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USSR Report

ENGINEERING AND EQUIPMENT

(FOUO 2/82)

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AERONAUTICAL AND SPACE

UDC 629.735.45 (07)

PRACTICAL AERODYNAMICS OF HELICOPTERS

Moscow PRAKTICHESKAYA AERODINAMIKA VERTOLETOV in Russian 1980 (signed to press 16 Oct 79) pp 2, 282-384

[Annotation and table of contents from book "Practical Aerodynamics of Helicopters", by Vyacheslav Fedorovich Romasevich and German Alekseyevich Samoylov, Voyenizdat, 13,000 copies, 384 pages]

[Text] Annotation

The book considers the aerodynamic characteristics, special features of helicopter design, stability and controllability, as well as the maneuvering and piloting properties, and special features of helicopter behavior and the technique of piloting for various modes of flying and maneuvers.

The book is intended for flying personnel of VVS [Military Aerial Forces], PVO [Antiaircraft Defense] and VMF [Military Marine Fleet]. It may be recommended to students in military aviation schools and flying personnel of the Ministry of Civil Aviation.

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'DOCK-SHIP' TRANSFER SYSTEM

Moscow SISTEMA PEREDATOCHNYY "DOK-SUDNO" in Russian 1981 (signed to press 29 Dec 80) pp 2-4, 128-129

[Annotation, foreword, table of contents from book "'Dock-ship' Transfer System", by Vitaliy Antonovich Topchiy, Izdatel'stvo "Sudostroyeniye", 800 copies, 129 pages]

[Text] Annotation

Launching ships by using transfer (launching) docks is related to solving the problem of launching safety, the strength of the ship, the dock and movable components of the launching devices. Calculations of the strength of the transfer dock-ship system differ considerably from those made for raising the ship to a floating dock; launching from a sloped longitudinal building slip etc.

The book gives the general characteristics of dock-ship system components at all stages of launching. Theoretical bases are given for calculating the strengths of the components of this system (by the finite element, Ritz and Kordyumov methods). Use of the finite element method to solve the static indeterminacy of the dock-ship transfer system is illustrated by examples.

The book is intended for design engineers and planners of shipbuilding enterprises, and it may be useful to students of shipbuilding vuz and vuz departments.

Foreword

Launching medium water displacement ships from building slips by floating repair docks or from transfer (launching) docks especially made for this purpose is widely used in domestic and foreign shipbuilding. At present, domestic design organizations and shipbuilding enterprises have a considerable amount of experience in designing and operating launching complexes with transfer docks which makes it possible to achieve all the advantages of their use and to determine the best methods and facilities for safe launching.

Information on the indicated experience in scientific-technical literature, in particular, that obtained in recent years, cannot be considered sufficient. In a number of fundamental papers, devoted to ship launching, special features of launching complexes with transfer docks are considered in the design aspect, or

mentioned only in general terms which may be due to the trend toward specific topics in the papers, as well as the position occupied until recently by the use of transfer docks and a number of other methods for launching ships. In periodicals devoted to launching ships, there is very little information on problems and methods for insuring the strength of the ships, the transfer dock and other components of the complex with this type of launching. This paper presents methods for calculating the transfer dock-ship system and gives a number of recommendations on implemnting practical calculations on the strength of this system's components with aim of filling the above-mentioned blanks to a certain degree.

The design features of launching complexes with transfer docks (number and rigidity of the dock supports, presence and type of hydraulic system of the ship-carrying train etc.), the essential changes in the process of launching, external forces and the interaction conditions between the dock and ship predetermine the necessity of considering several calculation arrangements of the transfer dock-ship system which leads to the necessity of using various methods within one calculation; for example, at the basis of which lie power methods, reduction of the problem to calculating beams on an elastic base and other methods using similar problems (raising the ship to a dock, launching from a longitudinal building slip etc.)for the solution. This circumstance, along with the necessity of making a series of calculations even within the limits of one launching period, determined the selection of the finite element method, one of the most perfect and universal methods for calculating complex ship designs, as the basic method, devoid of the above-mentioned inconvenience.

This paper provides a minimum amount of data on this method needed for practical calculations of rod structures which represent the transfer dock-ship system, and recommendations are given for the preparation of initial data, decoding the calculation results according to programs prepared for the "Minsk-32" computer.

Making approximate calculations of the transfer dock-ship system may be useful and efficient at the initial stages of the launch at the launch complex of the enterprise. Methods of these calculations presented in this book make it possible to obtain relatively simply and quickly the necessary data for the special features of operation of the launching system at various stages.

The author expresses his gratitude to staff workers of the "Construction Mechanics Department of the Komsomol'sk-on-Amur" Polytechnical Institute, V. D. Zhestkaya and N. A. Taranukha, who made a series of calculations, the results of which were used in the book.

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UNMANNED FREE SUBMERSIBLES

Leningrad AVTOMATICHESKIYE PODVODNYYE APPARATY in Russian 1981 (signed to press 10 Feb 81) pp 5-6, 219-221

[Annotation, authors' preface and table of contents from book "Unmanned Free Submersibles", by Mikhail Dmitriyevich Ageyev, Boris Anatol'yevich Kasatkin, Lev Vladimirovich Kiselev, Yuriy Gennad'yevich Molokov, Vladimir Vasil'yevich Nikiforov and Nikolay Ivanovich Rylov, Izdatel'stvo "Sudostroyeniye", 3100 copies, 224 pages]

[Text] An examination is made of planning and design of free submersibles, motion control in hydrophysical measurements in a water stratum, exploration of bays and searching for sunken objects under conditions of complicated bottom relief. The authors show the functional makeup and structure of control systems, methods of navigation and makeup of navigational exploration equipment.

Information is given on the shipboard complex and marine equipment for data processing. Development of the Skat unmanned free submersible is summarized, and an analysis is made of a number of original problems that must be solved in designing submersibles.

The book is intended for specialists engaged in developing free submersibles and their systems.

Authors' Preface

The field of submersibles had its inception comparatively recently, and is currently going through a developmental stage. Submersibles that have been developed in the past are quite diversified. Some of them have become widely known, and development on them is continuing. In addition to vehicles for which, figuratively speaking, "the principal source of information is the headlight", more and more recognition is being given to unmanned submersibles, or underwater robots as they are often called. This is no accident; unmanned submersibles have many advantages that have been proved in practice, and present-day advances in technology, especially in electronics, as well as the new research methods that they have engendered, are a good basis for their further development.

Judging from the persistent but isolated reports of the survey information press, such vehicles are being intensively developed and used outside the Soviet Union in a wide range of underwater work.

Among unmanned submersibles, an important part is played by self-contained, self-propelled vehicles with programmed control that are automatic facilities for studying the ocean.

Two principal distinguishing features characterize unmanned submersibles: absence of a connecting cable to the surface vessel, and small overall dimensions. In themselves, these features are not yet advantages, but they can be turned into advantages if the "brain" concentrated in the small space of the vehicle iw equipped with such functions as would to some extent compensate for the absence of a connecting cable.

During operation, the automatic submersible has limited capabilities for human communications, and therefore it must carry a set of devices that ensure normal operation, accumulation of information, and self-preservation in extreme situations. This complex must include:

information-measurement devices (including navigational) that form a representation of the ambient environment and state of the vehicle;

a control system that perceives and processes information and transmits control commands;

actuating devices that realize the commands of the control system;

facilities for at least intermittent human communication (input-output and communication devices).

With respect to their properties, unmanned vehicles can be classified as underwater information robots that comprise a separate class of submersible robotic systems. This circumstance, which is substantiated from general procedural principles in the book by V. S. Yastrebov et al., "Podvodnyye roboty" [Underwater Robots], Leningrad, Sudostroyeniye, 1977, is of great importance for consideration of fundamental problems of designing both the autonomous systems and the vehicle as a whole.

Experience in development of automatic vehicles is still rather sparse; many of their capabilities are so far not being used to solve urgent problems of investigation of the ocean. Automatic vehicles that belong to the first generation of robots are functionally simple, their actions can be rigidly programmed. However, even such devices that are unperfected in many respects can be successfully used in many underwater jobs. Recently the idea has been formulated and implemented of changing to multipurpose vehicles with adaptive behavior, the control structure and design confirming to unified requirements that ensure the most efficient operation when there is a change in the external conditions and internal state of a vehicle. In our opinion, the time has come to generalize available knowledge and experience in the development of unmanned free submersibles. That is the idea behind this book.

The initial material for the book has mainly been results of research on the Skat and Skat-geo vehicles done at the Institute of Automation and Control Processes of the Far Eastern Science Center of the USSR Academy of Sciences, as well as certain ideas aimed at further improvement of these vehicles.

Collectives of two laboratories at the Institute took part in developing the vehicles: the laboratory of underwater vehicle systems, and the laboratory of navigation and control systems. The authors thank workers at these laboratories, as well as all who helped make this book possible.

This is a multiplan book, since the problems involved in developing automatic vehicles are also multiplan. In addition, some of these problems are characterized by unconventional formulation of goals and so far do not have final solutions. This has obviously had its effect on the content of the book, and is responsible for some of its shortcomings. The greatest claims may be brought against the style of exposition of individual chapters, which are wirtten in "different languages" due to the very diverse nature in a physical sense of the problems that are considered. For example, the second chapter, which deals with general principles of constructing vehicle control systems, is written in the language of computer technology with its attendant terminology. The third to fifth chapters examine problems on motion control and navigation, using mathematical methods of the theory of regulation and random processes. The sixth chapter gives a rather detailed description of the design of the Skat vehicle (this chapter is somewhat reminiscent of an engineering description).

The book does not reflect all aspects of development of unmanned submersibles, but only those that have seemed to us to be the most important, and to which the literature has given little attention. For example, no consideration has been given at all to ensuring strength of hulls of deep-water vehicles, hydrodynamics, power engineering, manufacturing technology and so on. For all these questions, the reader can address himself to known works, in particular to the monograph "Proyektirovaniye podvodnykh apparatov" [Design of Submersibles] by A. N. Dmitriyev (Leningrad, Sudostroyeniye, 1978), that has become a reference on the subject.

The authors thank the reviewers, Professor, Doctor of Technical Sciences V. S. Yastrebov and Professor, Doctor of Technical Sciences I. B. Ikonnikov, who made some valuable comments on improving the manuscript. The authors are especially grateful to Candidate of Technical Sciences G. K. Krylov, who did considerable scientific editing of the work.

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NUCLEAR ENERGY

UDC 621.039.548

DESIGN AND TESTS OF THERMAL EMISSION FUEL ELEMENTS

Moscow PROYEKTIROVANIYE I ISPYTANIYA TERMOEMISSIONNYKH TVELOV in Russian 1981 (signed to press 2 Dec 80) pp 2, 4-5, 96

[Annotation, introduction and table of contents from book "Design and Tests of Thermal Emission Fuel Elements", by Vladimir Ivanovich Berzhatyy, Vladimir Aleksandrovich Mayevskiy, Viktor Vasil'yevich Sinyavskiy and Valeriy Geront'yevich Petrovskiy, Atomizdat, 980 copies, 96 pages]

[Text] Annotation

The book considers engineering aspects of creating power generating channels (EGK) of the basic unit of the thermoemission reactor-generator. Basic attention is given to the design and technology of manufacture of the EGK and the loop channel, optimization of geometry and calculation of the EGK and loop channels, reactor loop installation, methods for carrying out all tests and investigation stages, the analysis of test results and causes of characteristic changes and failures.

The book is intended for engineers and staff personnel working in the area of direct conversion of energy and nuclear power. It will be useful to instructors and students of engineering-physical and power vuz.

Two tables. Fifty-one illustrations. Bibliography contains 91 titles.

Introduction

The last several decades were characterized by intensive investigations and the practical implementation of new electric power sources based on direct (without machines) conversion of thermal to electrical energy.

Thermoemission power installations have certain advantages, especially if they are used as independent sources of electrical power higher than several kilowatts. These advantages are mainly simplicity of energy conversion and the possibility of operating the power installation at high operating temperatures and at the high bottom temperature of the thermodynamic cycle, which is a necessary condition for operating space power installations where expendable heat of the thermodynamic cycle may be removed only by radiation [1].

Various types of thermoemission power installations are being considered: sclar and isotopic (low power [2]), and high temperature superstructures added to the usual electric power plants and AES which make it possible to increase plant efficiency to 50% [1-3]. However, the advantages of thermoemission conversion (TEP) are demonstrated to the greatest degree when they are located directly in the core the nuclear fission reactor, for which purpose the TEP are combined with the fuel elements into a single thermoemission fuel element. In the USSR, such a thermoemission fuel element is more frequently called an electrogenerating channel (EGK), while single, series connected TEP are called electrogenerating elements (EGE). A reactor core assembled from such EGK together with regulating devices and a system for assuring the composition of the interelectrode medium and heat removal forms a thermoemission reactor-converter (reactor-generator) in which not only heat is generated, but the entire cycle of converting the heat energy liberated, as a result of nuclear fission of uranium into electrical energy, is implemented. Practical steps on creating power installations of such a type were initiated by and, under the direction of I.I. Bondarenko, culminated in successful tests, in the USSR, of the "Topaz," the first reactor-converter [4, 5] in the world.

One basic problem in creating such an installation is the development of an efficient and reliable EGK [6]. Since it is impossible, under laboratory conditions, to provide actual conditions for operating multielement EGK, the main stage of their development became the loop test of EGK in research reactors where all specific problems related to the creation of a long-term operating EGK are studied, including the stability and reproducibility of the power characteristics, state of the electrode surface, strength of the electrical insulation etc.

EGK reactor tests, in their turn, required solutions of a number of additional problems in connection with making these tests, such as: developing a loop channel for EGK tests [1, 4-6], creating universal reactor loop installations with gas-vacuum, thermal and electric systems and, in a number of cases, also modernizing the core of research reactors [7], developing methods for making prereactor, reactor and postreactor tests, as well as methods for monitoring and diagnostics of EGK and the loop channel systems. The solution of the indicated problems is comparable in its complexity to the creation of the thermoemission reactor-converter itself.

Several monographs [8-10] as well as textbooks [2,1] and popular publications were published in the USSR on problems related to thermoemission energy conversion. However, all these papers were devoted to the basic study of the thermoemission converter as a laboratory device and they, with the exception of papers [1,2], practically do not touch on the engineering aspects of creating thermoemission power installations. There is no information in these papers on experimental finishing-off of the EGK, including design, calculation and methods for testing the thermoemission of loop channels and the systematized analysis of obtained results; such information is contained only in individual uncoordinated articles and inaccessible reports of various research organizations.

With this book, the authors are attempting, even though partially, to make up for the existing deficiency.

Basically, the book describes results obtained by the authors themselves; however, published materials of other authors, which could be expounded upon from the same positions, were utilized.

The limited size of the book made it impossible to include a number of sections, for example, on technical diagnostics, automation of the loop experiment etc., which will be systematized in the book, "Principles of Engineering Diagnostics of Thermoemission Fuel Elements." The authors intend to write this book in the very near future and it will be a logical continuation of this book.

Since the thermoemission method has recently become a subject of broad investigation, it still has no set terminology in this area; however, in writing about this material , the authors attempted to follow recommendations in the handbook "Thermoemission Conversion of Energy" (Moscow, 1971), prepared by the International Communications Group on TEP.

All criticism with regard to the stated material, style of presentation and the cited results will be gratefully received by the authors.

The authors express their gratitude to Ye. M. Strel'nitskaya for her help in shaping the manuscript.

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NEUTRON RADIATION OF SPENT URANIUM-THORIUM FUEL

Moscow ATOMNAYA ENERGIYA in Russian Vol 51, No 2, Aug 81
(manuscript received 23 Jun 80) pp 125-126

[Article by N. S. Shimanskaya]

[Text] Considerable interest has recently been manifested in the thorium fuel cycle. The use of thorium in high-temperature and other power reactors is attractive primarily from the viewpoint of long-term support of nuclear power engineering with relatively inexpensive fuel. Moreover, U-233 is accumulated in the fuel in this case, which can be used along with U-235 and Pu-239 as the fissionable component after regeneration. Economic estimates also indicate the prospects of the thorium cycle [1].

One of the complicating factors upon regeneration of spent uranium-thorium fuel and subsequent use of the produced regenerate may be the high level of hard γ-radiation caused by accumulation of U-232 and its decay products [2]. From the viewpoint of predicting the expected radiation situation, it is of interest to also have available data on the neutron radiation of this fuel--its intensity and energy spectrum. So far as we know, there are not yet any corresponding experimental data.

Yield of Neutron Radiation of Spent (UO_2-ThO_2)-Fuel With Different Burnup and Different Cooling Time After Unloading From the Reactor, 10^3 Neutrons/s·kg U-Th

(1) Выгорание, fifa	$t_{выд}$, год (2)					
	0	1	2	3	5	10
0,3	0,505	0,453	0,442	0,439	0,437	0,433
0,5	1,22	1,11	1,10	1,09	1,09	1,09
0,8	10,6	8,47	7,90	7,67	7,36	6,73
1,0	25,4	21,0	19,7[illegible]	19,0	18,1	16,2

Key:
1. Burnup, fifa
2. t_{vyd}, years

An attempt was made in this paper to obtain the required estimates by calculation for the initial stage of the thorium cycle when the accrued operating time of the U-233 occurs in uranium-thorium fuel. The results of quantitative analysis of irradiated spherical fuel elements of type AVR were used in this case [3]. The initial Th-232, U-235 and U-238 content in the fuel element was 81.9, 16.8 and 1.3 percent, respectively. The extent of fuel burnup varied from 0.29 to 1.02 fifa.* The Th-232, Pa-231, U-232-236 and U-238, Np-237, Pu-238-242, Am-241, Am-243 and Cm-242 and Cm-244 content was determined upon analysis.

The yield of neutron radiation and its energy spectrum were calculated similar to how this was done in [4, 5] for spent UO_2-fuel. Based on interpolation of the values of the individual nuclide content for four selected burnup values w (w = 0.3, 0.5, 0.8 and 1.0 percent fifa), the partial yields of spontaneous fission neutrons and neutrons of the (αn)-reaction in oxygen were determined. The values of the total neutron yield Y_n are given in the table. Curves that characterize the ratio of contributions of the most important neutron emitters for (UO_2-Th_2)-fuel with burnup of 0.5 and 1.0 fifa and variation of these contributions as the cooling after irradiation increases are presented in Figure 1.

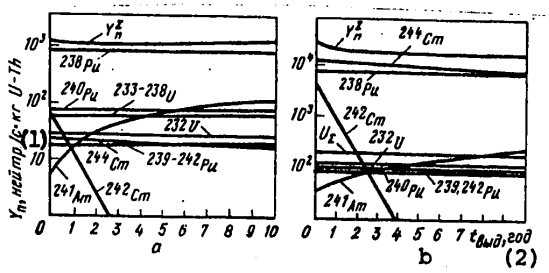

Figure 1. Partial Contributions of Individual Nuclides to Neutron Yield of Spent (UO_2-ThO_2)-Fuel with Burnup of 0.5 (a) and 1.0 fifa (b) and Their Dependence on Cooling Time After Irradiation. The initial mass composition of the fuel was 81.9 percent Th-232, 16.8 percent U-235 and 1.3 percent U-238

Key:
1. Neutrons/s·kg U-Th
2. t_{vyd}, years

An increase of Y_n with burnup for freshly unloaded fuel (t_{vyd} = 0) corresponds to the function $Y_n \approx w^{3.3}$, which essentially coincides with the function found for uranium fuel [4]. The exponent for cooled fuel is somewhat less and varies in the range of 3.3-3.0 for cooling of 0-10 years.

With burnup up to 0.6 fifa, the determining factor is the contribution of Pu-238 and the neutron radiation of Cm-244 begins to predominate gradually with high

*Ratio of the total number of fissions in the fuel to the initial number of fissionable nuclei (editor's note).

burnup. The partial yields of individual nuclides for uranium-thorium and uranium fuel at similar values of burnup differ very strongly. The total yield of neutrons Y_n also differs by approximately two orders. It is obvious that this is explained by the different initial composition of the fuel, primarily by different percentage content of U-235 and U-238 in it. The fraction of U-238 is approximately 97 percent in the VVER [water-moderated, water-cooled power reactor] fuel and this value is approximately one-half as much for AVR fuel. The contribution of reactors in U-235 that lead to formation of Pu-238 is accordingly considerably greater in AVR fuel and the neutron radiation of Cm-244 begins to dominate only with high burnup and the relative constribution of Pu-238 neutrons decreases. The thorium itself and the nuclides formed during its irradiation in a reactor do not produce significant neutron radiation. The partial neutron yields of U-232 and U-233 with burnup of 0.8-1.0 fifa do not exceed 1 percent of the total yield Y_n. Accumulation of nuclides of the U-232 decay chain increases slightly--by 3-5 percent--with the same burnup Y_n.

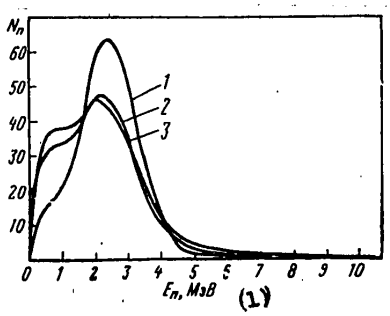

Figure 2. Energy Spectra of Neutron Radiation of Spent (UO_2-ThO_2)-Fuel With Burnup of 0.5 (1), 1.0 (2) and 1.0 (3) fifa and $\bar{E}_n$ = 2.35, 2.17 and 2.21 MeV, respectively. For curve 3, t_{vyd} = 10 years

Key:
1. MeV

The initial content of U-235 and U-238 will determine the neutron radiation intensity of spent uranium-thorium fuel even in the case of a closed thorium cycle. Thus, according to our estimates one can expect that the neutron yield at $t_{vykh} = 0$ will comprise approximately $9.4 \cdot 10^3$ neutrons/s·kg of U-Th for fuel with initial ratio of Th-232: U-233: U-235: U-238 = 92.4: 2.4: 4.7: 0.5 [6] and burnup of approximately 1.0 fifa for the eqilibrium cycle of the htgr reactor in which regenerated uranium and U-235 make-up are used. The presence of U-233 in the fuel and the accumulation of U-232 with repeat utilization of uranium regenerate in the reactor have essentially no effect on the neutron radiation intensity of the spent fuel.

Calculations showed that the energy spectra of neutrons also vary considerably with an increase of burnup (Figure 2). The energy spectrum of neutron radiation of UO_2-ThO_2 fuel varies appreciably even after it is unloaded from the reactor. The relative contribution of neutrons of (αn)-reactions increases over time and the hardness of the spectrum increases. We recall that the neutron spectrum of uranium fuel of power reactors, on the contrary, softens as cooling time increases [5].

The use of uranium and thorium carbides in the thorium cycle instead of uranium and thorium oxides should not result in appreciable variation of the level of neutron radiation of the fuel since the yield of (αn)-reactions on thick targets of UC and UO_2 differs by no more than 30-50 percent at E_α = 5.0-6.5 MeV [7, 8].

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REGULATING ENERGY DISTRIBUTION OF REACTOR IN SECOND UNIT OF BELOYARSKAYA ATOMIC POWER STATION

Moscow ATOMNAYA ENERGIYA in Russian Vol 51, No 2, Aug 81
(manuscript received 7 Jul 80) pp 91-95

[Article by O. L. Bozhenkov, V. G. Dunayev, N. A. Kuznetsov, I. A. Luk'yanets, V. V. Mal'tsev, P. T. Potapenko, V. N. Sarylov, E. I. Snitko, Ye. V. Filipchuk and A. G. Sheynkman]

[Text] Operation of AMB reactors of the Beloyarskaya AES imeni I. V. Kurchatov (BAES) demonstrated the economic effectiveness of nuclear superheating of steam that has now achieved further development in the project of the RBM-KP [1]. Equalized energy distribution and optimum ratio of outputs for production and superheating of steam in the thermal balance must be maintained in the core when operating power reactors of the given type. Therefore, the experience of solving these problems with respect to the existing reactors of the BAES is also useful when working out effective control algorithms for the RBM-KP.

An algorithm for controlling the positions of the control rods (RS) at steady power levels for the AMB-200 reactor has now been proposed which ensures the best equalization of energy distribution in the sense of the selected entire function with a given set of production restrictions.

Postulation of the problem. Charging of the AMB-200 includes 998 production channels (TK): 732 evaporative channels (IK) and 266 superheating channels (PK) and the latter are located in the center of the core, alternating rows with the IK. A total of 78 control rods is also located in the reactor core.

Controlling the operation of the reactor requires that a strictly specific ratio of output of the superheating and evaporative circuits be provided ($\pi = N_{PK}/N_{IK} = \text{const}$) and that the energy distribution $Q(r)$ equal throughout the core radius be maintained [2]. This is achieved in practice by physical profiling: by a corresponding arrangement of the TK with different uranium and RS enrichment and also by profiling the fuel burnup through the reactor radius. The core is conditionally divided according to the arrangement of the TK into four concentric zones characterized by given mean values of the neutron multiplication factor $k^0_{\omega i}$ for physical calculations.

Under operating conditions, TK recharging and uranium burnup are selected so that the mean values of $k_{\omega i}$ in each isolated region correspond to the given values at

the end of the operating interval (prior to fuel recharging). An attempt is made to maintain deviation of the mean values of the multiplication factor from the given values [$\Delta k_{\infty i} = k_{\infty i} - k\&_i$ ($i = 1, \ldots, 4$)] at a minimum level corresponding to redistribution of the submerged length of the control rod during the period between recharging [2]. Performing this operation in practice is related to the need for operational analysis of a large volume of information that characterizes the actual state of the reactor. To eliminate possible erroneous actions of the operator and to increase the reliability and quality of control at this level, a computer can be used, allocating to it the function of advisor to operational personnel in optimum management of the production process.

According to regulations for reactor operation, the goal of control can be reduced to minimizing the components of vector $\Delta Q(r) = Q(r) - Q^0(r)$ that characterizes deviation of the actual energy distribution $Q(r)$ from energy distribution $Q^0(r)$, clearly determined by the given distribution of the multiplication factor $k_\infty^Q(r)$. The validity of this approach follows from the fact that the coefficient of nonuniform energy distribution assumes a minimum value for a given length of the operating interval of a reactor between recharges of the TK and for a system of conditions that determine its completion (average burnup of unloaded fuel and retention of criticality at full power with equilibrium xenon content when all the control rods are removed from the core), if the energy distribution remains constant from the beginning to end of the operating cycle [3].

Reliable heat dissipation from the core that guarantees the absence of emergencies due to deterioration of heat transfer must be provided during operation of a reactor at power close to maximum. For example, the temperature of the fuel element jackets must not exceed the maximum permissible value [4]. Therefore, the following production restrictions are introduced in AMB reactors by the temperature of superheating steam at the output from them for PK and by the margin to maximum output for IK. Taking this into account, the problem of controlling a reactor in which the best equilization of energy distribution is achieved during the entire interval between recharges can finally be formulated as one of finding the components of the control vector (movements of the control rods) that provide the best approximation to energy distribution $Q^0(r)$ while conforming to production restrictions.

Mathematical model of the reactor. The specifics of the problem of stabilizing steady energy distribution permits one to use linearized equations with respect to slight deviations (perturbations) from steady values of parameters when constructing the mathematical model of a reactor. In this case the reactor can be regarded as a control object in combination with the integral regulator of total output. Its mathematical model can then be represented in the form of a static transfer matrix found on the basis of experimental data [5].

Workers of NPO [Scientific production association] Energiya, A. Anikin and A. Oveshkov, determined in November 1977 on the reactor of the second unit of the BAES how the control rods influence the energy distribution and steam temperature at the output from the PK by moving individual control rods and by recording the established values of DPZ currents and steam temperature corresponding to these movements. The results of these experiments were used by them in constructing the

mathematical model of a reactor on the basis of physical calculation for the problem of optimization of energy distribution.

A different approach, the basis of which is the harmonic model of the neutron field of a reactor, was used in this paper to describe a reactor as a control object. The most typical spatial harmonics of the neutron field excited during movement of the control rods had to be determined to work out this model. For this purpose, the authors of this paper carried out experiments in October 1978 on the AMB-200, during which they recorded the readings of the DEZ and thermocouples at the output of the PK when individual control rods and groups of control rods (from two to four rods simultaneously) were moved. The results of these experiments were also used in this paper to calculate the coefficients of the transfer matrix of a reactor used in determining the optimum movements of the control rods.

The method of processing the experiments reduced to the following. Relative changes of the output of the channels being monitored were calculated by DPZ readings measured before and after the control rods were moved. The increase of the nuetron flux density at an arbitrary point of the core was represented in the form of a linear combination of approximating functions of given type with accuracy sufficient for practical purposes that describe the more typical harmonics for the reactor under consideration as the first radial and the first and second azimuth. The effect of higher harmonics was taken into account by adding the weighting functions of the control rods calculated on the basis of physical calculation. Moreover, the harmonics mentioned previously were excluded from the weighting function.

The amplitudes of the approximating functions were calculated by the least squares method from the condition of best approximation of the approximate distribution at control points to experimental data. The coefficients of the transfer matrix of the reactor were determined from the values of amplitudes and the known type of approximating functions found in this manner. It was also taken into account that the automatic control rods for total output may excite the first radial and second azimuth harmonics during operation of the disturbing actions. A check of the adequacy of the developed model to experiment showed that the mean square deviation of energy distribution found in experiment and on the model comprises approximately one percent when the same control rods are moved.

Formalization of the problem. Algorithm for calculations. The practical suitability of linearized models to describe a reactor as a control object in steady modes permits one to use effective mathematical methods of linear programming theory when working out optimum control algorithms. Some versions of this approach to the problem of optimum control of energy distribution for domestic reactors were first considered in [6, 7]. Solution of the problem of formulating the energy distribution profile using the standard simplex method in the sense of the minimum coefficient of margin to maximum power was suggested in [6].

Unlike [6], an entire function determined by regulation of AMB reactor operation and that characterizes the maximum modulus of deviation of the actual energy distribution from the given distribution is used in this paper and the heat engineering restrictions are taken into account so that equalization of energy distribution is achieved while retaining the given level of heat engineering reliability. Moreover, a more effective algorithm of the modified simplex method was used when

working out the computer program which made it possible to reduce the calc ating time by approximately an order of magnitude when compared to [6].

Let us select vectors Q and Q^0 of the production channel output of the core as components Q_i and Q_i^0 with actual and given energy distribution. To eliminate extreme requirements on the capacity of the internal storage of the computer, by analogy with [6] let us divide the core into p polycells with number of production channels in each of them M_p and let us determine the mean output of the production channel for each polycell at the actual and given energy distribution:

$$\hat{Q}_p = \frac{1}{M_p}\sum_{i=1}^{M_p} Q_i,\ \hat{Q}_p^0 = \frac{1}{M_p}\sum_{i=1}^{M_p} Q_i^0,\ p = 1, \ldots, P. \tag{1}$$

Variation of the deviation of mean output of the production channel of each polycell from its value at given energy distribution is written as a function of the control vector on the k-th control step with regard to equation (1) in the form

$$\Delta\hat{Q}_p^{(k)} = \hat{Q}_p^{(k-1)} - \hat{Q}_p^0 + \frac{1}{M_p}\sum_{j=1}^{n}\left(\sum_{i=1}^{M_p} Q_i^{(k-1)} a_{ij}\right)\delta\rho_j^{(k)}, \tag{2}$$
$$p = 1, \ldots, P,$$

where a_{ij} are the coefficients of the static matrix of the reactor model, $\delta\rho_j^{(k)}$ is the reactivity introduced by the j-th control rod at the k-th control step and n is the number of control rods.

Thermophysical calculations and operating practice show that selection at maximum output of the AMB-200 is essentially not affected by the IK for which the safety factor to maximum output of the channel K^z exceeds 1.3 [4]. This permits one to take into account the heat engineering restrictions of type

$$z_i^{k-1}\left(1 + \sum_{j=1}^{n} a_{ij}\delta\rho_j^{(k)}\right) \leqslant z_{\text{макс}} \tag{3}$$

only for those IK in which the values of $K^{z(k-1)}$ satisfy the relation $K_i^{z(k-1)} \leq 1.3 + \Delta$, where $z_i^{(k-1)} = 1/k^{z(k-1)}_i$, z_{maks} is a constant inversely proportional to the minimum permissible value of the safety factor at given level of heat engineering reliability of the reactor and Δ is a value established experimentally provided that $K^{z(k)}$ in the IK not included in inequality (3) is not reduced to a value less than 1.3 at the k-th control step.

The restrictions on the steam superheating temperature at the output from the production channel can be written with regard to the linearity of the reactor model in the form of the inequality:

$$T_i^{(k-1)} + \xi_i \sum_{j=1}^{n} a_{ij}\delta\rho_j^{(k)} \leqslant T_{\text{макс}}, \tag{4}$$

where $T_1^{(k-1)}$ is the steam temperature at the output from the 1-th superheating channel at the end of the (k - 1)-th control step, ξ_1 is the proportionality constant that relates the relative variation of output of the 1-th PK to the increase of steam temperature at its output and T_{maks} is the maximum permissible steam temperature at the output from the PK. Since the radial energy distribution of the AMB-200 is rather stable, to reduce the total number of restrictions, inequality (4) can be taken into account only for those PK, the steam temperature at the output from which exceeds the average superheated temperature throughout the reactor.

Having supplemented inequalities (3) and (4) by relations of type

$$\alpha_j^{(k)} \leqslant \delta\rho_j^{(k)} \leqslant \beta_j^{(k)}, \quad \alpha_j^{(k)} \leqslant 0, \quad j = 1, \ldots, n \tag{5}$$

(here $\alpha_j^{(k)}$ and $\beta_j^{(k)}$ are the lower and upper maximum values of reactivity introduced by the j-th control rod which are determined by control requirements) and

$$\gamma^{(k)} - \varepsilon \leqslant \sum_{j=1}^{n} \delta\rho_j^{(k)} \leqslant \gamma^{(k)} + \varepsilon, \tag{6}$$

where $\gamma^{(k)}$ is a constant that determines the overcompensation of automatic control rods of total output and ε is the error of maintaining the balance of reactivity which is selected in the range of the error of the system for monitoring the position of the control rods, we find the total number of restrictions of the problem in the form of relations (3)-(6). Let us select the norm $L_\infty = \max_{p=1, \ldots, P} |\Delta \hat{Q}_p^{(k)}|$ that characterizes the maximum modulus of the difference of the mean output of the production channel of the polycell for all polycells at the actual and given energy distribution as the entire function of the problem of the optimum control of control rod positions. The initial problem then reduces to the form of linear programming problems by introduction of the nonnegative variable $y = \max_{p=1, \ldots, P} |\Delta \hat{Q}_p^{(k)}|$ and by supplementing the system of restrictions (3)-(6) by inequalities

$$-y \leqslant \Delta\hat{Q}_p^{(k)} \leqslant y, \quad p = 1, \ldots, P. \tag{7}$$

The linear programming problem, equivalent to the initial control problem, is formulated as [8]:

$$\text{Minimize } y \tag{8}$$

at restrictions (3)-(7) with $\Delta\hat{Q}_p^{(k)}$ determined by relations (2).

Using the introduction of additional variables into relations (3)-(7), problem (8) easily reduces the linear programming problems to canonical form and it is sufficient to introduce a single artificial variable to find the first permissible basic solution. In this case the matrix of coefficients of canonical form of problem (8) contains approximately 90 percent of zero elements. This made it possible to effectively utilize the algorithm of the modified simplex method with multiplicative representation of the reciprocal matrix which has considerable advantages compared

to the standard form of the simplex method in the accuracy of the rate and capacity of the required computer memory [9]. Moreover, these advantages were determined by the weak filling (sparsity) of the initial matrix of the coefficients of the linear programming problem.

The sparsity of the matrix of coefficients of problem (8) also permits one to effectively utilize the computer memory by using the compact form of storage of the initial matrix in which only its nonzero elements are located in the internal storage [10]. For comparision let us point out that an internal storage capacity approximately equal to 800 kbytes would be required in the standard form of the simplex method to locate only the initial simplex table of problem (8) in the computer memory with total number of relations (3)-(7) not exceeding 450. This capacity is reduced to a value not exceeding 100 kbytes in modified form with compact storage.

Table 1. Initial Parameters for Calculating the Optimum Movements of Control Rods Without Regard (a) and With Regard (b) to Restrictions (9)-(11)

	3 X 3 TK		4 X 4 TK	
Parameter	a	b	a	b
Number of polycells	124	124	69	69
max $\lvert\Delta Q_p^{(k)}\rvert$, kW	153.3	153.5	145.9	145.9
Number of control rods	40	40	40	40
Mean output, kW				
for all TK	427.7	427.7	427.7	427.7
for TK of quadrants 3 and 4	436.0	436.0	436.0	436.0
for TK of quadrants 1 and 2	419.6	419.6	419.6	419.6
Average steam temperature at output, °C				
for all PK	499.8	499.8	499.8	499.8
for PK of quadrants 3 and 4	501.6	501.6	501.6	501.6
for PK of quadrants 1 and 2	497.9	497.9	497.9	497.9
Number of temperature restrictions (inequality (4))	132	124	132	139
Total number of restrictions in linear programming problem	424	422	314	317

As an illustration the results of calculating the optimum movements of control rods for the practical state of the AM3-200 on 17 December 1979 are presented below. The calculations were made on a YeS-1022 computer with internal storage capacity of 256 kbytes using a special program developed in FORTRAN-IV language that realizes the algorithm of the modified simplex method with multiplicative representation of the reciprocal matrix and compact form of input data storage.

The actual thermal output of the reactor was 420 MW. The main parameters that characterize the energy distribution and steam temperature at the output of the

superheating channel and the total number of restrictions for the solved equivalent linear programming problems are presented in Table 1. The reactor parameters found as a result of optimum movements of the control rods for two dimensions of polycells are presented in Table 2.

Table 2. Reactor Parameters Found as a Result of Moving Control Rods Calculated by Optimization Program

Parameter	3 X 3 TK		4 X 4 TK	
	a	b	a	b
max $\lvert\Delta\hat{Q}_p^{(k)}\rvert$, kW	117.9	120.3	104.5	110.3
Percent variation of max $\lvert\Delta\hat{Q}_p^{(k)}\rvert$	-23.2	-21.6	-28.4	-24.4
Average of TK, kW				
of quadrants 3 and 4	420.5	427.0	421.1	427.3
of quadrants 1 and 2	433.0	426.6	432.6	426.2
Average temperature of superheated steam for PK, °C				
of quadrants 3 and 4	494.2	498.7	494.5	498.8
of quadrants 1 and 2	506.8	501.2	505.9	501.3
Time for calculating optimum movements of control rods, min	29.6	39.5	24.3	23.5

It is obvious from Table 4 that realization of optimum motions of control rods, calculated when solving problem (8) with system of restrictions (3)-(7), reduces the maximum modulus of deviation of the mean output of the production channel by more than 20 percent for all polycells. However, the error of the mean output and mean temperature of the steam for production channels located in quadrants 1 and 2 and 3 and 4 of the core (see column a in Table 2) and related to different loops of the production circuit is retained in this case. Since equal or similar values of production parameters must be maintained in the loops, elimination of this error is one of the significant conditions of AMB-200 operation. Therefore, additional conditions must be introduced into the system of restrictions of problem (8)

$$-\varepsilon_Q \leqslant \frac{1}{N_{24}}\sum_{i=1}^{N_{24}} Q_i^{(k-1)} - \frac{1}{N_{13}}\sum_{j=1}^{N_{13}} Q_j^{(k-1)} + \sum_{l=1}^{n}\left(\frac{1}{N_{24}}\sum_{i=1}^{N_{24}} Q_i^{(k-1)} a_{il} - \frac{1}{N_{13}}\sum_{j=1}^{N_{13}} Q_j^{(k-1)} a_{jl}\right)\delta\rho_l^{(k)} \leqslant \varepsilon_Q; \tag{9}$$

$$-\varepsilon_Q \leqslant \frac{1}{N_{14}}\sum_{i=1}^{N_{14}} Q_i^{(k-1)} - \frac{1}{N_{23}}\sum_{j=1}^{N_{23}} Q_j^{(k-1)} + \sum_{l=1}^{n}\left(\frac{1}{N_{14}}\sum_{i=1}^{N_{14}} Q_i^{(k-1)} a_{il} - \frac{1}{N_{23}}\sum_{j=1}^{N_{23}} Q_j^{(k-1)} a_{jl}\right)\delta\rho_l^{(k)} \leqslant \varepsilon_Q; \tag{10}$$

$$\varepsilon_T \leqslant \frac{1}{M_{34}}\sum_{i=1}^{M_{34}} T_i^{(k-1)} - \frac{1}{M_{12}}\sum_{j=1}^{M_{12}} T_j^{(k-1)} + \\ + \sum_{l=1}^{n}\left(\frac{1}{M_{34}}\sum_{i=1}^{M_{34}} \xi_i a_{il} - \frac{1}{M_{12}}\sum_{j=1}^{M_{12}} \xi_j a_{jl}\right)\delta\rho_l^{(k)} \leqslant \varepsilon_T, \tag{11}$$

where N_{12}, N_{34}, N_{14} and N_{23} are the number of production channels in quadrants 1 and 2, 3 and 4, 1 and 4 and 2 and 3, respectively, of the core, M_{12} and M_{34} are the number of superheating channels in quadrants 1 and 2 and 3 and 4 and ε_Q and ε_T are the error of maintaining mean output and temperature of superheated steam, respectively.

Fulfillment of inequalities (9) and (10) excludes excitation of the first azimuth harmonic when realizing optimum control actions. Inequality (11) eliminates the possibility of error in average superheated steam temperature in the superheating channel located in quadrants 1 and 2 and 3 and 4, respectively, of the core.

The results of solving problem (8) with system of restrictions (3)-(7) and (9)-(11) for ε_Q and ε_T, equal to 2.5 kW and 2.5°C, respectively, are presented in column b of Table 2, from which it is obvious that introduction of additional restrictions (9)-(11) essentially leads to total equalization of the values of mean output of the production channel and of the mean steam temperature in quadrants 1 and 2 and 3 and 4 of the core. The advantage of this approach is that restrictions of type (9)-(11) permit a sharp reduction of the required frequency of solving the optimization problem with energy distribution close to instability.

It must be noted in conclusion that an increase of the dimensions of polycell from 3 X 3 TK to 4 X 4 TK has essentially no effect on the parameters of the calculated energy distribution and at the same time reduces the time for calculating the optimum control actions from 30-40 to 24 minutes.

Conclusions. The energy distribution control problem of the AMB-200 reactor can be formulated with regard to operating characteristics as one of finding the best approximation to the form of energy distribution $Q_0(r)$ in a given set of production restrictions, clearly determined by given distribution of the multiplication factors $k_\infty^0(r)$.

The algorithm for calculating the optimum movements of the control rods, which utilizes the procedure of the modified simplex method with multiplicative representation of the reciprocal matrix on the basis of the coefficients of the initial matrix of restrictions jointly with the compact form of storage in the computer memory, provides acceptable calculating time. Let us note for comparison that the time required to calculate optimum movements of the control rod comprise approximately 20 minutes on the BESM-6 computer with standard form of the simplex method [6]. Introduction of additional restrictions of type (9)-(11) eliminates the excitation of the first azimuth harmonic when realizing optimum control actions and reduces the required frequency of repeated solution of the optimization problem.

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ORGANIZATION OF FUEL UTILIZATION AT KOLA ATOMIC POWER STATION

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[Article by A. A. Matveyev, Ye. I. Ignatenko, A. P. Volkov and B. A. Trofimov]

[Text] When planning to generate electric power in an energy system consisting of a GES [Hydroelectric power plant] and AES [Atomic power plant], it is difficult to predict with a sufficient accuracy the influx of water into the reservoirs of the hydroelectric power plant. Hence, it is possible to estimate the fraction of energy generation by hydroelectric power plants in the total generation of electric power in the energy system and errors in determining the nature of the future fuel cycle of the AES are possible. The result of these errors are operation of the AES with low charging factor, "underburning" of nuclear fuel or unjustifiable prolonged operation of the fuel charge in the extended run mode in the power and temperature effects of reactivity.

The first fuel charges of the first and second units of the Kola AES were operated with low load factor. This occurred due to underestimation of the water situation in the Kola power system (underestimated hydrological forecasts) and the priority for the GES in production of electric power. The exaggerated hydrological forecast in 1976 and the related intensified consumption of water reserves in reservoirs of the GES of the Kola power system led to the fact that the second unit was shut down for recharging with unselected reactivity reserve (approximately 15 effective days) and an acute shortage of electric output occurred during the maximum winter loads of 1976-1977, which led to operation of the first unit in the extended run mode in the output and temperature effects of reactivity of 84 effective days.

The main problem in increasing the economy of the fuel cycle of an AES is to generate the planned amount of electric power with minimum fuel expenditures. A measure to improve the economy of the fuel cycle is an increase of the percentage of fuel burnup. The energy capacity of the fuel charges must be corrected with regard to these prerequisites as a function of the planned fraction of power generation of the AES in the total generation of electric power by the energy system. There are no essential difficulties in selecting the fuel charges of cores for operation of an AES with load factor variable over a wide range (0.7-0.9) provided that the reactivity reserve for burnup is fully exhausted by the moment the reactor is shut down for recharging and with length of the working cycle of approximately one year between recharges.

An exchange of cycles of abundant- and low-water years is typical for fluctuations of river flow over many years. The generation of the electric power of a GES also fluctuates as a direct function of the water situation. An AES should be regarded as a source of electric power that makes up the balance of energy generation in the energy system under consideration. As shown by experience, the energy content of the fuel charges of a reactor, equal to the design value (approximately 7,000 effective hours), is adequate when an AES is operating at a nominal power level during low-water years, while it becomes necessary to depart from the planned recharging scheme and to reduce the energy content of fuel charges during abundant-water years.

The energy content of fuel charges can be varied by enriching the make-up fuel and by the number of recharged assemblies. The energy content of the charge should be reduced only by reducing the amount of make-up fuel of the maximum planned enrichment, which is economically disadvantageous with fixed projected number (approximately one-third of the total number) of recharged fuel assemblies. When analyzing two make-up schemes equivalent in burnup reactivity reserve, it was established when using only fuel assemblies with enrichment of 1.6 percent with respect to U-235 in the first version and only assemblies with 3.6 percent enrichment in the second version that the expenditures on the first version will be 39 percent greater. We also note that the extent of fuel burnup increases when the number of make-up assemblies is reduced.

The energy content of the fuel charge was corrected beforehand with the second fuel charging of the second unit of the Kola AES according to the known reliable hydrological forecast for the Kola energy system. Make-up of the core was carried out by reducing the number of fresh working assemblies (84 compared to 102) with 3.6 percent enrichment while retaining the planned recharging scheme of the fuel parts of the SUZ [reactor control system]. This made it possible to reduce fuel expenditures by 17 percent and also to increase burnup of 18 working fuel assemblies left in the reactor core for the second cycle and an additional 18 assemblies also left for the third cycle.

One of the ways to improve the engineering and economic indicators of the energy blocks of AES is related to accelerating the unit output of the reactor and energy block as a whole. The rate of combustion of nuclear fuel is increased in this case, i.e., the scheduled length of the fuel cycle is reduced. Therefore, the energy content of fuel charges must be increased to retain the annual operating cycle of a reactor between recharges with high load factor during the fuel cycle.

The simplest method of achieving this goal is to increase the number of make-up assemblies. For example, an average of 127-132 assemblies instead of the planned 113-121 was recharged annually during four fuel cycles of the reactor of the fourth unit of the Novovoronezhskaya AES to ensure the scheduled duration for one year. Similar deviations from the planned mode occurred in other units. The disadvantage of this method of increasing the energy content of the fuel charge of a reactor consists in the fact that, by increasing only the number of recharged assemblies, one must consciously reduce the extent of burnup of the unloaded fuel, i.e., a certain number of underburned fuel assemblies must be unloaded along with the maximum burned-up fuel.

The next step that increases the efficiency of fuel utilization is rejection of combination make-up of a reactor. It is known that the VVER-440 is made up mainly by fuel assemblies with 3.6 percent enrichment and partially with 2.4 percent enrichment. To increase the energy content of the charge, it is more feasible to use working assemblies of only 3.6 percent enrichment as the make-up fuel and to turn to the use of the fuel parts of SUZ with 3.6 percent enrichment along with the planned 2.4 percent enrichment.

An experimental lot of the fuel parts of an SUZ with 3.6 percent enrichment was manufactured for the Kola AES. Operation of them was begun during the fifth fuel cycle of the first unit. The reactor was made up with working fuel assemblies having only 3.6 percent enrichment. Experimental assemblies with 3.6 percent enrichment (seven units) were used along with assemblies having 2.4 percent enrichment (six units) as the make-up fuel parts of the SUZ. Because of this it was possible to increase the average enrichment of the make-up fuel to 3.54 percent. This made it possible to operate the first unit at 107 percent output while retaining the annual interval between recharges and extent of burnup of assemblies subject to unloading no lower than the planned burnup.

According to the plan, 114 assemblies are replaced during the odd recharging by fresh fuel (average enrichment of the make-up fuel is 3.48 percent), while 121 assemblies are replaced during even recharging (average enrichment of the make-up fuel is 3.4 percent). Fuel charges differing from the planned charges by the number and average enrichment of the make-up fuel (Table 1) had to be repeatedly formulated during seven years of operation at the Kola AES.

Table 1. Average Enrichment and Number of Make-Up Fuel Assemblies in First and Second Units*

Number of Recharging	Average Enrichment of Make-up Fuel, percent		Number of Make-Up Fuel Assemblies	
1	3.48	3.46	114	96
2	3.40	3.46	121	115
3	3.48	3.48	114	114
4	3.54	3.44	121	97

*First number--first unit, second number--second unit.

Forming the next charge, one must see that the make-up fuel enrichment is maximum (3.6 percent for the VVER-440 at the current phase) while maintaining nonuniform coefficients of energy release through the radius of the reactor core within permissible limits.

The fundamental solution of the problem of developing fuel charges of high energy content without an increase and even with a decrease of the number of make-up fuel assemblies compared to the planned value is conversion to makeup of the VVER-440 with more highly enriched fuel. The use of this fuel permits an even greater increase of the extent of burnup due to an increase of the core multiplication factor and consequently a reduction of the component fuel cost of electric energy.

However, manufacture of these assemblies is related to an increase of expenditures for uranium enrichment. The optimum fuel enrichment of the VVER is approximately 5 percent [1].

The main difficulty in using fuel of increased enrichment in the VVER-440 is the mechanical resistance of UO_2 pellets and fuel element jackets at the operating parameters of the reactor and with achievement of considerable burn-up. An extent of burnup of approximately an average of 33,000 MW X days/ton for unloaded fuel was achieved in reactors of the first and second units of the Kola AES. The maximum extent of burnup of individual unloaded assemblies reached 37,000 MW·days/ton and this did not lead to disruption of the integrity of fuel elements above permissible values and even more so to breakdown of them. No relationship of any kind was established between the operating modes of reactors and the number of unsealed assemblies.

It is suggested that additional fuel assemblies with 4.0 and 4.4 percent enrichment be used for the VVER-440. This selection is based on the fact that the technique of manufacturing assemblies with 4.4 percent enrichment will be developed for the VVER-1000. The core of the VVER-1000 is designed to achieve average extent of burnup of 40,000 MW·day/ton with maximum average burnup through the fuel element up to 44,000 MW day/ton [1], which is 8.1 percent higher than the extent of burnup achieved at the Kola AES. The use of uranium of the same enrichment to manufacture assemblies for the VVER-440 and VVER-1000 should reduce their cost.

The use of assemblies with 4.0 enrichment in the VVER-440 can be regarded as a measure that permits conversion to reactor make-up from fuel with 3.6 percent enrichment to fuel with 4.4 percent enrichment without a sharp increase of the nonuniformity coefficients in the output of assemblies. An increase of fuel enrichment to 4.4 percent leads to an increase of nonuniform energy release in the fuel assembly. Profiling the properties of fuel elements through the assembly cross-section, i.e., locating fuel elements with 3.6 percent uranium enrichment in the peripheral row, leads to a decrease of the nonuniform coefficients of the assembly to permissible values [1, 2].

Thus, different values of make-up fuel enrichment (3.6, 4.0 and 4.4 percent) permits variation of the energy content of fuel charges and consequently permits an increase of the duration of the reactor run within the required limits. Safe operation of charges using fuel of increased enrichment at accelerated levels of reactor output should first be substantiated by calculation.

The reliability of the main equipment of an AES is one of the factors that determine the cost of electric energy. Equipment failures caused by "running-in" of it are typical for the initial operating period of an AES. Installation and design defects are determined and eliminated by replacement or repair during this period. All this has been confirmed by the experience of operating the first unit of the Kola AES, on whose units work was conducted on equipment repair that required shut-down of the unit, disconnection of the loops and shut-down of the turbogenerators. Since planned and preventive maintenance (PPR) at an AES has traditionally been combined with fuel recharging, the duration of recharges during the initial operating period is rather significant and varies from cycle to cycle

(Table 2). The length of repairs combined with recharging cannot always be guessed beforehand. Consequently, nonuniformity of the energy content of the fuel charges of reactors to the energy generation schedule for the forthcoming operating period may occur with unforeseen extended repair. The presence of several energy units in an AES ensures freedom of economic maneuvering.

Table 2. LF and OF Coefficients for Fuel Cycles and Duration of Recharges

Number of Fuel Unit	First Unit			Second Unit		
	LF	Length of PPR and Fuel Recharging, days	OF	LF	Length of PPR and Fuel Recharging, days	OF
1	0.56	130	0.81	0.47	64	0.80
2	0.59	49	0.91	0.72	76	0.73
3	0.78	33	0.91	0.93	55	0.83
4	0.96	105	0.67	0.94	45	0.88

The cost of electric energy, being an important indicator of the economy of an AES, is determined by the sum of the constant and fuel components. The constant component is inversely proportional to the amount of electric energy produced by an AES, while the fuel component is slightly dependent on the amount of electric energy generated. The fraction of the constant component of cost for the Kola AES is equal to 50-55 percent. Therefore, the cost of electric energy decreases when those operating conditions are realized at which the nominal electric output of an AES is utilized in the best manner.

If the reactor core corresponds in energy content to the required generation of electric energy of an AES during the current fuel cycle, i.e., unloading of the AES is eliminated by the requirement of the energy system determined by the desire to achieve intrasystem optimization of expenditures for production of a unit of electric energy, then the degree of utilization of nominal output will depend on the length of current repairs of the main equipment of the energy unit: turbines, pipelines, reactor and so on.

An operating regime with fluctuations of output for the fuel cycle, especially during the initial period of operation, is typical for AES. The length of operation of the units of the Kola AES at the nominal level of output comprised 20-40 percent of the length of the cycle during the first three fuel cycles. Operation of the energy unit at output below nominal leads to a decrease in the efficiency of the unit, i.e., to an increase of the cost of electric energy [3].

An estimate of the degree of utilization of the main equipment of an AES by the useful energy output N_{netto} measured on the output buses of the station, i.e., without regard to the power consumed for internal needs and losses in transformers, is widely used abroad [4]. The load factor LF that shows the degree of utilization of the nominal output of the energy unit is determined as

$$\mathrm{LF} = W_{\text{отп}}/N_{\text{ном}}^{\text{нетто}}T,$$

where $W_{отп}$ is the amount of electric energy generated by the unit into the energy system during the considered period T, $N_{ном}^{нетто}$ is the nominal electric output of the unit (net) and T is the length of the considered operating period of the unit without regard to shutdown for PPR combined with fuel recharging.

Another no less important value that characterizes the operating mode of the energy unit is the operation factor OF, which is determined as

$$OF = \frac{T_{раб}}{T} = 1 - \frac{T_{ост}}{T},$$

where T_{rab} is the scheduled operating time of the unit at any level of output during the considered period, T_{ost} is the total length of reactor shutdown, including that for PPR related to fuel recharging during the considered period and $T = T_{rab} + T_{ost}$ is the length of the considered operating period of the AES.

Value 1--OF--shows the fraction for shutdown of the energy unit of the total length of AES operation. As can be seen from Table 2, the load factor increases from cycle to cycle and because of this the cost of electric energy decreases. A significant increase of the load factor of the units of the Kola AES during the past few years is explained by more careful selection of the required energy content of the core with unconditional exhaustion of the reactivity margins for burnup by the moment of shutdown for recharging and by the length of the operating cycle between recharging close to one year, by accelerating the output of the AES reactor and by increasing the reliability of the main equpment and producing the length of current preventive maintenance.

Thus, the economy of the fuel cycle of the VVER-440 is increased if the energy content of the fuel charge corresponds to the required energy generation of the AES. The optimum methods of forming the fuel charges of the VVER-440 of different energy content are reactor make-up with a reduced number of fuel assemblies of maximum planned enrichment when the energy content of the charge is reduced and displacement of assemblies with 2.4 percent enrichment from the make-up fuel by assemblies with 3.6 percent enrichment while retaining the planned number of make-up assemblies.

It is suggested that fuel enrichment be increased to 4.0 and 4.4 percent U-235 to form fuel charges of high energy content with number of make-up assemblies below the planned number. The results of monitoring the integrity of fuel jackets at the level of burnup achieved at the Kola AES confirm the possibility of utilizing fuel of increased enrichment in the VVER-440.

The presence of several reactors in an AES ensures freedom of economic maneuvering and permits one, by varying the energy content of fuel charges as a function of the specific established situation, to achieve intrastation optimization of fuel utilization.

BIBLIOGRAPHY

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2. Ovchinnikov, F. Ya. et al, "Ekspluatatsionnyye rezhimy vodo-vodyanykh energeticheskikh reaktorov" [Operating Modes of Water-Moderated, Water-Cooled Power Reactors], Moscow, Atomizdat, 1977.

3. Shishov, A. N. et al, "Ekonomika energetiki SSR" [The Economics of Power Engineering in the USSR], Moscow, Vysshaya shkola, 1979.

4. Operating Experience With Nuclear Power Stations in Member States in 1973, IAEA-168, Vienna. 1974.

6521
CSO: 8144/096

UDC 541.16

METHODS FOR CALCULATING GAS LIBERATION AND ESTIMATING DANGER OF EXPLOSION IN RADIATION-CHEMICAL APPARATUS WITH WATER COOLANT OR BIOLOGICAL SHIELDING

Moscow METODY RASCHETA GAZOVYDELENIYA I OTSENKI VZRYVOOPASNOSTI RADIATSIONNO-KHIMICHESKIKH APPARATOV S VODYANYM TEPLONOSITELEM ILI BIOLOGICHESKOY ZASHCHITOY in Russian 1981 (signed to press 12 Mar 81) pp 2-3, 50

[Annotation, foreword and table of contents from book "Methods for Calculating Gas Liberation and Estimating Danger of Explosion in Radiation-Chemical Apparatus with Water Coolant or Biological Shielding", by Sergey Andreyevich Kabakchi and Aleksey Konstantinovich Pikayev, Energoizdat, 740 copies, 51 pages]

[Text] Annotation

In this book, methods are considered for calculating limiting gas concentrations formed at the radiolysis of water in apparatus with water coolant or biological shielding for given dose rate, temperature and geometry of apparatus. Methods are developed for calculating the composition of the gas mixture (hydrogen, oxygen, inert gas, water vapor) and a qualitative estimate of the danger of its explosion in free volumes of radiation-chemical apparatus of various designs, for various conditions of operation.

The book is intended for scientific workers, engineers and technologists, working in the area of nuclear power engineering and radiation-chemical apparatus building.

Nine tables. Twenty illustrations. Bibliography contains 47 titles.

Foreword

Water is widely used as a coolant or biological shielding in various radiation-chemical apparatus (isotopic radiation sources, containers for transporting spent fuel elements in nuclear electric power plants etc.). This is because water has good thermophysical properties and is cheap. However, water, along with positive techological characteristics, also has a shortcoming. In water, located in the field of ionizing radiation, there forms an explosive mixture whose explosion may lead to the destruction of the apparatus. The formation of hydrogen poses the problem for engineers and technologists of removing it from the apparatus, or creating such conditions in the latter that the explosion of the mixture is impossible. In open types of apparatus, the problem of removing the hydrogen formed is solved relatively simply -- by organizing an efficient system

of blowing the gas away from the surface of the water. The explosion safety in such apparatus may be provided by suppressing the gas separation, or by a special selection of apparatus parameters that make the explosion of the mixture impossible. Here, in any case, it is necessary to be able to calculate the liberation of the radiation gas according to the apparatus parameters (geometry, amount of water, free volume, power absorption in water).

This book describes the process of the liberation of radiation gas in sealed containers of water, subjected to γ and β radiations. Using the theory of radiation chemistry and extensive experimental material obtained by the author, the principles of engineering, methods for calculating the compositions of gas mixtures (hydrogen, oxygen, inert gas, water vapors) were developed in free volumes of radiation-chemical apparatus filled with water and estimating the explosion danger of this mixture for various operating conditions. Radiolysis of water in the core of nuclear reactors is not discussed here since this problem requires special consideration.

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ABSTRACTS OF ARTICLES IN COLLECTION 'RADIATION SAFETY OF AES'

Moscow TRUDY VTI: RADIATSIONNAYA BEZOPASNOST' AES in Russian No 26, 1979 (signed to press 27 Feb 80) pp 141-148

[Abstracts from collection "Radiation Safety of AES", edited by V. N. Mironov, A. I. Rymarenko and S. G. Tsypina, USSR Ministry of Power and Electrification, All-Union Thermal Engineering Institute imeni F. E. Dzerzhinskiy, 500 copies, 151 pages]

UDC 621.039.58.001.5

RADIATION CONDITIONS IN BUILDINGS ADJACENT TO REACTOR UNITS III AND IV OF THE NOVOVORONEZHSKAYA AES

[Abstract of article by Sedov, V. K., Baranov, M. A., and Vlasenko, V. N., pp 3-9]

[Text] An analysis was made of experimental data on the dose rate of γ-radiation from a number of structural equipment components of the first loop of units III and IV of the Novovoronezhskaya AES in 1973-1977. This data indicated that there was no significant increase in dose rate with increased operating time. Experimental data was obtained for the first time on the distribution of the dose rate of γ-radiation along the height of the ionization chamber channel. Data is cited of the measurements of the radiation field in the region of the upper reactor unit and in the building for servicing drives of the main circulation pumps.

UDC 621.039.58.001.5

PASSAGE OF FAST NEUTRONS THROUGH AXIALLY SYMMETRICAL MEDIA OF LIMITED DIMENSIONS

[Abstract of article by Kizhevnikov, A. N., Khokhlov, V. F., Tsypin, S. G., Shul'gin, A. I., and Sheyno, I. N., pp 10-15]

[Text] Experimental data is given on the spatial-power distribution of fast neutrons beyond the axially symmetrical media of limited dimensions of polyethylene, iron and lead. A comparison was made between it and the calculation results using the Monte-Carlo method.

Bibliography contains seven titles.

UDC 621.039.58.001.5

CALCULATION PROGRAM FOR NONUNIFORM AXIALLY SYMMETRICAL SHIELDING BY THE MONTE-CARLO METHOD

[Abstract of article by Blyskavka, A. A., Solov'yev, N. A., and Shimkevich, I. Yu., pp 16-21]

[Text] A modular program is described for using the Monte-Carlo method to calculate flows of scattered neutrons of point or plane distributed sources within or outside of nonuniform axially symmetrical shielding. Based on the library of evaluated data, group interaction constants were calculated.

Bibliography contains five titles.

UDC 621.039.58.001.5

SHIELDING CALCULATION RESULTS COMPARISON USING A BASIC EXPERIMENT

[Abstract of article by Bolyatko, V. V., Vyrskiy, M. Yu., and Stroganov, A. A., pp 22-29]

[Text] A comparison is made of multigroup single dimensional ANISN and ROZ programs, based on the discrete ordinates method used widely abroad and in the USSR. DLC-20 neutron constant libraries based on ENDF-BIII and ARAMAKO-2F were used in calculations in both cases.

Calculated data on reactor neutron distribution in the heterogeneous steel-graphite composition, characteristic for the top shielding of fast neutron reactors, was compared to the results of the basic experiment.

UDC 621.039.58.001.5

POSSIBILITIES AND EXPERIENCE IN USING PROGRAMS FOR CALCULATING PASSAGE OF RADIATION THROUGH SUBSTANCES ON COMPUTERS

[Abstract of article by Brodkin, E. B., Kozhevnikov, A. N., and Khrustalev, A. V., pp 30-38]

[Text] A description is given of a series of programs created or assimilated during the past five years for calculating the passage of neutrons and γ-quanta in media: PEGAS-2.4, MOKDIF, ANKON-Ts, SABINE-3 and FASTER. Considerations are given concerning the degree of program readiness for broad and most feasible utilization. The roles of the experiment and calculation in solving the problem of radiation transfer in the substance are discussed.

Bibliography contains seven titles.

UDC 621.039.538.7

LIGHT SIMULATION METHOD FOR TRANSFER OF IONIZING RADIATION IN AN ATTENUATING MEDIUM

[Abstract of article by Mironov, V. N., Iz'yurov, A. S., and Kurakin, N. Ye., pp 38-50]

[Text] An installation is described and engineering solutions assumed in its creation are substantiated. The results of simulating the transfer of ionizing radiation through protection barriers with their nonuniformities included are compared to known analytical solutions and computer calculations. An example is given of using the considered method to solve the problem of organizing biological protection for rod openings for cell hardware of nuclear electric power plants.

Bibliography contains 11 titles.

UDC 621.039.58.001.5

CALCULATION OF INTEGRAL CHARACTERISTICS OF γ-RADIATION FIELD FROM VOLUMETRIC SOURCES BY THE METHOD OF RADIAL ANALYSIS AND SEQUENTIAL COLLISIONS

[Abstract of article by Luzhnov, A. M., and Tsypin S. G., pp 50-56]

[Text] A method is proposed for calculating the dose rate and density of energy flux at points located outside the dispersing object with uniformly distributed monoenergetic gamma source. Each volume element is considered as an isotropic point source with a discrete spectrum consisting of an infinite series of average Compton scattering energies. The power of each line is calculated according to a certain law. The input of individual groups to the sought-for functional is determined by integrating over the volume of the source. A comparison was made with calculations using the Monte-Carlo method. The precision of the method was evaluated.

Bibliography contains five titles.

UDC 621.039.538.7

APPLYING RADIATION ANALYSIS METHOD TO THE CALCULATION PROBLEM OF DOSE RATE OF γ-RADIATION OUTSIDE VOLUMETRIC SOURCES WITH SHELLS

[Abstract of article by Luzhnov, A. M., Ragi-zade, R. F., and Tsypin, S. G., pp 57-62]

[Text] A method is proposed that using radiation analysis makes it possible to calculate the dose rate outside a volumetric source with one shell. Its efficiency is proved by comparison with the results of calculations made by the Monte-Carlo method. Boundaries of applicability and the precision of the proposed method were evaluated.

Bibliobraphy contains eight titles.

UDC 621.039.58

EFFECT OF NEUTRON FLUX DENSITY ON THE RADIATION OPERATING LIFE OF AES REACTOR HOUSINGS

[Abstract of article by Bass, L. P., Gridnev, S. P., Lomakin, S. S., Morozov, A. G., Morev, A. B., Petrulevich, A. A., and Khmylev, A. N., pp 63-68]

[Text] Values of integral densities of fast neutron flux and the integral of damages in the VVER-440 housing were obtained by calculating in accordance with the "Raduga" program.

Bibliography contains nine titles.

UDC 621.039.58.001.5

USING THE METHOD OF RAVINES IN PROBLEMS OF OPTIMIZING RADIATION SHIELDING

[Abstract of article by Dorofeyev, A. A., Dubinin, A. A., Zhuravlev, V. I., Kurachenko, Yu. A., Petrov, E. Ye. Utkin, V. A., and Fedotov, Yu. G., pp 68-74]

[Text] The method of ravines is described for problems involving the search for the miminum of the function of many variables in the presence of linear limitations. The method is applied to solving the problem of minimizing the full dosage on the outer surface of the protection by varying thicknesses and zone composition for a fixed mass or dimensions of the protective composition for a fixed mass or dimensions of the protective composition. Examples of solutions of problems are given.

Bibliography contains six titles.

UDC 621.039.58.001.5

PROGRAM FOR OPTIMIZING MATERIAL COMPOSITION PARAMETERS IN ACCORDANCE WITH DIFFERENTIAL CHARACTERISTICS OF THE RADIATION FIELD USING THE MONTE-CARLO METHOD

[Abstract of article by Barsov, P. A., and Sakovich, V. A., pp 75-82]

[Text] Optimization is proposed of the composition parameters of the protection against reactor radiations in accordance with differential spatial-power characteristics of the radiation fields simulated by some volumetric source. A computer program using the Monte-Carlo method was developed for this purpose.

An optimization was carried out for coinciding the radial radiation field with the preliminarily obtained radiation field.

Bibliography contains eight titles.

UDC 621. 039.58. 001.5

"OMEGA" PROGRAM FOR CALCULATING THE γ-RADIATION IN A MEDIUM WITH A NONUNIFORMITY BY THE MONTE-CARLO METHOD

[Abstract of article by Yefimov, Ye. I., pp 82-91]

[Text] A program is described for calculating, by the Monte-Carlo method, the γ-radiation field from an isotropic point source, located in an infinite medium, containing a truncated cone of arbitrary dimensions and made of material with other physical properties. Calculation indicated that by examining $2x10^3$ - $2x10^4$ histories, the program makes it possible to calculate with a satisfactory accuracy the integral characteristics of the γ-radiation field up to distances between the source and the detector equal to 10 to 15 free path lengths.

Bibliography contains eight titles.

UDC 621.039.538.7

EXPERIENCE OF DEVELOPING AND IMPLEMENTING PROGRAMS FOR CALCULATING PHYSIO-TECHNICAL CHARACTERISTICS OF RADIATION SHIELDING FOR AES TECHNOLOGICAL EQUIPMENT

[Abstract of article by Bychkov, Ya. A., Grigor'yev, V. A., and Lavdanskiy, P. A., pp 91-102]

[Text] Experience accumulated in the process of developing computer engineering programs for calculating and designing biological protection against γ-radiation of active technological equipment was systematized and a comparison made of a number of engineering programs. A brief description was given of the "KONTUR"(T-3) program which combines the advantages of previously created programs.

Bibliography contains 18 titles.

UDC 621.039.58.001.5

FACTORS IN ACCUMULATING γ-RADIATION BEHIND LAMINATED WATER-LEAD BARRIERS

[Abstract of article by Viks, Ye. A., Dubinin, A. A., Yefimov, Ye. I., Kurachenko, Yu. A., Pankratov, D. V., and Fadeyev, I. A., pp 103-110]

[Text] Results are given of calculating accumulation factors from a plane monodirectional source of gamma radiation with energies of 2 and 6 million electron volts on the surface of a water-lead shield with a thickness of from 5 to 25 free path lengths. Calculations of accumulation factors were made in accordance with the ROZ-5 program by the Monte-Carlo method and by approximate methods. A refined formula recommended by D. L. Broder and coworkers, as well as methods based on homogenizing the shielding and using Kalos' formula, were considered.

Bibliography contains ten titles.

UDC 621.039.538.7

CALCULATION OF γ-QUANTA ACCUMULATION DOSAGE FACTORS IN TWO-LAYER SHIELDS

[Abstract of article by Luzhnov, A. M., Tagi-zade, R. F., and Tsypin, S. G., pp 110-119]

[Text] A method is proposed for calculating γ-quanta accumulation dosage factors in two-layer shields. Calculation results according to the obtained formula were compared with experimental data.

Bibliography contains four titles.

UDC 621.039.58.001.5

MODIFICATION OF THE MONTE-CARLO METHOD FOR CALCULATING DEEP PENETRATION OF γ-QUANTA

[Abstract of article by Petrov, E. Ye., and Fadeyev, I. A., pp 120-127]

[Text] A modification of the MD method is proposed that takes into account the trajectory of particles in sections with a voltage opposite that on the detector. This modification makes it possible to calculate more accurately the low energy part of the spectrum. Calculations were made of γ-radiation transfer in the barrier geometry and compared with other methods.

Bibliography contains ten titles.

UDC 621.039.51.001

USE OF GADOLINIUM FILTERS FOR MEASUREMENTS AT AES

[Abstract or article by Lomakin, S. S., Taratulov, V. P., and Kulikov, V. I., pp 127-136]

[Text] Effective activating cross sections and parameters which determine effective cross sections in the Westcott model were calculated for a number of activation detectors shielded by gadolinium filters. The calculations were made up to temperatures corresponding to the nominal power of the AES reactors.

Bibliography contains six titles.

UDC 621.039.564.5

KGO METHOD WITH OVERCOMPENSATION ON VVER-440 REACTOR

[Abstract of article by Gridnev, S. P., Lelyukhin, A. O., Lomakin, S. S., Luzanova, L. M., and Proselkov, V. N., pp 136-140]

[Text] Gas tightness of fuel cladding is monitored (KGO method) by a loop technique with respect to delayed neutrons with overcompensation of the field of energy release. Localization left less than 25% of the leaky cladding undetected. References 3.

2291
CSO: 1861/108

NON-NUCLEAR ENERGY

POWER ENGINEERING IN SPACE

Moscow KOSMICHESKAYA ENERGETIKA in Russian 1981 (signed to press 4 Jun 81) pp 2, 150-151

[Annotation and table of contents of book "Power Engineering in Space", by Petr Grigor'yevich Poletavkin, Izdatel'stvo "Nauka", 10,700 copies, 152 pages]

[Text] A scientific hypothesis concerning possible ways of producing great energy from the region in outer space around the earth is expounded in the book, and the topic of generation of a circular ionospheric current and utilization of its electric energy is examined. The author also talks about the internal structure of the earth, about the planet's atmosphere and magnetic field, about the cause of the earth's rotation, polar drift, etc.

Intended for a broad circle of readers.

Responsible editor: Academician A. Ye. Sheyndlin

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CSO: 1861/98

UDC 537.312.62:621.313.322-81

TURBOGENERATORS USING SUPERCONDUCTIVITY

Leningrad TURBOGENERATORY S ISPOL'ZOVANIYEM SVERKHPROVODIMOSTI in Russian 1981 (signed to press 17 Aug 81) pp 2, 229-231

[Annotation and table of contents from book "Turbogenerators Using Superconductivity", by Igor' Alekseyevich Glebov, Yanush Bronislavovich Danilevich and Valentin Nikolayevich Shakhtarin, edited by A. A. Karymov, All-Union Scientific Research Institute of Electric Machine Building, Izdatel'stvo "Nauka", 1,000 copies, 232 pages]

[Text] The book outlines prospects for developing turbogenerators that use superconductivity, and describes their designs and the materials used. An examination is made of electromagnetic and heat fields, principles of selecting a superconductive field winding, current lead-ins, electromagnetic and thermal shielding. An investigation is made of mechanical stresses and critical frequencies of rotor speed. Conditions of operation in a power system are analyzed. Data are given on thermodynamics and cooling of rotor with superconductive field winding. Figures 94, tables 25, references 60.

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CSO: 1861/131-A

INDUSTRIAL TECHNOLOGY

ADOPTION OF TYPICAL SYSTEM FOR ENTERPRISE MANAGEMENT

Moscow VNEDRENIYE TIPOVOY SISTEMY UPRAVLENIYA PREDPRIYATIYEM in Russian 1981 (signed to press 7 May 81) pp 2, 346-348, 350-351

[Annotation, conclusion and table of contents from book, "Adoption of Typical System by Enterprise Management", by Viktor Mikhaylovich Portugal, Aleksey Ivanovich Semenov and Aleksandr Lazarevich Margolin, USSR Academy of Sciences, Central Economic Mathematical Institute, Izdatel'stvo "Nauka", 3100 copies, 352 pages]

[Text] Annotation

This paper is devoted to solving a complex of problems originating when adopting a typical management system. The book reveals the difficulties originating in the process of applying typical design solutions to a model, algorithmic and program levels, and analyzes the factors that affect the formation of a typical management model.

The book is intended for a wide circle of developers of automated management systems at enterprises [ASUP], production associations and design institutes involved in transferring an automated system for enterprise management to third generation computers.

Conclusion

In conclusion, it is necessary to discuss again one of the most important problems of typicalizing design solutions. This is the problem of the advisability of adopting a typical management system which, on the algorithmic or model level, differs from the management system already in use at a given enterprise.

First of all, it is necessary to analyze what is meant by the management system "already in use." Fairly frequently it is a management method traditionally composed at the enterprise and oriented toward nonautomatic data processing. In spite of the fact that such a method,as a rule, cannot withstand any comparison with automation, nevertheless any changes in present methods are very painful to accept by management apparatus.

It is precisely in this situation that most frequently a decision is adopted that the typical automated management system is "not suitable." This is natural,since

a typical system, designed by qualified specialists, oriented in principle toward automatic data processing and satisfying all principles of ASU [Automatic Control System] design, will hardly be similar to the system exisitng at the enterprise.

Thus, before adopting a solution on whether the typical system is adequate for the conditions of a given enterprise, it is necessary to analyze the existing management method from the position of automating it. The typical automated management system must be compared to an automated system, existing or planned.

Let us assume that we are making the comparison at the model level. If we have a typical ASU, designed for production, corresponding to the type of our enterprise (according to the typicalization method described in Chapter 3), then differences should not be very significant. Actually, the type of production also determines the management model. Differences may be due to:

a) use of optimizing models instead of calculated ones;

b) degree of detail in data furnished for management;

c) traditionally composed special features of the organizational structure of management.

The first of the indicated causes cannot be called an obstacle to the adoption of a typical ASU. In spite of the fact that the adoption of optimization models for enterprise management is implemented for a number of reasons fairly slowly, the necessity of optimization calculations does not give rise to any doubts. Therefore, if optimization models are used in typical systems, they must be adopted where they conform to production conditions.

The second cause is more serious. If sufficiently detailed data is not available to the enterprise, necessary for solving management problems in a typical ASU, this makes the direct adoption of the system impossible. A question arises: is this data needed at the given enterprise or can it be accommodated by the rough data system already created? As a rule, the problem is solved as follows: the enterprise needs a finer system but, for a number of reasons, its creation is delayed; therefore, the enterprise proposes the adoption of a rougher management system. In such a case, the adoption of a finer typical system gives additional stimulus to the creation of a more detailed data system.

The reverse situation need not be considered: i.e., a version in which an enterprise has data more detailed than used in a typical ASU is extremely improbable.

Finally, the third reason, as a rule, serves as a basic obstacle to the adoption of a typical system. It is considered that if documentation produced by a typical system in its form and content differs from that traditionally accepted at the enterprise, this reduces management efficiency. Such an opinion, even if it is only partly true, should not be considered the decisive one in investigating the question of adopting a typical management system. In fact, it will necessary to put huge expenditures for designing, programing and adopting an individual system on the other side of the scales.

Therefore, it appears that there is sense in making some changes in the document turnover in the existing management system in order to free the enterprise from these expenditures. Especially since these changes may be found to be temporary; as a rule, a typical management system allows for the possibility of comparatively easy changes. In particular, the system described in this book has a modular structure in which almost any procedure may be changed without changing the data base and other procedures.

Thus, the following conclusion may be drawn from the above-stated. The best strategy in creating an ASU on the basis of a third generation computer is to adopt, as soon as possible, a typical system with a consequently slower individualization. In this case, if the enterprise already has a developed ASU on the basis of a second generation computer, this approach will make possible a continuity of changeover from one computer generation to another. If, however, a new ASU is being created at an enterprise, such an approach will mean a considerable reduction in the time needed for design development and adoption. In this case, the effect of typicalization will be demonstrated as being due to a reduction in expenditures for design, as well as to putting the ASU into operation more quickly.

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UDC 539.4 624.07-546/11: 620.9

ABSTRACTS FROM MACHINE BUILDING SYMPOSIUM

Kiev PROBLEMY MASHINOSTROYENIYA in Russian No 13, 1981 (signed to press 5 Mar 81) pp 2, 109-112

[Annotation and abstracts from "Machine Building Problems," symposium edited by A. N. Podgornyy, Ukrainian SSR Academy of Sciences, Institute of Machine Building Problems, Izdatel'stvo "Naukova dumka", 1000 copies, 112 pages]

[Text] Annotation

The results of the symposium on the investigation of structural components under the effect of dynamic forces, as well as of hydraulic power equipment on the economic indicators of hydroelectric power plants. Questions were considered of reproducing oscillation and a vibration control system; solutions for multilayer plate and shell optimization problems are cited; and the problem of using hydrogen in power machines was covered.

The symposium is intended for specialists involved in questions on the dynamics and strength of machines and structural parts, as well as in studying operating processes in power machine building.

UDC 621.01: 621:63

DYNAMIC COEFFICIENT DETERMINATION FOR A DRIVE WITH A NONLINEAR CLUTCH

[Abstract of article by Yevmenkin, V. I., and Matz, V. I. pp 3-7]

[Text] A relationship between the moment values on sections of the clutch characteristic curve and the maximum value of the moment in the system obtained to optimize the parameters of the planetary clutch characteristic curve. The installation of such a clutch in the mechanism for moving an overhead crane reduced the dynamic coefficient of the system.

Three illustrations. Bibliography contains 2 titles.

UDC 621.771.531.3

INVESTIGATION OF DYNAMIC FORCES IN A UNIVERSAL JOINT OF A ROLLING MILL

[Abstract of artilce by Pukhal'skaya, A. N., pp 7-11]

[Text] Analytical expressions were obtained for elastic force moments in the shaft or in the universal joint. Their form makes it possible to estimate the effect of the parameters of the mechanism (masses, rigidities and angular gap in the hinge) on the dynamic force. The effect of changes in the rigidity of the shaft and the universal joints and the relationships between masses and values of angular gaps in the hinges on the dynamic forces in the universal joint components were investigated on an electronic model. An analytical solution and a solution on an electronic model were compared which indicated that the analytical solution may be used with a fair degree of accuracy when calculating and designing universal joints.

Three illustrations. Two tables. Bibliography contains 5 titles.

UDC 539.3

DERIVATIONS OF OSCILLATION EQUATIONS OF A ROTATING ORTHOTROPIC CONICAL SHELL

[Abstract of article by Vorob'yev, Yu. S., andDetistov, S. I., pp 12-17]

[Text] Expressions were obtained for the potential and kinetic energies, as well as of the work of the centrifugal and Coriolis forces, and oscillation equations under natural boundary conditions for an S. P. Timoshenko type of orthotropic conical shell rotating around its axis. In certain particular cases, the obtained expressions coincide with well-known relationships.

Four illustrations. Bibliography contains 8 titles.

UDC 620.178.5.05-52

METHODOLOGICAL PROBLEMS OF PLOTTING CONTROL SYSTEMS BY VIBRATION TESTING

[Abstract of article by Koshcheyev, A. A., pp 18-20]

[Text] Problems related to plotting control systems by vibration testing are discussed. An approach is proposed for forming the vibration processes on the basis of a criterion for achieving the test goal that uses the mode equivalence concept. Ways are pointed out for the possible utilization of mathematical models and experimental data.

It was shown that to raise the efficiency of the system, it is advisable to introduce a loop to regulate the dynamic properties of the vibration test stand that replaces a part of the tested structure.

Bibliography contains 4 titles.

UDC 620.178.5.05.-52

CONTROL ALGORITHM FOR MULTIDRIVE VIBRATION TEST STANDS

[Abstract of article by Gvozdev, A. N., pp 20-22]

[Text] For plotting a system to control vibrations of an elastic structure, it is proposed to utilize coordinate conversion that reduces a mathematical model of the controlled object to a totality of unconnected or weakly connected differential equations of the second order. The controlled values in this case become the main coordinates of the vibrating structure which is ideally close to methods for analyzing the vibration loading of the structures.

Bibliography contains 4 titles.

UDC 620.178.5

METHODS FOR SEPARATING MOVEMENTS IN MECHANICAL DEVICES FOR REPRODUCING VIBRATIONS

[Abstract of article by Gnoyevoy, A. V., and Kosmodem'yanskaya, G. N., pp 22-29]

[Text] Increasing the precision of vibration reproduction is related to eliminating the mutual effect between the reproduced vibrations or to the separation between the vibrations (movements).

Two methods are proposed for separating vibrations reproduced by an elastically suspended "table-product" system: separation by regulating the parameters of the system suspension and separation by regulating the disturbing forces.

Requirements are formulated for the proposed methods and conditions are cited for separating the vibrations in the general case. The proposed methods for separating vibrations are demonstrated on the example of a three-coordinate vibration test stand.

Three illustrations. Bibliography contains 2 titles.

UDC 62-503.5: 620.178.5

MATHEMATICAL MODELS OF RANDOM PROCESSES IN PROBLEMS SIMULATING OPERATIONAL VIBRATIONS

[Abstract of article by Koshcheyev, A. A., and Dudareva, V. I., pp 29-33]

[Text] Certain problems are considered of using angular modulation (frequency and phase) for the purpose of removing undesirable periodicity and localizing the spectrum for a signal, formed on the basis of a pseudorandom model, representing the sum of harmonic components with a random phase.

An asymptotic estimate of the spectral density is substantiated whose use is convenient for an arbitrary frequency change law, especially in cases where the precise calculation of spectral characteristics is difficult.

One illustration. One table. Bibliography contains 3 titles.

UDC 539.3

EXPERIMENTAL INVESTIGATION OF NONLINEAR INTERACTION BETWEEN FLEXING SHAPES OF VIBRATIONS OF CYLINDRICAL SHELLS FOR PARAMETRIC EXCITATION

[Abstract of article by Galaka, P. I., Koval'chuk, P. S., Mendelutsa, V. M., and Telalov, A. I., pp 33-38]

[Text] An experimental investigation was made of the interaction between the shapes of the vibrations of smooth cylindrical fiber glass shells when they are excited kinematically. Cases of interaction between conjugated (corresponding to the same wave parameters) and nonconjugated (with different wave parameters) shapes are considered.

Six illustrations. One table. Bibliography contains 10 titles.

UDC 532.516

ELEMENTARY HYDRODYNAMIC ANALOGY OF ROLLING (THEORY OF MOMENTS)

[Abstract of article by Petrosyan, L. G., pp 38-42]

[Text] The theory of moments of liquid (theory of structural liquid) is used to design a theory of an elementary hydrodynamic analogy of rolling. Analytical expressions were obtained for the calculated characteristics of foil and polymer film. The microstructure effect is demonstrated in curves.

Five illustrations. Bibliography contains 9 titles.

UDC 62-526.001

POWER SUPPLIES FOR RANDOM PROCESS SIMULATORS

[Abstract of article by Koshcheyev, A. A. pp 43-46]

[Text] Problems are discussed which are related to the selection of basic parameters for random process simulators that provide for movements of a tested object near the real ones. A method for determining simulator requirements is described on the basis of the proximity criterion of process correlation functions. A method is proposed for forming the least favorable random process which makes it possible to obtain the upper estimate of the motor power.

One illustration. Bibliography contains 5 titles.

UDC 518.34: 007

ADAPTIVE METHOD FOR AUTOMATIC SEARCH FOR ROOTS OF EIGENVALUE OF OPERATOR

[Abstract of srticle by Strel'nikova, Ye. A., and Shelud'ko, G. A., pp 46-50]

[Text] Problems of separating and making more precise the real roots of equations are combined on the basis of a single approach -- adaptive control of the search process. This made it possible to design an automated procedure for solving the equation on the section. The method is free of derivatives. Its effectiveness is demonstrated by solving test examples and problems on natural vibrations of a plate on an elastic base.

Two tables. Bibliography contains 10 titles.

UDC 677.72.001

FORMING CABLE LOOP ON DRUM OF MINE HOISTING MACHINE

[Abstract of article by Listopad, I. A., pp 50-53]

[Text] On the basis of a theoretical investigation, a differential equation using limiting conditions is reduced to a formula. This formula makes it possible to investigate the strength and durability of a cable when it is formed on a hoisting machine drum for various geometrical parameters, as well as to solve a number of problems related to increasing the efficiency of steel cables in a drum hoist.

Three illustrations. Bibliography contains 7 titles.

UDC 539.3: 534.1: 62-50

MINIMIZING THE WEIGHT OF MULTILAYER PLATES AND SHELLS IN THE PRESENCE OF PULSE FORCES

[Abstract of article by Shupikov, A. N., pp 54-59]

[Text] The problem is considered of designing multilayer plates and shells of minimal weight with limitations imposed on stresses originating due to the action of pulse forces.

The vibrations are described by equations of a refined theory of multilayer plates and shells with a rigid filler. The problem of optimization was solved by a hybrid basic research method.

Results are given of an investigation of the effect of the composition and curvature of the cylindrical panel on the value of the minimum weight.

Two illustrations. Bibliography contains 17 titles.

UDC 62-50

SINGLE-DIMENSIONAL HYBRID LOCALIZATION OF EXTREMUM OF NONDIFFERENTIABLE FUNCTIONS

[Abstract of article by Shelud'ko, G. A., and Rzhevskaya, I. Ye., pp 60-65]

[Text] A hybrid method of single-dimensional research is described for the extremum of nondifferentiable and piecewise-continuous functions on a section based on the method of quadratic interpolations and a plotted procedure for localizing the internal point (type of Fibonacci method). This paper describes the results obtained in minimizing test functions of a broad class. Effectiveness is demonstrated in the case of a nondifferentiable function on a section with a fairly high reliability of the research process.

One table. Bibliography contains 9 titles.

UDC 681.34: 536.21

IDENTIFICATION OF THERMOPHYSICAL MATERIAL CHARACTERISTICS BY SOLVING THE UNIVERSAL THERMAL CONDUCTIVITY PROBLEM

[Abstract of article by Matsevityy, Yu. M., Grabchenko, A. I., Lushpenko, S. F. and Rusanov, V. V., pp 66-72]

[Text] A method is described for determining the thermophysical material characteristics by means of analog and hybrid calculations. The results are given of the calculation of specific heat and the relationship between the heat conductivity coefficient of polycrystalline material and the termperature.

Four illustrations. Bibliography contains 15 titles.

UDC 621.224:001.5

QUASI-THREE DIMENSIONAL PROBLEM OF CALCULATING FLOW IN A HYDRAULIC MACHINE TAKING INTO ACCOUNT THE FINITE NUMBER OF FINITE THICKNESS VANES

[Abstract of article by Zhukovskiy, M. I., Kazachkov, L. Ya., and Topazh, G. I., pp 73-79]

[Text] A method is proposed for solving direct and inverse quasi-three-dimensional problems based on the complex solution of three two-dimensional problems. Unlike other papers, in solving the problem of averaged axially-symmetrical flow, surface S_2, which represents the analog of the surface of the vane for the axially-symmetrical model of motion of the liquid, is not introduced. Equations were obtained which tie in directly the geometry of the real vane with the averaged flow parameters. This makes it possible to solve the quasi-three-dimensional problem in a more substantiated manner.

One illustration. Bibliography contains 13 titles.

UDC 621.311.21.002.5

INVESTIGATIONS OF POWER-ECONOMIC PARAMETERS OF SIMULATED AND NATURAL HYDRAULIC TURBINES

[Abstract of article by Zabolotskiy, Yu. A. and Obukhov, Ye. V., pp 79-81]

[Text] Described are principles for preparing a mathematical model to determine the power-economic parameters of GES equipment, and the results of the investigations by means of the developed algorithm.

One table. Bibliography contains 6 titles.

UDC 621.311.21.002.5

EFFECT OF HYDRAULIC POWER EQUIPMENT ON ECONOMIC INDICATORS OF HYDROELECTRIC POWER PLANTS

[Abstract of article by Zabolotskiy, Yu. A., and Obukhov, Ye. V., pp 82-88]

[Text]A developed numerical algorithm for selecting parameters of GES hydraulic power equipment for the "Minsk-22" and YeS 1020 computers, as well as the results of the investigations made are described.

Six illustrations. Bibliography contains 3 titles.

UDC 621.438

CALCULATION OF GTU [Gas turbine installation] OPERATING WITH A REGULARLY VARIABLE GAS PRESSURE AHEAD OF THE TURBINE

[Abstract of article by Merzlyakov, V. A., and Vitkovskaya, T. S., pp 88-93]

[Text] Materials of a verifying thermal calculation of an experimental GTU are described. Two versions of calculations were made according to the well-known method on the assumption of fuel burning at $\rho =$ const, and a method developed in the IPMash of the Ukrainian SSR Academy of Sciences assuming $\rho =$ var which takes into account regular changes in the static pressure of the temperature and gas consumption.

As a result of the work done, when regular gas parameter pulsations ahead of the turbine are present, and the pressure is measured by rapid-response sensor, thermal calculations assuming $\rho =$ var have advantages over the known ones -- it makes it possible to utilize more fully the energy of the pulsating flow; it determines changes in the turbine power and the effective power of the installation during the action of large and small values of the gas parameters and, with its help, detects the relationship between the actual irregularity of rotation and the effective power, as well as the useful load and changes in the energy of the rotary masses of the rotor. The power per second coincides well with the measurement.

Bibliography contains 5 titles.

UDC 621.438

TURBINE CONTROL DRIVE AND ITS CHARACTERISTICS

[Abstract of article by Skvorcheskiy, Ye. A., pp 93-97]

[Text] An analysis is made of the power characteristics and operating speed of turbine controlling drives which convert the energy of the hot and cold compressed gas into the force developed at the actuator rod. A method is described for designing turbine controlling drives, and their advantages are demonstrated as compared to pneumatic and hydraulic drives.

Two illustrations. Bibliography contains 6 titles.

UDC 621.438.11: 662.769.21

TOXIC AND CARCINOGENIC SUBSTANCES FROM GTD [Gas turbine engine] EXHAUST GASES AND WAYS TO REDUCE THEM

[Abstract of article by Varshavskiy, I. L., Kanilo, P. M., Khesina, A. Ya., Smirnov, G. A., and Ryabeka, V. P., pp 98-102]

[Text] An analysis is given of the problem of reducing environmental pollution by toxic and carcinogenic components of exhaust gases from engines of transport facilities. Comparative data is cited on carcinogenic substances in exhaust gases of piston and gas turbine engines. Ways are considered for reducing the toxicity of GTD exhaust gases by activating the fuel-air mixture in the combustion chamber by hydrogen additives. Results are given of experimental investigations of a gas turbine engine when operating on diesel fuel with hydrogen additives.

Four illustrations. One table. Bibliography contains 5 titles.

UDC 661.961.1

PARAMETERS AND OPERATING CONDITIONS OF HYDROGEN REACTIVE INSTALLATIONS

[Abstract of article by Troshen'kin, B. A., and Dolgikh, T. N., pp 102-1-6]

[Text] The basic parameters and operating conditions of hydrogen reactive installations are described. A relationship is established between the quantity of water supplied to the reactive installations and the temperatures in the installations. The effect of the size of the particles used on the reaction speed was investigated.

One illustration. Bibliography contains 12 titles.

2291
CSO: 1861/110

UDC 621.7.077

DESIGNING SYSTEMS FOR AUTOMATIC HANDLING OF MINIATURE ITEMS

Moscow PROYEKTIROVANIYE SISTEM AVTOMATICHESKOGO MANIPULIROVANIYA MINIATYURNYMI IZDELIYAMI in Russian 1981 (signed to press 10 Apr 81) pp 2-4, 269-271

[Annotation, foreword and table of contents from book "Designing Systems for Automatic Handling of Miniature Items", by Anatoliy Andreyevich Ivanov, Izdatel'stvo "Mashinostroyeniye", 7,700 copies, 272 pages]

[Text] The basic processes for handling objects of different types using original systems constructed on the principles of combined (contact and contact-free) force effect on parts and items are examined in the book. The systems provide an increase by a factor of 10-15 in labor productivity. The author presents the most efficient engineering design for group contact-free control and precision combination of components using various sensor units having a sensitivity of a fraction of a micrometer, etc.

The book is intended for engineering and technical workers engaged in over all automation in instrument building and machine building.

FOREWORD

This book is a logical continuation and development of topics examined for the first time in the author's monograph "Automation of the Assembly of Miniature and Microminiature Items" (Moscow, Izd-vo "Mashinostroyeniye", 1981). At the same time, it poses as its primary task the solution of an independent problem, the creation of bases for designing systems for automatic handling of items, taking into consideration requirements of microminiaturization and principles of the combined (contact and contact-free) force effect on the article. Presently, only isolated papers have dealt with this problem in the USSR and elsewhere, and no complete resolution is available. Systems for handling rigid, durable items with relatively large size and weight are described in most papers. However, practice shows that microminiaturization imposes restrictions on manufacturing processes and automation equipment that preclude equivalent use of conventional techniques that have been tried in other branches of industry.

A wide gamut of methods and equipment for automated handling of small items is examined in the book, taking into consideration recent developments by Soviet and non-Soviet science and engineering. It is at the same time based on basic tenets of works by Soviet scientists on the principles of automation of production processes and theories of automated machinery.

The material for the book is assembled so that a specific type of handling system is examined in each of its main chapters (mechanical, vibromechanical, pneumatic, magnetic and electrical), which are classified according to the feature of the predominant force effect on the item during its displacement, orientation, combination and location. Mechanical systems are considered for handling complex items of irregular geometric shape with different numbers and locations of flexible elements.

The most efficient vibromechanical systems with parallel operating arrangement are examined for complex multicomponent items with varied surface layer strength. Pneumatic systems are presented for brittle and low-rigidity items with particularly clean surfaces characterized by relatively low material density and developed bearing surfaces or a considerable flow surface. Magnetic handling systems are examined as applicable to a vast group of ferromagnetic items of diverse types without considering the skin-effect, and consequently, forces of an electrodynamic nature associated with the use of d.c. and low-frequency a.c. fields. Systems for handling items made from dielectrics and conductors with low strength characteristics are representative of systems using an electrical field. Furthermore, problems of item electrification by friction, the influence of static electricity on handling processes and quality characteristics of the items, as well as methods for local neutralization of electristatic charges are examined.

Systems for precision positioning which have various sensing units to recognize the object being handled are treated in a separate chapter.

We request that comments and suggestions concerning the book be sent to the following address: 107076, Moscow, B-76, Stromynskiy per., d. 4, Izd-vo "Mashinostroyeniye".

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CSO: 1861/107

HIGH-ENERGY DEVICES, OPTICS AND PHOTOGRAPHY

HEAVY-ION ACCELERATORS

Moscow TYAZHELOIONNYYE USKORITELI in Russian 1980 (signed to press 17 Jan 80) pp 168-169

[Table of contents from book "Transactions of Radio Engineering Institute, USSR Academy of Sciences, No 36: Heavy-Ion Accelerators", edited by V. K. Sloka, Radiotekhnicheskiy institut AN SSSR, 250 copies, 169 pages]

[Text] Contents page

6610
CSO: 1861/126

COLLECTION OF PAPERS ON CHARGED PARTICLE ACCELERATORS, PART 1

Dubna TRUDY SED'MOGO VSESOYUZNOGO SOVESHCHANIYA PO USKORITELYAM ZARYAZHENNYKH CHASTITS in Russian Vol 1, 1981 (signed to press 19 May 81) pp 2-12

[Annotation, editor's preface, data on organizational committee and table of contents from book "Proceedings of Seventh All-Union Convention on Charged Particle Accelerators, Dubna, 14-16 October 1980, Vol 1", edited by T. Ya. Zhabitskaya, V. M. Zhabitskiy, E. V. Ivashkevich and Ye. L. Semenova, Ob"yedinennyy institut yadernykh issledovaniy, 800 copies]

[Text] Taking part in the work of the convention were more than 400 Soviet and non-Soviet specialists. The proceedings of the convention include reports on new large accelerator projects, heavy ion accelerators, colliding beams, dynamics of charged particle beams, and also various systems and components of accelerators. Trends in accelerator development are reflected.

Editor's preface

The scope of the Seventh All-Union Convention on Charged Particle Accelerators held in October 1980 at Dubna covers a wide range of topics in the physics of accelerated beams of charged particles, as well as problems in developing and using accelerators.

The papers delivered at the convention and published in "Proceedings of the Seventh All-Union Convention" deal with accelerators for fundamental and applied research, for the national economy and medicine. Accelerators of protons, electrons, heavy ions and positrons are currently being developed and used in acceleration centers. Facilities with colliding proton-antiproton beams are close to completion. These papers deal with nearly all types of accelerators--from enormous proton synchrotrons for fundamental research to electron accelerators of modest size for the national economy and medicine.

The material presented in the published papers gives a fairly complete reflection of the state of this rapidly growing area of science and engineering involving charged particle accelerators. Scientists, engineers and students will be able to find much that is interesting and useful in the materials of the Seventh All-Union Convention.

A. A. Vasil'yev

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COLLECTION OF PAPERS ON CHARGED PARTICLE ACCELERATORS, PART 2

Dubna TRUDY SED'MOGO VSESOYUZNOGO SOVESHCHANIYA PO USKORITELYAM ZARYAZHENNYKH CHASTITS in Russian Vol 2, 1981 (signed to press 2 Jun 81) pp 3-11

[Editor's preface and table of contents from book "Proceedings of Seventh All-Union Convention on Charged Particle Accelerators, Dubna, 14-16 October 1980, Vol 2", edited by T. Ya. Zhabitskaya, V. M. Zhabitskiy, E. V. Ivashkevich and Ye. L. Semenova, Ob"yedinennyy institut yadernykh issledovaniy, 800 copies]

[Text] Editor's preface

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The material presented in the published papers gives a fairly complete reflection of the state of this rapidly growing area of science and engineering involving charged particle accelerators. Scientists, engineers and students will be able to find much that is interesting and useful in the materials of the Seventh All-Union Convention.

A. A. Vasil'yev

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CSO: 1861/126-A

UDC 621.396

ROBUST DETECTION AND RANGING DEVICES

Leningrad ROBASTNYYE LOKATSIONNYYE USTROYSTVA in Russian 1981 (signed to press 13 Jan 81) pp 2-5, 180-182

[Annotation, introduction and table of contents from book "Robust Detection and Ranging Devices", by Anatoliy Arkad'yevich Ovodenko, Izdatel'stvo Leningradskogo universiteta, 1399 copies, 183 pages]

[Text] The monograph is devoted to the problem of developing promising detection and ranging devices for tracking moving objects that are capable of operation in an a priori unknown and statistically variable interference environment. An investigation is made of new designs and research methods, as well as results of mathematical modeling of invariant filters of tracking detection and ranging devices with specific examples of implementation.

The book is intended for scientific workers, graduate students and upperclassmen in engineering colleges specializing in electronic devices of control systems.

Figures 37, tables 5, references 83.

Introduction

Recent years have seen intense development of statistical synthesis and analysis of electronic devices in control systems in the direction of working out methods for overcoming a priori uncertainty for the purpose of obtaining structures that are resistant to changes in the statistical and energy characteristics of input factors.

Two classes of problems are distinguished in statistical synthesis of sensing elements of control systems: with parametric and with nonparametric uncertainty. In problems with parametric a priori uncertainty, the family of likelihood ratios (plausibility functionals) is parametric, while in the case of nonparametric uncertainty, the likelihood ratio is nonparametric, i. e. the form of the distribution functions for the interference and for the signal-interference mixture is unknown.

There are several methods of overcoming a priori uncertainty: methods of the theory of statistical solutions, the adaptive approach, use of special principles of asymptotic optimality, and methods of nonparametric statistics.

Solving detection and ranging problems in the case of parametric a priori uncertainty by methods of verifying complex hypotheses [Ref. 13, 19, 21, 26, 28, 35] has a major advantage in the capability for synthesizing uniform most powerful algorithms to distinguish the informational signal in the case of arbitrary finite sample spaces, as well as in the capability for detailed analysis of working characteristics of the sensitive elements of control systems. However, the limits of applicability of this principle are bounded by an exponential family of distributions (normal additive interference). In the case of reception of independent samples, nonparametric algorithms are synthesized for isolating useful signals that are characterized by fixed probability of false alarms for any distributions of steady-state interference and for any finite sample spaces--sign, rank and sign-rank algorithms [Ref. 26, 28, 59]. But the retention of a constant level of false alarms for arbitrary sample size when using nonparametric algorithms involves rigid requirements of independence of observations and steady-state interference. Besides, the selection of a given nonparametric algorithm is frequently heuristic rather than being based on definite test of optimality. An acknowledged universal means of overcoming a priori uncertainty is the adaptive approach, which has been covered in a large number of papers [Ref. 56, 60, 65, 67]. The use of adaptive methods obviates the restrictions characteristic for methods of the classical theory of statistical solutions and nonparametric statistics. Negative points of adaptive algorithms are the additional time necessary for teaching or learning, lack of unambiguous estimates of unknown characteristics; and difficulties in estimating the convergence of the adaptive algorithm to the optimum [Ref. 69, 67]. Asymptotically optimum algorithms have been worked out in detail for detecting signals against a background of interference [Ref. 26, 59], and these have their own positive and negative features.

Recently in the Soviet Union [Ref. 32, 39, 41, 59, 67] and elsewhere [Ref. 54, 74, 75, 76] researchers have begun to give earnest attention to developing and analyzing robust algorithms for operation of a variety of devices, including detection and ranging devices. Robust detection and ranging devices must be capable of stable operation in the case of a priori uncertainty and with a continuous change in the statistical and energy paraemters of the information signal and of the interfering factors while keeping the output quality characteristics of the sensitive elements of the control systems within given limits. This monograph formulates the problem of using robust devices to isolate detection and ranging signals in the case of a priori uncertainty of the input information; a survey is given of known algorithms that are robust with respect to varying interference characteristics. A study is made in section 3 of a new approach to analysis of robust sensitive elements with the use of methods of the theory of invariance [Ref. 7, 35, 37, 39, 41], and after its application the problem is formulated as one of the classical problems of the theory of verifying nonparametric hypotheses. Algorithms are obtained for operation of different robust filters with analog and digital output signal. These filters have the property that the distribution function of their output signals is independent of the statistical characteristics of interference when only interfering actions are present at the filter input.

To study systems for controlling moving objects with different sensing elements, including robust ones, it is important to have plausible multidimensional mathematical models of objects and of interference actions. The fourth and fifth

sections are devoted to developing mathematical models of detection and ranging signals reflected from large objects, and signals reflected from the surface of the sea. Shaping filters are synthesized for reproducing fluctuations of amplitudes and durations of detection and ranging signals. Results obtained in the monograph are applicable not only to the investigation of detecting and tracking signals from objects, but for solving other problems as well associated with robust isolation of useful information in the case of a priori uncertainty of the characteristics of interfering actions.

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CSO: 1861/128

FLUID MECHANICS

UDC 533

NUMERICAL AND ANALYTICAL METHODS FOR SOLVING PROBLEMS IN MECHANICS OF CONTINUOUS MEDIUM

Sverdlovsk CHISLENNYYE I ANALITICHESKIYE METODY RESHENIYA ZADACH MEKHANIKI SPLOSHNOY SREDY in Russian 1981 (signed to press 24 Mar 81) pp 2, 126-128

[Annotation and abstracts of articles from collection "Numerical and Analytical Methods for Solving Problems in Mechanics of Continuous Medium", edited by A. F. Sidorov and Yu. N. Kondyurin, Ural Science Center, USSR Academy of Sciences, 1000 copies, 128 pages]

[Text] The collection deals with investigation of new exact solutions of equations of hydrodynamics and gas dynamics, development of new approaches to solution of problems of the kinetic theory of gas motion, and obtaining solutions to some specific problems. New analytical and numerical methods are given for studying solutions of linear and nonlinear differential and integral equations in the mechanics of a continuous medium. Exact solutions of equations of gas dynamics and the dynamics of viscous fluid are considered. Some specific problems of gas dynamics are solved, an examination is made of computational procedures of the Monte Carlo type for calculating the equation of state and functionals of the solution of Boltzmann's kinetic equation, and regularizing algorithms are constructed for solving unsteady integral equations of special structure encountered in processing data of x-ray structural analysis.

The collection brings together some original studies on analytical and numerical methods of the mechanics of a continuous medium and is of interest to specialists in this area.

UDC 518:517.948+667.017:535.33

CONSTRUCTING REGULARIZING ALGORITHMS FOR DETERMINING STRUCTURE OF AMORPHOUS SOLIDS BY X-RAY SPECTRAL STRUCTURAL ANALYSIS

[Abstract of article by Ageyev, A. L., Babanov, Yu. A., Vasin, V. V. and Yershov, N. V.]

[Text] The paper outlines physical principles of a method for studying information on the structure of amorphous solids based on x-ray absorption spectra. An integral equation is derived that relates the sought function of radial distribution of atoms g(r) to an experimentally determined function $\kappa(k)$. Regular

algorithms for approximate solution of integral equations of the first kind are studied. A model problem corresponding to crystalline copper is solved by the proposed computational procedure, and results of a numerical experiment are discussed. Figure 1, references 21.

UDC 517.911

REPRESENTATION OF SOME SOLUTIONS FOR ORDINARY DIFFERENTIAL EQUATION OF TYPE $ta(t, u, u')u''+b(t, u, u')=0$ IN NEIGHBORHOOD OF POINT $t=0$

[Abstract of article by Vershinin, S. V.]

[Text] Conditions are found for coefficients a and b of an ordinary differential equation of form $ta(t, u, u')u''+b(t, u, u')=0$ which when satisfied at point $t=0$ make the solution of the Cauchy problem ($u(0)<\infty$, $U'(0)<\infty$) representable by a functional Mellin series in the vicinity of point $t=0$. The author proves local convergence of the Mellin series in the neighborhood of the point $t=0$ when coefficients a and b are polynomials. The constructed solutions are illustrated by examples from gas dynamics. References 7.

UDC 533.6.011

CLASS OF EXACT SOLUTIONS OF GASDYNAMIC EQUATIONS FOR THREE-DIMENSIONAL UNSTEADY FLOWS OF IDEAL GAS WITH VARIABLE ENTROPY

[Abstract of article by Zubov, Ye. N.]

[Text] It is established that a flow of double-wave type with nonlinear level manifolds exists for spatial unsteady flows of ideal gas with variable entropy. A class of exact solutions of this type is constructed that contains two arbitrary functions, one of which depends on one variable, while the other depends on two variables. It is shown that in flows described by these solutions, a transition may be made from subsonic to supersonic velocities. References 8.

UDC 533.7

NEW MODIFICATIONS OF METROPOLIS METHOD FOR CALCULATING PARAMETERS IN EQUATION OF STATE

[Abstract of article by Kondyurin, Yu. N.]

[Text] Two new classes of estimates of a Monte Carlo method (Metropolis method) are suggested for problems of calculating the parameters of the equation of state of matter.

Estimates of the first class are suitable for computing the parameters of state of a substance in the case of non-ergodicity of a Markov chain of the conventional Metropolis method. Construction of estimates of this class is based on representing the sought quantity as a linear functional of the solution of a linear Fredholm's integral equation of the second kind with substochastic kernel. Conditions are determined that guarantee finiteness of dispersion of an estimate of this type.

The second class of proposed estimates is associated with steady-state distribution of a diffusion process that is continuous with respect to time. A system of stochastic differential equations that defines the given diffusion process is obtained on the basis of transient density of a Markov chain of the conventional Metropolis method. References 10.

UDC 533.7

NEW APPROACHES TO SOLUTION OF HYDRODYNAMICS PROBLEMS BY MONTE CARLO METHOD

[Abstract of article by Kondyurin, Yu. N.]

[Text] An examination is made of new approaches to Monte Carol solution of problems of the kinetic theory of gas dynamics. It is shown that in the usual assumptions for the kinetic theory there is a relation of the known statistical Metropolis method. This enables demonstration of a simple numerical Monte Carlo procedure for solving the Boltzmann equation. References 12.

UDC 518

GEOMETRIC METHOD OF CONSTRUCTING THREE-DIMENSIONAL DIFFERENCE GRIDS

[Abstract of article by Koshkina, T. N. and Sidorov, A. F.]

[Text] An algorithm is proposed for automatic construction of regular curvilinear difference grids for three-dimensional regions of star type. The algorithm is based on the idea of nonuniform stretching of a reference hexahedron in which a regular uniform grid is constructed. The principal elementary cells of partition are nonintersecting dodecahedra. The algorithm is realized on a computer for three-dimensional regions bounded by pieces of second-order surfaces. An example of numerical calculation is given. References 7.

UDC 533.6.011

CLASS OF SOLUTIONS OF GASDYNAMIC EQUATIONS AND NATURAL CONVECTION EQUATIONS

[Abstract of article by Sidorov, A. F.]

[Text] New classes of solutions are found for equations of gas dynamics and natural convection of an incompressible viscous fluid for the general unsteady three-dimensional case where the components of the velocity vector depend on some of the spatial corrdinates. Systems of equations are derived that describe these classes of solutions, and new exact solutions of gasdynamic equations are found. An example is given of an exact solution that is a triple nonconical vortex wave with rectilinear generatrices for an arbitrary adiabatic exponent γ in the equation of state. The exact axisymmetric solution of Navier-Stokes equations is examined. Figures 3, references 11.

UDC 532.591

INVESTIGATION OF SERIES USED FOR SOLVING SOME TRANSSONIC FLOW PROBLEMS

[Abstract of article by Titov, S. S.]

[Text] An estimate from below is found for the radius of convergence of a logarithmic series for solution of an axisymmetric Karman equation, the numerical recursion for its coefficients is given, and it is shown that the radius of its convergence is inversely proportional to the thickness of a body in the flow. References 3.

6610
CSO: 1861/131

UDC 534.222.2

PARTICULARS OF SHOCK WAVE STRUCTURE FOR UNDERWATER EXPLOSIONS OF SPIRAL CHARGES

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian No 5, Sep-Oct 80 (manuscript received 4 Apr 80) pp 51-59

[Article by V. K. Kedrinskiy, Novosibirsk]

[Text] For many years, explosive sources of sound have attracted the interest of researchers as the main component of various kinds of sonar devices used for producing directional quasitonal emissions (bursts) of large duration and acoustic power. The range of these sources is rather broad, and includes spark discharge generators [Ref. 1], condensed liquid explosives [Ref. 2], solid explosives [Ref. 3-5], gas explosive mixtures [Ref. 6-8] and effects of shock wave generation by collpasing cavities [Ref. 9, 10]. Integrated energy parameters of some explosive sources of sound in water are compared in Ref. 11, and the spectral characteristics are studied experimentally in Ref. 12-16.

Naturally, explosive sources have adequate power, and their radiation can be registered at considerable distances. However, this quality is not enough for an extensive class of problems in geophysical research, acoustic navigation, and also scientific studies of processes of shock wave propagation in the ocean. Problems come up such as the directionality and relatively long duration of the signal, which generally speaking are not easily realized in explosive sources as these are mainly "point" sources. An important problem is the tonal "coloring" of the signal for protection from reverberation interference. Therefore it is no wonder that some solutions that have been found are based on known concepts of classical acoustics of directional radiation of specially distributed sources. These include the line depth charge with preferred propagation of a shock wave in the direction perpendicular to its axis [Ref. 5]; a vertical chain of concentrated charges initiated with a certain frequency [Ref. 3] giving a predetermined sequence of shock waves, i. e. in some way solving the problem of duration and "coloring" of the radiated burst at the expense of directionality. A cumulative effect is used to set up directional radiation as a result of exploding a charge at the base of a specially shaped cone [Ref. 4].

Recent years have seen an upsurge of interest in sources of the helical type formed from a high-explosive line charge. Radiation of such sources has a number of advantages: directionality both in the vicinity of the axis (typical ring source, thanks to high detonation rate [Ref. 17]), and in the plane perpendicular to the axis (a certain model of a linear source in the case of a long helix), duration [Ref. 18] and easily controllable frequency of shock wave sequence for the same total length of the line charge [Ref. 19]. The particulars of wave field formation with underwater explosion of such charges is of definite interest. Here we will take up some of the principal results of studies of these sources done at the Institute of Hydrodynamics, Siberian Department, USSR Academy of Sciences.

Ring Charge. The basis of the investigated type of charge is a ring element of detonation line initiated from one end. The rate of detonation of standard detonation lines is approximately five times the compressional acoustic wave propagation rate in liquid, which is a good basis for using the instantaneous explosion model in preliminary estimates. In particular, explosion of a ring wire can be used for this purpose.

Experiments of this kind were done on a high-voltage facility with capacitor bank enabling energy accumulation up to several megajoules with allocation of the required part of this energy to a ring about 5 cm in diameter (nichrome, d = 0.15 mm). Explosion of such a ring in liquid enabled tracking of the principal effects of wave field formation. A typical record of this process is shown in Fig. 1 [photos not reproduced]. Here it can be clearly seen that the shock wave front has the shape of a toroidal surface; focusing and reflection of the wave takes place in the vicinity of the axis of the ring, and is recorded as a compression wave by a pressure sensor. The photographic record shows that interaction of the reflected wave with the explosive cavity inside the ring results in propagation of a converging rarefaction wave, behind which intense bubble cavitation occurs. It can be assumed that with some correction for displacement of wave focusing, a similar pattern will occur in the case of explosion of a ring with finite detonation rate.

Formation of the wave structure of radiation upon explosion of a turn of detonation line was studied for charges with diameters of 0.65, 1.65 and 3 mm, range of ring radii of a = 3-30 cm, and distances from the charge of 0.5-5 m. Typical photographic records of the process of wave generation and pulsation of the toroidal cavity upon explosion are shown in Fig. 2a-c [photos not reproduced]. It can be seen (Fig. 2a) that three waves are radiated into the space, the order of their succession depending on the location of the point of registration relative to the initiation section. In all cases the first to arrive is shock wave 1 from the section of the ring closest to the sensor. This is followed by wave 2 or 3 (see Fig. 2). Wave 2 is excited behind the front of wave 1 by the terminal section of the ring when the detonation wavefront completes its first circuit. This instant corresponds to the start of a new revolution of the detonation front around the circle. Wave 3 arises as a result of focusing of wave 1 in the internal region of the ring. Let us note that the time interval between the last two frames in Fig. 2a is 6 times longer than the preceding ones.

The photograph of Fig. 2b shows a continuous scan of the development of the wave process inside the ring, the ring plane being parallel to the window. The slit cut off two diametrically opposite sections of the ring: the section furthest from the initiation point can be seen on the upper part of the photograph as a thin dark line, while the near section merges with the lower boundary of the frame. The position of the charge relative to the slit was such that the focusing point was on the slit, since otherwise we could not have eliminated the possibility of recording the phase velocity of the converging waves, resulting in a sudden strong increase in the velocity of the front. In fact, as can be seen from the photograph, "pure" acoustics occurs for the used types and parameters of explosives.

The motion picture of pulsations of the explosive cavity (Fig. 2c, diameter of ring 30.5 cm, diameter of explosive charge $d_0 = 0.65$ mm, film transport speed 1500 frames/second, detonation rate $D = 7.7$ km/s) shows that the cavity retains the shape of a torus, at least throughout the first pulsation. According to the data of this film record, the maximum dimension of the cross section of the cavity with products of detonation at the instant of cessation is $\sim 120R_0$. It can be seen that, just as in the case with exploding wire, the ring region cavitates strongly.

Pressure measurements showed considerable dependence of wave structure on position of the registration point in the zone close to the charge. A transition was observed from clear separation of the wave into the three above-mentioned types to gradual degeneration into a single wave. The nature of change in parameters of the wave field was also distinguishable. Fig. 3 shows changes of maximum amplitudes of the first wave (taken relative to hydrostatic pressure $p_\infty = 10^5$ Pa) as a function of relative distance along the axis for different radii of the charge rings $a = 30$, 20 and 10 cm (curves 1-3 respectively).

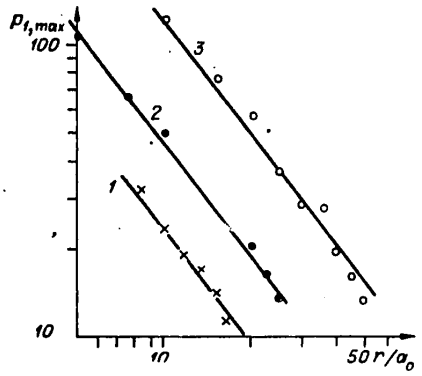

Fig. 3

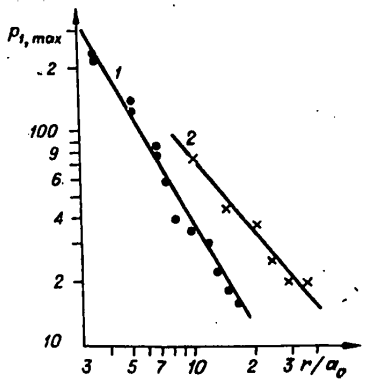

Fig. 4

All three curves have the same power-law behavior $p_{1,m} = A(\bar{r})^{-1.29}$, the coefficient A depending on the weight of the charge, i. e. it is determined by the radii of the charge R_0 and the ring a for fixed density ρ_* and type of explosive. The amplitude of the first wave on the axis of the ring is approximately

$$p_{1,m} \simeq 1.32 \cdot 10^6 (R_0/a)^{0.21} (r/R_0)^{-1.29}.$$

On the basis of this relation it is interesting to note that the amplitude of wave 1 will be higher for a ring with smaller a at the same value of r/R_0.

Experimental data on the distribution of $p_{1,m}$ in the ring plane are shown in Fig. 4 (1--a = 30 cm, 2--a = 10 cm). It was found that the pressure on the front of the shock wave from the charge of greater radius a falls more rapidly with distance (power of ~1.65) than for small rings (power of ~1.15). This result suggested that in the ring plane at distances $\bar{r} = r/a \gg 1$, the nature of pressure distribution is analogous to the case of concentrated charges with weight equal to that of the explosive in the ring. An experimental check verified this assumption: satisfactory coincidence with data for equivalent concentrated charges is observed in the ring plane from distances $\bar{r} \cong 10$, along the generatrix of a cylindrical surface with radius a from distances $\bar{r} \cong 30$-40. Measurements of maximum amplitudes of the second waves showed that they may reach appreciable magnitudes, and sometimes may exceed the amplitude of the first wave, but they decrease more rapidly with distance in the ring plane than along the axis. This effect may be determined both by focusing of waves in the region of the axis and by wave attenuation as a consequence of interaction of reflected waves with the explosive cavity in the ring plane.

Toroidal Cavity Dynamics and Radiation. As noted above, despite the complexity of the wave structure of the field in the near region of a ring charge and the finiteness of the detonation rate, evaluations of different kinds can be made in the analysis of the process within the framework of model formulations. For example, using the experimental fact that the explosive cavity keeps the shape of a regular torus during the first period, we can study its dynamics in a one-dimensional formulation, and apply the results to analysis of the structure of the wave field in the point source approximation.

The equation of pulsations of such a cavity within the framework of an ideal incompressible and imponderable fluid is readily derived [Ref. 20]. To do so, we find the potential $\phi(\alpha, \beta, \gamma, t)$ in region $\Omega(t)$ bounded by a closed smooth toroidal surface $\sigma(t)$ so that when $t \geqslant 0$,

$$\Omega(t)\colon \Delta\varphi = 0,\ \varphi \to 0 \ (\alpha \to 0,\ \beta \to 0),$$
$$\zeta(\alpha, \beta, \gamma, t) = 0,\ \zeta_t + \nabla\varphi\nabla\zeta = 0,$$
$$\sigma(t)\colon \varphi_t + (1/2)(\nabla\varphi)^2 + p/\rho_0 = p_\infty/\rho_0,$$
$$p = p_0(V_0/V)^{\gamma_0}.$$

When $t = 0$, $p = p_0$, $\alpha = \alpha_*$, $\dot{\alpha} = 0$, $\sigma(0)$ is the surface of the torus. Here $\zeta(\alpha, \beta, \gamma, t) = 0$ is the equation of the boundary of region $\Omega(t)$ in the orthogonal toroidal coordinate system α, β, γ; γ_0 is the adiabatic exponent of the detonation products; V is the volume of gas bounded by surface $\sigma(t)$; p_∞ is pressure at infinity.

In the axisymmetric case the solution for potential ϕ takes the form

$$\varphi = (2 \operatorname{ch}\alpha - 2\cos\beta)^{1/2}\,[AP_{\nu-1/2}(\operatorname{ch}\alpha) + BQ_{\nu-1/2}(\operatorname{ch}\alpha)](C\sin\nu\beta + D\cos\nu\beta).$$

Assuming that $\sigma(t)$ is always a coordinate surface, we can get an expression on the basis of the Cauchy-Lagrange integral for pressure at an arbitrary point in

space, and an equation of pulsations that is written in the polar coordinate system in the form

$$\rho_0\left[(\ln 8a/R)(R\ddot{R}+\dot{R}^2)-\frac{1}{2}\dot{R}^2\right]=p_0(R_0/R)^{3\gamma_0}-p_\infty, \tag{1}$$

where ρ_0 is the density of the fluid, R is the cross sectional radius of the gas cavity, and a is the radius of the ring.

Within the framework of the acoustic approximation an equation is derived in Ref. 20 for pulsation of a toroidal cavity in a compressible fluid

$$(\ln 8a/R)[(1-2\dot{R}/c_0\ln 8a/R)R\ddot{R}+(1-\dot{R}/c_0\ln 8a/R)\dot{R}^2]- -\dot{R}^2/2=\omega+R\dot{\omega}/c_0, \tag{2}$$

where $\omega=\int dp/\rho$, and is determined on the wall of the cavity. Calculation showed that the principal energy characteristics of pulsation--time of expansion t_* and maximum radius of the cavity R_*--agree satisfactorily with data of an experiment done for different detonation lines made of RDX with detonation rate of 7.7 km/s.

Analysis of the results of experimental studies done over a wide range of ring radii a yielded an analytical expression for the maximum value of the relative radius of an expanding toroidal cavity with detonation products

$$\bar{R}_*\simeq 141(1-(2/3)\ln^{-1}8a/R_0).$$

This implies that if a increases without limit, R_* asymptotically approaches the value $R_*\cong 141$ for a cylindrical cavity.

Experiments and calculations have shown the period of pulsation of a toroidal cavity has a peculiarity: it increases continuously, although slowly, with increasing a, and the period of pulsation of a cylindrical cavity is not asymptotic in this case. An expression for the period of pulsation of a toroidal cavity can be found on the basis of the traditional approach to problems of this kind--analysis of collapse of an empty cavity in an ideal incompressible fluid. In this case, of course, the initial radius must be taken as the maximum radius R_* of the explosive cavity. let us replace $\ln 8a/R$ in equation (1) with $\ln 8a/R_0/R_*$ on the basis of the well known fact that during collapse of a cavity its initial radius over a considerable portion of a half-period varies but little, and disregard the term $\dot{R}^2/2$ in (1). Then, setting $p_0=0$, we get the equation

$$\rho_0(R\ddot{R}+\dot{R}^2)\ln 8a/R_0R_*\simeq -p_\infty.$$

This enables us to get a solution for R(t) in explicit form

$$R=\sqrt{R_0^2R_*^2-p_\infty t^2/\rho_0\ln(8a/R_0R_*)}.$$

From this we can easily determine the time of collapse, and in virtue of symmetry of the process and expansion of the cavity with detonation products

$$t_*=R_0R_*\sqrt{(\rho_0/p_\infty)\ln 8a/R_0R_*}. \tag{3}$$

It was found that the time of collapse determined on the basis of (3) coincides with the results of experiment and calculation by equation (2) except for a constant $0.02R_0$. Thus the final expression for the first period of pulsation of an explosive cavity of a ring charge can be defined as

$$T \simeq 2R_0\sqrt{\rho_0/p_\infty}\,(R_*\sqrt{\ln 8a/R_0R_*} + 20).$$

Let us use the model of a ring source to evaluate the structure and parameters of the pressure field, assuming that the source is "switched on" instantaneously or is approximated by a set of point sources that are "switched on" sequentially with the detonation rate. It is assumed that time variation of source power at each point of the ring is identical, and is determined by solving equation (2). Numerical estimates of wave structure are made with consideration of delay by the velocity of propagation of detonation D and by the velocity of the acoustic wave c_0. In accordance with the given formulation, we can define the acoustic pressure as

$$p = \rho\frac{a}{4\pi}\int_0^{2\pi}\frac{\ddot{S}(t-\tau)}{f}\,d\alpha,$$

where $f = \sqrt{z^2 + r^2 + a^2 - 2ar\cos\alpha}$; z, r, α are cylindrical coordinates; $\tau = (f/c_0 - \alpha a/D)$ is delay time; angle α is reckoned from the line connecting the center of the ring to the point of initiation; S is the cross sectional area of the toroidal cavity. The calculation can be considerably simplified if the "peak" approximation is used [Ref. 22].

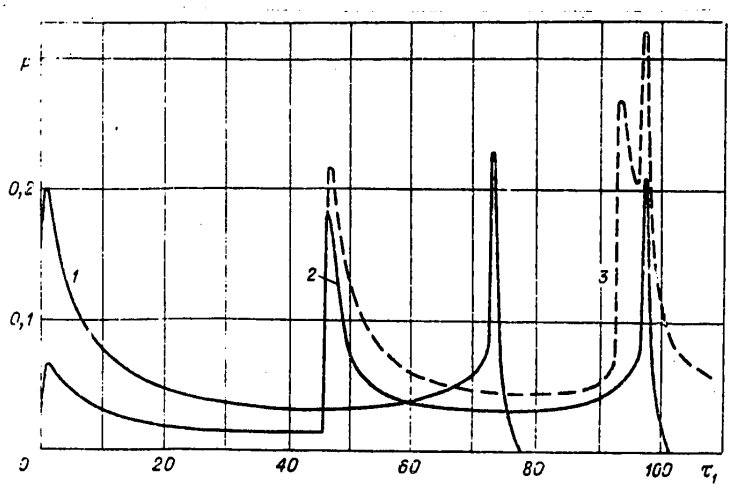

Fig. 5

Fig. 5 shows the result of calculation of the wave structure at a point lying at a distance $r = 2a$ in the ring plane on the line joining the center of the ring to the initiation point. The calculation was done for $R_0 = 0.15$ cm, $a = 15$ cm, $D = 7.7$ km/s. Conditional relative pressure $P = 4\pi p/ap(0)$ is plotted along the vertical, where p(0) is the initial pressure in the detonation products after decay. Time τ_1 is taken relative to constant $\theta_0 = 2.7R_0/c_0$. Curve 1 corresponds

to an instantaneous blast in which only two waves are generated: a shock wave and a compression wave that is reflected from the axis of the ring; in curve 2 the detonation rate is finite. Here three waves arise, in complete accord with the experiment. The first and second are shock waves from the initial and final sections of the ring respectively, and the third is the compression wave that is reflected after focusing. Curve 3 describes the initial unsteady profile of the wave for the case of continuous revolution of the detonation wave around a ring of radius a.

Wave Structure Upon Explosion of Helical Charges. The experimental and theoretical data given above imply that continuous revolution of the detonation front around a circle must lead to radiation of a periodic sequence of shock waves into the surrounding space. This is proved by the experimental photographic record shown in Fig. 6a-c [photos not reproduced].

Fig. 6a, b demonstrate the formation of a sequence of three shock waves radiated into liquid upon underwater explosion of three-dimensional helical and flat spiral charges. The period of succession of waves in such a burst is exactly equal to the time required for the detonation front to travel the length of one turn. It is quite apparent that depending on the detonation rate and a linear dimension of the spiral (helix) (pitch, diameter), two situations can occur by the instant that the detonation front reaches the beginning of the next turn. First: the coordinate of the shock wavefront reckoned from the preceding turn is much greater than the pitch of the spiral (helix). Then explosion of the next turn will occur in a region far from the shock wavefront, and thus at fixed parameters of the spiral (helix) the radiation will be determined by a sequence of shock waves of nearly identical amplitude for a spiral (helix) that is uniform in size. Second: the shock wavefront velocity and axial component of the detonation rate coincide (Fig. 6a). In this case, pressure oscillograms show wave amplification, and the overall nature of the radiation changes: no longer is there a sequence of waves, but rather a long wave that is amplitude-modulated with the frequency of rotation of the detonation front around the annular elements of the charge. Of course, these frequencies may be different if the charge contains annular elements with different linear dimensions.

Fig. 6b, c and Fig. 7 [photos not reproduced] clearly show the process of formation of a burst of shock waves upon underwater explosion of charges in the form of a flat spiral of detonation line. The continuous scan (Fig. 6c) shows interaction of waves in the inner region of a spiral of five turns initiated from the outside. Upon explosion of such a charge we can expect preferential radiation of a burst in the direction of the axis of symmetry or close to it. The pressure oscillogram shown in Fig. 7 was recorded by a sensor placed 20 m from a flat spiral with outside radius of 1 m and on its geometric axis. The length of the scale section reproduced on Fig. 7 corresponds to 400 μs. Charge initiation from the outside section leads to a converging detonation front and to complicated interaction of the radiated waves that apparently results in periodic amplitude modulation. The latter develops against a background of the naturally expected amplitude modulation in virtue of the variability of radii of the conventional annular elements of the flat spiral.

This analysis enables fairly simple evaluation of the parameters of a burst from an explosion of charges of complex shape with annular or near-annular elements.

The burst consists of a sequence of shock waves whose amplitudes are determined from the data of concentrated charges with equivalent weight of explosive material from each turn. The frequency of succession of shock waves in the burst is determined by the length of a turn and the detonation rate, while the length of the entire burst is determined by the total length of the detonation line in the charge. The latter fact is quite interesting since it is only charges of this type that enable practical comparison of the duration of a radiated wave burst and the time for the detonation front to travel the length of the entire charge.

The author thanks V. M. Yermak, V. T. Kuzakov and S. T. Stebnovskiy for assisting with the experiments.

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CSO: 8044/0576

MECHANICS OF SOLIDS

UDC 539.3:531.011

OSCILLATIONS AND STABILITY OF MECHANICAL SYSTEMS

Leningrad KOLEBANIYA I USTOYCHIVOST' MEKHANICHESKIKH SISTEM in Russian 1981 (signed to press 16 Feb 82) pp 2, 267-269, 272-279

[Annotation and abstracts of articles from collection "Oscillations and Stability of Mechanical Systems", edited by Professor N. N. Polyakhov, Izdatel'stvo Leningradskogo universiteta, 1099 copies, 280 pages]

[Text] The collection contains articles dealing with the theory of oscillations and stability of motion, and automatic control theory. An examination is made of linear and nonlinear oscillations and stability of mechanical and electromechanical systems, and problems of rotational motion of artificial satellites. An investigation is made of elastic oscillations and stability of shells, plates, rods and certain other problems of applied mechanics.

The collection is intended for scientists, mechanics and engineers of various categories. It may also be of use to upperclassmen in the mathematics and mechanics departments of universities.

UDC 531.011

DYNAMICS EQUATIONS AS NECESSARY CONDITIONS OF MINIMIMIZED GAUSS CONSTRAINT

[Abstract of article by Polyakhov, N. N., Zegzhda, S. A. and Yushkov, M. P.]

[Text] A system of differential equations of motion of a mechanical system made up of n material points is written as a vector equation by introducing an imaging point. In examining constrained motion of this system, the acceleration vector of the imaging point is represented in the form of two mutually perpendicular vectors. One of these is completely defined by equations of noholonomic constraints (which may be nonlinear as well), while the other vector does not enter at all into the equations obtained from the equations of constraints by differentiation. It is shown that Newton's fundamental law written for such a vector can be treated as a necessary condition of Gauss minimum constraint. References 3.

UDC 534.143

INTERACTION OF MECHANICAL OSCILLATORY SYSTEM WITH NONIDEAL ENERGY SOURCE

[Abstract of article by Yefanov, N. M., L'vovich, A. Yu. and Sidoruk, R. A.]

[Text] Differential equations are derived that describe processes of interaction of a mechanical system and an induction motor for cases of elastic and inertial

excitation of mechanical oscillations. Dependences are found for quantities that characterize steady-state conditions, and their stability is studied.

UDC 531.55:521.1

STRAIGHT EQUILIBRIUM POSITIONS, THEIR STABILITY AND OSCILLATIONS OF SATELLITES WITH ELECTROSTATIC SHIELDING

[Abstract of article by Kuznetsov, L. I. and Chikova, N. V.]

[Text] An investigation is made of oscillations of a satellite with electrostatic shielding around equilibrium positions. It is shown that straight (unbiased) equilibrium positions exist in an orbital coordinate system and criteria are derived for the stability of oscillations around these positions. Figures 3, table 1, references 6.

UDC [Not given]

ROTATIONAL MOTION OF BODY IN CENTRAL GRAVITY FIELD PERTURBED BY LORENTZ FORCES

[Abstract of article by Chikova, N. V.]

[Text] An examination is made of perturbed motion of a gravitationally stabilized body around a center of mass due to the action of Lorentz forces caused by motion of a charged spherical surface in a geomagnetic field. The integral of equations of motion is obtained for the case of an equatorial orbit with satisfaction of a certain condition on displacement of the center of a shielding sphere relative to the center of mass of the body. The stability of the equilibrium position is studied. References 8.

UDC 531.55:521.1

SPECIAL CASES OF MOTION OF ELECTROSTATICALLY SHIELDED BODY RELATIVE TO CENTER OF MASS

[Abstract of article by Lyakhovka, G. V.]

[Text] An examination is made of the joint influence of gravitational moments and moments of Lorentz forces on motion of a body in a circular equatorial orbit. It is assumed that the kinetic energy of rotation of the body is much greater than the work of perturbing forces, and that the center of the electrostatic shield coincides with the center of mass or is displaced along the principal central axis z'. Equations in osculating elements were averaged with respect to rapid rotation. Figure 1, references 4.

UDC 621.312

CONTROLLING START OF INDUCTION MOTOR

[Abstract of article by Pasynkov, V. Ye.]

[Text] A mathematical model is constructed that describes starting of a three-phase induction motor from a line of unlimited power. The optimum control problem is formulated on the basis of this model. References 3.

UDC 534.0:621.30

APPLICATION OF ASYMPTOTIC METHODS TO THEORY OF ELECTRIC MACHINES

[Abstract of article by Rodyukov, F. F.]

[Text] A general method of reducing equations of electric machines to a form containing a minimum number of pa[rameters] is considered on the basis of the comparatively simple example of a two-phase induction motor. References 6.

UDC 531.8

MOTION OF SOLID WITH CONTROLLING CONSTRAINTS

[Abstract of article by Trifonenko, B. V.]

[Text] A theoretical analysis is made of a six-degree rocker stand. The stand is a solid body fastened to six rods that can change length. Formulas are obtained for calculating the change in these lengths, and also the forces in the rods that ensure predetermined motion of a platform. An example of calculation is given. Figure 1, tables 3, references 2.

UDC 62-50

EQUILIBRIUM OF LOCOMOTION VEHICLE DURING MOTION

[Abstract of article by Tertychnyy, V. Yu. and Fomin, V. N.]

[Text] An examination is made of conditions of retention of quasistatic and dynamic stability of a legged vehicle and constraints on controlling torques. A regulator is synthesized that ensures stabilization of the vehicle in the vicinity of programmed motion and that guarantees motion stability. References 4.

UDC 624.07:534.1

DAMPING SELF-OSCILLATIONS IN DEEP DRILLING

[Abstract of article by Kuznetsov, T. I., Makarov, B. G. and Nemtsev, B. A.]

[Text] The authors obtain the conditions to be imposed on parameters that give rise to self-oscillations during deep drilling of holes. A method is proposed for damping such oscillations. Figures 2, references 5.

UDC 620.01.05+629.119.004

USING PRACTICAL HARMONIC ANALYSIS IS STUDYING MOTION OF MOTOR VEHICLE ON BRAKE STAND

[Abstract of article by Yushkov, M. P.]

[Text] A method of successive approximations is used to study inertia of a wheel in the investigation of motor vehicle motion on a two-drum stand for checking

brakes. Fundamental ideas of refined practical harmonic analysis are used for repeated analytical approximation of curves. Convenient formulas are presented for calculating the Fourier coefficients of the approximating function, the graph of this function being a set of third-order parabolic curves drawn through every four sequentially located points of the curve. Figure 1, references 3.

UDC 517.9:534.1

USING PHASE FUNCTIONS TO STUDY OSCILLATIONS OF SYSTEMS WITH PERIODIC PARAMETERS

[Abstract of article by Mironov, M. V.]

[Text] The problem of determining boundaries of zones of stability and the general solution of the Hill equation is solved by a method of phase functions that is a modification of the method of variation of arbitrary constants. The given problem is reduced to integration of a first-order nonlinear differential equation for the phase function on an interval equal to the period of the variable coefficient of the Hill equation. In the case where pulsation of the variable coefficient is not too great, simple computational formulas are derived for constructing the boundaries of zones of instability and determining the general solution in these zones. Use of these formulas requires calculation of only a few integrals. Figure 1, references 7.

UDC 539.3

ASYMPTOTIC BEHAVIOR OF SOLUTIONS FOR PROBLEMS OF THIN PLATE BENDING WITH DISCONTINUOUS LOADS

[Abstract of article by Nazarov, S. A. and Semenov, B. N.]

[Text] An examination is made of the problem of bending of a thin plate with smooth boundary contour under the action of loads that undergo a discontinuity of the first kind on the smooth contour without going beyond the boundary of the plate. Complete asymptotic expansions are constructed for the solution of this problem. References 7.

UDC 534.121.1

USING VARIATIONAL METHODS AND THE NET-POINT METHOD TO SOLVE NONLINEAR DYNAMIC PROBLEMS OF ELASTICITY THEORY

[Abstract of article by Dmitriyeva, Zh. N., Morozov, N. F., Nikiforova, Ye. V. and Semenov, N. N.]

[Text] The authors consider the boundary value problem of oscillation of a rigidly clamped spherical shallow shell under symmetric loading. The problem is solved by two methods: a variational method and the net-point method. In solving the nonlinear system of equations by the Bubnov-Galerkin variational method, a local approximation is selected with subsequent numerical realization of the resultant approximation of the system by the Runge-Kutta method. In solving the problem by the net-point method, an explicit difference scheme is used with seven-point

template (r_i, t_j). Comparison of results showed that the computer program for the net-point method is much simpler and shorter than the program for the Bubnov-Galerkin method. At the same time, the program for the variational method has greater universality and makes it comparatively easy to calculate the action of the load for long time intervals, while the rigid condition for selection of the step in the solution by the net-point method in the given case increases the number of time layers of the grid. References 3.

UDC 534.121

DETERMINING SHAPE OF BENT FLEXIBLE CIRCULAR FREE PLATE

[Abstract of article by Voloshinova, T. V. and Yershov, B. A.]

[Text] An exact solution is found for an inhomogeneous biharmonic equation of the bent surface of a plate that approximately satisfies boundary conditions. References 4.

UDC 539.3:534.1

AXISYMMETRIC RESPONSE OF VISCOELASTOPLASTIC SHELL OF REVOLUTION TO IMPACT LOAD

[Abstract of article by Kovalev, A. M.]

[Text] An examination is made of the axisymmetric response of a viscoelastoplastic shell of revolution to an impact load applied to an end face. The problem is solved for not very thin shells in the geometrically linear formulation. The main thrust is on studying discontinuous stress waves. An algorithm of the method of characteristics is constructed that retains the discontinuities on all characteristics. References 4.

UDC 539.3:534.1

FREE AXISYMMETRIC OSCILLATIONS OF CONJUGATE SHELLS OF REVOLUTION: COMPARISON OF ASYMPTOTIC AND NUMERICAL RESULTS

[Abstract of article by Filippov, S. B.]

[Text] Frequencies and modes of free oscillations of conjugate shells of revolution are determined by an orthogonal sweep method. Results are compared with data of asymptotic analysis of the given problem. Figures 5, tables 2, references 5.

UDC 539.3:534.1

GENERALIZED FOURIER INTEGRAL IN CASE OF AXISYMMETRIC OSCILLATIONS OF ZERO-MOMENT SHELL OF REVOLUTION WITH DIFFERENT FASTENING CONDITIONS

[Abstract of article by Ulitin, M. I.]

[Text] A generalized Fourier integral is constructed for a system of eigenfunctions of the zero-moment problem of axisymmetric oscillations of a thin shell of revolution for different versions of boundary conditions. References 7.

UDC 539.3:534.1

OSCILLATIONS OF ROTATING SHELLS OF REVOLUTION

[Abstract of article by Smirnov, A. L.]

[Text] The author considers the problem of free and forced oscillations of rotating thin shells of revolution. The Ostrogradskiy-Hamilton principle is used in deriving the equations of oscillations. A condition of orthogonality of normal modes of oscillations is derived and used in satisfying the initial conditions. Figure 1, references 4.

UDC 539.3:534.1

ASYMPTOTIC METHOD FOR CONSTRUCTING AND SOLVING TUNCATED EQUATIONS OF THIN SHELLS

[Abstract of article by Kvasnikov, B. N.]

[Text] The author proposes a method that is applicable to fairly general equations for constructing truncated equations in the case of variable coefficients. Figures 6, references 18.

UDC 539.3:534.1

INFLUENCE OF AXISYMMETRIC LOCAL IMPERFECTIONS OF SHAPE ON STABILITY OF CYLINDRICAL SHELL UNDER AXIAL COMPRESSION

[Abstract of article by Bauer, S. M.]

[Text] The paper gives numerical results that characterize stability of a cylindrical shell that is compressible along the axis with a local axisymmetric dent. To determine the dependence of the critical load on the amplitude of the dent, a method of iterations is used that is applied to the integral equation of the problem derived by Fourier transformation. Figures 4, references 5.

UDC 539.3:534.1

NORMAL AND CRITICAL DIMENSIONS OF SHELLS OF REVOLUTION WITH NEGATIVE CURVATURE

[Abstract of article by Petrov, M. B.]

[Text] A variational method preceded by asymptotic analysis is used to determine critical loads for a number of boundary conditions on shells of revolution of negative curvature, these loads being less than the critical levels calculated for normal dimensions. A numerical example is given. Figure 1, references 7.

UDC 539.3:534.1

INFLUENCE THAT AXISYMMETRIC SHAPE IRREGULARITIES IN EDGE VICINITY HAVE ON BIFURCATION POINT OF AXISYMMETRIC EQUILIBRIUM IN SHELLS OF REVOLUTION

[Abstract of article by Teterin, I. Yu.]

[Text] An examination is made of sensitivity of shells of revolution of nonnegative gaussian curvature to an axisymmetric imperfection of shape situated near an edge. Derived asymptotic formulas enable estimation of the influence of additional subcritical strain generated by edge dressing and initial bending on the upper critical load. References 4.

UDC 539.3:534.1

INITIAL TRANSCRITICAL EQUILIBRIUM OF THIN SHELLS OF REVOLUTION UNDER TWISTING

[Abstract of article by Teterin, I. Yu. and Tovstik, P. Ye.]

[Text] The authors consider the problem of stability of initial transcritical equilibrium of thin elastic shells of revolution with twisting. The study covers strictly comvex shells, shells of negative gaussian curvature, and cylindrical shells. An energy method is used in combination with asymptotic analysis with respect to the number m of waves along a parallel ($m \gg 1$). Figures 2, references 5.

UDC 539.3:534.1

ASYMPTOTIC ANALYSIS OF FREE NONAXISYMMETRIC OSCILLATIONS IN SYSTEM COMPRISING CYLINDRICAL SHELL AND ELASTIC MEDIUM

[Abstract of article by Bergman, R. M. and Latifov, F. S.]

[Text] An investigation is made of the influence that an isotropic elastic medium has on frequencies and modes of oscillations of a circular cylindrical shell. Two types of contact conditions between shell and medium are considered: rigid engagement and a contact that allows slipping but not separation between the shell and the medium. In either case it is assumed that the stiffness of the elastic medium is much less than that of the shell material, and the inertia of the elastic medium must be considered in determining frequencies. It is shown that the asymptotic order of the minimum frequency of the shell with fixed wave formation in the longitudinal direction can be reduced in comparison with the order of the corresponding frequency of oscillations of a shell that is not coupled with the medium. References 6.

6610
CSO: 1861/129

UDC 625.2.001:534

LOAD CAPACITY AND DYNAMIC PROPERTIES OF MECHANICAL SYSTEMS

Kiev NAGRUZHENNOST' I DINAMICHESKIYE KACHESTVA MEKHANICHESKIKH SISTEM: SBORNIK NAUCHNYKH TRUDOV in Russian 1981 (signed to press 31 Aug 81) pp 205-216

[Abstracts of articles from collection "Load Capacity and Dynamic Properties of Dynamic Systems", edited by V. F. Ushkalov, Institute of Technical Mechanics, UkSSR Academy of Sciences, Izdatel'stvo "Naukova dumka", 600 copies, 216 pages]

UDC 625.2.001:534.1

FORCED TRANSVERSE OSCILLATIONS OF INHOMOGENEOUS RODS WITH CONSIDERATION OF LONGITUDINAL FORCE

[Abstract of article by Konashenko, O. I. and Repetya, V. Ye.]

[Text] The authors consider forced transverse oscillations of compressed rods with parameters that vary arbitrarily lengthwise, and concentrated inclusions. It is assumed that inelastic resistance conforms to a special Voigt hypothesis. The method of generalized coordinates is used. Figure 1, references 4.

UDC 534.1

SPLINE-CONVERSION OF ARGUMENT AS APPLIED TO SOLVING PROBLEM ON LONGITUDINAL OSCILLATIONS OF INHOMOGENEOUS ROD SYSTEM

[Abstract of article by Naumenko, N. Ye.]

[Text] An investigation is made of analytical relations for finding normal modes of elastically coupled parallel rods with distributed parameters that are piecewise constant functions. For forced oscillations, the solution is found in the form of an expansion with respect to normal modes. Figure 1, references 3.

UDC 625.2.001

REDUCING ORDER OF HAMILTONIAN SYSTEMS

[Abstract of article by Dlugach, L. A. and Tatarinova, V. A.]

[Text] A method is proposed for reducing the order of a system of differential equations of motion written in hamiltonian form. References 2.

UDC 517.91:534

REDUCING ORDER OF DIFFERENTIAL EQUATION SYSTEMS

[Abstract of article by Sil'berman, I. A.]

[Text] A method is proposed for approximating a high-order linear differential equation system by a "simplified" system that does not require solution of the complete problem of eigenvalues of the matrix of coefficients of linearized equations. Table 1, references 3.

UDC 625.2.001:534.014.2

SIMPLIFYING COMPUTATIONAL SCHEME FOR MODELING THREE-DIMENSIONAL VIBRATIONS OF RAILROAD PASSENGER CARS

[Abstract of article by Mashchenko, I. A. and Mokryy, T. F.]

[Text] A method is considered for simplifying a complete system of equations of spatial vibrations of a railway carriage in vertical planes (longitudinal and transverse). Based on the example of carriage calculation, the feasibility of the simplifications is demonstrated and an estimate is made of the error introduced. Figure 1, references 6 titles.

UDC 531.31/.35:629.4:51-7

APPLICATION AND SIMPLIFICATION OF MATHEMATICAL MODELS FOR CURVILINEAR MOTION OF RAILWAY CARRIAGES

[Abstract of article by Radchenko, N. A. and Zinchenko, V. I.]

[Text] An algorithm is proposed for simplifying mathematical models in studying steady states and motion stability of railway carriages moving along track sections of constant curvature, and the region of applicability is defined for these and previously used models. References 3.

UDC 625.2.001:625.032

CREEP FORCES AND LATERAL OSCILLATIONS OF RAILWAY CARRIAGES

[Abstract of article by Demin, Yu. V. and Ratnikova, O. M.]

[Text] An examination is made of the feasibility of using a linear model of the forces of interaction of wheels and rails in studying forced oscillations of complex mechanical systems represented by railway carriages. It is shown that the dynamic characteristics of rolling stock depend appreciably on the model used for creep forces. Figure 1, table 1, references 6.

UDC 531.3:629.4.001

INFLUENCE OF ELASTICALLY DISSIPATIVE SUSPENSION ELEMENTS ON MOTION STABILITY OF FREIGHT CAR

[Abstract of article by Radchenko, N. A.]

[Text] An investigation is made of steady states and stability of freight car motion with TsNII-KhZ trucks. The author demonstrates the feasibility of using non-jamming dry-friction dampers and reducing transverse stiffness of elastic components of the spring suspension. Tables 2, references 3.

UDC 518:517.91/94

NUMERICAL METHOD OF SOLVING RIGOROUS SYSTEMS OF DIFFERENTIAL EQUATIONS

[Abstract of article by Zil'berman, I. A.]

[Text] The author considers a rigorously stable method for numerical integration of systems of ordinary differential equations that does not require determination of derivatives on preceding steps. A demonstration is given of the efficiency of the method for large dimensionality of differential equation systems. Figures 2, references 6.

UDC 625.2.001+656.2.50:681.332.518.5

MATHEMATICAL MODELING OF TRAIN MOTION OVER LONG TRACK SECTION AS MULTIMASS SYSTEM

[Abstract of article by Blokhin, Ye. P., Masleyeva, L. G.]

[Text] The authors demonstrate stability of numerical solution of a system of differential equations of train motion on a large integration interval. Results of calculation are given for longitudinal dynamic forces in a train of elevated weight as it moves over a track section 35 km long. Figures 2, tables 2, references 8.

UDC 629.4.0.5-531.391

SHOCK WAVE FORMATION IN NONLINEAR HOMOGENEOUS SYSTEMS WITH PROPAGATING DISTURBANCE

[Abstract of article by Manashkin, L. A., Knyshenko, V. S.]

[Text] An estimate is made of the influence that the rate of increase and the velocity of propagation of an external force have on shock wave formation in a system of solid bodies connected into a chain by compliant joinings with rigid characteristics. Figures 2, references 7.

UDC 534.11

DETERMINING FORCES IN ONE-DIMENSIONAL SYSTEMS OF SOLIDS WITH LIQUID IN PRESENCE OF PROPAGATING DISTURBANCE

[Abstract of article by Bogomaz, G. I.]

[Text] An examination is made of longitudinal oscillations of a system of solids with cavities containing sloshing liquid connected by elastic bonds. An investigation is made of the influence that parameters of the system and the perturbing load have on the magnitude of longitudinal forces. Figures 2, references 5.

UDC 629.4.028.001.57.532

MATHEMATICAL MODELING OF UNSTEADY MOTION FOR TRAINS EQUIPPED WITH AUTOMATIC ABSORBING HYDROGAS COUPLING DEVICES

[Abstract of article by Khachapuridze, N. M., and Krivovyazyuk, Yu. P.]

[Text] An examination is made of a mathematical model of a train with cars equipped with multichamber hydrogas absorbing devices for the purpose of studying unsteady modes of motion. Figure 1, references 3.

UDC 629.2/7.015.027.001.57

CALCULATING COEFFICIENT OF FORCES OF INELASTIC REISSTANCE OF HYDRAULIC SHOCK ABSORBER

[Abstract of article by Manashkin, L. A., Ratner, B. S. and Baranovskiy, A. Z.]

[Text] The calculation is done with respect to the predetermined force characteristic of the shock absorber with consideration of compressibility of the fluid, the pliability of the structure being protected, and connection of deformable components in series with the hydraulic shock absorber. References 4.

UDC 622.023

INVESTIGATION OF CONVEYER TRAIN MOTION ALONG BROKEN SECTIONS OF LONGITUDINAL TRACK PROFILE

[Abstract of article by Krivenkova, L. Yu., Naumenko, N. Ye., Radzikhovskaya, T. Yu. and Suslovich, B. Z.]

[Text] An investigation is made of the influence that the location of pusher and braking devices as well as variation of tractive force have on the maximum forces in the intertruck connections of the train for unsteady modes of motion. Figures 5, table 1, references 5.

UDC 625.245.6:534.012

INVESTIGATION OF DYNAMIC PROCESSES IN TANKER TRAINS WITH CONSIDERATION OF RESTRICTION OF LIQUID OSCILLATIONS

[Abstract of article by Bogomaz, G. I.]

[Text] It is shown that selection of different laws of variation of oscillator parameters when modeling processes of interaction between liquid and the upper part of tank cars has little effect on maximum forces in the connections between cars. Figures 6, references 5.

UDC 624.072.33.001.24

METHOD OF DETERMINING STRESSES IN STRUCTURAL COMPONENTS UNDER LOADING BY FALLING WEIGHT

[Abstract of article by Barbas, I. G. and Popkovich, A. V.]

[Text] An approximate method is proposed that is based on replacing the impact force obtained from solution of the problem of transverse elastic impact with an equivalent static load. Results of calculations are compared with experiment. Figures 2, table 1, references 4.

UDC 621.01:531.66

EQUIVALENCE OF SHORT-TERM LOADS WITH DIFFERENT FORMS OF TIME DEPENDENCE

[Abstract of article by Grigor'yev, Ye. T. and Migur, V. V.]

[Text] An investigation is made of the equivalence of short-term loads of six different forms. The test object is described by a linear differential equation. Two criteria of equivalence are examined. Figures 4, references 8.

UDC 634.1:625.2

UNSTEADY RANDOM OSCILLATIONS OF MECHANICAL SYSTEM UPON MOTION ALONG A TRACK WITH UNEVENNESSES

[Abstract of article by Reznikov, L. M.]

[Text] An algorithm is developed for determining correlational moments of displacements, velocities and accelerations of a multimass system that moves with variable velocity along a track with unsteady random unevnnesses. Figures 4, references 7.

UDC 531/534:62+501.1

COMPARING STATISTICAL LINEARIZATION COEFFICIENTS FOR FRICTIONAL DAMPER

[Abstract of article by Boyarintseva, L. P.]

[Text] The author considers two versions of mathematical description of a friction damper when the input action is a steady-state random signal, or the sum

of such a signal with a sine wave. A comparison is made between coefficients of statistical, and jointly statistical-harmonic linearization. References 3.

UDC 625.032.4

USING SPECTRAL DENSITIES OF VERTICAL ACCELERATIONS OF JOURNAL BOXES IN PROBLEMS ON ESTIMATING PERTURBATIONS

[Abstract of article by Ushkalov, V. F., Red'ko, S. F. and Leont'yeva, N. M.]

[Text] The authors consider determination of consistent estimates of spectral characteristics of vertical accelerations of journal boxes and make recommendations on using them as characteristics of perturbations is studying vertical oscillations of transport carriages. Figures 2, references 8.

UDC 534.1:625.2

USING STATISTICAL LINEARIZATION IN STUDYING UNSTEADY RANDOM OSCILLATIONS OF MULTIPLE-MASS SYSTEMS

[Abstract of article by Reznikov, L. M.]

[Text] An algorithm is described for calculating mathematical expectations and correlation moments of coordinates of a system with elastically dissipative nonlinear constraints in the presence of unsteady random perturbations. Figures 3, references 2.

UDC 625.2.001:625.032.432

ACCOUNTING FOR TORSIONAL STIFFNESS OF THE BODY IN STUDYING SPATIAL OSCILLATIONS OF RAILWAY CARRIAGE

[Abstract of article by Korotenko, M. L., Danovich, V. D., Malysheva, I. Yu. and Tatarinova, V. A.]

[Text] In natural and forced oscillations of a carriage, an investigation is made of the influence that torsional stiffness of the body has on amplitude of displacements and wavelength of oscillations. Figures 4, table 1, references 3.

UDC 625.2.001:534.1

OSCILLATIONS OF RODS WITH VARIABLE CROSS SECTION CONSIDERING ROTATIONAL INERTIA AND SHEAR STRAIN

[Abstract of article by Repetya, V. Ye.]

[Text] The author considers natural oscillations of a rod with arbitrary parameters that are variable with respect to spatial coordinate and with concentrated inclusions, considering rotational inertia and shear strain. References 3.

UDC 534.1

ESTIMATING SIGNIFICANCE OF PARAMETRIC OSCILLATIONS

[Abstract of article by Grigor'yev, Ye. T., Konstantinov, K. G., Monatko, N. V., Olemskaya, N. S., Petrushevskiy, V. A. and Sokolov, V. A.]

[Text] It is demonstrated on the basis of experimental data that the dynamic characteristics of real objects must be determined with consideration of the possibility of oscillations on frequencies that are fractional and multiple with respect to the excitation frequency. Figures 3, tables 2.

UDC 539.3:534.1

SPLINE-CONVERSION OF ARGUMENT IN DYNAMICS OF CYLINDRICAL SHELLS WITH DISCONTINUOUS PARAMETERS

[Abstract of article by Bryuza, A. A.]

[Text] An examination is made of the feasibility of applying spline-conversion of an argument to investigation of oscillations of cylindrical shells in which the parameters vary along the generatrix. Frequencies of free oscillations of a shell of piecewise variable thickness are determined. Figures 2, references 5.

UDC 532.59

USING FINITE ELEMENT METHOD TO CALCULATE DYNAMICS OF SOLIDS WITH LIQUID

[Abstract of article by Zakora, L. V.]

[Text] The author considers application of the finite element method to studying the dynamics of solids that contain a liquid. Figures 2, tables 2, references 4.

UDC 533.01:624.5

AERODYNAMIC CHARACTERISTICS OF MODERN GUYED BRIDGES

[Abstract of article by Kazakevich, M. I.]

[Text] The paper describes the results of experimental wind-tunnel studies of models of a stiffness beam in modern guyed bridges. It is shown how the angle of attack of the wind flow influences aerodynamic characteristics. Figures 3, references 4.

UDC 62-50

IDENTIFYING STIFFNESSES AND DAMPING PARAMETERS OF MECHANICAL SYSTEMS

[Abstract of article by Red'ko, S. F.]

[Text] The author considers a method of using experimental data to determine stiffnesses and damping parameters of mechanical systems based on analyzing individual subsystems rather than the system as a whole. Figures 2, references 6.

UDC 62-50, 519.27

DETERMINING NATURAL FREQUENCIES AND DAMPING COEFFICIENTS FROM ANALYSIS OF FREE OSCILLATIONS

[Abstract of article by Kovalev, I. Ye., Krasnikov, A. V. and Tu?(y)ev, V. I.]

[Text] Two methods are given for computer analysis of free oscillations of a structural component to determine its natural frequencies and damping coefficients. References 4.

UDC 531.44.001.57

EXPERIMENTAL DETERMINATION OF FRICTION COEFFICIENT

[Abstract of article by Knyshenko, Yu. V., Logachev, P. P.]

[Text] The paper describes an experimental facility and method for determining the coefficient of friction. The coefficients of friction are determined for felt-steel and felt-aluminum couples. An investigation is made of the influence of changing the sliding rate and the load on the contact area. Figures 3, references 2 Russian.

UDC 620.178.53:539.43

TEMPERATURE FIELD OF COMPONENT UNDER CYCLIC LOADING

[Abstract of article by Veselovskiy, V. B. and Voytsekhovskiy, N. I.]

[Text] Based on the method of sequential intervals a solution is found for the nonlinear problem of heat conduction for a cyclically loaded cylindrical part. It is shown that accounting for nonlinearity considerably improves accuracy of determining the temperature field. Figures 4, table 1, references 9.

UDC 533.01:624.5

AERODYNAMIC STABILITY OF PRISMATIC STRUCTURES

[Abstract of article by Kazakevich, M. I.]

[Text] An investigation is made of conditions of aerodynamic stability of prismatic components of rectangular cross section such as those used for bridge pylons. Methods and results of wind-tunnel tests are given. Figures 4, references 3.

UDC 621.643-656/621.51

STUDYING PROCESSES OF CONTAINER DECELERATION IN PNEUMOTRANSPORT LINE

[Abstract of article by Shvets, G. A., Zel'dina, E. A. and Degtyarneko, V. I.]

[Text] An investigation is made of the influence of gasdynamic wave processes on deceleration of a container in an inclined braking section. It is shown that wave processes should be considered at positive angles of inclination and high braking rates. Figures 2, references 6.

UDC 539.3

EQUIVALENCE OF PRINCIPAL FORMULATIONS OF OPTIMUM STRUCTURE DESIGN PROBLEMS

[Abstract of article by Volkova, I. M. and Zevin, A. A.]

[Text] An examination is made of the relation between some typical problems of optimum design of structural elements. Conditions are found under which problems of different formulation are equivalent. Figure 1, references 6.

6610
CSO: 1861/130

DYNAMICS OF RADIATING GAS

Moscow DINAMIKA IZLUCHAYUSHCHEGO GAZA in Russian 1981 (signed to press 9 Jun 81) pp 3-4, 95

[Introduction and abstracts of articles from collection "Dynamics of Radiating Gas", edited by Yu. D. Shmyglevskiy, Computing Center, USSR Academy of Sciences, 370 copies, 95 pages]

[Text] Introduction

The introduction to the second number of this collection (1976) had the subtitle "System of Methods for Calculating Steady-State Axisymmetric Flows of Radiating Gas", and the introduction to the third number (1980) had the subtitle "Some Nonstationary Problems of Dynamics of Radiating Gas." In 1971-1975, the people working at the Computing Center of the USSR Academy of Sciences were mainly developing numerical methods, and in 1975-1980 they were mainly using these methods to solve problems. This is what determined the content of the collections.

The collection offered herewith includes articles that can be subsumed only under the title of the collection itself. They deal with calculating the optical properties of gases, methods of the dynamics of a radiating and scattering gas, and solution of two problems with axial symmetry. Due to incompleteness of publications, A. A. Charakhch'yan was forced, in his words, to turn to the technology of computing the absorption coefficient, and to carry out the computations with his own hands. V. I. Gryn', after publishing his own results, to compensate for the limited scope of the journal article presents an extended text of the paper and supplements it with the method of computing the motion of a gas with radiation, as well as with Thomson and Compton scattering. V. I. Zubov, V. M. Krivtsov, I. N. Naumova et al. continue the study of interaction of laser emission with an aluminum vessel and its radiating vapor. Their article gives results in the case of use of a neodymium laser. Ye. V. Shil'nikov uses the idea of focusing laser radiation in air, and carries out the calculation of this effect. Thus the number of axisymmetric problems of dynamics of spectrally radiating and absorbing gas that have been solved at the Computing Center of the USSR Academy of Sciences has been brought to five.

It was noted in the introduction to the third collection that a test of the moment method of calculating transfer of spectral radiation under severe conditions where temperature ranges from thousands to tens of millions of degrees yields

inadmissible errors even in integrated characteristics such as electron temperature in calculating the behavior of a laser target. In this collection, V. I. Gryn' offers a multigroup moment method which, although it requires a greater volume of computations, shows errors with testing on the same problem of 1% for thermodynamic quantities and for the energy luminesced by the target. Thus there has been progress in this area as well.

The methods presented in these collections have been efficacious in solving quite complicated problems. At the same time, the complex geometric characteristics of the phenomenon being studied raise new questions associated with computational grids. In the four problems with axial symmetry whose solution was published in the second and third collections, it was possible to use a single grid to solve each problem as a whole. In this collection, Ye. V. Shil'nikov solves the problem of movement of air under the action of laser emission focused by a parabolic mirror. Use of a unified grid in this case leads to supersaturation of the computational algorithm with nonstationary elements. The author uses three different grids for equations of gas dynamics and equations of transfer of the laser and normal radiation. The fields of the functions have to be interpolated with transition from one grid to another in the iteration procedure of the calculation. Ye. V. Shil'nikov carries out these interpolations in such a way that laws of conservation of mass, momentum and energy are not violated. This measure among other things ensures success of the work. The most complicated phenomenon of dynamics of a radiating gas is reproduced in detail.

The first, and forced, test of carrying out calculations on different grids has been crowned with success, although even here the realization of the algorithm of computations requires incredible efforts.

17 December 1980

Yu. D. Shmyglevskiy

UDC 533.1:535

CALCULATING OPTICAL PROPERTIES OF HIGH-TEMPERATURE GASES BY HOBNER PERTURBATION THEORY: ZWITTERION MODEL

[Abstract of article by Charakhch'yan, A. A.]

[Text] The paper describes technology for computing the absorption coefficient based on the work of Argo and Hobner. The Fermi-Dirac statistic is used. The technology is realized on the BESM-6 computer, and gives the coefficient of absorption of high-temperature mixtures with nuclear charge not exceeding 30.

UDC 533.6.011.6:535.1

SCHEMES FOR CALCULATING RADIATION TRANSFER

[Abstract of article by Gryn', V. I.]

[Text] The author constructs and studies homogeneous difference schemes for the equation of unsteady transport of spectral radiation in a moving gas that is scattering with respect to angles. A numerical scheme is proposed for calculating

radiation transport with Compton scattering. The paper gives the results of calculations that illustrate the accuracy of the numerical schemes.

UDC 533.6.011.6:535.1

INTERACTION OF NEODYMIUM LASER RADIATION WITH ALUMINUM VESSEL AND ITS VAPOR

[Abstract of article by Zubov, V. I., Krivtsov, V. M., Naumova, I. M. and Shmyglevskiy, Yu. D.]

[Text] An examination is made of the process of heating of the flat bottom of a tapered vessel, vaporization, heating and movement of the vapor, and heating and vaporization of the side wall as a result of radiation of the vapor. In some versions the intensity of laser radiation is constant, while in others it increases from zero to a maximum, and then decreases. The authors discuss the particulars of the process. Detailed illustrations are given.

UDC 533.6.011.6:535.1

INVESTIGATION OF GAS MOTION UNDER THE ACTION OF FOCUSED LASER RADIATION

[Abstract of article by Shil'nikov, Ye. V.]

[Text] A solution is found for the axisymmetric unsteady problem of air motion under the action of a laser pulse. The air is taken as spectrally emissive, non-scattering, inviscid and thermally nonconductive. Laser radiation is focused by a parabolic mirror. The equation of gas dynamics is integrated by S. K. Godunov's method. The angular distribution of radiation intensity is accounted for by the method of discrete ordinates, and the frequency dependence is taken into consideration by a multigroup moment method.

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CSO: 1861/127

UDC 531/534

KINETOSTATICS OF THREE-DIMENSIONAL MECHANISMS

Moscow KINETOSTATIKA PROSTRANSTVENNYKH MEKHANIZMOV in Russian 1981 (signed to press 9 Apr 81) pp 2, 101-102

[Annotation and table of contents from book "Kinetostatics of Three-Dimensional Mechanisms", second revised and enlarged edition, by Nikolay Grigor'yevich Bruyevich and Bella Ovseyevna Marder, Institute of Machine Science imeni A. A. Blagonravov, USSR Academy of Sciences, Izdatel'stvo "Nauka", 1300 copies, 104 pages]

[Text] The book presents theoretical methods and practical techniques for computer solution of problems of kinetostatics of three-dimensional mechanisms.

While basically retaining the ideas developed in the first edition, major revisions have been made (with consideration of extensive use of present-day computer facilities) in the methods of analyzing mechanisms. Methods of solution are algorithmized, programs of calculation are developed for specific three-dimensional mechanisms.

The monograph may be a useful handbook for engineers, designers, graduate students and scientists specializing in the area of three-dimensional mechanisms.

Figures 18, references 59.

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TESTING AND MATERIALS

UDC 621.039.531

RADIATIONAL DAMAGE TO HOUSING STEEL OF WATER-COOLED WATER-MODERATED REACTORS

Moscow RADIATSIONNOYE POVREZHDENIYE STALI KORPUSOV VODO-VODYANYKH REAKTOROV in Russian 1981 (signed to press 27 May 81) pp 2-4

[Annotation and table of contents from book "Radiational Damage to Housing Steel of Water-Cooled, Water-Moderated Reactors", by Nikolay Nikolayevich Alekseyenko, Amir Dzhabrailovich Amayev, Igor' Vasil'yevich Gorynin and Vladimir Aleksandrovich Nikolayev, Energoizdat, 1250 copies, 192 pages]

[Text] Annotation

Investigation results are correlated and analyzed for a number of scientific and engineering problems related to the efficiency of housings of water-cooled, water-moderated power reactors [VVER] of nuclear electric power plants. A complex of requirements is expected of materials of VVER housings, the principles of their selection, as well as the properties in the presently used and promising materials. The basic part of the book is devoted to the behavior of the housing materials and neutron radiation conditions, in particular, when in contact with the reactor coolant. The basic change mechanism is described by neutron radiation in the strength, ductility and toughness of the steel and metal of the welded joints, depending upon the thermal treatment, structure, alloying, nature and quality of the alloying elements and a number of other factors. Information is given on the specifics of the behavior of hydrogen and irradiated materials.

This book is intended for workers and engineers involved in problems of creating nuclear power installations, as well as instructors, graduate students and students of corresponding specialties in vuz.

Twenty-seven tables. Ninety-four illustrations. Bibliography contains 321 titles.

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UDC 621.374

MEASURING OSCILLATORS IN NUCLEAR ELECTRONICS

Moscow IZMERITEL'NYYE GENERATORY V YADERNOY ELEKTRONIKE in Russian 1981 (signed to press 24 Nov 80) pp 2, 255-256

[Annotation and table of contents from book "Measuring Oscillators in Nuclear Electronics", by Yevgeniy Alekseyevich Meleshko and Aleksandr Aleksandrovich Mitin, Atomizdat, 1600 copies, 256 pages]

[Text] Annotation

The book considers pulse oscillators intended to monitor parameters of recording electronic apparatus for experimental physics and basic methods of such monitoring. Special attention is devoted to methods for forming pulses of precise amplitude and methods for reproducing given time intervals. Methods are considered for pulse sequences with various pulse distribution laws in time, and methods for peaking and shortening pulses, as well as program control of measuring parameters of oscillators and their use in automatic monitoring systems.

The book is intended for a wide audience of scientific-technical workers concerned with pulse measurements.

Ninety-eight illustrations. Bibliography contains 284 titles.

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UDC 662.75:665.613:66-794

USING LIQUID FUELS AT LOW TEMPERATURES

Moscow PRIMENENIYE ZHIDKIKH TOPLIV PRI NIZKIKH TEMPERATURAKH in Russian 1980 (signed to press 11 Nov 80) pp 2-4

[Annotation and table of contents from book "Using Liquid Fuels at Low Temperatures", Third Revised and Enlarged Edition, by Boris Abramovich Englin, Izdatel'stvo "Khimiya", 3340 copies, 208 pages]

[Text] The book presents the operational properties of liquid fuels (flight, automotive, diesel, heating, gas turbine, engine, boiler) at low temperatures, describes the changes undergone by fuel under these conditions, points out the steps necessary for eliminating all complications that arise when liquid fuels are used under low temperature conditions.

The book is intended for petroleum refinery engineers, engineering and technical workers in automotive, air, railway and water transportation, as well as workers in the power industry involved with the operation of machines and power plants at low temperatures (under winter conditions, in the far north, at high altitudes and so on). Figures 87, tables 47, references 228.

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