SELECTED ABSTRACTS OF D.SC. AND PH.D. THESES SUBMITTED AT RUSSIAN UNIVERSITIES

The texts of the abstracts originally written in Russian are published in the first part of the issue.

Тексты авторефератов на русском языке публикуются в первой части данного выпуска.

DOI: https://doi.org/10.30932/1992-3252-2022-20-3-14
World of Transport and Transportation, 2022, Vol. 20, Iss. 3 (100), pp. 230–240

Berestok, N. O. Improving safety of production processes at railway transport enterprises based on reducing the influence of the human factor. Abstract of Ph.D. (Eng) thesis [*Povyshenie bezopasnosti proizvodstvennykh protsessov predpriyatii zheleznodorozhnogo transporta na osnove snizheniya vliyaniya chelovecheskogo faktora. Avtoref. dis... kand. tekh. nauk*]. Moscow, RUT publ., 2021, 24 p.

The train traffic is the technical and technological basis for production processes of a transport enterprise. The continuous repetition of accidents, derailments, train collisions and the prerequisites for them, for almost the same reasons, is associated with the human factor. According to statistics, 90 % of all incidents occur due to violation of the rules and regulations governing the actions of employees. This indicates that the existing system for prevention of violations of train traffic safety in organisation of the transportation process is not sufficiently effective.

Increasing the level of safety of industrial transport processes by traditional methods due to significant amounts of capital investments in the short term is an unlikely option. Therefore, the study of the issue of improving safety by reducing the negative impact of the human factor seems to be relevant.

The objective of the thesis is to develop a methodology for assessing the level of safety of production processes of railway transport enterprises, taking into account the influence of the human factor.

To achieve this goal in this study, it is necessary to solve the following tasks:

• To analyse existing approaches to safety management of industrial transport processes.

• To structure safety violations of production transport processes.

• To substantiate the tools for obtaining expert data on the relationship between types of violations and signs of safety culture.

• To propose an approach to assessing the impact of the human factor on safety of production transport processes.

• To substantiate the technology of cluster analysis of violations of train traffic safety rules, considering the influence of the human factor.

• To develop a methodology for assessing the level of safety of production processes of railway transport enterprises, considering the influence of the human factor.

• To test the developed methodological solutions and offer recommendations for minimising the negative impact of the human factor on ensuring safety of production transport processes.

As a result of the research carried out in the thesis, the scientific problem of developing a methodology for assessing the level of safety of production processes of railway transport enterprises was solved, considering the influence of the human factor. The main scientific and practical results obtained are as follows.

The analysis of the state of safety of production transport processes was carried out, which showed that the human factor has a significant impact on the level of safety and development of methodological tools for assessing this impact is required.

A hypothesis has been put forward about the connection between violations actually committed by employees and signs of safety culture which is a new tool for the activity of railway enterprises in ensuring safety of train traffic. The hypothesis is confirmed by expert assessments obtained during the thesis research.

A specific structuring of safety violations of production transport processes was carried out, which made it possible to reduce the variety of single violations to a specific number of their types, which have a stable character, which makes it possible to streamline

their processing and analysis in specific production situations.

A methodology has been developed for assessing the level of safety of production transport processes, taking into account the influence of the human factor. The technique includes:

• Comprehensive average assessment of the overall level of safety for the established types of violations.

• Average expert assessment of the degree of connection between violations and signs of safety culture.

• A method for quantifying the level of safety of production transport processes, considering the influence of the human factor.

• Cluster analysis used to obtain structured information that complements the generalised average estimates.

Approbation of the methodology on the example of 2018 data made it possible to establish the following values of average estimates:

• Average assessment of the relationship of violations with signs of safety culture: 0,27.

• The level of safety of production transport processes without considering the influence of the human factor: 0,35.

• The level of safety of production transport processes considering the influence of the human factor: 0,31.

The Harrington scale, modified by the author, is proposed for the qualitative characteristics of quantitative assessments of the level of safety of production transport processes. Its modified version differs from the original one in more stringent requirements for the interpretation of quantitative estimates. The value of 0,31 on the Harrington scale and on the scale proposed in the thesis for assessing the safety violation of production transport processes, considering the influence of the human factor, corresponds to a low level of safety.

A cluster analysis toolkit is proposed that allows obtaining information that supplements the average estimates necessary for making managerial decisions to improve the safety level of production transport processes and reduce the negative impact of the human factor. The toolkit includes a method of expert assessments for establishing a connection between types of violations and signs of safety culture, nine clusters of violations with their author's grouping according to aspects of safety culture, the author's interpretation of the content of each cluster.

The fact of a close connection between safety violations committed by employees of the enterprises of traffic organisation of JSC Russian Railways, with the mistakes of students of a transport university when they work with the author's test content has been established. An explanation for the existence of such a relationship is given.

Recommendations are proposed to improve the safety level of production transport processes and reduce the negative impact of the human factor, including at the university stage of staffing transport production.

The obtained results, conclusions and proposals have found application in the work of the department of traffic safety of JSC Russian Railways, LLC Project Technologies and the department of railway stations and transport hubs of RUT (MIIT).

Based on the results of the analysis, technological maps were developed for each cluster of violations, aimed at increasing the level of safety of production processes by minimising the influence of the human factor.

The prospect of further development of the topic is the improvement of indicators characterising a systematic approach to the culture of production at the enterprise.

05.02.22 – Organisation of production (transport).

The work was performed and defended at Russian University of Transport.

Chekalova, E. A. Scientific and technological bases for formation on the surface of a cutting tool and parts of discrete diffusive oxide layers to improve their durability. Abstract of D.Sc. (Eng) thesis [*Nauchnie i tekhnologicheskie osnovy formirovaniya na poverkhnosti rezhushchego instrumenta i detalei diskretnykh diffuzionnykh oksidnykh sloev dlya povysheniya ikh dolgovechnosti. Avtoref. dis… doc. tekh. nauk*]. Moscow, MAI publ., 2021, 45 p.

The strategy of increasing reliability and durability of machines requires a fundamental improvement of quality of parts and assemblies of manufactured products. Successful solution to this problem is practically impossible without development and introduction of new, more advanced materials and efficient technological processes. A special place in achieving the required number of machine parts is occupied by the surface hardening of tool and structural materials.

Classically, hardening of tool and structural materials is achieved by introduction of alloying elements and heat treatment through rational control of the chemical composition and structure of materials.

At the same time for a number of the most massive and critical parts, such as compressor blades of gas turbine engines operating under the influence of high alternating loads, corrosion and erosion effects of the gas environment, which as a rule, play a decisive role in the life of engines as a whole, the problem of developing new, more efficient methods of surface hardening is very relevant.

The problem of strengthening tool and structural materials became especially acute in development of new highly loaded energy-intensive machines, in solving the problems of reducing labour intensity and cost, and significantly increasing their competitiveness in the world market.

Creation of promising gas turbine engines is inevitably accompanied by a sharp tightening of their operating conditions, an increase in the level of thermomechanical cyclic loads, the need to use more advanced tool materials, and improvement of quality of surface treatment. In this regard a very promising direction in solving the problem of increasing reliability and durability of tools and products is creation of new highly effective wear-resistant coatings.

The main cause of premature loss of efficiency of compressor blades and tools is destruction of hardening coatings. Establishing the mechanisms of wear and destruction of coatings on tool and structural materials is of paramount importance in solving the problem of durability.

Another important task is development of new, more reliable and economical industrial technologies of formation of hardening surfaces, which ensure high stability of quality and reproducibility of physical and mechanical properties. The establishment of functional relationships between the parameters and the technological process of formation of coatings and their operational characteristics is becoming highly relevant.

An integrated approach to solving the set tasks involves, first, a deep study of the mechanisms of destruction of coatings under the influence of non-stationary thermo-mechanical loads, then a scientific substantiation of purposeful alloying of the surface layer of parts and tools to obtain specified operational properties.

The paper proposes a fundamentally new solution to the problem of durability of machine parts and tools, which consists in development of a new type of diffusion coatings with a discrete cellular structure of non-stoichiometric composition, which have increased wear resistance.

The objective of the work – to improve technological and operational properties of tools and parts by creating a surface diffusion discrete oxide layer during treatment with a corona discharge current.

The study allowed achieving the following results.

A theoretical model of durability of a sample with a diffusion discrete oxide layer has been developed for a comparative assessment of the effect of a discrete oxide layer and a continuous coating on the physical and mechanical properties of the surface layer of the material.

A new method has been developed for obtaining discrete oxide layers by the corona discharge current at low temperatures (up to room temperature) on the surface of a cutting tool and parts made of tool and structural materials, and recommended process parameters have been determined that increase durability of the cutting tool and parts under operating conditions.

The influence of the chemical composition of the gas environment and parameters of the technological process on the structure of the formed oxide layer of materials of the tool ad parts being processed, and the influence of structural features of discrete oxide layers on

physical-mechanical and cutting properties the tool material and physical-mechanical properties of the structural material have been established.

The mechanism of wear deceleration of the cutting tool with a discrete oxide layer during turning and milling has been revealed.

A technique and criterion for assessing durability of materials with a discrete oxide layer by the value of the molar activation energy U_{ef} has been developed.

A method has been developed to increase durability of compressor blades for the second resource by restoring a wear-resistant coating on anti-vibration shrouds.

Equipment and technology for obtaining discrete diffusion oxide layers on instrumental and structural materials have been developed.

2.6.5 – Powder metallurgy and composite materials.

The work was performed at Moscow Polytechnic University (Moscow Poly) and scientific-research department-9 of Moscow Aviation Institute (National Research University), defended at Moscow Aviation Institute (National Research University) (MAI).

Grachev, N. V. Energy-saving control of power installations of gas turbine locomotives. Abstract of Ph.D. (Eng) thesis [*Energosberegayushchee upravlenie silovymi ustanovkami gazoturbinnykh lokomotivov. Avtoref. dis… kand. tekh. nauk*]. St. Petersburg, PGUPS publ., 2022, 16 p.

At present, one of the target tasks is to increase the efficiency of operation of gas turbine locomotives using natural gas as a motor fuel.

The object of the study was the power plant of a gas turbine locomotive. The subject of the study was the main physical processes of converting gas energy into electrical energy in the gas turbine-generator system and its control to increase the efficiency of gas turbine locomotives.

The objective of the thesis research was to increase the energy efficiency of gas turbine locomotives by improving the methods and algorithms for controlling their power plants.

The following tasks were solved in the work:

• A review and analysis of existing systems for transferring energy from a gas turbine to wheel sets of an autonomous locomotive has been carried out.

• Main physical processes of conversion of gas energy into electromagnetic energy in the gas turbine-generator system and its control have been studied.

• Mathematical models of the power plant of a gas turbine locomotive and the output power controller of the turbine-generator system of a gas turbine locomotive of the GT1h series have been developed.

• Electromagnetic processes in the traction electric drive of gas turbine locomotives of the GT1h series were studied in various modes of its operation.

• Operation of control algorithms for power plants of gas turbine locomotives was studied.

• A method for implementing the control of a gas turbine loaded on a traction generator has been substantiated to improve the efficiency of its operation at partial loads.

• In accordance with the proposed approaches to controlling a gas turbine and regulating the output power of the gas turbine-generator system, an algorithm for controlling the power of the turbine-generator system has proposed, which ensures formation of rational gas turbine loading trajectories according to the free power of the turbine in the entire range of its use, which makes it possible to reduce the specific consumption fuel consumed by a gas turbine locomotive for train traction.

• Processing of experimental data obtained during operation of gas turbine locomotives of the GT1h series Nos. 001, 002 on the public tracks of the infrastructure of Sverdlovsk Railway – a branch of JSC Russian Railways was executed using the proposed algorithm for controlling power plants of gas turbine locomotives, providing an increase in their economic efficiency.

In the thesis work, an urgent scientific and technical problem was solved, which consists in increasing the efficiency of gas turbine locomotives by improving the algorithm for controlling power plants. In the course of the

work, the following main results and conclusions were obtained.

An analysis of existing gas turbine traction systems showed that one of the priority tasks for improving the efficiency of gas turbine locomotives is to reduce fuel consumption of gas turbine engines at idle and under partial loads by improving the algorithms for controlling power plants of gas turbine locomotives.

A mathematical model of the power plant of a gas turbine locomotive has been developed, which includes models of a gas turbine engine, a traction electric drive, and an automatic control system for a gas turbine locomotive, which make it possible to study electromagnetic processes in a traction electric drive.

Based on the results of the study of electromagnetic processes in the traction electric drive of a gas turbine locomotive, using the developed mathematical model, the stability region of the PI-controller of the automatic control system was obtained and the rate of gaining a given power of the traction generator was determined.

A method for implementing the control of a gas turbine loaded on a traction generator is substantiated, which improves the efficiency of its operation at partial loads.

Limitations were determined during operation of the combined power and speed controller of the gas turbine engine and the power controller of the turbine-generator system. The limitations considered the changing speed of the power turbine shaft and the available power of the gas turbine engine in various control ranges, the speed of the power turbine shaft.

A mathematical model of the observer of the state of a gas turbine engine has been developed, designed to calculate free power of a gas turbine engine during its operation in an energy-saving mode.

According to the proposed method, an algorithm for controlling the power of the turbine-generator system has been developed, which makes it possible to form rational trajectories for loading a gas turbine in the entire range of its use.

It is shown that considering the restrictions on free power of the gas turbine engine during operation of the output power controllers of the turbine-generator system allows one to form rational trajectories of loading the gas turbine engine.

The specific fuel consumption of a gas turbine locomotive during driving was reduced: for light trains weighing 1500 tons by 35,5 %, for trains weighing 6000 tons by 16,2 %, and for heavy trains weighing 9000 tons by 9,57 %.

The expected integral economic effect from operation of a gas turbine locomotive on Surgut–Voynovka section with heavy trains weighing 9,000 tons will be 17 478,18 thousand rubles per year with a payback period of 0,003 years due to the low cost of software changes.

05.22.07 – Railway rolling stock, train traction and electrification.

The work was performed and defended at Emperor Alexander I St. Petersburg State Transport University.

Hoang Ngoc Anh. Mathematical and algorithmic support for calculating the performance indicators of maintenance and repair of complex equipment. Abstract of Ph.D. (Eng) thesis [*Matematicheskoe i algoritmicheskoe obespechenie vychisleniya pokazatelei effektivnosti obsluzhivaniya i remonta slozhnogo oborudovaniya. Avtoref. dis… kand. tekh. nauk*]. Irkutsk, IrGUPS publ., 2021, 18 p.

The development of engineering and technology has led to creation and improvement of methods and means of ensuring reliable operation of equipment for various purposes. These tools include reliability methods, as well as monitoring and diagnostic tools for complex equipment.

The reliable functioning of the equipment is largely determined by the system used for its maintenance and repair. In this regard, in our country and abroad, various technologies for its maintenance and repair are being developed and improved. Maintenance and repair of equipment takes place in conditions of limited financial resources, therefore, various methods of system analysis, mathematical and simulation modelling are widely introduced into organisation of repair works.

The thesis research is devoted to the study of maintenance and repair of complex equipment in conditions of uncertainty and limited financial resources. The thesis recommends a maintenance and repair procedure for complex equipment using an insurance fund that performs two functions:

1) Accumulates payments with a given frequency to perform various types of repair work.

2) Pays for these works as necessary. A mathematical description of the state of the insurance fund at time t is proposed to be carried out based on a special type of risk process used in the mathematical theory of risk.

To model this risk process, it is proposed to use a simulation approach that involves creation of a simulation program based on the event method, which creates sample values of time points when there are no financial resources to perform equipment repairs. These values are then processed according to the proposed algorithms to obtain the values of equipment maintenance efficiency indicators. The search for models for evaluating the effectiveness of the repair work of complex equipment during its operation is an urgent task that needs to be solved. All the above justifies the relevance of the chosen topic of the thesis work and allows us to formulate its objective and tasks.

The objective of the thesis work is to increase the efficiency of managerial decision-making through development and application of mathematical, algorithmic and software for calculating indicators that evaluate the maintenance and repair of complex equipment during its operation.

To achieve this objective, it was necessary to solve the following tasks:

• To create mathematical software, using the risk process, to simulate the maintenance and repair of equipment using an insurance fund that performs the functions of accumulating payments at different intervals and paying for these works as needed.

• To select probabilistic models used in describing the components of the risk process and necessary for modelling time intervals between repairs and the costs of their implementation.

• To develop an algorithmic support for calculating the efficiency indicators of maintenance and repair of equipment based on simulation data.

• To create a software package for modelling and comprehensive research of maintenance and repair of complex equipment according to the proposed performance indicators.

• To test the created algorithmic and software for influencing factors based on computational experiments with a simulation program for the selected initial data.

The object of research in the thesis work is maintenance and repair of complex equipment during its operation. The subject of the thesis research is mathematical and algorithmic support in relation to the calculation of the proposed indicators of risk and reliability in maintenance of equipment based on the results of simulation modelling.

As a result of the thesis research, the following main results were achieved.

The formalisation and formulation of the problem of a systematic approach to maintenance and repair of complex equipment with the use of an insurance fund that performs the functions of accumulating payments at various intervals and paying for these works has been completed. For a mathematical description of the state of this fund, it is proposed to use a special type of risk process.

The probabilistic models used to evaluate the components of the risk process are selected. These models describe time intervals between repairs and the costs of their implementation. As these models, the following are chosen: the Pareto distribution with a zero point, the gamma distribution, the Birnbaum–Saunders distribution, etc.

A special algorithmic software for information processing has been created, containing probabilistic models and algorithms for obtaining simulation results using an event-based approach and a calendar of events of a special type according to three main influencing factors:

a) The method of ensuring the excess of revenue over expenditure.

b) Share of payments by types of repair work.

c) Frequency of payments.

Algorithms have been developed for calculating performance indicators based on the results of simulation modelling in the form of point and interval estimates of resource-costly and financial risks and reliability indicators «Denial of service» for financial reasons.

A software package has been developed based on a simulation program that uses an event approach, which makes it possible to conduct computational experiments and implement the developed methods and algorithms for evaluating performance indicators that characterize the maintenance and repair of complex equipment. The software package is implemented in MatLab programming language. There are two certificates of state registration of the created programs.

Using one of the programs, testing of the module required for the modeling program was carried out. Testing has shown that mathematical and software for evaluating reliability indicators has the necessary accuracy and can be recommended for the main simulation program.

Four tasks of a comprehensive study of the effectiveness of repair work of complex equipment are formulated. The first three tasks use assessments of resource-intensive and financial risks as indicators for comparing options, the fourth task uses assessments of the «Denial of Service» reliability indicators. This made it possible for the first time to conduct a comprehensive study based on 30 computational experiments with a modeling program and 120 options for evaluating performance indicators and obtain practically important results: the excess of revenue over expenditure must be done at the expense of the initial annual value of the insurance fund; the frequency of payments should depend on the type of repair work and the initial data; the share of payments must be different.

2.3.1 – System analysis, management and information processing.

The work was performed out at Irkutsk State Agrarian University named after A. A. Yezhevsky, defended at Irkutsk State Transport University (IrGUPS).

Osipova, V. E. A model for managing the energy complex of a railway enterprise for intellectual support of decision-making processes. Abstract of Ph.D. (Eng) thesis [*Model upravleniya energeticheskim kompleksom zheleznodorozhngo predpriyatiya dlya intellektualnoi podderzhki protsessov prinyatitya reshenii. Avtoref. dis... kand. tekh. nauk*]. Irkutsk, IrGUPS publ., 2021, 17 p.

A feature of operation of railway transport facilities is the uneven load of the system over time, which makes it difficult to form a complete initial database characterizing the system under consideration.

The variety and uncertainty of factors describing the state of its individual elements does not allow full use of the data of one of the existing accounting systems of the railway industry (ACSTP), as a result, makes it difficult to make a decision to control the technological process. The operating modes of the specialised equipment of such objects are usually distinguished by the presence of strict time limits and the complexity of describing changes that characterise the state of the system at a certain point in time.

All this contributes to development of complex mathematical models for the purpose of making managerial decisions. The most promising of which is the application of fuzzy set theory. Thus, the relevance of the thesis research is due to the need to improve the methodology for formation of the fuel and energy balance of the energy supply system based on the theory of fuzzy sets.

The objective of the thesis work is to improve the management system of the energy complex of a railway enterprise by effectively forming the fuel and energy balance based on system analysis, developing a mathematical model and methodology for managing fuel and energy resources.

To achieve this objective in the course of the thesis research, it was necessary to solve the following tasks:

• To conduct a systematic analysis of the initial data uncertainty and study the principles and features of operation of the fuel and energy resources consumption management system of the energy complex of a railway enterprise (TER EKZhP).

• To determine the selection criteria, the main systemic links and patterns of functioning

of EKZhP, to create a base of rules for managing consumption of fuel and energy resources.

• To develop a mathematical model for managing the consumption of TER EKZhP.

• To evaluate and to analyse the adequacy of the results of the developed management models, to determine the economic effect of implementation of the proposed model.

• To propose a method for managing consumption of TER EKZhP based on the theory of fuzzy sets using the rule base of fuzzy inferences and fuzzy controllers.

The object of the study is the system for managing the consumption of fuel and energy resources of the energy complex of a railway enterprise. The subject of the study is mathematical methods for managing the consumption of fuel and energy resources of a railway enterprise, methods of fuzzy control and fuzzy conclusions, and the methodology for forming a balance of fuel and energy resources created on their basis.

As a result of the thesis research, new scientific results were obtained aimed at improving the efficiency of the fuel and energy resources consumption management system of the energy complex of a railway enterprise. The practical application of the results of the study will improve the efficiency of technical systems management, as well as reduce the cost of energy supply.

A systematic analysis of uncertainty of the initial data and the features of operation of existing fuzzy control models in relation to EKZhP has been performed, the sampling criteria and the main interdependencies between the parameters of the system under consideration have been determined.

Equations are proposed for determining the «centre of gravity» in the process of defuzzification based on the Mamdani−Sugeno algorithm, which formed the basis of a mathematical model for controlling the consumption of TER EKZhP.

A new algorithm for formation of the fuel and energy balance of EKZhP has been developed, which provides an increase in the efficiency of decision-making under conditions of uncertainty, through the use of the mathematical apparatus of fuzzy logic.

The software implementation of the developed model for managing the consumption of fuel and energy resources EKZhP has been implemented. The economic effect from introduction of the proposed methodology is a reduction in operating costs for the purchase of fuel and energy resources by 2−4 %.

A methodology for formation of the fuel and energy balance is proposed, focused on improving the efficiency of decision-making using modern methods of information processing, in conditions of uncertainty of the initial data.

2.3.1 − System analysis, management and information processing.

The work was performed and defended at Irkutsk State Transport University (IrGUPS).

Semenov, A. P. A model for managing the life cycle of locomotives using modern methods of technical diagnostics. Abstract of D.Sc. (Eng) thesis [*Model upravleniya zhiznennym tsiklom lokomotivov s ispolzovaniem sovremennykh metodov tekhnicheskogo diagnostirovaniya. Avtoref. dis… doc. tekhn. nauk*]. Moscow, RUT publ., 2021, 39 p.

In the world and domestic practice of technical maintenance and repair (TMR) of traction rolling stock, there is a tendency to move from a planned preventive system to repair, considering the actual technical condition. At the same time, there is a transition to integrated maintenance and repair management throughout the entire life cycle of the locomotive, for which a life cycle contract for service TMR is concluded with the manufacturer. These trends are due to development of automated control systems (ACS) for production, microprocessor control systems for locomotives (MCS), automated technical diagnostic systems (ASTD) – built into equipment, on-board based on MCS, depot portable and stationary ASTD.

The mass introduction of cyber-physical production systems allows us to talk about the «fourth industrial revolution», the methods of which should be comprehended and applied, including in the locomotive repair complex. Scientific and practical study of the new technology of ACS TMR is required. The

development of a model for managing the life cycle of locomotives using modern methods of technical diagnostics and the principles of building ACS is relevant.

The thesis develops scientific foundations of locomotive reliability management through the development of a locomotive life cycle management model using modern methods of technical diagnostics.

The object of the study is traction rolling stock of railways, the locomotive life cycle management system, the locomotive maintenance and repair system using automated systems for technical diagnostics of locomotive equipment.

The objective of the thesis work is to increase reliability and efficiency of TRS operation through improvement of the TMR system by switching to a locomotive life cycle management model with the integrated use of modern diagnostic systems (hereinafter referred to as the Model).

The thesis substantiates technical and technological proven solutions in the field of locomotive life cycle management (LCL), the implementation of which makes a significant contribution to the development of the locomotive repair complex of Russian railway transport.

A technological model of an automated locomotive life cycle management system (ACS LCL) has been developed, which is a cyber-physical production system that combines, according to the principle of internal interoperability, automated systems for technical diagnostics of locomotive equipment (ASTD), including on-board and built-in, technological equipment with microprocessor control and automated control systems for technical maintenance and repair (TMR) of locomotives (using the methods of Industry 4.0, quality management systems, lean manufacturing, service maintenance, etc.), as well as combining, according to the principle of external interoperability, all automated control systems involved in the life cycle of a locomotive: automatic design of equipment for locomotives (CAD), automated control systems for locomotive construction and locomotive repair plants, automated control systems for operating organisations (including automated control systems for JSC Russian Railways), automated control systems for maintenance and repair of service companies with decision support functions. At the heart of the Model, it is proposed to create a database management system (DBMS) «Locomotive Life Cycle» (LCL), for which the procedure for its formation and updating is described.

The analysis of the world and domestic experience in managing the life cycle of locomotives was carried out using literary sources and own experience. The analysis showed that, along with the planned preventive system of service TMR, which remains the basis, there is a tendency to use data from on-board ASTD based on microprocessor control systems for locomotives (MCS), which enter ACS TMR via a radio channel in real time (online) for additional individual planning the volume of TMR. Both foreign leaders in locomotive building and domestic companies have experience in using the data of on-board and built-in ASTD when organizing service TMR of locomotives. At the same time, it is important to combine the technological processes of monitoring and diagnosing with the technological processes of planning in ACS TMR. World and domestic experience are used in the developed Model.

A method has been developed for evaluating the efficiency of using traction rolling stock (TRS) through the efficiency factor K_{AP}: the ratio of the time the locomotive is in the state of «traction in the head of the train» according to the classifier ASOUP JSC Russian Railways to the total operating time (in fractions of a unit or percentage). Appropriate software was developed in the Visual BASIC for Applications (VBA) algorithmic language in the MS Excel environment, with the help of which an analysis was made of operation of the domestic locomotive fleet: 8 series of electric locomotives and 4 series of diesel locomotives) for 400−500 days of their operation (taking into account TMR, this is the year of operation). The size of a representative sample guarantees reliability of the results obtained. It has been proven that, on average, locomotives have K_{AP} = 48 % with simultaneous non-compliance with the requirements of service contracts for reliability. At the same time, there are individual

locomotives, which, according to the results of work for the year, have $K_{AP} \geq 75$ %. Losses in operation $\Delta K_{AP} = 25$ %, in anticipation of TMR $\Delta K_{AP} = 14{,}4$ %, during TMR $\Delta K_{AP} = 5$ %. At the same time, TMR takes about 10 % for electric locomotives and 20 % for diesel locomotives of the total time budget. Thus, the optimal model of the life cycle of locomotives is an important reserve for increasing the efficiency of their operation, both by increasing the efficiency of using locomotives and by increasing the efficiency of service TMR, incl. by reducing the downtime at TMR to the level of the standard and above.

The analysis of reliability indicators taken in the locomotive life cycle contracts (LCC) between JSC Russian Railways and locomotive suppliers by failure categories according to the classifier of KAS ANT failure accounting system of JSC Russian Railways showed that the categories of failures are more dependent on the operating conditions of locomotives and not on hardware manufacturers. A probabilistic-statistical method has been developed to establish the relationship between reliability indicators provided for by the standard and the indicators taken in the LCC.

A method for evaluating the information efficiency of technical diagnostic systems from the standpoint of the theory of knowledge (epistemology), information theories, automatic control and digitalization has been developed. The Shannon formula taken as a basis is supplemented by the statistical probability of a failure and the cost of eliminating a failure in specific units. The coefficient of information efficiency of ASTD is introduced as the ratio of its information content according to the proposed formula to the total information entropy of the object of diagnosis. The proposed method was used to analyse the information efficiency of the most common automated technical diagnostic systems (ASTD). It has been proved that on-board ASTD have limited information content even with the expansion of their functionality, therefore it is impossible to exclude depot stationary and portable ASTD from TMR system.

A method has been developed for technical and economic evaluation of effectiveness of implementation of ASTD by simulation modelling in the MS Excel environment using a program specially developed on VBA for monthly calculation of the net present value of the project (NPV). It is proved that the use of all types of existing ASTD equipment for locomotives is not economically feasible. The effectiveness of the use of on-board ASTD, automated systems for rheostatic tests of diesel generator sets, vibration tests of wheel-motor units and a number of other ASTD has been proven.

A method has been developed for an operational expert assessment of the duration of TMR during its organization with individual planning for the scope of repairs for each section, taking into account the diagnostic data of the totality of all ASTD. The method is based on probabilistic-statistical modeling of duration of individual repair operations in order to probabilistically estimate the expected maintenance and repair time for each specific section of the locomotive. To test the method, the corresponding software was developed in the MS Excel environment in VBA.

The practical implementation of TMR system according to the proposed locomotive life cycle model (LCL) was carried out in Bratskoye service locomotive depot at Vikhorevka station (East Siberian Railway) of the LocoTech group of companies in relation to AC electric locomotives with rectifier-inverter converters manufactured by NEVZ. The implementation of the model made it possible to significantly increase the efficiency of the depot (downtime at maintenance and repair was reduced by three times, the availability factor was brought back to normal, logistic losses were reduced by 30 %, etc.), thereby proving the effectiveness of the proposed technical and technological solutions based on the results of theoretical studies. It is planned to replicate the technology in all service locomotive depots of the Eastern range of JSC Russian Railways, serving similar electric locomotives.

The prospect for further development of the topic is:

• Adaptation of the developed model and TMR technology for other series of locomotives.

• Encapsulation in ACS TMR of all proposed mathematical control methods to

increase the efficiency of TMR system according to the proposed Life Cycle Management Model.

• Expanding the functionality of onboard ASTD by installing additional sensors, developing ASTD built into the equipment itself, developing additional methods for predicting the residual life of the equipment and the locomotive as a whole.

• Further integration of all types of ASTD into ACS TMR, into the information systems «Digital Depot» and «Digital Railway» (ISUZhT).

05.22.07 – Railway rolling stock, train traction and electrification.

The work was performed and defended at Russian University of Transport. ●

NEW BOOKS ON TRANSPORT AND TRANSPORTATION

The list of titles in Russian is published in the first part of the issue.

Список на русском языке публикуется в первой части данного выпуска.

DOI: https://doi.org/10.30932/1992-3252-2022-20-3-15

Artemiev, B. V., Artemiev, I. B., Vlasov, A. I. [*et al*]. Pipeline systems: engineering workshop: Study guide [*Truboprovodnie sistemy: inzhenerniy praktikum: Ucheb. posobie*]. Moscow, Bauman MSTU, 2022, 104 p. ISBN 978-5-7038-5807-3.

Busurin, V. I., Makarenkova, N. A., Shleenkin, L. A. Fundamentals of obtaining information in measuring and control systems: Study guide [*Osnovy polucheniya informatsii v izmeritelnykh i upravlyayushchikh sistemakh: Ucheb. posobie*]. Moscow, MAI publ., 2022, 102 p. ISBN 978-5-4316-0890-2.

Davdiev, K. A., Omarov, A. Z. Car and engine repair: Study guide [*Remont avtomobilei i dvigatelei: Ucheb. posobie*]. Moscow, Infra-M publ., 2022, 356 p. ISBN 978-5-16-014999-8.

Kobzev, V. A., Alaev, M. M. Innovative technical means for ensuring safety of securing trains on station tracks: Monograph [*Innovatsionnie tekhnicheskie sredstva obespecheniya bezopasnosti zakrepleniya sostavov na stantsionnykh putyakh: Monografiya*]. Moscow, RUT (MIIT) publ., 2022, 100 p. ISBN 978-5-907555-68-6.

Kravchenko, V. A., Panichkin, A. V., Bozhanov, A. A., Lomakin, D. O. Ground transport and technological machines: cars and tractors: Textbook [*Nazemnie transportno-tekhnologicheskie mashiny: avtomobili i traktory: Uchebnik*]. Oryol, Turgenev OSU, 2022, 310 p. ISBN 978-5-9929-1197-8.

Kuznetsov, S. M. Computer-aided design of electric transport devices: Study guide [*Avtomatizirovannoe proektirovanie ustroistv elektricheskogo transporta: Ucheb. posobie*]. Novosibirsk, NSTU publ., 2022, 102 p. ISBN 978-5-7782-4672-0.

Lubentsova, E. V., Lubentsov, V. F. Theory of automatic control. Theoretical foundations for synthesis and analysis of linear systems: Study guide [*Teoriya avtomaticheskogo upravleniya. Teoreticheskie osnovy sinteza i analiza lineinykh sistem: Ucheb. posobie*]. Krasnodar, KubSTU publ., 2022, 227 p. ISBN 978-5-8333-1104-2.

Modestova, S. A., Voronov, V. A., Shalygin, A. V. Transport and storage of liquefied gases: Study guide [*Transport i khranenie szhizhennykh gazov: Ucheb. posobie*]. St. Petersburg, Lema publ., 2022, 83 p. ISBN 978-5-00105-719-2.

Naigert, K. V., Rozhdestvensky, Yu. V. Workflows and the basics of calculating the hydraulic drives of a car: Study guide [*Rabochie protsessy i osnovy rascheta gidroprivodov avtomobilya: Ucheb. posobie*]. Chelyabinsk, SUSU publ., 2022, 76 p.

Peschansky, A. I. Semi-Markov models for prevention of an unreliable single-channel queuing system with losses: Monograph [*Polumarkovskie modeli profilaktiki nenadezhnoi odnokanalnoi sistemy obsluzhivaniya s poteryami: Monografiya*]. Moscow, Infra-M publ., 2022, 266 p. ISBN 978-5-16-017734-2 (print).

Pimenov, A. T., Barakhtenova, L. A., Dyakova, K. S. Ways to improve stability of the foundations of highways [*Sposoby povysheniya ustoichivosti osnovanii avtomobilnykh dorog*]. Novosibirsk, Novosibirsk State University of Architecture and Civil Engineering, 2022. ISBN 978-5-7795-0936-7.

Rozhitsky, D. B. Non-traction power engineering of railway transport. Rationing the consumption of fuel, energy and water resources: Monograph [*Netyagovaya energetika zheleznodorozhnogo transporta. Normirovanie toplivno-energeticheskikh i vodnykh resursov: Monografiya*]. Moscow, RAS publ., 2022, 322 p. ISBN 978-5-6047616-3-2.

Stepanov, S. N., Chernykh, L. G., Khrustaleva, I. N. [*et al*]. Design and assembly of a car. Calculation of traction characteristics: Study guide [*Proektirovanie i sborka avtomobilya.Raschet tyagovykh kharakteristik: Ucheb. posobie*]. St. Petersburg, Politekh-Press, 2022, 94 p. ISBN 978-5-7422-7679-1.

Tyulkin, V. A. Theory of similarity in estimating the parameters of the temperature regime of a car engine [*Teoriya podobiya v otsenke parametrov temperaturnogo rezhima dvigatelya avtomobilya*]. Tyumen, Tyumen Industrial University, 2022, 58 p. ISBN 978-5-9961-2821-1.

Vlasova, E. P., Kostolomov, E. M., Losev, F. A. [*et al*]. Operation of power equipment of oil pumping stations: Study guide [*Ekspluatatsiya energeticheskogo oborudovaniya nefteperekachivayushchikh stantsii: Ucheb. posobie*]. Tyumen, TIU publ., 2022, 130 p. ISBN 978-5-9961-2808-2.

Zub, I. V., Ezhov, Yu. E., Stenin, N. N. The use of handling equipment and vehicles for handling large-capacity containers: Monograph [*Ispolzovanie podemno-transportnogo oborudovniya i transportnykh sredstv dlya obrabotki krupnotonnazhnykh konteinerov: Monografiya*]. St. Petersburg, Admiral Makarov State University of Maritime and Inland Shipping, 2022, 250 p. ISBN 978-5-9509-0468-4.

Compiled by N. OLEYNIK ●