

## SELECTED ABSTRACTS OF D.Sc. and Ph.D. THESES

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

*For the original Russian text please see p. 284.*

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**Kovkin, A. N. Methods and models for ensuring the technical efficiency of power equipment for controlling of devices of railway automation and telemechanics. Abstract of D.Sc. (Eng) thesis [Metody i modeli obespecheniya tekhnicheskoi effektivnosti silovoi apparatury upravleniya ustroystvami zheleznodorozhnoi avtomatiki i telemekhaniki. Avtoref. dis... doc. tekhn. nauk]. St. Petersburg, PGUPS publ., 2020, 32 p.**

Microprocessor systems of railway automatics and telemechanics (RAT) are a set of computing facilities and power control equipment, the central link of which is object interface device (OID). The key features of automation systems that directly control switches and signals are high safety requirements meeting internal equipment failures and the impact of external destabilising factors. Modern trends in development of systems provide for expansion of functions related to monitoring of executive objects, which requires the implementation of appropriate solutions at the hardware level. These factors are the reason for increased complexity of the power control equipment. As a result, competitiveness of new RAT systems and the economic effect achieved because of replacing relay systems with microprocessor analogues are largely related to the technical level of the specified equipment. This determines the need for an integrated approach to assessing the effectiveness of hardware, development of methods for quantitative analysis of efficiency, development of practical methods for constructing highly efficient power equipment.

The object of the research is the power equipment for controlling executive objects of RAT, and the subject of research is associated with the methods of quantitative assessment

and of increasing the level of technical efficiency of the power equipment, which provides direct control of the executive objects.

The objective of the research is to develop methods of quantitative assessment of the effectiveness of power equipment that controls RAT objects, as well as methods for practical implementation of highly efficient hardware.

Based on the research carried out in the thesis, the following main results were obtained:

1. The concept of power control equipment has been defined and the analysis of the existing concepts of constructing safe equipment for interfacing with objects has been carried out.

2. Criteria of the technical efficiency of hardware are formulated, the role of safety as of a determining criterion is determined, the need to analyse parametric safety of hardware is substantiated, and a system of indicators of technical efficiency is proposed.

3. A method is proposed for calculating residual voltages at traffic light emitters under conditions of using sinusoidal voltages, based on the use of capacitive models of cable lines and the method of an equivalent generator, followed also by a quantitative assessment of residual voltages at traffic light emitters for a pair of twisted cables in case of imbalance of a capacitive bridge.

4. A method has been developed for calculating residual voltages in traffic lights under non-sinusoidal influences by means of harmonic analysis, considering capacitive and resistive parameters of the line.

5. As a result of research, it has been established that safe control of station traffic lights in case of non-sinusoidal voltages in the cable network can be ensured by lowering the voltage at the output of OID and the orderly use of cable cores.

6. It has been established that the proper level of safety in contactless control of traffic lights under the conditions of malfunctioning of cable lines is ensured by the presence of transformers as part of conversion circuits and the refusal to use common wires for several signal indications.

7. A model is proposed for calculating energy consumption and current load, based



on the concepts of intrinsic and object components of energy parameters.

8. A quantitative analysis of safety of various power supply circuits has been carried out, methods have been proposed to increase safety, and effective ways have been developed to implement the power supply of OID from DC and AC buses.

9. Quantitative assessment of the effectiveness of control of the actual lighting of signal indicators by measuring the current in the output circuit of control devices has been carried out, and a method has been developed for calculating the change in current in the control circuit of LED emitters in case of failure of LED matrices.

10. A method for safe implementation of control of a cold thread by means of impulse action is proposed, and main parameters of testing impulses are determined, which ensure effective implementation of control in conditions of extended lines.

11. A device has been developed to monitor integrity of the operating circuit of a switch drive with a three-phase asynchronous motor by monitoring the flow of direct current.

12. The proposed technical solutions for safe control of floor objects by using small-sized relays with rigidly connected contact groups.

13. A device has been developed that implements safe logic signal processing in a duplicated control structure by using conversion circuits.

14. Non-contact equipment for control of traffic lights and switches has been developed, based on the use of conversion circuits, and containing circuit solutions that provide control of cold filaments of traffic lights and control of integrity of the working circuit of electric drives.

15. As a result of comprehensive assessment of interface devices, it was found that contactless traffic light control equipment is an effective solution in the case of devices being powered from a DC bus, and contactless control equipment for asynchronous motors is advisable to use for any concept of constructing devices of electric power supply.

The actual direction of subsequent practical developments should be focused on creation of

highly efficient control equipment for various types of LED emitters and valve motors for switch actuators.

*05.22.08 – Traffic control management.*

*The work was performed and the defence took place at Emperor Alexander I Petersburg State Transport University.*

**Rakhimov, R. V. Load of carriage running gears and of track and substantiation of the possibility of increasing axle loads on the railways of the Republic of Uzbekistan. Abstract of D.Sc. (Eng) thesis [*Nagruzhenost' khodovykh chastei vagonov i vozmozhnosti uvelicheniya osevykh nagruzok na zheleznikh dorogakh Respubliki Uzbekistan. Avtoref. dis... doc. tekhn. nauk*]. St. Petersburg, PGUPS publ., 2020, 32 p.**

Railways are among most important elements in structuring and development of the economy of the Republic of Uzbekistan. Railway transport, working in close relationship with other sectors of the national economy of the Republic, from the moment of its creation to the present day, has been continuously developing and improving. Despite possibilities for mass transportation of goods and technical and economic advantages over other modes of inland transport in the conditions of the Republic of Uzbekistan, the share of railway transport in the total volume of freight traffic and freight turnover has decreased over the past decade.

Currently, to increase the efficiency of railway transport in implementation of the export and transit potential of the Republic of Uzbekistan with limited lengths of receiving and departure tracks at the stations of the country, the most promising way is putting into operation of rolling stock with increased axle loads. However, at the same time, the impact of rolling stock on the railway track increases, therefore, the actual area of research is dynamic interaction of rolling stock and the railway track to substantiate the possibility of increasing the axle loads of rolling stock on railway network of the Republic of Uzbekistan.

The object of research is running gears of carriages and the railway track. The subject of research is loading of carriages and railway tracks during the dynamic process of interaction between rolling stock and track.

The objective of the thesis is development of scientifically based technical and technological solutions for measuring dynamic processes of interaction between rolling stock and the railway track to substantiate the possibility of increasing axial loads of rolling stock on railways of the Republic of Uzbekistan.

*05.22.07 – Railway rolling stock, train traction and electrification.*

*The work was performed and the defence took place at Emperor Alexander I Petersburg State Transport University.*

**Raschepkina, D. V. Evaluation of the resource of cast parts of freight wagon bogies after the occurrence of a fatigue crack. Abstract of Ph.D. (Eng) thesis [Otsenka resursa litykh detalei telezhek gruzovogo vagona posle vozniknoveniya ustalostnoi treshchiny. Avtoref. dis... kand. tekhn. nauk]. St. Petersburg, PGUPS publ., 2020, 16 p.**

Requirements for increasing the efficiency of railway transport led to an increase in the length of guaranteed sections for safe movement of rolling stock and a reduction in downtime at technical stations. Achievement of such goals requires from developers of elements of running gears of wagons, in particular side frames and bolsters, refined methods for predicting the fatigue strength margin, and assessing the resource of the part after a crack. Despite available achievements of science and production technology, the efforts of the employees of the wagon divisions to control the technical condition of bogies in operation, there are cases of derailments of wagons every year due to fractures of the cast side frames. Therefore, the issues of predicting the resource of cast parts of bogies after the occurrence of fatigue cracks are relevant.

Object of the research: cast side frames and bolsters of freight wagon bogies.

Subject of the research: the resource of cast parts of freight wagon bogies after the occurrence of a fatigue crack.

The objective of the thesis is to predict the mileage of a freight wagon after the occurrence of a fatigue crack in a cast bearing part of a bogie by solving the scientific problem of assessing the resource of a part considering the stage «initiation of a fatigue crack – ultimate fracture».

In the thesis, the solution of the scientific problem of assessing the resource of cast parts of a freight wagon bogie after the occurrence of a fatigue crack is presented, which provides an increase in the efficiency of designing new and modernising existing structures of parts.

A review and analysis of works in the field of investigation of crack resistance of cast steels is carried out. Analytical and experimental methods for calculating the parameters of crack resistance are considered. Methods for assessing and calculating the resource of parts with a crack are analysed. The necessity of predicting the resource of cast frames and beams after the occurrence of a dangerous failure has been established.

Based on the results of the analysis of data on fractures of side frames and bolsters of freight wagon bogies that occurred in the period from 2006 to 2018, the geometry of the fatigue crack was determined, the dependences of its geometric parameters were established, and the distribution intervals of the crack areas relative to the fracture sections were obtained.

A method is developed for determining the critical length (relative area) of a crack in cast parts of freight wagon bogies and an algorithm for modelling its growth in the ANSYS universal software system for finite element analysis.

FE models of cast side frames and bolster with a crack have been developed, considering the peculiarities of the stress field distribution in the vicinity of its vertices, allowing to perform an updated calculation of the parameters of crack resistance.

The calculation of the parameters of crack resistance of side frames with a crack has been performed. The dependences of lengths and relative areas of fatigue cracks on the recovery



factor ( $K_f$ ) are obtained. The critical lengths of fatigue cracks in the frames under study after 13 and 25 years of operation have been determined. Loss of bearing capacity of the frame conv. No. 1 occurs when the fatigue crack reaches a length of 210 mm (25 % of the cross-sectional area) and 135 mm (17 %) after 13 and 25 years of operation. For side frames conv. No. 2 and conv. No. 3 critical crack length 295 mm (34 %), 185 mm (23 %) and 285 mm (45 %), 185 mm (31 %) after 13 and 25 years of operation, respectively. The calculated values of the relative area of the fatigue crack for the side frame with conv. No. 1 is verified by the results of analysis of data on fractures in operation.

The method of experimental determination of  $K_f$  and cyclic fracture toughness ( $K_{fc}$ ) of a cast part of a freight wagon bogie with a crack under static loading after cyclic operating time has been refined, due to a preliminary calculation of the size of plastic deformation zones. The  $K_f$  values were experimentally determined with development of the fatigue crack length from 41 mm to 220 mm. The critical length of the fatigue crack of the bolster is determined to be 220 mm and.

The dependence of degradation  $K_{fc}$  on the service life of the bearing cast parts of the undercarriage is obtained, which makes it possible to predict the equivalent service life of the studied part with a critical fatigue crack. Predicted  $K_{fc}$  value for cast steel 20GL, 20GFL after 32 years of operation.

An algorithm was developed for calculating the resource of a cast bearing part of a freight wagon bogie for the stage «crack initiation – limiting state» based on the model of degradation of mechanical properties and  $K_{fc}$  of steel 20GL, 20GFL.

A method is proposed for formation of load blocks of parts through combinations of vertical, longitudinal and transverse forces arising from movement of the train in straight and curved track sections, jerks and impacts.

The calculation of the resource of the side frame structure after the occurrence of a fatigue crack in the inner corner of the axle-box opening under the action of operational loads has been carried out. As a result of the

calculation, the number of cycles until the appearance of a crack with a length of 10 mm, the number of cycles until the loss of bearing capacity, relative survivability, limiting length and area of a fatigue crack, and the rate of its development were determined. The loss of the bearing capacity of a part with a crack occurs after 498 thousand loading cycles, the relative survivability of the side frame is 0,062. The limiting fatigue crack length is 60 mm, the occupied area of the total fracture section is 6,35 %. The crack growth rate changes with crack growth from 0,2260 mm<sup>2</sup>/thous. cycles up to 31,4942 mm<sup>2</sup>/thous. cycles.

The mileage of a loaded wagon after formation of a fatigue crack in the side frame is calculated. The mileage of a wagon with a steadily developing fatigue crack with a length of 10 mm to 60 mm is 1,398 thousand km.

Comparison of the calculation results with the data of the sample on the fractures of the side frames for the period from 2006 to 2018 allows to make a conclusion about the correctness of the developed methods for calculating critical lengths of fatigue cracks, the resource of parts and the mileage of the wagon. The application of the methods at the design stage makes it possible to assess the performance of a new or modernised structure of a cast side frame (bolster beam) after the occurrence of a fatigue crack, as well as to give recommendations on establishment of overall shoulders.

*05.22.07 – Railway rolling stock, train traction and electrification.*

*The work was performed and the defence took place at Emperor Alexander I St. Petersburg State Transport University.*

**Timokhovets, V. D. Improvement of methods of remote monitoring of traffic flows for design of the road network of large cities. Abstract of Ph.D. (Eng) thesis [Sovershenstvovanie metodov distantsionnogo monitoring transportnykh potokov dlya proektirovaniya ulichno-dorozhnoi seti krupnykh gorodov. Avtoref. dis... kand. tekhn. nauk]. Omsk, TIU publ., 2020, 21 p.**

The use of methods for obtaining data on traffic conditions applicable for a single street does not meet the requirements of modern

cities. There is a need to develop an operational method for obtaining information with minimal resource costs and to study the possibility of designing a street-and-road network based on the method of remote monitoring of transport flows based on decrypting online images using Internet resources. In the Ph.D. thesis, the author compares the methods of studying transport flows, in which the absence of a detailed study of the street-and-road network as a network object is revealed.

The main idea of the work is theoretical and experimental substantiation and improvement of methods for remote monitoring of transport flows for design of street-and-road networks in large cities.

The object of the research: the parameters of the transport flow that justify design solutions for design of the street-road network.

The subject of the research is improvement of methods for increasing the efficiency of functioning of transport facilities, convenience, safety, and environmental friendliness of traffic.

The aim of the thesis is to improve the methods of remote monitoring of transport flows for design of the street-and-road network of large cities.

The theoretical and methodological basis: postulates of the theory of transport flows. They consist in the analysis of the modes of movement of cars in various road conditions, considering their dynamic capabilities, the composition of the transport flow and the psychophysiological characteristics of drivers. In the studies carried out, theoretical and computational and analytical research methods were used.

The analysis of applicability of monitoring methods and scientific papers on the theory of transport flows made it possible to formulate the relevance of the problem under consideration, to confirm the need to obtain representative data on the parameters of transport flows when considering a city as a network object. The necessity of integrating several methods of remote monitoring is substantiated: hardware-resource methods and development of a mathematical dependence of transformation of a static picture into a dynamic one with the possibility

of considering the objective parameters of the street-road network.

The form of the function has been established, which, with the smallest error (up to 13,21 %), determines the equation of transport flows for each of the developed types of streets. The dependence of the scale on resolution of satellite images is determined to identify transport flows by composition. A typification of streets and city roads has been developed, classifying transport and road factors, and demonstrating the features of the intensity distribution during the day for a more accurate determination. Significant factors are selected that affect the change in the parameters of the transport flow, and a model has been developed that considers the characteristics of the life cycle of each network object, the lane and the state of the roadway coverage.

For the first time, multiparameter dependencies have been developed to determine the traffic intensity, considering transport, road and meteorological factors. Comparison of the calculated and actual values of the intensity obtained by the video surveillance method according to the approximation criterion, which demonstrates the efficiency of the developed dependences, which increase the completeness and reliability of information, is carried out.

A software product has been developed that makes it possible to automate the processes of determining the parameters of transport flows on the street-road network of large cities for reconstruction of existing facilities, construction of backup streets and organization of traffic on streets and city roads.

Directions and prospects for further research are development of a method for express typing of unexplored streets and adaptation of the identified dependencies for the purpose of their application on streets with irregular traffic.

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

*The work was carried out at Tyumen Industrial University.*

*The defence took place at Siberian State Automobile and Highway University (SibADI). ●*

