EFFICIENCY CRITERION IN LIFE EXTENSION OF TRACTION ROLLING STOCK

Krasheninin, Alexander S., *Ukranian State University of Railway Transport, Kharkov, Ukraine.*

ABSTRACT

Operating experience of traction rolling stock shows that due to economic and financial problems it is necessary to study the effectiveness of its use in the period, exceeding the standard. The author conducted a research to determine the effectiveness criterion of TRS regarding repair, modernization or replacement. Criterion, based on the dimension theory, enables us to find maximum operation efficiency of traction means in real economic conditions.

Keywords: railway, economics, finance, cost recovery, efficiency criterion, traction rolling stock.

Background. *Given the lack of economic and industrial resources the need for modernization of traction rolling stock (hereinafter referred to as TRS) becomes relevant to railways. Its implementation, taking into account a number of factors, allowing extending the service life of TRS provides significant savings during maintenance and repair [5].*

Clearly, this is a reminder of the importance of the cost-effectiveness of measures to modernize, because cases may arise where such efforts do not pay off, or vice versa, modernization stops, although it clearly promises an effect.

In practice, when deciding on the effectiveness of the modernization of the old TRS, which extends its service life, indicators of three options must be compared: extension of service life due to repair and operation of old TRS, its modernization or replacement with a new one.

Sometimes the rationale of economic efficiency of modernization boils down to two options, i.e. organization of future repair and operation of TRS or its modernization. It is motivated by a lack of funds to replace the exhaust sample [1, 9-11].

However, regardless of these arguments comparison of modernization and replacement is a prerequisite. In a sense, this makes it possible to determine which bearers should be planned and what is necessary to hold the replacement of old equipment, when in fact there is a reason for it. Similarly, a comparison cannot be limited only to the cost of repair and replacement of the old TRS with the new one. Informative indicators to perform an objective comparison of the options are availability of capital investments in appropriate measures [2, 3].

Objective. *The objective of the author is to find an efficiency criterion in life extension of traction rolling stock.*

Methods. *The author uses general scientific methods, mathematical methods, simulation, dimension theory.*

Results. *In many cases, we have the following relation of these indicators on the options:*

$$R_C < K_M < K_H \; ; \; C_H < C_M < C_C \; ; \; P_C < P_M < P_H \; , \qquad (1)$$

where P_X, K_M, K_H are costs of repair in extension of life, modernization, replacement of old TRS with the new one;

C_H, C_M, C_C are cost of transportation after repair, modernization, replacement of old TRS with the new one, on an annual basis;

P_C, P_M, P_H are performance of TRS after repair, modernization, replacement with the new one.

As can be seen, for the third group of indicators it is necessary to increase productivity of TRS, so the search for the best option should be conducted not in absolute, but in specific dimensions of costs.

Pic. 1 shows a block diagram of a procedure of finding the best embodiment with different ratios of these indicators.

At the same time in this formulation it is impossible to determine time when it is necessary to take relevant measures to upgrade or replace TRS [4, 6, 8].

As follows from Pic. 2, the dynamics of changes in the characteristics P(t), C(t) is quite complicated, which requires the monitoring of performance of TRS, and the cost of the work over time. It is quite difficult to ensure this during operation.

It may be noted that the required relationship between P_M and P_C must meet the ratio $P_M \geq \frac{K_M}{R_{\tilde{N}}} \cdot P_C$ *(Pic. 3).*

In order to avoid uncertainty in the search for optimal ratio between price, performance or cost we use the method of dimensions.

The search for criterion for assessing the modernization or replacement of the old TRS with the new is accomplished by a method of dimension in a form

$K=f(P, R(K_M, K_C), C) \rightarrow max$ (2)

Let's represent the dimension of this criterion, taking into account the meaning of ensuring the efficiency of transportation as the ratio of performance to price and cost parameters (hryvnia – UAH)::

$$[K] = \left[\frac{tkm}{hryvnia. \cdot \frac{hryvnia}{tkm}} \right] = \left[\frac{(tkm)^2}{(hryvnia)^2} \right]. \qquad (3)$$

Hence we get a general view of the criterion as a square root of the square of the dimension in the final form:

$$K = \sqrt{\frac{P}{R \cdot C}} \; . \qquad (4)$$

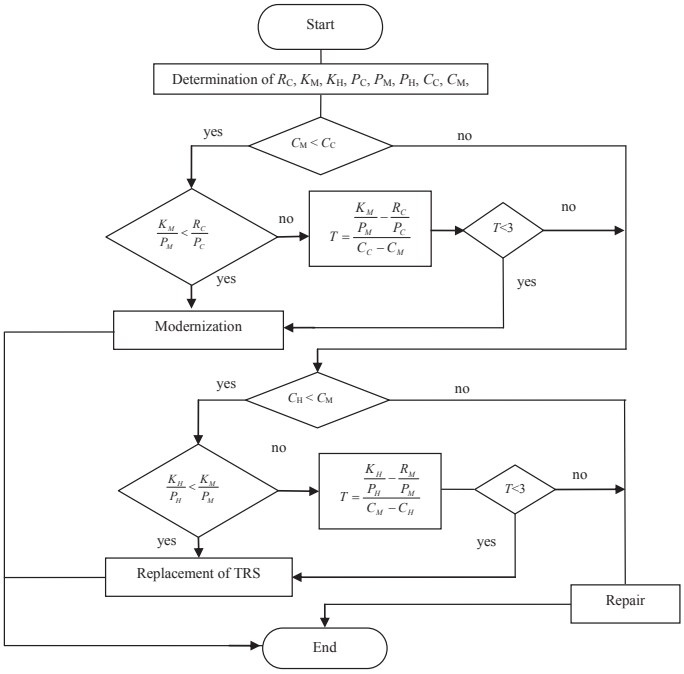
In determining the effort to modernize or replace old TRS with a new one we will present this criterion in a form suitable for simulation:

$$K_M = \sqrt{\frac{(P_C + \Delta P_M)}{(R_C + \Delta K_M)(C_C - \Delta C_M)}} \; ; \qquad (5)$$

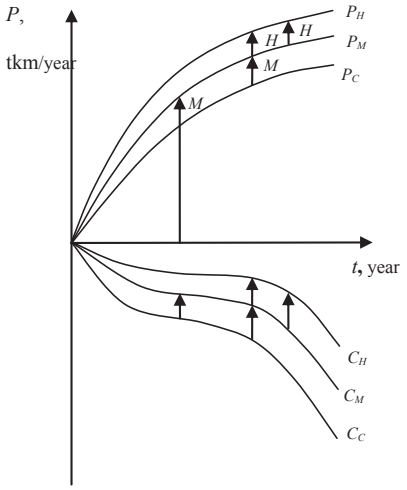
$$K_H = \sqrt{\frac{(P_C + \Delta P_H)}{(R_C + \Delta K_H)(C_C - \Delta C_H)}} \; . \qquad (6)$$

To simplify the simulation we denote initial values of performance, repair costs, and the cost of transportation like, P_C=1, R_C=1, C_C=1 and define corresponding parameters of their changes in the range ΔP=0,1-0,9; ΔK=0,1-0,9; ΔC=0,1-0,9. With the program MathLab values obtained for each value of ΔK graphic dependences are partially shown in Pic. 4.

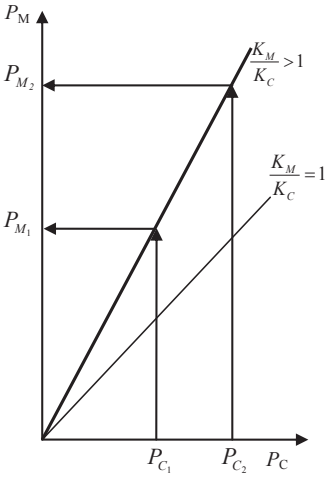
On the basis of graphic dependences it can be stated that repairs (ΔK=0,1), modernization (ΔK=0,3) or replacement (ΔK=0,5) allows virtually in the entire range to increase the efficiency of locomotives' use. At ΔK=0,5 there is a slight decrease in efficiency relative to the option ΔK= 0,3. However, it is clear that the modernization as compared with replacement of lo-



Pic. 1. Block diagram of options of life extension, modernization, replacement of TRS.



Pic. 2. The dynamics of changes in TRS productivity and cost of transportation.



Pic. 3. Dependence $P_M = f(P_C)$.

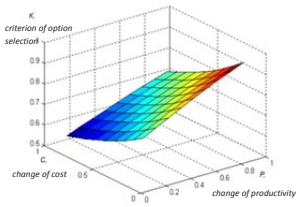
comotives can achieve a significant increase in performance with simultaneous destruction of unit costs. It is clear to consider that the option d) $\Delta K = 0,9$ reproduces the situation of locomotive's replacement, in which the price of a new one is about 1,9 times more than the total measures for in-depth repair and modernization of the locomotive. Depending on expected parameters of the dynamics and according to given dependencies it is possible to decide on measures to maintenance of locomotives [5, 7, 10].

Conclusions.

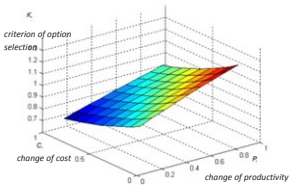
1. The complexity of developing a database to modify the parameters of effective use of TRS requires a search for alternative ways to solve the problem of extending the life of TRS, its modernization or replacement with a new one.

2. Preliminary calculations with account for the payback period of measures to modernize or replace TRS should be performed using an algorithm that takes into account the ratio of parameters, realizing efficient use of TRS.

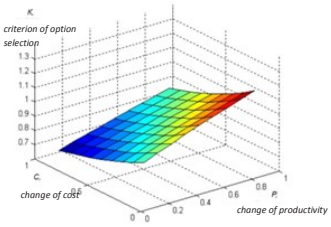
3. A formal process of searching for the term of the measures to modernize or replace TRS are determined by the achievement of maximum of K with corresponding investments ΔK in repair, modernization or replacement of traction rolling stock in the range of changes of performance ΔP and cost of transportation ΔC.



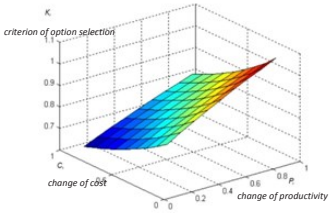
a) ΔK= 0,1



b) ΔK= 0,3



c) ΔK= 0,5



d) ΔK= 0,9

Pic. 4. Determination of criterion K, depending on the dynamics of ΔP and ΔC: a) ΔK=0,1; b) ΔK= 0,3; c) ΔK=0,5; d) ΔK=0,9.

Assuming the relative value ΔK, according to statistics it is possible to define for different ratios of ΔP, ΔC the area to maximize the operational efficiency of TRS.

REFERENCES

1. Galkin, V.G., Paramzin, V.P., Chetverov, V. A. Reliability of traction rolling stock: a tutorial [*Nadezhnost' tjagovogo podvizhnogo sostava: uchebnoe posobie*]. Moscow, Transport publ., 1981, 184 p.

2. Kolegaev, R. N. Determining the optimal durability of technical systems [*Opredelenie optimal'noj dolgovechnosti tehnicheskih system*]. Moscow, Sovetskoe radio publ., 1967, 113 p.

3. Konson, A. S. Economics of machines' repair [*Ekonomika remonta mashin*]. Moscow-Leningrad, Mashgiz publ., 1960, 235 p.

4. Kozlov, B.A., Ushakov, I. A. Manual for calculation of reliability of electronics and automation equipment [*Spravochnik po raschetu nadezhnosti apparatury radiojelektroniki i avtomatiki*]. Moscow, Sovetskoe radio publ., 1975, 472 p.

5. Krasheninin, A.S., Kharlamov, P. O. Assessment of the efficiency of the system of prolongation of the lifecycle of TRS over period fixed by regulations and renewal of operation fleet [*Ocinka efektivnosti sistemi podovzhennja terminu sluzhbi TRS bil'sh normativnogo i onovlennja ekspluatacijnogo parku*]. *Visnik Shidnoukraïns'kogo universitetu im. Volodimira Dalja,* 2012, Iss. 3 (174), pp. 109-113.

6. Mikhlin, V. M. Prediction of technical condition of machines [*Prognozirovanie tehnicheskogo sostojanija mashin*]. Moscow, Kolos publ., 1976, 287 p.

7. Severtsev, N. A. Reliability of complex systems in operation and testing: a tutorial [*Nadezhnost' slozhnyh sistem v ekspluatacii i otrabotke: Ucheb. posobie*]. Moscow, Vysshaya shkola publ., 1989, 432 p.

8. Sukharev, E.A.. The theory of operational reliability of machines: a lecture course [*Teorija ekspluatacionnoj nadezhnosti mashin: Lekcionnyj kurs*]. Rivne, Vidavnictvo UDAVG, 1997, 162 p.

9. Tartakovsky, E.D., Grishchenko, S.G., Kalabukhin, Yu.E., Falendysh, A. P. Methods for assessing the life cycle of traction rolling stock of railways: Monograph [*Metody ocenki zhiznennogo cikla tjagovogo podvizhnogo sostava zheleznyh dorog: Monografija*]. Lugansk, Noilidzh publ., 2011, 174 p.

10. Yakunshevich, I.P., Krasheninin, A.S. Metodika viznachennja potencijnih vidmov v elementah nesuchih konstrukcij lokomotiviv. Collection of scientific works [*Zb. nauk. prac'],* UkrDAZT, 2012, Iss. 128, pp. 233-237.

11. Cantos, Pedro, Pastor, Jos M., Serrano, Lorenzo. Efficiency Measures and Output Specification: The Case of European. *Journal of Transport and Statistics,* 2000, Vol. 3, Iss. 3, pp. 61-68.

Information about the author:

Krasheninin, Alexander S. – D. Sc.(Eng.), professor at the department of Operation and repair of rolling stock of Ukrainian State Academy of Railway Transport, Kharkov, Ukraine, info@kart.edu.ua.

Article received 11.12.2014, accepted 02.03.2015.

IT

ПРОБЛЕМЫ УПРАВЛЕНИЯ • ADMINISTRATION, MANAGEMENT AND CONTROL