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

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Gordon, M. A. Methods and algorithms for automating the synthesis of interdependencies of the position of switches and readings of traffic lights in electrical interlocking systems. Abstract of Ph.D. (Eng) thesis [*Metody i algoritmy avtomatizatsii sinteza vzaimozavisimostei polozheniya strelok i pokazanii svetoforov v sistemakh elektricheskoi tsentralizatsii. Avtoref. dis… kand. tekh. nauk*]. St. Petersburg, PSTU publ., 2021, 16 p.

The main goal of the dissertation research is to improve the methods and algorithms for automating the synthesis of the interdependencies of the position of switches and signal indications within the routes of electrical interlocking (EC).

The scientific novelty of the dissertation research is as follows:

• A digital model of the table of dependence of the position of switches and signal readings of traffic lights in routes (TVZ) was proposed, which allows storing all information about the dependencies of EC of the station.

• Methods for automated synthesis of TVZ based on a digital model of a schematic plan have been developed, which make it possible to reduce the cost of its creation by 10–12 times.

• The features in the EC dependencies at docking stations of various types of traction current are described and algorithms for the automated synthesis of TVZ at such a station are developed.

• Algorithms for the automated synthesis of tables of preliminary tests, individual «no-load» tests, tests during complex testing, included in the electronic test log (ETL), using templates have been developed.

• A block diagram of a digital model of functional verification of projects of EC systems was designed based on a universal electronic format of technical documentation.

The following main results were obtained in the work:

− It was found that a large number of errors in projects of railway automation and telemechanics (RAT) can be avoided with development and implementation of effective computer-aided design systems and automated examination of design solutions.

It was found that for information compatibility of various tasks in the automation and telemechanics departments of JSC Russian Railways, it is necessary to formalize the submission of project documentation, to create a universal electronic format for technical documentation (UEF TD).

− The data structure of electronic TVZ in UEF TD is proposed, presented in the form of five elements. The composition and requirements for the algorithms for the automated synthesis of TVZ are determined.

− An algorithm for automated synthesis of the route table using a digital model of the station topology in the form of a directed graph, developed on the basis of the depth-first search method, made it possible to ensure the correctness and completeness of the set of possible routes.

− Using the pattern search method, algorithms have been developed for the automated synthesis of cases of additional closure of switches and oversized switch-track sections and a table of interdependence of readings. This ensures that the templates are adjusted at the level of the initial data without changing the algorithms.

− A separate type of station is a docking station of various types of current, the features of the dependencies of the EC system of which have not been previously described anywhere. At such stations, the EC additionally controls the type of current (direct or alternating) in the contact network. A method for formalizing TVZ docking stations based on the formation of a second-level graph of overhead contact network elements is proposed.

− Experimental studies have shown that the use of the proposed methods and algorithms for the automated synthesis of TVZ can increase labour productivity by 10–12 times.

− Carrying out a check of technical documentation requires maintaining an ETL, which must include the test tables necessary for a particular station and can store the reference values of checks. This log can also be used during commissioning. The proposed algorithms for the synthesis of ETL tables substantiate the completeness of the necessary checks for examination by the fact that they are developed based on standard test methods for a specific EC system, which describe the necessary and sufficient list of tests.

− The developed scheme of a digital model for functional verification of projects of EC systems based on UEF TD allows checking the technical documentation of the project for compliance with regulatory documents and check the operability of circuit solutions.

05.22.08 – Management of transportation process.
The work was performed and defended at Emperor Alexander I St. Petersburg State Transport University.

Khromov, I. Yu. Analysis of the influence of operating modes on the technical condition of locomotives. Abstract of Ph.D. (Eng) thesis [*Analiz vliyaniya rezhimov ekspluatatsii na tekhnicheskoe*

***sostoyanie lokomotivov. Avtoref. dis... kand. tekh. nauk*]. Moscow, RUT publ., 2021, 24 p.**

A significant and most large-scale change in the railway complex within the framework of the reform is separation of the operation function and the function of technical maintenance and repair (TMR) of locomotives, to support the activities of which, the following subdivisions have been created: the Traction Directorate (CT) − a branch of JSC Russian Railways and the Traction Rolling Stock Repair Directorate (CTR) − a branch of JSC Russian Railways. To improve the quality of TMR and the locomotive operation system, since July 1, 2014, the main TMR functions have been transferred to private service companies (LLC TMH Service (now LocoTech-Service) and LLC STM-Service), whose work is not paid for the number of repairs performed, but for the useful work of locomotives − kilometers traveled for mainline locomotives and operating hours for shunting locomotives. Due to this, an interest arose in increasing the maintenance-free runs of locomotives, increasing their useful work, improving the technical condition of the locomotive fleet.

The objective of the study is to increase reliability of locomotives by identifying patterns between operating modes and the technical condition of locomotives according to data from on-board microprocessor control systems of locomotives for use in automated maintenance control systems under conditions of service repair locomotive depots.

Scientific novelty of the thesis:

− Scientifically proven or confirmed patterns between violations of operating modes (NRE) of locomotives and their technical condition.

− Development of improved scientifically grounded classifier of violations of operating modes with an indication of their possible impact on the technical condition of locomotives.

− Development of a method for protecting locomotives from dangerous violations of operating modes using on-board microprocessor control systems for the existing and expanded set of sensors for the technical condition of locomotive equipment.

− Development of a method for automated planning of the scope of maintenance and repair of locomotives in the conditions of service locomotive depots in the presence of violations of operating modes.

− A feasibility study of the practicability of implementing the proposed technical solutions has been completed.

As a result of the research carried out, new complete scientifically grounded technical and technological solutions have been obtained, aimed at increasing the efficiency of the functioning of the locomotive complex of JSC Russian Railways. The main scientific and practical results of scientific research are as follows:

− The regularity between violations of operating conditions and deterioration of the technical condition of locomotives was scientifically substantiated, for which an expanded volume of statistical data on operation of locomotives was processed (more than 21,1 million events in 12 months at 85 service locomotive depots) using the methods of probabilistic-statistical and correlation analysis, which made it possible to identify the presence of violations of the operating modes of locomotives, significantly affecting their technical condition. The main violations should be considered violations associated with non-observance of temperature regimes of coolants and non-observance of speed regimes when following a leading ascent. The analysis of physical processes and correlation analysis made it possible to identify the resulting failures or deterioration of the technical condition, with the most susceptible to the influence of diesel and diesel equipment of freight diesel locomotives (for passenger and shunting locomotives, the influence is less), traction motors and a wheel-motor unit of main-line freight diesel locomotives and electric locomotives, moreover, regardless of the year of manufacture. At the same time, the correlation coefficient between various violations and the presence of failures ranged from 0,537 to 0,989. The average value of the correlation coefficient for the studied dependencies was 0,805, which makes it possible to judge the presence of a high correlation between violations and equipment failures. In TMR system, it is necessary to take into account the operating modes of locomotives.

− Based on the conducted scientific research, an expanded classifier of typical (occurring in practice) violations of operating modes has been developed, indicating the consequences that they can have on the technical condition of the locomotive. The classifier consists of 54 violations, defined by more than 30 locomotive series and groups of series. The classifier has been agreed with service companies, approved and put into effect by the Traction Directorate of JSC Russian Railways in the locomotive service system.

− To protect locomotives from hazardous operating modes, a set of algorithms has been developed that are implemented in the software of the on-board MSU of diesel locomotives of TEP70BS series of registration TChE «Saratov-Passazhirskoe», 2TE116U registrations TChE «Dno» and 2 (3) TE10MK (UK) registrations TChE «Komsomolsk-on-Amur». Algorithmic protection made it possible to reduce the number of unscheduled repairs of protected equipment by an average of 3 times.

− An extended set of sensors was proposed: it is necessary to additionally monitor the temperature of the traction electric motor (anchor, main and additional poles), the temperature of the ambient air and vibration acceleration of the locomotive undercarriage. The rest of the existing set of sensors is sufficient to control the operating modes.

− For the automated TMR system, a method has been developed for the practical use of data on the operating modes of locomotives for the individual formation of the volume of repairs for scheduled and unscheduled types of maintenance and repair, which is an automated workstation for a diagnostician with the module «Correlation NP-NRE» developed for ASU TMR of the group of companies LocoTech and put into operation in 85 service locomotive depots.

Based on the analysis of data for 12 months of 2018 on unscheduled repairs that occurred due to violations of operating modes, a matrix of the impact of violations of operating conditions on locomotives was developed, which allows timely assessing the most susceptible to violations of a series of locomotives and their equipment and developing appropriate corrective measures that are relevant in specific study period.

The effect of implementation of the research results is achieved by reducing the cost of unscheduled repairs, reducing the number of violations of operating conditions and reducing the labor intensity in the study of NR. There are certificates on implementation of research results.

As recommendations for further increasing reliability of locomotives, improving their technical condition and eliminating the negative influence of the human factor, it is recommended to organize continuous monitoring of the technical condition and operating modes according to the data of on-board MSU with remote (online) data transmission to service enterprises for preliminary work planning and ordering spare parts and materials, improvement of maintenance and repair methods with a gradual transition to repairs based on the actual technical condition.

05.22.07 – Railway rolling stock, train traction and electrification

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

Malakhov, S. V. Optimization of energy consumption for traction of trains based on a refined method of traction calculations. Abstract of Ph.D. (Eng) thesis [*Optimizatsiya energozatrat na tyagu poezdov na osnove utochnennogo metoda tyagovykh raschetov. Avtoref. dis... kand. tekh. nauk*]. Moscow, RUT publ., 2021, 20 p.

Reducing the energy consumption for traction of trains can be achieved in several ways: development of methods of energy-optimal rationing in cases of manual train driving, development and implementation of energy-optimal automatic train driving systems, an increase in the energy efficiency of traction rolling stock (TRS), an increase in the energy efficiency of power supply sources, etc.

The first two directions do not require significant investment and can be implemented through the application of the applied part of the theory of train traction – traction calculations. However, the methods for performing traction calculations until recently did not allow simultaneously increasing the accuracy, reducing the calculation time and reducing the need for computing resources, which is especially important for automatic train control or for performing many parallel calculations. The proposed integrated approach makes it possible to expand the possibilities of using traction calculations in systems requiring the solution of optimization problems under constantly changing conditions.

Thus, the task of reducing energy consumption for traction of trains is relevant and can be solved by improving the methodology of traction calculations in terms of increasing accuracy while reducing the time spent on the calculation, which is important for use in promising unmanned train control systems.

The objective of the dissertation is to improve the method of traction calculation for obtaining energy-optimal trajectories of train movement and software implementation of the proposed method.

Scientific novelty:

a) Development of a method of traction calculation using ANN for a train model in the form of discrete bodies and a locomotive with discrete traction control.

b) An efficient numerical implementation of the optimal traction calculation method based on the Bellman principle of optimality is proposed, characterized in that energy-optimal trajectories are found for all possible travel times along the section, and adapted for ANN training.

c) A software package has been developed for the operational regulation of energy consumption for traction of trains with continuous training of the neural network.

d) The architecture was chosen and the specifics of the placement of the neural network as an optimal train traffic controller in an isolated software environment for promising locomotive microprocessor train traffic control systems was determined.

An analysis of the methods of traction calculations is carried out, as a result of which a conclusion is made about the feasibility of obtaining the only best vector of train controls. Therefore, the problem of optimal traction calculation is formulated in order to reduce energy consumption and a method for its solution is determined.

A modern mathematical apparatus was selected that is most applicable for solving the formulated optimal problem.

An algorithm and software based on it for performing optimal traction calculations have been developed.

The results of traction calculations performed by the developed software are analyzed in terms of applicability for practical tasks. Significant limitations of the developed software have been identified, which require the use of a search for new methods for performing traction calculations.

A new improved method has been developed for performing optimal traction calculations with increased accuracy, with less time and computational resources. The main advantage of the developed method is a decrease in regulation time and a decrease in energy in relation to simplified models, a decrease in hardware requirements, both in stationary use and in conditions of work on board a locomotive, as well as continuous improvement of solutions through additional training.

A comparative analysis of a new method for performing optimal traction calculations with Bellman's method under conditions of stationary use is carried out. The results obtained show the

achievement of the set goals for development of an improved method of traction calculations.

A mechanism has been developed for introducing new software for optimal traction calculations based on the ANN method into promising locomotive train control systems. The developed ANN method allows the use of unified hardware for various types of trains, which means it can organically fit into the architecture of promising on-board safety, control and diagnostics devices, which ensures fulfillment of the requirements of the digital railway concept and contributes to fulfillment of the indicators of long-term development plans of JSC Russian Railways directorates.

05.22.07 – Railway rolling stock, train traction and electrification.

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

Morozov, E. B. Study of the interaction of a soil massif with a screen made of a rarefied row of piles. Abstract of Ph.D. (Eng) thesis [*Issledovanie vzaimodeistviya gruntovogo massiva s ekranom iz razrezhennogo ryada svai. Avtoref. dis... kand. tekh. nauk*]. Moscow, RUT publ., 2021, 24 p.

The objective of the thesis is to develop a methodology for determining optimal design parameters of a protective geotechnical screen from a rarefied row of piles, depending on the required degree of reduction of additional settlement of a nearby building.

One of the main design solutions for pit fences in difficult engineering and geological conditions and a high level of groundwater standing is a monolithic reinforced concrete «wall in the ground» of a trench type, the use of which in cramped conditions of urban construction is complicated by the significant impact of its design on surrounding buildings. According to the available data, additional settlement of buildings of surrounding development caused by the installation of a trench under the «wall in the ground» can reach 80 % of the total additional settlement caused by construction of a new facility.

A possible variant of protective measures to reduce the effect of the «wall in the ground» arrangement on the settlements of surrounding buildings is a geotechnical screen made of a rarefied row of piles, the effectiveness of which for this purpose is shown by numerical studies performed in this thesis, according to which the settlements of the protected building due to the arrangement of the said screen can be reduced by 30...75 %.

The studies carried out have established that efficiency of using a screen from a rarefied row of piles, characterized by the efficiency coefficient K_{ef} increases with an increase in the diameter and length of piles and decreases with an increase in the distance between them, the depth of the trench and its distance from the building, as well as with an increase in the modulus of deformation of the soil massif.

The factor analysis, based on the theory of experiment planning, determined that the depth of the trench being developed has the greatest influence on efficiency of using a geotechnical screen from a rarefied row of piles to protect buildings and structures of surrounding development from development of additional settlements caused by installation of a trench under the «wall in the ground», its distance relative to the building foundation, the diameter and length of screen piles, the modulus of deformation of the soil mass and the relative axial distance between piles have a lesser effect. When calculating the geotechnical screen, all of the above factors should be considered as significant.

It is shown that the use of a protective screen from a rarefied row of piles is most effective when it is installed to a depth of no more than 1,2 of the trench depth and its location closer to it. The efficiency of the screen is significantly higher in sandy soils compared to clay soils.

Calculations have shown that the construction of screen piles from bored piles, made with excavation, significantly reduces the coefficient of efficiency of its use to protect against development of additional settlement of buildings located in the zone of influence of construction. A screen made of metal screw-in piles is more effective.

The established functional dependencies (regression equations) of the efficiency coefficient of the geotechnical screen application from variable factors, presented in the form of nomograms, for different soil conditions and two pile manufacturing technologies, make it possible to significantly simplify the selection of the main dimensions of the protective pile structure.

The developed method for optimizing design parameters of a geotechnical screen from a sparse row of piles, which allows choosing such a combination, in which additional settlements of the building caused by development of a «wall in the ground» of a trench type will be reduced to the specified values while at the same time achieving the best technical and economic indicators of the screen in terms of consumption material.

Analytical solutions obtained using classical solutions of soil mechanics, describing the physical process of interaction of elements of the system «trench – soil massif – geotechnical shield – building foundation», can be used to check the results of numerical calculations, as well as to perform preliminary calculations of geotechnical screens and additional sediment of the foundations of the buildings they protect according to simplified schemes.

The calculation algorithm developed on the basis of the conducted analytical studies allows, by varying design parameters of the protective shield, to determine their combination, in which the additional settlement of the building caused by development of the trench under the «wall in the ground» will be reduced to the specified values with a minimum consumption of materials by 1 p.m. of its arrangement.

05.23.02 – Bases and foundations, underground structures.

The work was performed by National Research Moscow State University of Civil Engineering, defended at Russian University of Transport.

Zhetesova, G. S. System mechanisms of interaction in implementation of ESM quality strategy in the conditions of industrial and innovative development of the Republic of Kazakhstan. Abstract of Ph.D. (Eng) thesis [*Sistemnie mekhanizmy vzaimodeistviya pri realizatsii strategii kachestva ESM v usloviyakh industrialno-iovatsionnogo razvitiya Respubliki Kazakhstan. Avtoref. dis… doc. tekh. nauk*]. Moscow, MAI publ., 2021, 44 p.

As a result of dissertation research, the scientific problem of developing systemic mechanisms for implementation of a new ESM quality strategy, based on formation of a network distribution of responsibility of subjects of education, science, and production, and which is of great economic importance for industrial and innovative development of the Republic of Kazakhstan, was solved.

The sets of indicators have been established within the framework of the formulated basic strategies, considering the factors of intersectoral influence of education, science and production based on a cross-analysis of regulatory legal acts, program documents of the Republic of Kazakhstan, conclusions of domestic and foreign experts, processing a large amount of statistical data and identified priority areas of development.

Responsibility for implementation of a set of joint activities and the levels of mutual influence of the subjects of ESM triangle are formulated, the structural elements of the process of intersubjective interaction and the personal contribution of the subjects to achieve the set goal, focused on the result, are identified.

A subject-by-subject methodology for implementation of a complex of strategic decisions based on a qualitative analysis of risks by the levels of their influence has been developed.

A mathematical model has been developed that establishes the relationship between the groups of assessment criteria and development indicators with the following boundary conditions: development indicators $D \in$ clusters $Cl_1 \cup Cl_2 \cup Cl_3 \sum D = 1$, specific weight $x \in D$, while $\sum x = 1$, with the principle weighting factor $P_i > 0{,}05$, $\sum P_i = 1$. A sequence of criteria with the calculated coefficient of multiple rank correlation of the agreement of experts opinions is constructed 0,82.

The concept of ESM quality strategy has been developed in accordance with the identified principles:

• Continuing education – directed formation of the competencies of future specialists, associated with sustainable development of scientific research and production.

• Collective responsibility of subjects of the scientific, production and educational process – training of personnel with competencies, creative thinking and entrepreneurial skills that are in demand in various sectors of the economy.

• Long-term planning – a consistent assessment of the level of demand for engineering and technical personnel, taking into account development of sectors of the economy.

• Development of human capital – directed, continuous and systematic development of scientific and pedagogical personnel in accordance with the structure of competencies required for an innovative economy.

• Guaranteed demand – personnel training aimed at meeting the needs of the labor market.

• Corporate governance – implementation of a fundamentally new policy of educational organisations in relation to separation of powers and determination of joint responsibility of all participants in the educational process.

• Modernisation of the educational and production environment – purposeful bringing the existing educational, scientific laboratories, information resources of the educational organisation in line with the basic needs of production.

A distinctive feature of ESM quality strategy concept is that its application ensures distribution of responsibility between the subjects of interaction «Education», «Science», «Production» for quality of the final result which is cumulated human capital.

The methodology for implementation of a set of strategic decisions within the framework of ESM quality strategy has been introduced in 87 educational institutions of the Republic of Kazakhstan, at 101 industrial enterprises and research institutes of the Republic of Kazakhstan. The sustainability of the implemented quality strategy is confirmed by an expert assessment. The results of the thesis are used in the educational process in training of students, Ph.D. students and D.Sc. students.

The developed model is sensitive to aspects of state policy, and its further development and adaptation in EAEU countries is proposed as recommendations for application of the results of thesis research.

Prospects for further research development are:

– An in-depth study of peculiarities of distribution of responsibility with an increase in the number of external factors.

– Expanding the field of research on implementation of possible strategies based on combinations of proposed solutions for six or more lines of influence of external and internal factors.

– Detailed study of the processes during renewal and expansion of intersubjective relationships in the context of changes in the priority directions of the state policy of the Republic of Kazakhstan.

– A study of flexibility and applicability of ESM quality model in the context of a shift in emphasis on science and production.

– A study of the possibility of transforming the model with an increase in the subjects of interaction and a change in its configuration.

05.02.23 – Standardisation and product quality management.

The work was performed and defended at Moscow Aviation Institute (National Research University).