

SUMMARY
of dissertation for academic degree of Doctor of Philosophy (PhD)
in specialty 6D071300 – Transport, Transport Equipment and Technology

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**Modernization of Straightening-tamping-lining
VPO-3-3000 Machine**

Relevance

In the address "Strategy "Kazakhstan-2050" New political course of the established state" there are set the tasks of joining Kazakhstan to the 30 most developed countries in the world by 2050. The national logistics operator, the NC KTZh solves the tasks of the Strategy "Kazakhstan-2050" to develop transit potential and to increase transit traffic through Kazakhstan by 10 times in 2050.

The operational length of public railways in the country is kept at the level of 21.2 thousand km. Modernization and repair of the railway and logistics infrastructure after the development of the transport and logistics complex is one of the key aspects in the state program for the Nurly Zhol infrastructure development.

An important issue is mechanization of the repair work of railway tracks. There are a number of machines for these works: VPO-3-3000, Duomatic, Unimat, VPR, DGS. One of the most frequently used in RK machines is the VPO-3-3000 machine. The machine is designed for straightening, tamping and lining the track and has a significant cost up to \$ 1,000,000.

As the analysis has shown, as a result of downtime due to the failure of the units of this machine, a significant amount of time is lost, which is needed for the repair and restoration of railway tracks.

Purchasing new machines is very expensive. Therefore, it is possible and necessary to modernize these machines by replacing some components and assemblies.

This determines the relevance of this dissertation research aimed at modernizing the VPO-3-3000 machine.

The purpose of the work is to establish dependences that allow developing options for upgrading the VPO-3-3000 machine.

The main idea of the work is to increase the efficiency of work on the repair of railway tracks through modernizing the VPO-3-3000 machine, which is much more efficient than purchasing new ones.

To achieve the purpose, it is necessary to solve the following tasks:

- to analyze the state of the railways of Kazakhstan and to carry out an analytical review of the designs of machines used in the repair and construction of railways;

- to collect and to analyze statistical data on the frequency of failures of machines for repair, and their causes depending on the interval of the path and the time of operation;

- to select a method of improving the efficiency of VPO-3-3000 through modernization of its units;
- to substantiate the criterion of optimality and to establish the dependence of the optimal time for modernization of units on cost parameters;
- to carry out a statistical analysis of the causes of the vibrating plate failures;
- to justify the application and to perform the hydraulic drive design;
- to study the stress-strain state of the lifting and straightening device during the operation of the VPO-3-3000 track machines;
- to calculate the economic efficiency of the proposed design changes, to develop technical specifications.

The object of study is a machine for repair and construction of railways.

The subject of study is modernization of the VPO-3-3000 machine.

Research methods are as follows: economic-mathematical modeling, optimization theory, machine experiment, mathematical modeling.

Scientific novelty of the dissertation is determined by changing the design and principle of operation of the vibrating plate drive and straightening grippers, and consists in:

- obtaining statistical dependences of the frequency and causes of failures of units and assemblies of machines for repair of railway tracks depending on the interval (section length) and MTBF;
- substantiating methods of modernizing the VPO-3-3000 machine;
- establishing the economically optimal time for modernizing units of equipment;
- obtaining dependences that describe the stress-strain state of the lifting and straightening device of the VPO-3-3000 machine.

The practical value consists in developing a methodology of determining the optimal time for modernization, selection of modernization objects and calculation of the parameters of their work, and in developing technical specifications.

The author submits for the defense:

- the obtained experimental data of the frequency and causes of failures of machines for repair;
- the selected method of modernizing the VPO-3-3000 machine;
- the obtained calculations of the volumetric hydraulic drive of the vibrating plate;
- dependences that describe the stress-strain state of the lifting and straightening device structure during operation;
- dependences that determine the optimal time for replacing a unit with a new one;
- results and methods of calculating the economic efficiency of the proposed modernization;
- technical specifications.

Validity and reliability of scientific statements, conclusions and results is confirmed by the correctness of the problem statement, the adequacy of theoretical and machine research.

The author's personal contribution consists in setting tasks, determining the most frequently failing units of the VPO-3-3000 machine, developing and analyzing an economic-mathematical model that allows evaluating modernization of the VPO-3-3000 machine according to optimization criteria, performing machine experimental studies that made it possible to determine the parameters of the hydraulic drive of the vibrating plate, developing and studying the design of the lifting and straightening device, developing technical specifications for the design of experimental structures of the lifting and straightening device and the hydraulic drive of the vibrating plate.

Implementation of the work results

The manual for modernizing the VPO-3-3000 machine and the methodology of calculating the optimal time for modernization of the units of the VPO-3-3000 machine were transferred to the JSC NC "KTZh" "Shusky mechanized track distance" and to JSC NC "KTZh" "Akadyr mechanized track distance" in 2021 year.

Information of publications

Based on the materials of the dissertation, 12 papers have been published in Russian, Kazakh and English, among them an article in a journal included in the database of the rating agency Scopus, four articles in the editions recommended by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan. The work was tested at six international conferences including two foreign ones. There is a certificate of state registration of rights to the copyright object.

Conclusions

The work contains new scientifically based results, the use of which provides a solution to an important applied problem.

The paper draws the following conclusions:

- the analysis of the Kazakhstan railways state and an analytical review of the structures of machines used in the repair and construction of railways has been carried out;
- statistical dependences on the probability of failure-free operation of the VPO-3-3000 machine show that the greatest downtime of the machine occurs due to the lifting and straightening device and the electric drive of the vibrating plate;
- the method of determining the time optimal for the efficiency of replacing upgraded units has been obtained;
- it has been found that in order to increase the efficiency of the VPO-3-3000 machine, it is necessary to modernize two units;
- the method of increasing the efficiency of the machine VPO-3-3000 has been substantiated;

- the criterion of optimality has been substantiated and the dependences of the optimal time for modernization of units have been established depending on the cost parameters;

- a statistical analysis of the causes of vibrating plate drives failures has been carried out and the hydraulic drive has been designed;

- the stress-strain state of the lifting and straightening device has been studied during the operation of the VPO-3-3000 track machines using the ANSYS program;

- the calculation of the annual economic efficiency of modernization has been made, taking into account the probability of failure of two mechanisms. Partial machine rebuilds meet the requirements of increasing profit, that is, increasing the revenue and reducing the costs. At the same time, the annual economic effect from the partial modernization of the VPO-3-3000 machine will amount to 60,000 tenge per machine.