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## *SYSTEM ANALYSIS, CONTROL AND INFORMATION PROCESSING*

## *MACHINES, AGGREGATES AND TECHNOLOGICAL PROCESSES*

*are driven by a drive consisting of a power plant and a gearbox. A cylindrical gear drive is adapted to synchronize the rotation of the shafts.*

*This study aims to obtain an equation for calculating the resistance when mixing bitumen-mineral mixtures in a helical stirrer, the active surface formed by a guiding curve. The following tasks were solved when the research was to find out the reasons:*

*— the description of the mixer design with stirrers having a working surface formed by a guide curve is given;*

*— the mathematical model of forces acting on a stirrer having a working surface formed by a guiding curve is described;*

*— expressions are obtained to determine the mixing resistance and the power the drive consumes. The analysis of the obtained equations showed that their value depends on several factors: the physicomechanical properties of the mixture, the shear resistance and the coefficient of external friction, the degree of filling of the helical stirrer, the number of stirrers and the angle of their installation to the plane of rotation, the number of revolutions of the shafts and their radius of the stirrers.*

**Keywords:** helical stirrer, mixing resistance, power consumption.

**V. S. Romanenko, K. A. Yudin**
INFLUENCE OF CIRCULATION RATE IN A HORIZONTAL ROLLER MILL WHEN OBTAINING MARBLE SAND

*The article discusses a horizontal roller mill with an internal separator. The purpose of using such mills is to reduce the energy consumption of the grinding unit. The design of the mill is given. Formulas for calculating the productivity of a horizontal roller mill are presented. In accordance with the theory of experimental planning, experiments were carried out to determine the influence of the circulation ratio and drum rotation speed on the technical and economic parameters of a horizontal roller mill. Marble chips were chosen as the starting material. Experimental dependencies are presented. The kinetic equation is given. The dependence of grinding fineness by residue on sieve $R_{0071}$ on the circulation rate is presented. The optimal operating mode of a horizontal roller mill with an internal separator has been selected depending on certain values of input factors and an experimentally confirmed circulation ratio.*

**Keywords:** horizontal roller mill, roller, marble, productivity, housing rotation speed, circulation rate.

**M. S. Chepchurov, B. S. Chetverikov, N. S. Ljubimyj, A. S. Luk'janov**
ABOUT CHARACTERISTICS OF AUTOMATIC LINES FOR OPTICAL SORTING OF FRUITS AND VEGETABLES

*The paper discusses issues related to the characteristics of automatic sorting lines for fruits and vegetables. The authors analyzed the structure of the sorting technological process, on the basis of which the characteristics of the fruit and vegetable sorting complex have been identified, allowing the implementation of a project to create automatic sorting equipment. As a result of the study, it has been found that the critical parameter of the sorting line is the speed of product movement. It is its value, for a given average fruit weight, that influences not only the sorting performance, but also the time it takes to complete the limiting operation. It is necessary to note that when increasing productivity, parallel placement of product flows is preferable rather than increasing the speed of fruit movement along an automatic line, since the latter can lead to distortion of the identifiable parameters of the product due to a decrease in the time limit for optical identification of the product.*

**Keywords:** sorting, automatic line, efficiency, shape defect, optical control, weight control.

**K. V. Kaisheva, E. A. Kraikina, A. I. Bogdanov**
EVALUATION OF THE PARAMETERS OF THE DISTRIBUTION LAW OF THE WEIGHTING COEFFICIENTS OF INDIVIDUAL INDICATORS OF PRODUCT QUALITY
*The article considers the issues of estimating the parameters of the distribution law of the weighting coefficients of individual quality indicators for randomly selected consumers (Dirichlet distribution). An equation is obtained, the numerical solution of which makes it possible to calculate maximum likelihood estimates under certain additional conditions. A universal approach to the estimation of Dirichlet distribution parameters is also considered. Calculations were made based on the results of a survey of 35 potential consumers of products about the importance of 5 single indicators of the quality of women's jackets.*
**Keywords**: quality, single indicator, generalized indicator, randomness, Dirichlet distribution, maximum likelihood estimation.

**G. I. Korshunov, A. Yu. Tumanov, E. S. Yarmonova**
A METHOD FOR REDUCING THE RISKS OF PROJECTS TO CREATE SYSTEMS TO ENSURE THE STABILITY OF THE FUNCTIONING OF INSTRUMENT-MAKING FACILITIES
*The purpose of the presented work is to create a model and a means of preliminary assessment of damage to ensure the quality and resources of processes using neural networks. Many processes are similar when setting the task of preliminary assessment of attracting and activating resources to minimize possible damage. The article presents a generalized process of choosing a quality assurance option and attracting resources. The selection problem is considered under the condition of changing input data on external influencing factors. The use and training of a neural network ensures a given accuracy of the preliminary assessment of damage to decision-making. The processes of selecting suppliers and predicting the consequences in emergency situations are considered.*
**Keywords:** quality, process resources, damage, neural networks, security. damaging factors, factors of supplier selection.

**K. V. Kaisheva, E. A. Kraikina, A. I. Bogdanov**
INVESTIGATION OF THE LAW OF DISTRIBUTION OF CONSUMER ESTIMATES OF QUALITY INDICATORS OF LIGHT INDUSTRY PRODUCTS
*The article is devoted to the study of the law of distribution of consumer estimates of quality indicators of light industry products. It examines the main criteria of agreement used in testing statistical hypotheses about the law of distribution of a random variable (Pearson, Romanovsky, Kolmogorov) and the areas of their practical application. For the collected statistical information on consumer ratings of five indicators of the quality of women's jackets, hypotheses about the normal distribution law and the β-distribution were tested. According to the results of calculations based on the Kolmogorov criterion, the first hypothesis was rejected, and the second was accepted. Estimates of the β-distribution parameters for all quality indicators of women's jackets were obtained.*
**Keywords:** quality indicator, random variable, distribution law, criterion of agreement, β-distribution.

**M. B. Sukhanov, M. D. Dudnik**

STATISTICAL STUDY OF DATA ON THE TIME OF NEURAL NETWORK GENERATION OF IMAGES FOR TEXTILE DESIGN

*The introduction of neural networks into the practice of textile design creates prerequisites for studying the associated costs of working time. The **aim of the work** is a statistical study of the time of image generation using a neural network based on a diffusion model for their application in textile design. **Research objectives**: 1. Analysis of scientific literature on the research topic. 2. Obtaining data on the time of generation by a neural network of images of different styles with ornaments according to their textual description. 3. Making a decision on the recommended time limit for the generation of textile ornaments in the artistic design of textiles. **Research methods**: review and analysis of scientific literature; generation of images of different styles with geometric shapes using the Kandinsky 2.2 neural network, descriptive statistics, plotting a frequency histogram of a random variable.*

*__Results__: Based on machine learning, the search for several product variants using a neural network allows you to reduce the time for creating drawings and partially, but not completely, automate the process of designing drawings.*

*On a modern computer, creating images using a neural network usually takes no more than a few tens of seconds. The interval of 15–28 seconds is proposed to be considered as the norm of time for generating textile ornaments using a neural network, provided that the style of the drawing is preset.*

**Keywords**: production planning, time norm, substantiation of time standards, microelement rationing of labor, light industry, artificial intelligence, generative design.


**A. I. Bogdanov, B. P. Kasatkin**
MATHEMATICAL MODEL OF RISK MANAGEMENT OF INDUSTRIAL ENTERPRISE PROJECT

*The article deals with the issues of risk management of industrial enterprise project. The scheme of states of the enterprise project is offered on the basis of which the system of differential equations of Kolmogorov for probabilities of states is made. The calculation of the final probabilities of the states and the resulting profit for different sets of measures to prevent risk events, as a result of which the optimal set of measures is determined.*

**Keywords:** entrepreneurial project, risk, Markov random process, final probabilities of states, profit.


**L. N. Nikitina, E. A. Kraikina**
PROSPECTS FOR THE DEVELOPMENT OF LIGHT INDUSTRY ENTERPRISES OF THE RUSSIAN FEDERATION

*The purpose of the study is to substantiate the prospects for the development of light industry enterprises, taking into account modern requirements for organizational and technical resources. In accordance with this goal, clustering is calculated using the k-means method for light industry enterprises.*

**Keywords:** cluster analysis, k-means method, light industry enterprises, capital return, efficiency of information resources, labor productivity, profitability of production, coefficient of sustainability of production growth.


**E. R. Martynets, A. V. Kornienko, V. A. Leventsov**

PROCESS MODEL OF DESIGN AND TECHNOLOGICAL PREPARATION OF MANUFACTURING WITH A FOCUS ON DIGITAL TWIN TECHNOLOGY

*Enterprises often carry out a lot of expensive iterations related to the development and testing of products, and therefore it is necessary to improve the tools used at the development and manufacturing stage. The use of digital twins in industry contributes to meeting a variety of requirements from the customer and consumer, increasing the speed of product launch to the market, reducing the cost and duration of new product development. The paper proposes an approach to the design and technological preparation of manufacturing based on the creation of a digital twin of product. A comparative analysis of traditional and modern approaches to the organization of manufacturing is carried out. The possibilities of improving the design and technological preparation of manufacturing based on the developed process models of traditional and modern approaches are presented.*

**Keywords:** organization of manufacturing, product design and engineering, design and technological preparation, manufacturing, digital twin technology, process model.

**A. S. Tur**
METHODOLOGY FOR ESTIMATING THE VALUE OF INAUTHENTIC COMPONENTS UNDER UNCERTAINTY

*The article presents a scheme of allocation of standard costs to cost objects (components), develops a matrix for calculating the allocated cost of each product, analyzes the risks arising from the replacement of original components with inauthentic ones.*

**Keywords:** quality improvement, non-authentic components, functional-cost analysis.

**N. K. Popov, P. A. Shikov, Yu. A. Shikov**
ASSESSMENT OF ECONOMIC EFFICIENCY AT DIFFERENT STAGES OF IMPLEMENTATION OF AN INNOVATION PROJECT IN THE PROCESS OF DIGITAL TRANSFORMATION OF AN INDUSTRIAL ENTERPRISE

*The article discusses the problems and main approaches to determining the economic efficiency of innovative projects implemented at chemical industry enterprises based on the concept of Industry 4.0 and methodological recommendations of UNIDO (United Nations Industrial Development Organization) in the modern economy of the Russian Federation. The experience of implementing modern digital platforms is studied on the example of the leader of the branch of PJSC "Khimprom". The integral economic effect obtained during the entire life cycle of an innovative project based on the methodology of measuring the economic and digital environment, targeted investments of industrial enterprises in digitalization, both production and technological capacities, and in management processes is presented.*

**Keywords:** the concept of Industry 4.0, innovative project, digital platform, digitalization of production, investment, criterion of economic efficiency.

***TECHNOLOGY AND PROCESSING OF SYNTHETIC AND NATURAL POLYMERS AND COMPOSITES***

**V. A. Pechilin, N. P. Midukov, M. A. Midukova**
THE MODERN LEVEL OF FOREIGN RESEARCH ON THE TWO-STAGE DRY DEFIBRATION AND DEINKING OF RECOVERED PAPER

*The article presents an overview of the current state of research abroad in the field of studying the properties and structure of paper products obtained by dry and aerodynamic molding, as well as its purification from toner and ink. In particular, the potential of using recovered paper dispersed at equilibrium humidity is being investigated. The materials on advanced methods*

used by scientific centers of the world investigating the process of forming paper products from fibers in conditions of equilibrium humidity are presented. Critically analyzing foreign publications on this topic, the authors propose a new approach that allows us to develop technology and devices for preparing semi-finished products and molding paper products in conditions of equilibrium humidity, contributing to the implementation of resource-saving processes in homeland production. Unlike existing foreign studies using dry or aerodynamic defibration methods in a gap between rotor and stator, the authors propose a hybrid approach combining both wet and dry methods to meet specific product strength requirements. The proposed method also allows to achieve a balance between the quality of the final product and the energy costs associated with the production of secondary fiber.
**Keywords:** dry defibration, cast containers, paper products, reduction of energy consumption.

**M. A. Litvinov, I. V. Anisimov, M. V. Kuznecov**
NEURAL NETWORKS IN ASSESSING THE QUALITY OF PAPER AND CARDBOARD
*The article is devoted to a new method of controlling the parameters of fibrous materials such as paper and cardboard using artificial intelligence. To do this, the optical properties of the material were considered, and a neural network was developed. The advantages of using a neural network are considered. In the course of the study, optical properties determined using a neural network and a standard method were compared. The graphical processing was performed using the ImageJ program, which made it possible to prepare images of the surface of the fibrous material for further analysis by the neural network.*
**Keywords:** paper, cardboard, fibers, whiteness, brightness, neural network, artificial intelligence.

**N. P. Midukov, V. S. Kurov, M. A. Zilbergleit**
MICROSTRUCTURE RESEARCH TO EVALUATE THE PRINTING PROPERTIES OF PAPER AND CARDBOARD
*The paper-base for the packaging material is considered in the study and a method for evaluating the uniformity of paper and cardboard by the microstructure of the cross section is proposed. Cross sections are prepared using ion cutting and analyzed using scanning electron microscopy. The resulting microstructure image is processed using graphical software to select the profiles of the upper and lower layers. The distribution of the fibrous material is estimated based on these selected areas. The uniformity of the formation of the material is determined by analyzing the diagram of the distribution of layer thicknesses over the cross section. The study showed that the bottom layer has the most uniform shape, while the molding process of the top layer can be improved to enhance printing properties. This method complements existing methods for estimating the heterogeneity of cellulose composite materials and contributes to the development of a 3D fiber model.*
**Keywords:** fibrous composite material, microstructure, heterogeneity of molding, paper and cardboard.

**I. V. Porotikova, N. V. Evdokimov, D. V. Serbul**
MANUFACTURE OF EQUIPMENT PARTS FOR THE PRODUCTION OF CAST CONTAINERS MADE FROM WASTE PAPER
*The article presents the main stages of designing and manufacturing a complex-shaped part using a 3D scanner, as well as a two-extruder 3D printer. The blade for the conveyor of a line for the production of cast containers from waste paper is considered as the subject of research. In the manufacture of the part, a patented device was used to implement combined 3D printing by liquid layering (LDM - Liquid deposit molding) and extrusion of a polymer rod (FDM —*

*Fused deposit molding). The result of 3D printing was a working part (blade), which was later used in production.*
**Keywords:** 3D-design, 3D-scanner, complex shape detail.

**N. P. Midukov, N. V. Evdokimov**
*DOI 10.46418/2619-0729_2024_1_20*
OVERVIEW OF EXTRUDER DESIGNS FOR THE LAYERED FORMATION OF
PRODUCTS BASED ON LIQUID WOOD-POLYMER COMPOSITES
*The article presents the results of a critical analysis of the designs of extruders for layer-by-layer molding of products based on liquid wood-polymer composites. Foreign and homeland analogues are considered as a comparison. Based on a detailed study of the extruder designs, a two-extruder 3D printer device was proposed, which made it possible to combine the technology of fused deposition modeling (FDM) and technology of extrusion with a liquid deposition modeling (LDM) to obtain high-quality products. The technical result of the device being developed is to improve the surface quality, while simultaneously using a nozzle for supplying water-soluble plastic for applying the contour of decorative products and structural elements of pulp and paper industry equipment of simple and complex geometric shapes and a nozzle for supplying liquid wood-polymer composite, by synchronizing the operation of extruders.*
**Keywords:** wood-polymer composite, extruder, combined 3D printing.

## *TECHNOLOGY OF PRODUCTION OF TEXTILE AND LIGHT INDUSTRY PRODUCTS*

**A. V. Demidov, A. G. Makarov**
*DOI 10.46418/2619-0729_2024_1_21*
DEFORMATION-RESTORATION PROCESSES OF POLYMER TEXTILE MATERIALS
AND THEIR DIGITAL PREDICTION
*Using the example of the deformation-recovery process of a polymer thread made of polyethylene terephthalate (lavsan), the use of a "force" version of the governing equation of nonlinear-hereditary viscoelasticity for the computational prediction of complex deformation-recovery processes is considered. Comparison of calculated values with experimentally measured ones allows us to recommend the developed computational forecasting methods for use. The elementary function normalized arctangent of the logarithm of reduced time is used as the basis of the mathematical model — the delay function.*
**Keywords:** polymer textile materials, deformation-restoration processes, digital forecasting, mathematical modeling.

**N. V. Pereborova**
*DOI 10.46418/2619-0729_2024_1_22*
DIGITAL CRITERIA OF RELIABILITY OF FORECASTING DEFORMATION AND
RELAXATION PROCESSES OF POLYMER MATERIALS
*The article considers problems of reliability of forecasting of relaxation and deformation properties of polymer materials in the field of action of non-destructive loads, close to conditions of their operation, on the basis of mathematical modeling of relaxation and creep processes. For the practical evaluation of the reliability of such forecasting, integral criteria have been obtained on the basis of the determining equations of the deformation and relaxation processes of said materials.*
**Keywords:** reliability of forecasting, digital criteria, viscoelasticity, deformation, relaxation, creep, mathematical modeling.

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