MATHEMATICAL MODELING

SOLUTION OF THE PROBLEM OF SET THEORY ON THE BASIS OF ALGEBRA OF PREDICATES AND PREDICATE OPERATIONS

The mathematical tools of algebra of predicates and predicate operations to solve the problems in the set theory are applied in the article. The basic concepts of algebra of predicates and predicate operations, their types and formulas are considered. The quantifier algebra of predicate operations, which is complete and plays an important role in the description of operations on predicates, is considered. The basic identities and laws of quantifier algebra of predicate operations are considered. With the help of quantifier algebra of predicate operations describes the concept of linear logical operator and Galois mapping, which are usable with the capture of data quantifiers in an empty domain. The basic concepts of set theory are described. The proper interpretation of the language of algebra predicates and predicate operations received operations of union, intersection, complement, difference, symmetric difference and inclusion of sets. Some problems of set algebra are solved by means of sets of algebra of predicates and predicate operations. The advantages of using these tools to solve the problems of algebra of sets are marked.

Keywords: algebra of predicates and predicate operations, set algebra, set operations.

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STUDY OF THE DOUBLE REBUILDING EFFECT OF THE NONSTATIONARY LONGITUDINAL WAVE IN ROD WITH RECTANGULAR CROSS SECTION

The article investigates obtained by the author new effect of a dual modification of non-stationary wave in a rod with rectangular cross section. The dynamics of rod is described by derived earlier improved one-dimensional dynamic equations of the longitudinal deformation. This equations were got basis on strict mathematical algorithm (so-called non-minimal simplification of the three-dimensional dynamic equations of the theory of elasticity) — «asymptotic-group» analysis.

On the solutions of mentioned equations were built graphs of the longitudinal wave distribution in the rod. Analysis of them allowed to describe tridimentionality of the process. At the same time the transfer of three-dimensional state of strain to one-dimensional classic case followed by arising of the appropriate quasifronts is studied.

Also must pay attention to the fact that all wave fronts velocities are the same as in the problems of theory of elasticity.

Keywords: asymptotic-group, dynamic load, wave front, quasifront, non-stationary wave.

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MATHEMATICAL MODELING OF CHEMICAL REACTIONS IN MICROREACTORS

In this paper it is conducted a review of published data on the use of microstructural reactors for the optimization of chemical processes and reactions, a detailed description of which is possible with the use of modern methods and modeling tools.

Microreactor is a miniature reactor apparatus having dimensions in the submillimeter range. Chemical reactions in the microreactor are carried out in one or a plurality of parallel channels, the channel diameter is not more than the mean free path of the molecules in the gas phase reactions. The advantages of the microreactors may include a large surface area contact between the phases, laminar flow (and reducing energy costs and increasing residence time), high radial diffusion coefficient, simplifying scaling and enhanced characteristics of safety selectivity of processes occurring in them.

On the basis of established technical and economic advantages of microsystem devices it is proved the feasibility of their implementation in production.

Keywords: microreactor, structural reactor, microchannel, kinetics, modeling.

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TO THE PROBLEM OF BUILDING A MATHEMATICAL MODEL OF ONE-DIMENSIONAL OBJECT

page 16–21

Methods of mathematical modeling of one-dimensional object using the method of least squares approximation and Chebyshev polynomials are investigated. Object is eight-stage centrifugal filter. The aim of the article is the building the mathematical relationship of aerodynamic drag depending on the gas flow. Approximating procedures of polynomial coefficients determination and calculation of residual variance in the system of Mathcad are developed. The influence of the degree of the polynomial degree on the accuracy of the results is analyzed. The obtained values of the residual variance indicate coincidence of results using both methods. From obtained results it can be argued that the investigated approximation methods give the same results, and to build approximating polynomial for the communication of parameters for input and output of object can be used both methods. If compared in terms of simplicity of constructing an algorithm method of least squares is simplest for implementation.

Keywords: mathematical modeling, Chebyshev polynomials, approximation, method of least squares.

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INVESTIGATION OF INTERPOLATION ALGORITHMS FOR COMPUTER IDENTIFICATION OF DYNAMIC MODELS ON EXPERIMENTAL DATA

Despite the large number of developed algorithms of identification of dynamic models of transient, still little attention was paid to the computer implementation of iterative methods for the problem of identification of the transfer function for the transient response based interpolation algorithms approximation. This article provides an analysis of variational and interpolation algorithms for solving the problem of identification of an aperiodic transient object with a self-leveling, it is developed a set of programs that implements the algorithm of variational modeling in modern MATLAB system through combination of symbolic mathematics and calculations. The selected algorithm allows providing a certain amount of independence of members in terms of approximating the number of interpolation points. The article describes the software system, and describes the results of test examples that show a large approximation error in the initial part of the transition process. The obtained results can serve as the basis for the creation of combined iterative interpolation algorithm in the study of transient stability of dynamical systems.

Keywords: interpolation, transfer function, transient process, stable dynamical system.

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MATHEMATICAL AND COMPUTER MODELING OF SEISMIC PROCESSES BASED ON A SOLITON APPROACH

In this paper we consider a mathematical model of seismic process, taking into account the role of solitary waves as a shocks «trigger». Methods of forecasting are based on evaluating trajectories of individual solitons and clarification of shocks probability. We allocate among the entire set of shocks individual subsets caused by the same soliton and construct of hypothetical trajectory of the solitons. The probability of a shock can be verified taking into account the soliton components of seismic process. The information system for the analysis of soliton component seismic processes was developed. We show the effectiveness of soliton approach and the possibility of its application to the analysis of seismic processes in several regions of the Earth by using this information system.

Keywords: soliton, solitary wave, earthquake, dynamic system.

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DETERMINATION OF PASSENGER PATH CHOICE MODEL PARAMETERS IN THE CITIES

page 32–36

On the basis of statistical processing of the results of the questionnaire survey it is developed a passenger path choice model in transit. The factors taken into account in the model: the parameters of transport service, the level of fare indicators that characterize the socio-economic conditions of the population. Processing of the results of the questionnaire survey allowed us to determine the parameters of the passenger path choice model. The model is based on the generalized transportation cost at alternative paths. It was found that the change in the proportion of traffic flow distribution at alternative paths with sufficient adequately describes the evaluation function with nonlinear elasticity. Parameters of passenger path choice model which were identified can be used to solve problems in passenger flow forecasting in urban transit network.

Keywords: transportation path, choice model, generalized cost of transportation, questionnaire survey, traffic flow distribution.

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SIMULATION AND NUMERICAL ANALYSIS OF DYNAMICAL SYSTEMS WITH COMPETITIVE INTERACTIONS

page 36–41

The effects of the destabilization of competitive coexistence «populations» — actors described by a system of differential equations of Lotka-Volterra for three classes of objects: the economic system «producer-mediator», the Keynesian model of the economy of several countries, and weak sinusoidal external influences on the rate of «reproduction». The stability of such systems is investigated. Numerical solutions are found at frequencies of exposure close to the frequency of the unperturbed system.

Such systems are soft classical models of many real objects in environment, economy and other areas, and their studies are relevant.

It is known that the corresponding system of nonlinear equations, especially with the right part of the disturbed, generally cannot be solved. Numerical experiment revealed bifurcation when changing the amplitudes of n, and the period of the disturbance Ω. Trophic parameters of the unperturbed system do not lead to bifurcations for the classical Lotka-Volterra system.

The studies found that the variation of the amplitude (in the range $0-0{,}15$) lead to the transition of the system of periodic motions to sustainable growth, and then to chaotic oscillations. So, bifurcation introduces asymmetry in the structure of the characteristic exponents, and with it the instability and «withdrawal» of path to infinity. There are possible both monotonous and chaotic type.

Keywords: Lotka-Volterra model, model perturbations, stability problems, periodic solutions, attractor, limit cycle.

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APPROXIMATE SOLUTION OF THE NAVIER-STOKES EQUATION FOR DIGONAL DUCTS

This article presents the analysis of the pressure laminar flow in the digonal duct with the section formed by two equal arcs. Such ducts are used in soft film heat exchangers. In addition, they are formed in rocks for underground water. The first attempt was to perform the analysis similarly to flows in round pipes. This direction gives wrong parabolic velocity profile with a rib at the long axis of the digonal section. In addition, it causes pressure drop calculation results understated up to 14,3 %. Therefore, to obtain adequate results we need to solve the Navier-Stokes equation. We propose a grid with unequal steps for this kind of section and solve the equation numerically. The convergence is very quick. For most of the tasks, it is enough to use a 4×4 grid. To integrate the profile in case of very quick convergence and a sparse grid the interpolation with the highest possible order is required. We introduce a new coordinate system to map the digonal section to a rectangle. We perform polynomial interpolation of all nodes in the new coordinate system. The integration of this polynomial cause velocity field coefficient to converge on the 4×4 grid for most of the tasks (the error does not exceed 2,2 % compared to the 100×100 grid). We show possibility of pressure drop calculation with the same formula as for the round pipes with the error of no more than 2,86 %. However, we offer equations for more precise calculations of the pressure drop and velocity field coefficient.

Keywords: laminar flow, digonal duct, heat utilization, polymer film, polymer heat exchanger, underground water.

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INFORMATION AND CONTROL SYSTEMS

DEVELOPMENT OF METHOD FOR SYNCHRONOUS SPARK EXCITATION OF ULTRA-WIDEBAND ANTENNA ARRAY ELEMENTS

page 51–55

To test the effectiveness of screening facilities and equipment to ensure information security simple compact generators of electromagnetic radiation is needed. For this purpose it is proposed to use spark generators-radiators of powerful ultra-wideband microwave pulses. A new method to synchronize the array of spark generators-radiators is offered. This method allows to simplify the synchronization of the antenna array. The analysis of dependence an array factor on switching time of fuses and voltage distribution on the plates of strip radiators at the time of fuses breakdown is conducted. The results of mathematical modeling parameters of the linear array of spark strip radiators are confirmed by experimental results. During the experiment the effect of coherent addition of pulses generated at the breakdown time of the spark gaps of strip radiators has been observed. As a result generator radiation directivity and power has increased.

Keywords: ultra-wideband pulse generator, ultra-wideband antenna array, a high voltage pulse generator.

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SIMULATION OF THE BRAKING SYSTEM OF CAR UNDER THE CONTROL OF ABS IN MATLAB SIMULINK

page 55–59

It is developed a mathematical model of the braking system of a car equipped with ABS by means of MATLAB SIMULINK. The results, which allow visually explore the basic physical processes associated with the exploration and development of existing and new control algorithms of ABS, are received. The article deals with a pneumatic braking system under the control of ABS, which is most common and installed on buses and trucks. Its modeling is performed on a graphical interface of MATLAB SIMULINK, and is essentially a means of visual programming.

This work allows us to estimate the correct approach to the study of the dynamic and technical parameters of the ABS and achieve clarity of the processes occurring during operation of the ABS.

The study found that this model in the first approximation can be used as the primary outcome correct approach to mathematical modeling of the ABS.

The obtained results are important for the further improvement of the primary model, namely, accounting for additional factors that affect the correct operation of the brakes of the car (road condition, accuracy of the sensors, dynamics of the car traffic, wheel drift during turn, etc.).

Keywords: braking system of car, ABS, MATLAB, SIMULINK.

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RESEARCH OF MAGNETIC FIELD IN THE WORKING AREA OF ELECTRIC MOTOR WITH PERMANENT MAGNETS

page 60–62

Available software packages for magnetic field parameters modeling in working area of electric motors have a number of restrictions. For instance, the choice of design conditions and their values is restricted. As a rule, mathematical model for calculation of magnetic field components is not affordable.

The computational algorithm based on well-known analytical methods of solving the direct problem of magneto statics with the usage of «secondary sources» method was proposed in this article.

The article contains developed mathematical model for designing conditions of magnetic field parameters in the working area of electric motor with pole pieces. On the basis of the mathematical model a new computational algorithm was proposed and specialized software was launched.

A number of experiments on magnetic field modeling in working area of engine was carried out. The obtained data allowed to increase the calculations accuracy of the magnetic system of electric motors.

Keywords: mathematical model, algorithm, electric motor, calculation of the magnetic field.

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ANALYSIS OF THREATS TO PERSONAL DATA AND THEIR PROTECT FEATURES

page 63–67

The analysis of threats to personal data and means to counter them are analyzed. The problems that must be implemented to protect personal data are considered. Shows Solutions to minimize threats to personal data are given. It is established that the perimeter of information system defended a greater extent than minimized the internal threats and external threats countermeasures implemented more widely than internal threats countermeasures. Classification of information systems is given. It is shown that only system for identifying and data leakage prevention (DLP-system) is the only solution that prevents leakage of information outside of secure information space in real time based on data filtering or trappings that accompany the process of moving data. The architectural control system for information leaking over perimeter of secure information system is presented. It is shown that prevention of unauthorized leakage of personal data by networking channels requires the introduction of special systems of detection and blocking of this sending by network channels.

Keywords: information protection, personal data, threats, information security, systems, facilities, information.

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