

**Y.K. Mailybayev**, A.B.Shinykulova, D.A.Djumabekova  
International Transport and Humanities University, Almaty, Kazakhstan  
E-mail: ersind@mail.ru

## REVIEW AND ANALYSIS OF SOFTWARE FOR MODELING THE TECHNOLOGICAL PROCESS OF A RAILWAY STATION BASED ON SIMULATION MODEL

**Abstract.** Analysis of scientific works devoted to the problem of technical and operational assessment of the work of railway stations showed that today they mainly deal with the development of effective functional models, mainly using computers. At the same time, insufficient attention is paid to the identification of these models, their parameterization, and the determination of the conditions for carrying out simulation experiments. Errors in identifying station models and incorrectly chosen modeling conditions can significantly distort their technical and operational estimates. In this regard, these issues require additional research.

**Keywords.** Simulation, railway station, application packages.

### Introduction.

For modeling the railway technological process RS based on a simulation model, many software tools have been proposed, but they solve the problems of modeling technological processes one-sidedly and do not provide unambiguous answers to questions of logistics or modeling of railway technological processes RS [1-4].

### Materials and methods.

The current stage of railway development can be conditionally defined as the period from the 1990s to the present. There have been no significant shifts in the direction of automation of railway design over the past ten years. An analysis of the results shows that the researchers are faced with a rather unconventional problem that covers numerous aspects of design, and is difficult to formalize. The quality of the design solution with traditional approaches is determined, first of all, by the level of qualification of the designer.

The skills and experience of a professional solve the problem of linking the structure of the railway circuit with numerous internal and external factors, and there are no descriptive procedures for the designer's experience yet. During this period, a unified algorithmic approach to the interpretation of design requirements and rules for the implementation of station structures in the design begins to take shape. The so-called SCADA systems (or computer-aided design systems - CAD) are being developed.

Such systems contribute to the introduction of automated forms of end-to-end development of the most complex projects. They cover all stages of design and allow you to get integrated solutions for railway systems. The electronic circuits of the railway made it possible to track the condition of individual locomotives on the display screen at a point with coordinates determined by mobile GPS receivers via the global satellite navigation system. The most important factor that began to hinder the rapid creation of an effective CAD railway was the heuristics of the very process of building a railway circuit. However, thanks to the efforts of scientists engaged in theoretical research in this field, and a number of theoretical and practical studies and publications, the cognitive orientation of the results obtained in this field of science has grown.

Similar studies and works have also been conducted abroad [3, 4]. For these works, a characteristic feature was the accumulation of materials on the problem of developing transport CAD systems. At the same time, the works of foreign colleagues were dominated by methodological works in the context of the development of mathematical methods, which formally described the structure of railway development. Combinatorial, topological, matrix, and graph models were used, which displayed essential features.

Also, foreign researchers emphasized the importance of a correct graphical representation of the railway's technical equipment. All this combined made it possible to formulate a number of canonical requirements that are usually imposed on mathematical analogues of real railway circuits. The analysis of these works shows that there are two directions in which foreign scientists conducted their research in the field of railway design automation:

- technical design of the track infrastructure;
- technical and technological modeling of railway elements and processes.

Solving problems related to the problems of CAD synthesis, domestic and foreign scientists did not focus only on a narrow range of problems of optimizing the geometric properties of projected objects. They also linked the models being developed with the development of wagon processing technologies. As a result of this dual orientation of research in the field of CAD of railway stations, scientists have so far failed to obtain a complete solution.

The heuristics of systems used for design automation at the beginning of the 21st century, first of all, began to be associated with the need for direct active involvement in the design processes and analysis of design solutions for both performers and customers. In this case, design automation methods have become secondary and they are used only as tools and tools for reproducing the result of designers' activities.

In fact, the heuristic orientation of the design processes can be interpreted as the separation of the goals of designers and the CAD software environment itself. The capabilities of typical CAD systems turned out to be quite complete for the calculation and graphical modeling of railway circuits. However, practically no CAD system provides full-fledged interactive control functions on the part of designers over the progress of the railway development process. The weak side of many CAD systems is only the actual visual monitoring of the development of object structures.

CAD implements standard computer modeling techniques that allow you to design and simultaneously visualize the design results directly during development. As a result, it turns out that using direct methods of standard CAD, it is possible to develop integral structures of visual forms of railway stations and some technological objects. However, it is necessary to seriously rebuild the basic environment, complementing it with active modules of special content.

The problem can be solved by using ergatic or graphoanalytic methods that ensure the construction of a model of railway operation in an automated mode. However, human participation in the process of building a model and analyzing not only the overall performance of the railway, but also the course of its technological processes dramatically reduces the duration of the modeling period.

In these conditions, an urgent problem for railways is the development of methods for determining such estimated volumes of work, for which the results of modeling the functional states of railways (for a limited period of time) would allow making reasonable conclusions about the compliance of their technical equipment and technology with promising volumes of work. The calculation is carried out for conditions of uneven transportation.

An analysis of the conducted research and modern publications on the problems of research has shown that the trend of scientific research related to the computerization of technological processes at railway stations and procedures for making operational decisions in the tasks of technical and operational assessment of railway work has become generally recognized in the world today.

The creation of new models of computerization of the processes of technical and operational assessment of railway work, methods and hardware-oriented algorithms for the intellectualization of these processes, provides for scientific research in the field of organization of modern information technologies for the synthesis of automated systems of technical and operational assessment of railway work.

### Results and Discussion.

According to the estimates of domestic and foreign scientists, it can be concluded that a significant increase in the effectiveness of the use of modern computer technologies is possible only by studying the general properties of mathematical modeling, methods of building intelligent systems, algorithms used in control tasks, features of modern and promising intelligent technologies for railway, as well as architectural features of automation systems for technical and operational assessment of work Railway station.

AnyLogic [5] -is a multifunctional package designed for building simulation models. AnyLogic software is capable of supporting all the approaches that are encountered in the simulation process.

AnyLogic's interconnected modules are focused on building such models: process-oriented, system-dynamic, agent-based and multi-agent. AnyLogic is capable of supporting combinations of the above models. Since the AnyLogic environment is written in Java, the flexibility and versatility of this language allows you to take into account a wide variety of nuances during the construction of models.

It is possible to take into account a wide variety of configurations, for example, when modeling the operation of railway stations, see figure 1. Graphical interfaces of the AnyLogic environment, tools and libraries used for modeling allow you to accelerate the synthesis of models for a wide range of tasks.

In AnyLogic, you can model not only any production or logistics sector, but also solve the problems of finding optimal management options for complex transport systems.

AnyLogic's advanced multimedia tools and the integration into this software of capabilities for animating the processes of the simulation model in real time give researchers additional advantages in the process of developing plans for the development of research facilities and conducting experiments.

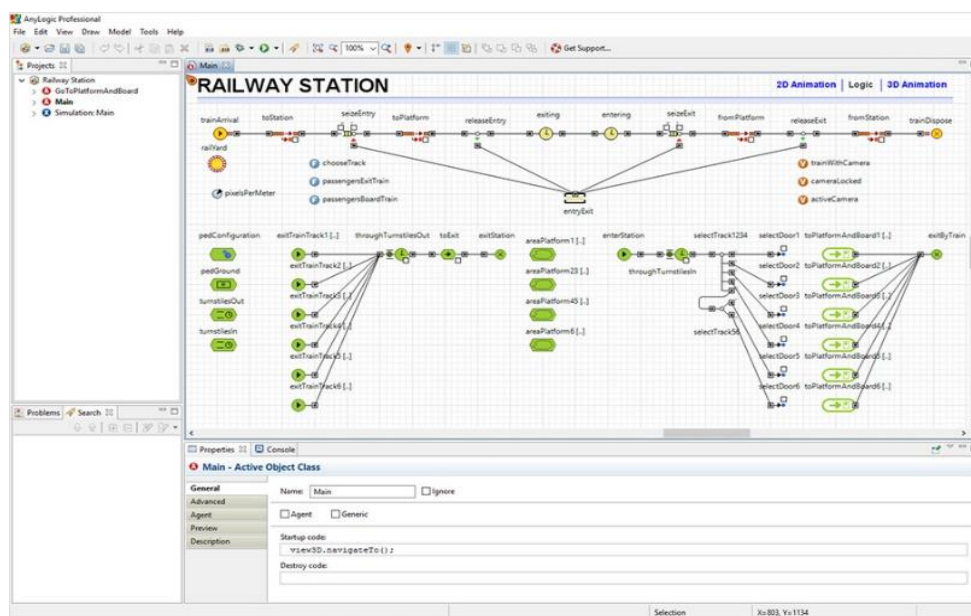


Figure 1 –General view of the AnyLogic modeling environment

The Aimsun simulation package [6] is a software for traffic modeling. With thousands of licensed users in government agencies, universities, as well as many consultants around the world, Aimsun stands out for its extremely high simulation speed.

The AutoMod software [7] is intended for building graphical models in the tasks of visualizing logistics and production systems. AutoMod allows for a detailed analysis of operations and material flows in logistics. In addition, AutoMod is widely used to solve analytical problems related to the analysis of various production processes of processing systems.

The AutoMod software, see Figure 2, has a fairly flexible structure, which makes it suitable for practical use for a wide variety of problem statements in a wide range of applied modeling by economic sectors.

Another interesting product in the field of production modeling is the MvStudium software, Fig. 3. This simulation environment allows you to analyze physical and dynamic systems. With MvStudium, you can quickly create and virtualize a wide variety of interactive models. Unlike other similar software products on the production modeling market, MvStudium allows us to consider multicomponent continuous, discrete and hybrid systems.

Systems built in the MvStudium environment can be analyzed using active computational experiments. Creating models, visualizing the results obtained during simulation experiments and the ability to manage computational experiments does not require researchers to write their own program code. Models can be described at the level of mathematical abstractions.

For example, a differential algebraic approach has been applied to describe the continuous behavior of a production or logistics system. In order to describe the discrete and hybrid (continuously discrete) behavior of the system, MvStudium uses the potential of visual behavior maps.

The advantages and disadvantages of the considered software packages are summarized in Table 1.

To simulate the operation of the station using these packages, you need to have a detailed railway model.

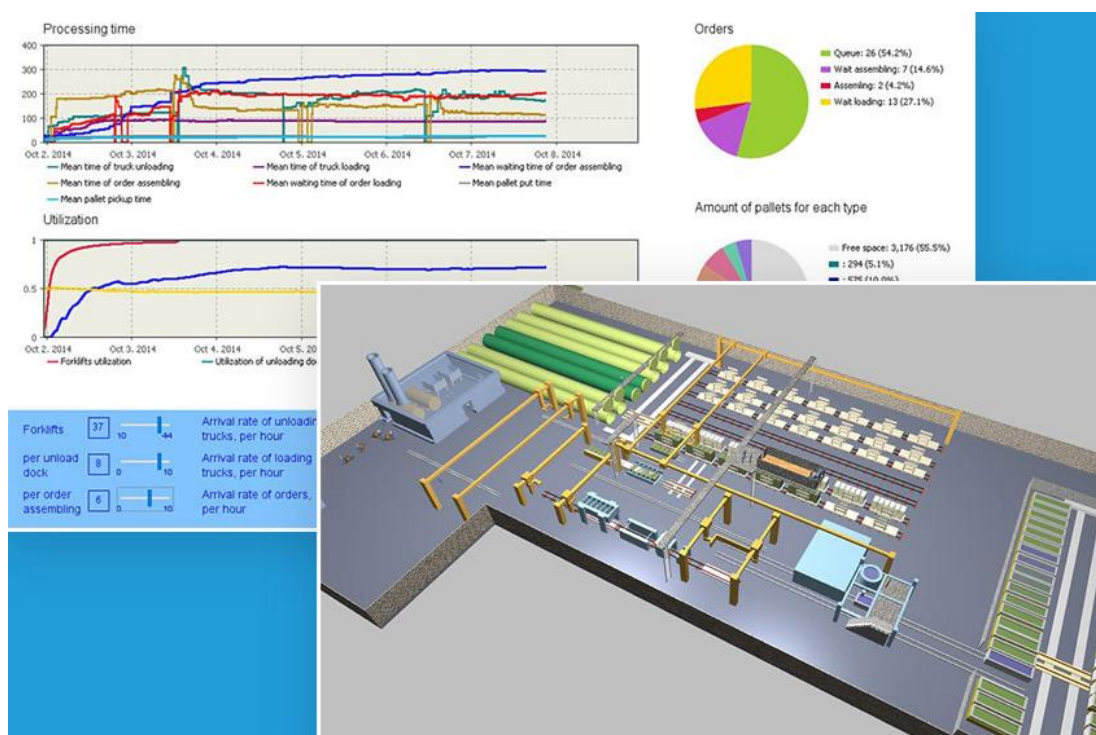


Figure 2 – General view of the AutoMod modeling environment

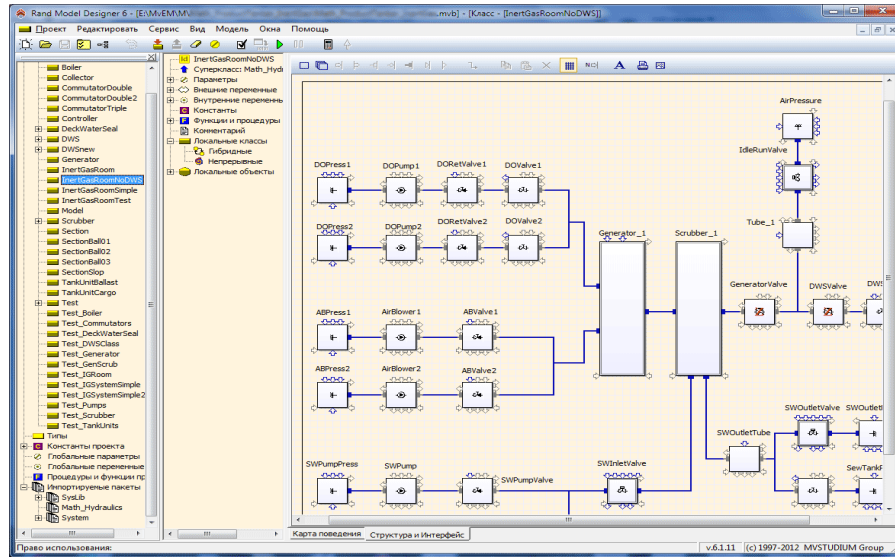


Figure 3 – General view of the MvStadium modeling environment

Table 1 - Advantages and disadvantages of the considered software packages

The system	Approach to Modeling	Advantages	Disadvantages
Arena	Discrete-event (DE)	It is possible to create your own templates and modules. A device for simulation experiments.	Only 1 approach to the model.
AGNES	A Agent-based (A). E Events are discrete.	Cross-platform (Cross-platform). The possibility of simulation and full-scale modeling.	The cost of the license
GPSS	DE	An object-oriented modeling paradigm. The possibility of simulation and full-scale modeling.	Only 1 approach to the model. A complex interface.
AnyLogic	DE+A	Two approaches. Visualization, optimization, and proprietary libraries.	Only 1 approach to the model. The cost of the license.
Simplex3	DE	Chart visualization capabilities. Cross-platform	One approach. Subscribe to updates.
Simio	DE+A	Visualization of models, different forms of presentation of results.	Reduced functionality. A relatively small list of tasks to be solved.
SeSAM	A	Import vector and raster files, work with text files.	Only 1 approach to the model. Lack of support
SimPy	DE	The ability to run models in real time. Cross-platform.	Only 1 approach to the model. There is no visualization.
Aivika	DE+A	Cross-platform. Parallel computing.	A complex interface. A fairly long training period is required, taking into account the features

Note that these behavior maps are essentially extended state maps of the UML modeling language MvStudium allows you to automatically create computer models that correspond to a given mathematical formulation of the problem, and at the output you can conduct computational experiments to verify the model's operability.

The computer model is implemented as a separate program or dynamic library. This is convenient because the dynamic libraries obtained in this way can then be used separately without binding to the MvStudium package. MvStudium software supports an object-oriented modeling and programming paradigm, which provides opportunities for users to create their own components based on the input language. MvStudium has support for 2D and 3D animation.

The railway station is a system that is in close cooperation with the mainline railway transport system, shippers and consignees and is connected to them by a large number of forward and backward connections that vary over time.

At the same time, its technical support (track development, shunting facilities, freight substations), control system (operational dispatch apparatus) and wagon traffic (VagT) are considered as enlarged elements of the station. Physical and information connections and corresponding channels are implemented between the elements of the system.

The external environment for railways is the railway transport system. The state of the system is characterized by the degree of involvement of the station's technical facilities and operations for processing VagT. The input of the system is the VagT and the information flow coming to the address of the railway station.

The output of the system forms a VagT and an information stream sent from the railway station. The elements of the railway's technical equipment are the functional units of the station's technological process. The behavior of the system is determined mainly by the influence of the control system. At the same time, one of the elements of this system is a human dispatcher. That is, the railway is an ergatic system, see Figure 4.

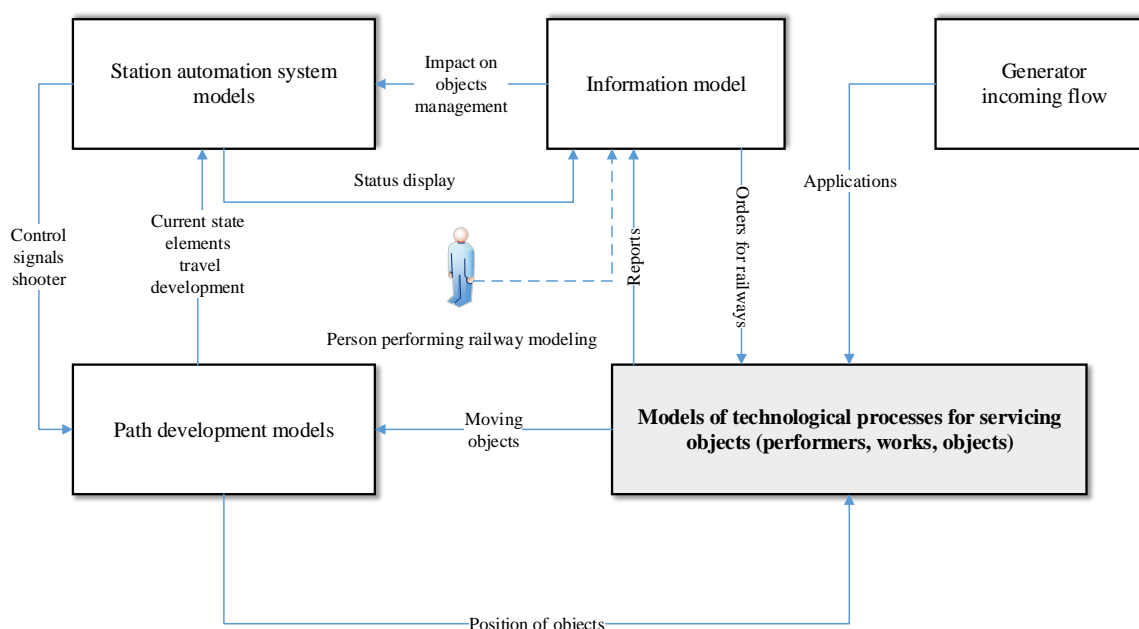


Figure 4 – Diagram of the ergatic railway system

Taking into account the characteristics of the railway as a complex technical system, as well as the results of the analysis of the degree of research on this issue [8, 9, 10], the following tasks for subsequent research are formulated:

- development of a procedure for identification of functional railway models;

- improvement of the feasibility study methods for evaluating the work of the railway in order to take into account changes in the volume and structure of the railway over time;
- improvement of methods of functional modeling of railway operational operation using visual programming methods.

### Conclusions.

The analysis of scientific works devoted to the problem of the feasibility study of the railway showed that today they mainly address the issues of developing effective functional models mainly using computers. At the same time, insufficient attention is paid to the issues of identification of these models, their parameterization, and determining the conditions for conducting simulation experiments. Errors in the identification of station models and incorrectly selected modeling conditions can significantly distort their feasibility studies. In this regard, these issues require additional research

### REFERENCES

- [1] Karpov, YU. G. Imitatsionnoye modelirovaniye sistem. Vvedeniye v modelirovaniye s AnyLogic 5. / Karpov, YU. G. / - SPb: BKHV-Peterburg, 2006. - 400 s.
- [2] Dong, H., Ning, B., Cai, B., & Hou, Z. (2010). Automatic train control system development and simulation for high-speed railways. IEEE circuits and systems magazine, 10(2), 6-18.
- [3] Goodman, C. J., Siu, L. K., & Ho, T. K. (1998, April). A review of simulation models for railway systems. In 1998 International Conference on Developments in Mass Transit Systems Conf. Publ. No. 453 (pp. 80-85). IET.
- [4] Zauner, G., Leitner, D., & Breitenecker, F. (2007, July). Modeling Structural-Dynamics Systems in MODELICA/Dymola; MODELICA/Mosilab and AnyLogic. In Proceedings of the 1st International Workshop on Equation-Based Object-Oriented Languages and Tools: Berlin; Germany; July 30; 2007; conjunction with ECOOP (No. 024). Linköping University Electronic Press.
- [5] Railway library manual: official website of AnyLogic company [Electronic resource] - Access mode: <http://www.anylogic.ru/anylogic/help/index.jsp> - Checked: 05.10.2020/
- [6] Yatskiv, I. V., Yurshevich, Ye. A., & Kolmakova, N. V. (2005). Ispol'zovaniye vozmozhnostey imitatsionnogo modelirovaniya dly aanaliza transportnykh uzlov. Imitatsionnoye modelirovaniye. Teoriya i praktika (IMMOD-2005): sb. dokl, 237-245.
- [7] Rohrer, M. W. (2000, December). AutoMod tutorial [simulation package]. In 2000 Winter Simulation Conference Proceedings (Cat. No. 00CH37165) (Vol. 1, pp. 170-176). IEEE.
- [8] Kaakai, F., Hayat, S., & El Moudni, A. (2007). A hybrid Petri nets-based simulation model for evaluating the design of railway transit stations. Simulation Modelling Practice and Theory, 15(8), 935-969.
- [9] Li, Yaohong, et al. "An improved operation strategy for CCHP system based on high-speed railways station case study." Energy Conversion and Management 216 (2020): 112936.
- [10] Harris, Nigel G., Christian S. Mjøsund, and Hans Haugland. "Improving railway performance in Norway." Journal of Rail Transport Planning & Management 3.4 (2013): 172-180.

**Ерсайын Майлыбаев**, PhD, Халықаралық көліктік-гуманитарлық университет Алматы, Қазақстан, [ersind@mail.ru](mailto:ersind@mail.ru)

**Анель Шинькулова**, PhD, Халықаралық көліктік-гуманитарлық университет Алматы, Қазақстан, [sh.anel4@mail.ru](mailto:sh.anel4@mail.ru)

Дария Джумабекова, магистр, Халықаралық көліктік-гуманитарлық университет, Алматы, Қазақстан, , dzdariya@mail.ru

## ТЕМІРЖОЛ СТАНЦИЯСЫНЫҢ ТЕХНОЛОГИЯЛЫҚ ПРОЦЕСІН БАЛАМАЛЫҚ МОДЕЛЬ НЕГІЗІНДЕ МОДЕЛЬДЕУГЕ АРНАЛҒАН БАҒДАРЛАМАЛЫҚ ЖАСАҚТАМАЛАРҒА ШОЛУ ЖӘНЕ ТАЛДАУ

**Аңдатпа.** Темір жол станцияларының (ТЖС) жұмысын техника-эксплуатациялық бағалау (ТЭБ) проблемасына арналған ғылыми жұмыстарды талдау, бүгінгі таңда ЭЕМ-ді пайдалана отырып, тиімді функционалдық модельдерді әзірлеу мәселелері басым қаралатынын көрсетті. Сонымен қатар, модельдерді сәйкестендіру, оларды параметрлеу, модельдеу эксперименттерінің шарттарын анықтау мәселелеріне жеткіліксіз көңіл бөлінеді. Станция модельдерін анықтаудағы қателер және дұрыс таңдалмаған модельдеу шарттары олардың ТЭБ-ін айтарлықтай бұрмалауы мүмкін. Осыған байланысты бұл сұрақтар қосымша зерттеуді қажет етеді.

**Түйінді сөздер.** Модельдеу, теміржол станциясы, қолданбалы бағдарламалар пакеттері.

**Ерсайын Майлыбаев**, PhD, Международный транспортно - гуманитарный университет, Алматы, Казахстан, ersind@mail.ru

**Анель Шинькулова**, PhD, Международный транспортно-гуманитарный университет, Алматы, Казахстан, sh.anel4@mail.ru

**Дария Джумабекова**, магистр, Международный транспортно-гуманитарный университет, Алматы, Казахстан, dzdariya@mail.ru

## ОБЗОР И АНАЛИЗ ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ ДЛЯ МОДЕЛИРОВАНИЯ ТЕХНОЛОГИЧЕСКОГО ПРОЦЕССА ЖЕЛЕЗНОДОРОЖНОЙ СТАНЦИИ НА БАЗЕ ИМИТАЦИОННОЙ МОДЕЛИ

**Аннотация.** Анализ научных работ, посвященных проблеме технико-эксплуатационной оценки (ТЭО) работы железнодорожных станций (ЖДС), показал, что сегодня в них преимущественно рассматриваются вопросы разработки эффективных функциональных моделей в основном с использованием ЭВМ. В то же время вопросам идентификации указанных моделей, их параметризации, определения условий проведения имитационных экспериментов уделяется недостаточное внимание. Ошибки в идентификации моделей станций и неправильно выбранные условия моделирования могут существенно исказить их ТЭО. В связи с этим указанные вопросы требуют дополнительного исследования.

**Ключевые слова.** Моделирование, железнодорожная станция, пакеты прикладных программ.

\*\*\*\*\*