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18 FEBRUARY 1987

USSR REPORT

ENGINEERING AND EQUIPMENT

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USSR REPORT

ENGINEERING AND EQUIPMENT

CONTENTS

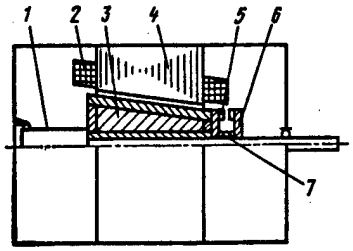
HIGH-ENERGY DEVICES, OPTICS AND PHOTOGRAPHY

/13046

CONTROLLED ELECTROMAGNETIC BRAKE

Moscow MASHINOSTROITEL in Russian No 5, May 86 p 26

[Article by Doctor of Technical Sciences I.Kh. Khayrullin, D.I. Batyrgareyev and Candidate of Technical Sciences F.R. Ismagilov, under the "It Can Be Used at Your Enterprise" rubric]



[Text] A controlled electromagnetic brake (Certificate of Authorship 694953) with a tapered secondary system for use in shock-absorption systems of automatic and electrical drive equipment and in mating mechanisms for dissipation of kinetic energy of moving masses has been developed at Ufa Aviation Institute imeni S. Ordzhonikidze. The electromagnetic brake consists of stator 4 with concentrated excitation windings 2, tapered squirrel cage rotor 3, driving tooth-type half-coupling 6, installed on shaft 1, and driven tooth-type half-coupling 5. The output end of the brake shaft is connected rigidly to the object of braking; when the latter operates, rotor 3 is accelerated by rotating shaft 1, due to friction forces. Constant voltage is supplied to excitation winding 2, whereas the ensuing electromagnetic force turns rotor 3, overcoming the resistance of spring 7. Driven half-coupling 5 kinetically engages with driving half-coupling 6. As a result, the rotor occupies the operating position, limited by the size of the brake air gap, and stops in the axial direction. When the voltage is turned off, the rotor moves under the influence of elastic forces of the spring, and the tooth-type coupling disengages. Braking electromagnetic torque is created by interaction of eddy currents, induced in the tapered squirrel cage rotor, with the

magnetic field in the brake air gap. The capability to turn the rotor relative to the shaft, that is fixed in the axial direction, makes it possible to reduce dynamic shock torque, when engaging the brake.

12770
CSO: 1861/468

SUSPENSION OF MACHINE TOOL TO DAMPEN VIBRATIONS TESTED

Moscow IZOBRETATEL I RATSIONALIZATOR in Russian No 8, Aug 86 pp 10-11

[Article by Yu. Yermakov: "'There On Chains of Iron ...' A Machine Tool Was Protected from Vibration, Cooling and Overheating of the Base through Suspension on Cables"]

[Text] Structural rigidity is good where there is no vibration. The rule: "The more rigid the structure the more reliably and accurately it operates" is effective until the first shock. The first buildings to be destroyed in earthquakes are precisely those on rigid foundations. Rigid structures are the most sensitive to vibrations.

At the beginning of the 1960's we designed tangential turning lathes. On them the cutting tools move along the tangent to the rotating blank and not radially, as is usual. Among its many virtues it is no accident that the high rigidity of the system stood out - both the spindle and the carriage were mounted in one housing (the way they are configured can be seen from the diagram). In fact the unified spindle and carriage head was the lathe, but the bed ... Here this respected part served as nothing more than a support and a trough for shavings. Thus it happened that in determining the form of the lathe the designers shuffled the poor head from pillar to post at various heights until they discovered by chance that it did not matter what it stood on - whether on a trestle, on a wooden table or on an iron base. The cutting forces, rampaging between the spindle and the carriage quieted down in the housing of the head itself, and the internal trembling from their contention is hardly perceptible on the outside. This means that if the support is transformed into a cushion this trembling too could easily be dampened. Would it be possible to dispense with the cushion too? The head could be suspended on cables like a cradle!

A serious "fault" was quickly seen in this proposal: it contradicted the classical concept according to which rigid machine tool foundations are necessary. In everything else, however, the idea was not bad. In fact, even a locomotive, suspended by a super-strong wire will not move anywhere, as though it did not get up steam and the crank did not chatter.

Could a machine tool be suspended as for transport on the hook of a truck crane? It is reliable enough in view of the fact that the number of attachment points corresponds to the number of basic supports. Cables from above, however, clutter the productive space and hinder the operation of auxiliary

mechanisms and the traveling crane. There is another shortcoming: the distribution of the weight on inclined cables generates horizontal forces that deform the bed in the longitudinal direction.

You'll never believe it but help came from ... Pushkin.

"Her casket to six pillars
There on chains of iron
Carefully was fastened,
With a lattice guarded. "

The poet understood intuitively that suspension from one point would deform the casket but suspension from several points on parallel chains would distribute and balance the load evenly.

We too are utilizing the genius's hint. We shall mount posts along the perimeter of the bed and suspend the lathe from them.

It turned out to be more convenient but still rather clumsy. Then we hid the posts underground. The foundation was simplified to the extreme: just a few openings under the bottom of the bed, pipes on which the bed is supported are lowered into them on cables, and the cables are fastened to pedestals mounted on the shop floor with the aid of adjusting screws. The result was a multiple pendulum suspension (inventor's certificate No. 931 353). By slightly changing the distance of the support washers of the cables from the pedestals with the screws it is not difficult to adjust the horizontal position of the machine tool.

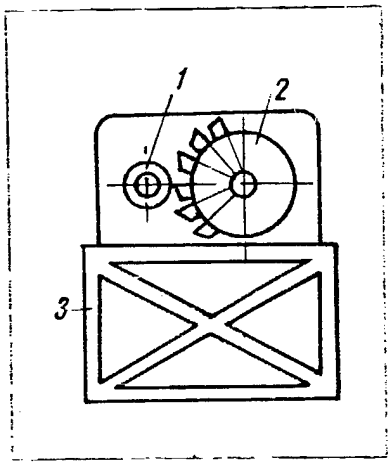
The system turned out to be exceptionally reliable and vibration-resistant. The pendulum suspension is capable of dampening vibrations of any amplitude and frequency. In the strongest earthquakes the suspension reliably preserves the machine tool from damage, and during normal operating vibrations it reliably insulates the bed from any shaking of the base. If a cable breaks it is not a disaster, since the bottom of the bed drops down on the shop floor (the gap is not large).

A short time after the receipt of the inventor's certificate a request arrived from the Arctic for a flexible fastening system. In permafrost conditions installing machine tools and machinery to, let us say, pillars is a very difficult matter. Sometimes resort is even made to freezing, as the Leningraders did during the blockade winter in 1942. Then the workers in the hoisting and conveying equipment plant installed a machine tool in the pit under the foundation, substituting water for cement! The thirty-below-zero weather in the unheated building bound the bed with ice, and the icy base held the machine tool reliably until the April thaw. Such inventive innovations, however, were tricks made necessary by an exceptionally difficult situation. Flexible suspension on cables, on the other hand, is suitable under any conditions and at any temperatures. The technology for installing it is extremely simple. It is sufficient to drill several openings in the permafrost with a diameter of 60 - 80 mm to a depth of one to one and one-half meters, cut

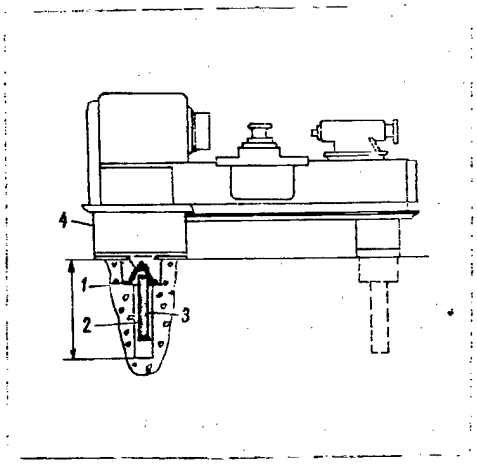
suitable pipes and select cables of the appropriate length. In place of steel cables hemp or nylon ropes can be used. The materials are common; they are always at hand in field conditions. The pedestal is simple; it can be welded from a standard angle iron and strips. Suspending the machine tool above the foundation means protecting it from the permafrost and protecting the permafrost from thawing.

Ice and flame. It was requested in the polar region but the first ones to introduce it were the metallurgists at the Podolsk chemical and metallurgical combine. Only they had to protect themselves not from cold but from heat. The machine tool, which is suspended above the casting floor of the metallurgical shop, is reliably protected from contact with the molten metal and with the heated foundation. The fiery river runs under the machine tool as though it were a bridge, flowing past the pedestal of the flexible suspension. Now it is not necessary to set up a complicated base insulated from the heat.

Suspending machine tools and machinery on cables is just taking its first steps at present, but there is no doubt that it does not fail in extreme circumstances. Reliable vibration and heat insulation in combination with extreme simplicity of construction, adjustment and repair provide a guarantee for this.



Tangential turning. The spindle 1 and the rotating carriage 2 are mounted in one housing. The system is rigid and the bed 3 here is just a support and a trough for shavings.



Suspended lathe. The cables 2 are fastened to the pedestals 1 in the pipes 3. The bed 4 is suspended from these cables.

12893
CSO: 1861/6

FIRST PHASE OF NEW HIGH-CAPACITY ROLLING MILL COMPLETED

Moscow EKONOMICHE SKAYA GAZETA in Russian No 21, May 86 p 5

[Article by M. Semenov]

[Text] The 27th CPSU Congress pointed out the need for improving the structure and quality of metal products on the basis of wide-scale technical re-equipment of ferrous metallurgy. The Izhorskiy Zavod association recently completed the erection of the first start-up complex of the first section of the "5000," a mill which has a design capacity of 120,000 tons a year. The design possesses enormous technical capabilities. The time periods established for run-in of the first start-up complex were reduced by a third. Contributing to the success of the task was the fact that many persons presently producing high-quality products with this mill participated in the installation and adjustment of the equipment. The significance of the event goes far beyond the limits of the enterprise, which is a bellweather of domestic power machine construction. The plates and sheets of high-strength low-alloy stainless steels make it possible to considerably enhance productivity and improve the characteristics of equipment intended for nuclear power plants and chemical production facilities. This kind of product is also needed in ship construction. "The total planned capacity of the mill is 650,000 tons, including 550,000 tons a year with heat treatment for sheets. This is the outlook. The first section of the '5000' is rated at 370,000 tons," said V.G. Zorin, production administration deputy chief of Minenergomash [Ministry of Power Machine Building]. This project includes, in addition to the mill proper, electric smelting and heat treatment shops. It has been determined that the cost of all construction amounts to about one billion rubles. The work done so far accounts for 160 million rubles. Here it will be possible to produce rolled metal in thicknesses of 10 to 450 millimeters. Sheet width after the edges are cut is 4-6 meters, and length, 16 meters. Maximum size plate or sheet is rolled from a single ingot weighing up to 120 tons. A force of 9,000 tons is obtained in the rolling process. The chemical composition, mechanical and physical properties are uniform in the entire length of the sheet. Designers will be able to effect considerable weight reduction in machines made of the high-strength material. The large sheet sizes make it possible to decrease the number of welded joints in the fabrication of various assemblies. The unique equipment installed in the first start-up complex was made by the Izhorskiy Zavod and Novokramatorsk machine builders themselves. They are also fabricating the equipment for the remaining mill sections. It is planned to produce only negative tolerance products, thus making it possible to conserve large amounts of valuable metal.

13005/13046
CSO: 1861/360

BRIEFS

NEW TECHNICAL DISCOVERIES--The acceleration of scientific and technical progress has benefited by the research performed by laureates of the Lenin Komsomol Prize for 1985 in science and technology. Pointed out below are the prospects opened up by discoveries made by young scientists. "Investigation, Development and Implementation of an Explosion Welding Process Cycle Relative to the Manufacture of Assemblies and Equipment for Power Machinery, Ferrous Metallurgy and Railroad Applications." This "puff-pastry," which can be made of virtually any metals, can be "baked" by the explosion welding method. The young scientists were awarded the prize for their continuing developmental work. This "pastry" can, if required, be as hard as steel and as light as aluminum. In addition, the entire process has a duration of 0.000001 second, which has made it possible, for example, to join a bleed line to a pipeline in use. The flow of water in the main was not interrupted, not even for a second! "Development and Application of a Carbon Monoxide Oxidation Catalyst to Catalytic Cracking Units." Just one pinch of white powder and 200 tons of carbon monoxide, which was previously exhausted into the atmosphere, burn up in a petroleum catalytic cracking unit. However, the miraculous oxidation catalyst not only protects the air from harmful exhausts. It also makes it possible to conserve up to half the fossil fuel. "Research and Development of Progressive Scientific and Technical Solutions Relative to Improving the Operational Reliability of Railroad Tracks." A foam plastic blanket offers reliable protection from freezing for railroad embankments subjected to expansion. And a concrete bed resting on strong supports will soften the impact of train wheels against rails during entry onto a bridge or in a tunnel. [By S. Kuzmin] [Text] [Moscow KOMSOMOLSKAYA PRAVDA in Russian 11 Feb 86 p 1] 13005/13046

NEW TANK MANUFACTURING PROCESS--Die-forging equipment and a method for manufacturing hermetically sealed tanks and containers in various shapes made of heterogeneous and homogeneous metals using pressure welding (author's certificates 620355 and 1011353) have been developed in the Tula Polytechnic Institute. The use of the new technology will make it possible to increase the labor productivity an average of 30% compared to rolling, extend product storage life by 2 to 25 times (up to 25 years) and conserve ancillary materials (sealants). Strength of the joint is increased by 1.5 to 2 times. The annual savings anticipated by applying the technology will amount to 350,000 rubles. [VDNKh SSSR] [Text] [Moscow MASHINOSTROITEL in Russian No 3, Mar 86 p 3] 13005/13046

NEW FITTING INSTALLATION MACHINE--The OM-25, a highly efficient machine which installs couplings on the ends of high pressure hoses, has been developed in the scientific production association VPTIstroydormash [All-Union Planning and Technological Institute for Construction and Road Machinery Manufacture]. It assures a leak-proof seal and high bond strength for the fittings and reinforced hose. By means of a changeable tool, the machine is capable of accommodating high pressure hoses of various types, sizes, and designs of any length, with different nominal inside diameters and with straight (i.e., directed along the hose axis) positioning of terminal fittings. The machine has been introduced at the Moscow plant Mettallorukav, where the annual savings will comprise 15,000 rubles. [VDNKh SSSR] [Text] [Moscow MASHINOSTROITEL in Russian No 3, Mar 86 p 3] 13005/13046

ROMANIA'S POWERFUL DRILL PUMP--Photo [photo not reproduced] shows the most powerful drill pump in the world. The unit was produced at the May 1 Plant, in the city of Ploesti, Romania, which is especially famous in the international market. The TIB-85 pump, exhibited at the Bucharest International Trade Fair, is impressive in size, has 2,050 h.p., and is able to develop pressure up to 1,050 atmospheres. [Text] [Moscow TEKHNIKA I NAUKA in Russian No 7, Jul 86 p 39] [COPYRIGHT: "Tekhnika i nauka," 1986] 6091/13046

NUCLEAR PLANT CONFIGURATION SYSTEM DEVELOPED--A special system of the SIS-type was developed by the NPO TSNIITMASH [Scientific Production Association of the Central Scientific Research Institute of Machine Building] for determining the size, shape and relative surface configuration of large components and equipment for nuclear power plants. It provides a series of methods and systems for coordinate measurement that are used with heavy-duty metal-cutting NC machine tools. A.s. [inventor certificate] No 891218. Address for inquiries: Moscow, 10988 Sharikopodshipnikovskaya Street No 4. [Text] [Moscow TEKHNIKA I NAUKA in Russian No 7, Jul 86 p 33] [COPYRIGHT: "Tekhnika i nauka," 1986] 6091/13046

CORROSION SPECTROPOTENTIOMETER DEVELOPED--A unique instrument, according to the specialists, was developed recently at the republic Center of Electronic Microscopy at the Georgian Polytechnic Institute imeni V.I. Lenin. This device, named "spectropotentsiostat" by its inventors, is automated and considerably facilitates and enhances the study of corrosive processes in metals in any electrolytic media. This instrument can be successfully utilized by chemical, petrochemical and metallurgical industries. Construction of the "spectropotentsiostat" is already protected by an inventor's certificate, and is patented in West Germany, the United States, England, and Japan. The device was demonstrated at a series of international exhibitions where it attracted the attention of reputable scientists. Recently in Bulgaria, it received an award from the Worldwide Young Investors Exhibition. [By Mikhail Dzhindzhikhashvili] [Excerpts] [Tbilisi ZARYA VOSTOKA in Russian 7 Aug 86 p 4] 6091/13046

CSO: 1861/59

UDC 658.512

STATE-OF-ART COMPUTER-AIDED DESIGN SYSTEM FOR TECHNOLOGICAL PROCESSES IN FLEXIBLE MANUFACTURING SYSTEMS

Moscow MEKHANIZATSIYA AVTOMATIZATSIYA PROIZVODSTVA in Russian No 5, May 86 pp 25-28

[Article by N.I. Reshetnev, candidate of technical sciences, and Ya.D. Penek, engineer]

[Abstract] The latest computer-aided design system for reliable machining process planning within a sufficiently short time includes data input with automatic supplementation of initial data, layout of machining routes, setup of manufacturing operations, composition of tools and fixtures, formulation of programs, and documentation. Input data come from models of FMS subsystems, warehouses, and production forecasts. Most important is the setup of manufacturing operations, based on five rules for combining process bases used to shape parts, machine surfaces, and produce holes; the principal three categories of process bases being supporting, reference, and guiding surfaces. In the case of multioperational machine tools, seven possible conditions have been identified which will determine the sequence of operations and the distribution of transfers in layout of routes. The design program, in coded form, follows the appropriate flow charts and tabulations for each stage of the design process. Figures 4, tables 7.

2415/13046
CSO: 1861/509

UDC 621.317.08

OPTIMAL AND SUBOPTIMAL ALGORITHMS FOR ESTIMATING EKG PARAMETER WHEN NOISE IS PRESENT

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 28, No 6, Jun 85 (manuscript received 4 May 84) pp 66-71

[Article by Yu.S. Radchenko and D.A. Presnyakov, Voronezh State University imeni Leninist Komsomol]

[Abstract] Microprocessor EKG analysis algorithms are deterministic, making effective utilization difficult when fluctuation noise is present. This work

reports on the synthesis of optimal and near-optimal algorithms for estimating the signal repetition period (heart rate) in noisy EKG recordings, investigates the noise tolerance of the algorithms and reports on studies of one algorithm, implemented on an Elektronika-60 M microcomputer. The optimal algorithm is quite noise tolerant, but its implementation is difficult due to variations in the shape of EKG pulses as loads change and from subject to subject, and because the algorithm requires the syncing of a reference pulse sequence with the first EKG pulse. A near-optimal algorithm is suggested which does not have these disadvantages, and has much less sensitivity to instability of the heart rate during the course of observation. Figures 3, references 2: Russian.

6508/13046
CSO: 1861/476

UDC 621.921:666.1

LOW-TEMPERATURE VITRIFIED-BONDED ABRASIVES

Kiev VISNYK AKADEMIYI NAUK UKRAYINSKOYI RSR in Ukrainian No 6, Jun 86 pp 57-61

[Article by P.S. Kyslyy, corresponding member, Ukr SSR Academy of Sciences, and Ye.K. Bondaryev, candidate of technical sciences]

[Abstract] The need for precise instruments for novel abrasives and the processes used to provide such high-quality abrasive products are discussed. Ceramic (vitrified-bonded) materials meet and even exceed wear resistance shown by metal-based abrasives. However, the processing temperatures involved -- on the order of 1000-1500°C -- exceed the upper stability limits of diamond and cubic boron nitride. In view of this, novel systems have been developed with processing temperatures of 800°C or lower that meet all the strength, stability, and abrasiveness requirements. The most promising bonding systems in this category appear to be represented by $Na_2O-B_2O_3-SiO_2$ (F-1) and $PbO-ZnO-B_2O_3-SiO_2$ (STs). Experience to date shows that the loss of the diamond component due to oxidation in air and chemical interaction with the bonding material under various conditions of temperature and technical processes in STs and F-1 has been reduced 7- to 10-fold and does not exceed 2.5%. Losses of cubic boron nitride in such materials are generally less than 3%, again confirming the extensive scope of application of these materials. Figures 2, tables 1, references 19: 17 Russian, 2 Western.

12172/13046
CSO: 1861/535

UDC 621.372.412/.414:537.228.1

LOCAL ENERGY LOSSES IN A PIEZOCERAMIC RESONATOR UPON ELECTRIC EXCITATION

Moscow ELEKTRICHESTVO in Russian No 4, Apr 86 (manuscript received 24 Sep 85) pp 66-70

[Article by A.V. Mezheritskiy and P.Ye. Kandyba, Moscow]

[Abstract] A study is made of the electro-elastic field in zirconium-lead titanate piezoceramic materials in the case of weak fields, assuming no free space charges. The solution of the problem is sought in the quasi-electrostatic approximation. Equations are derived for the balance of local energy losses in such resonators considering the dissipative properties of the piezoceramic by representing the mechanical, dielectric, and piezoelectric constants in complex form. The distribution of local losses and thermal losses is calculated for mild oscillation in a rod-type resonator. It was experimentally established that at certain frequencies in the vicinity of a primary resonance the local losses are less than the dielectric losses, which is directly related to the presence of the imaginary part of the piezoelectric modulus. The presence of a piezoelectric energy loss component changes the energy efficiency of the resonance characteristics of a resonator. References 10: 6 Russian, 4 Western.

6508/13046
CSO: 1861/496

UDC 681.2.531.7

METHOD OF CONSTRUCTING MATHEMATICAL MODEL OF THEORETICAL ERRORS IN 2-ARM LEVER MECHANISMS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 29, No 5, May 86 (manuscript received 24 Oct 85) pp 58-64

[Article by M.N. Ivanova and V.P. Petrov, Leningrad Institute of Precision Mechanics and Optics]

[Abstract] In planning 2-arm lever mechanisms, the traditional method is to determine the motion transformation function of the mechanism and then determine the theoretical error. A second approach is also possible, combining two single-arm leverl mechanisms. This article presents a comparison of these planning methods on the example of use of mathematical models of the theoretical errors. It is recommended that the second method be used to plan 2-arm lever mechanisms. References 1: Russian.

6508/13046
CSO: 1861/478

UDC 62.758.2

CALCULATION OF DYNAMIC CHARACTERISTICS OF PRINTED CIRCUIT BOARDS WITH COMPLIANT AND DAMPED MOUNTINGS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 29, No 5, May 86 (manuscript received 4 Jul 85) pp 64-68

[Article by A.S. Panov, Leningrad Institute of Precision Mechanics and Optics]

[Abstract] A study is made of the influence of linear compliance and the damping properties of point mountings of a printed circuit board on the frequency of its resonant oscillations and bending dynamic coefficient. Studies were performed by a finite-difference method on a computer using a group of programs written in FORTRAN-IV. It is concluded that by regulating the linear stiffness of mounting points for boards mounted at 4 points, it is possible to change the resonant oscillating frequency over a broad range. Support point rigidity significantly influences the dynamic coefficients for various points on the boards. The change in resistance coefficient has little influence on resonant frequency over a broad range. The resistance factor of the mounting points has an optimal value for minimizing dynamic coefficients and thus maximizing vibration damping. The use of compliant and damping mounts can thus decrease the dynamic coefficient. Figures 3, references 4: Russian.

6508/13046
CSO: 1861/478

UDC 539.3

USE OF FOURIER SERIES FOR CALCULATION OF NONLINEAR STRAINS IN CIRCULAR RING OF VARIABLE STIFFNESS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 22, No 6, Jun 86 (manuscript received 15 Oct 84) pp 69-75

[Article by A.M. Timonin]

[Abstract] The method of Fourier series for solution of nonlinear stress-strain problems, applicable to nonaxisymmetric bodies such as a closed ring with variable cross-section, is extended to a ring with circumferentially variable stiffness. The problem for such a ring of a shear-resistant orthotropic material is formulated in a three-dimensional system of rectangular coordinates with two axes, normal and transverse, not necessarily principal or central axes of a ring cross-section but coinciding with the axes of orthotropy. The complete system of nine geometrical relations for strains and displacement, six equations of balance for forces and moments, and six equations of elasticity is reduced to a resolvent system of 12 nonlinear first-order ordinary differential equations in forces and moments as well as

linear and angular displacements, three of each. The system has been solved with the aid of Fourier series for a ring with a stiffness distribution symmetric with respect to a diameter, under a radial load uniformly distributed over two diametrally opposite segments also symmetric with respect to the same diameter. Numerical results for a typical ring agree closely with results of exact solution by the method of quasi-linearization and numerically stable discrete orthogonalization in each successive approximation. Figures 1, tables 1, references 12: Russian.

2415/13046
CSO: 1861/469

UDC 539.377:624.073:624.072.4

THERMALLY STRESSED STATE OF CIRCULAR PLATES COUPLED THROUGH SLEEVE

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 22, No 6, Jun 86 (manuscript received 22 Jan 85) pp 75-81

[Article by Yu.A. Chernukha and N.I. Voytovich, Institute of Application Problems in Mechanics and Mathematics, UkSSR Academy of Sciences, Lvov]

[Abstract] The thermomechanical behavior of compound structures during heating is analyzed, as a specific example being considered a solid disk fitting inside an annular disk with clearance but offset coaxially and coupled to it through a cylindrical sleeve-beam. The thermal problem of the temperature field in this structure is formulated as a system of differential equations of heat conduction, in dimensionless form with the Biot number, and the temperature analog of mechanical bending moments. Its solution requires determination of thermal resistances and heat transfer coefficients. The thermoelastic problem of the equilibrium state of stress and strain is then formulated so as to include not only thermal flexure but also the generalized plane state of stress. The results of calculations for a sleeve of carbon steel coupling a solid disk of carbon steel or quartz glass to an annular disk of duralumin reveal that stresses and strains within the coupling zones remain constant as the outside radius of the annular disk is increased beyond a critical magnitude which depends on the physico-mechanical properties of all three components. They also indicate that asymmetry of coupling will influence the state of stress and strain quantitatively as well as qualitatively, with a possibility of forces on the solid disk reversing direction. Figures 5, references 3: Russian.

2415/13046
CSO: 1861/469

UDC 620.178.5.05+628.517.4+62-752-85

PNEUMATIC VIBRATION ISOLATION SYSTEMS WITH VARIABLE STRUCTURE

Moscow MASHINOSTROITEL in Russian No 5, May 86 p 27

[Article by A.V. Andreychikov, candidate of technical sciences, O.S. Kochetov, candidate of technical sciences, and V.A. Grishin, candidate of technical sciences]

[Abstract] Pneumatic systems with variable structure, automatically adaptable to the frequency of external perturbing forces, are now considered most promising for vibration isolation. The first version of such a system (USSR patent No 1161736) has still a permanent structure, which includes a shell made of corded rubber with bilateral corrugation to serve as sensing chamber, a movable cleat, a damping chamber, a parallelogram of levers, a jet tube, and a float lever mechanism with level-regulating valve holding it in a horizontal position under variable weight. The air pressure under a man's weight of 80 kg is 0.42 MPa. The second version (USSR patent No 1201585) has already a variable structure, with a lever whose one arm is hinged to a movable cleat and the free other arm carries a dead weight of 9 kg. The lever ratio is 2.9 and the air pressure under a man's weight of 80 kg is 0.28 MPa. The next two versions employ a throttling device for adaptively varying the structure on the basis of resonance. One of them employs a gate valve as resonator in a beaker with radial holes around the stem (USSR patent No 954261). Another one employs a spring-supported horizontal baffle inside a damping chamber, with several tapered holes in the baffle for tapered resonator plugs to slide in or out (USSR patent No 1145184). All these pneumatic devices with variable structure were tested in diesel locomotives, with magnetic recording of vibrations and with computer processing of data for performance evaluation. They were found to perform satisfactorily at infralow resonance frequencies as well as at high frequencies above resonance. Figures 1.

2415/13046
CSO: 1861/484

UDC 621.865.8

NEW STRUCTURAL DESIGNS FOR MANIPULATOR GRIPS WITH GRIPPING FORCE ENHANCEMENT MECHANISMS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 5, May 86 pp 5-6

[Article by Yu.F. Gvozdev, egnineer]

[Abstract] Force multiplication by increasing the mechanical advantage of linkages operating the gripping jaws of manipulators is preferable in applications where size and weight must be minimized. Three new structural designs for such mechanical linkages are pictured and discussed in detail

(USSR Patent Nos 960008, 1016156, and 1104018). The force multiplier in the first is a hinged four-member linkage in a pneumatic drive containing two pistons. The second design employs a wedge mechanism in order to increase the grip and provide a constant applied force in operation. The sleeves of the pneumatic cylinders and their seals wear more because of the high concentrations of stresses in the above two designs. The third structure is a modification of the second that provides stronger components at the stress points. The designs develop significantly increased clamping force that is constant over the travel of the jaws with a low air consumption for the pneumatic drive, which enables the use of small cylinders. The grips are applicable to assembly operations such as riveting and pressing in pins. Figures 2.

8225/13046
CSO: 1861/373

UDC 621.865.8:621.98.043

MANUFACTURING ENGINEERING ASPECTS OF DESIGN OF ROBOT-EQUIPPED MANUFACTURING SYSTEMS FOR SHEET METAL DIE FORGING

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 5, May 86 pp 46-47

[Article by Ye.I. Semenov, doctor of technical sciences]

[Abstract] Questions of the requisite changes in sheet metal forming technology related to the use of industrial robots that handle workpiece blanks have been inadequately treated in the literature. This paper is a brief and general discussion of the requirements placed on sheet metal blanks, the die forging process itself, the dies, forging presses, and the robot control systems. In addition to enumerating such obvious requirements as the reliability of the manufacturing process, the cleanliness of the workpieces, prohibitions against cutting two sheets simultaneously, etc., the necessity of having a control system that generates signals for the end of travel of a press, the presence of a blank in the feeder and in the work position as well as alarm signals is also noted. More extensive use of sensors (such as die wear and blank positioning transducers) is called for. The very general treatment provides neither specific figures, drawings, nor examples of system designs.

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CSO: 1861/372

UDC 621:658.62.018.012

PRODUCT QUALITY CONTROL IN MACHINE BUILDING

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 5, May 86 pp 55-61

[Article by A.D. Nikiforov, doctor of technical sciences]

[Abstract] Task-level quality control systems are being devleoped within the framework of a systems engineering approach in order to solve the problem of product quality control. A general description of the control system structure is followed by the details of the sequence of steps for product quality control in the machine building sector. The inputs at the top of the flow chart showing this sequence are the quality indicators and constraints that condition the formulation of the task, the choice of control parameters, the design of the functional structures of the product, with the sequence output being the manufacturing precision, standardization, and the actual quality control testing of the products. The basis for the functional analysis of products is mathematical modeling, employing comprehensive optimization of the quality control in order to eliminate the gap between the specified and final QC indicators. Such modeling is illustrated with a flow chart showing the initial input the selection of the quality indicators that in turn governs both physical and mathematical simulation so as to ultimately generate the final QC data and recommendations. Procedural approaches are being developed for the construction and study of mathematical models for the optimization of the functional parameters of products and their components. The study of such models has shown that comprehensive optimization of components must be executed simultaneously for the aggregate of parameters in three groups: quality indicators, material and geometric parameters. While this paper notes that an algorithm has been developed for the comprehensive optimization of the parameters of machines and metal components in terms of mechanical properties, no specific numerical data or application examples are cited. The design of problem-oriented packages of applied programs has been started in order to formulate the process of optimization on an industrial basis at the Moscow Higher Engineering School imeni N.E. Bauman in conjunction with the organizations of Gosstandart. Figures 3.

8225/13046
CSO: 1861/372

UDC 389:003.13

ESTIMATION OF COST EFFECTIVENESS OF METROLOGICAL SUPPORT DEVELOPMENT UNDER PRESENT CONDITIONS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 5, May 86 pp 67-71

[Article by L.V. Besfamilnaya and I.V. Kurnikov, candidates of economic sciences]

[Abstract] Since a characteristic feature of the metrological support services for Soviet industry is the fact that the final result has no specific physical form, but rather creates conditions for better production and the acceleration of scientific and engineering progress, cost effectiveness analysis of such support must be based on criteria that reveal the economic essence of the impact of measurement quality on manufacturing quality and efficiency. The inherently infrastructural nature of metrological support (metrological services are usually rendered on an interregional, intersectoral, or even statewide level) necessitates a comprehensive national economic approach to the analysis of metrological efforts. In linking the goals of metrological support to the goal of socialist production, this comprehensive approach must take into account the following: 1) Maximum consideration of the major economic consequences of improving the level of metrological support for the economy as a whole and the individual cost accounting unit (including social and ecological consequences); 2) Maximum consideration of the requisite costs of a particular metrological effort; 3) Evaluation of the overall national economic impact, first as applied to the end product, and then in interrelationship with all of the equipment, physical and human resources used in the operation of the particular product; 4) Estimation of the integral (national economic) savings over the long term; 5) Assurance that the metrological support variants being compared are identical with respect to the main criteria; 6) Estimation of the comprehensive indicator indicating the level of metrological support as a function of the resulting error in measurements and the quality of the testing of the physical parameters; 7) Development and implementation of metrological standards in the calculations of overall manufactured system efficiency; 8) Selection of the comparison base and base year for the estimation of the major directions for metrological support expansion; 9) Estimation of participation of individual enterprises and units as well as individual metrological support components in generating the total national economic savings during the specified accounting period and 10) Estimation of overall cost effectiveness of metrological measures taken in the accounting period, against the background of the obligatory, established total national economic savings. The target indicators for social and economic development must be brought into line with appropriate cost effectiveness criteria through the development of a system of goal-directed, comprehensive indicators for metrological support expansion that reflect the extent to which the demand for such support is met on a national scale. An empirical expression is given for calculating the total national economic impact of metrological support efforts as well as an expression for the total cost accounting based economic impact over the accounting period. No sample calculations or application examples are given. References 12: Russian.

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CSO: 1861/372

UDC 621.830

DESIGN OF TOOTH-CUTTING TOOL AND OF SPROCKETS FOR CHAIN DRIVES

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 6, Jun 86 (manuscript received 21 Nov 85) pp 47-52

[Article by I.I. Lisitskiy, graduate student, P.N. Uchayev, candidate of technical sciences, docent, and K.P. Zhukov, candidate of technical sciences, professor]

[Abstract] Design of a tooth-cutting tool for automatic production of chain-drive sprocket wheels by a machine tool is analyzed, considering a rack and a wheel as the two basic forms of such a tool. The forward problem is to determine the true profile of sprocket teeth formed by the tool in accordance with the given generating contour. The inverse problem is to determine the true profile of tool teeth for cutting sprocket teeth with the given profile. Both problems are solved on the basis of geometrical and kinematic analysis according to the theory of envelopes, their solution being reduced to determination of the respective enveloping surface. The true profiles are then compared with theoretical or standard ones, considering that the performance of a chain drive will depend on the correspondence of the radii of curvature and of the angles at corresponding points of the two profiles. Such a comparison was made on a YeS-1022 computer according to the REVKA program, for a specific chain drive. The results indicate that profile deviations do not depend significantly on the form of cutter, whether rack or wheel. However, a wheel is preferable for sprockets with up to 12 teeth and a rack is preferable for sprockets with more than 12 teeth. Figures 2, tables 1, references 2: Russian.

2415/13046
CSO: 1861/538

UDC 658.512.011.56:681.3.06

FORMING AND SELECTING STRUCTURE OF OPERATIONS FOR FABRICATION OF HULL PART IN NC MACHINE-TOOL MODULE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 6, Jun 86 (manuscript received 20 Sep 85) pp 145-148

[Article by N.M. Kapustin, doctor of technical sciences, professor, Ye.A. Zagoruyko, candidate of technical sciences, docent, and V.A. Tsekhmeystruk, graduate student]

[Abstract] The authors have developed a computerizable procedure for forming and selecting operational structures in an NC machine-tool module. The problem is solved in three stages, the first stage being presentation of input data on the machine-tool module and on the part to be fabricated in a form most convenient for determining the transfer distribution. The next

stage is construction of the algorithm which will yield possible distributions of transfers in one setting, under given machining constraints. The last stage is selection of the optimum operational structure or transfers distribution according to the efficiency criterion, namely, minimum total time including not only productive time and idle time but also retooling time after a change of setting. The algorithm is constructed so as to allow for storage of better structures from among which the optimum one will be selected. Figures 1, references 5: Russian.

2415/13046
CSO: 1861/538

UDC 621.91:621.9.011

INCREASING PRODUCTIVITY OF CUTTERS IN NC MACHINE TOOLS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 6, Jun 86 (manuscript received 20 Dec 85) pp 152-154

[Article by A.V. Kibalchenko, candidate of technical sciences, S.P. Babak, graduate student, and G.A. Zhigarev, graduate student]

[Abstract] The problem of optimizing cutter performance in an NC machine tool is considered, the conventional criteria being maximum volume of material a rough-machining tool removes in its useful life and maximum surface area a fine-machining tool covers in its useful life. These criteria need to be modified by including tool life as a variable so that also the cutting process can be optimized with adaptation to machining requirements. The principal parameters of the cutting process are cutting speed, depth of cut, feed rate, and tool wear. An increase of the feed rate, for maximum productivity, is limited by excessive temperature rise and resulting excessive tool wear. A study including nondestructive inspection made on a 16K20T1 NC lathe, and with a VCo8 tool bit in an MNTP fixture for cutting 15Cr18Ni12Si4TiAl heat-resistant steel, has revealed a dependence of the surface finish on the tool wear at various constant feed rates over the 0.1-0.4 mm/rev range. The surface roughness increases monotonically with increasing feed rate. As a function of the tool wear, the surface roughness first increases slightly till the tool wear reaches 0.2 mm and then decreases smoothly till the tool wear reached 0.8 mm. Within that range, therefore, the feed rate may be increased without degradation of the surface finish. The results of measurements indicate that both the cutting force and the temperature (thermo-e.m.f. of thermocouple) increase monotonically with increasing tool wear, which renders them unsuitable as basis for optimum feed rate control. As basis for optimum feed rate control can serve the amplitude distribution of acoustic emission signals, namely, the number of pulses within that distribution, which becomes minimum before the tool wear reaches 0.8 mm. Figures 2, references 5: Russian.

2415/13046
CSO: 1861/538

UDC 66.047

ANALYSIS OF JET FLOW IN PROBLEMS OF DRYING WITH JET NOZZLES AND MODIFIABLE DRYING CHAMBER GEOMETRY

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNICHESKIKH NAUK in Russian No 10, Issue 2, Jun 86 (manuscript received 4 Jul 84) pp 51-54

[Article by O.L. Danilov, V.I. Kosepkov, E.D. Sergiyevskiy, and Ye.S. Stepanova, Moscow Institute of Power Engineering]

[Abstract] Convective drying of thin flexible material by normally incident gas jets is considered, a 40-80% increase of the drying rate having been found to be attainable upon change of the trajectory of the wet object moving under the array of nozzles. An experimental study was made using an aerodynamic jar, with a single jet discharged from a nozzle impinging normally on flat or bent bottom surfaces, impermeable or permeable. The nozzle orifice was rectangular and 10 mm wide, with the initial dimensionless eddy viscosity 0.0012 or 0.0021 at the nozzle throat, while the bottom of the jar was 60 mm wide. Measurements were made with a set of "TSI" thermoanemometers, for a determination of velocity and turbulence profiles in jars with rectangular, parabolic, and V-form bottom surface. These profiles were then used as basis for numerical calculation of mean heat transfer rates. A theoretical study was made on the basis of the applicable energy equation and elliptical Navier-Stokes equations describing the evolution of a two-dimensional jet flow, assuming an incompressible heat carrier, a quasi-steady process, and a constant temperature of the jar walls, also that the thermophysical properties of both the heat carrier and the material to be dried are not temperature dependent. On this basis has been determined the dependence of the Nusselt number on the Reynolds number. All results reveal a strong role of filtration flow in the increase of the heat transfer rate upon change of the target surface from impermeable to permeable and from flat to bent. They also indicate the feasibility of reducing the size of a drying chamber to less than one-third by redesign. Figures 6, references 4: Russian.

2415/13046
CSO: 1861/528

UDC 621.224

PREPARATION OF GEOMETRIC INFORMATION ON HYDRAULIC TURBINE DRIVE WHEEL BLADE SURFACE FOR WORKING OF THE SURFACE ON AN NC MACHINE TOOL

Kiev PROBLEMY MASHINOSTROYENIYA in Russian No 24, Dec 85 (manuscript received 5 Mar 84) pp 98-101

[Article by I.S. Veremeyenko, S.S. Dekhtyar and A.Ya. Fainshraiber, Nuclear Turbine Building Production Association, Kharkov Turbine Plant imeni S.M. Kirov]

[Abstract] Working of a turbine blade on an NC machine tool requires calculation of the trajectory of motion of the milling cutter, which in turn requires centerline data. Processing of compound curves on a 3-axis NC machine tool requires the use of piece-wise approximating of the curves with straight lines. This means that one need define in the centerline data only a discrete number of points sufficient to allow working with the required accuracy and height of irregularities. Equations are derived for this purpose. The method developed for representing the surface of the blade is not universal, as is a method developed at the Institute of Mathematics, Siberian Division, USSR Academy of Sciences, and called the "blade system." However, the new method does not require redefinition of the surface of the blade and requires significantly less machine time than does the "blade system." Figures 1, references 2: Russian.

6508/13046
CSO: 1861/295

UDC 621.9.048.4-5

OPTIMUM CONTROL OF ELECTRICAL PARAMETERS IN ELECTRICAL DISCHARGE MACHINING

Moscow STANKI I INSTRUMENT in Russian No 2, Feb 86 pp 26-28

[Article by I.G. Veksel and A.I. Levin]

[Abstract] Automation of machine tools for electrical discharge machining in a flexible production system requires optimum sequencing and switching of process modes on the basis of the thickness of the layer of material removed from the blank-electrode by the tool-electrode. The object is to reduce the surface roughness of the blank part by wearing off a volume of material in minimum time, this being achieved by switching the process through a given number of stages. The process performance indicators are initial and final roughness of the blank-electrode surface, relative wear rate, and productivity. The variable and controllable parameters are repetition rate and duty factor of current pulses, ideally square ones, number of transistors in the power modules, and number of turned-on power modules in the pulse generator determining the pulse amplitude. A mathematical model of this process with a cylindrical copper tool-electrode and a steel blank-electrode with equal

active surface area in a "face-to-face" configuration has been constructed on the basis of a regression analysis of experimental data. On the basis of this model is now proposed an algorithm of automatic control, namely, automatic selection of the optimum sequence of process modes and optimum timing of mode switching. This algorithm has been programmed for electrical discharge machining of parts with various degrees of intricacy and for various products. Figures 3, tables 2, references 4: Russian.

2415/13046
CSO: 1861/308

UDC 621.923.6:621.9.025.726.5:658.524

SHARPENING CUTTERS FURNISHED WITH TIP MADE OF 'ELBOR-R' SUPERHARD COMPOSITE MATERIAL IN SERIES-PRODUCTION MODE

Moscow STANKI I INSTRUMENT in Russian No 2, Feb 86 pp 20-22

[Article by G.D. Zlochevskiy, S.V. Parsegov, and Yu.M. Zubarev]

[Abstract] The working surfaces of cutters produced at the Leningrad "Instrument" tool manufacturing plant have inserts made of the "Elbor-R" superhard composite material, both tip and haft being sharpened by plane grinding as an integral unit. A study of this grinding technology was made, for the purpose of optimization in the series-production mode. Experiments had already revealed that 1A1 250x75x15x5 ASA 80/63 wheels containing diamond grains with A2 coating and V2-01 binder are highly productive when grinding the front surface (2300 cutters/shift) but not so productive when grinding the back surface, owing to cracking and chipping of the superhard surface with a consequently high reject rate. Special 1A1 diamond wheels were, therefore, developed at the All-Union Scientific Research Institute of Natural Diamonds and of Tools. They contain uncoated diamond grains and the V1-08 organic binder on A1-1P polyalkane imide resin instead of the V2-01 organic binder on SFP-012A phenol formaldehyde resin. This binder was found to ensure less diamond wear and smoother tool surfaces than all other organic binders tested with these wheels. The wheels were tested in a model 3Ye711V plane grinding machine tool at the Leningrad "Instrument" Plant. The optimum parameters of the grinding process for tools with "Elbor-R" inserts are: linear velocity 35 m/s, forward feed rate 10-15 m/min, lateral shift 2-4 mm per double pass, cutting depth 0.015-0.02 mm/pass, cooling and lubricating with 5% aqueous EGT emulsion. Tables 2, references 3: Russian.

2415/13046
CSO: 1861/308

UDC Δ65.011.56:666.293.522.5

FLEXIBLE AUTOMATIC PRODUCTION OF COLOR ENAMELS

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 3, Mar 86 pp 15-16

[Article by Z.A. Tsakhilov, engineer, V.M. Okhtov, engineer, Kh.I. Gurnikov, engineer, Ye.V. Manusov, candidate of technical sciences, and M.M. Gorbacheva, candidate of technical sciences]

[Abstract] Flexible automatic production of color enamels by a technological process consisting essentially of two stages is described, first pastes of a few single-color pigments being prepared by semicontinuous grinding of pigment lumps in bead mills and then different pastes being mixed in various ratios to produce enamels in any of a large assortment of hues. Theoretically, enamels in tens and even hundreds of hues can be produced from as few as 10-12 different single-color pigments. On the basis of this principle, the Cherkessk Chemical-Industrial Association and the State Scientific and Design Institute of the Varnishes and Paints Industry have developed a scheme for producing a gamut of color enamels from two white enamels and nine single-color pigments. The binders used for the pigment pastes are necessarily compatible with each of those two white enamels. The production process includes automatic sampling for measurement of optical absorption and reflection coefficients, calculation of optimum mixing formula by computer, and batching of ingredients for the final product. An important advantage of this new scheme is that the number of equipment units at the Cherkessk plant (producing two grades of automobile enamel: ML-12 and ML-152) has been reduced by 45%. The operation has been programmed on a YeS-1022 computer, for mixing one white enamel with one single color pigment to match an optical standard, but this computer will eventually be replaced with an SM-2m minicomputer. Figures 1.

2415/13046
CSO: 1861/311

UDC 621.798.002:629.118.6

COMPLETE MECHANIZATION OF MOTORCYCLE CRATING

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 3, Mar 86 pp 17-18

[Article by V.M. Yarevskiy, engineer, V.P. Mitrozhin, engineer, L.D. Kondratyeva, engineer, and Yu.G. Pospelov, engineer]

[Abstract] The crating of motorcycles at the Izhevsk Motorcycle Manufacturing Plant has been completely mechanized, from end of the assembly line to shipment station. The facility for this purpose is a special warehouse equipped with an elevator, two overhead chain conveyors for two-way traffic, a roller

conveyor, and a 5 t overhead traveling crane for load transfer. A crate is a box of 2000x625x1030 mm^3 size made of meshed wood boards and solid masonite boards. The warehouse is divided into two zones, one for loading-unloading operations and one for storage on racks with the aid of stackers. The mechanization has eliminated all manual labor, releasing 20 workers and 5 trucks with an annual cost saving of over 50,000 rubles. Figures 3, tables 3.

2415/13046
CSO: 1861/311

UDC 539.62

CONTACT PROBLEMS CONSIDERING WEAR FOR SPHERICAL AND CYLINDRICAL FRICTION BEARINGS WITH THIN BUSHINGS

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 86 (manuscript received 19 Feb 85; after revision 15 Oct 85) pp 81-88

[Article by P.P. Usov and M.A. Galakhov, Moscow]

[Abstract] Contact problems are studied considering wear for cylindrical and spherical friction bearings with thin bushings and exponential wear. The equations obtained are correct for both rotary and translational movement of shafts. An example is presented of calculation of the durability of a spherical hinge. Figures 5, references 4: 3 Russian, 1 Western.

6508/13046
CSO: 1861/385

UDC 681.3.06:518.5.531.3

NONANALYTIC METHOD OF SOLVING INVERSE PROBLEM FOR ROBOT MANIPULATORS

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 86 (manuscript received 8 Oct 84; after revision 16 Dec 85) pp 3-9

[Article by N.S. Anishin, Krasnodar]

[Abstract] A geometric object is suggested, modeling of which can be used to solve the inverse problem of coordinate transformation; a 3-dimensional lattice of an initial, perhaps cartesian space, in which the hinges and elements of the manipulator move. Among the finite sets of nodes of the lattice, some are identified which coincide with an accuracy to within one-half of a lattice step with the instantaneous position of the hinges and other characteristic units of the manipulator. The modeling allows each hinge and supplementary characteristic unit of the manipulator to be set in correspondence with a unique node, the coordinates of which represent the initial position for computation of the initial angular coordinates which are the solution to the inverse problem. Figures 3, references 12: 11 Russian, 1 Western.

6508/13046
CSO: 1861/385

UDC 621.01

EXPLICIT SOLUTION OF INVERSE PROBLEM OF MANIPULATOR POSITIONING WITH 6 DEGREES OF FREEDOM

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 86 (manuscript received 2 Oct 84; after revision 10 Jun 85) pp 10-21

[Article by A.I. Korendyasev, B.L. Salamandra and L.I. Tyves, Moscow]

[Abstract] The direct and inverse problems of positioning of a manipulator refer to use of the known joint coordinates of the manipulator elements to determine the cartesian coordinates of the clamp and, inversely, using the known cartesian coordinates to determine the required joint coordinates. A previous work has shown that for structures with 6 rotational couples, the inverse problem is reduced to solution of algebraic equations of not higher than 4th order if the structure contains 3 couples, the axes of which intersect at a common point. The present article proves that there is a broad class of structures with n=6 for which the inverse problem is solved in explicit form (that is, can be reduced to solution of equations of not over 2d order) and presents a method for producing the initial equations for any structure in this class. This condition is satisfied by structures containing 3 couples with parallel axes, in addition to the characteristic indicated in the previous work. The equations are decreased to 2d order when the additional couples include 2 with intersecting or parallel axes. The class of structures with these characteristics contains 24 different plans of manipulators with n=6. Figures 6, references 7: 6 Russian, 1 Western.

6508/13046
CSO: 1861/385

UDC 621.822.5

HYDRODYNAMIC CHARACTERISTICS OF RADIAL BEARINGS WITH LUBRICATION INPUT AT END

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 86 (manuscript received 2 Dec 85) pp 74-80

[Article by M.Ye. Podolskiy and L.P. Senchurin, Leningrad]

[Abstract] A study is made of the hydrodynamic portion of the problem of bearings with lubrication input at the ends. The analysis was performed numerically, by computer solution of a system of difference equations approximating the Reynolds equation and boundary conditions. The viscosity of the lubricant was assumed constant, the operating mode of the bearing steady. The Reynolds condition and flow balance condition were used in composing the boundary conditions. Graphs are presented illustrating the nature of change in lubricant flow density through the intake cross section of the gas as a function in polar coordinates. Figures 6, references 9: 7 Russian, 2 Western.

6508/13046
CSO: 1861/385

UDC 621.671.2

VERTICAL CENTRIFUGAL PUMP UNIT 2400V-25/100

Moscow KHIMICHESKOYE I NEFTYANOYE MASHINOSTROYENIYE in Russian No 6, Jun 86 pp 2-3

[Article by engineers L.G. Zadanovskiy, R.V. Gordeyeva, and R.I. Zhukovskiy]

[Text] The VNIIgidromash [All-Union Research and Development Institute for Hydraulic Machinery] has developed a 2400V-25/100 electric pump unit intended for installation at the Volga-Don Canal pumping stations and other places. The pump unit is manufactured by the Uralgidromash imeni Ya.M. Sverdlov.

Technical data of the 2400V-25/100 pump:

Capacity, m^3/sec	25
Water head, m	100
Rotational speed, rpm	214.3
Permissible positive suction head, m	14
Impeller diameter, m	4.09
Weight, kg	120,000

The general view of the electric pump unit is shown in the figure. The pump is driven by a 32 MW 13.8 kV synchronous electric motor DSV 565/140-48. The large dimensions of the pump determined the principal differences of its design and of its flow-through part from the design of the currently manufactured V-type centrifugal pumps. The main differences are the installation of the stator behind the impeller and the cast and welded construction of the helical discharge housing.

An analysis of the engineering designs of centrifugal pumps and combined pump-turbine units with specific speeds (n_s) of 120 to 140 was made before the development of the flow-through part of the 2400V-25/100 pump. Based on this analysis, meridional cross sections of impellers were selected, their principal rheometric parameters were determined, the method of calculation of the helical discharge allowing for the installation of stator blades was refined, and optimal geometry of the flow-through part was found for computer design of the impellers.

The materials analyzed were practically devoid of recommendations regarding the stator design. Therefore, the main task of the experimental studies

carried out was to select a combination of the flow-through-part elements that would ensure minimal hydraulic losses consistent with the required strength and technological characteristics.

A well-proven intake pipe with a knee consisting of regular geometric surfaces that enable the knee to be made by welding was selected as a means of feed.

A fundamental innovation in the design of the pump is its housing, which is made in the form of a cast and welded steel stator to which the shells of the spiral chamber are welded. Such a design solution makes it possible to reduce its weight by 30 tons compared to the series-produced pumps, whose housings are cast. The stator is the load-bearing part of the pump. It has six columns that connect the upper and lower fellies, absorbs the forces produced by pressure in the helical discharge of the pump and transmits them to the foundation, and reduces the radial forces acting on the pump impeller.

For ease of transport by rail, the stator is divided into two parts. The helical discharge shells are welded on at the assembly site. The shells are test-assembled at the manufacturing plant prior to shipment.

The rotor of the unit rotates in three plummer bearings, two of which are installed in the crosspieces of the electric drive and one on the pump cover. The guide bearing of the pump has self-adjusting inserts lined with babbit, and it is lubricated with petroleum oil. Tubular oil coolers, supplied with water being pumped, are installed in the oil bath to remove the heat generated in the bearings.

The impeller, equipped with two slit-type seals, is made of cast material. The upper felly of the impeller is equipped with openings that permit the pressure ahead of the shaft seal and the axial force transmitted from the pump to the electric drive's thrust bearing to be lowered. The shaft seal is installed on the pump cover.

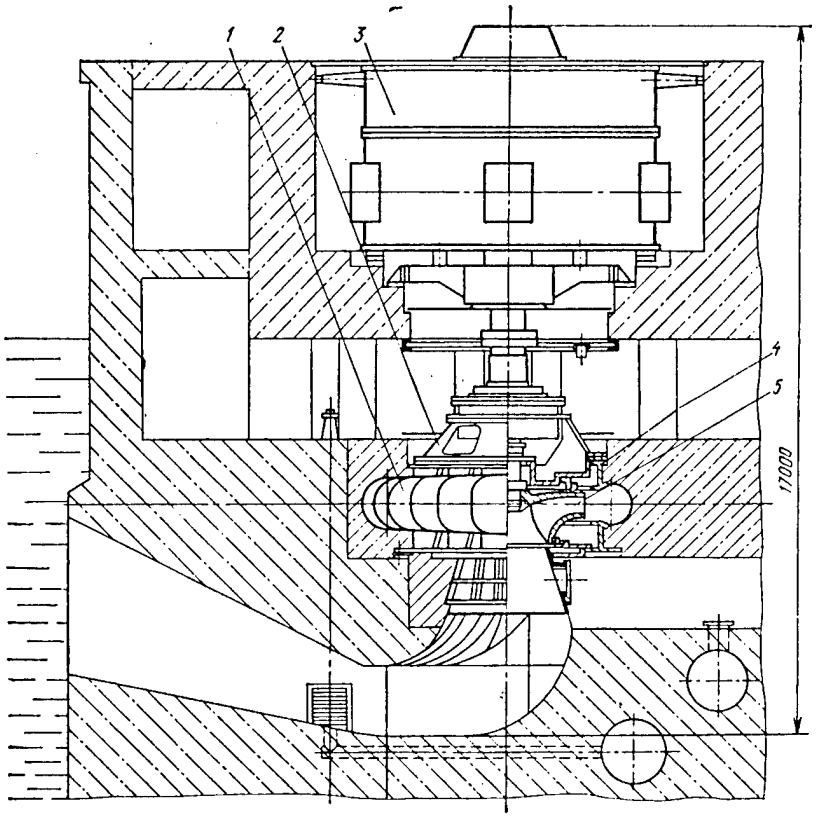
Water is discharged from the pump by means of a metal pipe equipped with a hydrolically operated disc gate having a nominal inside diameter of 2800 mm.

The 2400V-25/100 pump is disassembled by means of boring the electric drive stator. A special circular overhead-track hoist is installed in the pump house for repairing the shaft-seal and guide-bearing assemblies of the pump without dismantling the electric drive.

The main parts of the pump are made of carbon steel. The impeller and the packing rings are cast from steel 10Cr12Ni-DL.

Automatic safety shutoff and control of the pump are included in the design developed. This makes it possible to operate the pumps without constant presence of the operating personnel and prevents the pump from being started when the pressure ahead of the impeller is below the permissible value. It also provides for warning signals indicating low pressure at the intake to the impeller, reduced water supply for cooling the pump bearing, increased temperature of the bearings and of the oil in the bearing oil bath, increase

of water level on the pump cover, increase or decrease of oil level in the bearing oil bath, and emergency stoppage of the unit owing to overheating of guide-bearing shells, impermissible water level on the pump cover, and operation of the pump with the gate closed for more than 3 minutes. Microprocessor technology is included in the operation and control system of the pump at the pumping station.



2400V-25/100 Electric Pump Assembly
1 - pump; 2 - pump cover; 3 - electric motor; 4 - stator; 5 - impeller

For transporting large pump parts such as impellers, which are considered to be oversize for rail transportation, special transportation specifications were developed with agreement of the Traffic Ministry.

The annual savings resulting from the use of the 2400V-25/100 unit are expected to amount to about 500 thousand rubles.

12973/13046
CSO: 1861/458

DEVELOPMENTS IN MACHINE RELIABILITY, SERVICE LIFE REVIEWED

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 8, Aug 85 pp 74-84

[Article by Academician K. V. Frolov: "The Reliability and Operating Life of Machines and Mechanisms" under the rubric: "In the Departments of the USSR Academy of Sciences"]

[Text] The effectiveness of the utilization in the national economy of power, production, transport, and other machines is determined by the quality, and to a substantial degree, depends on the solution of the problem of reliability. Reliability and the technical perfection of machines, as is well known, are the principal components of quality.

It is increasingly difficult to insure reliable operation in machines, due to increasing complexity as new capabilities are added, as well as broader operating conditions and more rugged construction. At the same time, in the building and use of such demanding structures as nuclear power equipment, transport machines, and the apparatus for chemical production, a high level of reliability, in which the probability of occurrence of dangerous failure is the very least, must be provided despite any degree of complexity.

It should be noted that reliability is not simply a synonym for freedom from failure. As a comprehensive property, reliability includes, for instance, the concept of durability. The comprehensive property is characterized by an extremely capacious indicator - operating life; that is, by the machine operating time during which it is efficient and allowable to use it under given operating conditions. Between reliability and operating life a complex dialectic interrelationship exists which must be taken into account at all stages of the life cycle of a machine.

The theory of reliability widely uses mathematical methods of determinate and stochastic analysis for the investigation, evaluation, and monitoring of reliability. It also uses similarity methods which permit establishing criteria for selecting analogs and substantiating technical characteristics and work capacity of articles being designed. The "practicality" of this theory has been demonstrated by the impressive successes of Soviet machine building and, in particular, by the development of highly reliable models of

complex machines, equipment, apparatus, and instruments (space and aviation equipment, nuclear power reactors). Domestic induction electric motors, clocks, photographic and motion-picture equipment have high reliability. Over a short time, the operating life of automobiles and metal cutting machine tools has risen by a factor of 1.5-2.

Along with this, the use of the theory of reliability is a necessary but by no means a sufficient condition for the successful development, introduction, and assimilation of new equipment. For instance, probability and statistical methods are of great assistance in describing and analyzing the mechanisms of the reliability of engineering systems and devices. It also helps in calculating the endurance of machine parts, in forecasting operating life in design and operational stages, in designating the periodicity of inspection and operational stages, in designating the periodicity of inspection, planned repairs and the output of spare parts, and in the development of a strategy for maintenance. The effectiveness, however, of the theory of reliability is realized in full measure only under the conditions of simultaneous deepened elaboration, development, and substantiation of the efficient use of the whole arsenal of the newest methods and means which provide for the necessary increases in reliability and operating life of machines. In their own turn, the effectiveness of measures for increasing reliability can be evaluated definitely by enlisting probability and statistical methods.

The reliability and technical performance of machines are determined during design. But if, in principle, technical performance is preserved in the production process, then reliability is ensured only at the manufacturing stage, and makes it almost completely technology dependent. Now that the theory of reliability has been rather well elaborated, it is necessary to substantiate scientifically and widely to introduce the methods and means to assure and sustain reliability in a number of branches of machine building which require accelerated development, and also to prolong the operating life of machines and strucutres. In so doing, the achievements of the technical diagnosis of machines should be used, and the ergonomic factors and ecological requirements flowing from the investigations of the biomechanics of the systems "man-machine-environment" should be taken into account. The development of such a comprehensive approach to the problems of providing for the reliability and operating life of machine building articles on a basis of the rational combination of theoretical and applied research is one of the most important problems of modern machine building (Ref. 1).

As is well known, the reliability of articles produced by different branches of machine building can be substantially different. The reliability of articles depends on the status of the technological discipline, production efficiency, and the qualifications of the workers. At enterprises, insufficient effectiveness of comprehensive systems for product quality control, imperfect technical and economic calculations, and failing in the first place to take into account the indicators of reliability and power consumption, have a negative effect on reliability. The presence of "bottle necks" in machine building is explained also by the noninterchangeability of technological solutions which have been decided and the newest achievements

of science and technology appearing in the past decade that did not take industrial applications into account during the design stage. Inasmuch as a clearly coordinated long-term All-Union program on reliability has not been developed up to now, interindustry utilization of advanced experience is controlling itself. For instance, the progressive methods for determining and assuring the reliability of welded pressure vessels which have worked quite well in nuclear power machine building have not yet received proper application in the design and manufacture of machines and apparatus for the chemical industry. Similar examples can be cited.

In the further development of the science of reliability, it is necessary to take into account the nature of breakdowns characteristic for machine building which most frequently have been brought about by premature loss of strength. In this case impermissibly large ductile deformations form and develop or some sudden or gradual failure takes place - brittle failure, quasi-brittle failure, slow failure, delayed static failure, fatigue failure, or surface deterioration. The probability of these processes grows under the effects of an aggressive ambient environment, of low or high temperatures, of increased speed of loading, of high specific loadings, and of strong physical fields. The experience of exploiting Siberia and the Extreme North and the laying of the BAM [Baikal Amur Mainline Railroad] testifies, for instance, to the insufficient reliability of individual types of mining and earth moving machines, motor vehicles, cranes, and drilling equipment. The number of breakdowns of these machines spasmodically increases in winter time.

Breakdowns of a number of articles can take place when the rules for operation are violated, for instance because of a reduced functional capability and work capacity of the operator controlling the machine. This takes place if the operation of the machine is accompanied by vibrations, noise, and other phenomena having a harmful effect not only on the machine but on the person and the surroundings.

Sixty to eighty percent of metal cutting machines, tractors, agricultural, transport, and other machines go out of service as a consequence of surface failure during wear which causes colossal expenditures for repairs, spare parts and maintenance. The frictional research and friction engineering aspects of the problem of the reliability of machines is thus extremely important and must be taken into account in research on the optimum design and technological solutions for increasing operating life.

Examining the causes of failures in machine building products once again convinces us of the necessity of a comprehensive approach to the problems of reliability in which the engineering, social and economic, ergonomic and ecological requirements are taken into account in all stages of the design, calculation, production, testing, finishing, operation, and repair of machines.

The Institute of Machine Sciences imeni A. A. Blagonravov of the USSR Academy of Sciences together with a number of academic and industry institutes is

conducting a wide circle of investigations directed at: perfecting methods of calculating and designing, lowering the acting dynamic loadings in structures (damping vibrations, vibration isolation, attenuation of vibration, and balancing), and at the rational use of the improved hardening technologies and of new structural and lubricating materials. Also being developed are: effective experimental methods for investigating and evaluating loading, strength, and frictional characteristics, the parameters of the interaction of men and machines; and methods and means are being developed for diagnosis without disassembly and for automated control.

Being unable to deal with the results of all of the research conducted, we will be limited to a brief description of only a few which have achieved practical realization in a number of the industrial branches of machine building.

Progressive methods have been developed for the design of machines on the basis of a systems and multicriteria approach and for the design of systems of automated design which combine the means of automated processing of design information on small computers with the problems solved by large computers. These methods are an effective potential for research on the optimum design and on the technological solutions which assure increasing the effectiveness of machines and structures. They permit substantially reducing design time and totally automating the noncreative routine operations. In order to expand the scale of the use of these methods it is necessary to increase the production of the corresponding computer equipment and to organize the training of a new type of engineer able to use all-around modern methods of designing and manufacturing machines.

As the practice of the production association MosavtoZIL [Moscow Automobile Plant imeni I. A. Likhachev], the VNIIstroydormash [All-Union Scientific Research Institute for Construction and Road Machine Bulding], and other organizations has shown, probability methods have been effective in the stages of designing and finishing experimental specimens of machines. The unification of these promising methods, ending with the development of corresponding standards and methodical instructions, which is being carried out by the Institute of Machine Sciences together with industry institutes, design bureaus, and organizations of USSR Gosstandart, is contributing to the expansion of the sphere of application of these methods.

In recent years, additional research has been done in reliability theory on substantiating the norms for strength, for methods for acceptance and intermediate inspection, for the calculation and forecasting of the indicators of reliability and endurance, and also for the safety of critical machines and structures. This research is oriented particularly toward the solution of the problems of nuclear power machine building and also of the construction and operation of main gas and oil pipelines.

In order to assure the reliability and operating life of frictional subassemblies (plain and roller bearings, gearing, and so on) it was required to conduct fundamental and applied research on the surface failure of rigid

bodies in the processes of wear. In so doing, physical, chemical, and mechanical phenomena, contact intensity, kinematics of the motion, the condition of the lubricating layer, and other factors were taken into account (Ref. 2). In particular, a new theoretical-invariant method of calculating the intensity of surface damage of rigid bodies during rubbing was developed (Ref. 3). The equations obtained permit forecasting the conditions of intense surface damage brought about by seizure during the rubbing of surfaces which is necessary for determining effective methods to combat this phenomenon which frequently leads to breakdown of mechanisms.

On the basis of completed research, lubricating, friction and antifriction materials, and special additives are being developed. Also, progressive technologies are being worked out for the controlled treatment of surfaces and the application of special coatings which increase the operating life of rubbing assemblies (Ref. 4).

Other effective solutions to engineering friction problems should be brought to bear, e.g., vacuum-plasma methods which utilize both physical and chemical processes. New compounds are formed in the course of plasma-chemical reactions on the surface of a part which can provide coatings of very dissimilar materials in various combinations.

Investigations of parts having coatings based on titanium nitride applied by the method of condensation during ion bombardment and the reactive-plasma method, showed their high service properties. The merit was confirmed of using these methods for creating coatings on completely finished parts with precision moving and stationary contact surfaces (unassembled) since the coating can be both hard, wear-resistant, and antifrictional on the basis of molybdenum disulphide having low values of the coefficient of friction.

Laser technology gives significant possibilities for increasing the reliability of rubbing subassemblies when used, for instance, for the controlled changing of the frictional properties of rubbing surfaces. By way of laser treatment, hardening of the surface, the deposition of wear-resistant coatings, and the alloying of the surface layer is carried out.

Laser hardening can be used also as the finishing operation in a production line since, in this case, the number of finishing operations can be reduced to a minimum or even excluded. It has been established experimentally that laser treatment substantially lowers the friction coefficient, increases surface resistance to fretting and wear, and significantly reduces the speed of crack propagation during cyclic loading (see Figure 1). A supplementary reserve for increasing reliability and operating life of parts subjected to laser strengthening is the development of compressive stresses in layers near the surface.

As the investigations showed, laser treatment is promising for agricultural machine building.

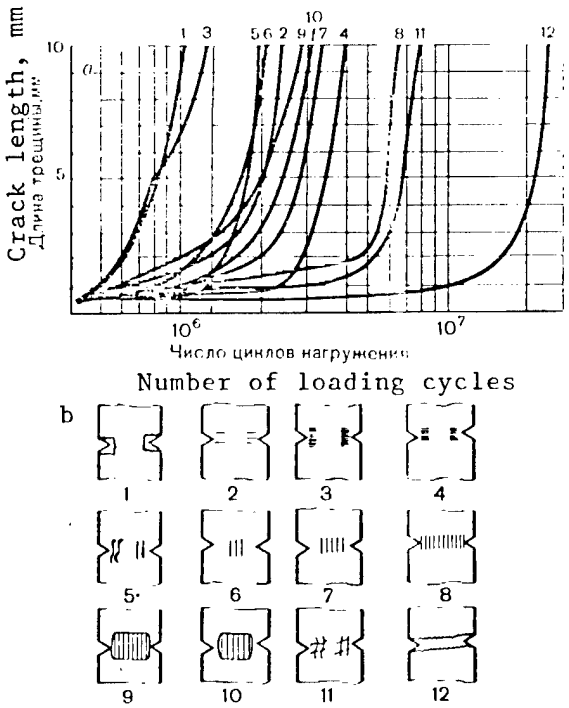


Figure 1. The effect of laser treatment on resistance to fatigue failure during cyclic loading.

a - the speed of propagation of cracks in specimens subjected to 12 different versions of laser strengthening.
b - sketches of specimens with stress concentrators, the strokes indicate the version of laser strengthening, the greatest strengthening is achieved when the zone of laser treatment is disposed along the probable trajectory of crack propagation (the 12th version).

Increasing the reliability and operating life of machine tool industry articles can be accomplished on the basis of using antifriction and antijump coatings for machine tool guideways operating at low translational velocities. On NC machine tools, difficulties frequently arise with accurately positioning the cutting tool because of sudden jumps caused by friction in the guiding supports. A new class of polymer coatings - trankilite - has good antijump properties. As industrial examination has shown, highly reliable friction-force couples can be produced from this material, and it really helps to restore the operating life of large-sized parts which have undergone wear.

The manufacture of metallofluoroplastic bearings for critical machine subassemblies is convincing confirmation of the effective use of new materials with unique antifriction properties (Ref. 5). Bearings made of this material can be operated without lubrication or with insufficient lubrication in the temperature range from -200 to +300 C (with short-time operation up to 350 C). Metallofluoroplastic tape and the bearings stamped from it are

produced at enterprises of a number of ministries and are widely used in the construction of civilian aircraft, in articles for the consumer and food industries, in motor vehicle construction, and in the electrical engineering industry.

For rubbing assemblies operating under extreme conditions, new hard, lubricating materials have been developed based on diselenides of molybdenum, tungsten, and niobium. In comparison with already known materials, the new materials have a wider temperature range of operability, increased wear resistance, and lower initial values of the coefficient of sliding friction. These materials can be operated in a vacuum at temperatures up to 1000°C, and in air up to 500-600°C.

Use of magnetica-ly-active lubricating powders fed into the contact area by a relatively weak nonuniform magnetic field may prove to be a cardinal solution to reliability problems in dry friction assemblies. Investigations made at the Institute of Machine Sciences have shown that magnetic powder methods permit substantially increasing the operating life of mechanisms which are operated for a long time in extreme conditions.

The use of gas lubrication in joints of the type "shaft and bushing" or "journal and bearing" contributes to a significant increase in the reliability of spindle assemblies of machines and the accuracy of movement (rotation) of the moving elements. In the Production Association AvtoVAZ [Volzhskiy Motor Vehicle Plant] gaseous bearings, developed in the Institute of Machine Sciences, are being used in boring heads, as result of which, their operating life has become 10-15 times greater than that of specimens of this equipment produced by well-known foreign firms.

The solution of the problems of increasing the reliability and operating life of machines and mechanisms in large part depends on the quality of the building materials. The quality of traditional metallic materials is determined by the scale of the use of the progressive methods of smelting steels and alloys, the use of vacuum-arc and electroslag remelting, electron beam melting, and other effective methods of metallurgical production including the continuous casting of steel and high-productivity methods of processing metals with pressure. In its turn, this requires the solution of a number of problems of metallurgical machine building, the production of articles for which involves extremely large demands for metal. Therefore, the task of reducing metal consumption by the use of new materials, with a simultaneous increase in reliability and operating life for all kinds of machines, is extremely urgent.

In a number of industrial sectors a variety of composition materials are now being used, particularly, composites having a polymer matrix reinforcing continuous carbon, glass, boracic, or organic fibres. In this case, not only is weight reduced and durability increased, but a number of special properties are provided. At the Institute of Machine Sciences new phenomenological mechanical models have been developed of the failure of composites of a given class and on this basis ways of increasing the reliability are being

determined simultaneously with ways for reducing their metal consumption. Right now the optimization of structures made of composition materials is being carried out as applied to motor vehicle construction, robot equipment, agricultural equipment, and machine building for animal husbandry.

In the chemical and petroleum industries, in power machinery building and other fields of equipment, bimetals and multilayer clad metals are finding more and more application. The advent of controlled bimetallization which leads to the optimum strength of a discontinuity, can, in a number of cases, serve as an effective means of prolonging the operating life of large-sized elements of structures at the stage of crack development. Using the criteria of linear and nonlinear fracture mechanics, associates of the Institute of of Machine Sciences investigated the question of the static and cyclic cracking resistance of bimetals; and, in collaboration with the Production Association of the Leningrad Metals Plant developed a new method of repairing hydraulic turbines (Ref. 6). Tough crack-stoppers are increasing the parameters of fracture mechanics. They impede, and in the final analysis, they stop the development of cracks (see Figure 2). This method of repair was successfully used on an element of the structure of the powerful hydraulic turbine of the Ust-Ilimsk GES and a number of other facilities (Ref. 7).

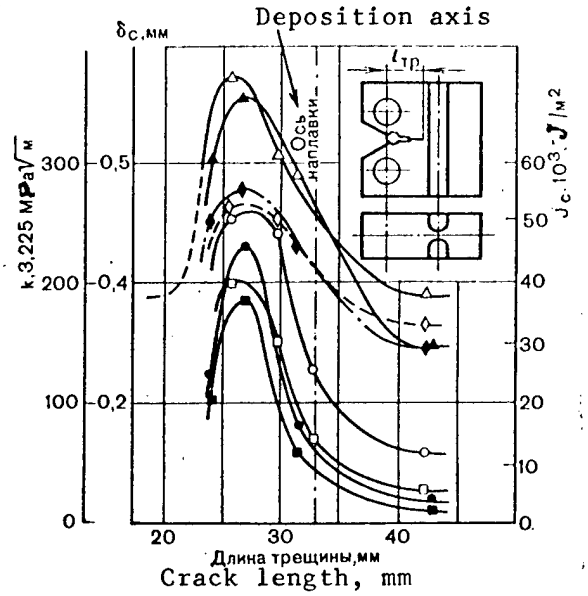


Figure 2. The distribution of fracture-toughness characteristics in a specimen of structural steel (shown in inset) into which a tough metal crack-stopper has been introduced by deposition.

k - stress intensity coefficient, δ_c critical crack opening, Jc - integral characterizing the work of failure, $l_{тр}$ dimension of crack, △ and ▲ correspond to k_c*, , ◊ and ♦ correspond to k_Q, , ○ and ● correspond to δ_c, , □ and ■ correspond to Jc, light symbols correspond to a temperature of 293 K, and the dark symbols to a temperature of 213 K.

The organization of operational monitoring of the condition of machines without disassembly by means of vibroacoustic diagnostics has great importance for the solution of problems of reliability and operating life. It makes it possible to determine the moment damage occurs in a mechanism and, in accordance with the rate of change of a diagnostic feature, to establish scientifically well-founded periods for carrying out repairs (see Figure 3). In this way the conditions are created for a transition from servicing in accordance with operating life to a more progressive maintenance according to the actual condition of machines and mechanisms.

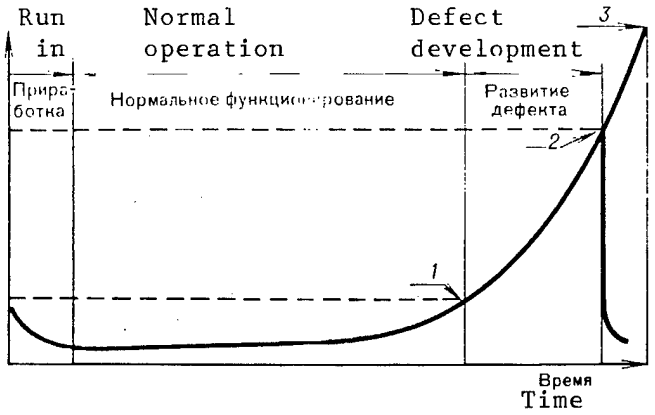


Figure 3. The change in the parameters of condition as a function of machine operating time.

1 - birth of defect, 2 - repair, 3 - breakdown.

Theoretical and experimental research have revealed the laws of change in the informational properties of vibroacoustic processes during defects in installation and the development of degradation phenomena in the course of operating machines (Ref. 8). The basic degradation effect leading, for instance, to a breakdown of rubbing assemblies, is the development of local damage to contacting surfaces; namely, spalling, fretting, and cracks. The method of observing and diagnosing nascent operational defects is based on analysis of properties of the forced and natural vibrations of defective assemblies. In particular, in all forms of defects, the development of damage is accompanied by an increase in amount of amplitude-pulse modulation in the region of the natural frequency of a defective assembly. On the basis of experimental research and the building of diagnostic models, algorithms and procedures for diagnosis have been developed and realized in vibroacoustic diagnostic systems based on mini- and micro-computers.

The wide introduction at machine building enterprises and in operating and repair organizations of vibroacoustic diagnostics without disassembly together with modern methods of nondestructive monitoring is an important resource for increasing the quality of the manufacture and repair of machines, and for reducing unproductive equipment idleness, the expenditure of spare parts and combustible lubricating materials, labor costs and capital investments. The transition from maintenance according to service life to maintenance according to condition can substantially prolong the period of service of domestic machines and mechanisms.

The development of the products of the new technology, with the forcing of their speeds and loadings, is accompanied by an increase in the intensity and an expansion of the spectrum of vibration and vibroacoustic fields, the more so, as highly effective vibration and vibroshock processes are being used in industry and construction (Ref. 9). As is known, the greatest number of breakdowns of machines come about not by static, but by alternating stresses and dynamic loadings caused by vibration and shocks. The conditions of rubbing and the wear of contacting surfaces of machine parts are being changed because vibration lowers the support capabilities of parts, and micro- and macrocracks are formed leading to the fatigue failure of the materials. Vibration and noise turn out to have a direct effect on man; therefore the protection of men from vibration determines the reliability of the system "man - machine - environment" (Ref. 10)

Study of the functional and physiological capabilities of a human operator under conditions of vibration effects has permitted determining norms and methods for making controlled vibration-protection systems. Research conducted on the human operator as a living link in a unified biotechnical system subjected to vibration effects, confirmed the idea we spoke of earlier about the need for re-forming the vibration field so as not only to exclude harmful vibration effects on the living organism, but also to increase labor activity as a result of vibration stimulation (Ref. 11). Machines of high reliability, as already noted, must answer to all the demands of ergonomic and ecological cleanliness.

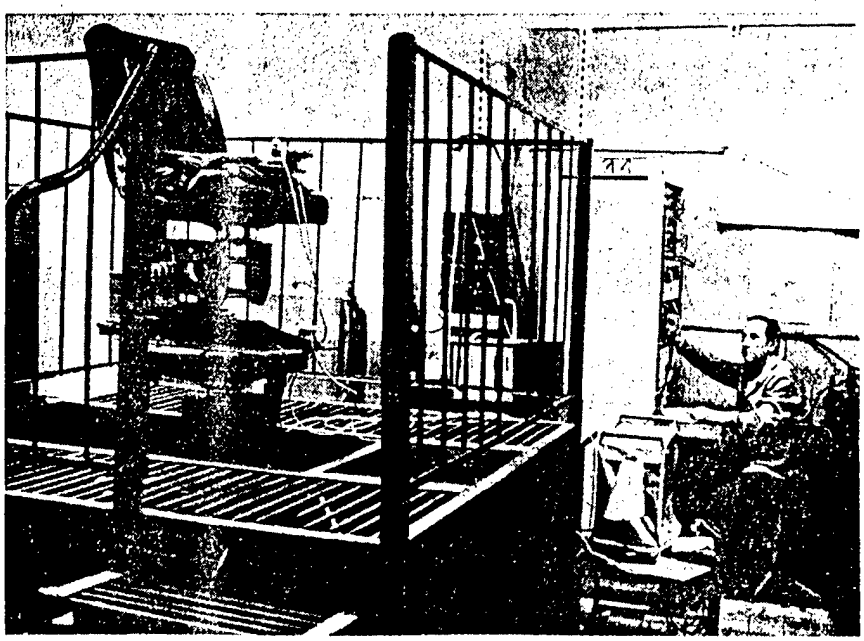


Figure 4. Testing a vibration-protective pneumatic seat in the Institute of Machine Sciences of the USSR Academy of Sciences.

New types of pneumatic seats, distinguished by structural simplicity and standardization, have been developed for protecting the human operator from vibration (see Figure 4). The nonlinearity of the characteristic of the pneumatic seat permits achieving insignificant damping (and, correspondingly, vibration transmission) for low amplitude excitation of the floor of the cab and substantial damping at high levels. High-amplitude oscillations in the cab of a grain combine are realized in the low frequency region (2-3 Hz) and are explained by the natural oscillations of the frame of a machine on pneumatic tires.

For an objective comparison of the properties of various types of seats, field tests were conducted on the serially produced combine SK-6. The data recorded under field conditions on a magnetic tape recorder were processed on a data measuring complex at the Institute of Machine Sciences. The best type of seat was acknowledged to be a hybrid pneumatic seat with a mechanical filter and damper. In its design, the positive properties of a pneumatic suspension were successfully combined with the filtering properties of a mechanical structure which "cuts out" the most dangerous band of frequencies - 2-3 Hz.

It should be noted that the solution of the problem of the reliability and operating life of articles of machine building, to a known degree, are determined by the level of development of methods and means for comprehensive experimental evaluation of the effective loading of structures, of the stress-strain and vibration conditions, of the parameters of the structure of the materials, of the strength and crack resistance, and of the dynamic characteristics of the body of the human operator under vibration and other effects. This information assists in evaluating the degree of completeness of the experimental adjustment of machines and structures in laboratory and full-scale tests, in determining the influence of operating conditions on an article, and in establishing the remaining life of structures.

A variety of equipment has been developed at the Institute for experimental research. For example, systems for high-temperature and cryogenic tensiometry (temperatures from -269 to +700 C) are being used under the effects of various physical exposures in static, quasi-static, and dynamic conditions in a range of frequencies from 0 to 1,000 Hz. In installations of the IMASH type, at the same time, the structure is being studied and the properties determined of metallic structures at temperatures from -50 to 1,500 C (see Figure 5). Frictional materials undergo a rational cycle of tests on rubbing machines. All this and other original equipment , installations, stands, and instruments are effective for investigating and monitoring the reliability characteristics of materials, elements of structures, and full-scale engineering facilities, and also for establishing the complementarity of the functions of operator and machine.

With regard for the demands for flexible automated production, monitoring and measuring machines and measuring robots have been developed and the corresponding search-algorithms and programs have been worked out along with the means for their realization. Development of these fundamentally new systems will permit increasing the reliability and quality of machine building products.

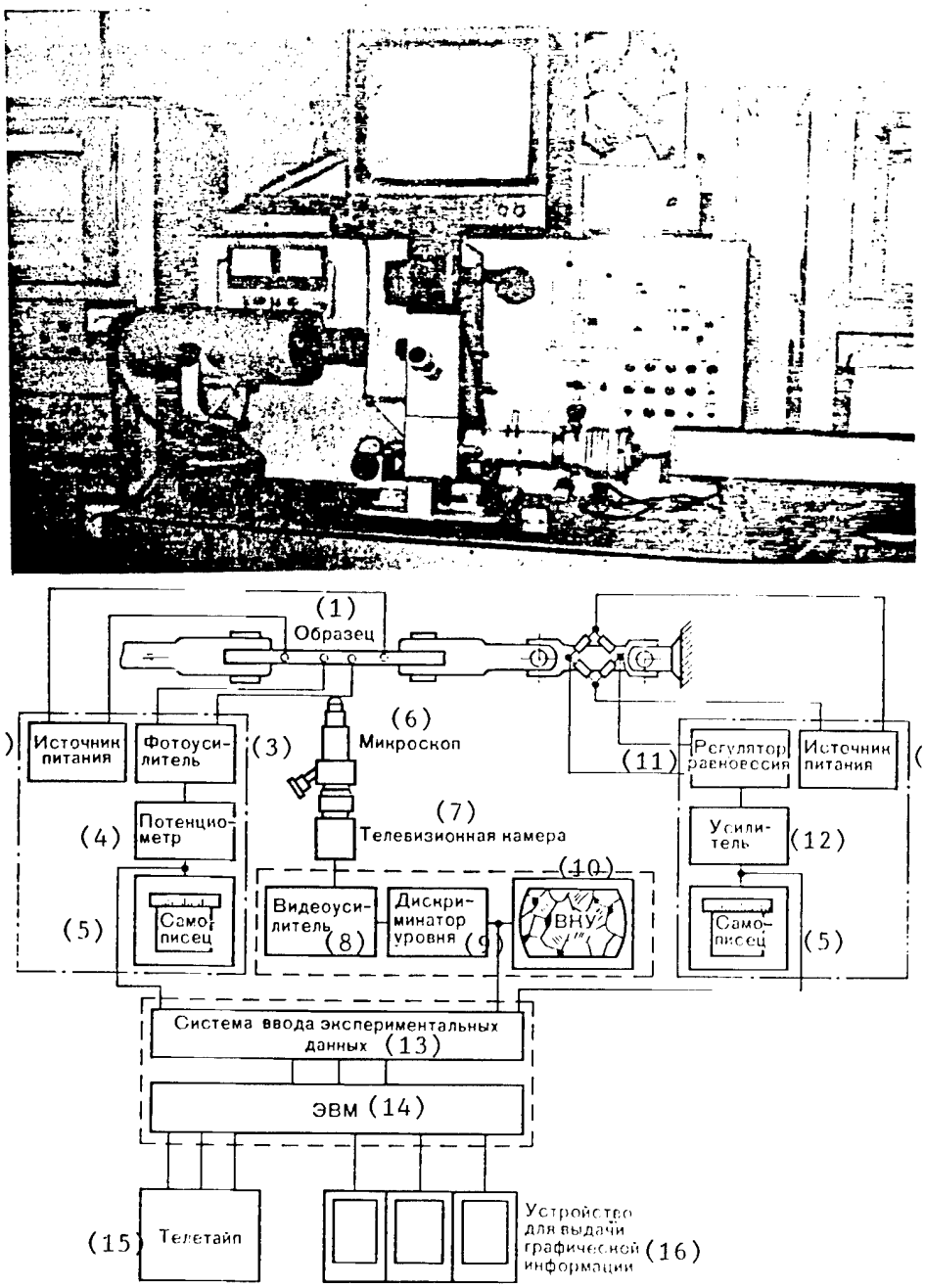


Figure 5. Installation IMASH-20-78 for combined physical and mechanical investigations of metallic materials during programmed thermal action and mechanical loading in a vacuum or gaseous media, and a block diagram of a prospective variant of this installation.
(1)- specimen, (2)- power supply, (3)- photoamplifier, (4)- potentiometer, (5)- recorder, (6)- microscope, (7)- television camera, (8)- videoamplifier, (9)- level discriminator, (10)- display, (11)- equilibrium regulator, (12)- amplifier, (13)- experimental data input system, (14)- computer (15)- teletype, (16)- graphic data output.

It is necessary to expand scientific work on machine building including that applicable to the problem of the reliability of machines and mechanisms. The USSR Academy of Sciences must carry out the organization and coordination of this work in the country.

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COMPARATIVE INVESTIGATIONS OF VIBROACOUSTICS OF METAL, POLYMER, AND METAL-POLYMERS GEARINGS

Minsk VESTI AKADEMII NAVUK BSSR: SERIYA FIZIKA-TEKHNICHNYKH NAVUK in Russian No 2, Jan-Mar 86, pp 59-62

[Article by I.V. Zhuk and S.A. Osipenko from the Reliability Problems and Machine Extended Service Life Institute, BSSR Academy of Sciences]

[Text] Gearings are one of the main sources of noise and vibrations of operating machines and mechanisms. Reducing their vibroacoustic characteristics makes it possible to improve the working conditions of service personnel, increase production quality, and increase the reliability and service life of machines.

Using polymer materials in the design of gearings is one way of reducing noise and vibrations. One or both wheels comprising the gearing may be manufactured entirely of polymer material or may contain necessary polymer design components.

This study was conducted to establish the effectiveness of using polymer and metal-polymer wheels instead of metal ones for improving the vibroacoustic characteristics of gearings.

Gearings with four types of wheels were studied. The first and second were polymer wheels made of 45 steel and caprolon V respectively. The third type was a reinforced gear [1] that was a metal gear-fitting onto whose sharpened teeth a facing made of P610 polyamide resin was applied. The fourth type of wheel consisted of metal toothing and a metal hub that are connected by a polymer interlayer located in the gap between them [2]. Before the polymer interlayer was formed, the toothing and hub were assembled in such a way that the slotted protrusions implemented on them were arranged opposite one another in ring-shaped grooves that were specially provided for the toothing and hub. The spaces between the slots form through openings in which the polymer-faced inserts serving to transmit the torsional moment were arranged.

The experimental gears had the following parameters: modulus $m = 4$ mm, number of teeth $z = 30$, tooth slope $\beta = 0°$, addendum modification shift $x = 0$, width of gear ring $b = 32$ mm. The basic rack was in accordance with the All-Union State Standard [GOST] 1643-81. The degree of precision of the first and second types was 9-12-12, and it was 12-12-12 for the third and fourth types.

The teeth of the metal and entirely plastic wheels were cut with pure gear milling. The polymer facing on the teeth of the reinforced wheels and the polymer interlayer in the composite wheels were formed by the method of injection molding without subsequent finishing of the gear ring.

Six versions of gearings assembled from the previously described types of wheels were studied, and their legend is presented in the Table.

The tests were conducted according the the method in work [3]. A stand with an open loading circuit and a PT-100 M electromagnetic powder brake as a loader was used [4]. The pinions' rotation freqency varied in three stages: n = 500, 1,000, and 1,500 min^{-1}. The value of the torsional moment was specified at each of these frequencies: T = 0, 50, 100, 150, and 200 N x m. The gearings being tested were lubricated with I-20 oil that was kept under pressure in the tooth contact zone.

The noise levels of the gearings being tested were measured with an 00019 sound level meter of the firm RFT using three-octave filters in accordance with GOST 12.1.028-80. The microphone was mounted at a distance of 1 m from the field level and the stand reduction gear.

Table. Versions of the Designs of the Gearings Being Tested

	Pinion Type		Wheel Type	
	Metal	Polymer	Reinforced	Composite
Metal	MM	MP	MR	MS
Polymer	--	PP	--	--
Composite	--	--	--	CC

Vibroacceleration levels were registered with the help of an SI-1 spectrometer-inductor and a D-14 vibration transducer that were mounted on the housing of the reduction gear.

We will examine how replacing a polymer wheel with a polymer or metal-polymer wheel affects the total noise level of the gearing. It should be noted that although a common regularity in the growth of the noise level as the load or rotation frequency was increased is observed for all the gears tested they differ sharply with respect to both noise level and nature of the change in noise level. As follows from the experiment results presented in Figure 1a, the greatest difference in noise level is manifest in an idle run and at low loads (T = 50 N x m); however, as the rotation frequency and load increase, these differences are reduced to the point that when n = 1,500 min^{-1} and T = 150 to 200 N x m, all the gearings with the exception of the PP version become practically equal and have a noise level that is even higher (by 2 to 2.5 decibels) that the MM gearing with metal pinions and a metal wheel.

When the rotation frequency is n = 500 min^{-1}, the gearing in which the metal wheel is replaced by a polymer one (version MP) has a noise level that is 1 to 2 decibels lower than the standard (version MM) throughout the entire load range. When the rotation frequency is increased to 1,000 min^{-1}, the effectiveness of such a gearing decreases. Only at an idle run was a 2.5-decibel reduction in noise obtained, at all the remaining load stages, this gearing has practically no advantages over the standard type: the difference in noise level does not exceed 1 decibel. When T > 50 N x m, further increase of n to 1,500 min^{-1} results in a sharp increase in noise, and the noise exceeds that of the standard by 1 to 2 decibels.

The best results were obtained with the gearing with polymer pinions and a polymer wheel (version PP). In all speed modes when the loads were T = 0 to 50 N x m, it had a noise level 3 to 6.5 decibels lower than that of the MM gearing. However, a sharp increase in noise level was observed when the torsional moment was increased to T = 100 N x m. When n = 500 min^{-1}, the difference in noise level between the PP and MM gearings was only 2 decibels, and it was not more than 1 decibel when n = 1,000 and 1,500 min^{-1}; i.e., the gearings became equal with respect to noise level.

The nature of the change in noise level of the MP version of the gearing that has been described here is evidently related to the fact that at the specified loads, which are significantly in excess of admissable loads for wheels made of caprolon, there is an extreme growth in the elastic and residual deformation of the polymer teeth that leads to an increase in the difference of the steps of the intercoupling teeth of the metal and polymer wheels [5], which causes an edge impact. If both wheels in the gearing are made of polymer material, the difference in the steps changes only under the effect of elastic deformations inasmuch as the residual deformations changing the profiles of the teeth of both wheels act analogously to an increase in the profile angle. Therefore, the increase in noise level in this case is less significant.

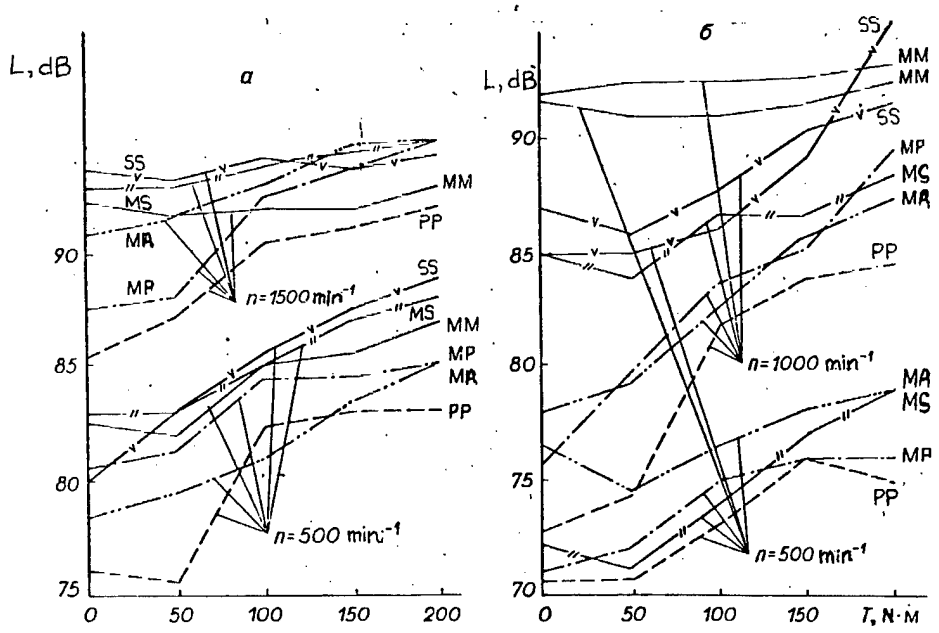

Figure 1. Relation of total noise levels (a) and vibroaccelerations (b) of the gearings tested to the magnitude of the torsional moment and rotation frequency of the pinions.

Using a reinforced wheel with a polymer tooth facing (version MR) when n = 500 min^{-1}, yields a 2- to 4-decibel noise reduction, i.e., larger than that of the MP version of the gearing. However, when the rotational frequency increases, the noise level increases, and when n = 1,500 min^{-1}, the noise level exceeds that of the standard by 2 decibels.

Using composite wheels (versions MS and SS) yielded a negative result. Only in the case where n = 500 min^{-1} and T = 0 did the SS version of the gearing show a 2.5-decibel reduction in noise level below that of the metal gearings; in all other test conditions, both gearings had a noise level that was 1.0 to 2.5 decibels above the standard.

Comparison of the three-octave noise spectra of the gearings made of metal and polymer wheels showed that the values of the noise components in the polymer wheels was 2 to 15 decibels less than those of the metal wheels in the entire frequency range studied, excluding the frequencies 100 to 160 and 6,300 to 10,000 Hz.

Figures 1b and 2 present experimental data on the total vibroacceleration levels under different speed and load conditions. Analysis of the graphs shows that damping the vibrations by using polymer and metal-polymer wheels in the gearings is most effective at a low rotation frequency (n = 500 min^{-1}) (Figure 1b). In this case, the total vibroacceleration levels are 13.5 to 21 decibels less than in the version with completely metal wheels excluding the SS gearing, which has vibroacceleration levels below that of the MM gearing (except at T = 200 N x m); however, the difference only equals 3 to 6 decibels.

When the rotation frequency increases, the vibroacceleration level of the gearings with polymer and metal-polymer wheels generally increases faster than the standard gearing.

For example, when n changes from 500 to 1,000 min^{-1} and further to 1,500 min^{-1}, the vibroaccelerations of the PP version of the gearing increased by 9 (Figure 1b) and 7.5 (Figure 2) decibels respectively, whereas under the same conditions, the increase in the vibroacclerations of the MM gearing were 1.5 and 3.0 decibels. However, despite the higher growth rate, the vibroaccleration levels of the gearings with polymer, reinforced, and composite wheels (PP, MP, MR, MC) remained lower than that of the standard MM gearing throughout the entire range of loads and rotation speeds. The difference in the vibroacceleration levels at n = 1,500 min^{-1} equals 1 to 11.5 decibels.

Among the versions tested, the PP gearing, which possesses the lowest vibration activity at all values of n and T, may be singled out.

In the MR version a relative reduction in vibration activity is observed with an increase in rotation frequency, and when n = 1,500 min^{-1}, it is close to the PP version with respect to the vibroacceleration level.

The frequency spectra of the vibroaccelerations of the gearings made of polymer wheels are arranged significantly lower than the spectra of the gearings made of metal wheels. When n = 500 min^{-1}, the reduction equals 5 to 25 decibels (excluding the frequencies from 1,600 to 2,500 Hz) and when n = 1,500 min^{-1}, it equals 5 to 40 decibels. The greatest reduction is observed in the low frequency range (up to 200 Hz).

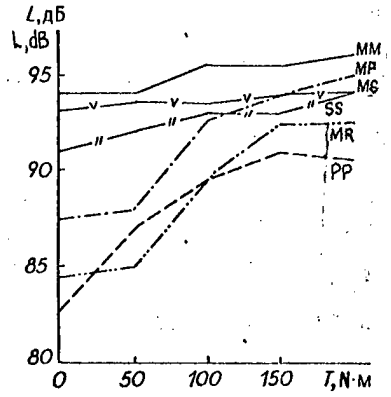

Figure 2. Effect of type of gearing and magnitude of torsional moment on the total level of vibroaccelerations when n = 1,500 min^{-1}

Conclusions

1. All of the aforementioned gearing designs may be used to reduce vibrations; only the polymer and reinforced versions may be used to reduce noise.

2. It is most effective to use gearings with polymer and reinforced wheels at loads where T < 100 N x m and with a rotation frequency below 1,500 min^{-1} (MP and PP) and 1,000 min^{-1} (MR).

3. The total level of vibrations generated by gearings with polymer and reinforced wheels depends on the transmitted load and rotation frequency to a greater degree than in gearings with metal wheels.

4. The magnitude of the load transmitted affects the total noise level of the gearings with polymer wheels in the range from 0 to 100 N x m.

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12794
CSO 1861/456

UDC 681.3-181.48

DIGITAL SIMULATOR OF DEKKA RADIO NAVIGATION SYSTEM SIGNALS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 28, No 6, Jun 85 (manuscript received 12 Nov 84) pp 25-32

[Article by V.D. Luginin and G.N. Andryushov, Leningrad Higher Marine Engineering School imeni Admiral S.O. Makarov]

[Abstract] A study is made of the design principles of a digital DEKKA navigation system signal simulator used to model the physical signals of a chain of DEKKA stations. The simulator performs two major functional tasks: formulation of a diagram describing the operation of a chain of stations and computation of the values of the navigational parameter for each station considering the statistical RF propagation conditions, with subsequent synthesis of the resultant physical signal. The simulator consists of two modules: a computer module based on an Elektronika S 5-02 microcomputer and a logic unit made of series 155 digital integrated circuits. A block diagram of the simulator is presented. The operational algorithm of a microcomputer and a block diagram of the digital phase shifter are also presented. References 9: Russian.

6508/13046
CSO: 1861/476

UDC 621.313.323

DYNAMICS OF ELASTICALLY SUSPENDED 2-STAGE GYROSCOPE WITH STEPPING DRIVE ON PRECESSION AXIS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 29, No 5, May 86 (manuscript received 20 Mar 85) pp 48-52

[Article by A.I. Zavedeyev, K.K. Koloskov, S.P. Kuzmin, Ye.M. Khromov and V.B. Chemodanov, Moscow Aviation Institute imeni S. Ordzhonikidze]

[Abstract] A study is made of the influence of resilience of the suspension of a 2-stage gyroscope and specifics of the mechanical drive on dynamic properties of a stepping motor precession axis drive. The mechanical model used includes a stepping motor, the output shaft of which is connected

through a reducing gear arrangement with some clearance and an elastic link to the body of the gyroscope. A method is presented for estimating the influence of resilience on the properties of the system. The model was used to analyze the properties of a specific gyrosystem. The reliability of conclusions based on the model was subsequently confirmed by digital simulation. Practice has shown the expediency of using this method in preliminary investigation of planned systems, since it allows a well-founded approach to the construction of simplified system models. Figures 3, references 5: Russian.

6508/13046
CSO: 1861/478

UDC 629.7.054.001

THERMAL DRIFT OF FLOATING GYROSCOPIC DEVICES DUE TO HYDROSTATIC PRESSURE FORCES IN WORKING FLUIDS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 29, No 5, May 86 (manuscript received 8 Jun 85) pp 52-57

[Article by V.E. Dzhashitov, V.N. Leonov and V.M. Pankratov, Saratov Polytechnical Institute]

[Abstract] Convective movement of the working fluid around noncircular cylindrical sensing elements in a floating gyroscope resulting from unevenness of the temperature field in the element-housing gap results in a drift moment relative to the float suspension axis. The nonuniform density of the working fluid also results in hydrostatic pressure forces acting on the float, the nature of the interaction of such forces with the float depending on the shape of the float. This article investigates the forces and moments acting on such a sensing element under these conditions, producing analytic equations for the main vector and moment of forces considering convection of the fluid. The expressions produced can be used to calculate the moments and forces of hydrostatic pressure as a function of working fluid parameters and the temperature field and geometric characteristics of the gap, thus allowing investigations of the conditions of buoyancy and determination of thermal drift. Figures 1, references 6: Russian.

6508/13046
CSO: 1861/478

UDC 629.123.4.053-52

AUTOMATION OF NAVIGATION AND MONITORING SEAWORTHINESS CHARACTERISTICS OF TRANSPORT SHIPS

Leningrad SUDOSTROYENIYE in Russian No 9, Sep 85 pp 28-31

[Article by V.A. Antonenko, A.A. Koshevoy and N.I. Sokolov]

[Abstract] A description is presented of the Soviet "Briz" and "Biryuza" automated navigation and ship management systems, said to be comparable to the American Diginav system. The "Briz" navigational system utilizes Decca, Loran, and Omega electronic navigation systems as well as a radio direction finder, a hydroacoustical log, and an electromagnetic log to maintain constant information concerning location, course, speed, and course and speed made good. The collision avoidance system automatically tracks up to 15 other vessels simultaneously, indicating collision avoidance maneuvers, both numerically and graphically. The cargo operations system features a plasma display which indicates locations where cargo should be loaded. The "Biryuza" system performs the same functions as the "Briz" system and is also capable of adjusting numerical coordinate information based on use of the Transit and Cicada satellite navigation systems. The "Biryuza" also features a microprocessor architecture. Photographs are presented of the major units of both systems. Figures 6, references 2: Russian.

6508/13046
CSO: 1861/137-B

UDC 620.1.088.328

CLIMATIC TEST BENCH FOR STRUCTURAL ELEMENTS OF PARABOLIC REFLECTORS

Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK in Russian No 1, Jan-Feb 86 (manuscript received 20 Mar 84) pp 20-24

[Article by Yu. R. Bapbyyev, M. A. Gurbanyazov, I. S. Lisker and M. Khandurdyyev, Scientific Production Association Solntse, Turkmen SSR Academy of Sciences]

[Text] Further study of space is inherently related to broad development of radio astronomy, which in turn requires design and development of large high-precision antennas. It is known [2] that the mirror system of large precision antenna arrays consists of individual elements--facets, on the precision of manufacture and installation of which on the load-bearing frame largely depends the precision of the entire "mirror." Along with this, the indicated precision must be maintained during operation to obtain high precision characteristics of mirror systems, taking into account the effect of weight, inertial and time-variable climatic factors. The influence of climatic factors on the overall variation of the configuration of both individual elements and of the entire mirror system of antenna arrays as a whole has now been least studied. However, the load of regulating the operation of the arrays makes it difficult and sometimes does not even permit these types of experiments on them. It is also known [1, 3] that the set of conditions under which the antenna array operates is very diverse. They can be divided into statistical and dynamic. In the former, the "thermal pattern" of the designs varies slowly over a period of days if there is no intermittent variation of climatic factors. In the dynamic mode, the thermal processes in the design proceed rapidly under the same conditions.

All this requires design and development of a bench for simulation of the conditions, identical to the operating conditions of large antenna arrays, within the limits of several facets with recording information about the climatic factors and temperature field of the structural elements to be investigated.

The proposed bench consists of a support-rotating device, a device for programmed implementation of the recording operation, a F-30K measuring complex and a measuring computer complex, developed on the basis of the small Elektronika TZ-16M computer.

According to the block diagrams (Figure 1, a and b), solar radiation, wind and humidity affect the object of investigation. A rotary support unit, on the

removable load-bearing frame of the three-dimensional structure of which are attached the elements of the antenna array to be investigated by pin assemblies, is used to orient the object of investigation. The design of the unit permits rotation of the attached element in azimuth from 0 to 360° and in elevation from 0 to 180°. Primary information converters, the type and design of which the investigator determines, are installed on the unit to record the reaction of the object to climatic factors. The ends of the converters terminate in a distributing box and are led by cable to a bus plug panel to the unit for programmed implementation of the recording operation. Two modes of polling the primary information converters are provided in the recording unit. The F-30K measuring complex is connected to this unit (the first mode) is slowly occurring thermal processes must be recorded. When investigating rapidly developing thermal processes, the unit is converted to the second mode with the measuring computer complex connected.

The unit for programmed implementation of the recording operation provides programming and implementation of recording of primary information about the factors affecting the object of investigation and about the parameters of its reaction to them when performing climatic tests of the structural elements of the antenna unit. The latter, using separate button arrays, permits one to compile the program for selecting the quantity, sequence and duration of polling the sources of primary information at each step of the polled cycle in real time of performing the experiment. The number of maximum polled converters of primary information in a single cycle is 126 and the length of recording of them is 0.1 s, 10 s, 1 min and 10 min. The electric signals from the primary information sources are switched by means of "dry" RES-44 relay contacts.

The switched signal is transmitted to the input of the F-30K measuring complex (see Figure 1, a) for measurement and recording on the continuous paper roll of the EUM-23D electric typewriter. The control signal of the typewriter is converted and output by a F-5033 transcriber. The next signal is switched for subsequent recording only after a carriage return signal has been transmitted from the typewriter, required to reset the number counter of the sensor in the integration module of the unit under consideration in the primary mode. The polling and recording cycle of one primary information converter is 4-5 s with regard to the low printing speed.

Parallel with measuring the temperature of the structural element of the antenna array, the devices for recording meteorological parameters provide information about direct, total and scattered radiation and also about the wind velocity and direction.

When investigating rapidly occurring processes in the structural elements of the antenna array, the composition of the measuring complex is represented by the following elements (see Figure 1, b): a universal digital measuring instrument, interface board module, Elektronika TZ-16M special computer (SVM) and Konsul-254 electric typewriter. The first element provides [translator's note: complete page of text omitted]

by constant, calibration tables that establish the function T = f(U) are usually employed for machine processing. This method is unacceptable in our case, since the memory of the Elektronika TZ-16M special computer is small. Therefore, a

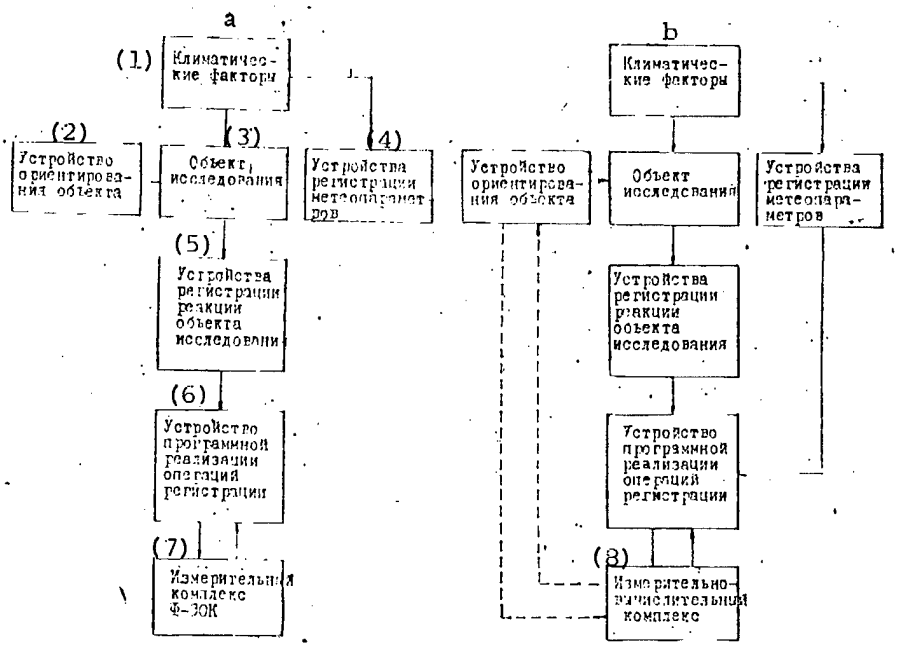

Figure 1. Block Diagrams of Recording Reaction of Object of Investigation to Climatic Factors

KEY:

1. Climatic factors
2. Object orientation unit
3. Object of investigation
4. Devices for recording meteorological parameter
5. Devices for recording reactions of object of investigation
6. Unit for program implementation of recording operations
7. F-30K measuring complex
8. Measuring computer complex

different method of converting the thermoemf to degrees is used. Its essence includes the following. The entire range of the thermoemf to be recorded (-0.5 to +7 mV), based on the given accuracy of recalculation (0.1°C), is divided into three bands. Each of them contains the dependence of temperature on thermoemf, which is given analytically in the form of a bilinear function

$$T = (K_1U + K_2)/(K_3U + K_4), \qquad (1)$$

where K_1, K_2, K_3 and K_4 are unknown coefficients.

The coefficients of the function are calculated by the least squares method and are entered into three recalculation subroutines. After the values of voltage on the sensor of the special computer have been analyzed, the necessary program is selected and the computation is made. The program steps (Figure 3) ensure sequential implementation of it. Thus, the first program step--the "reset" command, restores the corresponding cell, which is used as the number counter

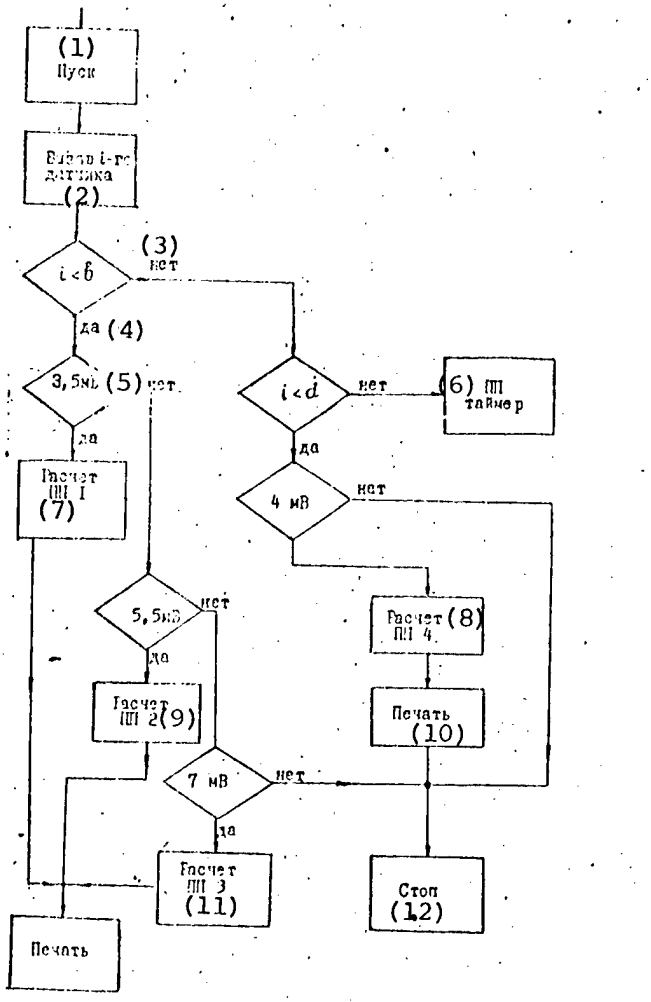

Figure 3. Block Diagram of Program for Conversion of Thermoemf to Degrees

KEY:

1. Start
2. Call of i-th sensor
3. no
4. yes
5. mV
6. Timer routine
7. Computation of routine 1
8. Computation of routine 4
9. Computation of routine 2
10. Print
11. Computation of routine 3
12. Stop

of the sensor, the second step stops the special computer after all sensors have been processed and the values of voltage: -0.5 mV < U < 3.5 mV, 3.5 mV < < U < 5.5 mV and 5.5 mV < U < 7 mV, are analyzed after calling the sequential values from the computer memory. The voltages are then converted to degrees according to the following formulas:

$$T = 10^3 \cdot U/1{,}22\,(U - 0{,}5) + 63{,}45 \qquad (2)$$

where 0.5 mV < U < 3.5 mV;

$$T = 10^3 \cdot U/0{,}7\,(U - 3{,}5) + 67{,}11 \quad (3)$$

for 3.5 mV < U < 5.5 mV;

$$T = 10^3 \cdot U/0{,}2\,(U - 5{,}5) + 68{,}52 \quad (4)$$

for 5.5 mV < U < 7 mV.

The calculations according to formulas (2), (3) and (4) implement the corresponding steps of the program.

The next program, required for automation of the process, is the timer routine. It is implemented by introducing an operational loop with given operating time into the rogram. The time interval between the two sensor polling cycles is entered by the operator in the corresponding cell. The counter of the number of main cycles and the counter of the number of the sensor are embedded on a single cell for economical use of the main memory of the special computer.

Two versions are also possible for recording meteorological data: the first is identical to the recording version already described (see Figure 1, a) and the second provides for connection of the units for recording meteorological parameters to the measuring computer complex through a matching unit. Implementation of the versions is determined as a function of the load of the special computer memory. The software of the measuring computer complex is available for corresponding modification of the rotary support unit for automatic orientation of the element to be investigated with respect to the sun with subsequent measurement and recording of the indicated characteristics.

Conclusions

A bench was developed for climatic tests of the structural elements of large antenna arrays. Because of the mobility of the unit for programmed implementation of the recording operations, connection of both the F-30K measuring complex and similar complexes for investigation of slowly variable processes and of the measuring complex based on the Elektronika TZ-16M computer is possible, which provides complete automation of the process of measurement and recording of the "thermal pattern" of the structural elements of antenna arrays during rapidly variable heat transfer processes. The temperature fields of fragments of the reflecting surface of large parabolic concentrating systems were investigated on the bench.

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6521
CSO: 1861/526

BRIEFS

NEW LENS DEVELOPED AT BELORUSSIAN OPTICO-MECHANICAL ASSOCIATION--"VEGA-22UTs" is a high-quality five-piece anastigmatic lens. It is used for printing enlarged color and black-and-white pictures from 6 x 9 cm and smaller negatives. The lens can also be used for reproductions. Due to built-in correction light filters, it is possible to continuously vary the optical density of color. [Text] [Minsk NARODNOYE KHOZYAYSTVO BELORUSSII in Russian No 3, Mar 86 p 2] [COPYRIGHT: "Narodnoye khozyaystvo Belorussii," 1986] 12770/13046

SOME APPLICATIONS OF INFRARED IMAGING--Photo [omitted] shows a fragment of a "thermal portrait" of a large industrial city. It is received by digital processing of an infrared image, performed at the Space Research Institute, AN SSSR. Using this method, it is possible to estimate heat leakages from buildings of any type, industrial installations, thermal lines, etc. Infrared imaging helps in selecting optimal means for thermal insulation, revealing environmental pollution sources; it is also successfully used in many branches of national economy. [Text] [Moscow NTR: PROBLEMY I RESHENIYA in Russian No 7, 8-21 Aug 86 p 4] 12770/13046

CSO: 1861/468

UDC 778.38

EQUIPMENT FOR MEASURING DYNAMIC DEFORMATION OF DIFFUSELY-SCATTERING OBJECTS BY HOLOGRAPHIC AND SPECKLE INTERFEROMETRY AND MOIRE METHOD

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 5, May 86 (manuscript received 2 Jul 85) pp 22-24

[Article by A.L. Churayev, D.I. Staselko, S.I. Kuznetsov, and V.P. Alekseyev]

[Abstract] Equipment has been designed and built for measuring the dynamic deformation of diffusely scattering surfaces by three methods, covering a deformation range from a fraction of micrometer to several centimeters and applicable to sheet and strip products under impact. This equipment, for holographic and speckle interferometry and moire measurements, consists of a laser pulse-pair set, an illuminator, and recording instrumentation. The laser set contains two OGM-20 industrial lasers, each emitting pulses of 20 ns duration and 20-30 mJ energy at specific instants of time. The illuminator brightens the object from two directions, with a diverging light beam almost normally incident for holographic and speckle interferometry and with two coherent beams nearly parallel to the surface from a 2-mirror Mach-Zender interferometer for moire measurements. Recording instruments include two "Zenith-E" photographic cameras with "Helios-44" objectives for simultaneous recording of holographic and speckle interferograms by one and moire patterns by the other. High-sensitivity moire recording requires high-precision optics, to ensure a sharp contrast in a field with high spatial frequency. The moire method is preferable for determining surface displacements during long pauses between pulses, when interference fields have become decorrelated, while holographic interferometry is preferable for determining initial displacements and velocities. Figures 2, references 13: 9 Russian, 4 Western (1 in Russian translation).

2415/13046
CSO: 1861/530

UDC 535.24.07/08

MEASUREMENT OF SMALL BRIGHTNESS COEFFICIENT OF NONSELECTIVE LIGHT-SCATTERING MATERIALS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 5, May 86 (manuscript received 29 Jul 85) pp 44-46

[Article by S.M. Leykin, O.M. Mikhaylov, M.M. Seredenko, A.M. Frost, and E.I. Khapugina]

[Abstract] An instrument for measuring a brightness coefficient within the 0.01-0.05 range characteristic of nonselective light-scattering materials has been developed and tested, a 2-beam photometer operating by the optical null-balance method. A reference plate of ONS4 glass with a 0.163 brightness coefficient is recommended, but a barite plate with a neutral filter is also acceptable. The nearly parallel incident light beam impinges at a 45° to the surface and readings normal to the surface are taken on a drum dial. The systematic relative error does not exceed 20% at the 0.01 end of the scale and 10% at the 0.05 end. The photometer has been calibrated with an RN8-20 lamp as light source and a lens focusing the light onto the test specimen, a diaphragm for setting the aperture of the reflected light beam, a diaphragm for setting the photometer field of vision, a filter for correcting the spectral sensitivity of the photometer, and a photodiode as measuring device. Reference plates were calibrated against a GOvernment STandard plate of MS20 glass. Each balancing operation requires and must not exceed 30 s. Figures 1, tables 3, references 6: Russian.

2415/13046
CSO: 1861/530

UDC 772.932.45

RELATION BETWEEN PROCESSING PARAMETERS AND DEFORMATION CHARACTERISTICS OF PHOTOTHERMOPLASTIC FILM

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 5, May 86 (manuscript received 4 Oct 85) pp 46-47

[Article by V.V. Kryukov and I.I. Dukhopel]

[Abstract] Processing of photothermoplastic films is considered, design of the recording system and optimization of the recording mode being two principal interrelated problems and optimization of the film being the third one. Power of the generally nonsquare-wave thermal developing pulse, estimated on the basis of its rise time or duration, and processing temperature are the critical variables on which the ratio of charge relaxation time to surface relief relaxation time depends. Increasing thermal pulse power would be difficult in the processing equipment, being limited by the capacity of the electric circuit as well as by "frost noise," which increases with

increasing thermal power and reduces the signal-to-noise ratio. The most expedient way to maximize that ratio of relaxation times is to modify the chemical structure of the film material and particularly its thermoplastic component, either by addition of a plasticizer or by alteration of the composition along with the molecular mass, which will allow developing with a lower thermal power. A hologram of a plane wave front was produced on a film of a composite material containing a styrene-butadiene copolymer, deposited by centrifuging on a 1 cm thick glass substrate with aluminum substrate, and then developed in a stream of hot air for 20 s. Figures 1, references 4: Russian.

2415/13046
CSO: 1861/530

UDC 535.8:539.216.23

PRODUCTION OF OPTICAL COATINGS BY CHEMICAL DEPOSITION FROM GASEOUS PHASE

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 5, May 86 (manuscript received 20 Jun 85) pp 47-56

[Article by B.G. Gribov, I.V. Baranenkov, V.N. Petrov, A.V. Koshchiyenko, and B.I. Kozyrkin]

[Abstract] The advantages of chemical deposition from the gaseous phase over production of optical coatings by other methods such as vacuum evaporation, cathod or magnetron sputtering, ion-beam treatment, or chemical reaction are high rate of film buildup and high degree of versatility in terms of film materials. Chemical deposition as an equilibrium process can be easily monitored on the basis of its thermodynamics, for control of film composition and buildup rate. Coatings thus produced are of high quality, with nearly zero porosity, high mechanical strength, and strong adhesion to various substrates. The prerequisites for chemical deposition from the gases phase are volatile raw materials, organoelemental compounds being most universally applicable but hydrides and chlorides being also suitable. The deposition process is based on their thermal decomposition yielding an oxide, a nitride, a sulfide (selenite), or a metal depending on the raw material used. Equipment for this process consists of a vapor-gas mixture generating and feeding system, a reactor, and a substrate heater. Plasma-pyrolytic reactors are of horizontal, vertical, or bell jar construction, slotted horizontal reactors with rectangular cross-section being most efficient. The plasma is excited either inductively or capacitively, radiative defects in both coating and substrate being minimized by prevention of direct contact between plasma and substrate. Substrates are heated by the electrical-resistance method most efficiently and safely with low-cost equipment, by infrared radiation fastest and most economically over the 573-1473 K temperature range, or by rf electric current. The last method ensures a clean process, with fast and uniform heating, but requires intricate and costly equipment which is potentially unsafe because of the high voltage. An ultraviolet laser is used, typically with a quartz reactor, for deposition of coatings

from the gaseous phase of organoelemental compounds which absorb UV radiation so that photodissociation of their molecules occurs while the substrate is heating up. Films producible by chemical deposition from the gaseous phase include films for interference coatings (SiO_2, TiO_2, ZrO_2, SnO_2, HfO_2, ThO_2, Al_2O_3, Nb_2O_3, In_2O_3, MgO, Ta_2O_5, ZnSe, Si_3N_4), films with selective transmission spectra for ultraviolet, visible-light, infrared filters (CoO, Co_3O_4, Cr_2O_3, Fe_2O_3, MoO_3, WO_3), optically transparent and electrically conductive films for optoelectronic data processing devices (ZnO, In_2O_3, In_2O_3:Sn, SnO_2, SnO_2:F, SnO_2:Sb), reflective metal films (Al, Cr, Mn, Fe, Co, Ni, Mo, Sn, W, Re), and absorptive films for selective coatings on solar energy covnerters (Si, Cr + Cr_2O_3, Cr + Cr_2O_3 + VO_2, Ni + NiO, Mo + MoO_3, W). Figures 6, tables 5, references 44: 19 Russian, 25 Western.

2415/13046
CSO: 1861/530

UDC 621.326.7

PROBLEMS OF HEAT EXCHANGE IN HEAT LAMPS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 28, No 6, Jun 85 (manuscript received 4 Jun 84) pp 86-91

[Article by A.N. Gordov, I.V. Rodionova and M.I. Shpakova, Leningrad Institute of Precision Mechanics and Optics]

[Abstract] A study is made of the influence of heat exchange between a tungsten filament and the gas filling a heat lamp bulb at the temperature of the strip filament. Studies were performed on series-produced SI-6-100 heat lamps by measurement of the distribution of brightness temperature along the filament strip with the lamp placed horizontally or vertically with 3 power supply modes, all using DC of the same polarity. Currents varied from 5.87 to 8.46A, brightness temperatures from 1100 to 1538°C. It is found that the temperature field of the vertical strip can be considered the result of superposition of the vertical distribution of gas temperature and the distribution of temperature along the strip resulting from heat transfer to the supports and radiative heat exchange. This is used to determine the distribution of temperature along a horizontal strip. It is concluded that the change in vertical temperature gradient of the gas near the vertical heated strip in the process of free convection, decreasing with increasing strip temperature, is well explained theoretically by the corresponding increase in gas flow velocity. References 4: Russian.

6508/13046
CSO: 1861/476

UDC 528.711

GENERAL MODEL OF OBSERVATION SPACE TRANSFORM IN RASTER OPTICAL-ELECTRONIC DEVICES

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 28, No 6, Jun 85 (manuscript received 2 Apr 84) pp 54-58

[Article by A.S. Batrakov, Leningrad]

[Abstract] A development is suggested for methods of modeling raster optical-electronic devices, based on the idea of reducing the system to a dynamic central projection in which elements of external orientation of the photosensitive surface are functions of time. A mathematical model is developed to establish the relationship between coordinates of points on the light-sensitive surface and the space being observed. The geometric conversion model developed can be extended to raster devices with arbitrary numbers of sensing elements by determining the matrix operators of each element and finding their product in the sequence in which the transforms are performed. References 8: Russian.

6508/13046
CSO: 1861/476

UDC 519.688;535.317.7

ACCELERATED MODIFICATION ALGORITHM FOR FAST KOTELNIKOV INTERPOLATION

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 28, No 6, Jun 85 (manuscript received 20 May 83) pp 37-39

[Article by I.P. Agurok and V.Ye. Zakharin, Leningrad Institute of Precision Mechanics and Optics]

[Abstract] A previous work by the same authors suggested an algorithm for fast Kotelnikov interpolation of a function with finite spectrum based on a limited number of samples. This work suggests an expansion of the approximation range of the composite function allowing a decrease in the computer time required to restore the function over several ranges of interpolation. The number of coefficients of the approximation is found to increase more slowly than the range expansion coefficient, resulting in additional acceleration. References 2: Russian.

6508/13046
CSO: 1861/476

UDC 621.375.826

PULSE-PERIODIC TEA CO_2 LASER

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 29, No 5, May 86 (manuscript received 11 Jun 85) pp 93-96

[Article by N.Ye. Averyanov, Yu.A. Baloshin, V.M. Gromovenko, V.M. Irtuganov, V.P. Kalinin, K.I. Krylov, Yu.P. Nikonov, I.V. Pavlishin, O.A. Shorokhov and V.I. Yurevich, Leningrad Institute of Precision Mechanics and Optics]

[Abstract] A description and results of experimental testing of the discharge and lasing characteristics are presented for pulse-periodic transverse electric-discharge atmospheric pressure (TEA) CO_2 laser with a closed gas loop. Gas circulation is supported by a centrifugal fan. A diagram of the device is presented. The discharge chamber in the upper portion of the gas system has a volume of 0.85 l. Cavity can be Q-switched for stable, unstable, and selective modes. Mean output power is as much as 510 W. Peak lasing energy of 17 J was obtained for a CO_2:N_2He mixture with a ratio of 1:1:5 and pressure 10^5 Pa. Advantages of the device include relatively low voltage rectifier, use of semiconductor thyristors as switching elements, and rapid charging of the capacitor banks, allowing significant reduction in dimensions of high voltage power transformer and power supply in general. Figures 3, references 9: Russian.

6508/13046
CSO: 1861/478

UDC 53.089.5:621.375.826

INSTRUMENT FOR MEASURING EMISSION PARAMETERS OF TECHNOLOGICAL LASERS

Moscow IZMERITELNAYA TEKHNIKA in Russian No 4, Apr 86 pp 13-14

[Article by V.A. Ageykin, Ye.N. Antonov, B.A. Mishke, N.A. Panina, S.P. Fetisov, Ye.B. Shelemin, and V.A. Yakovlev]

[Abstract] An instrument which measures and records not only the average emission power of technological CW lasers but also parameters of its fluctuation has been developed for use in quality control of laser-beam manufacturing processes such as cutting and welding. It operates according to the principle of diffractional beam splitting by means of a phase grating. The zeroth-order reflected radiation is sent to the machining zone, while the radiation diffracted at a 0.1 rad angle in the ±N-th order (N = 1,2,3,...) and constituting only 0.0001-0.001 of the total is sent through a set of optics to the receiver-converter input stage of the instrument. This stage consists of an optical modulator with mechanical drive and a preamplifier. The measuring and recording stage behind that preamplifier consists of a linear detector followed by an analog-to-digital converter and then a code converter, both connected to a synchronizer, with a controlled indicating device for average

power at the output, also a fluctuation discriminator and a tolerance limits marker followed by a comparator and then a controlled indicating device for fluctuation of average power at the output. This instrument has been designed for the 10.6 μm radiation wavelength and laser beams 10-70 mm in diameter. Its power ranges are $5 \cdot 10^{-2}$-$5 \cdot 10^{3}$ W with diffraction grating and $5 \cdot 10^{-2}$-5 W without one, the maximum allowable power density being 500 W/cm^2 or 3 W/cm^2, respectively. It indicates the average power with a systematic error, including the calibration error, not larger than 10%. It can operate continuously for 8 h, after up to 5 min warmup time. The fluctuation limits can be ±3%, ±5%, or ±10% and the maximum recordable number of fluctuations during the operating period is 198. Only up to 1% of the technological laser radiation is diverted for measurement. The instrument draws a power of not more than 100 VA. Figures 1, references 3: Russian.

2415/13046
CSO: 1861/506

UDC 389.14:681.7.069.223:681.782.423.3

STABLE SOURCE OF INFRARED RADIATION FOR PHOTOMETER CALIBRATION

Moscow IZMERITELNAYA TEKHNIKA in Russian No 4, Apr 86 pp 14-15

[Article by A.I. Pyzhov, S.A. Lyutov, and S.V. Nikolin]

[Abstract] A stable calibrating reference source of infrared radiation has been developed, to be built into photometers which measure the energy of laser radiation. Its basic element is an AL107B light-emitting diode, stabilized by constancy of both current and temperature. The diode is thermostatically controlled inside a cylindrical double-wall shell, two metal sheaths separated by polyurethane foam, with a 12-ohm nichrome heater coil wound inside and connected into the circuit of a KT814B power transistor controlled by a comparator. The diode bias is set by a high-precision direct-current generator consisting of a KP902A field-effect transistor and a 140UD7 operational amplifier with two resistors, one of them adjustable, and a D818Ye stabilitron as reference-voltage generator. The radiation power of this diode has a temperature coefficient of 0.3%/°C. The voltage drop across the diode junction has a negative temperature coefficient of 3.5-4 mV/°C so that the diode can also serve as thermoelectric converter. The maximum radiation power of this source is 7 mW at a diode current of 80 mA and a diode temperature of 40°C. Regulation from 7 mW down to 0.4 mW is possible by sliding the adjustable resistor from 10 ohm to 200 ohm. The radiation spectrum of this source extends over the 0.92-1.04 μm range of wavelengths, with maximum intensity at the 0.96 μm wavelength. Such sources built into photometers measuring the energy of laser radiation pulses have stabilized their readings, with a drift of not more than 2% over a period of 2 years. Figures 1, references 1: Russian.

2415/13046
CSO: 1861/506

UDC 535.8:539.213

SELF-ENHANCEMENT OF HOLOGRAPHIC RECORDING IN AMORPHOUS As_2S_3

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR in Russian No 3, Mar 86
(manuscript received 17 May 85) pp 128-131

[Article by M.Ya. Reynfelde, A.O. Ozols, and K.K. Shvarts, Institute of Physics of the Latvian SSR Academy of Sciences]

[Abstract] Films of the As_2S_3 0.6 to 12 micrometers thick were vacuum deposited on glass substrates and illuminated with light intensities of less than 0.6 W/cm^2. The self-enhancement of the resulting holograms were studied as a function of the film thickness and holographic grating period (0.6 to 20 micrometers). Argon laser beams at 514.5 nm recorded a low-diffraction-efficiency (less than 1%) hologram and the self-enhancement was determined by reading the hologram with the same beam or with He-Ne laser at 632.8 nm directed onto the sample from the opposite side. The holograms were recorded and read at room temperature. The diffraction efficiency is defined as the ratio of the incident radiation and the radiation stopped down to the maxima of the ±1st order. The degree of self-enhancement is defined as the ratio of the diffraction efficiency when the hologram is read to the initial diffraction efficiency at the conclusion of the recording process. The self-enhancement is a function of the sample thickness, holographic grating period, initial diffraction efficiency and the read beam wavelength. Strong absorption and a maximum self-enhancement of approximately 10 are observed when the hologram is read at 514.5 nm. Curves showing the self-enhancement as a function of the exposure and grating period when excited by light at 514.5 nm and read at 632.8 nm show self-enhancement peak values of 240, 180, and 80 for film thickness of 11.7, 6.5, and 3.5 micrometers, respectively. Self-enhancement in such amorphous materials and its behavior confirm the vector model advanced earlier by the authors (IZVESTIYA AN LATVIYSKOY SSR, SERIYA FIZIKI I TEKHNICHESKIKH NAUK, 1985, No 1, pp 27-29) for holographic gratings. The general laws governing self-enhancement kinetics in lithium niobate and amorphous As_2S_3 are the same. Figures 4, references 7: 4 Russian, 3 Western.

8225/13046
CSO: 1861/362

UDC 533.6.011.5

CHARACTERISTICS OF HYPERSONIC FLOW PAST MODELS IN WIND TUNNELS OF VARIOUS TYPES

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian
No 2, Mar-Apr 86 (manuscript received 23 Jan 85) pp 181-184

[Article by V.I. Alferov, A.N. Labazkin, and A.P. Rudakova, Moscow]

[Abstract] An experimental study of longitudinal hypersonic flow past models with obtuse (apex angles 100-130°), and acute (apex angle 80°) conical noses, and a hemispherical nose, was made for a comparative evaluation of three different wind tunnels. Tests were performed at gas stream velocities of N_M = 6-9 in two hypersonic wind tunnels, one with Joule-effect and the other with electric-arc preheating of the gas in the forechamber, and in an ultrahigh-speed wind tunnel. Total pressure in the forechamber was measured, as well as the distribution of static pressure over the model surface, and along the nozzle, deflection angle of the shock wave, distance from the tip of the nose to the point of separation of the shock wave, and the critical nose cone angle corresponding to separation at the tip. A spherical source of gas stream was used with a conical nozzle, which made it necessary to account for nonuniformity of flow in the oncoming stream as determined by the ratios R/r^* and L/R (R - radius of nose base circle and cylinder, r^* - radius of spherical stream source, L - distance from center of stream source to tip of nose): $R/r^* = 0.48$ and $L/R = 26$ for the two hypersonic tunnels with preheating, $R/r^* = 0.7$ and $L/R = 20$ for the ultrahigh-speed wind tunnel. Analysis of wave shapes and measurement of separation distances with a "Microphot" instrument under x4.9 magnification and with a "PENTAKTA" instrument under x14.5 magnification, at the same Mach number in each wind tunnel, have been supplemented with calculations according to an appropriate modification of Newton's theory for flow of an ideal gas. The results indicate formation of an entropic relaxation layer at the surface of nose cones, especially in the ultrahigh-speed wind tunnel but also in the hypersonic wind tunnel with electric-arc preheating. Correction for a shock wave in a real gas indicates that the distance from the tip of a hemispherical nose to the point of separation of the shock wave depends on the intensity of thermodynamic processes (adiabatic expansion) and chemical processes (O_2 dissociation) in the shock layer. The behavior of a real gas during hypersonic flow past bodies can evidently be reproduced in an ultrahigh-speed wind tunnel, to a much lesser extent in a hypersonic wind tunnel with electric-arc preheating. Figures 2, tables 1, references 12: 8 Russian, 4 Western (1 in Russian translation.

2415/13046
CSO: 1861/503

UDC 681.121.845.001.24

ACOUSTIC CONTINUITY TRANSDUCER FOR FLOW METERS OPERATING IN TWO-PHASE MEDIA

Moscow IZMERITELNAYA TEKHNIKA in Russian No 4, Apr 86 pp 42-43

[Article by A.A. Alekseyev and A.L. Seyfer]

[Abstract] Existing acoustic flow and continuity meters for use in gas-liquid media have been supplemented with an ultrasonic one operating on the basis of change in the acoustic impedance, this change depending on the frequency of ultrasonic waves as well as on the changes in their velocity and attenuation in the medium. The acoustic flow-through transducer module consisting of a coaxial hollow piezoelectric radiator-inside-receiver pair is fitted into a break along the pipeline and fastened to the latter at both ends through flanges so as to close the break. The gap between the two cylinders as well as the gap between the receiver cylinder and a surrounding metal sheath are filled with a mixture of epoxy resin and piezoceramic powder. A typical application is measuring the gas content in an air-water mixture. Measurements are made with the radiator excited by electric signals from an oscillator and the receiver connected to a phase-difference meter. With the frequency varied from 0 to 200 kHz, the signal phase is measured at each frequency first with pure water and then with pure air flowing through. On the resulting phase-frequency characteristic is selected the frequency corresponding to the maximum difference between signal phases with full and empty module respectively and subsequent actual measurements are made at that frequency. Such measurements were made in pipelines 6-50 mm in diameter carrying various media, their densities covering the 0.8-1.45 g/cm^3 range with a dielectric constant from 1.5 to 80 and their flow velocity covering the 0-10 m/s range. One such module consisting of a 1 mm thick radiator cylinder with an 18 mm inside diameter and a 2 mm thick receiver cylinder with a 28 mm outside diameter, both 25 mm long, was connected to a GZ-118 audio-frequency oscillator, a ChZ-33 frequency meter, a V7-27A voltmeter, an F2-16 phase-difference meter with a 2 Hz-2 MHz frequency range, an SI-118 2-beam oscilloscope for waveform analysis, and an N-391 recording instrument with an I-37 amplifier. Figures 2, references 7: Russian.

2415/13046
CSO: 1861/506

UDC 532.582

MOTION OF BODY IN VIBRATING FLUID

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 289, No 2, 1986 (manuscript received 20 Jul 84) pp 314-317

[Article by B.A. Lugovtsov and V.L. Sennitskiy, Institute of Hydrodynamics imeni M.A. Lavrentyev, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] Motion of a solid body in a vibrating fluid is analyzed theoretically, for confirmation of the experimentally discovered anomaly that a body made of a material heavier than the liquid will buoy and a body made of a material lighter than the liquid will sink when the vessel containing the fluid performs sufficiently intense translational oscillations. While a closed vessel containing a fluid performs such oscillations relative to some reference system, the body moves under the forces of gravity and fluid pressure. The fluid is assumed to be an ideal incompressible one, and initially at rest so that its subsequent motion is potential. The body is assumed to be homogeneous sphere. The equation of motion for the center of inertia of this sphere is formulated in a noninertial system of coordinates rigidly fixed to the vessel, with the appropriate initial conditions for the radius-vector of that center of the sphere. This equation and the equation of continuity for the velocity potential, with appropriate boundary conditions, need not be solved for determination of the radius-vector as a function of time. Instead, inasmuch as the Hamilton variational principle is applicable here, the corresponding system of Lagrange equations for kinetic energy and working force is derived and then averaged with a displacement resolved into a large slowly varying one and a small fast varying one. The period of vessel oscillations is assumed to be much shorter than the time of total vertical body travel in a quiescent fluid and the total distance traveled by the body under the force of gravity alone to be much larger than the amplitude of vessel oscillations. An analysis of the Lagrange equations in this form confirms the anomalous behavior of a body under the given conditions. It is demonstrated in the specific example of a fluid half-space. It can be theoretically extended to several bodies of arbitrary shapes in a vibrating fluid, though no experimental evidence of that is yet available. Article was presented by Academician M.M. Lavrentyev on 4 July 1984. References 4: 2 Russian, 2 Western (both in Russian translation).

2415/13046
CSO: 1861/540

SPREADING OF PLANE LIQUID JET OVER PLATE SURFACE

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNICHESKIKH NAUK in Russian No 10, Issue 2, Jun 86 (manuscript received 28 May 85) pp 55-59

[Article by V.A. Yermakov, V.V. Bondarik, and N.V. Skorik]

[Abstract] An axisymmetric free liquid jet incident on a solid plate is considered (surface cleaning is a typical application), and subsequent spreading of the liquid film over the surface is analyzed as a problem of hydrodynamics. The region around the stagnation line and the region where a dynamic boundary layer builds up are of particular concern, inasmuch as the frictional shearing stresses are maximum at the boundary between them. The velocity distribution over the plate is found from the corresponding equation for a generally oblique incidence jet of ideal liquid, this transcendental equation being solved by the Stefensen method, and is then approximated with a power-law relation $u/v_0 = nx^m$ by the method of least squares. Both coefficient n and exponent m are calculated for forward flow and reverse flow, the velocity distribution depending in each case more or less on the angle of jet incidence. The standard system of boundary-layer equations for steady flow of an incompressible fluid can then be replaced by a system of ordinary differential equations with appropriate boundary conditions. These have been solved by numerical integration according to the Gill variant of the Runge-Kutta method with fourth-order precision. Calculations based on measurement of frictional shearing stresses in dimensionless coordinates for a vertical jet impinging on a horizontal plate yield values lower than the theoretical ones, evidently because the theoretical values are based on a thin boundary layer and on a velocity at the film surface in this region equal to the velocity in the jet. In reality the velocity here is lower and the boundary layer is thicker. Figures 4, references 3: 1 Russian, 2 Western (1 in Russian translation).

2415/13046
CSO: 1861/528

UDC 629.124

POSSIBILITY OF NONPERTURBING MOTION OF BODY IN LIQUID

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNICHESKIKH NAUK in Russian No 10, Issue 2, Jun 86 (manuscript received 28 Jun 85) pp 37-44

[Article by V.I. Merkulov, Institute of Theoretical and Applied Mechanics, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] Nonperturbing motion of a body in a liquid is considered, the problem being formulated as one of determining the shape of the body and to describe its motion near the free surface which will not generate waves at any point within some closed control surface. The body has a parallelpiped exterior with open ends, and the interior walls converge to form a "waist" near the middle of the body; therefore the external flow is one-dimensional, and the internal flow two-dimensional. A vortex sheet arises at the boundary of the two flows. The motion of such a body is analyzed in three projections, the flow function being implicitly dependent on the shape of the itnernal "waist" of the body. The problem is solved by separation of variables, for symmetric bodies only. First is determined the shape of a body generating a plane flow when moving and then is determined the possibility of reducing perturbation in the outer layer while maintaining potential flow. Action of the limiting planes, which extend beyond the liquid-displacing part of the body, is replaced by action of some vortex sheet, these planes providing boundaries at which velocity jumps and pressure drops can occur. A qualitative analysis of the solution yields exact results in the integral representation and sufficiently accurate results in the asymptotic representation, corrections being required in the latter case especially when viscosity of the liquid needs to be taken into account. Figures 6, references 2: Russian.

2415/13046
CSO: 1861/528

UDC 532.5:532.517.4

DERIVATION OF EQUATIONS OF MOTION FOR DISCRETE VORTEX PARTICLES IN AXISYMMETRIC FLOW

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNICHESKIKH NAUK in Russian No 10, Issue 2, Jun 86 (manuscript received 27 Dec 84) pp 45-50]

[Article by A.N. Veretentsev, P.A. Kuybin, V.I. Merkulov, and V.Ya. Rudyak, Institute of Theoretical and Applied Mechanics, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] The variational method of constructing discrete vortex models for two-dimensional flow is extended to axisymmetric flow of an inviscid fluid.

The flow function is defined in a cylindrical system of coordinates, assuming an incompressible fluid and toroidal vortices with finite cross-section. After change to Lagrangian variables, the closed system of two equations of motion is put in Hamiltonian form, also derivable from the corresponding variational principle. Moments of the vorticity field are calculated accordingly, the Hamiltonian being invariant with respect to axial shear and not an explicit function of time so that the laws of momentum and energy conservation apply. References 8: 4 Russian, 4 Western (3 in Russian translation).

2415/13046
CSO: 1861/528

UDC 533.924

EXPERIMENTAL STUDY OF THERMAL PERFORMANCE CHARACTERISTICS OF HOT EVAPORATING CATHODE IN STATIONARY VACUUM ARC WITH DIFFUSE PINNING TO CATHODE

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 24, No 3, May-Jun 86 (manuscript received 2 Apr 85) pp 422-429

[Article by S.N. Paranin, V.P. Polishchuk, P.Ye. Sychev, V.I. Shabashov, and I.M. Yartsev, Institute of High Temperatures, USSR Academy of Sciences]

[Abstract] An experimental study of a vacuum arc with a rare earth metal such as gadolinum as evaporating cathode material was made, for the purpose of determining the temperature dependence of cathode performance and of arc-to-cathode pinning. Relevant theoretical background is given on the temperature dependence and the work function dependence of the maximum ion-to-electron ratio in accordance with the Richardson-Dushman law, also the heat balance at the cathode surface is analyzed. Experiments were performed in a vacuum chamber under a residual pressure not exceeding 10^{-3} Pa, its wall made of metal with three quartz windows for optical measurements and with water cooling. Inside the chamber were placed a meltable gadolinum cathode in a molybdenum crucible, a molybdenum disk anode, the latter movable so that the interelectrode distance could be varied over the 1-6 cm range, an electron-beam cathode heater consisting of a straight annular tungsten cathode-emitter and a focusing electrode, and a shutter behind the anode. Measuring instruments included an optical pyrometer and a photoelectric pyrometer as well as a multiplex spectrum recorder. Electrical accessories included a power rectifier and a high-voltage rectifier, also a heater for the cathode of the electron-beam heater. An arc was initiated by the high-voltage rectifier supplying the breakdown voltage to vapor of gadolinum heated to a temperature of approximately 2000 K. The results of the experiment revealed formation of an arc with stationary diffuse pinning to the cathode, at a cathode temperature of 1900 K or higher and at a cathode current density of 10 A/cm^2 or higher, without flicker of microspots over the cathode surface as a result of shifting local overheat and without high-frequency megahertz fluctuations of arc voltage characteristic of low-temperature high-current vacuum arcs. Cathode erosion proceeded through evaporation, the 1900-2300 K

temperature range corresponding to 1-100 Pa pressure of saturated Gd vapor. Figures 5, references 21: 15 Russian, 6 Western (4 in Russian translation).

2415/13046
CSO: 1862/246

UDC 533.951

DYNAMICS OF ELECTROSTATIC INSTABILITIES IN HOT ELECTRON BEAMS

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 24, No 3, May-Jun 86 (manuscript received 12 Apr 85) pp 430-436

[Article by V.N. Novikov, Moscow Institute of Aviation imeni S. Ordzhonikidze]

[Abstract] Electrostatic instabilities in electron beams are analyzed theoretically, taking into account a high initial temperature of electrons injected by the emitter into vacuum and the effect of "hot" injection (mean electron velocity at emitter of the order of thermal electron velocity) on the development of these instabilities. The analysis is based on the Vlasov equation of electron injection dynamics in dimensionless form and the Poisson equation of an electrostatic field in one-dimensional approximation, for a planar electron beam without collisions. These equations are solved for appropriate boundary conditions by a numerical method which involves implicit straight-through calculation of the characteristic distribution function in the distance-velocity-time phase space, with the normalized mean electron velocity and mean distance between electrons as governing parameters. Advantages of this method include absence of numerical diffusion and usability of a regular or special grid in the phase space. Its algorithm is demonstrated by use of a floating and adaptive grid, eliminating the need for multiple interpolation on the time steps but conveniently accounting for acceleration of particles, also ions, with attendant buildup of directional currents and including a correction for second-order precision with respect to the time step generally made equal to a fraction of the reciprocal of the electron plasma frequency. The method facilitates simulation of boundary conditions in a three-dimensional phase space and is, moreover, readily extendable to a Vlasov equation with a Bhatnagar-Gross-Crook collision integral on the right-hand side. The method was applied to an electron beam with a sufficiently large space charge and thus and thus with a virtual cathode in the drift space, this cathode back-scattering some electrons and oscillating either weakly when located close to the emitter or strongly when located far from the emitter. The method was also applied to the Pierce problem (J. APPLIED PHYSICS Vol 15, 1974, p 721) for analyzing various mechanisms of electrostatic instability in a "hot" electron beam. The author thanks B.V. Alekseyev and A.A. Rukhadze for fruitful discussions. Figures 2, references 12: 10 Russian, 2 Western (1 in Russian translation).

2415/13046
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UDC 533.6:013.42

EFFECT OF INITIAL STRESSES ON SURFACE WAVES IN SYSTEM CONSISTING OF PRESTRESSED COMPRESSIBLE BODY AND VISCOUS COMPRESSIBLE FLUID

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 22, No 6, Jun 86 (manuscript received 27 Feb 85) pp 32-36

[Article by A.M. Bagno, Institute of Mechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] Propagation of Stoneley waves along the interface of a compressible elastic solid and a Newtonian compressible viscous fluid is considered, with prestressing of the solid, of particular concern being the dependence of both velocity and attenuation of such waves on the initial stresses in the solid. The analysis is based on the corresponding linearized equations of the three-dimensional theory of elasticity with large finite initial strains for the solid and linearized Navier-Stokes equations for the fluid. This system of equations has been solved numerically for acrylic glass and water or glycerin, with the triply invariant elastic Murnaghan potential. The results reveal that the velocity increases and the attenuation coefficient decreases as the initial stresses are increased, this effect of initial stresses being stronger when the fluid is more viscous. Increasing the frequency of waves from $1 \cdot 10^5$ s^{-1} to $1 \cdot 10^6$ s^{-1} was found to decrease their velocity and increase the attenuation coefficient. Figures 4, references 17: 15 Russian, 2 Western.

2415/13046
CSO: 1861/469

UDC 539.3

STABILITY OF RIBBED CONICAL SHELLS UNDER EXTERNAL PRESSURE OR AXIAL COMPRESSION FORCES

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 22, No 6, Jun 86 (manuscript received 2 Jan 85) pp 44-48

[Article by Yu.A. Sannikov, Institute of Mechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] Two stability problems are considered for truncated closed circular conical shells on hinge supports, stiffened by a web of hoops on the outside and stringers on the inside, namely, stability of such shells under external pressure and under axial compression forces, respectively. The hoops are assumed to lie in planes parallel to the bases and the stringers are assumed to lie parallel to the axis. Assuming a zero-moment subcritical state, the critical loads in each case have been calculated according to the Kirchhoff-Love theory of thin elastic shells and the Kirchhoff-Clebsch theory of thin curvilinear beams. The corresponding systems of equations were solved analytically by the energy method, with displacements approximated as monomial trigonometric functions, and then numerically by the Bubnov-Galerkin method on an M-4030 computer according to a program written in FORTRAN-4. A shell with a 0.64 rad divergence angle, 75 mm radius of the smaller base, 225 mm radius of the larger base, 0.5 mm sheath thickness, 5.75 mm^2 stringer cross-section, -1.935 mm stringer eccentricity, 6.75 mm^2 hoop cross-section, +2.723 mm hoop eccentricity, all made of a material with a Young's modulus of $6.8 \cdot 10^4$ MPa and a Poisson ratio of 0.3 was loaded for a determination of the dependence of the critical load in each case on the number of hoops and the number of stringers. The results indicate that such a shell with 3-5 hoops and 32 stringers is weakest. Instability modes are analyzed and economical stiffener patterns are determined on this basis. Figures 5, references 4: Russian.

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CSO: 1861/469

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ON THEORY OF THICK PLATES ON ELASTIC FOUNDATION

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 50, No 2, Mar-Apr 86 (manuscript received 14 Feb 85) pp 255-262

[Article by M.A. Sumbatyan and I.F. Khrdzhiyants, Rostov-on-Don]

[Abstract] A plate of an isotropic elastic material rests without friction on a linearly deformable, isotropic foundation. The stress deformed state of the plate is found from a solution of Lamé equilibrium equations written in terms of the displacements and the stresses are related to the displacements by

Hooke's law. The stresses are due to the loading of the plate on the top face by a normal distributed load. A class of homogeneous solutions is found for the case of a free top face and linearly elastic contact of the plate with the foundation on the bottom face. The latter condition takes the form of a relation using an integral operator for the contact problem of a linearly deformable foundation, coupling the settling of the plate and the contact stress. There are three types of such homogeneous solutions: potential, vortical, and harmonic. Finding the characteristic numbers of the potential solution reduces to finding the eigenvalues of the integral operator. The method is illustrated with the example of the axially symmetric problem of the deformation of a circular plate with a free side surface on a Winkler foundation. In the specific case of a concrete foundation, the error in meeting the boundary conditions, including those for the rib stiffening, was no more than $3 \cdot 10^{-3}$ and the computing time for any of the stresses or displacements at any point in the plate was 1 s on the YeS-1022 computer. Such numerical studies show that thin plates can have regions of large negative normal stresses several times greater than the characteristic stress and in reinforced concrete foundation slabs, this can lead to cracks and fractures. This approach enables the evaluation the minimum plate thickness for which negative stresses are not excessive. The method can also be extrapolated to dynamic problems of harmonic oscillations of a thick slab on an elastic foundation. Figures 2, references 11: 10 Russian, 1 Western.

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UDC 539.36:534.1

VIBRATIONS OF SEGMENT OF LONGITUDINALLY MOVING STRING OF VARIABLE LENGTH

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 50, No 2, Mar-Apr 86 (manuscript received 12 Apr 85) pp 219-223

[Article by V.V. Popov, Leningrad]

[Abstract] Waves propagate longitudinally along a string segment, one end of which is stationary while the other end moves longitudinally outward in a uniform manner. The equations describing the wave propagation in such a string moving at a constant longitudinal velocity are reduced by the sequential application of Galilean and Lorentz transformations to a boundary value problem in turn reduced to the problem of a segment with fixed ends. The general solution of the problem of wave description in the variable length moving string segment takes the form of the sum of the resonant oscillations. A general analytical expression is found for the motion of the moving end of the segment for different functions governing the change in the segment length. A procedure is given for the determination of the expansion coefficients of the solution in terms of eigenfunctions for the initial conditions specified in the initial variables. The existence of the expansion of the general solution in the form of the sum of resonant oscillations with constant coefficients is evidence that the nonsteady-state vibrational

processes under consideration have steady-state characteristics. No numerical examples or applications are cited in this theoretical analysis. Figures 1, references 3: Russian.

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UDC 531.391

ON ROTATIONAL MOTION OF RIGID BODY, SUPPORTING A VISCOELASTIC DISK, IN CENTRAL FORCE FIELD

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 50, No 2, Mar-Apr 86 (manuscript received 31 Oct 84) pp 187-193

[Article by N.Ye. Bolotina, V.G. Vilke, and Yu.G. Markov, Moscow]

[Abstract] A symmetrical rigid body moves in a circular Keplerian orbit around a gravitational center. The body carries a circular plate, located in the equatorial plane of the ellipsoid of inertia of the rigid body and has the same center of mass as the body. Bending oscillations of the disk have no influence on the motion of the system. These bending deformations of the disk, accompanied by the dissipation of energy, are the cause of the evolution of the system's rotational motion. It is assumed in the description of the deformed state of the disk that the usual assumptions of the linear theory of small deflections of thin plates apply. Approximate equations are solved in order to describe the rotational motion evolution; the resulting solution corresponds to system rotation about an axis of symmetry coinciding with a normal to the orbit. Since the solid is symmetrical, its angular velocity does not agree with the orbital angular velocity. The nature of this evolution of symmetrical solid body motion with such a disk is similar to the evolution of the motion of a symmetrical solid with viscoelastic, flexible rods arranged along the axis of symmetry of the solid. No numerical examples are given in this theoretical analysis. References 5: Russian.

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UDC 629.197

STABILITY OF SATELLITE RING ROTATION

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 50, No 2, Mar-Apr 86 (manuscript received 3 Jan 85) pp 179-186

[Article by V.V. Beletskiy and Ye.M. Levin, Moscow]

[Abstract] A homogeneous, flexible, and extensible filament, closed in a ring, is located in the field of a stationary gravitating center. The motion

of any such ring is inherently unstable with any modulus of elasticity of the filament. Since the motion of a solid ring of the materials known today cannot be approximated with a rigid ring, this instability of uncontrolled elastic rings indicates the necessity of control. This paper derives expressions for ring motion and finds the conditions that assure the stability of ring rotation with the appropriate control. The ring characteristics do not follow Hooke's law in this case. The results are applied to the study of the stability of the rotation of a large number of artificial satellites, strung together in an orbiting ring by means of weightless cables of variable length. A broad class of control functions for the tension of the connecting cables, where the functions provide for the stabilization of the satellite ring, is found. An analogy with the dynamics of meteor and satellite rings is also found and a model is proposed for a meteor ring in the form of a ring of an equivalent flexible filament with a specified function describing the extensibility. Figures 3, references 8: 3 Russian, 4 Western, 1 Russian in English translation.

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CSO: 1861/375

UDC 534.833:681.3

SIMULATION OF RESONANT VIBRATIONS OF VIBRATION INSULATION SYSTEM UNDER EFFECT OF LOW-FREQUENCY PARAMETRIC EXCITATION

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 86 (signed to press 7 Sep 83, resubmitted 16 Oct 85) pp 89-92

[Article by S. V. Vlasov, M. D. Genkin, E. G. Gudushauri and V. G. Yelezov, Moscow]

[Text] In connection with the trend noted in modern engineering toward a decrease in stiffness of equipment suspensions and the application of multistage vibration insulation systems, the problem of reducing low frequency, and especially resonant, vibrations in vibration insulation systems is acquiring important practical significance.

The enrichment of the frequency spectrum of vibration insulation systems and the shift of this spectrum to the low-frequency region are increasing the susceptibility of systems to low-frequency disturbances, and the presence in this range of a series of natural vibrations of the human body and its individual organisms gives rise to an especially dangerous resonant nature of the effect of this type of vibration on the human organism [1-3]. Damping resonant vibrations in multistage vibration insulation systems with reduced rigidity of the vibration insulators is a complicated engineering problem and usually it leads to reduced efficiency in the transresonant region.

In this paper a study is made of the possibility of lowering the resonant vibrations of vibration insulating systems by means of parametric excitation of them. The basis of the investigated method of vibration protection is experiments in which the effect of vibration and noise on the human organism with different spectral structure has been studied [4]. The results of reference [4] permit the conclusion to be drawn that a wide-band or polyharmonic process (noise or vibration) in the general case has a less harmful effect on the human organism than sound (vibration) of a pure tone with identical integral power of them. This means that a vibration protection system that redistributes the energy of harmonic vibrations of the frequency band is just as effective as a system that lowers the energy of these vibrations.

In the given paper results are presented from a study of the traditional vibration insulation system (Figure 1) with a disturbing force of mass m (the case of installing vibration active equipment) and variation of the natural frequency of the vibration insulation system by a harmonic law. The latter is accomplished by applying vibration insulators with rigidity control

by the output voltage of the modulating signal generator. It is easy to show that the obtained results extend to the case of kinematic disturbance on the part of the base.

The dynamics of a vibration insulation system (Figure 1) in the presence of the selected types of control and perturbing inputs are described by the equation

$$\ddot{x}+\delta\dot{x}+\omega_0^2(1+h\cos\nu t)x=F\cos pt, \tag{1}$$

where x, $\dot{x}$, $\ddot{x}$ are the displacement, the velocity and acceleration of a mass; δ is the damping coefficient, $\omega_0=(k/m)^{1/2}$ is the natural frequency of the vibration insulation system; h is the parametric excitation factor; ν is the parametric excitation frequency; F, p are the amplitude and frequency of the perturbing force acting on the mass m.

The investigation of vibrational systems of this type has been the subject of many theoretical papers [5-6, 8] and experiments based on the results of mathematical simulation [7]. However, there are no studies for the case where the frequency of the exciting force (kinematic excitation) is close, but the parametric excitation frequency is much less than the frequency of the natural vibrations of the vibration insulating system. As will be demonstrated below, this case is of interest because it is for these relations of the system parameters that it is possible to insure effective reduction of resonant vibrations as a result of redistributing the vibrational energy over the frequency band.

The forced components of the vibrations of a vibration insulation system (Figure 1) are defined as the partial solution to equation (1) which can be written in the form of the sum of terms of a harmonic series [5]

$$x(t)=\sum_{k=-\infty}^{\infty}A_k\cos[(p+k\nu)t+\varphi_k]. \tag{2}$$

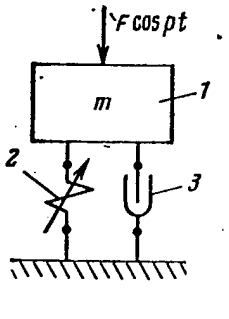

Figure 1

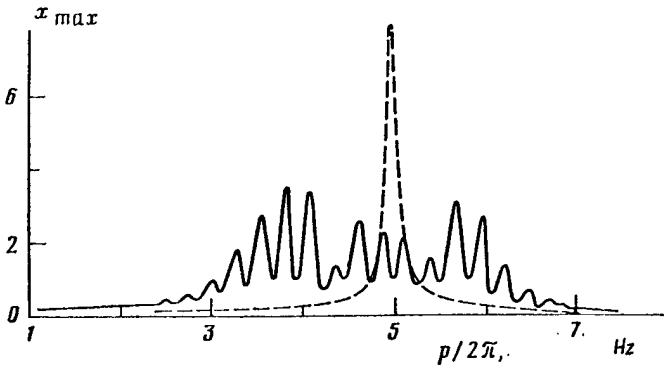

Figure 2

Analysis of the partial solution of (2) indicates that the perturbing force with frequency $\bar{p}$ causes forced vibrations with frequencies

$$p_k=(p\pm k\nu), \quad k=0, 1, 2, \ldots \tag{3}$$

in the vibrational system (Figure 1) with harmonically varying natural frequency.

For determination of the energy relations between the vibrations excited in the system, equation (1) was simulated on the MN-18M analog computer. The solutions obtained in the time domain were processed on the spectral analyzer built by Bruel and Kajer (B&K model 2033).

Characteristic results of the simulation are presented below for the following system parameters: $\omega_0/2\pi=5$ hertz; $h=0.5$; $F=2$. The remaining parameters (p, ν, δ) were varied, and their influence on the investigated processes was reflected in the conclusions by the results of simulation of equation (1).

For determination of the structure of the system response at different frequencies of the disturbing force, a relation was constructed for the limiting (maximum) values of the displacements x_{max} of a mass m as a function of a frequency p varying according to a linear law $p(t)=\dot{p}t+p_{init}$, where p_{init} is the initial value of the frequency; $\dot{p}$ is its variation rate.

Figure 2 shows the envelope function $x_{max}=f(p)$ (the solid line) for $\delta=0.05$, $\nu/2\pi=0.27$ hertz, $\dot{p}/2\pi=10^{-4}$ (hertz)^2, $p_{init}/2\pi=1$ hertz. Here, the dotted line represents the frequency -amplitude characteristic of the investigated system in the absence of a parametric excitation.

Analysis of the graphs in Figure 2 reveals that the dependence of the limiting values on the frequency has clearly expressed peaks at a frequency p_0 close with respect to magnitude to the natural frequency of the system ω_0 and on frequencies of $p_1=p_0\pm\nu\ell$ ($\ell=1, 2, 3, \ldots$).

The frequency shift p_0 with respect to ω_0 and the nature of the envelope of the frequency function of the limiting values essentially depend on the parameters δ and h. The level of peaks outside the range of $[p_0(1-\sqrt{h}); p_0(1+\sqrt{h})]$ decreases rapidly.

A comparative analysis of the relations presented in Figure 2 permits the conclusion to be drawn that the parametric excitation of a vibration insulation system significantly reduces the magnitude of the resonant vibrations. Outside the range of $[\omega_0-\nu/2; \omega_0+\nu/2]$ the limiting values of x_{max} exceed the amplitude of the forced vibration in the system without parametric excitation This excess turns out to be insignificant in the vicinity of frequencies $p_{min\ maxima}=p_0+\nu/2\pm\nu k$ ($k=0, 1, 2,\ldots$) and increases near the frequencies of the of the function. Thus, with polyharmonic nature of the exciting force, along with reduction of the resonant frequencies in the investigated system intensification of the vibrations outside the range $[\omega_0-\nu/2; \omega_0+\nu/2]$ can occur. However, by appropriate selection of the frequency ν and the amplitude h of the parametric excitation it is possible to avoid or reduce

the amplification effect of the vibrations while retaining significant vibration protection effect in the vicinity of resonance.

In order to discover the spectral composition of the vibrations, a spectral analysis was made of the obtained signals which were processed in the frequency range of 0 to 10 hertz with frequency resolution of 0.25 hertz and averaging time of 300 seconds.

Spectrograms of the vibrations of mass m are presented in Figure 3 for $\nu/2\pi=0.27$ hertz and different values of p and δ (a--$p/2\pi=5$, $\delta=0.05$; b--$p/2\pi=5.12$, $\delta=0.05$; c--$p/2\pi=5.11$ hertz, $\delta=0.5$).

The spectrum of the vibrations in the absence of a parametric excitation is depicted by a dotted line on each of the spectrograms. The level of spectral density on the graphs is presented in decibels with respect to zero level $x_0=1\cdot10^{-7}$ related to the scale of the analog computer used.

From the spectrograms presented in Figure 3 it is obvious that in each spectrum there are discrete components present with frequencies (3). A comparison of the spectra for different δ (Figure 3, b and c) indicates that an increase in damping leads not only to a reduction in level of vibrations of mass m in the presence and absence of parametric excitation, but also a reduction (for fixed value of h) of the vibration protection effect caused by redistribution of the vibration energy. In this case it is possible to achieve an increase in effectiveness of the investigated system by increasing the parametric excitation factor h.

Analysis of the spectrograms considering the partial solution of (2) permits the following conclusions to be drawn.

1. In spite of the fact that the vibration spectrum is unlimited with respect to frequency, the significant levels of discrete components (levels exceeding 0.1% of the vibration amplitude in the absence of parametric excitation) are in practice within the frequency range $[\omega_0(1-\sqrt{h});\ \omega_0(1+\sqrt{h})]$.

2. As a result of redistribution of the energy of the forced vibrations with respect to the combination frequencies, a decrease in the level of the discrete component on the excitation frequency takes place. The vibration protection effect in decibels as a result of redistribution is estimated by the empirical formula $\Delta A\approx10\ \lg\ [\omega_0(2h)^{1/2}/\nu]$ with sufficient accuracy for practice.

3. If the frequency of the perturbing force p lies outside the frequency range $[\omega_0(1-\sqrt{h});\ \omega_0(1+\sqrt{h})]$, then the combination frequencies are not excited in practice. With consideration of the graphs depicted in Figure 2, the presented conclusions indicate that with significant separation of the components of the exciting force with respect to frequency (for example, more than 0.5 octave) it is possible to select the parameters ν and h so as to insure significant (~20 dB) reduction of the resonant vibrations in the system without noticeable increase in vibration outside the resonant region.

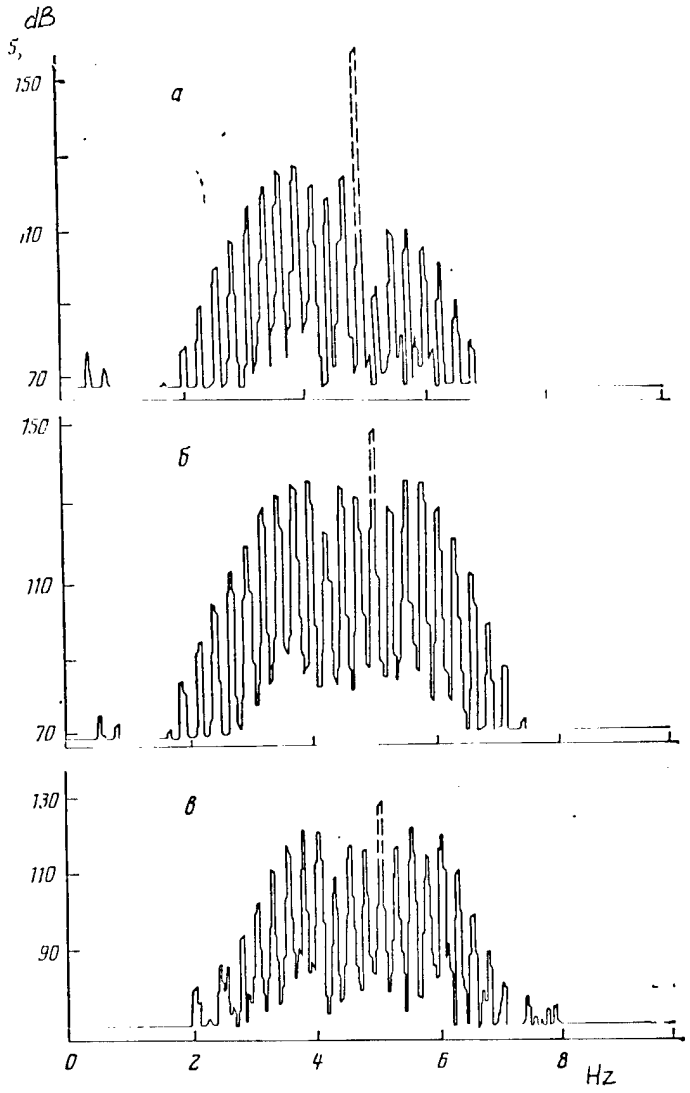

Figure 3

As practical ways of implementing the investigated method of vibration protection it is necessary above all to note the application of vibration insulators with adjustable rigidity. Thus, parametric excitation of the vibration insulation system with the investigated parameters can be realized by means of a vibration insulator made on the basis of thin layer rubberized metal elements and piezoelements [9].

Other devices by means of which the investigated method of vibration protection can be implemented include the known [10] vibration insulators with automatic control using signals proportional to the forces transmitted by the vibration insulators or their deformations.

Inasmuch as in this case control leads to variation in stiffness of elastic suspension, for parametric excitation of the system it is necessary to vary the amplification coefficients in the control channels by a given law.

It is obvious that it is most expedient to apply the investigated method of vibration protection to systems under the effect of a low-frequency polyharmonic force or kinematic disturbance where the use of ordinary multistage vibration insulation systems leads to excitation of the resonant vibrations. The objects of use of the proposed method include transport units, powerplants, powerful pumps, and so on.

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10845
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INFLUENCE OF ATMOSPHERIC FACTORS ON PROPERTIES OF WOOD-POLYMER COMPOSITE MATERIALS

Minsk VESTSI AKADEMII NAVUK BSSR: SERIYA FIZIKA-TEKHNICHNYKH NAVUK in Russian No 1, Jan-Mar 86 (manuscript received 10 Jul 84) pp 35-38

[Article by B.I. Kupchinov, N.V. Nemogay, and R.I. Ayzyatulova, Institute of Mechanics of Metal-Polymer Systems, BSSR Academy of Sciences]

[Abstract] An experimental study has been made concerning the influence of atmospheric factors on mechanical properties of composite materials consisting of wood particles and phenol formaldehyde resin. Mixes were produced using 2-25 mm long birch plywood pieces 1-1.5 mm thick and 1-5 mm wide (composite A), with 15 wt.% leaves added (composite B), with 15 wt.% Ag-4S fibers added (composite C), with 15 wt.% carbon-graphite cloth added (composite D), and resin constituting 25 wt.% of the dry residue. Specimens for testing, 120 mm long and 15x10 mm^2 in cross-section, were produced by pressing these mixes under 40 MPa at a temperature of 423 K for 0.02 h per millimeter of thickness. Tests were performed in three modes. The first mode was a cycle consisting of 3 h in a weather chamber with ultraviolet radiation from a DRT-375 mercury-quartz lamp, at a temperature of 323 K with 90% humidity, then 3 h in an "HCL" 250/70 freezer at 228 K, and again 3 h in the weather chamber. The second test was continuous, 24 h, over a period of 24 months inside an MIM special thermostat at 323 K with 90% humidity. The third test was under natural atmospheric conditions according to GOST [State Standard] 17170-71. Changes in strength characteristics, namely, in hardness and toughness, as well as in wear resistance and in the supermolecular structure served as indicators of the effect of these tests. The supermolecular structure was examined in a DRON-2 x-ray diffractometer at 40 kV accelerating voltage, with a copper anode and a CuK_o- radiation source. Surfaces were examined under a "Neophot" MIM-8Mi optical microscope. The results indicate that the resin binder rather than the wood filler is subject to atmospheric aging, ultraviolet radiation being the most detrimental factor but becoming effective only after 4-5 years of exposure. Figures 3, references 5: Russian.

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