ABSTRACT AND REFERENCES

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STUDYING PATTERNS IN THE FLOCCULATION OF SLUDGES FROM WET GAS TREATMENT IN METALLURGICAL PRODUCTION (p. 6–13)

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The influence of a solid phase concentration in the model sludges of wet gas purification, as well as the flocculant consumption, on a change in the solid phase sedimentation rate and the strength of floccules has been examined. This is important because fluctuations in the solid phase concentration in waste water represent an uncontrolled process that significantly affects the kinetics of the solid phase sedimentation and leads to an increase in the flocculant consumption.

We have proposed a procedure for determining the sedimentation rate of the flocculated sludge and the strength of floccules following the hydromechanical influence, which takes into consideration the solid phase concentration and the flocculant consumption. The study was carried out on model waste water, synthesized by mixing the dust from dry gas purification at actual production site with water. It has been determined that the solid phase concentration affects the rate of floccule deposition. It has been established that the optimum conditions for aggregate formation within a given model system are observed at the solid phase concentration in the interval 8–12 g/l. Increasing the solid phase concentration above 16 g/l decreases the floccule sedimentation rate disproportionately to the flocculant concentration. It is possible to reduce flocculant consumption and to optimize its dosage by carrying out a cleaning process taking into consideration the specified patterns.

It was established that the hydromechanical influence on aggregates exerts the destructive effect, whose degree depends on the solid phase concentration. In particular, increasing the rate of fluid motion leads to greater damage to floccules than increasing the time for a less intense exposure. The way to minimize the destructive effect on floccules could be lowering the suspension transportation speed resulting from a decrease in the installation performance or through the increased cross-section of the channel (a pipeline). An increase in the solid phase concentration of the model system above 16 g/l is accompanied by a significant reduction in the strength of floccules. Therefore, when designing wastewater treatment plants that utilize flocculants, it is necessary to provide optimum conditions for aggregation and to minimize the hydromechanical effects on floccules by lowering the velocity of fluid motion.

Keywords: flocculation, aggregation, strength of aggregates, deposition rate, optimization, hydromechanical destruction of floccules.

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PREDICTION OF THE PROCESS OF BIOLOGICAL DEFERRIZATION OF UNDERGROUND WATER IN A BIOREACTOR (p. 14–22)

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Research in the field of groundwater treatment indicates the prospects for the development of its complex purification involving various morphological types of microorganisms, fixed on inert contact materials. It was indicated that at certain parameters of water quality (pH 6–7; Eh 50...200 mV, in the presence of dissolved carbon dioxide and at magnitudes of permanganate oxidation of up to 5 mg O_2/dm^3), development of bacteria of genus Gallionella prevails in groundwater, and development of bacteria of genera Lepthothrix, Crenothrix prevails at pH values of 6.5–7.5; Eh = –200...300 mV and PO > 5 mg O_2/dm^3. This provides a series of advantages in the use of the biochemical method over conventional physical and chemical methods, in particular, acceleration of the process of water purification from ferrite compounds.

It was shown that much less attention was paid to modeling the kinetics of the processes of treatment of underground water in bioreactors than to conventional physical-chemical methods, for which modern mathematical models were developed. That is why the development of the direction of modeling the biochemical process of water purification from iron compounds is a relevant task. The mathematical model is represented by the Cauchy problem for a nonlinear system of differential equations in partial derivatives of the first order. The system of the Cauchy problem consists of five equations with five unknown functions, which describe the distribution the concentration of ferrum cations, bacteria and the matrix structures in two phases (movable and immobilized) both in space and time. When constructing the model, we used both technological (maximum contamination capacity (2.6 kg/m^3), boundary magnitude of the bacteria biomass in the matrix structures (9.5 g/m^3), maximum specific rate of their growth (0.17–0.18 h^{-1}), saturation coefficient (0.65–0.7 g/m), flow rate in the range of 5–20 m/h), and design parameters (the height of contact load of a bioreactor – 1.3 m). In the considered model, the time of effective operation of a bioreactor depends on the concentrations of cations of Fe^{2+}, which in natural waters can be in the range of 0.5–20 mg/dm^3, the number of ferrobacteria (10^2–10^4 kl/dm^3), as well as the water flow rate. The inverse influence of the characteristics of the process, in particular, the concentration of matrix structures in the inter-pore space, as well as characteristics of the medium with the help of coefficients of mass exchange and porosity, were taken into account. The model allows determining the optimum operation time of a bioreactor between washings.

Keywords: biochemical processes, kinetic model of biological deferrization, matrix structures, method of characteristics.

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ESTIMATION OF FIRE PROTECTION EFFICIENCY OF ARTICLES MADE FROM REED UNDER AN EXTERNAL ACTION OF GASOLINE FLAME (p. 23–30)

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Our study into the process of reed ignition has established the mechanisms of heat transfer to a material, which makes it possible to influence this process. It has been proven that the process of ignition implies heating a material to the critical temperature when an intensive decomposition begins with the release of the required amount of combustible gases. Knowing this process makes it possible to determine the efficiency of fire protection and the properties of roofing compositions on the process of reed ignition deceleration. Under a thermal action on fire-proof samples, a swollen layer formed at the surface resulting from the decomposition of the retardants under the influence of the temperature, with the release of non-combustible gases that inhibit the oxidation processes of the material and substantially increase the formation of a thermoprotective layer of coke at the reed surface. This leads to an increase in the thickness of the coke layer and to the deceleration of heat transfer of high-temperature flame to the material. Given this, it has become possible to determine conditions for protecting reed from fire by forming a barrier to thermal conductivity. In addition, when applying a fire-proof coating, temperature influence is carried out in the direction of reactions in a pre-flame area towards the formation of ash-like products at the surface of the natural combustible material. That allows us to argue about feasibility of the established mechanism that forms the properties of fire protection of reed by swelling compositions and about practical significance of the proposed technological solutions. The latter, in particular, relate to determining the amount of a polymeric component as reed is characterized by hydrophobicity and an aqueous solution of the fire retardant flows down from the surface. Adding a PVA-dispersion leads to a decrease in the intensity of washing the flame retardant out of the material by larger than 6...8 times. Our experimental research has shown that when exposed to a gasoline flame the untreated model sample of a thermal insulation mat made from reed ignited on second 205, which led to its complete combustion while the flame-retardant sample did not ignite under thermal action, the flame did not propagate; in this case, we observed the swelling of a protective coating on the area of about 0.028 m^2, which reached 3...4 mm. Thus, there is reason to argue about the possibility of targeted control over the processes that protect reed from fire by using an integrated roofing composition of a mixture of fire retardants, which contains a natural polymer capable of forming a fire-protective film on the surface of the material.

Keywords: fire protection of reed, impregnating solutions, coatings, surface treatment, ignition time, flame propagation.

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DEVELOPMENT OF COMPOSITION FORMULATIONS, BASED ON NATURAL BISCHOFITE, TO PROTECT WOOD FROM FIRE (p. 31–41)

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We have studied the chemical composition of natural bischofite extracted from well No. 1 at Zaturin deposit and revealed that the sufficient saturation of $MgCl_2$ allows its use as an environmentally-oriented base for composition formulations in order to protect wood from fire. Our experimental research has confirmed the efficiency of applying organic synthetic dyes (methyl orange, bromothymol blue) as coloring additives for the reported composition formulations. Technological features have been defined for using the pigment concentrates of trade marks «Amber» and «Sniezko», which form two-phase systems with a solution of natural bischofite. It has been proven that the proposed coloring additives ensure the stable wood coloration and saturated color of its surface. The efficiency of using coloring additives (bromothymol blue and methyl orange; the pigment concentrates of TM «Amber» and TM «Sniezko») for the developed composition formulations aimed at fire-protective treatment of wood has been confirmed under laboratory conditions. Our experimental study has established that flammability time of the timber treated with a composition formulation without coloring additives increases by 4 times compared to untreated wood. The fire-retardant mechanism of the developed composition formulations is predetermined by the successive processes of bischofite salt conversion under a temperature influence and by the addition of orthophosphoric acid, which is a strong fire retardant. Introducing the coloring additive (colorant) methyl orange to the composition formulation increases its flammability time by more than 4 times, compared to untreated wood. Thus, there is reason to argue that the developed composition formulations that contain coloring additives (colorants) are environmentally-oriented and economically feasible. At the same time, the results obtained resolve an integrated task, namely ensuring fire- and bio-protection, as well as visualizing the applied treatment of wood-based construction structures at residential buildings and non-residential facilities.

Keywords: bischofite, coloring additive, pigment concentrate, composition formulation, fire-protective agent, visualization of treatment.

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CONSTRUCTION OF AN ALGORITHM FOR BUILDING REGIONS OF QUESTIONABLE DECISIONS FOR DEVICES CONTAINING GASES IN A LINEAR MULTIDIMENSIONAL SPACE OF HAZARDOUS FACTORS (p. 42–49)

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The issue of danger emanating from industrial devices with combustible gases has been considered in the linear multidimensional continuous space of dangerous factors. Dangerous factors are categorized into factors associated with industrial devices and the physical-chemical properties of gases that these devices contain. The actual existing combustible gases are characterized by numerical discrete properties such as molecular mass, specific heat of combustion, etc. An abstract model space of gases is represented in the space of dangerous factors by points whose coordinates are the physical-chemical properties of gases. Given the continuity of the space of dangerous factors, actual gases will be represented by individual points within this space or regions in which certain properties, for example temperature, density, volume, are continuously changing. In addition, there would be a large number of points at which the properties of gases are incompatible, that is such that are impossible for real gases. This has allowed us to consider the issue of danger emanating from combustible gases from some general positions. Thus, using the methodology of p-functions has made it possible to split the space of dangerous factors into dangerous and safe parts. It was also possible to identify the border regions in which the task of determining the hazard from a device is incorrect. That means that some variation of dangerous factors within the accuracy known about them leads to different, mutually exclusive conclusions about danger. Such areas are termed the regions of questionable decisions. It has been found that the regions of questionable decisions may be complex in shape and their size depends on the accuracy that is inherent in the quantitative values for dangerous factors. An algorithm for constructing regions of questionable decisions has been developed that could define whether a device containing gas belongs to a region of questionable decisions. It has been shown that determining whether a device is associated with a region of questionable decisions is a numerical problem with an unambiguous solution.

Keywords: potentially dangerous objects, simulation modelling, high risk object, category of fire safety, fire hazard, p-function.

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DEVELOPMENT OF MATHEMATICAL MODELS OF GAS LEAKAGE AND ITS PROPAGATION IN ATMOSPHERIC AIR AT AN EMERGENCY GAS WELL GUSHING (p. 49–59)

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The study tackles the development of new mathematical means for determining distribution in space and time of technogenic load on atmospheric air as a result of non-burning gas well gushing. To date, modeling is the only tool for studying and solving pressing problems of environmental safety in operation of gas condensate fields. This is especially true for those issues that cannot be solved in practice, such as studying causes and predicting occurrence of emergencies with a low probability of occurrence but with heavy devastating consequences. Drawbacks of the existing mathematical models and methods which make impractical their use in modeling atmospheric pollution in the case of non-burning gas well gush were pointed out. The problem of forecasting the level and distribution of atmospheric air pollution in open gash of a gas well involves two steps: determining amount of gas releases, their parameters and composition; calculation of harmful substance scatter in the near-surface atmosphere. Physical peculiarities of the gas mixture movement through the well and distribution of pollutants in atmospheric air during non-burning well gushing were studied. Mathematical models of stationary and burst release of a mixture of gases from a well were constructed as differential equations with corresponding initial and boundary conditions. These models take into account all major factors affecting intensity of the gas mixture flow during an emergency gushing and adequately describe the process. A new mathematical model of pollutant spread in atmospheric air during release from a well has been constructed. This model, unlike the existing ones, is a set of three analytical dependences describing distribution of contaminants in space and time in the case of burst, short-term and continuous releases, respectively. The results of mathematical calculations were compared with the data of field measurements of concentration of pollutants that were part of the gas flow during emergency release at a gas condensate field in Poltava region. It was established that the modeling error did not exceed 15 % for all substances under study. This comparison has confirmed high adequacy of the developed models and the possibility of their application to solving a wider (compared to existing models) class of problems related to monitoring the atmospheric air in the territories of gas wells under various release conditions, meteorological characteristics, and the drilling rig operation conditions.

Keywords: oil and gas complex, well, environmental safety, atmospheric air, modeling of emergency release.

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