Main criteria of complex evaluation of subway train power facility technological productive potential

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Abstract. Maintaining the train safety and passenger transportation safety is regulated by the technical condition of rolling stock, which meets the requirements of regulatory documentation. Modern conditions of operation of traction rolling stock units (UTRS) are characterized by insufficient use of production and technological potential. One of the main reasons for this situation is the lack of necessary scientific and methodological developments that describe and improve system methods, models and criteria for the effectiveness of the production processes of UTRS.

1. Introduction

The present stage of activity of the enterprises is characterized by competition growth that demands continuous process of improvement and optimization of productions [1-4]. Along with such measures for optimization of functioning of the enterprises as resource-saving and energy efficiency [5-14], level of automation and mechanization, more productive is use of complex indicators of efficiency of activity of the enterprises and their divisions [15-16].

The greatest efficiency of use of complex indicators can be reached at the enterprises with complex administrative structure and a large number of structural divisions. It is possible to carry transport enterprises with branched structure to such enterprises, in particular the subways.

For example, in the Kyiv subway, except divisions that directly provide transportation of passengers, expenses for operation, repair and complex service of artificial constructions, track elements [17-18] and tunnels, and rolling stock in which service three train depots – Darnytsa, Obolon and Kharkivska – are engaged in constantly growing.

Wide range of the equipment that is served by the locations of structural divisions becomes the reason of low efficiency of functioning of the specified divisions.

Criteria of efficiency of complex assessment of production and technological potential use of UTRS in real to the functioning environment in work were formulated and offered. The mathematical model of calculation and level of use of production and technological potential and quality of management of productions of UTRS was developed.
2. Methods and course of the study

Production and technological capacity of divisions of the traction rolling stock represents a possibility of performance of useful work with maximum efficiency of use of the fixed business assets and also human, material and financial resources.

For definition of PTP UTRS it is used following expression:

\[ W_i = \frac{W_{ip}}{n} \]

where \( W_i \) is the size that characterizes the production and technological potential of PTRS on a period \( i \); \( W_{ip} \) is useful work which is performed by repair shop on \( i \) period.

Size \( W_i \) and its components \( W_{ip} \) can be expressed in natural and monetary value. It is expedient to express the size \( W_i \) in terms of money as it allows to present various physical quantities by means of uniform indicators (expenses on work implementation: Income, the job got for performance, etc. Irrational use of the equipment testifies to insufficient the level of use of fixed assets of UTRS.

Lack of scientific and methodical capacity of the enterprise; Lack of scientifically based lists of works which could be executed in UTRS (except the established types of activity); Lack of effective mechanisms of management of productions of UTRS in the conditions of the market relations, cause irrational use of UTRS.

For the purpose of improvement of efficiency of functioning of processes of repair and the current maintenance of the traction rolling stock it is necessary to carry out the analysis of the parameters influencing the size \( W_{1i} \) which decides on the help of the following expression:

\[
W_i = \left( \sum_{j=1}^{K} \sum_{k=1}^{P} h_j L_{ji} \right) (1 + r_k) + \left( \sum_{j=1}^{K} a_j c_j q_{ij} \right) (1 + r_k) + \left( \sum_{j=1}^{K} b_j c_j q_{ij} \right) (1 + r_k) + \left( \sum_{j=1}^{K} \sum_{p=1}^{P} c_{ip} Q_{ip} \right) (1 + r_k)
\]

\[
= (1 + r_k) \left( \sum_{j=1}^{K} \sum_{k=1}^{P} h_j L_{ji} \right) + \sum_{j=1}^{K} a_j c_j q_{ij} + \sum_{j=1}^{K} b_j c_j q_{ij} + \sum_{j=1}^{K} \sum_{p=1}^{P} c_{ip} Q_{ip}.
\]

\[ i = 1, 2, \ldots, M; \quad j = 1, 2, \ldots, N; \quad k = 1, 2, \ldots, K; \quad p = 1, 2, \ldots, P, \]

where \( r_k \) is the set level of profitability of functioning of productions to repair and service of the traction rolling stock on \( i \) period (0 < \( r_k < 1 \));

\( c_{ip} \) is the cost of the rendered service \( p \) on \( i \) period;

\( Q_{ip} \) is the number of the rendered services and the performed works in the environment of functioning of productions on repair flowing to deduction traction rolling stock on \( i \) period.

\( h_j \) may include such standard costs: the salary with charge of the technological personnel occupied with repair and the current maintenance of the traction rolling stock on \( i \) period; spare parts; operational materials; electric energy; thermal energy; expenses on compressed air. The norm of expenses \( h_{ij} \) can be determined from expression

\[
h_{ij} = h_{ij} k_{ai} + h_{Mj} k_{Mj} + h_{aj} k_{aj} + h_{cj} k_{cj} + h_{Tij} k_{Tj} + h_{CTij} k_{CTj}
\]

where \( h_{ai} \), \( h_{Mj} \), \( h_{aj} \) is the standard of expenses on the salary, materials and spare parts for name mechanisms \( j \) in the basic period, respectively;

\( k_{ai} \), \( k_{Mj} \), \( k_{aj} \) is the index of growth of expenses on the salary, materials, spare parts in \( i \) period, respectively;

\( h_{cj}, h_{Tij}, h_{CTij} \) are standards of expenses on electric, thermal energy and compressed air in the basic period, respectively;

\( k_{cj}, k_{Tij}, k_{CTij} \) are respectively indexes of growth of standard costs, on electric, thermal energy and compressed air in \( i \) period.

Size \( \sum_{j=1}^{K} a_j c_j q_{ij} (1 + \alpha_a) \) depends on the cost of the equipment and coefficient of its intensity of use \( \alpha_a \).

Size \( \sum_{j=1}^{K} \sum_{p=1}^{P} c_{ip} Q_{ip} \) depends on the number of the rendered services and the performed works \( Q_{ip} \).
So, UTRS making sizes $W_i$ of production and technological potential depends on efficiency of use of human, material and energy resources and extension of the nomenclature of the performed services and works due to increase in coefficient of intensity of use of the equipment.

For realization of reserves of use of production and technological potential there is a need of introduction of standard target methods of management of productions of UTRS which provide formation of scientifically based standards of expenses of the resources necessary for implementation of production economic activity, and development of the corresponding mechanisms purposeful on achievement of the high end results. One of the main criteria of efficiency of use of production and technological potential of UTRS at realization of standard target methods of management is the size

$$E_{d_i} = |W_{i1} - \bar{W}_{i1}|, \alpha \omega_i W_{i1} \bar{W}_{i1}$$  \hspace{1cm} (4)

The value of $E_{d_i}$ for some interval $[O,T]$ can be expressed using the expression

$$E_{d_i} = \int_O^T \varphi_i(i, W_1, \bar{W}_1) W_1(i) - \bar{W}_1(i) di$$  \hspace{1cm} (5)

where $\varphi_i(i, W_1, \bar{W}_1)$ weight function, which shows that the same deviations at different points in time are not the same $\varphi_i(i, W_1, \bar{W}_1) \leq 1$.

It can be noted that the work of the management system of production processes of UTRS is reduced to minimizing the functionality

$$E_{d_i} = \min_{U_i} \left[ \int_O^T \varphi_i(i, W_1, \bar{W}_1) W_1(i) - \bar{W}_1(i) di \right]$$  \hspace{1cm} (6)

The effectiveness of UTRS production process management can be assessed using the following parameter:

$$e_{d_i} = \frac{\int_O^T \varphi_i(i, W_1, \bar{W}_1) W_1(i) - \bar{W}_1(i) di}{\int_O^T \bar{W}_1(i)di}$$  \hspace{1cm} (7)

Considering the stochastic nature of size $e_{d_i}$ it can be written:

$$\bar{e}_{d_i} = M\{e_{d_i}\} = M\left\{ \frac{\int_O^T \varphi_i(i, W_1, \bar{W}_1) W_1(i) - \bar{W}_1(i) di}{\int_O^T \bar{W}_1(i)di} \right\}$$  \hspace{1cm} (8)

The obtained mathematical expressions for assessment of production and technological potential and effective management of processes of repair shops, allow solving problems of optimization.

Indicators of level of use of PTP have to be operated whether that is allowed to establish the necessary value and to support its state to change it in the necessary direction. Most fully the level of use of PTP can be estimated by the system of the indicators classified by the principle of characteristics of the made products, objects and means of labor and also action methods regarding work. Concerning repair production the indicators characterizing an object of the labor can enter such system; means of labor; action methods regarding work.

Increase in efficiency and quality of use of production and technological potential of UTRS provides, first of all, development of means of labor and establishment of rational ratios between
human and automated by work. For a research of technological level of production at all stages of life cycle, it is necessary to have the set (standard) model of a condition of PTP. In the presence of such model it is possible to define as far as to it there corresponds the current situation of production.

Figure 1 show the list of major factors and indicators under the influence of which the production and technological potential of UTRS, the level of its development and extent of use is formed.

Significantly the quantitative and qualitative structure of processing equipment influences on the level of use of technological potential production.

The most dynamic factor determining the level of use of production and technological potential is the technological level of processes of production. The package of measures for optimization of technological processes leads to decrease in labor input, increase in labor productivity and quality of the performed works.

\[ \text{Figure 1. Major factors and indicators under the influence of which the production and technological potential of UTRS, the level of its development and extent of use is formed.} \]
Each of the presented factors is characterized by a set of indicators which quantity depends on a real condition of the concrete enterprise. Definitions of influence of all factors and indicators on the level of use of production and technological potential is relevant to the scientifically applied to the task which can be solved on the basis of economic-mathematical modeling.

On the basis of the carried-out analysis it is possible to draw a conclusion that systematization and classification of the main criteria of efficiency and quality of use of production and technological capacity of divisions of the traction rolling stock allows passing to realization of system model of functioning of UTRS in modern operating conditions of the enterprise.

3. Conclusions
Summing up, the level of utilization of production and technological potential of the units for maintenance of the subway traction rolling stock influences on the quantitative and qualitative composition of technological equipment, and the complex of measures for optimization of technological processes leads to reduction of complexity, increase of labor productivity and quality of the performed works. The mathematical model for estimation of production technological potential and efficiency of management of production processes of PTS is offered which gives an opportunity to solve problems of optimization with the use of mathematical model of enterprise functioning.

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