

ABSTRACTS of Ph.D. THESES

**Selected abstracts of Ph.D. theses submitted
at Russian transport universities and research
organizations**

For the original Russian texts please see p. 248.

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Afanasyev, V. S. Complex experimental evaluation of dynamic parameters of span structures of girder bridges. Abstract of Ph.D. (Eng) thesis [Kompleksnaya eksperimentalnaya otsenka dinamicheskikh parametrov proletrykh stroenii balochnykh mostov. Avtoref. dis... kand. tekhn. nauk]. Moscow, RUT publ., 2020, 25 p.

The main goal of the work was to improve the system for assessing dynamic parameters of span structures of girder bridges during the operation period for transition from planned maintenance measures to activities based on the actual state of the structure within the framework of the industrial Internet of Things implementation. A number of tasks have been solved. The application of the method of vibration control of span structures of girder bridges to determine the technical condition of the structure has been substantiated. A sequence of calculations has been developed prior to dynamic testing of span structures of girder bridges. Operational modal analysis for field tests of span structures of girder bridges has been implemented. A technique has been developed for determining carrying capacity of span structures of girder bridges based on data on their dynamic parameters. Methods for considering the effect of temperature changes in the bridge span on its dynamic parameters are considered.

The main scientific result of the work is to improve the system for assessing the technical condition of bridges and to create prerequisites for introduction of the industrial Internet of Things in the field of bridge infrastructure. The scientific novelty of the most significant results is as follows: statistical models of regression analysis have been developed to determine the correlation between carrying capacity and dynamic parameters of span structures of girder bridges; for the first time, mathematical methods of statistics and machine learning were used to consider the influence of temperature changes on the results of assessing dynamic parameters of bridge spans.

A method is proposed for predicting carrying capacity of span structures of the same type of girder bridges based on data on their dynamic parameters, a software has been developed for dynamic testing of beam bridges in order to determine the optimal vibration measurement time, while the effect of temperature changes in the

bridge span on its dynamic parameters was considered.

05.23.11 – Design and construction of roads, subways, airfields, bridges and transport tunnels. The work was carried out at Russian University of Transport.

Goryunov I. O. Particularities of selection of parameters of traction electric engines considering the similarity of electromagnetic processes. Abstract of Ph.D. (Eng) thesis [Osobennosti vybora parametrov tyagovykh elektricheskikh mashin s uchytom podobiya elektromagnitnykh protsessov. Avtoref. dis... kand. tekhn. nauk]. Moscow, RUT publ., 2020, 24 p.

Today it is preferable to use numerical methods of calculating magnetic fields. Currently, the widespread use of computers allows to make high-precision calculations of the magnetic field of electric engines. However, methods based on the application of Kirchhoff laws do not fully solve the problem. Methods of similarity theory are widely used in the analysis of physical processes. In the case of magnetic processes in electric engines, the methods of similarity theory have not been widely used. Therefore, improving the methods of calculating and analyzing the magnetic field in electric engines using the methods of similarity theory is an actual task.

The similarity of magnetic processes in collector traction electric engines can be characterized based on n -theorem. The following ratios should be used as dimensionless groups:

- the ratio between anchor and main poles' MMF;
- the ratio between anchor and additional poles' MMF;
- the ratio between main and additional poles' MMF.

Loss of energy from steel magnetization reversal is one of the important components of the overall loss of energy in electromechanical energy conversion. Mathematical modelling confirmed that the greatest losses in the steel anchors of the electric motor are at the bottom of the groove. The final criterion, which characterizes the efficiency of energy conversion by electric engines of constant and pulsating current, including by traction collector electric motors, is the ratio between energy losses during magnetization reversal of steel anchors and energy consumed (total losses).

The solution of the criterion problem allowed to determine the coefficients for calculating the main dimensions of traction electric engine, to identify dependencies between main dimensions considering the area of the anchor groove.

Specialty 05.09.01 – Electrical mechanics and electrical devices. The work was performed at Russian University of Transport.

Nekrasov G. I. Improving the efficiency of cooling system of locomotive diesel engine using individual water pump drive. Abstract of Ph.D. (Eng) thesis [Povyshenie effektivnosti systemy ohlazhdeniya teplovoznogo dizelya s ispolzovaniem individual'nogo privoda vodyanykh nasosov. Avtoref. dis... kand. tech. nauk]. Moscow, RUT publ., 2020, 24 p.

After conducting patent and information search, priority areas for the development of cooling system elements have been identified and the technical requirements for the system with individual water pumps drive have been formulated.

A mathematical model has been developed to estimate the distribution of heat and coolant velocity on the front side of the radiators and to calculate the minimum performance of the water pump, ensuring its operation without overcooling and overheating of the coolant at any values from within the design range of ambient temperatures. The results of the simulation are confirmed by the results of comparative tests, the simulation error was 3 %.

Cooling system control algorithms have been built to maintain the recommended temperature of cold and hot circuits with minimal energy consumption by the cooling system drive.

Algorithms of the system of control of individual drives of water pumps of locomotive for cold and hot circuits have been developed, allowing, as compared to the serial system, to:

- ensure the circulation of the coolant after the diesel stops;
- increase the idle time of the locomotive with the stopped diesel engine without overcooling of the coolant within the entire calculation range of ambient temperature values;
- minimize power consumption of diesel cooling system.

The developed mathematical model of the diesel cooling system in operation showed that the use of individual water pump drive reduces the total fuel consumption spent on the cooling system drive by 22,4 % by reducing the operating time of the cooling chamber fans, and reduces the operating consumption of diesel fuel by 2,5 %.

Specialty 05.22.07 – Railway rolling stock, train traction and electrification. The work was performed at Russian University of Transport.

Obukhov, Yu. V. Simulation models, algorithms and programs for the analysis of flight safety in the air traffic control system. Abstract of Ph.D. (Eng) thesis [Imitatsionnye modeli, algoritmy i programmy dlya analiza bezopasnosti poletov v sisteme upravleniya vozdushnym dvizheniem. Avtoref. dis... kand. tekh. nauk]. Moscow, GosNIAS, 2020, 22 p.

Due to the constantly increasing intensity of air traffic (AT) in our country, modernization of the air traffic control system (ATCS) has been carried out for several years. Flight safety (FS) is a priority for development of civil aviation. Therefore, changes in

ATCS require careful analysis in order to determine that they do not lead to an unacceptable change in the level of FS.

The purpose of the study was to develop simulation models, algorithms and programs designed to analyze safety of flights in the air traffic control system.

To achieve this goal in the thesis, the following tasks were solved: analysis of existing methods and models for assessing FS; development of methods and algorithms for FS analysis using simulation; development of a simulation model of a controlled air traffic based on detailed modelling of dispatchers' operations during air traffic controlling, conflict detection and resolution; development of a software tool (ST) intended for the analysis of FS in air traffic control systems.

The following was developed:

- method for analyzing FS in ATCS using simulation;
- an algorithm for generating random searching of air traffic flows based on real actual flight plans for statistical simulation;
- algorithm for obtaining statistical data by saving the state of the system at certain moments and returning to the saved states;
- a simulation model, which simulates in detail operations for air traffic control, which makes it possible to analyze FS, taking into account totality of deterministic and random factors affecting FS;
- structure and composition of the software tool designed for analysis of FS in the ATCS sector.

The developed models and algorithms were the basis for practical implementation of the software tool intended for the analysis of FS in the ATCS.

On the basis of the results obtained in the work, studies were carried out to assess FS during organization of St. Petersburg Integrated Air Traffic Safety Center. Also, studies were carried out to assess the FS for the prospective airspace structure of Moscow regional dispatch center. The research results were taken into account when making a decision on introduction of a promising airspace structure into operation.

Specialty 05.13.18 – Mathematical modelling, numerical methods and program complexes. The work was performed at State Research Institute of Aviation Systems. The defense took place at Moscow Aviation Institute (National Research University).

Polyev A. V. Development of algorithms to recognize the commands of the cockpit speech interface. Abstract of Ph.D. (Eng) thesis [Razrabotka algoritmov dlya raspoznavaniya rechevogo interfeisa kabiny pilota. Avtoref. dis... kand. tekh. nauk]. M., MIPT, 2020, 23 p.

An automatic algorithm for splitting words into homogeneous parts has been developed, the positioning of the boundary of the parts is made with the help of multiparametric optimization. Criteria have been formulated that implement the principle of maximizing the similarity of phonetic material within the part and measure of difference between the



neighbouring parts. Algorithms based on the dynamic programming method are offered for numerical solution of a high-performance problem.

An algorithm for improving the quality of the reference standard has been developed, based on selection and optimization of the principal components. The reference standard obtained by optimizing the coefficients for the principal components showed a significantly lower number of errors in recognition of most of the records. Methods have been studied and algorithms have been developed for compressing information on a parametric portrait using Chebyshev polynomials. Experiments have shown that compression can be attained either separately for frequency and in time, or for both dimensions simultaneously. In the latter case, it is possible to reduce the storage space for the parametric portrait by 5–10 times with practically no deterioration in the recognition quality.

Algorithms based on Bayes formula and the method of committees have been developed, allowing to significantly reduce the number of recognition errors when using multiple standards. The performance of both developed algorithms is confirmed by the test results. When using 7 sample standards obtained from the recordings of various speakers, a noticeable decrease in the percentage of errors by 1.5–2 times is achieved: the average error for the algorithm based on Bayes formula decreased from 8.42 to 5.62 %, and for the algorithm based on the committee method to 5.3 and to 3.13 % when using time adjustment.

The algorithms for recognition of speech commands based on artificial neural networks of deep learning have been studied and modified.

05.13.01 – System analysis, management and information processing. The work was carried out at Moscow Institute of Physics and Technology (National Research University). The defense took place at Moscow Aviation Institute (National Research University).

Protopopov, A. L. Survivability of cast parts of rolling stock with technological defects. Abstract of Ph.D. (Eng) thesis [Zhivuchest' litykh detalei podvizhnogo sostava s tekhnologicheskimi defektami. Avtoref. dis... kand. tekhn. nauk]. Moscow, RUT publ., 2020, 24 p.

The performed computational and experimental studies confirm that it is possible to identify with acceptable accuracy the spectrum of operational loading of the load-bearing elements of three-element bogies of 18–100 type models by means of virtual modelling. A 3D model of a freight wagon was created as a mechanical system of absolutely rigid bodies and elastic side frames, the dynamic behaviour of which was simulated by the Craig-Bampton dynamic substructuring method.

Analysis of the stress-strain state of the side frame of a freight wagon bogie shows that the most dangerous zone, from the point of view of initiation and development

of a fatigue crack, is the axle box opening's corner (radius zone R55). This is confirmed by numerous examples of its destruction during operation. Modelling the development of a fatigue crack before the loss of the frame's bearing capacity by reproducing a casting technological defect in the zone of the axle box opening's corner shows its satisfactory correspondence to the two-stage (surface and through) development. This is confirmed by investigation of the fracture locations of the sidewalls that collapsed during operation.

A close coincidence of the results simulated on the developed model of crack propagation with cases of frame failure during operation has been achieved.

It has been determined that time of growth of an internal defect in casting metal in the corner of the axle-box opening of the bogie frame until it reaches the surface of the frame, depending on the depth (3–6 mm) and the area of schematization (25–120 mm), by an elliptical crack is in the range from six months to 40 years.

It was found that the period of development before destruction (survivability) of a frame with a through crack is 2–5 % of the total time of damage accumulation before destruction.

The area of a fatigue crack in a brittle fracture, depending on the season of operation, can be from 20 to 50 percent of the cross-sectional area of the frame in this place (the smaller value is in the winter period).

For safe (with a reliability of 0.999) operation of freight wagons during the period between overhauls, it is proposed to establish the minimum allowable survivability margin $[n_s]$ of bearing cast elements of the bogie equal to 2.0. Regarding the current frequency of freight wagons' repairs (per 100–200 thousand km of run), this indicator is provided if a crack is up to 2.6 mm deep and up to 5.6 mm wide.

The dependence of the magnitude of the survivability margin $[n_s]$ on the value of the surface defect area S was determined. Based on this, it seems possible to foresee the frequency of inspections of the side frames by non-destructive testing methods with a given level of margin for the safety conditions of their operation during this period.

The proposed method for studying the operational stress-strain state of the side frame of a freight wagon's bogie can be applied at the stage of designing new three-element bogies of 18–100 type models to assess with acceptable accuracy the spectrum of the operational loading of their load-carrying elements by means of virtual modelling.

Further prospects for development of the topic can be related to the issue of clarifying development of surface and internal defects in the axle box opening of the side frame of a freight wagon not only for the case of detachment but also for the cases of shifting and cutting.

05.22.07 – Railway rolling stock, train traction and electrification. The work was performed at Russian University of Transport. ●