

УДК 631.37

Распределение потоков мощности и КПД механической трансмиссии полноприводного колесного трактора / А. Ю. Ребров // Вісник НТУ «ХПІ». Серія: Математичне моделювання в техніці та технологіях. – Харків: НТУ «ХПІ», 2016. – №6 (1178). – С. 104 – 109. Бібліогр.: 8 назв. – ISSN 2222-0631.

Предложен метод определения составляющих потока мощности и КПД на примере трансмиссии полноприводного колесного сельскохозяйственного трактора. Метод предполагает на основе предварительно рассчитанных долей мощности в месте разветвления потока мощности от двигателя к ведущим мостам трактора определить КПД трансмиссии в режимах работы при наличии и отсутствии циркулирующей мощности. Для практических расчетов также установлена взаимосвязь долей мощности в месте разветвления потока мощности с долями мощности непосредственно на колесах ведущих мостов трактора.

Ключевые слова: мощность, поток мощности, приводы ведущих мостов трактора, трансмиссия трактора.

УДК 629.7.085.24

Концепция проектирования компактных наземных пусковых устройств для запуска беспилотных летательных аппаратов / В. А. Серда // Вісник НТУ «ХПІ». Серія: Математичне моделювання в техніці та технологіях. – Харків: НТУ «ХПІ», 2016. – №6 (1178). – С. 110 – 115. Бібліогр.: 6 назв. – ISSN 2222-0631.

Сформулирована проблематика ввода в полет с поверхности беспилотного летательного аппарата за счет внешней энергетики. Записана полезная функция, а также общие и частные управляющие параметры наземных пусковых устройств (НПУ). Приведены кинематические схемы НПУ различного типа, полученные в результате модернизации. Описана лежащая в основе метода оптимизации длины направляющей комплексно-сопряженная модель катапульт. Изложен принцип параметрического поиска закона распределения тягового усилия путем нормирования работы расширения в определенном интервале.

Ключевые слова: пусковое устройство, полезная функция, параметрическая оптимизация, характеристический критерий, управляющие параметры, комплексная модель.

УДК 519.6; 532.5

Вычислительные технологии для метода дискретных вихрей / Д. И. Черный // Вісник НТУ «ХПІ». Серія: Математичне моделювання в техніці та технологіях. – Харків: НТУ «ХПІ», 2016. – №6 (1178). – С. 116 – 123. Бібліогр.: 12 назв. – ISSN 2222-0631.

Рассмотрены вычислительные технологии для разрешения проблемы (метода дискретных вихрей), связанной с аппроксимацией непрерывных границ упорядоченной системой дискретных вихрей в задачах моделирования плоских нестационарных течений. Метод и алгоритм предназначены для вычисления непрерывных характеристик (определяемых через неоднозначные функции) в области их определения вплоть до ее границ, являющихся естественными линиями разрыва непрерывных характеристик. Предлагаемый метод и алгоритм преобразования системы дискретных особенностей универсальны для границ произвольной геометрии («ветвистые» контура, замкнутые контура). Результаты преобразований позволяют вычислять кинематические и динамические характеристики для отрывных течений, с учетом возникновения новых элементов границ в точках отрыва.

Ключевые слова: метод дискретных вихрей, метод дискретных особенностей, вычислительные технологии.

УДК 519.6

Математическая модель манжетных уплотнений из фторопласта для агрегатов пневмоавтоматики ракетных двигателей / С. А. Шевченко, С. А. Валивахин, А. Л. Григорьев, М. С. Степанов // Вісник НТУ «ХПІ». Серія: Математичне моделювання в техніці та технологіях. – Харків: НТУ «ХПІ», 2016. – №6 (1178). – С. 124 – 143. Бібліогр.: 12 назв. – ISSN 2222-0631.

При использовании линейных дифференциальных уравнений упругой деформации тонкостенной цилиндрической оболочки переменной толщины исследовано статическое напряженно-деформированное состояние фторопластовой манжеты с коническими боковыми поверхностями, применяемой для уплотнения клапана и поршней регулятора давления газа ракетного двигателя. Поставлена и решена одномерная задача аэроупругости, возникающая при анализе контакта между фторопластовой манжетой и цилиндрической стенкой из металла, на основе чего разработан метод расчета эффективного зазора и утечек газа через данное уплотнение. Разработан новый расчетный метод для определения контактной силы между манжетой и цилиндрической поверхностью втулки или штока, который учитывает проникновение давления газа или смазки вглубь уплотняемого зазора. Исследованы теоретические закономерности упругопластической деформации лепестков распорной пружины и разработан метод расчета давления, оказываемого лепестками на стенку фторопластовой манжеты. Описаны методы экспериментального исследования трения и утечек газа в манжетах, а также результаты испытаний, уточняющие известные зависимости трения от уплотняемого давления и скорости скольжения фторопласта. Предложены новые формулы для оценки силы трения в подвижных уплотнениях, которые предлагается использовать конструктору на стадии эскизного проектирования узла. В этих формулах учитываются упругие и пластические характеристики фторопласта – модуль Юнга и твердость по Бринеллю.

Ключевые слова: манжетное уплотнение, упругость манжеты, контактная задача, утечки газа, коэффициент трения фторопласта, лепестковая пружина, сухое и вязкое трение, сила трения в манжете.

ABSTRAKTS

UDC 621. 226

Mathematical model of universal bench for hydraulic valves testing / P. M. Andrenko, D. S. Pogorelov, M. S. Svinarenko // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 5 – 13. Bibliog.: 27 titles. – ISSN 2222-0631.

A principle hydraulic scheme of a universal, energy-efficient bench for testing hydraulic machines is presented. The characteristic features of the bench are an adjustable axial piston pump and a piston hydropneumatic accumulator. The range of the design and operation parameters of hydraulic machines is determined by the evolution tendencies of the hydraulic machines produced by the world's leading manufactures of hydraulic equipment. The output parameters of the universal bench for testing hydraulic machines are defined by the maximum values of the operation parameters of the investigated apparatus. The choice of the conduit diameter is explained. The hydraulic units and devices for building the bench are selected. The assumptions made while developing the bench mathematical model are justified. An explicit mathematical model of the bench is developed taking into account the maximum number of factors. This model combined with the mathematical model of a hydraulic machine allows to determine the hydraulic machine operation characteristics at the hydraulic machine design stage. The prospects of further improvement of the bench scheme and units with the view of increasing its energy efficiency are discussed.

Key words: bench, hydraulic valve, operating parameters, mathematical model, performance criteria.

UDC 62-531.4

Two-level model of a hydraulic system with parallel structure / O. P. Gubarev, O. V. Levchenko, A. V. Korzhovnyy // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 13 – 17. Bibliog.: 5 titles. – ISSN 2222-0631.

A two-level model of hydraulic drive systems with parallel structure is presented. The logical component of the model describes the logical interaction of the actuators in accordance with their operation in parallel streams. The logic component is a set of control commands for each operation, which is presented as a combination of signal states and logic functions. The functional component defines technological and operational characteristics of each operation, which are the basis for determining the level of energy consumption of the hydraulic system. This methodology allows simulating hydraulic systems with a large number of actuators in a fairly short period of time. The received power characteristics of the system can be used in designing new hydraulic machines and in upgrading existing hydraulic systems. The main features of the functional component are the force applied and the speed of the forward and reverse action of each operation. Also, this approach can be used to predict changes of energy system consumption taking into account such factors as deterioration of the equipment, a change in the cost of electric energy, lifetime, etc. In addition, the prospects for further research in the direction of identifying and forecasting system efficiency are considered.

Key words: two-level model, hydraulic drive system, parallel structure, energy efficiency.

UDC 621.3.078.3

Reduction of closed-loop control system for multivariable process of growing single crystals / Yu. S. Kozmin, V. S. Suzdal // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 18 – 24. Bibliog.: 7 titles. – ISSN 2222-0631.

When growing large-size single alkali halide crystals, with increasing length of the growing sample, one experiences disturbances connected with qualitative change of the character of heat exchange in the crystal-melt system. The crystallization of large single crystals becomes non-stationary. The study of crystallization process shows that the task of managing the growth process can be reduced to the management of an object with uncertainty. The designed control system should provide acceptable quality of transient processes and required accuracy. Therefore, the solution of the problem of quality management of crystallization process should be sought in the class of robust control systems.

An indirect method for synthesizing the controllers of low order and given structure is used to control the crystallization process. A balanced truncation procedure is applied to obtain the robust reduced-order controller. The approach is based on the task of managing by norm. This approach reduces the error due to the application of the reduced controller. An example provided shows that there is no significant deterioration of the robust properties for permissible conservation of the system properties at high frequencies.

Key words: PID Tuning, Robust Control, Single Crystal, Multivariable Processes.

UDC 001.57

The study of the conditions of formation of pulp flow in the sand chute of a single-spiral classifier / V. A. Kondratets, A. N. Matsui // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 24 – 30. Bibliog.: 20 titles. – ISSN 2222-0631.

The results of studying the formation and dynamics of pulp flow in the sand chute of a mechanical single-spiral classifier are presented. Upon the impact of sand and water a mixture of evenly spaced firm is formed in the sand chute that does not change during the motion of the pulp. The variable volumetric efficiency of the classifier sands makes the pulp movement uneven. The variable in time sand flow in the hydraulic system is automatically compensated by varying its height in the sand chute. Only under this condition the material balance and the continuous transporting of the material persist. There exist mathematical dependences between the variable sand costs, average speed and pulp height. Using the dependences obtained at some point in time it is possible to determine the average speed and the height of pulp in the sand chute, which characterize uniquely the conditions of formation of the flow, allow restoring the mechanism of interaction between the batches of the material and studying the ways to improve the accuracy of measurement of the process variable.

Key words: spiral classifier, sands, sand chute, pulp, flow, velocity, height, cost.

UDC 621.43

Forming database of thermodynamic properties of fatty acid esters of biodiesel fuel in the gas phase (part 1) / A. M. Levterov, A. A. Levterov, L. I. Levterova // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 30 – 37. Bibliog.: 32 titles. – ISSN 2222-0631.

The share of alternative fuels from biological raw materials (ethanol, the biodiesel) in the balance of motor fuels increases constantly. A set of data on thermodynamic and thermal properties of these fuels is required for a comprehensive research of the working processes of piston engines. The properties of ethanol are well known and have been successfully used in experimental and numerical researches. The physical and chemical properties of biodiesel are studied and known, so there are no obstacles for experimental research of biodiesel-fired engines. These questions have been the subject of many scientific articles. Difficulties arise in the numerical simulation of workflows that require data on the thermodynamic characteristics of the high-temperature components of this fuel. The known thermodynamic databases do not contain such information. Therefore, the description of the combustion process has been maximally simplified. Biodiesel is an organic substance which consists of a chemically bound complex methyl and ethyl esters of higher fatty acids of different vegetable oils or animal fats. The presented research has been devoted to collecting and analyzing information about the thermodynamic and thermochemical properties of higher fatty acid esters, which are part of the biodiesel, available in the literature. This applies to isobaric heat capacity, enthalpy and entropy in the temperature range 300 – 3000 K. As a result of the research a sample for twenty two methyl and ethyl esters of eleven higher fatty acids has been compiled. These data make it possible to present the results in the form of polynomial dependences of thermodynamic functions for biodiesel obtained from a variety of vegetable oils.

Key words: biofuels, fatty acid esters, vegetable oils, mathematical modeling, working process, thermodynamic properties, thermochemical properties, polynomial.

UDC 621.43

Forming database of thermodynamic properties of fatty acid esters of biodiesel fuel in the gas phase (part 2) / A. M. Levterov, A. A. Levterov, L. I. Levterova // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 37 – 43. Bibliog.: 8 titles. – ISSN 2222-0631.

Numerical researches of the working processes of piston engines with self-igniting fuel mixture working on biodiesel have been hampered by the lack of information on the thermodynamic characteristics of the high-temperature components of this fuel. In the second part of the paper we complete the task of forming the database of thermodynamic characteristics of twenty two complex methyl and ethyl esters of eleven higher fatty acids chemically bound in the biodiesel in various combinations. The combinations of the fuel esters depend on the type of vegetable oil from which the biodiesel is obtained, and the mass fraction of each constituent ester. The aim is to derive an approximate analytic dependence on the temperature of the main thermodynamic values (such as isobaric heat capacity, enthalpy and entropy in the temperature range 300 – 3000) for a number of biodiesel fuels. The discrete data are approximated by the least-squares procedure implemented by a universal software module. A polynomial of the 7th degree is used as an initial polynomial for isobaric heat capacity. Other thermodynamic functions (enthalpy, entropy) can be obtained by simple integration on the basis of the relations that link the thermodynamic functions. Standard enthalpy of the substances and the entropy at standard temperature are taken as constants of integration. Approximation coefficients and integration constants are tabulated.

Key words: biofuels, fatty acid esters, vegetable oils, mathematical modeling, working process, thermodynamic properties, thermochemical properties, polynomial.

UDC 519.6

Method for increasing accuracy of expanding discontinuous functions of one variable in Fourier series / O. M. Lytvyn // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 43 – 46. Bibliog.: 6 titles. – ISSN 2222-0631.

In this paper we propose using discontinuous splines for numerical implementation of the A.N. Krylov method of improving the accuracy of expanding discontinuous functions of one variable in Fourier series. The possibility of its generalization to a function of two variables to improve diagnosis using computed tomography projections obtained by computer tomograph is discussed. We propose using discontinuous splines for improving the accuracy of approximation of functions of one and two variables by Fourier sums in the Krylov's method.

Key words: discontinuous functions, Fourier series, improving convergence, method of identifying singularities.

UDC 519.6

Mathematical model of spatial distribution of a set of minerals in the crust using borehole core data by function interlineation method / O. M. Lytvyn, O. O. Lytvyn, F. F. Koval, O. S. Chorna // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 46 – 50. Bibliog.: 5 titles. – ISSN 2222-0631.

The problem of recovering a finite set of elements of the periodic table or their combinations distributed with linear density at a given depth at each point between a given set of oblique boreholes is studied. We do not consider all the elements of the periodic table but restrict ourselves to a set of n chosen elements and their combinations. A method for constructing a matrix function interlineation operator is proposed. Each component of the interlineation matrix function depends on three variables on a system of curves. The interlineation matrix function coincides with the approximated matrix function at the given depth in each of the boreholes and allows to determine the approximated matrix function values at the given depth at each point between the boreholes. The method of constructing mathematical models of spatial distribution of the minerals between the oblique boreholes proposed in the paper allows creating mathematical models of the Earth crust using all mineral compositions present in the cores of the oblique boreholes which will contribute to the development of efficient methods of mineral prospecting and mining. The prospects of further research are also discussed.

Key words: mathematical model, interlineation functions, spatial distribution, borehole cores.

UDC 519.6

An estimate for total absolute error of cubature formula of approximate calculation of the integral of high oscillating functions of three variables / O. M. Lytvyn, O. P. Nechuiviter, G. V. Kargapol'tseva // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 50 – 56. Bibliog.: 19 titles. – ISSN 2222-0631.

The article is dedicated to the improvement of mathematical models of digital signal processing and imaging by the example of constructing cubature formulas of approximate calculation of integrals of high oscillating functions of three variables. The feature of the proposed cubature formulas is using the input information about the function as a set of traces of the function on planes or a set of traces of the function on lines or as a set of values of the function at points. The theory of interlineation and interflotation of functions is the most effective in this case. An estimate for the total absolute error of cubature formula of approximate calculation of the integral of high oscillating functions of three variables is obtained in the case when the information about the function is given by its traces on perpendicular planes approximately with a set maximum error. A cubature formula is constructed using the interflotation operator, the function belongs to the Lipschitz class with the additional conditions. A specific example demonstrates validity of the theorem about estimating the error of the method of solution rounding.

Key words: integrals of high oscillating functions of three variables, cubature formula, interflotation, the error of the method, irreducible error, the error of rounding.

UDC 539.3

The inverse problem for non-stationary vibrations of a string system / E. S. Malakhov, A. V. Voropay // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 56 – 62. Bibliog.: 7 titles. – ISSN 2222-0631.

Non-stationary transverse vibrations of a system of ropes, which are simulated by strings, are studied. A system of three strings is considered. It is supposed that each string contacts the other string at a single point. String displacements are identical at these contact points. The displacements of the points of the strings are described by a system of three one-dimensional wave equations. The inverse problem is reduced to solving a system of the first kind Volterra integral equations. A system of linear algebraic equations for the unknown contact forces is obtained as a result of discretization. The Cramer generalized algorithm and the Tikhonov regularization algorithm are used for solving the block matrix equation. The unknown external load is identified by the known noisy displacement of a point of the third string in time. A computational example, graphs of string displacements and forces are given.

Key words: system of strings, transient load, the wave equation, regularization algorithm, Volterra integral equation, identification of forces.

UDC 519.25

Modeling of nonstationary processes with structural breaks / T. O. Marynych, L. D. Nazarenko, K. V. Gets // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 62 – 68. Bibliog.: 8 titles. – ISSN 2222-0631.

The paper deals with creating an optimal model of non-stationary time series with adequate static features and high prediction options. The daily statistic data on the hryvnia to US dollar interbank exchange rate form the information basis of the model. The deterministic and stochastic components are studied to determine the type of the series stationarity. The expediency of smoothing and leveling time series with seasonality, cyclic recurrence, and trend is tested. Autoregressive integrated moving average (ARIMA) and autoregressive conditional heteroscedasticity (ARCH) models are developed for the initial data. The model residues are analyzed and model adequacy is tested. The conditions for using dummy variables for eliminating the data structural breaks and model residue problems are studied. The algorithm proposed allows determining the SARIMA optimal model, which includes the seasonality parameters and the structural break dummy variables.

Key words: autoregression model, forecast, stationary process, structural break, dummy variable, autocorrelation, heteroscedasticity.

UDC 621.382:62-1/-9(045)

Programming of multiplexing micro- and nanocircuits / O. S. Melnyk, V. O. Kozarevych, A. O. Reshetnik // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 68 – 74. Bibliog.: 4 titles. – ISSN 2222-0631.

The increasing specialization of large-scale integrated circuits (LSI) with improved performance and reliability is always at odds with their versatility, which expands the required range and reduces the amount of release of each individual toponomy. Elimination of contradictions between specialization and versatility is achieved through the development of multiplexing LSI, which necessary algorithms are programmed by the developer of electronic equipment. The use of LSI in digital micro- and nanoelectronic devices can significantly improve their operational capabilities, primarily to improve reliability and performance, reduce power consumption and overall dimensions. However, the development of LSI is a lengthy and costly process, which is economically justified only if the volume of finished products is sufficiently large. Increasing specialization of IP while improving the above indicators is always in conflict with their versatility, which expands the required range and reduces the amount of production of each individual part type. The latter leads to an increase in the production cost. Automated methods for programming multiplexing micro- and nanocircuits to produce logical functions of multiple arguments are presented. The proposed devices have been simulated and verified using modern computer systems.

Key words: micro- and nanocircuits with programmable structures, multiplexer, computer-aided design.

UDC 519, 64, 539.3

Method of energy modeling of diffraction of elastic waves / A. M. Nazarenko // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 74 – 82. Bibliog.: 26 titles. – ISSN 2222-0631.

Well-conditioned algorithms based on the method of energy modeling of diffraction of elastic waves on finite and periodic grids and reduced to solving singular integral equations on closed and open contours are presented. Integral representations of the diffracted field displacements are derived using the reciprocal work theorem for two different states of the mechanical system. An efficient method for distinguishing singular kernels that allows to accelerate significantly the convergence of the function series in the case of periodic nonhomogeneity system is proposed. The singular integral equations are solved numerically by the methods of discrete singularities and mechanical quadratures.

Key words: method of energy modeling, diffraction of elastic waves, finite and periodic grid, singular integral equations, method of discrete singularities, method of mechanical quadratures.

UDC 656.56/681.5:004.78

A method of determining the location of switching devices and devices for collecting and transmitting information when synthesizing a regional gas supply monitoring system / L. I. Nefedov, M. V. Shevchenko // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 83 – 89. Bibliog.: 11 titles. – ISSN 2222-0631.

The article is devoted to solving one of the problems of regional gas monitoring system synthesis. The structure of the regional gas monitoring system is hierarchical. On the lower level of the hierarchy are the measurement tools that allow you to monitor performance. On the second level of the hierarchy are devices to collect and transmit information, and collect data from the measuring instruments. At the third level, there are devices that provide switching and support for communication protocols.

When performing structural-topological synthesis of a hierarchical system, determining the locations of information collection and transmission devices and switching devices is one of the primary subtasks. In addition, it is necessary to determine the list of measuring devices that will connect to each of the devices collecting and transmitting information and the lists of information collection and transmission devices to be connected to the switching device. A method to solve these subtasks that allows taking into account the vagueness of the source data by using interval estimates and choosing a rational option depending on the specific situation is proposed in the article.

The proposed method allows improving the efficiency of the regional gas monitoring system by considering the regional gas monitoring system as a multilevel structure. The cost of the topological synthesis when connecting measuring instruments can also be reduced.

Key words: method, topology, synthesis, monitoring, regional gas supply.

UDC 629.429.3:621.313

An algorithm for synthesizing an expert electric rolling stock traffic control system on the basis of solution of the Hamilton-Jacobi-Bellman equation / O. M. Petrenko, B. G. Lyubarskii, M. L. Glebova // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 89 – 95. Bibliog.: 11 titles. – ISSN 2222-0631.

To solve the problem of optimal motion an expert system of conducting an electric rolling stock on a track section is created. The system allows to determine the best modes of the variation of the rolling stock motion on the basis of the criterion of energy consumption for a given average speed. An optimal average speed is selected based on the expert systems of reference vehicle on a section of the route at different average speeds and an integrated efficiency criterion. In this paper, an algorithm for solving the Hamilton-Jacobi-Bellman equation for the problem of motion of an electric rolling stock on a track section with a given profile and motion graphics is developed, which allows to create an expert traffic control system. The feature of this algorithm is the use of penalty functions to describe the restrictions imposed by the timetable, namely, the predetermined time for reaching the destination point by the train, the speed limit on the road sections, as well as the lack of downtime during the train motion. A unified penalty function approach is also used for imposing restrictions on the clutch. This approach allows to reduce significantly the computing time and standardize (simplify) the energy cost calculations.

Key words: expert systems of conducting vehicle, an algorithm for solving the Hamilton-Jacobi-Bellman equation, penalty function, movement resistance, energy costs when driving electric rolling stock.

UDC 629.7.05

Generalization of a three-frequency trigonometrical quaternion model of a rigid body rotation. Second type of model / Yu. A. Plaksy // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 96 – 104. Bibliog.: 8 titles. – ISSN 2222-0631.

A new continuous rigid body rotation model based on a general representation of a model quaternion of orientation in functions of the angles simultaneously linearly changing in time is proposed. Analytical dependences for the quasicordinates at a step of calculations of the parameters of orientation and the components of the quaternion corresponding to such rotations are constructed. The model is numerically implemented for several sets of the parameters. The results obtained are presented in the form of dependences of quasicordinates on time and trajectories in the configuration space for the orientation parameters. It is shown that the new model describes the rotation of a rigid body other than the case of regular precession. The model can be used as a reference model for estimating the errors of orientation algorithms in strapdown inertial navigation systems.

Key words: quaternion, orientation, reference model, quasicordinates, trajectories in configuration space.

UDC 631.37

Distribution of power flows and efficiency of four-wheel drive tractor mechanical transmission / O. Yu. Rebrov // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 104 – 109. Bibliog.: 8 titles. – ISSN 2222-0631.

The article presents a method for determining the components of the power flow and efficiency on the example of the transmission of an all-wheel drive farm tractor. The method involves determining the efficiency of the transmission in the modes with and without power circulation using the pre-calculated fractions of power at the point of the power flow branching from the engine to the drive axles of the tractor. For practical calculations the interrelation of the power fraction at the branching point of the power flow with the power fraction on the tractor drive axles is determined. The approach presented in this paper can be used to justify the methods of transmuted the power from the tractor engine to the agricultural machine not only through the tractor chassis system, but also directly to the working bodies or chassis system of the implement, which seems to be perspective from the standpoint of increasing the efficiency of the machine-tractor unit as a whole.

Key words: power, power flow, tractor axle drives, tractor transmission.

UDC 629.7.085.24

The concept of designing compact ground launching devices for launching unmanned aerial vehicles / V. A. Sereda // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 110 – 115. Bibliog.: 6 titles. – ISSN 2222-0631.

The problems of launching an unmanned aerial vehicle (UAV) from the surface using external energy are formulated. The general shortcoming of modern ground launching devices (GLD) is a significant length of the UAV acceleration. Using intensive methods for improving dynamic performance of GLDs is ineffective. The goal is to develop the methods of optimization of dynamic characteristics of GLDs. To this end a useful function, as well as general and specific control parameters of ground catapults are derived. Cinematic schemes for GLD of different types, obtained by modernizing the timing drive or transmission gear ratio are presented. We describe the complex conjugate model of pneumatic catapult underlying the optimization method family. The principle of parametric determination of the law of distribution of traction by normalizing the expansion work in a certain range is discussed. The software for implementing the optimization algorithm using machine methods is proposed. The capacities of the design tools are presented in the form of a phase cut of a pneumatic GLD calculation domain. The comparative analysis of the results of optimization of different types of catapults obtained by modernizing their transmission or drive is carried out.

Key words: launching device, useful function, parameter optimization, characteristic criteria, control parameters, complex model.

UDC 519.6; 532.5

Computing technologies of the discrete vortices method / D. I. Cherniy // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 116 – 123. Bibliog.: 12 titles. – ISSN 2222-0631.

Computing technologies for approximating continuous boundaries by an ordered system of discrete vortices in the problems of modeling flat transient flows using discrete vortices method is considered. The method and algorithm developed allow computing continuous characteristics determined by multivalued functions in their domains up to the boundaries, which are the natural separation lines of the continuous characteristics. The method and algorithm for transforming discrete singularities proposed in the paper can be applied for the boundaries of arbitrary geometry, e.g. branching contours or closed loops. The relations obtained allow computing kinematic and dynamic characteristics for separated flows taking into account the new boundary segments arising at the separation points.

Key words: method of discrete vortices method of discrete singularities, computing technology.

UDC 519.6

Mathematical model of PTFE seals for hydraulics units of rocket engines / S. A. Shevchenko, S. A. Valivakhin, A. L. Grigoriev, M. S. Stepanov // Bulletin of National Technical University «KhPI» Series: Mathematical modeling in engineering and technologies. – Kharkiv: NTU «KhPI», 2016. – №6 (1178). – pp. 124 – 143. Bibliog.: 12 titles. – ISSN 2222-0631.

The stress-strained state of a PTFE lip seal with conic side surfaces applied to seal the valve and piston of a rocket engine gas pressure regulator is studied using linear differential equations of elastic deformations of a thin cylindrical shell. The one-dimensional aero elasticity problem arising in the analysis of PTFE lip seal and metal cylindrical wall contact is set and solved. Based on the problem a method for computing the effective clearance and gas leakage through the seal is developed. A new computing method for determining the contact force between the lip seal and the cylindrical surface of the sleeve or rod taking into account the penetration of gas pressure or lubrication inside the sealed gap is proposed. The theoretical laws of elastic-plastic deformation of fingers of a finger spring are studied; the method for calculating the pressure of the fingers on the wall of the PTFE lip seal is developed. The methods of experimental study of friction and gas leakage through a seal as well as the test results specifying the known dependencies of friction on the sealing pressure and sliding speed of PTFE are presented. New formulas for estimating the friction force in a flexible seal, which can be used at the stage of unit conceptual design, are proposed. The formulas take into account the elastic and plastic properties of PTFE, namely, the Young's modulus and the Brinell hardness number.

Key words: sealing ring, sealing ring elasticity, contact problem, gas leakage, PTFE friction coefficient, finger spring, dry and viscous friction, the friction force in the cuff.