

## ABSTRACT AND REFERENCES

## INFORMATION TECHNOLOGY: INDUSTRY CONTROL SYSTEMS

DOI: 10.15587/1729-4061.2020.201694  
**CONSTRUCTION OF A MATRIX DISCRETE MODEL OF A THREE-DIMENSIONAL BODY FOR THE RECONSTRUCTION OF ITS SHAPE (p. 6–16)**

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A matrix model of the representation of spatial objects for the synthesis, reconstruction, and analysis of their shape is proposed. The model is built on the basis of discrete data about the object, such as, for example, raster images or readings of spatial scanners. Unlike similar voxel models, matrix models describe not the volume but the surfaces of objects and, while preserving the advantages of voxel models, such as simplicity and regularity of structure, eliminate their inherent redundancy. It is shown in the work that, while retaining information on the form sufficient for visualizing the object, the matrix model can occupy 1.5–3 times less memory (the comparison was carried out for models in the VOX format of the MagicaVoxel package). The conditions are established under which the matrix model remains more economical than the voxel model, and it is shown that these conditions are satisfied for practically significant cases.

An algorithm for constructing a discrete matrix model based on a voxel is described.

A general approach to solving the problem of the resampling of models of three-dimensional graphics objects is proposed, which does not depend on the dimension of the source data array. In the framework of this approach, the matrix model is resampled. The necessary transformations of the model matrices are described, including both resampling and requantization, which ensures their controlled accuracy of the representation of spatial objects.

Procedures for monitoring and restoring integrity have also been developed for the proposed matrix model. The obtained conditions for monitoring the integrity of the model in practically significant cases (when the number of model elements is more than  $15^3$ ) can reduce the number of elements viewed, compared with the voxel model.

The limitations of matrix models are established associated with the possible loss of information about a part of the surface hidden from an external observer

**Keywords:** voxel model, matrix model, three-dimensional objects, shape reconstruction, resampling, redundancy elimination

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**DEVELOPMENT OF A METHOD FOR SELECTING THE APPROXIMATING FUNCTIONS FOR THE OBSERVABLE PROCESSES OF CLOUD INFRASTRUCTURE (p. 17–24)**

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This paper considers the techniques for improving the effectiveness of monitoring the cloud infrastructure processes implying the reduction of a computational burden while maintaining the required level of measurement accuracy. A technique for organizing the monitoring of cloud infrastructure processes, based on the approximation of accumulated measurements, has been further developed in this study. The necessary and sufficient set of approximating functions has been built, corresponding to the key properties of the observable processes. A method for selecting the approximating functions for the observable cloud infrastructure processes has been constructed. The method implies the assessment of properties of an observable process and the selection of its approximating function.

The practical value of this research relates to the ability to reduce the computational burden by reducing the number of planned measurements at an acceptable level of the decrease in their accuracy. The originality of the approach is the use of the a priori data about the observable processes aimed to obtain more accurate estimates of their properties. The practical implementation of the proposed method shows a 20–40 % decrease in the number of planned measurements at the level of monitoring accuracy not lower than 95 %. The proposed method makes it possible to reduce the load on cloud infrastructure components, to decrease the use of processor time, as well as the disk and random-access memories of physical and virtual nodes. The results of the study can be used for the software implementation of the system of cloud infrastructure monitoring.

**Keywords:** cloud infrastructure monitoring, computer network, function approximation, computational burden.

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#### MATHEMATICAL MODELING OF AN INDUCTION MOTOR FOR VEHICLES (p. 25–34)

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It has been proposed, in order to model an induction motor for vehicles, to employ a system of differential equations recorded in the «inhibited coordinates». To improve the algorithm robustness, the number of the system's equations was reduced by expressing the phase currents through the phase flux linkage. The parameters of the prototype engine have been defined in line with the classical procedure. An algorithm has been constructed in order to account for the mechanical losses and power losses in the engine steel. An induction motor with symmetrical windings has been simulated in the MATLAB programming environment. The basic technical parameters for the engine were determined using the simulation model. The simulation results have been compared with the results of classic calculations. The error in determining the parameters based on the model and those calculated did not exceed 7 %. This indicates a high convergence between the simulation results and the results of calculations. It has been proposed, in order to study an induction motor with the asymmetrical stator windings, to apply the algorithm that implies accounting for a change in the mutual inductance at a change

in the integrated resistance in the single or several phases of engine windings. The proposed algorithm for managing the asymmetric regime of stator windings could make it possible, without changing the structure of the model, to investigate the dynamic processes in an induction motor in case of the asymmetry of stator windings phases when they are damaged. Taking into consideration the losses of power in steel, as well as the mechanical losses, would improve the reliability of the results obtained. The error of determining the parameters of an induction motor at asymmetrical stator windings, obtained at modeling, and acquired experimentally, did not exceed 3 %, which testifies to the adequacy of the model.

That would make it possible to apply the proposed simulation model of an induction motor when studying the dynamic processes in the engines used in the transportation infrastructure, in case of such a defect as the interturn short circuit in the stator windings.

**Keywords:** optimal transportation management, railroad infrastructure parameters, mathematical modeling, induction motor, asymmetry of windings.

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**IMPROVING THE OPTIMAL SYSTEM OF AUTOMATED CONTROL OVER THE LEVEL OF ELECTRIC POWER QUALITY INDICATORS IN ELECTRIC NETWORKS (p. 35–45)**

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This paper reports solving an important scientific task of minimizing the losses caused by the established deviation and the asymmetry of voltage in the distributing electrical networks with a rated voltage of 10 kV.

It has been found that the existing systems of automated control over the mode parameters of distributing electrical networks do not fully take into consideration the multifunctional influence of symmetry-compensating devices at the level of electricity quality indicators.

It has been proposed to use, as the criteria functions for the task on automated control over the electric power quality indicators, the functional dependences that assess the level of losses caused by the established deviation and asymmetry of voltage in electrical networks. That has made it possible, in contrast to existing control systems, to better account for the negative impact of the established deviation and asymmetry of voltages on the modes of electric network operation.

We have determined the functional dependences between the input and output parameters of the control object (a distributing electric network with a voltage of 10 kV with a symmetry-compensating device), which formed the basis of the criteria functions for a multi-criteria optimization problem. The ultimate solution to the problem on a multi-criteria optimization based on a method of approaching a utopian point in the criteria space was derived by minimizing the Chebyshev distance from the utopian point to a Pareto-optimal set of solutions. Based on the obtained solution to the problem on a multi-criteria optimization, we have built an algorithm for determining the vector of optimum control.

Computer simulation of the optimal automated control system for the power quality indicators in distributing electrical networks has been performed.

Analysis of the simulation results has revealed that the automated control system proposed in this work, when compared with the existing ones, makes it possible to reduce the negative effect exerted by the above-the-norm values of the established deviation and asymmetry of voltage on the operation of electrical networks.

**Keywords:** automated control system, electricity quality indicators, multi-criteria optimization, voltage asymmetry.

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**SYNTHESIS AND INVESTIGATION OF THE CONTROL SYSTEM FOR THE PROCESS OF CARBON ARTICLE MOLDING (p. 45–51)**

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Among the most energy-intensive industries is the production of carbon articles, therefore, the improvement of its efficiency is a relevant scientific and technical task. One of the ways to resolve the set task is to create a modern production management system.

This paper considers the creation of a control system for one of the essential technological processes in carbon articles production – the process of their formation. Underlying the control system is the optimality criterion based on the specific cost of products taking into consideration their quality indicators. The control method used is Model Predictive Control (MPC). The results of studying the dependence of an optimality criterion on the setting parameters of an MPC-controller have made it possible to determine the optimum values for the prediction and control horizons, which could ensure the minimization of the products' specific cost. The structure of the proposed control system, developed in the Simulink programming environment, makes it possible to investigate a given control system through computer simulations.

The efficiency of the proposed system to control the process of carbon product molding was examined by comparing the quality of control by a given system and by the system that uses the classic PID control law. To this end, a three-circuit control system based on the PID-controllers was synthesized in the Simulink programming environment. Each controller was set, using a Powell method, for a minimum value of the integrated criterion. The results of the comparative study have demonstrated that at each operation cycle the optimality criterion value in the control system employing an MPC-controller was 8.8 % less than that in the system with PID-controllers at the same indicators of product quality. That testifies to the improvement in the technical and economic indicators of the formation process. This fact is of particular importance when taking into consideration the circularity of the technological process of carbon product formation.

**Keywords:** manufacture of carbon products, molding process, hydraulic press, control system, optimality criterion, MPC.

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**DEVELOPMENT OF A DIAGNOSING SYSTEM FOR THE ABSORPTION-DISTILLATION DEPARTMENT OF SODA ASH PRODUCTION (p. 52–59)**

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Production of soda ash using the ammonia method belongs to the class of complex continuous chemical-technological systems and is characterized by multidimensionality, inertia, the existence of cycles of material flows, complex dependences between the input and output parameters of technological modes. The research into the operation of this production and its performance indicators revealed that 24–26 % of losses in soda ash production were caused by violations of the technological mode at the absorption-distillation department. Many of these violations can be prevented, and losses can be significantly reduced, by developing a system of diagnosing the state of technological processes at this department. The main task of the diagnosing system at the absorption-distillation department is to determine the moment of transition of the technological process to the emergency state, disabling the control system, informing a technologist-operator about the probable cause of the emergency, and giving recommendations for its elimination. After the elimination of the reasons for the deviation of the technological process from normal functioning, the measures on switching on the control system are taken. The system of diagnosing an absorption-distillation department of soda ash production should be implemented based on the passive observations of the course of the technological process. This is due to the continuity of production, on the one hand, and the requirement to adhere to the mode of the normal functioning of the technological process, on the other hand. The results of the analysis of diagnosing emergencies prove that the implementation of the method of logical decision tables will enhance the speed of the diagnosing process and improve its quality due to the prevention and timely liquidation of emergencies. It was established that if the same emergency analysis vector corresponds to different causes of emergencies in this system, it is necessary to use characteristics of the statistical theory of solutions.

**Keywords:** soda ash, diagnosing system, logical decision tables, analysis vector.

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