

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

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

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**Khamidov, O. R. Scientific fundamentals for improving methods for diagnosing asynchronous traction electric motors of locomotives on the railways of the Republic of Uzbekistan. Abstract of D.Sc. (Eng) thesis [Nauchnie osnovy sovershenstvovaniya metodov diagnostirovaniya asinkhronnykh tyagovykh elektrodvigatelyei lokomotivov na zheleznnykh dorogakh Respubliki Uzbekistan. Avtoref. dis... doc. tekhn. nauk]. St. Petersburg, PGUPS publ., 2021, 32 p.**

The thesis stated and solved an important scientific and technical problem of developing scientifically based methods for diagnosing and predicting the technical state of asynchronous traction electric motors (ATED) of locomotives to increase their operational reliability and ensure the safety of train traffic on the railways of the Republic of Uzbekistan. At the same time, the results of bench tests and processing of measuring information of ATED diagnostic tools of locomotives in operation were used with the help of data mining, and specifically with the use of artificial neural networks (ANN) technology and expert systems.

It has been established that the existing systems for monitoring, diagnostics and management of locomotive operation require significant improvements. The process of monitoring and diagnostics of locomotives can no longer be standardised within the framework of «normal» maintenance and repair programs; software and technical maintenance poorly adapts to rapidly changing operating conditions and there is no support system, either decision-making system, or specialised software for parametric identification of forward and reverse neural network models of locomotive ATED.

The concept of construction of modern intelligent control systems, diagnostics and forecasting of the technical state of ATED equipment of locomotives based on the use of quantitative and qualitative models using neural

network technologies and methods of decision theory using expert systems is proposed.

It was found that a condition for effective use of bench tests and built-in diagnostic tools for ATED of locomotives is associated with the need to develop additional measures at the design stage of a modern locomotive, when it is necessary to provide for identification of critical groups of equipment subject to in-depth control, diagnostics, as well as for development of a list of controlled parameters and the choice of scientifically based methods for processing the received information on the basis of the performed analysis of methods of domestic and foreign stationary and built-in tools of technical diagnostics.

A complex of models of the process of control, diagnostics of the technical state of ATED of locomotives has been developed on the basis of SADT-methodology and IDEF-technologies, which makes it possible to identify the main series of functional diagnostic problems and substantiate the requirements for the choice of methods, algorithms and decision-making in the process of monitoring, diagnostics and forecasting of the technical condition of locomotives, which provides an increase in reliability of the classification of the actual state of locomotives in monitoring and diagnostic systems.

It has been established that a feature of the tasks of obtaining and processing information in control systems, diagnostics, in addition to the data structure, is the presence of expert diagnostics experience, the use of which makes it possible to increase the efficiency of classifying the actual state of ATED of locomotives with a limited volume of the training sample, as well as of predicting its technical state.

Formalised methods and techniques have been developed for monitoring and diagnosing the technical state of ATED of locomotives using neural network technologies, expert systems, based on the use of the mathematical model of ATED in the diagnostic process, which allows to increase productivity and reliability of the processes of diagnosing the technical state of locomotive equipment based on the results of bench tests and analysis of measurement information of built-in diagnostic tools for operating locomotives, which allow to reduce costs for monitoring and diagnostics of the technical condition of locomotives during its bench tests and during operation by 2–3 times due to the more complete use of a priori and a posteriori information about ATED operation modes, automation of data processing, application of

modern methods of data mining at all stages of ATED diagnosis and decision making.

Simulation models of ATED of locomotives and its components were developed, with the help of which a training set for ANN was created.

A technique based on modern neural network technologies has been developed, which makes it possible to quickly and efficiently investigate asymmetric modes during operation of ATED of locomotives, allowing to solve a wide range of practical problems of monitoring the technical condition of locomotive ATED.

An improved method of deep learning (combining functions) for monitoring, diagnosing and predicting the technical condition of windings and bearing assemblies of ATED of locomotives is substantiated and proposed, which provides an opportunity to improve the learning ability using a deep auto-encoder of faults and ATED features to further increase the diagnostic efficiency. Deep linking functions are introduced into softmax environment to train an intelligent locomotive ATED winding and bearing fault diagnosis model. The results obtained confirm that the proposed method is more effective and reliable for studying the features and diagnostics of faults in windings and bearings of ATED of a locomotive than traditional methods. In comparison with the standard neural network, the proposed method shows slightly better performance.

The versatility of the developed methods and methods for detecting malfunctions, processing measurement information to improve quality of diagnosing ATED of a locomotive was confirmed in the process of implementing an improved deep learning method for detecting a malfunction, diagnosing and predicting the technical condition of the rotor and bearing assemblies of ATED of locomotives.

It is theoretically substantiated that the use of up-to-date intelligent methods and software of systems for monitoring parameters, diagnostics and forecasting the technical state of ATED with the use of ANN and expert systems gives a significant economic effect by preventing sudden failures and accidents, identifying incipient defects and taking timely measures to prevent their development, denial of routine maintenance on a serviceable ATED, correct planning of repairs, accurate planning of consumables for repairs and, as a result, a decrease in spare parts stocks, as well as by extending the service life of the objects of diagnostics.

Reliability and adequacy of neural network diagnostic models is confirmed by the stable convergence of simulation results and data obtained from the results of ATED bench tests of modern locomotives. The root-mean-square error of the response of the models is less than the random error of changing the monitored diagnostic parameters of locomotives.

It has been established that it is highly desirable to use an improved method of deep learning of neural networks to create diagnostic devices and software and hardware systems, since it is a powerful means of recognising and predicting signals, and its learning ability makes it possible to develop adaptive systems for protecting and diagnosing locomotive equipment. The use of neural network technologies for operational control, correction of the volumes of planned types of repairs, as well as assessment of the technical condition of locomotive equipment has good prospects, allowing the maximum use of the entire amount of diagnostic information stored on the onboard computer to improve efficiency of the maintenance and repair system.

The work had theoretically substantiated and experimentally confirmed the effectiveness of the proposed methodology, which diagnoses faults for balanced and unbalanced ATED data sets of locomotives using modern deep learning methods. First, the received signals are integrated into the constructed NS algorithm for layer-by-layer feature extraction, after which the extracted deeply sensitive features are transferred to the classifier for monitoring, diagnosing and predicting the technical state of ATED of locomotives.

*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.*

**Ledney, A. Yu. Development of methodological approaches to assessing the economic efficiency of development of transport infrastructure, considering the volume and unevenness of traffic. Abstract of Ph.D. (Economics) thesis [Razrabotka metodicheskikh podkhodov k otsenke ekonomicheskoi effektivnosti razvitiya transportnoi infrastruktury s uchetom ob'emov i neravnomernosti perevozok. Avtoref. dis... kand. ekonom. nauk]. Moscow, RUT publ., 2020, 24 p.**

The objective of the dissertation research is to develop an improved methodological toolkit for assessing effectiveness of development of transport



infrastructure, considering unevenness of transportation volumes.

The economic analysis of the use and development of the Russian transport infrastructure is carried out, the main problematic issues that need to be addressed to ensure sustainable development of the country's economy are highlighted.

The evolution of methods for assessing the economic efficiency of development of transport infrastructure has been analysed, considering domestic and international experience, and the directions for their improvement have been substantiated.

The problem of uneven transportation and its impact on the economic efficiency of projects and programs for development of transport infrastructure has been studied, the methodological tools for determining seasonal unevenness of the load of the transport infrastructure have been improved.

The influence of seasonal unevenness of transportation on economic indicators of the use and development of transport infrastructure (using the example of railways) is revealed.

An improved methodology for assessing effectiveness of capital investments in development of transport infrastructure, considering seasonal unevenness of transportation and the load of infrastructure, is proposed.

In the course of the completed dissertation research, the scientific task of improving the methodological tools for assessing the effectiveness of development of transport infrastructure, taking into account unevenness of transportation volumes, was stated and solved.

Using the improved methodological tools, the working hypothesis of the study was confirmed that when assessing the economic efficiency of transport infrastructure development projects, one should consider the factor of uneven traffic, which significantly affects the economic indicators of transport activity.

Based on the research carried out, in the future, it is planned to develop a comprehensive methodology for assessing the economic efficiency of development of transport infrastructure, considering the volume and unevenness of traffic, including an assessment of increase in the value of transport infrastructure by reducing unevenness of loading.

*08.00.05 – Economics and management of the national economy (economics, organisation and management of enterprises, industries and complexes – transport).*

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

**Makarova, E. A. Development of the method of strength calculation of rigid airfield pavements. Abstract of Ph.D. (Eng) thesis [Razvitie metoda prochnostnogo rascheta zhestkikh aerodromnykh pokrytii. Avtoref. dis... kand. tekhn. nauk]. Moscow, MADI publ., 2020, 24 p.**

The purpose of the dissertation research was to improve the method for calculating rigid coatings using optimisation methods.

The results of the research carried out made it possible to draw the main conclusions on the topic under study.

The limiting states of calculating rigid airfield pavements, presented in the form of inequalities without restraints, make the problem indefinite and lead to the appearance of non-optimal options for pavements.

Based on the study, it was found that replacing the distributed load with a concentrated force when determining the deflections is possible without restrictions, and for bending moments it is permissible only for aircraft with a track and a chassis bogie base exceeding 0,6 m.

The drawback of the method for calculating rigid airfield pavements is revealed, which consists in the existence of a false solution in the range of admissible pavement thicknesses. The false decision is typical for six-wheel aircraft supports with a track that exceeds the base. No false solutions were found for two- and four-wheel supports.

The estimation of the number of possible optimal solutions of the problem of strength calculation of airfield pavements is carried out.

It has been established that the structures of rigid airfield pavements studied at civil airports in Russia and foreign countries have a safety margin with a percentage of understressing reaching 34 %.

The introduction into the design practice of the proposed method for calculating rigid airfield pavements will reduce the required value of the pavement layer thickness on average for a single-layer option to 4 cm, and for a two-layer option – up to 7 cm. At the same time, a reduction in the cost of paving construction can reach 20 %.

The research carried out indicates that special attention should be paid to the following priority tasks: improving the methodology for calculating asphalt concrete airfield pavements; improvement of the methodology for calculating mixed airfield pavements; improvement of the methodology for calculating reinforced concrete

airfield pavements, considering new building materials.

*05.23.11 – Design and construction of roads, metro, airfields, bridges and transport tunnels.*

*The work was performed and defended at Moscow Automobile and Road Construction State Technical University (MADI).*

**Nguyen Van Huang. Application of predictive regulators to control distributed generation installations in railway power supply systems. Abstract of Ph.D. (Eng) thesis [Primeneniye prognosticheskikh regulyatorov dlya upravleniya ustanovkami raspredelennoi generatsii v sistemakh elektrosnabzheniya zheleznikh dorog. Avtoref. dis... kand. tekhn. nauk]. Irkutsk, IrGUPS publ., 2020, 18 p.**

Decentralised power generation technologies based on distributed generation (DG) installations are fully applicable to railway transport. The purpose of the research presented in the thesis was to develop methods and means to improve quality of control processes in power supply systems of railways (PSSR) equipped with distributed generation installations.

A structural-parametric synthesis of control systems for installations of distributed (own) generation of railway transport, implemented based on automatic excitation regulators (AER) and rotation speed (ASR), using predictive algorithms, has been performed.

A method for controlling the frequency of DG installations has been developed, based on the use of auto-predictive (self-adjusting) speed controllers and applicable in implementation of intelligent electrical networks (Smart Grid).

A method is proposed for determining time constants of predictive links for automatic controllers of excitation and speed of synchronous generators.

A technique has been developed for tuning digital automatic regulators of DG using predictive control of distributed generation installations with energy storage devices, which ensures a decrease in voltage dips; on the basis of computer studies, it is shown that the combined use of predictive algorithms and coordination of regulator settings makes it possible to obtain an additional effect when controlling the rotor speed and voltage of synchronous generators of DG in transient operating modes.

A method for eliminating flicker in low voltage networks based on controlled distributed generation

units has been developed; prognostic algorithms are proposed for controlling the modes of gas turbine plants.

Digital models and results of modelling dynamic processes in the areas of non-traction consumers' power supply and practical recommendations on the use of predictive controllers for DG installations were used in the scientific and technical developments of the «Parametr» centre. Practical suggestions for the use of predictive algorithms are implemented in the recommendations for tuning automatic regulators of a turbine generator set with a capacity of 3,125 MW•A of the central production site of Khiagdinskoye field. The thesis materials are used in the educational process at the departments of educational institutions of Irkutsk and the Phu Tho province of the Socialist Republic of Vietnam.

The prospect of further development of the topic may consist in conducting research aimed at using nonlinear predictive models in the excitation and speed controllers of DG generators, as well as multi-agent technologies for coordinated adjustment of AER and ASR.

*05.13.06 – Automation and control of technological processes and production (transport).*

*The work was performed at Irkutsk National Research Technical University and Irkutsk State Transport University, defended at Irkutsk State Transport University.*

**Rasskazova, E. E. Management of resource supply of the innovative development of a transport company. Abstract of Ph.D. (Economics) thesis [Upravlenie resurso-obespecheniem urovnya innovatsionnogo razvitiya transportnoi kompanii. Avtoref. dis... kand. ekonom. nauk]. Moscow, RUT publ., 2020, 24 p.**

The purpose of the dissertation research is to develop an economic toolkit for comprehensive assessment and management of the innovative development of a transport company in a highly dynamic environment.

As a result of the study, the hypothesis was confirmed that the structure of innovative potential and its resource supply determine the degree and rate of innovative development of a transport company, and also significantly affect other components of the potential.

A set of indicators characterising the components of potential, which determine the level of innovative development of the company, is revealed. They are associated with the





resources used, their structure, applied technologies. Based on this analysis, the components of the company's innovative potential were formed.

Models and an algorithm for determining the degree of innovative development of a transport company have been developed, which make it possible to assess its impact on all components of its potential, to increase the objectivity of assessing the actual level of innovative development of a transport company.

A methodological approach to assessing the impact of the components of the innovative potential on economic indicators of a company is proposed, and an algorithm for assessing the necessary change in the components of the potential for the given requirements for changing economic indicators is formed. The algorithm can be used as the basis for a system for monitoring the economic activity of a transport company.

As prospects for further research on this topic, it seems necessary to elaborate on the level of innovative development of a transport company, as well as to analyse the relationship between the structure of resources and the level of innovativeness of technology, the nature and phases of the life cycle of the project being implemented.

*08.00.05 – Economics and management of the national economy (economics, organization and management of enterprises, industries, complexes – transport).*

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

**Tyulyandin, O. N. Development of methods and means of RFID-navigation for control of movement of metro trains. Abstract of Ph.D. (Eng) thesis [Razrabotka metodov i sredstv RFID-navigatsii dlya upravleniya dvizheniem poezdov metropolitena. Avtoref. dis... kand. tekhn. nauk]. St. Petersburg, PGUPS publ., 2020, 18 p.**

The purpose of the study was to increase efficiency of functioning of automatic control systems for movement of metro trains using RFID navigation, where navigation accuracy and reliability are the main indicators.

In the course of the research carried out in the thesis work, an analytical review of existing methods and means of binding metro trains to the coordinates of the track in Russia and abroad

was carried out. Based on the results of the review, it was proposed to create RFID navigation, in which navigation accuracy and reliability are the main indicators.

The functions of RFID navigation are determined, including continuous positioning of trains in operation on the route with sufficient accuracy to solve problems of automatic control of movement of metro trains. The main difference between RFID navigation and existing methods is the automatic input of initial coordinates of trains without participation of the driver. A compensation method has been developed that made it possible to ensure the continuity of the binding when zeroing the accumulated errors.

Probabilistic methods, mathematical models, and programs for assessing the probability of gaps in reading radio frequency tags for readers with external triggering and with continuous scanning have been developed, which made it possible to investigate their causes and give recommendations for reducing the number of gaps by two orders of magnitude, which consists in increasing the scanning time to the maximum value. For new developments, a transition to continuous scanning readers is proposed.

Methods, mathematical models, and programs have been developed for assessing the navigation accuracy of positioning trains using radio frequency tags. In this work, accuracy characteristics of RFID-binding have been obtained for the first time. For readers with an external trigger, the binding accuracy in the low-speed zone is  $\pm 25$  cm, for readers with continuous scanning  $\pm 10$  cm. The results confirmed the possibility of using RFID navigation to control movement of trains at closed-type stations.

Original methods and algorithms for technical diagnostics of RFID-means have been developed, allowing to monitor and predict the technical condition of the radio-frequency path of SBPP equipment. The proposed solutions make it possible to timely detect an increase in the contact resistance in detachable connections in order to prevent gaps in the reading of radio frequency tags due to signal attenuation.

*05.22.08 – Management of transportation processes.*

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