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EXPERIMENTAL STUDIES OF THE KINETICS OF INFRARED DRYING OF SPENT COFFEE GROUNDS

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Burdo Oleg, *Doctor of Technical Sciences, Professor, Department of Processes, Equipment and Energy Management, Odessa National Academy of Food Technologies,Ukraine, e-mail: burdo.onaft@gmail.com, ORCID: http://orcid.org/0000-0002-2630-1819*

Bezbakh Igor, *Doctor of Technical Sciences, Associate Professor, Department of Processes, Equipment and Energy Management, Odessa National Academy of Food Technologies Ukraine, e-mail: igorbezbakh1003@gmail.com, ORCID: http://orcid.org/0000-0002-2353-1811*

Shyshov Serhii, *Postgraduate Student, Department of Processes, Equipment and Energy Management, Odessa National Academy of Food Technologies,Ukraine, e-mail: try2stopmeme@gmail.com, ORCID: https://orcid.org/0000-0001-8891-025X*

Zykov Aleksandr, *Doctor of Technical Sciences, Department of Processes, Equipment and Energy Management, Odessa National Academy of Food Technologie , Ukraine, e-mail: zav380@yahoo.com, ORCID: http://orcid.org/0000-0001-8345-1015*

Gavrilov Aleksander, *PhD, Associate Professor, Department of Technology and Equipment Production and Processing of Livestock Products, Academy of Bioresources and Environmental Management «V. I. Vernadsky Crimean Federal University»,Simferopol, Republic of Crimea, e-mail: tehfac@mail.ru, ORCID: http://orcid.org/0000-0003-3382-0307*

Vsevolodov Oleksandr, *PhD, Associate Professor, Department of Processes, Equipment and Energy Management, Odessa National Academy of Food Technologies, Ukraine, ORCID: https://orcid.org/0000-0002-5157-5977*

Sirotyuk Ilya, *Assistant, Department of Processes, Equipment and Energy Management, Odessa National Academy of Food Technologies, Ukraine, e-mail: ilyxin09@gmail.com, ORCID: http://orcid.org/0000-0002-2081-0954*

Terziev Sergey, *Doctor of Technical Sciences, Head of Board, Public Joint Stock Company «Enni Foods», Odessa, Ukraine, e-mail: poem.onaft@gmail.com, ORCID: http://orcid.org/0000-0002-0460-4288*

The object of research is drying of spent coffee grounds. In modern production, the issues of rational use of energy in all processes of food technology, including drying, are urgently raised. In many food technologies, 2–3 times more energy is used than is physically necessary for the process. This determines the energy intensity of production and the quality of products. Drying processes are among the most energy-intensive, and in many cases the proportion of energy in the cost of production is up to 30 %. When drying of spent coffee grounds, convective dryers are mainly used, the energy consumption of which is 5 MJ/kg of removed moisture and above. Convective drying uses 40 % of the supplied energy to evaporate moisture. Also, a significant drawback of convective dryers is the discharge of waste coolant into the atmosphere, which has a heat content of only 10–15 % less than the hot air supplied to the drying chamber. The paper proposes the use of infrared radiation for drying of spent coffee grounds in periodic and continuous units. This will allow in the future to reduce specific energy consumption. During the study, the influence of the energy supply intensity, temperature, air flow rate, product layer thickness and specific load on the kinetics of periodic infrared drying of spent coffee grounds is determined. The influence of the energy supply intensity, specific load, tape speed, and the number of infrared modules on the kinetics of continuous infrared drying of spent coffee grounds is determined. The results are compared with convective drying in terms of specific energy consumption. A feature of the use of infrared radiation is its high efficiency and high rate of moisture removal from the surface layers of spent coffee grounds, and as a result, an increase in the productivity of the drying method and a decrease in specific energy consumption. The specific energy consumption obtained during operation of infrared drying of spent coffee grounds is 3.2 MJ/kg. This is below existing convection dryers.

Keywords: infrared drying, spent coffee grounds, drying kinetics, periodic and continuous units, specific energy consumption.

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MECHANICS

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THE NUMERICAL CFD INVESTIGATION OF HUB LOSSES OF PUSHING AIR PROPELLERS WITH TANDEM JOINED BLADES OF SMALL SIZED UNMANNED AERIAL VEHICLES

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Kulyk Mykola, *Doctor of Technical Sciences, Professor, Head of Department of Aviation Engines, National Aviation University, Kyiv, Ukraine, e-mail: aki@nau.edu.ua, ORCID: https://orcid.org/0000-0003-2149-4006*

Kirchu Fedir, *PhD, Associated Professor, Department of Aviation Engines, National Aviation University, Kyiv, Ukraine, e-mail: fkirchu@gmail.com, ORCID: https://orcid.org/0000-0001-8437-4402*

Hanesh Hussein, *Postgraduate Student, Department of Aviation Engines, National Aviation University, Kyiv, Ukraine, e-mail: husseinalamy1970@gmail.com, ORCID: https://orcid.org/0000-0002-8995-7866*

The object of research is a pushing tandem propeller with joined blades. When analyzing the characteristics of pushing propellers, it was found that one of the problem areas is a decrease in their effectiveness due to a decrease in axial thrust, which occurs due to the formation of a zone of reduced pressure (vacuum) in the area of the hub and the propeller spinner. For pushing propellers of the classic design, the reduction in efficiency reaches a level of 1–2 %. For tandem propellers, such information is not available due to the fact that such structures are practically not used on aircraft. However, in recent years, potential opportunities and advantages over classical propellers have increased the interest of researchers in the issues of their use in aircraft. It is noted that the tandem propeller should have greater hub losses compared to the classic propeller, since the diffuser of the interscapular channel is greater. To assess the value and establish the factors influencing the formation of hub losses of tandem propellers, studies were carried out using numerical gas dynamics methods. During the study, to simulate the operation of the tandem propeller, the ANSYS CFX software package are used, which implements an algorithm for solving unsteady Reynolds averaged Navier-Stokes equations closed by the SST Menter turbulence model. As a result of modeling, it was found that the level of secondary losses in the hub part of a tandem propeller is significantly affected by the mutual arrangement of the profiles of the first and second blades. When the angle of profiles installation of the second blades row increases, the vacuum in the hub part and in the spinner zone increases, which leads to the appearance of reverse thrust and reduces the thrust of the propeller by an average of 3–4 %. The obtained results confirmed the assumption that the hub losses of the tandem propellers directly depend on the diffusivity of the interscapular canal in the blades root part. Consideration of research results in the design of tandem propellers will reduce hub losses and increase the efficiency of the propellers.

Keywords: propeller, secondary losses, propfan, hub vortex, tandem profile, Moebius band, box propeller, tandem propeller.

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MATERIALS SCIENCE

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THE INFLUENCE OF ORGANIC BINDERS AND THEIR DECOMPOSITION PRODUCTS ON THE MICROSTRUCTURE AND THERMOELECTRIC PROPERTIES OF CONDUCTIVE MATERIALS BASED ON Si_3N_4 WITH TRANSITIONAL METAL CARBIDES ADDITIVES

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Tsygoda Vladyslav, *Postgraduate Student, Department of Microelectronics, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: tsygoda@gmail.com, ORCID: http://orcid.org/0000-0001-6997-6384*

Kyrylenko Kateryna, *Assistant, Researcher, Department of Renewable Energy, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: katakyr20@gmail.com, ORCID: http://orcid.org/0000-0003-0353-8685*

Petrovsky Vitaly, *Doctor of Technical Sciences, Professor, Department of Microelectronics, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: drwit@zeos.net, ORCID: http://orcid.org/0000-0002-1544-4320*

The object of research is the formation of the functional zone of a multicomponent ceramic composite based on refractory anoxic compounds. One of the most problematic points is the determination of influence of the type of binder on the formation of the functional zone of the device.

During the study, the industrial powders of silicon nitride β – Si_3N_4 of the Baku Powder Metallurgy Plant (Azerbaijan) and hafnium and zirconium carbides of the Donetsk Chemical Reagents Plant (Ukraine) were used. The homogenization and grinding of the charge was carried out in a planetary mill of the Fritsch type (drum and Si_3N_4 balls) for 40 min. in ethyl alcohol. The concentration of the inclusion phase conductor in the composite thermoelectrodes was 5–40 %. The carboxymethyl cellulose compound in combination with a plasticizer, glycerol or rubber, was used as a binder for this method. Samples were made in the form of plates 100×7×6 mm. The investigated samples of nitro silicon composite materials were obtained by hot pressing of the prepared ceramic tapes using the induction method of heating the mold.

It has been found that in case of the rubber-containing samples with a resistive HfC additive, the weight loss increases in proportion to the HfC concentration up to the additive concentration of 27 %, while the further HfC concentration increase causes the decline of weight loss. When using cellulose gum as a binder, the weight loss decreases by about 1.3–1.6 times; the regularities of weight loss changes depending on the HfC concentration remain the same. It has been shown that the modulus of thermal electromotive force was higher in case of fine composites than in case of coarse ones for all concentrations. The maximum thermal emf value reached 120 μV/deg in the subthreshold zone of the additive concentration. In the suprathreshold zone the maximum thermal emf value reached 60 μV/deg for the fine-grained composite and 30 μV/deg for the coarse-grained one. It has been proved that composites without a binder differ not by the typical course of dependency between the additive concentration and the resistivity, while the thermal emf of these composites equals zero with accuracy up to experimental error.

Keywords: organic binder, hafnium carbide, zirconium carbide, high-temperature functional elements, rubber, carboxymethyl cellulose, functional element microstructure.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

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ESTIMATION OF THE SHORT CIRCUIT ACCIDENT PROBABILITY AT THE OVERHEAD ELECTRIC TRANSMISSION LINES

page 26–31

Kosterev Mykola, *Doctor of Technical Sciences, Professor, Department of Renewable Energy Sources, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: nicolkost@gmail.com, ORCID: http://orcid.org/0000-0001-5601-2607*

Litvinov Volodymyr, *PhD, Production and Technical Department, Affiliate «Dnipro Hydro Power Plant», PJSC «Ukrhydroenergo», Zaporizhzhia, Ukraine, e-mail: v.v.litvinov1985@ukr.net, ORCID: http://orcid.org/0000-0003-1974-0976*

The object of research is the probabilistic characteristics of the occurrence of a short circuit (SC) on overhead electric transmission lines (ETL) of voltage classes 110 kV and higher, the failure of which can lead to the development of an accident in the electric power system (EPS). The probabilistic characteristics of the SC occurrence on ETL depend on a large number of factors: the length and route of transmission of power lines, voltage class, weather conditions, and the qualifications of the staff in which charge, management and maintenance the power lines are located. The most problematic issues in assessing the SC occurrence on overhead power lines is the allocation of damage from a SC with general damage statistics, the quantitative consideration of such features of the functioning of overhead ETLs, such as meteorological conditions, the staff qualification level and the technical condition of a single piece of equipment.

In the course of the study, a fuzzy-statistical approach is developed to assess the SC occurrence on an overhead power line taking into account its individual characteristics of work, such as the staff qualification level, meteorological conditions of operation and the technical condition of the power line. To determine the unconditional probability of SC occurrence on an overhead ETL, statistical data on SC on lines of the corresponding voltage class are used. The technical condition of the power lines and meteorological conditions of operation are quantified by fuzzy models, the staff qualification level is determined at standard intervals of the Harrington scale. Conditional probabilities of the state of functioning of power lines are determined using a simplified fuzzy conclusion, which makes it possible to quantify the conditional probability in the absence of clear analytical relationships between the signs of the conditions of power lines.

The results obtained by the developed approach are recommended to be used in the goals of risk-oriented management of the EPS to increase the reliability of operation by reducing the risk of developing a system accident when a SC occurs in the EPS elements. Also, restrictions on the application of the developed approach to the problems of assessing the probability of equipment failure and the organization of risk-based management are identified.

Keywords: short circuit, power line, technical condition, staff qualification level, meteorological conditions, membership functions, reference matrices.

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DEVELOPMENT OF INFORMATION TECHNOLOGY FOR HEAT LOSSES MANAGEMENT OF CONSTRUCTION STRUCTURES

page 32–36

Yerokhin Andriy, *Doctor of Technical Sciences, Professor, Department of Software Engineering, Kharkiv National University of Radio Electronics, Ukraine, ORCID: http://orcid.org/0000-0002-8867-993X, e-mail: andriy.yerokhin@nure.ua*

Zatserklianyi Heorhii, *Department of Software Engineering, Kharkiv National University of Radio Electronics, Ukraine, ORCID: http://orcid.org/0000-0002-9258-9013, e-mail: george.zatserklyany@gmail.com*

The object of research in this work is unproductive heat loss in buildings and construction structures, due to the nature of the heat and mass transfer process, which operates in a complex architectural and structural scheme. One of the ways to reduce unproductive heat losses in buildings and construction is the use of information and control technologies and systems for managing such objects. These technologies and systems based on information processing on the state of buildings and construction facilities should ensure the formation of effective managerial decisions aimed at reducing unproductive heat losses and optimizing the structure of consumption of fuel and energy resources in the housing and communal sector. Today, both in the energy efficiency control systems of buildings and outside of their heat and mass transfer processes, they are analyzed either in a simple statement or in separate elements of the architectural design of a building structure. Such an approach to modeling the heat and mass transfer process does not provide a sufficiently complete assessment of unproductive heat loss. This is due to the fact that the process of heat and mass transfer is a complex interconnected and interdependent system and operates in a complex architectural and structural system of a building structure. In this paper, a component-oriented information technology is proposed that relies on a mathematical model of an interconnected and interdependent heat and mass transfer process that operates in any complex architectural and structural scheme of a house or building structure. This model, in comparison with other models used, covers all the basic properties of heat and mass transfer both in building envelopes and in vapor-air spaces. It takes into account the heat input to the house from heating and lighting systems, solar radiation and people in the building. So, it allows to more fully evaluate the heat loss in a house or building.

Keywords: interconnected and interdependent heat exchange processes, heat and mass transfer modeling, information and control technologies.

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EXPERIMENTAL STUDY OF THE TRANSITION OF TWO TYPES OF WEDGE GATE VALVES

page 37–40

Korolov Oleksander, *Doctor of Technical Sciences, Professor, Department of Nuclear Power Plants, Odessa National Polytechnic University, Ukraine, e-mail: korol118@ukr.net, ORCID: http://orcid.org/0000-0002-4158-7966*

Pavlyshin Pavel, *Acting President, National Nuclear Energy Generating Company «Energoatom», Kyiv, Ukraine, ORCID: http://orcid.org/0000-0002-3417-4346*

Titlov Alexander, *Doctor of Technical Sciences, Professor, Head of Department of Heat-and-Power Engineering and Oil-and-Gas Transportation and Storing, Odessa National Academy of Food Technologies, Ukraine, e-mail: titlov1959@gmail.com, ORCID: http://orcid.org/0000-0003-1908-5713*

Mironchuk Valentin, *Department of Nuclear Power Plants, Odessa National Polytechnic University, Ukraine, e-mail: mironchikvalik@gmail.com, ORCID: https://orcid.org/0000-0002-4630-5331*

The object of research is the type of power valves – gate valve or wedge valve. Gate valves or wedge valves take a leading place among

power valve. It has minimal hydraulic resistance, an almost linear dependence of the flow rate on the degree of opening, and is widely used on general-purpose pipeline systems. One of the problem areas of such valves is the loss of tightness or the transition of wedge gate valves. In addition, a more complex design increases the likelihood of failure of such valves. To solve this problem, it is proposed to carry out an experimental study of the gate transition depending on the effort of their closure, as well as research the trend of this dependence.

The studies are carried out on a bench that provides air pressure up to 3.0–3.5 MPa and is equipped with cast-iron and brass valves. Air transition is measured in a volumetric manner, displacing water from the measuring cell. To create a force on the rod that closes the valve, we used a KD-230 torque wrench (Russia) are used, which allows to measure torque up to 230 N·m. The experimental technique is as follows. The valve is closed with the necessary force wrench, then the compressor was turned on and the required pressure is reached. Air transition is measured by filling the measuring cell over time, fixed by a stopwatch.

Processing of the obtained experimental data allows to obtain the following dependences of the relative gap of the valve on the magnitude of the torque for the cast-iron gate valve: $(Q/\sqrt{\Delta P}) = 3458 \cdot M^{(-1.069)}$ and for the brass valve: $(Q/\sqrt{\Delta P}) = 6893 \cdot M^{(-2.435)}$. It is shown that gate valves as well as previously studied valves have one trend: $(Q/\sqrt{\Delta P}) = C \cdot M^{(-g)}$. The degree of torque shows that the larger it is in absolute value, the better the locking characteristics of the valve. So, to ensure the same air transition, the torque on the cast iron valves should have greater values than for the studied brass gate valve.

Keywords: wedge valve, torque, relative air admission, valve tightness, cast-iron gate valve, brass gate valve.

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REMOVAL OF TEMPERATURE DRIFT OF ZERO OF PIEZOELECTRIC ACCELEROMETER

page 41–44

Kvasnikov Volodymyr, *Doctor of Technical Sciences, Honored Metrologist of Ukraine, Head of Department of Computerized Electrical Systems and Technologies, National Aviation University, Kyiv, Ukraine, e-mail: kvp@nau.edu.ua, ORCID: https://orcid.org/0000-0002-7799-0001*

Perederko Anatolij, *PhD, Department of Metrology and Metrological Support, Odessa State Academy of Technical Regulation and Quality, Ukraine, e-mail: pal88@ukr.net, ORCID: https://orcid.org/0000-0002-9625-4798*

The object of research is the dependence of the results of measuring vibrational acceleration by a piezoelectric accelerometer on the influence of ambient temperature. The indicated dependence is a change in the constant level in the measured signal. This is caused by the generation of an additional charge by the piezoelectric element of the accelerometer in the absence of impact on it from the side of the measurement object. The specified additional charge is generated under the influence of changes in the temperature of the medium on the structure of the sensitive element. This leads to an increase in the error of the measurement result. The larger the range of fluctuations in temperature and the rate of change in the temperature of the medium over time, the greater the effect on the measurement results. Since changes in temperature over time compared with the frequency of measured vibrations are much slower processes and their influence on the measurement result is constant in the entire dynamic range of the accelerometer, they represent an additive component of the error in these measurements.

During the study, in order to prevent the temperature influence of the medium on the measurement process, methods for its elimination are considered and solutions for improving the piezoelectric accelerometer by introducing a compensation element in its design are proposed. In order to reduce the influence of temperature fluctuations of the medium on the measurement results, a controlled piezoelectric element operating on the inverse piezoelectric effect along the polarization axis is used as a compensation element. The resulting solution is easily implemented from a technical point of view, since the compensation element and the sensitive element are made of the same material and have the same coefficient of thermal expansion. The compensation element is controlled by an automatic regulation system that works on the principle of deviation regulation.

Thanks to the method proposed in this work, it is possible to increase the accuracy of measurements performed using piezoelectric accelerometers and to expand their scope in relation to the requirements for the ambient temperature.

Keywords: vibration acceleration, piezoelectric element, temperature effect, phase filter, compensation element, automatic control system.

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FIRE SAFETY IMPROVEMENT OF PYROTECHNIC NITRATE-METAL MIXTURES UNDER EXTERNAL THERMAL CONDITIONS

page 44–49

Dibrova Oleksiy, *Adjunct, National University of Civil Defence of Ukraine, Kharkiv, Ukraine, e-mail: okskir@meta.ua, ORCID: https://orcid.org/0000-0002-4496-2178*

Kyrychenko Oksana, *Doctor of Technical Sciences, Professor, Head of Department of Fire Prevention Work, Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Ukraine, e-mail: okskir@meta.ua, ORCID: https://orcid.org/0000-0002-0240-1807*

Motrichuk Roman, *Adjunct, Department of the State Emergency Service of Ukraine in the Cherkasy Region, Ukraine, e-mail: r_motrichuk@ukr.net, ORCID: https://orcid.org/0000-0002-5670-6788*

Tomenko Marina, *PhD, Associate Professor, Department of Fire Prevention Work, Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Ukraine, e-mail: marina_tomenko@ukr.net, ORCID: https://orcid.org/0000-0002-2354-9106*

Melnyk Valentin, *PhD, Head of Faculty, Faculty of Fire Safety, Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Ukraine, e-mail: poiskoviksy@yahoo.com, ORCID: https://orcid.org/0000-0001-6593-5964*

The object of research is the effect of the ratio of the components of the pyrotechnic mixtures and the pressure of the environment on the temperature of the products of combustion and their content in high-temperature condensate. This topic has its relevance due to the recent increase in the world of pyrotechnic articles of various purposes. One of the most problematic areas is the violation of fire safety rules during their storage, transportation and use. In these modes, their premature operation, resulting in the formation of high-temperature condensed combustion products. These substances collide in different directions and pose a fire hazard to the surrounding objects (buildings and structures of various purposes, timber structures, forests, parks, etc.).

The study used a database on the temperature of combustion products of pyrotechnic mixtures and their contents in high-temperature condensate, which determine their properties in relation to fire risk during operation in external conditions. The data in the study were obtained as a result of standard thermodynamic calculations and were collected using known multiple correlation and regression methods in the form of statistical models.

The obtained calculations established a significant influence of the ratio of the components of the pyrotechnic mixtures and the pressure of the environment on the temperature of their combustion products and their content in high-temperature condensate, which allowed to determine the optimal ranges of parameters of change. This ensures new results. For comparison, calculations were made with separate experimental data for which tungsten-rhenium thermocouples with special screens were used to prevent the adhesion of condensed products and probes for their selection. The results showed that the differences between them did not exceed 8–10 %.

Keywords: fire safety, pyrotechnic mixtures, nitrate-metallic mixtures, thermal action, pyrotechnic articles, thermodynamic calculations.

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