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RESEARCH OF CO-COMBUSTION OF SOLID BIOFUEL WITH LEAN AND BITUMINOUS COAL

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The object of research is the processes of thermal conversion of steam coal and biomass, with the aim of creating highly efficient environmentally friendly technologies for its joint combustion into fuel boiler units.

One of the important problems that impede the introduction of co-combustion of biomass with coal is the insufficient knowledge of the interaction of two very different solid fuels. The characteristics of grinding, particle aerodynamics, kinetics of all stages of combustion during the joint combustion of two solid fuels remain unexplored. Co-combustion of biomass with coal allows partially replacing scarce grades of steam coal, as well as reducing emissions of harmful gases and dust.

To study the peculiarities of co-combustion of coal and biomass, experimental and computational research methods are used, including combustion in a continuous installation designed to study the combustion characteristics of pulverized fuels.

Experiments on the combined combustion of lean and bituminous coal with various types of solid biomass showed an improvement in the ignition conditions of coal, with the addition of biomass from 5 to 15 % by heat. The effect of biomass impurities on coal on the temperature distribution along the length of the plume is shown. The paper presents the dependences of the conversion degree of bituminous coal and its blends with crushed pellets of pine, wheat straw and sunflower husk, and also explains the nature of this dependence. The gas analysis of the combustion products shows the effect of biomass blending in bituminous coals on the formation of nitrogen oxides.

The findings and dependencies justify the environmental feasibility and efficiency of co-combustion and allow to proceed to the development of a pilot project for partial replacement of coal with various types of solid biofuel.

Keywords: thermal power plants, coal-dust combustion, steam coal, solid biomass, co-combustion.

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REPORTS ON RESEARCH PROJECTS

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INVESTIGATION OF COMPLEX STRUCTURE SYSTEMS BASED ON SPECTRAL ANALYSIS

page 11–13

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The object of research is the process of processing the results of the movement of vibration-absorbing machines in the construction industry. One of the problems in the study of technological vibration machines is the determination of the parameters of the spatial motion of the working bodies of the machine and establishing their compliance with the calculated ones obtained as a result of calculations or numerical simulation. And also when establishing the state of structures under the influence of complex dynamic effects. Difficulties arising in the study of dynamic processes are caused by the determination of the nature and actual values of dissipative forces, the influence of unknown random variables, including interference and imperfections in the measuring technique.

The approach proposed in this paper is based on the hypothesis of considering a system of complex structure, has a dynamic effect as a single system with its corresponding dynamic characteristics. The implementation of this approach can be carried out by determining the dynamic parameters of the system with subsequent spectral analysis and the establishment of the main vibration frequencies that are due to external influence, as well as the identification and clear identification of higher harmonics. Recordings of continuous fixation of the vibration process with a known frequency of external influence are used to determine the necessary effective method for presenting the results. Further processing of such results on the basis of the spectral-correlation method makes it possible to determine an effective way to determine the fundamental frequency, to reveal the influence of higher harmonics and extraneous frequencies inherent in the investigated process. The vibration spectra in the linear and logarithmic scales with acceleration and spectral power are considered. According to the research results, it is found that the use of precisely the spectral power of the signal level is an effective method for determining the dynamic process and performing an integral assessment of the overall system.

The obtained research results can be used in the study of systems with complex motion with unknown parameters of external influence when performing diagnostics and evaluating the technical condition of technological machines, the vibrations of the supporting and enclosing structures of buildings.

Keywords: vibration spectrum, natural vibration frequencies, dynamic load, vibration diagnostics, spectral power.

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ANALYSIS OF THE PHOTOCATALYTIC ACTIVITY OF TiO_2 COATING ON A GLASS AS A CRITERION OF ITS ABILITY TO SELF-CLEANING

page 14–17

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The object of research is the process of photocatalytic degradation of methylene blue on glass coated with titanium oxide under the influence of ultraviolet radiation (UV radiation). The study aims to indirectly assess the ability of glasses to self-clean. An axiomatic assumption is made about the correlation between self-cleaning ability and photocatalytic activity.

The proprietary photocatalytic reactor is used. This is a cylindrical quartz glass cavity in the form of a glass, on the inner surface of which a photocatalytic coating of titanium oxide is preliminarily applied. The cavity of the glass is filled with a solution of methylene blue. Externally, the glass is irradiated with a mercury-quartz lamp. UV radiation passes unhindered through quartz glass and activates photocatalytic coatings on the back side. To activate the process requires the participation of atmospheric oxygen. To do this, the solution is bubbled with air from a perforated annular tubular collector located at the bottom of the glass.

The solution of methylene blue after various exposure times is subjected to spectral analysis. The kinetics of dye degradation is estimated by the photocolorimetric method with a decrease in the intensity of the characteristic absorption band of methylene blue. The bleaching process is clearly demonstrated on the color chart.

The novelty of the proposed scheme for the functioning of the photocatalytic reactor is that UV radiation activates the coatings acting on it from the side of the inner interface: quartz glass coating. Electron-hole pairs migrate to the surface and, under conditions of contact with oxygen, carry out the photocatalysis of the model solution. Such a design of the photocatalytic reactor device compares favorably with the known ones because UV radiation does not pass through the studied model fluid. This excludes the possibility of their interaction, may introduce an error in the final results.

Keywords: photocatalytic reactor, methylene blue, UV radiation, photocatalysis, spectral analysis, discoloration, color diagram.

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ANALYSIS OF METAMORPHISM AND TENDENCY OF BLACK COALS TO SPONTANEOUS COMBUSTION

page 18–25

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The object of this study is coals of different stages of metamorphism and the volatile products of their thermal decomposition. Currently, based on the basic genetic signs of metamorphism, there is no reliable regulatory framework for determining the hazardous properties of mine plastics, including the propensity of coal for spontaneous combustion. Difficulties in systematization consist in the absence of at least one classification parameter, which determines the need for an additional analysis of the physicochemical properties of coals of different stages of metamorphism and the volatile products of their thermal decomposition as an object of study.

Thanks to the obtained functional dependences characterizing the elemental composition of fossil fuels in the entire range of a series of metamorphism, it is possible to evaluate the classification indices of fossil fuels. The result shows that changes in the properties of coal as a result of transformations of the internal structure can take maximum or minimum values. It is impossible to judge the change in the properties of coals from the elemental content of these components by the monotonous and one-sided changes in the components C^0, O^0, and N^0. The nature of the dependence of H^0 on V^{daf} and specific gravity (K_d) suggests that coals acquire new properties after V^{daf} decreases by less than 30–25 %, and specific gravity at K_d>1.3.

It is noted that coals with the same properties can in some cases be characterized by different values of the classification indicators (V^{daf}, V_v^{daf}, C^{daf}, K_d), in others – coals with different values of the classification indicators have the same properties. The changes in the physicomechanical and calorific value of coal from V^{daf} and C^{daf} are complex and ambiguous. This is indirect evidence of changes in the internal structure of coals in the process of their geological transformation. The restructuring of the internal structure of coal led to a change in their electromagnetic characteristics.

It is proposed, when establishing the propensity of coal for spontaneous combustion by genetic and technological para-

meters, to use modern knowledge in the field of geology, historical geology and paleontology, physics, chemistry, thermodynamics, as well as experience in the industrial use of coal.

Keywords: metamorphism, endogenous fire, spontaneous combustion of coal, geological and genetic factors, elemental composition.

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RESEARCH OF THE HOMOGENIZATION PROCESS IN THE OPERATION OF A THREE-LEVEL CLOSED TURBINE MIXER

page 26–28

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The object of research is a three-level turbine mixer of the closed type, designed and manufactured in full size using a 3D printer.

One of the most problematic places of the fermentation process in a bioreactor is the homogenization of the medium. During mixing, stagnant zones form in most fermenters, in these zones the medium is heterogeneous, warms up worse, receives insufficient air (if the medium is aerobic) and causes the death of cultivated microorganisms. Thus, the final product is not 100 % of the same structure, and, accordingly, quality, which is critical for pharmaceutical products.

In the course of the study, 2 different methods were used, which were designed to confirm or refute each other, namely: the computer simulation method and the experimental method. The experiment consists in manufacturing the developed mixer model and carrying out the mixing process with its use. Mixing is carried out at different velocities, with different types of mixers and using a contrast tracer to visualize the type of formed streams. Graphical modeling consisted of creating a similar experimental model of the mixer and carrying out graphical modeling in the CFX block of the ANSYS program. This method makes it possible to see the created flows from different angles, find the most dynamic zones and study the physics of the process from the inside.

The obtained result shows that a three-level closed turbine mixer shows better homogenization speed results than a typical closed turbine. This is due to the fact that the proposed solution has a number of features, in particular, the cellular structure of the shaft. The proposed computational models in ANSYS make it possible to obtain velocity fields and establish the magnitude and direction of velocity vectors.

A similar technique for evaluating the effectiveness of homogenization can be used in the design of new designs of mechanical mixing devices.

Keywords: cultivation of microorganisms in a bioreactor, homogenizing device, closed turbine mixer, flow hydrodynamics.

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ANALYSIS AND SYNTHESIS OF CREATION OF VIBRATION MACHINES WITH AN ESTIMATION OF THEIR EFFICIENCY AND RELIABILITY

page 29–31

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The analysis of processes occurring in the medium under the influence of vibrational forces is considered. The obtained results are synthesized for the development of a new class of vibration machines that provide criteria for efficiency and reliability. The main criterion for evaluating the effectiveness is adopted function of the amplitude and frequency of vibrations, which determines the speed or acceleration of the compaction process. At the same time, the logic of the stage-by-stage examination of the compaction process is proved. The first of them – the process of reconnecting the components of the mixture – intensively proceeds only in the absence of any significant external loads. This process is realized by providing a machine with a low speed, that is, large amplitude and a low frequency of vibrations. The second is the process of approaching the particles of a mixture with a denser, more compact conclusion of the components of this mixture with each other. It proceeds in the presence of significant dynamic loads, the increase of which to a certain limit gives a positive effect. At this stage, small vibration amplitudes and a high frequency are realized. One of the most problematic places in solving this approach is the lack of not only generally accepted methods for assessing these properties, but even a single view of its nature. In a newly vibration machine, these processes are achieved through the targeted use of shock and vibration. Structurally, this is ensured by the use of vibration limiters. The object of research is vibration and vibration shock processes in machines for compaction of building mixtures in road and construction industries. Particulars of the corresponding selection of the rigidity of the vibration limiters are determined, the rational choice of the ratio of the impact time and the vibration period is made. Thanks to this, new phenomena are discovered during the implementation of staged modes of operation with the installation of several stable modes. The reliability analysis of vibration machines is carried out by methods of qualitative and quantitative analyzes. The simplicity of the machine design ensures its reliability. The mode of compaction of the concrete mix is reduced by half in comparison with the existing vibration parameters.

Keywords: vibration machine, compaction process, stages of compaction modes, mortar, amplitude and frequency of vibrations.

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DESIGN DEVELOPMENT OF A CONTINUOUS INDUSTRIAL DRYING PLANT FOR DRYING POMACE OF WALNUTS, PEANUTS AND PISTACHIOS

page 32–35

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The object of research is the drying process of the pomace of a walnut kernel, peanuts and pistachios in a fluidized bed dryer with an inert support. One of the most problematic places is the issue of recycling of secondary raw materials, which represent significant potential for the food industry. The solution to the problem that is urgent is the preservation of pomace of the walnut kernel, peanuts and pistachios for their further use in the food industry. At the same time, the advantages of dried semi-finished products:

– ability to transport over long distances;
– long shelf life of dried products;
– use in food technology;
– use as a protein supplement.

Therefore, the work is devoted to the development of new and modernization of existing drying methods. One of such methods is drying in a fluidized bed of an inert support; this product has not been used before for drying because of the complexity of the process.

During the study, the method of microscopic determination of the dispersed composition of the product is used, which allows measuring particles with a size of 0.3–100 microns. Test powders of different fineness are investigated using USB Digital Microscope. The mathematical processing of the results using modern computer programs is carried out. The data obtained are processed in the Mathcad environment and presented as integral and differential particle distribution functions for each analyzed sample. This is due to the fact that the analysis of the determination of the dispersed composition is a mandatory control method in all technological processes. Thanks to this, it is possible to obtain a given product size. In the course of the study, a design of a continuous industrial drying unit for drying pomace of walnut kernels, peanuts and pistachios was developed. The drying method proposed in this work has several advantages over other methods, the main of which are the reduction of energy consumption and improving the quality of the finished product.

Keywords: dispersed composition, microscopic method, product drying, integral and differential distribution function.

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HEAT EXCHANGE SIMULATION IN ENERGY ZONES OF A ROTARYKILN WITH CHANGE OF HEAT RESISTANCE OF THE BODY

page 36–41

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The object of research is high-temperature thermal units – rotary kilns. Rotary kilns are used in various industries. The specified equipment has high energy consumption, which is due to the operating conditions of the kiln units in compliance with a number of technological requirements for thermal conditions. At the same time, the problem of high energy intensity is aggravated by the low level of useful energy resources. One of the most problematic places is the thermal and operational characteristics of rotary kilns, as well as the use of lining with increased thermal resistance.

Physical and mathematical models are used. It is proposed to calculate a rotary kiln for the production of cement with a size of 5x185 m and a capacity of 75 t/h. A mathematical model is obtained for computer simulation of technological processes in rotary cement kilns. The possibilities of reducing fuel consumption by increasing the thermal resistance of the lining of a rotary kiln are considered. The most energy-intensive zones are determined and the effect on the thermal efficiency of using additional thermal insulation in various energy zones in a rotary kiln is analyzed. Calculations and the results of a numerical experiment are presented. The most rational areas for the use of lining with additional thermal insulation are determined. It is found that with the integrated application of the proposed method, fuel consumption in a thermal unit can be reduced by 9 %. And an increase in the thermal resistance of the lining installed in high temperature zones will increase the energy efficiency of the thermal unit. A significant advantage of this method is the fact that an increase in kiln productivity does not require additional fuel consumption, an increase in temperature, or an increase in the enthalpy of combustion products.

In the future, it is planned to study the mechanism for establishing a heat-insulating layer in the refractories of the lining, determining their optimal thermal efficiency and stress-strain state to eliminate the possibility of destruction. As well as determining the optimal structural form of the refractory and the cell with thermal insulation.

Keywords: rotary kiln, thermal resistance of the lining, additional thermal insulation, exhaust gases, thermal energy.

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DEVELOPMENT OF A SOLAR COLLECTOR BASED ON ALUMINUM CONSTRUCTION HEAT PIPES

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The object of research is the thermal efficiency of solar collectors based on aluminum structural heat pipes. Solar collectors with heat pipes have a structurally similar design. The heat-absorbing panel secures the heat pipes to the evaporation zone, and the condensation zones are located in the battery tank. The differences are only in the designs of the absorption panels, the areas of the condensation zones and the heat carriers of the heat pipes. One of the most problematic places of research is the justification and development of a new design of a heat-absorbing solar collector panel based on heat pipes.

A review of the publications showed that a solar collector based on aluminum structural heat pipes operating in the two-phase thermosyphon mode has a heat loss when transmitting radiation heat exchange in the long-wavelength range between the absorbing flat panel and the heat pipe. The project of a solar collector with a new, absorbing solar rays panel is proposed. To analyze the efficiency of the solar collector based on aluminum structural heat pipes with a new absorption panel, two models of solar collectors were created – with a flat absorber panel and a cylindrical absorber panel.

The models of solar collectors based on one aluminum structural heat pipe fixed on aluminum flat and aluminum cylindrical absorption surfaces are investigated by the method of thermophysical experiment.

The results of studies of the efficiency of solar collector models are presented. The thermal efficiency of a new solar collector based on an aluminum structural heat pipe with a cylindrical absorbing panel in the initial period of heating water is up to 15 % higher than that of a solar collector with a flat absorbing panel, and at the end of heating up to 4 %. The cylindrical surface of the panel plays the role of a concentrator of the reflected part of the radiation and the own radiation of the panel in the region of the heat pipe.

Further studies are planned to be conducted in the direction of optimization of the geometric parameters of the heat-absorbing surfaces of solar collectors.

Keywords: solar collector, aluminum structural heat pipe, aluminum flat absorber panel, aluminum cylindrical absorber panel.

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