SIMULATION OF COMBINED SCHOTTKY DIODE
p. 3-7
Egor Kiselev

Despite the fact that various designs of Schottky diodes with additional gate were developed and investigated, still little attention has been paid to the simulation of their operation modes at independent change of field electrode potential. The results of two-dimensional physical-topological simulation of combined Schottky diode with electrically separated anode and gate in the computer-aided design system TCAD Studio are given in the paper. Analysis of the obtained results shows that the management effectiveness of combined Schottky diode depends on the voltage value on the additional electrode-gate. The regulation degree of additional diode capacitance, according to the applied model has a value of about 22%. The research results can be used for further optimization of designs of combined Schottky diodes.

Keywords: Schottky diode, current, management, voltage, gate, electron concentration

Средствами системы TCAD Studio рассмотрены статические и динамические характеристики двухмерной конечно – разностной модели комбинированного диода Шоттки. Показано, что эффективность управления диодом зависит от величины напряжения на дополнительном электроде –затворе. Установлено, что степень регулирования дополнительной емкости, согласно модели, имеет значение примерно 22% .

Ключевые слова: диод Шоттки, ток, управление, напряжение, затвор, концентрация электронов

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THE SYSTEM OF DIAGNOSTIC OF A THERMOSTRESSED STATE AND OPERATION OF A RESOURCE FOR A ROTOR OF A HIGH PRESSURE OF TURBINE T-250/300-240 ON STATIONARY AND VARIABLE OPERATING MODES
p. 8-14
Mikola Shulzhenko, Pavlo Gontarowsky,
Jurij Matyukhin, Natalija Garmach,
Volodimir Gontarowsky

The system of diagnostic of a thermal stress state and of a service life wear of turbine T-250/300-240 high pressure rotor from low cycle fatigue and creep under operating conditions the turbine unit on its actual operating mode is presented. These operating modes are defined on technological parameters of automatic control system that does not demand installation on the turbine-driven set of additional thermocouples or other equipment. At an estimation of a thermal stress state and lifetime wear are considered actual start-stopping and replaceable operating modes of the turbine-driven set, including stopping with cooling before repair.

At definition of a damage from low cycle fatigue the elastic-plastic straining of a material in zones of diagnosing of a rotor for a system operating time is considered, and at definition of a damage from creep – time-history of stress, temperature, and also stress relaxation.

The developed system of diagnostic of a thermal stress state and the resource counter has passed check on the thermal power station and can be used for rotors of a high pressure of turbine units T-250/300-240 taking into account features of functioning of their systems of automatic control of technological parameters.

The system allows to detect regimes of the sped up a lifetime wear and to optimize start-stopping and transitive, that improve reliability and profitability of the turbine unit exploitation. The developed technique of diagnosing of a service life wear can be used for creation of similar systems for other steam turbines of power stations.

Keywords: resource, rotor, turbine, low cycle fatigue material creep

Описывается система диагностики термонапряженного состояния и срабатывания ресурса ротора высокого давления турбины Т-250/300-240 от малоцикловой усталости и ползучести в условиях эксплуатации агрегата с использованием архивированных параметров АСУ ТП.

Система позволяет определить наиболее опасные режимы срабатывания ресурса, а также оптимизировать пуско-остановочные и переходные режимы работы, что повышает надежность эксплуатации турбоагрегата. Разработанная технология диагностирования срабатывания ресурса может быть использована для создания подобных систем для других паровых турбин ТЭС и ТЭЦ.

Ключевые слова: ресурс, ротор, турбоагрегат, малоцикловая усталость, ползучесть

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MATHEMATICAL MODELING IN THE PROBLEM OF SELECTING OPTIMAL CONTROL OF OBTAINING ALLOYS FOR MACHINE PARTS IN UNCERTAINTY CONDITIONS

p. 15-23

Dmitry Demin

Relevance of research, results of which are given in the paper concerns the development of methods for estimating the parameters of mathematical models in case they are built on the passive experiment results in conditions of small sample of fuzzy data. The first stage in this process is to develop a fuzzy clustering procedure, which allows to "spread" all experimental points in a multidimensional factor space, having "attributed" them to this or that hypercube top, forming a plan of full factorial experiment to implement the further orthogonalization procedure. The mathematical model of the process is the regression equation in the form of the Kolmogorov-Gabor polynomial, describing the influence of fuzzy input variables, i.e. alloy structure, on its properties. It is so-called "structure - property" model.

As a result of realization of the proposed fuzzy clustering procedure, obligatory before building up the regression equation in case the planning area has an arbitrary shape, cluster, "nearest" to the considered experimental point can be installed and procedure of referring the corresponding point to this or that clustering center can be carried out. The results obtained can be used for the further construction procedure of the regression equation.

The fuzzy clustering algorithm was proposed, and calculation examples of membership functions, used in the implementation of this algorithm were given. Using the proposed procedure is effective in estimating the parameters of mathematical models according to the passive experiment data in conditions of small sample of fuzzy data.

Keywords: mathematical model, fuzzy clustering, passive experiment, uncertainty

Актуальность исследования, результаты которого приводятся в статье, связана с разработкой методов оценивания параметров математических моделей в том случае, если они строятся по результатам пассивного эксперимента в условиях малой выборки нечетких данных. Первым этапом на этом пути является разработка процедуры нечеткой кластеризации, позволяющей «разнести» все экспериментальные точки в многомерном факторном пространстве, «приписав» их к той или иной вершине гиперкуба, формирующего план полного факторного эксперимента для реализации последующей процедуры ортогонализации. Математическая модель процесса представляет собой регрессионное уравнение в виде полинома Колмогорова-Габора, описывающее влияние нечётких входных переменных – состава сплава – на его свойства. Это так называемая модель типа «состав – свойство».

В результате реализации предложенной процедуры нечёткой кластеризации, обязательной перед по-

строением уравнения регрессии в случае, если область планирования имеет произвольную форму, может быть установлен кластер, «ближайший» по отношению к рассматриваемой экспериментальной точке и осуществлена процедура отнесения соответствующей точки к тому или иному центру кластеризации. Полученные при этом результаты могут быть использованы для дальнейшей процедуры построения уравнения регрессии.

Предложен алгоритм нечеткой кластеризации и приведены примеры расчета функций принадлежности, используемых при реализации этого алгоритма. Использование предлагаемой процедуры является эффективным при оценке параметров математических моделей по данным пассивного эксперимента в условиях малой выборки нечетких данных.

Ключевые слова: математическая модель, нечеткая кластеризация, пассивный эксперимент, неопределенность

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FORMAL THEORY MODEL IN THE FORM OF COMMUTATIVE SEMIGROUP OF IMAGE CONSTRUCTIONS

p. 24-30

Oleg Bisikalo, Iryna Kravchuk, Hanna Kyrylenko

The paper deals with the issues of creating the mathematical apparatus for dialogue support with user, based on information generalization of each sentence in the text by the formal concept of linguistic image. Relevance of the research issues is associated with ensuring stepwise finding of the required specialized information during training and professional development of modern engineers within the question-answering systems.

Assuming syntactic relations between all meaningful words of each sentence and linguistic images, corresponding to these words are known, formal first-order theory was pro-

posed. The finite alphabet, procedures for constructing terms as character lines and formulas as admissible expressions of the formal theory \[Th\] were introduced into the theory structure. The axiom schemes such as 3 propositional calculus, 2 first-order predicate calculus, as well as proper axioms \[Th\] such as 6 commutative semi-groups and 4 applied axioms (productions) of the theory were singled out from many formulas. The concept of the term in the associative normal form (ANF) was introduced. Three theorems, allowing to convert any term into the ANF-term and any ANF-term into the question-answering structure of terms, and to present the ANF-term of the answering structure in the form of components (subtrees) from different sentences (trees) were formulated and proved.

The formal theory model \[Th\] was proposed as the commutative semi-group of image constructions; linguistic interpretation and model limitations were considered. Three rules were introduced for easy use of the formal theory model \[Th\] in linguistic applications. The research results allow to provide basic support functions for the dialogue, limited by the linguistic image concept at the formal level.

Keywords: formal theory, commutative semi-group, linguistic image, image construction, dialogue support.

Работа посвящена созданию математического аппарата для поддержки диалога с пользователем на основе обобщения информации предложений текста. Разработана формальная теория первого порядка, предполагающая построение модели в виде коммутативной полугруппы конструкций из языковых образов. На основе 15-ти аксиом сформулированы и доказаны теоремы, позволяющие обеспечить базовые функции поддержки ограниченного понятием языкового образа диалога.

Ключевые слова: формальная теория, коммутативная полугруппа, языковый образ, образная конструкция, поддержка диалога.

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MODEL OF CONTROLLING LATENT FAILURES OF TWO-COMPONENT SYSTEM USING DEACTIVATION OF COMPONENTS

p. 30-36

Yury Obgerin, Elena Boyko

A high quality level of controlling and measuring equipment and its diversity does not solve the problem of early detection of latent failures, which can be recognized only when monitoring. Taking into account the occurrence of latent failures, mathematical models of controlling recoverable systems make the solution to this problem possible.

For developing control models, the approach, based on the theory of semi-Markov processes with a common phase state space, is used in the paper. When working out models, this approach allows getting rid of some limitations, in particular, of the assumption, which concerns an exponential law of distributing random values, characterizing the system. It enables finding the system operation characteristics, which can be used for engineering applications. An effective method of finding the approximate system characteristics of high-dimension models is the method, sharing a common basis with the algorithms of phase enlargement.

The comparative results of exact and approximate values give reason for applying this method in researches regarding multicomponent systems.

Keywords: semi-Markov process, latent failure, steady-state characteristics, two-component system, availability factor.

На базе теории полумарковских процессов с общим фазовым пространством состояний построена математическая модель контроля скрытых отказов двухкомпонентной системы с последовательным соединением компонентов. Применен метод приближенного вычисления характеристик системы, основанный на алго-

ритмах фазового укрупнения. Найдены приближенные и точные значения стационарных характеристик функционирования системы: коэффициента готовности, средней удельной прибыли, средних удельных затрат.

Ключевые слова: полумарковский процесс, скрытый отказ, стационарные характеристик, двухкомпонентная систем, коэффициент готовности.

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STUDY OF THE SURFACE EMISSION CONCENTRATIONS OF INCINERATOR "ENERGY"

p. 37-42

Zoe Bezruk

The problems of the influence of toxic emissions from the incinerator on the environment were considered. The experimental models of the emission distribution were developed. The experimental data of the studies of air pollution, depending on the wind speed, chimney height, flue gas costs, concentration of corresponding gas component in the flue gas are given. Ecological impacts of incinerators are mainly related to air pollution, first of all with fine dust, oxides of carbon, sulfur, nitrogen, hydrocarbons, furans and dioxins. Serious problems also arise from the disposal of incineration ash, which constitutes up to 30 % by weight. To prevent the increase of the air pollution level in weather conditions, poor for hazardous substances dissipation, it is necessary to predict and consider these conditions.

Among the set of source data, the wind speed and specific mass of emissions have the greatest impact on the distribution characteristics, therefore, they were selected as variable parameters in the analysis. The pollutant formation models can be used not only for calculation of surface concentrations of flue gas components, but also for the selection of the optimal chimney height in the plant design. Therefore, atmosphere pollution, depending on the chimney height of the atmosphere polluting object was also studied.

Keywords: emissions, incinerator, flue-gas analysis, gas-analytical complex.

Рассмотрены проблемы влияния токсичных выбросов мусоросжигательного завода на окружающую среду. Разработаны экспериментальные модели распространения выбросов. Приведенные экспериментальные данные исследований загрязнения атмосферы в зависимости от скорости ветра, высоты дымовой трубы, расходов дымового газа, концентрации соответствующего газового компонента в дымовом газе.

Разработанные модели образования загрязняющих веществ можно использовать для выбора оптимальной высоты трубы при проектировании завода.

Ключевые слова: выбросы, мусоросжигательный завод, анализ состава дымовых газов, газоаналитический комплекс.

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STRUCTURAL ESTIMATION OF CRACK RESISTANCE OF WELDED JOINTS OF HIGH STRENGTH STEELS

p. 43-47
Olena Berdnikova

The results of studies of structure and phase composition formation features of welded joints of high-strength steel14HGN2MDAFB with the yield strength $\sigma_{0,2} > 700$MPa are given in the paper. Based on experimental data of optical scanning microscopy it was shown that the structure, formed in various zones of welded joints in terms of uniform change (without gradients) of structural parameters and microhardness should provide a uniform level of mechanical properties and crack resistance of welded joints.

Using analytical estimates for hardening in the high-strength steel welding zone, hardening effect of the structure (grain, subgrain, particles of carbide phases), which is connected with the contribution of grain boundary, substructural and precipitation hardening due to dispersion of structural components was established.

Computational estimation methods of crack-inducing stress in the zones of stress concentrators, based on experimental data of the quantitative fractographic analysis (with the account of destruction type) showed that in structural volumes of intragranular cleavage microcrack-inducing stress is ~ 70 ... 120 MPa (at T=-40^{o}C) that determines the catastrophic crack growth and crack resistance decrease, respectively.

Keywords: welded joints, high-strength steel, structure, phase composition, destruction, crack resistance.

Представлены результаты исследований особенностей формирования структуры и фазового состава сварных соединений высокопрочной стали 14ХГН2МДАФБ с пределом текучести $\sigma_{0,2} > 700$МПа. Показано, что структура, формирующаяся в различных зонах сварных соединений с точки зрения равномерного изменения (без градиентов) структурных параметров и микротвердости должна обеспечивать равномерный уровень механических свойств и трещиностойкость сварных соединений.

Ключевые слова: сварные соединения, высокопрочная сталь, структура, фазовый состав, разрушение, трещиностойкость.

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SURFACE MICROHARDNESS OF STAINLESS STEEL, MODIFIED BY IONIC IMPLANTATION

p. 47-51
Vitaliy Honcharov

The importance of the problem of applied systems synthesis with active components was established. Based on the analysis of literary sources, the optimal processing technology of the stainless steel carrier was chosen. The objective of this paper was formulated, and the task of

investigating the mechanical properties of steel-based systems was set. The techniques of obtaining and studying samples were considered. The samples were synthesized by implanting ions of nitrogen, chromium, aluminum, titanium, molybdenum on the stainless steel. The study of microhardness and ductility of the obtained samples was conducted by the scratching method. It was shown that ion implantation as the processing technology significantly improves mechanical characteristics of the initial carrier − stainless foil. Microhardness of samples is increased (except the implant with chromium), and ductility is slightly reduced. The prospects of applying the obtained composites as working elements of catalysts, heating and electrical equipment, etc., were shown.

Keywords: ion implantation, catalyst, microhardness, ductility.

Исследованы микротвердость и пластичность образцов на основе нержавеющей стали, обработанных с помощью имплантации ионов азота, хрома, алюминия, титана и молибдена. Показана перспективность применения полученных имплантатов в условиях механического нагружения.

Ключевые слова: ионная имплантация, катализатор, микротвердость, пластичность.

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THERMAL DEFORMATION OF IRON-CARBON ALLOYS AND ITS INFLUENCE ON THE DIAGRAMME OF FE-C STATE

p. 51-55

Nikolay Bereznoy, Viktoria Chubenko, Alla Hinotskaya, Sergey Matsishyn

Generalization of the results of theoretical and experimental studies of thermal expansion of iron-carbon alloys at heating to the melting temperature was conducted. The temperature dependences of specific volume and density of iron-carbon alloys were defined. The dependences between specific volume and lattice parameter were revealed. Temperature dependences of specific volume and density of steel and iron lattice parameter were corrected and complemented.

Using formulas, such concepts as dependence of linear and volumetric expansion values at heating steel bodies on the temperature, linear expansion coefficient for steel products, relative deformation, volumetric expansion of steel and insulated bodies, were described.

Graphs of the following dependencies: dependence of linear and volumetric expansion coefficients and linear and volumetric steel deformation relatives on the temperature, temperature dependences of the specific volume and density, dependences of specific volume and lattice parameter of iron modifications (α-, γ-, δ-Fe) on the temperature, dependences of specific iron volume on lattice parameters for different modifications, dependences of austenite lattice parameter on the carbon content and temperature were constructed.

Keywords: research, expansion, heating, alloy, iron, carbon, melting temperature, specific volume, density, lattice parameter.

Сделано обобщение результатов теоретических и экспериментальных исследований теплового расширения сплавов железа с углеродом при нагревании до температуры плавления. Определены температурные зависимости удельного объема и плотности железоуглеродистых сплавов. Установлены зависимости между удельным объемом и параметром кристаллической решетки. Исправлены и дополнены температурные зависимости удельного объема и плотности стали и параметр кристаллической решетки железа.

Ключевые слова: исследование, расширение, нагревание, сплав, железо, углерод, температура плавления, удельный объем

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REGULATORY PROVISION OF CREEP DEFINITION OF CONTINUOUS CAST BILLETS FROM COPPER ALLOYS

p. 56-61

Oleg Khoroshilov, Anna Pavlova

The definition of coefficients for calculating the damageability parameter of billets from copper alloys using the Bailey-Norton and Rabotnov-Kachanov equitations on the basis of experimental data of billet creep in the temperature range of its viscous area, that is at 0.90...0.95 from liquidus temperature was considered. The experimental data were obtained on the AIMA 5-2 machine on the condition of its design improvement and testing method development. This allowed to determine the creep at the viscous area temperature of the billet from copper alloys at increasing the creep rate up to 1650...2500 times. The developed method for samples creep testing in the temperature range of the viscous area is protected by the patent of Ukraine №15924. The improved design of the AIMA 5-2 machine is protected by the patent of Ukraine №17741. As a result, the regulatory provision of the billet creep definition was developed in the form of the methods for carrying out tests on the improved AIMA 5-2 machine and the method for calculating damageability parameter of billets from copper alloys using the Bailey-Norton and Rabotnov-Kachanov equitations.

Keywords: regulatory provision, billet crystallization interval, creep, long-term strength.

Предлагается в качестве параметра обеспечения качества непрерывнолитых полых заготовок из медных

сплавов рассматривать стабильность процесса литья. Определено условие стабильности процесса непрерывного литья и усовершенствована конструкция дорна путем выполнения срезов на его рабочей поверхности. Приведены рекомендации по обеспечению качества полых непрерывнолитых заготовок из медных сплавов с внутренним диаметром 0,05…0,15м.

Ключевые слова: обеспечение качества, полые заготовки, технологический процесс непрерывного литья, стабильность процесса.

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QUALITY IMPROVEMENT OF DISASSEMBLY OF MULTICOMPONENT JOINTS USING THERMAL ACTION

p. 61-65

Sergey Romanov, Anna Lagoda

Disassembly of interference joints or smelting of fusible fillers differ by the process non-stationarity since there are periodic thermal changes of elements along with real transformations. To ensure minimum energy consumption and maximum system efficiency thermal action should be fast and targeted, i.e. it is necessary to heat only those sections of the female part of joint, expansion of which will provide the expansion gap, required for disassembly, or the body section, which contains fusible filler, subject to smelting in the shortest period of time. Induction method of heating the female part of the joint or ferromagnetic container with fusible filler meets these criteria. The mathematical model of non-stationary thermal process, which is the system of second-order differential equations of variable structure depending on the temperature of elements of multicomponent joints is proposed in the paper. The model can be used both for heating control in the filler smelting processes and for heating control in the thermal disassembly of multielement interference joints. Using this model will allow greatly minimize energy consumption during the disassembly of multicomponent joints.

Keywords: disassembly of joints, induction heating, non-stationary thermal process, mathematical model.

Разработана математическая модель нестационарного теплового процесса, которая представляет собой систему дифференциальных уравнений второго порядка переменной структуры в зависимости от температуры элементов многокомпонентных соединений. Модель может быть использована как для управления нагревом в процессах выплавки наполнителей, так и для управления нагревом при тепловой разборке многоэлементных соединений с натягом.

Ключевые слова: разборка соединений, индукционный нагрев, нестационарный тепловой процесс, математическая модель.

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STUDYING PROCESSES OF PRODUCING OPTICAL ELEMENTS FROM ACOUSTO-OPTIC SINGLE CRYSTALS

p. 66-70

Larysa Prots

The research concerns the technology of an abrasive mechanical processing of workpiece surfaces and can be used in various industries where optical details, particularly, operating components of acousto-optic tools made of paratellurite single crystals, are manufactured. As a result of conducted studies aimed at improving technologies of a mechanical treatment, reducing labor intensity and increasing labor productivity, a special processing method has been developed and applied. The method implies using a specific circuit of the body of a mechanical processing tool. The tool consists of a specially designed cylinder-shaped instrument and a holder of an optical element under processing. Applying the proposed method of an abrasive mechanical processing has resulted in reducing labour intensity of polishing and cleaning processes by providing automation. It has been found that after starting the tool with the suggested operation circuit, the interference of optical elements of quantum devices has been decreased significantly and, virtually, has been reduced to monitoring the tool operation that, as is known, leads to an increase of labor productivity.

Keywords: mechanical processing (mechanical treatment), paratellurite single crystal, acousto-optic tools, operating component, optical detail.

Представленная робота относиться к технологии механической обработки поверхностей деталей и может быть использована в различных отраслях промышленности при изготовлении оптических деталей, в частности, рабочих элементов акустооптических устройств из монокристаллов парателлурита. В результате проведения исследований процессов механической обработки при изготовлении оптических элементов уменьшена трудоемкость и увеличена производительность за счет обеспечения автоматизации.

Ключевые слова: механическая обработка, монокристалл парателлурита, акустооптические устройства, рабочий элемент, оптическая деталь.

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