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DEVELOPMENT OF A SYSTEM MODEL FOR THE FUNCTIONING OF DISTRIBUTION ELECTRICAL SUPPLY SYSTEMS IN TRANSPORT INFRASTRUCTURE PROJECTS

Об'єктом дослідження є система електропостачання залізничного транспорту, яка є частиною об'єднаної системи і відноситься до класу територіально-розподілених електричних об'єктів. Основною складовою системи є електричні мережі, які являють собою ключову технологічну ланку транспортного процесу, яка забезпечує його енергією, складає вагому частину витрат, зв'язує територіально-розподілені об'єкти і тому являє собою одну з технологічних основ інтеграції управління транспортним процесом. Це суттєво впливає на ефективність роботи всіх ланок залізничного транспорту, що особливо вагоме з точки зору корпоративних інтересів галузі.

В ході дослідження використовувалися системний підхід, методи системного аналізу, підходи оптимального управління виробництвом із забезпеченням технологічного процесу поточного ремонту та утримання розподільних систем електропостачання. А також способи організації єдиного інформаційного простору первинної інформації, що відображає стан системи електропостачання. Отримано інформаційну модель системи управління процесами поточного утримання та ремонту, яка дозволить підвищити результативність системи управління вже на початкових стадіях їх проектування. Це пов'язано з тим, що запропонована модель має ряд особливостей функціонування та організації ремонтних робіт. Зокрема, планування робіт розподільних систем електропостачання, функціонування з врахуванням оптимізації ремонтних робіт, управлінських рішень, взаємодії структурних підрозділів служби електропостачання, які будуються на множині задач Z_{jk}.

Завдяки цьому забезпечується можливість отримання інформації про окремі процеси організації планування поточного утримання та ремонту розподільної системи електропостачання структурних підрозділів служби. У порівнянні з аналогічними це забезпечує такі переваги, як можливість реєстрації, передачі та обробки інформації в режимі управління електропостачання. А також можливість реалізовувати періодичний і епізодичний контроль і оцінку надійності системи, програмно-апаратних засобів та інформації, швидкого проведення системного аналізу різних ситуацій, можливість формування найбільш ефективних управлінських рішень.

Ключові слова: *системний підхід, розподільна система електропостачання, управління транспортним процесом, управлінські рішення.*

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1. Introduction

The main components of improving management responsiveness are reducing the time taken to perceive information about external and internal situations, evaluating and analyzing these changes, forming adequate changes to decisions, coordinating and making specific management decisions, and organizing their implementation. Efficiency of management depends on:

– availability of information on possible destabilization points of external and internal situations and management decisions corresponding to these situations [1];
– degree of perfection of the tools and methods for predicting situations;
– control and analysis of their condition;
– formation of adequate decisions by it;
– perfection degree of the management organization, including the rationality of the organizational structure of management.

The effectiveness of management as a whole is determined by:

– degree of interest of each employee in the management sphere in the effectiveness of decisions made, the achievement of high final results;
– degree of coordination of actions of all management services of structural units.

Modern and world experience shows that the management organization process, characterized by a high level of centralization, prefers administrative methods for organizing the work of railway transport enterprises [2, 3]. In the case of such management, the dominant way of transmitting information is directive, which in a market economy leads to a decrease in the effectiveness of the management system. At the present stage, one of the most significant factors affecting the efficiency of the railway transport enterprises is the information mechanism, which is at the stage of formation [4]. Therefore, it is relevant to improve the organization of the management of distribution power

supply systems (DPSS), which is aimed, on the one hand, to increase the efficiency of making and organizing the implementation of management decisions, planning repair work, and on the other, to ensure their optimality. The priority of decoupling and task setting is the basis of a systematic mathematical model for improving transport infrastructure projects, namely, power distribution systems for structural units of railway transport services.

Thus, *the object of research* is the power supply system of railway transport, which is part of a unified system and belongs to the class of geographically distributed electrical facilities. The main component of the system is electric networks, which are a key technological chain of the transport process. And *the aim of research* is development of an information model of the process control system for current maintenance and repair. This will ensure the introduction of a single database of reference information, online electronic journals with electronic signature to automate the work of dispatch personnel and other services involved in management processes.

2. Methods of research

A radical improvement in the quality of repairs and the current maintenance of DPSSs, significant savings in labor, material and financial resources, which are inextricably linked with the improvement of management at all levels of the hierarchy of the system, is possible through the development of system models that are based on set of problems Z_{jk}.

An analysis of existing production management systems, repair quality, and methods for their development revealed a number of significant problems, as well as important promising areas and tasks for improving the effectiveness of such systems.

Improving the quality and effectiveness of the management of repair production is associated with the organization of management processes for:

– achievement of specified end results of functioning;

– ensuring, on a single information basis, a multifunctional unity of production and management processes at all stages of the formation, adoption and implementation of managerial decisions [5].

The main objectives of improving the management of repair processes and the current maintenance of distribution systems of power supply are:

– creation of scientific and organizational-technological potential, which would ensure, on a single information basis, the solution of problems of optimal production management;

– creation of standard software and methodological tools that ensure the effective implementation of computer technology;

– development of information management technology [6, 7].

Information technology for the management of production processes of repair and the current content of the DPSS provides, based on the information on the description of the control object, diagnostics of its behavior, as well as effective management decisions at all hierarchical levels of the organizational structure of management. The central place in the development of information technology is given to the question of setting and solving new problems of optimizing the processes of repair management and the current content of DPSSs. Mandatory in organizing optimization procedures is the formation of economic incentive models for individual performers and structural units of the power supply service (PSS), focused on high end results [8]. To ensure the necessary level of repair quality and the current maintenance of DPSS electrical equipment, there is a need to optimize the management processes of production repair processes, planning the number of production personnel.

3. Research results and discussion

One of the main directions for improving the quality management system for the current maintenance and repair of DPSSs is increasing the degree of completeness and accuracy of general and special information about the requirements for mechanisms for influencing the state of the control object and its individual elements.

To increase the effectiveness of the control system already in the initial stages of their design, special attention is paid to the development of a complete information model of the control object, taking into account its relationship with the external environment and with the established target parameters [9]. The information model (Fig. 1) is the basis for building the database of the control system and should be constantly updated during the functioning of this system.

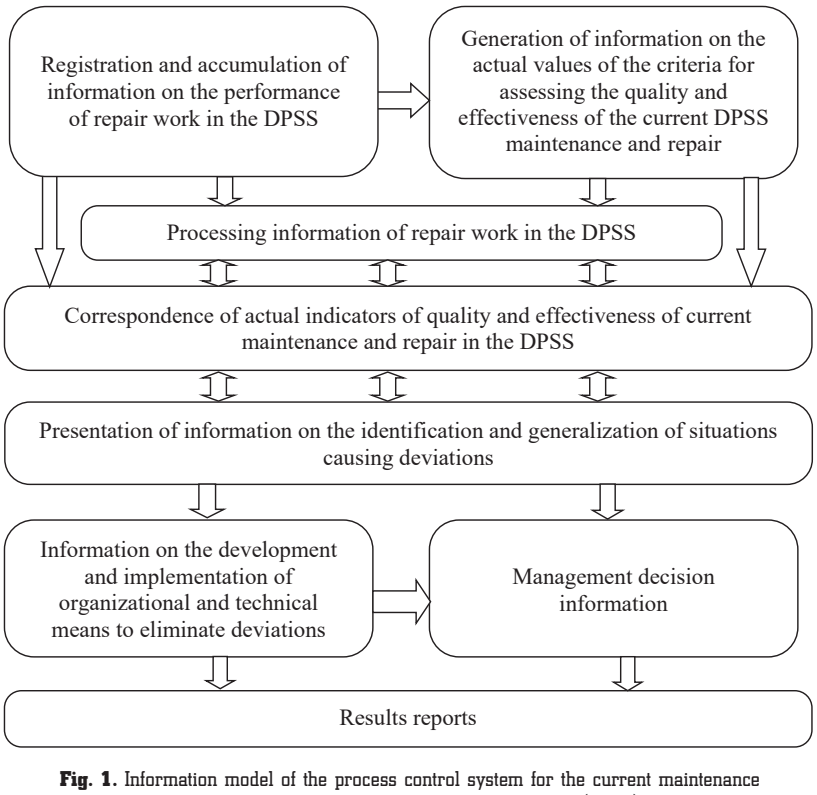

Fig. 1. Information model of the process control system for the current maintenance and repair of distribution power supply systems (DPSS)

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The database contains in general the following information:
– technological processes of repair and current maintenance of RFE and the relationship of these processes;
– the structure of the parameters of the goals, their relationship, dependence on the state of production processes;
– mechanisms of interaction of work performers with each other in the process of performing technological operations.

Formation, storage and updating of information in the management system should be organized in such a way as to provide the ability to quickly conduct a system analysis of various situations, the ability to form the most effective management decisions [10, 11].

The main tasks of improving the quality of repairs and the current maintenance of RFEs and the effectiveness of production management include:
– Z_{01} – improving the processes of using production and technological potential;
– Z_{02} – determination and optimization of the use of technological equipment and equipment;
– Z_{03} – automation and mechanization of production processes for repair and current maintenance of DPSS electrical equipment;
– Z_{04} – improvement of technology and increase of technological equipment of production repair processes and current maintenance of DPSS;
– Z_{05} – introduction of new materials, the use of secondary resources;
– Z_{06} – improvement and development of methods for the influence of the human factor on repair processes and the current content of DPSS;
– Z_{07} – forecasting, evaluation and optimization of the technological level of production;
– Z_{08} – development of criteria for the quality and effectiveness of the use of production and technological potential;
– Z_{09} – research and optimization of the structure of enterprise funds;
– Z_{10} – providing with modern technological processes;
– Z_{11} – organization of staffing;
– Z_{12} – improving the management of repair processes and the current maintenance of the energy sector as a result of the introduction of new information technologies and computer facilities;
– Z_{13} – formation of mechanisms for determining the system characteristics of the repair of electrical equipment;
– Z_{14} – simulation of DPSS repair processes;
– Z_{15} – optimization of DPSS repair management processes;
– Z_{16} – forecasting the status of the power supply service;
– Z_{17} – organization of a tender for the selection of DPSS equipment repair projects;
– Z_{18} – improving the management structure;
– Z_{19} – development of systems for the rational use of labor, material, financial and other resources;
– Z_{20} – development of reliability criteria in ensuring the operation of electro-cooling;
– Z_{21} – development of a system for organizing and managing energy-saving computer-integrated technologies.

The solution of the above problems ensures the effective implementation of factors to improve the quality of repairs and the current maintenance of DPSS, as well as improving the efficiency of production management, determines the rational use of fixed assets and material resources [12].

To ensure systemic efficiency in the functioning of the production and technological potential (PTP) of DPSSs, it becomes necessary to solve the set of problems:

$$\left\{\begin{matrix} Z_{01}, Z_{02}, Z_{03}, Z_{04}, Z_{05}, Z_{06}, Z_{07}, Z_{08}, Z_{09}, Z_{10}, \\ Z_{11}, Z_{12}, Z_{13}, Z_{14}, Z_{15}, Z_{16}, Z_{17}, Z_{18}, Z_{19}, Z_{20}, Z_{21} \end{matrix}\right\}. \quad (1)$$

All of the above tasks are one of the components of PTP power supply units.

System studies involve the analysis of all parts of the power supply system, modeling of production processes, the formation of production and technological structures, the development of effective mechanisms for the interaction of structural units that ensure the implementation of system goals and effective functioning.

A systematic approach to solving problems of increasing the DPSS efficiency and the quality of repairs provides [13, 14]:
– creation of rational information, production, technological and functional structures of DPSS;
– formation of system criteria for evaluating the activities of production and technological structures;
– creation of an effective system for the formation of integrated, targeted, scientific and technical programs for introducing achievements in scientific and technological progress in the DPSS.

The ineffective functioning of units is due to the following reasons:
– lack of scientific and methodological tools for assessing the effectiveness of the use of the production and technological potential of technical objects;
– lack of effective mechanisms for organizing production processes of DPSS.

Thus, optimizing the DPSS operation requires a substantial restructuring of the economic mechanism based on systematic research and modeling of production processes.

The effective DPSS operation is achieved through the implementation of such a system analysis formula:

<Production and technological potential>→ →<Processes for the targeted use of production and technological potential>→<Organization system that implements these processes>→<Results of the functioning of the organization system>.

The main tasks of ensuring the systemic effectiveness of DPSS are formed as a result of the complex interaction of the PTP structural divisions to repair electrical equipment and build on this basis system models (2)–(6).

A system model of the functioning of the structural units of the power supply service can be written on a variety of project tasks Z_{jk}.

The logical structure of the set of problems of projects $Z_{jk}^{(i)}$ is formed individually for each PSS, taking into account its specifics, that is:

$$P_{jk} \to z_{jk}^{(i)} : z_{jk}^{(i)} \in Z_{jk}^{(i)};\ j = 1,2,...,J;\ k = 1,2,...,K;\ i = 1,2,...,I. \quad (2)$$

The effectiveness of solving set of problems Z_{jk} at the hierarchy levels is determined using the function vector:

$$E = E\left\{R_{jk}^{(i)}, \overline{R}_{jk}^{(i)}, G_{jk}^{(i)}, \overline{G}_{jk}^{(i)}\right\};$$
$$j = 1,2,...,J;\ k = 1,2,...,K;\ i = 1,2,...,I, \quad (3)$$

where $R_{jk}^{(i)}, \overline{R}_{jk}^{(i)}$ – respectively, the actual and normative values of material, labor, financial and information resources of the first item spent on solving problems; $G_{jk}^{(i)}, G_{jk}^{(i)}$ – accordingly, the actual and predetermined level of quality of functioning of the PTP objects and processes.

The main methods for ensuring the effective use of DPSS PTP are:

– maximum focus on the final results of activities;
– systemic solution of many problems;
– maximum resource support for the DPSS operation.

$$F_{PSS} = F_{PSS}\left(F_{1i}, F_{2i}, F_{3i}, ..., F_{qi}\right);$$
$$i = 1,2,...,N;\ q = 1,2,...,Q, \quad (4)$$

where F_{PSS} – mathematical model of functioning on the i-th time interval; F_{qi} – mathematical model of the functioning of individual production processes of PSS at the i-th time interval.

$$F_{qi} = f\ \left(Z_{jk}^{(1)}; q = 1,2,...,Q; i = 1,2,...,N;\right.$$
$$\left. j = 1,2,...,J; k = 1,2,...,K\right). \quad (5)$$

$$D_{si} \to D_{jk}\left\{d_{jk} : d_{jk} \in D_{jk};\ j = 1,2,...,J; k = 1,2,...,K\right\};$$
$$D_{ji} \to Z_{jk}\left\{z_{jk} : z_{jk} \in Z_{jk};\ j = 1,2,...,J; k = 1,2,...,K\right\};$$
$$Z_{ji} \to M_{jk}\left\{m_{jk} : m_{jk} \in M_{jk};\ j = 1,2,...,J; k = 1,2,...,K\right\};$$
$$M_{ji} \to A_{jk}\left\{a_{jk} : a_{jk} \in A_{jk};\ j = 1,2,...,J; k = 1,2,...,K\right\}; \quad (6)$$
$$A_{ji} \to P_{jk}\left\{p_{jk} : p_{jk} \in P_{jk};\ j = 1,2,...,J; k = 1,2,...,K\right\};$$
$$P_{ji} \to S_{jk}\left\{s_{jk} : s_{jk} \in S_{jk};\ j = 1,2,...,J; k = 1,2,...,K\right\};$$
$$S_{ji} \to H_{jk}\left\{h_{jk} : h_{jk} \in H_{jk};\ j = 1,2,...,J; k = 1,2,...,K\right\},$$

where D_{si}, D_{jk} – respectively, the system and local goals of the PSS operation on the i-th time interval; Z_{jk} – set of problems that need to be set and solved at a given period of time to ensure the necessary level of effectiveness of the PSS operation; S_{jk} – set of systems (subsystems), which implements set of problems Z_{jk} in a given period of time; P_{jk} – software and methodological tools for solving problems Z_{jk}; M_{jk} – set of methods for solving problems Z_{jk}; A_{jk} – set of algorithms for solving problems Z_{jk}; H_{jk} – results of solving the set Z_{jk} at a given time interval.

So, the solution to the problem of increasing the effectiveness of the PSS operation is improving production, organization of labor and management, introducing new technologies, modern materials and advanced means of production.

4. Conclusions

The analysis of the main aspects of the work of units, are made based on which the causes and factors affecting the inefficiency of the units. According to the results of the research, ways of their solution are given, in particular, the effective functioning of the structural units of services in transport infrastructure projects, namely the power supply service. The main tasks of improving the quality of repairs and the current maintenance of the DPSS and the effectiveness of production management are given.

An information model of the control system for the processes of maintenance and repair of DPSSs is presented, taking into account the relationship with the external environment and with the established goals, which will improve the efficiency of the control system already at the initial stages of their design.

A mathematical model of the PSS operation as a subject of project management to maintain the proper state of the power supply economy is developed. This model is the basis for the formulation and solution in systemic unity of many repair tasks and the current maintenance of electrical equipment for a certain period of time.

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DEVELOPMENT OF A DIFFERENTIAL BLOCK CODING METHOD FOR APPLICATION IN MOBILE RADIO COMMUNICATION SYSTEMS USING MIMO SYSTEMS

Об'єктом дослідження даної роботи є методи і алгоритми просторово-часового блокового кодування, використовувані також в системах багатоантеного радіозв'язку (Multiple Input Multiple Output – MIMO). Реалізація систем MIMO когерентного прийому або попереднього кодування даних має на увазі знання інформації про стан каналу зв'язку і, відповідно, компенсацію його впливу. Для оцінки каналу спільно з інформаційними сигналами передаються пілот-сигнали, заздалегідь відомі на приймальній стороні. Періодичність відправки цих сигналів залежить від чинників, що змінюють стан каналу зв'язку, наприклад, один з яких – висока швидкість переміщення мобільних станцій. Але так як пілот-сигнали не несуть інформації користувачів, відбувається споживання ресурсу системи, що перешкоджає ефективному використанню радіочастотного спектру.

В ході проведення дослідження було розглянуто спосіб, що допускає відсутність необхідності знання інформації про стан каналу зв'язку – відносна фазова модуляція, який був узятий за основу і поширений для використання в системах MIMO. Даний спосіб передбачає некогерентний прийом, але, незважаючи на це, його застосування в повній мірі виправдовується, виходячи з отриманих результатів дослідження. Також були розроблені і інтегровані в систему ефективне деревоподібне кодування і алгоритм компенсації шумових складових сигналу. Це, відповідно, дозволило оптимізувати обчислювальні потужності реалізації системи і наблизити по ефективності пропонований метод диференціального просторово-часового блокового кодування (ДПВБК) до методів когерентного прийому.

Застосовуючи пакет програм MATLAB, виконано моделювання запропонованого методу ДПВБК для різних варіантів кількості передавальних і приймальних антен і видів модуляції. Проведено порівняння та визначено переваги методу ДПВБК. Викладений метод може знайти застосування в сучасних системах радіозв'язку з мінливими параметрами каналу зв'язку через високу швидкість переміщення мобільних станцій.

Ключові слова: *відносна фазова модуляція, комплексна ортогональна форма, когерентний прийом, просторово-часове кодування, система MIMO, деревоподібне кодування.*

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1. Introduction

When implementing coherent reception or precoding in multi-antenna multiple communication (Multiple Input Multiple Output – MIMO) systems [1–3], it is necessary to know the system of information about the state of the communication channel in order to compensate it. For channel estimation, together with information signals, pilot signals known at the receiving side are transmitted. The transmission of pilot signals consumes the resource of