**DEVELOPMENT OF A METHOD FOR OPTIMIZING OPERATION OF CENTRIFUGAL GAS SUPERCHARGERS UNDER CONDITIONS OF UNCERTAINTY (p. 6-17)**

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A problem of development of a method of optimal control of operation of natural gas superchargers by a criterion which both minimizes fuel gas consumption and takes into account power of nitrogen oxide emissions into atmosphere has been formulated. Technical conditions of gas pumping units, restrictions on technological parameters and the requirement to provide a planned indicator of gas pumping by a group of parallel-operated superchargers were taken into consideration.

Technical condition of each unit or its assembly is assessed based on certain attributes. If observation of such attributes is made for a certain period of time, a set of attributes is obtained. Using an artificial neural network of Kohonen type, the set of attributes (images) is divided into three classes. A certain number of points is assigned to each class. This number characterizes technical condition of the class. The number of points assigned determines utilization of each supercharger. This is taken into account when limiting overall performance of the supercharger group.

Formalized record of the optimal control problem contains dependences that are approximated by a polynomial of a specified order. This results in an empirical model whose structure is determined using an apparatus of genetic algorithms.

For a series of reasons (errors in measuring technological parameters, errors in measurement methods, external effects, limited scope of experimental material, etc.) identification of values of empirical model parameters is based on inaccurate information. Therefore, parameters of empirical models are treated as fuzzy quantities. Based on the adopted concept, a formalized record of the problem of optimal control of operation of natural gas superchargers was obtained.

Implementation of the study results will help save fuel gas and reduce nitrogen oxide emissions into environment.

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**DEVELOPMENT OF A PRICE OPTIMIZATION ALGORITHM USING INVERSE CALCULATIONS (p. 18-25)**

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An algorithm is proposed for solving the price optimization problem using inverse calculations. The algorithm includes two stages: solving the problem of unconditional optimization and solving the inverse problem using inverse calculations while minimizing changes in the arguments of the function. In this case, the solution of the inverse problem can be performed repeatedly within a given number of iterations to sequentially approach the set value of the constraint, and to determine the increment of the arguments, the values of the elements of the gradient/anti-gradient vector of the constraint function are used. To take into account the influence of the arguments on the change of the objective function, its second partial derivatives are used. Five options of the price optimization problem are considered, which nonlinear programming tasks with one restriction are. The revenue of the enterprise, the deviation of demand from the volume of production, the deviation of the sought price from its current value are considered as the objective function. It is shown that the solutions obtained in this way are consistent with the result of using classical methods (Lagrange multipliers, penalties), and the results are also compared with solving problems using the MathCad mathematical package. The advantage of the method is a simpler computer implementation, the ability to obtain a solution in fewer iterations compared to known methods. The method can also be used to solve other problems of the presented type with the following requirements for the objective function and restrictions:

1) partial derivatives of the objective function of the first order – linear one-dimensional functions;

2) the restriction has the form of equality;

3) the constraint is linear or the constraint is quadratic, and the partial derivatives of the first order of the constraint function are one-dimensional linear functions.

The article may be useful for specialists making decisions in the field of pricing policies of organizations, as well as the development of optimization models of economic facilities and decision support systems.

**Keywords**: inverse calculations, price optimization, quadratic programming, gradient method, inverse problem.

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Researchers widely use methods for calculation of recurrence plots based on measurement of dynamics of a vector of states in a phase space for visual and quantitative analysis of the behavior of complex dynamic systems in various fields. Such methods have high potential capabilities. However, one cannot use them directly for the operative calculation of recurrence plots at the real speed of measurements of a vector of states, taking into account irregularity of measurements. One of the reasons is the lack of a method, which would be capable of operative and reliable mapping of recurrence states of real systems in recurrence plots at irregular measurements of a vector of states.

We propose a method for the operative calculation of recurrence plots at irregular measurements. Its base is a scientific analysis of reasons for low reliability and impossibility of an operative calculation of recurrence plots, as well as search and substantiation of constructive methods for their elimination. Such methods include: current calculation of recurrence plots; improvement of a phase space by introduction of an operation of scalar product for vectors of states; adaptation of a recurrence threshold to measurement results. The base of a process of the current calculation of recurrence plots is a use of only current and previous measurements of a vector of states of the system. It is possible to reconcile two key factors of low reliability of mapping of recurrence states in diagrams related to uncertainty of a norm and a threshold of recurrence in the proposed improved phase space.

The above has made possible to propose a threshold adaptation method for conical regions of recurrence. It has been proposed to use two adaptive thresholds with different angular parameters of recurrence cones in the calculation to ensure reliable mapping of recurrence states in diagrams under conditions of irregular measurement of a vector of states. We confirmed the operability of the proposed operative method for calculation of recurrence plots and illustrated it by an example with irregular measurements of the real dynamics of a vector of states of dangerous pollution in the urban atmosphere.

**Keywords**: recurrence plot, complex dynamic systems, irregular measurements, atmospheric gas pollution.

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**FORMING A METODOLOGY FOR TRANSFORMING A MODEL AS THE BASIS FOR EXPANDING ITS INFORMATIVENESS (p. 34-43)**

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A problem on building the methodology for transforming the implicit form of a model has been stated and solved, which improves the efficiency of replacing complex nonlinear forms of mathematical models to reducing them to a recurrent sequence in the form of analytical expressions that allow quick express calculations.

New explicit forms of the models have been proposed that make it possible to use recurrent sequences for representing a solution to the problem and forming an error estimation expression, as well as and additional information. Given the fact that for many attributes the solution and an error estimation are critical, the analyticity of expressions reveals new properties and possibilities. Based on such factors as authenticity, accuracy, depth, materiality and completeness, the adequacy of the model is represented by a single analytical expression that would make it possible in future to simplify the process of comparison through the use of quantitative methods. Representation of transformations, according to which the connection between the error of two consecutive approximations and dependence on the approximation number was established, is predetermined by the necessity to analyze convergence dynamics based on the iteration number. Another variant, not less important, which can characterize the dynamics of convergence is the connection between an error of the first approximation and the arbitrary approximation. Based on the overall expansion of the implicit form of the model and the mean value theorem, the relationship between the two consecutive errors or norms has been established. It is demonstrated that if the error or a norm of error are assigned, the estimates for the first and second derivatives would make it possible to determine the boundary number of the iteration starting from which the error is less than the assigned one.

An example has been given for deriving an estimation for the general model of the magnitude of a maximally possible error, the boundary number of the iteration, starting from which the error acquires a value less than the assigned one. A comprehensive analytical assessment of adequacy based on a single expression has also been derived.

Representation of informational attributes in the quantitative form is predetermined by new opportunities that would emerge due to the obtained tools for quantitative analysis.

Numerical modelling has been performed; the character of dynamics of new informational indicators and attributes has been examined. The data given for nine iterations demonstrate efficiency and completeness of information to perform a quick analysis and draw a conclusion. Based on the dynamics of quantitative attributes for a relative error, as well as new ones, proposed based on the results from implementing the model transformation methodology, it has been shown that the possibilities emerge to run a quick analysis and draw a conclusion. It was demonstrated that the introduced attributes expand the informativeness of the methodology implementation for the further representation of a nonlinear model in the form of a recurrent sequence.

**Keywords**: nonlinear vector-function, recurrent model, informational attributes, analytical expressions, error estimation, boundary iteration, adequacy estimation.

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ROBUST IDENTIFICATION OF NONSTATIONARY OBJECTS WITH NONGAUSSIAN INTERFERENCE (p. 44-52)

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The problem of identification of non-stationary parameters of a linear object, which can be described by the first-order Markov model, with non-Gaussian interference is considered. The identification algorithm is a gradient minimization procedure of the combined functional. The combined functional, in turn, consists of quadratic and modular functionals, the weights of which are set using the mixing parameter. Such a combination of functionals makes it possible to obtain estimates with robust properties. The identification algorithm does not require knowledge of the degree of non-stationarity of the investigated object. It is the simplest, since information about only one measurement cycle (step) is used in model construction. The use of the Markov model is quite effective, as it allows obtaining analytical estimates of the properties of the algorithm.

Conditions of mean and mean-square convergence of the gradient algorithm in the estimation of non-stationary parameters and with non-Gaussian measurement interference are determined.

The obtained estimates are quite general and depend both on the degree of object non-stationarity and statistical characteristics of useful signals and interference. In addition, expressions are determined for the asymptotic values of the parameter estimation error and asymptotic accuracy of identification. Since these expressions contain a number of unknown parameters (values of signal and interference dispersion, dispersion characterizing non-stationarity), estimates of these parameters should be used for their practical application. For this purpose, any recurrent procedure for evaluating these unknown parameters should be applied and the resulting estimates should be used to refine the parameters included in the algorithms. In addition, the asymptotic values of the estimation error and identification accuracy depend on the choice of mixing parameter.

**Keywords**: Markov model, gradient algorithm, mixing parameter, recurrent procedure, asymptotic estimate, identification accuracy.

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**DEVELOPMENT OF INFORMATION TECHNOLOGY ELEMENTS FOR DECISIONMAKING SUPPORT AIMED AT RESTRUCTURING PRODUCTION AT VIRTUAL INSTRUMENTMAKING ENTERPRISES (p. 53-62)**

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This paper considers issues related to the re-structuring of virtual industrial enterprises, in particular the prospects for developing a virtual instrument-making enterprise (VIE). Such enterprises operate by employing external geographically distributed resources and could be flexible in terms of making a product demanded by market. We have proposed elements of information technology (IT) to support decision making on the organization of VIE operation. The IT elements include models and structures for decision making, including those aimed at the rational use of resources in the operation of VIE. The purpose of the proposed IT is to solve a task on supporting decision-making in the restructuring of production processes at virtual instrument-making enterprises based on market conditions. The need for re-structuring of production is caused by difficult conditions of market economy for small and

medium instrument-making enterprises. A production program is formed on the basis of the currently existing demand for different categories of articles included in the product range of an enterprise, or correspond to the direction of VIE operation. The IT elements include models for an informational-analytical portal (IAP), as well as a block diagram for deploying and supporting a unified knowledge space, at flexible re-structuring of production according to market conditions. The IAP also includes expert systems (ES). The designed IT for a decision-making support to a VIE head would make it possible to produce the product demanded in the market and profitable in manufacture. IT could enable determining the number and types of necessary resources according to the assigned criteria, their distribution, taking into consideration a direction of production re-structuring.

**Keywords**: resources, virtual instrument-making enterprise, decision making models, market conditions, re-structuring, mathematical models.

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