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ANALYSIS OF THE EFFECT OF THERMOHYDRAULIC IRREVERSIBILITY OF PROCESSES IN THE CYCLE OF A REFRIGERATION MACHINE WITH A NON-AZEOTROPIC MIXTURE OF REFRIGERANTS

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The object of research is the effect of thermohydraulic irreversibility of energy processes in the cycle of a refrigeration machine using an ozone-safe non-azeotropic mixture as a refrigerant on its energy efficiency. One of the most problematic places during the development and design of such refrigeration machines is that, due to the peculiarities of the thermodynamic properties associated with the different chemical composition of the components, non-azeotropic mixtures are characterized by differences in the equilibrium concentrations of the components in the liquid and vapor phases. This property of non-azeotropic mixtures presents a certain difficulty for their effective application in refrigeration machines and heat pumps. During the study, modern methods of analysis and synthesis of thermodynamic systems are used, based on the application of the theoretical apparatus of technical thermodynamics, thermoeconomics, the theory of heat and mass transfer, as well as elements of the theory of systems engineering. The issue of assessing the energy efficiency of the cycles of refrigeration units operating on a non-azeotropic mixture of refrigerants is considered, taking into account the variability of the composition of the components of the mixture. A method has been developed for the formation of the composition of a multicomponent mixture, taking into account the influence of the non-isobarity of processes in the hydraulic circuit of the refrigerant circulation on the energy efficiency of the refrigeration machine. Based on a numerical experiment, the influence of changes in the concentrations of the components of the mixture R32, R125, R134a on the non-isothermal phase transition in the evaporator and condenser, as well as on pressure losses in the hydraulic circuit elements of an autonomous air conditioner, is established. The effect of friction at a temperature level below ambient temperature on the exergy efficiency of the refrigeration machine is analyzed. An advanced exergy analysis of the refrigeration cycle with a non-azeotropic mixture is carried out, as a result of which the avoidable and unavoidable, as well as the endogenous and exogenous components of the destruction of exergy in the elements are determined. The proposed method, due to its visibility, can significantly simplify the finding of the thermodynamic parameters of the refrigerant at the nodal points of the refrigeration machine cycle during numerical simulation.

Keywords: exergy analysis, non-azeotropic mixture, non-isothermal phase transition, hydraulic refrigerant circuit.

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OBTAINING OF IRON-CONTAINING SILICATE COMPOSITES FOR CONTAMINATED WATER PURIFICATION FROM ARSENIC COMPOUNDS

page 14–19

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The object of research is palygorskite – a natural clay mineral with a layered ribbon structure. It is characterized by high specific surface area, secondary porosity and sorption capacity for metal cations. However, due to the negative charge of the surface, palygorskite is inefficient when cleaning water from pollution that is in anionic form, in particular, from arsenic compounds. A significant drawback of the use of dispersed aluminosilicates as sorbents is the difficulty of their separation from the liquid phase after the process of sorption purification. Therefore, to increase the sorption properties of palygorskite by pollutants in the water in the form of anions, the authors used the method of modifying its surface with iron-containing compounds, including treating the prepared palygorskite with iron salts (III) in a weakly alkaline medium. Physical and chemical methods are used to study the structure of modified and initial samples of palygorskite, in particular, the method of infrared spectroscopy (IR spectroscopy) and the method of low-temperature nitrogen adsorption-desorption. The results indicate that the surface of the palygorskite is coated with iron compounds (III), which led to an increase in the specific surface area from 213 m^2/g to 275 m^2/g and a pore size from 1.9 nm to 2.25 nm. The obtained samples differ from the original mineral by increased sorption capacity with respect to arsenic compounds (V). The maximum sorption of arsenic by the modified sample is 7.8 mg/g, which is significantly higher than that for natural palygorskite – 0.2 mg/g. It has been shown that arsenic is removed by iron-containing silicate rather quickly and does not depend on the pH value of the aqueous medium in the range 3–8. This is due to the fact that when processing the surface of palygorskite by iron oxyhydroxides the latter acquires an increased reactivity by increasing the number of active sorption centers.

Keywords: arsenic sorption, water purification, iron oxyhydroxides, clay minerals, surface changes.

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COMPUTER AND ANALYTICAL CALCULATIONS FOR OPTIMIZATION OF CYCLE SEPARATION OF ASH

page 20–25

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The object of research is the efficiency of cleaning of flue gases in group cyclones of CN-15 type with a diameter of 0.7 m steam boiler KE 10-14-285 when burning sunflower husk at an oil and fat plant. One of the biggest problems of different sunflower husk combustion technologies in boiler units at oil and fat plants is the low efficiency of trapping in typical cyclones of sunflower husk ash due to the considerable dispersion of ash and other factors.

The estimation was made by the use of the developed analytical models and computer technology CFD – Computational Fluid Dynamic of the Certified SolidWorks-2009 computer program on the settlement complex (KPI).

The calculated and experimental data on the estimation of the efficiency of flue gas cleaning in cyclones of the steam boiler «KE 10-14-285» (Ukraine) during the combustion of sunflower husk at the Vinnytsia Oil and Fat Plant (Ukraine) is given. The possibility of significant reduction of ash removal into the air during reconstruction according to of new technology of group cyclones type CN-15 (Ukraine) is shown. Using computer and analytical calculations, the possibility of increasing the overall efficiency of flue gas cleaning from ash during combustion in boilers of dream husk is substantiated to 90 % instead of 45...55 %.

In the course of the study, the technology of creating high-intensity cyclone cyclones at flow stage with flow of various turbulizers was used at the stepped inlet section. Thanks to this technology, it is possible to reduce the ash removal from cyclone by more than three times compared to similar indicators in typical cyclones prior to their modernization. This makes it possible to satisfy the sanitary standards of the European Union and Ukraine with minimal capital expenditure. This result is

achieved due to a number of features – in particular, a sharp increase in the ripple component of the flow rate.

Keywords: cyclone of steam boiler «KE 10-14-285», turbulence intensity, turbulence generator, cut-off diameter.

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FOOD PRODUCTION TECHNOLOGY

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FORMATION OF FUNCTIONAL AND TECHNOLOGICAL PROPERTIES OF FLOUR DOUGH AND QUALITY OF FINISHED PRODUCTS IN THE TECHNOLOGY OF CUSTARD GINGERBREAD WITH THE USE OF «MAGNETOFOOD» FOOD ADDITIVE

page 26–33

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The object of research is the technology of custard gingerbread from a mixture of rye and wheat flour using the food additive «Magnetofood». To improve the technology and to obtain high-quality products with a long term preservation of freshness, various technological methods are used, including the introduction of food additives that enhance complex action. Promising improvers of food systems (in particular, flour confectionery masses) are nano-additives that have a wide range of functional and technological properties, due to the specificity of their physico-chemical characteristics due to the nanoscale size and quantum mechanical effects. In order to study the influence of «Magnetofood» food additive on the functional, technological, physicochemical and structural-mechanical properties of flour, dough and quality indices of custard gingerbread, model dough of «Magnetofood» food additive was introduced into the prescription mixture in the form of a fat suspension in the «kneading the dough» stage. It is established that the introduction of the additive «Magnetofood» in the amount of 0.10 %; 0.15 %; 0.20 % by weight of the prescription mixture compared to the control in samples of rye-wheat flour:

– increases: water-binding ability – by (2±1) %; fat-holding capacity – by (8.8±0.8) %; swelling capacity – by (1.56±0.02) cm^3/g; water absorption capacity – by (6.6±0.2) %; water retention capacity – by (15.0±0.9) %; dough stability – at (0.7±0.1)·60 s;

– reduces the time of formation of the dough by (1.6±0.2)·60 s and the degree of vacuum of the dough – by (23±2) units of the farinograph;

– in samples of gingerbread dough increases humidity by (1.3±0.2) %;

– reduces the dough density by (0.7±0.1) g/cm^3;

– increases plastic viscosity by (2.2±0.4) kPa·s compared to control;

– in samples of finished products increases the output by (4.3±0.5) %, humidity by (2.4±0.1) %, and wetting by (20±2) %; improves fluidity on (0.5±0.2) points; reduces crumbling by (1.0±0.2) %.

Compared to similar well-known food system improvers, nanoobjects, which include nanopowder based on iron oxides Fe_3O_4 («Magnetofood»), exhibit antioxidant, bacteriostatic, sorption, emulsifying, structure-forming, moisture-and fat-retaining properties. This ensures the possibility of obtaining high values of the studied parameters.

Keywords: «Magnetofood» dietary additive, custard gingerbread, rye-flour, rye-wheat dough, quality indicators.

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REPORTS ON RESEARCH PROJECTS

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INVESTIGATION OF CHARACTERISTICS OF DRAIN SYSTEMS OF RAPID FILTERS ON WATER TREATMENT PLANTS

page 33–35

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The object of research is the modern design of drainage systems of rapid filters. The drainage distribution system of rapid filters is their most important element, which determines the uniformity of filtrate collection and its quality, as well as the distribution of washing water and overall filter washing efficiency. An analysis of the results of the reconstruction of filter drainage systems at the Dnipro water treatment complex of the Kharkivvodokanal utility company (Ukraine) is carried out. The analysis of operational indicators of the use of drainage systems of rapid filters carried out in the work reveals the feasibility of their use. Technical characteristics and operating experience shows that the systems made of polymer concrete are the most promising. Existing technologies make it possible to obtain porous polymer concrete of the optimal composition both in the factory and directly at the facility. Silica sand is used as a filler – grains with a size of 0.6–1.2 mm, which have a shape close to spherical (rounded). Each grain is covered with a layer of polymer binder, when connecting the grains intergranular structural bridges are formed. After completion of the polymerization process, a material with a regular structure with an extensive network of pore channels is formed. The high smoothness of the channels, as a result of coating with a polymer film, provides low values of hydraulic resistance of the filter materials. Timeliness and completeness of the regeneration of the filter provides a given service life. Otherwise, a gradual increase in the hydraulic resistance of

the filter is possible, which in the future can no longer be reduced even by high-intensity washing through contaminants in the pore channels. This will lead to the need for early replacement of filter elements. The use of polymer-concrete drainage systems will make it possible to abandon the gravel layers that support, avoid clogging the drainage, reduce the consumption of flushing water and water for own needs in general, and reduce energy consumption.

Keywords: water purification, rapid filter, drainage system, porous polymer concrete, filter washing, washing water.

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DEVELOPMENT OF THE PHYSICAL AND MATHEMATICAL MODEL OF THE BAKING PROCESS OF THE DOUGH PIECES IN BAKERY OVENS

page 36–40

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The object of research is the physical and mathematical models designed to describe the heat and mass transfer inside the porous material during baking. In order to improve the quality and at the same time reduce energy consumption in production, as well as improve the technical and economic indicators of the operation of furnaces, the duration and safety of their operation, the designs of furnace units are being improved, new ones are being developed and their thermal conditions are being optimized. One of the biggest problems is the task of replacing obsolete oven designs with new ones, with automatic regulation of the thermal regime of baking, which will ensure high quality bread while reducing fuel, steam, electricity and human resources. Since the quality of products, in particular, taste, aroma, porosity, gloss, appearance and other indicators of bakery products, largely depends on the design of the furnace unit, the thermal and hygrothermal conditions of the working chamber, as well as its proper operation. These factors affect the loss during baking, which can vary from 6 to 12 %, which affects the yield of bread. This paper presents a physical and mathematical model of the process of baking dough pieces in baking ovens using the example of the industrial oven K-BOM-25 (Ukraine) developed by the author.

A mathematical model of the process of baking bread in the gas channels of the baking chamber is given taking into account radiation-convective heat transfer, mass transfer taking into account the introduction of water vapor to moisten the dough pieces and turbulence of the multiphase flow. The dependence of the multiphase flow turbulence is formulated on the basis of the Euler equations averaged over Reynolds. This model allows with sufficient accuracy and detail to take into account the technological conditions and design features of modern conveyor baking ovens. And it also allows for extensive parametric studies of conjugate heat transfer in them with access to the final indicator – the quality of finished products.

Keywords: industrial oven K-BOM, radiation-convective heat and mass transfer, mathematical model of bread baking process.

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