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FEATURES OF EXISTING DESIGN CONCEPTS OF MULTIROTOR-TYPE UNMANNED AERIAL VEHICLES AND PROSPECTS FOR THEIR DEVELOPMENT

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The object of this study is the design of multirotor unmanned aerial vehicles (UAVs). One of the key challenges is the formulation of multirotor UAV design concepts for solving specific practical tasks.

Multirotor UAVs have recently experienced significant development both in terms of structural design and overall conceptual approaches. At the same time, the entire set of ideas, technical solutions, and justifications that determine the principles of design, structure, and the main characteristics of a future UAV has not been considered. Developers of multirotor UAVs have not established a comprehensive classification to support scientifically sound design decisions. This represents a challenge in UAV development, and the present study is dedicated to addressing it.

An analysis has been carried out of existing UAV design concepts, their on-board equipment, and fields of application, advantages and disadvantages, as well as potential opportunities for improvement. The study employed system and functional-structural analyses. All possible combinations of design variants were explored and compared with existing solutions.

An analysis of the characteristics of multirotor UAVs as a distinct class was carried out, and evidence supporting their designation as a separate type was presented. A study was conducted on the design features of five mini-class multirotor UAVs for performing various tasks, as well as four cargo multirotor UAVs from different countries of origin. Their advantages and disadvantages were identified. The characteristics of power components were described (all UAVs are fully electric, using brushless electric motors), as well as propulsion systems. Recommendations for the design of multirotor UAVs were developed.

The study provides insights into the design concept of multirotor UAVs, which can be used for the development of advanced models of such UAVs and the improvement of existing ones, and may serve as a topic for a promising direction of scientific research.

Keywords: existing design concepts, unmanned aerial vehicles (UAVs), multirotor type, development prospects.

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DETERMINATION OF THE PATTERNS OF CHANGES IN THE QUALITY INDICATORS OF CRUSHING CORN AND SUNFLOWER STEMS BY WORKING BODIES OF TECHNICAL EQUIPMENT

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The object of research is the technological processes of crushing plant residues, corn and sunflower stalks, working bodies of single and double roll crushers, disk harrow, as well as combined unit consisting of disk harrow and single roll crusher. The relevance of the research is due to the need to solve the problem of increasing the efficiency of technological crushing operations by intensifying (increasing) the effects of the working bodies of the tools on the plant environment.

A prototype of double roll crusher was developed and manufactured, the cutting knives of which are placed across the entire width of the grip in a staggered manner with the ability to change the angle of inclination to the axis of rotation of the drum in the range of 6–10°. The highest value of the relative frequencies of corn crushing by double roll crusher belonged to the ranges of 51–100 mm and 101–150 mm, the sum of which was 56% and 52%, respectively. The largest share of 48.25% of crushed sunflower stalks by double roll crusher was established for the range of 51–100 mm. The sum of the percentages of crushed sunflower stalks in the ranges less than 50–100 mm was 77.62%, which is 2.36 times more than the similar indicator of single roll crusher, 3 times more than that of a harrow, and almost coincided with the indicators of a combined unit. In a disk harrow, the largest number of shares of crushed corn stalks 42.2% belonged to the range of 151–200 mm, and sunflower stalks 35.2% to the range over 201 mm. In a combined unit, the largest value of the percentage of crushed stalks was established in the range less than 50 mm. For corn, the specified value was 65.4%, for sunflower 41.5%, respectively. The contribution of single roll crusher to the total percentage of crushed stems in the range of up to 150 mm in a combined unit was 44.7% for corn and 47.7% for sunflower.

The results of the research are recommended for crop growing systems under the conditions of choosing rational technical and technological solutions for crushing plant residues.

Keywords: stalk crushing, single and double roll crushers, disc harrow, combined unit, crushing quality indicators, corn and sunflower stalks.

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EXHAUSTIVE CHARACTERIZATION OF MARBLE TO INDUSTRIAL APPLICATIONS: CASE OF MARBLE FROM THE FILFILA DEPOSIT (SKIKDA, NORTHEAST ALGERIA)

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The object of this research is deals with the Filfila marble deposit of all types. The examined area is situated in the Filfila massif, a significant section of the Kabyle basement, in the inner region of the Alpine range in northeastern Algeria. Given that it has been mined for many years, this massif is especially notable for the importance of its marble reserves. There are three primary types of marble found in this deposit: mignonette marble, which is prized for its exquisite green tones; gray marble, which has delicate subtleties; and white marble, which is highly sought after due to its extreme purity.

Multi-scale petrographic techniques that integrate microscopic examinations with macroscopic observations (color, texture, and structure) form the basis of the methodology employed in this work. Under plane-polarized light, thin sections of 30 µm in thickness were created in the University of Annaba's geology lab. According to the results, the material had a uniformly large texture and was primarily composed of microcrystalline calcite. Carefully polished samples were subjected to scanning electron microscopy (SEM) analysis in order to advance the investigation. SEM was able to disclose fine microstructural characteristics, such as crystal shape, microcracks, porosity, and the distribution of mineral phases, because of its nanometric resolution, which shows a high purity of white marble in addition to the main impurities of gray marble. The mechanical characteristics and durability of the marbles were illuminated by these observations, which allowed for the identification of notable variations among them, especially with regard to the density of discontinuities and the size of the crystal grains. By combining optical and

electron microscopy techniques, this integrated approach made it possible to thoroughly characterize Filfila marble by exposing its physical characteristics and mineralogical composition. The results offer a solid scientific basis for possible industrial uses and are useful reference information for upcoming comparative geological studies.

Keywords: marble, Filfila deposit, petrographic, scanning electron microscopy, Energy-Dispersive Spectrometry (EDS).

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FORMATION AND PROPERTIES OF NbC-REINFORCED LAYERS OBTAINED BY ELECTROSLAG SURFACING IN A SMALL-DIAMETER CURRENT-FED CRYSTALLIZER

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The object of research is the process of forming NbC-reinforced composite layers by electroslag surfacing (ESS) in a small-diameter current-fed crystallizer (CFC). The problem being solved is the stable introduction of finely dispersed NbC into a small-diameter slag bath without dissolution and agglomeration, achieving uniform reinforcement, low porosity and high wear resistance.

The research is aimed at experimentally determining the microstructure, phase composition, hardness, porosity, and abrasive wear resistance of layers formed under controlled ESS conditions using powder wire containing 35 wt.% NbC, and justifying the technological feasibility of the process in small-diameter CFC.

The process was implemented in two-section CFC Ø 65–85 mm under the following conditions: $I = 1.1$ kA; $U = 22$ V; feed rate $V_{\text{supply}} = 2.0$ m · min⁻¹; melting duration 45 s; $T_{\text{bath}} = 1600$ – 1700 °C. Morphology and chemical homogeneity were determined by optical microscopy and SEM-EDS; phase composition – by X-ray diffraction; hardness – by Vickers HV10; abrasive wear resistance – according to ASTM G99.

Layers of 2.0 ± 0.2 mm without macro-cracks and slag inclusions were obtained, with a uniform distribution of NbC (≈ 2 – 5 μm) throughout the thickness. The average hardness is 1020 ± 30 HV10 (≈ 3 compared to steel 20), the linear wear rate is reduced by 3.4 times, porosity is ≤ 0.8 vol.% while maintaining high adhesive strength. It has been confirmed that the controlled feeding of non-current-carrying powder wire into the most heated zone of the bath ensures reproducible transfer of the refractory phase and prevents its dissolution and coarsening. The agreed microstructural features correlate with an increase in hardness and a decrease in wear, confirming the cause-and-effect relationship "structure → properties".

The proposed technology can be implemented on existing ESS installations without re-equipment and is recommended for the restoration of parts operating under conditions of abrasive wear, with the potential for scaling up by regulating modes and controlling slag composition.

Keywords: electroslag surfacing, carbide, niobium, composites, wear resistance, microstructure, hardness, porosity, tribotechnology, crystallizer.

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ELECTRICAL ENGINEERING AND INDUSTRIAL ELECTRONICS

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DETERMINATION OF THE INFLUENCE OF THE CONTROL PARAMETERS OF THE STEPPER DRIVE FOR ROTATING THE PLATFORM FOR A GAS-DETONATION MORTAR ON ITS ELECTRICAL AND MECHANICAL PERFORMANCE

pages 36–42

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The object of research is the processes of platform rotation during the operation of the stepper drive of a gas-detonation powderless mortar. The problem solved by the study is to determine the influence of the set current and the rotation frequency of the stepper motor for the rotation of the platform for a gas-detonation mortar on the effective value of the phase current, vibration and

maximum engine torques. According to the results of the research, it was determined that the effective value of the phase current has a variable character. The minimum value of the effective phase current is observed at a rotation frequency of 52.5 rpm, and a set current of 5.5 A, and is 0.875 A. The obtained dependence of the effective current on the control parameters has a non-monotonic variable character, due to a change in the shape of the current during engine operation, which, in turn, significantly changes the harmonic composition of the current. The dependence of the vibration torque of the engine also has a variable character. However, the minimum vibration is observed at a rotation frequency of 45 rpm, and a set current of 5 A, and is 7.715 N · m, and the maximum vibrations at the minimum operating frequency and the maximum setpoint current reach 39.72 N · m. The dependence of the maximum torque value on the stepper motor shaft has a decreasing character, due to the operation of the drive in the starting mode. The decrease in the starting torque is due, on the one hand, to a decrease in the setpoint current, and, accordingly, to the maximum motor current and an increase in the electromotive force in phase with an increase in the setpoint speed. The obtained research results can be used in practice when creating an automated electric drive for turning a gas-detonation mortar based on a stepper motor by selecting the parameters of the setpoint current for the semiconductor converter, in accordance with the rotation speed. The conducted research can be used as the basis for the methodology for determining the control parameters of the electric drive for turning based on a stepper motor.

Keywords: stepper motor, platform, gas-detonation mortar, setpoint current, vibration torque.

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RECOGNITION OF EYE MOVEMENT BASED ON BIOELECTRICAL SIGNALS USING NEURAL NETWORKS

pages 43–48

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The object of research is the process of generating and recording electrical signals caused by eye movements; the subject of research is the method of real-time recognition of eye movements based on these signals. It is implemented on the open VitalCore platform and uses a convolutional neural network (CNN) for real-time movement classification. One of the most problematic aspects is ensuring high accuracy with low power consumption and limited computing resources, as well as reducing the impact of noise and delay during signal processing. This is of particular importance when using the system in wearable devices and in real-world environments where signal quality may be unstable.

The study uses digital signal processing methods, in particular, filtering by the Savitsky-Goley algorithm, as well as architectural solutions in the field of neural networks: the use of a five-channel CNN with ordinary and transposed

convolutional layers, Flatten and softmax. The use of frequent sliding windows (every 8 ms) is proposed, which increases accuracy and reduces latency.

The result is obtained: the recognition accuracy reaches 85% with a time window of 625–833 ms and a latency of about 40 ms, which provides the ability to detect up to five movements per second. This is due to the combination of an energy-efficient sensor with an optimized CNN architecture, which provides noise immunity and fast classification in real time.

Thus, the method allows to achieve stable and reliable results while maintaining low power consumption. Compared with known analogues, it is distinguished by openness, scalability, reproducibility and the ability to work on peripheral devices without high-performance computing resources. The development can be integrated into wearable devices and used in brain – computer interfaces, VR/AR, assistive technologies and medical research, which emphasizes its practical value.

Keywords: movements, eyes, QVar, windows, classification, signals, VitalCore, recognition, directions, gaze, sensors, learning.

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INTEGRATION OF CONTACT NETWORK AND AUTONOMOUS TROLLEYBUSES FOR IMPROVING THE CITY'S TRANSPORT SYSTEM

pages 49–57

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The object of the study is the technical characteristics of autonomous trolleybuses and the systems that ensure their uninterrupted power supply.

A key challenge is the dependence of conventional trolleybuses on contact networks, which limits their route versatility, complicates operations in historic city centers, bridge crossings, and regions with underdeveloped infrastructure.

The article examines key technological aspects of autonomous trolleybuses, including types of charging stations (contact, inductive, with pantographs), charging efficiency, energy consumption, and autonomous range. Examples of the implementation of this technology in Ukraine are presented, along with an analysis of charging costs and energy characteristics for runs of 20–50 km. The prospects of using autonomous trolleybuses for optimizing the city transport network, reducing CO₂ emissions, and improving the quality of passenger service are emphasized. Calculations have been made of the energy required for a trolleybus to travel a distance of 20–50 km, taking into account the average energy consumption (1.2–2.0 kWh/km), charging station capacity (up to 100 kW) and charging efficiency (0.9). Calculations have shown that for an autonomous trolleybus run of 30 km, 45 kWh of energy is required. Modern lithium-ion batteries and charging stations with a capacity of up to 100 kW provide a full charge in 30 minutes. Intermediate charging at stops minimizes contact infrastructure while maintaining transport system flexibility. Autonomous trolleybuses reduce dependence on contact networks, which is especially relevant for bridge crossings with complicated construction or maintenance and historic centers requiring architecture preservation without excess infrastructure. They also significantly reduce CO₂ emissions to promote ecological sustainability and improve urban air quality by lowering pollution and benefiting public health.

Keywords: autonomous trolleybuses, station, pantograph, charging, battery, contact network, power.

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DEVELOPMENT OF A HARDWARE-SOFTWARE SYSTEM FOR GESTURE RECOGNITION BASED ON ELECTRO-IMPEDANCE, ELECTROMYOGRAPHIC, AND FORCE-MYOGRAPHIC SIGNALS

pages 58–62

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The object of the research is the process of gesture recognition and proportional assessment of muscle activity using electromyographic (EMG), electroimpedance (EI), and force myographic (FMG) signals. The subject of the research is methods and means of collecting and analyzing these signals to increase the accuracy of gesture recognition and assessment of muscle activity in real time.

The research is aimed at developing an integrated hardware and software system for collecting and analyzing EMG, EI, and FMG signals for gesture recognition and proportional assessment of muscle activity.

The problem that needs to be solved is the lack of reliable multimodal platforms capable of providing simultaneous acquisition, filtering, and digital processing of biosignals of various natures in real time. Existing solutions are limited to one or two modalities, are characterized by low noise immunity, and require complex equipment, which complicates practical use.

The proposed solution is based on the use of Ag/AgCl surface electrodes, piezoelectric and capacitive sensors in combination with multi-channel ADCs. Optimized filtering and amplification, digital processing and synchronization

of signals, as well as data transfer via USB or UART to a personal computer, are implemented. The software performs frequency analysis based on the fast Fourier transform, visualization, and export of results.

Experimental studies have confirmed that the obtained signals correlate with motor activity: an increase in grip strength is accompanied by an increase in the amplitudes of FMG and EI, which allows for proportional control. The choice of optimal filtering frequencies, gain coefficients, and methods of sensor mounting made it possible to minimize noise and distortion, and the use of multi-channel ADCs ensured the processing of large volumes of data online.

The innovation of the development lies in the integration of bioelectrical and mechanical channels into a single multi-channel platform with support for up to 8 channels, high spatial and temporal resolution, and flexible architecture. This ensures high reliability and practical applicability of the system in rehabilitation, diagnostics, and control of bionic devices.

Keywords: bionic manipulators, control, electrical impedance, electromyography, force myography, signals, analysis, proportional, anthropomorphic.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

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DEVELOPMENT OF A LOGISTIC MODEL FOR ENERGY TRANSITION TO RENEWABLE ENERGY SOURCES WITH ENERGY SECURITY CONSIDERATION

pages 63–69

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The object of the study is the process of energy transition to renewable energy sources (RES) at the enterprise or regional level, aimed at replacing traditional carbon-based sources of electricity. One of the most problematic issues is the insufficient consideration of energy security factors in existing forecasting models, which leads to risks of electricity shortages, especially under conditions of RES intermittency and geopolitical challenges such as military attacks or import dependence. A literature review showed that existing models do not account for dynamic constraints in the implementation of RES, which limits their practical applicability for ensuring power system resilience.

In the course of the research, numerical modeling methods were used, in particular an adaptation of the logistic growth equation with an integrated dynamic security factor $S_p(t)$. This makes it possible to fill the gaps in existing models with regard to risk assessment and ensuring system stability. The obtained logistic model predicts the energy transition with RES reaching a 68% share in 24 years for a typical region without compromising security. This is due to the fact that the proposed model has such features as the integration of the coefficient of energy transition rate (C_{ETR}) and the dynamic constraint $S_p(t)$, which adapts to changes in demand and reserve. This allows identifying the potential to increase system resilience through the optimal balance of RES and traditional sources during the transition.

As a result, it becomes possible to achieve such indicator values as a 68% share of RES, owing to the model's flexibility to local conditions (variations of ρ, γ, k) and the consideration of worst-case scenarios (C_{Fmin}). Compared with similar known models, this provides advantages such as adaptability to regional risks, more accurate forecasting of the transition rate, and reduction of blackout probability. This is particularly relevant for vulnerable power systems, both in Ukraine and worldwide.

Keywords: energy transition, renewable energy sources, modeling, energy security, logistic model, forecasting, resilience, risks.

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