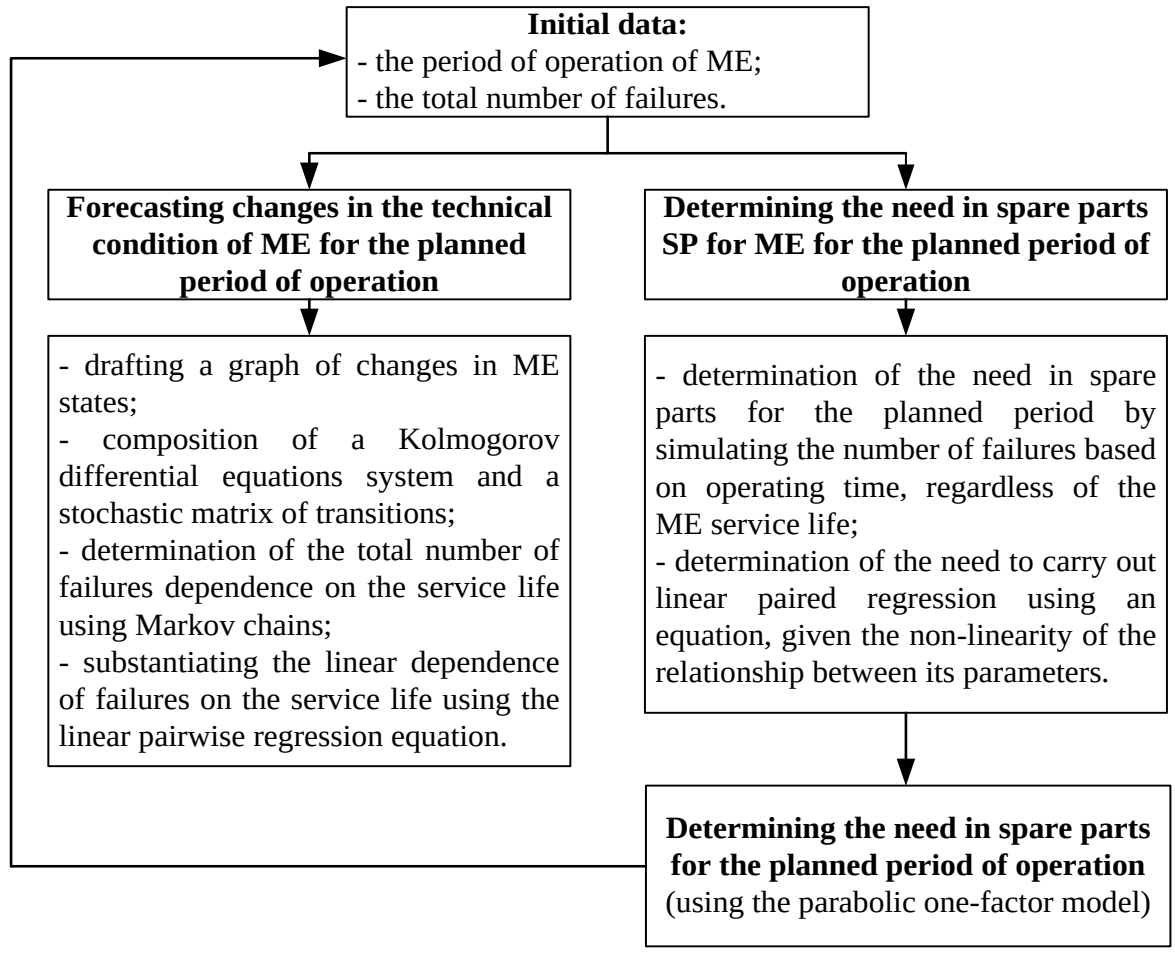

Figure - 1. The scheme of the algorithm for the implementation of the methodology for determining the nomenclature of SP for ME for the planned period of operation.

3. CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH.

Thus, the proposed improved methodology for determining the necessary nomenclature of SP for the planned period of operation, which, unlike the existing ones, includes: the stage of forecasting the change of ME TC, that takes into account the parameter of the system failure flow, which depends on the operating time and service life; the stage of determining the necessary nomenclature of SP, which is based on the developed mathematical model for forecasting changes of ME TC, that allows to adjust the nomenclature and number of SP in total, taking into account the reliability

of units and systems depending on the operating time and service life.

Besides, application of the developed theoretical provisions of the methodology for determining the necessary nomenclature of SP for ME for the planned period of operation, allows to obtain numerical values of the failure flow parameter and the probability of failure-free operation for each group of ME, divided according to the operating time and service life. This makes it possible to reduce the time required to carry out maintenance and repair of ME, by adjusting the nomenclature and number of SP taking into account the reliability of ME units and systems, as well as the operating time and service life. It was established that according to the results of the calculations of the coefficient of technical use of ME with different terms of their service life, the efficiency of functioning of ME maintenance and repair system will increase.

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