ABSTRACT AND REFERENCES

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A METHOD FOR PREVENTING THE EMERGENCY RESULTING FROM FIRES IN THE PREMISES THROUGH OPERATIVE CONTROL OVER A GAS MEDIUM (p. 6–13)

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A method has been proposed to prevent anthropogenic emergencies caused by fire in the premises, based on using the current measure of increment recurrence in the vector of the gas environment state in order to detect possible dangers of maintenance personnel injuries and equipment destruction in the premises. The proposed measure makes it possible to monitor the dynamics of the gas environment state and to identify dangerous states caused by the emergence of fires in the premises at a facility. It has been shown that the gas environment in the premises a means for the transition of impacts from a source of ignition when danger appears in the form of a fire. We verified the proposed method using an example of detecting danger in the form of ignitions of alcohol and paper in a model chamber, which simulated a no hermetic location of an object. It has been established that the estimation of the probability of recurrence of increments in the states of the gas environment tends to increase from zero to 0.5 for alcohol and 0.6 for paper before the moment of the start of a fire. One should note that a sharp and periodic change in the probability estimate is characteristic of the growth trend in the estimation of the probability of recurrence of increments in the gas environment state. It was revealed that there is a random change of phase states corresponding to the mode of the dynamic stability in the dynamics of increments before the emergence of a danger caused by the ignition of a material. The estimate of the probability of recurrence of increments becomes close to zero when danger emerges in the form of ignition of a material. Such a situation corresponds to the loss of dynamic stability of the state of the gas environment. After that, there are the individual random recurrence points, which belong to the region of the main diagonal of the recurrence plot in the dynamics of increments. Further development of the danger under consideration leads to the chaotic nature of increments in the gas environment state.

It has been shown that monitoring the dynamics of increments of the states of the gas environment makes it possible to identify the moments of the emergence of a danger caused by the ignition of materials in the premises at a facility. The above indicates the efficiency of the proposed method to prevent emergencies caused by fires at facilities by early detection of ignitions of materials based on the identification of moments when the stability of increments of the states of the gas environment in the premises is disrupted.

Keywords: emergency, fire in the premises, current measure of recurrence, increment of states, gas environment, recurrence plot.

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MODELING THE PROCESS OF MOISTURE DIFFUSION BY A FLAME-RETARDANT COATING FOR WOOD (p. 14–19)

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Description of performance of fire-protective coatings during operation of a wooden construction structure is a separate and complex task that covers both stages of the protection process: both moisture protection and further heat transfer that occurs when the coating swells. It has been proven that they imply creating a layer at the surface of the material, which prevents the penetration of moisture to wood when the swelling of a wooden structure and the destruction of the coating begins. Due to this, it becomes possible to determine the effect of flame retardants and the properties of protective formulations on the process of decelerating the rate of moisture absorption of wood. When using fire-retardant coatings for wood, as it is indicated by the research results, typical processes imply the formation of a protective layer under the impact of temperature and a decrease in humidity, which slow down the moisture diffusion processes. It seems likely that such a mechanism of a fire-retardant coating is a factor in regulating the degree of formation of a weather-resistant protective layer and the effectiveness of heat and moisture insulation of the material. We have modeled the process of moisture transfer by a fire-retardant coating; the diffusion coefficient was determined and the estimation dependences were derived, which made it possible to obtain a change in the dynamics of moisture when drying a fire-retardant coating. Based on the derived dependences, the moisture diffusion coefficient of a fire-retardant coating was calculated, which amounts to $0.163 \cdot 10^{-9}$ m^2/s. The results from determining the mass loss of the coating sample during drying indicate the ambiguous effect of the nature of a protective agent on the change in humidity. In particular, this implies the availability of data sufficient for the qualitative implementation of the process of inhibition of moisture diffusion and the identification, on its basis, of the point in time that gives rise to a drop in the coating efficiency. The features of inhibiting the process of moisture transfer to wood, which was treated with a fire-retardant coating, include several aspects. Specifically, the use of water-insoluble flame retardants and other components, as well as a polymer binder, characterized by the formation of a heat-insulated layer at the wood surface.

Keywords: protective means, fire resistance, mass loss, moisture diffusion, surface treatment, protection efficiency.

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IMPROVING THE EFFICIENCY OF WATER FIRE EXTINGUISHING SYSTEMS OPERATION BY USING GUANIDINE POLYMERS (p. 20–25)

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This study has established the possibility of obtaining water extinguishing agents, which can reduce hydraulic resistance (polymer turbulence drag reduction) by using guanidine derivatives.

A cationic polyhexamethyleneguanidine hydrochloride surfactant with a molecular weight of 10,000–11,000 u was used for experimental study.

It has been shown that the addition of insignificant concentrations (0.03–0.290 %) of polyhexamethylene guanidine hydrochloride, which belongs to class IV of toxicity and is an effective inhibitor of biocorrosion, increases a flow rate of water fire extinguishing agent by 1.20–1.78 times when using the RSK-50 fire barrel.

We have established experimentally an increase in the flow rate of a polymer solution from drencher nozzles by 1.86–7.69 % in the concentration range (0.3–1.4 %) along the examined pipeline (1 m and 13 m). An increase in pressure by 2–6 % has been observed compared with the initial values under such conditions.

The used polymer has properties of a «biologically soft» surfactant and meets high environmental requirements of the environmental protection and rational use of natural resources. One can use it to develop formulations for environmentally acceptable water extinguishing agents and their application in firefighting practice.

The above allows us to argue that the directed use of salts of polyhexamethylenguanidine hydrochloride is possible to reduce hydraulic losses in water extinguishing systems. One can apply them to improve engineering and technical measures for preventing and responding to emergencies.

Keywords: polyhexamethyleneguanidine hydrochloride, water extinguishing agent, firefighting, hydrodynamic activity, polymer turbulence drag reduction.

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STUDYING THE SHIELDING OF AN ELECTROMAGNETIC FIELD BY A TEXTILE MATERIAL CONTAINING FERROMAGNETIC NANOSTRUCTURES (p. 26–31)

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The technology has been proposed for manufacturing a textile material that contains ferromagnetic nanoparticles for shielding electromagnetic fields. It has been shown that the most effective method of sticking together between nano-particles and the fibers of the textile material is the application of magnetic liquid with nanoparticles on the material and its exposure in a heterogeneous permanent magnetic field. Under the condition of a magnetic field intensity of 450 A/m and the exposure to it for 12 hours, the implantation of the nanoparticles into the linen fabric becomes almost irreversible. The protective properties of the developed material have been investigated. When impregnated with a magnetic liquid in the amount of 45–50 g/m^2 (a ferromagnetic particle content of 9 % by weight), the material's shielding coefficients for 1–3 layers amount to: for the electric field of industrial frequency 1.4÷4.8; for a magnetic field, 1.9÷8.1. Following the magnetic treatment, these indicators are 2.9÷8.6 and 2.3÷8.9, respectively. In order to remove technological components such as vacuum oil and oleic acid from the magnetic fluid, it would suffice to apply a synthetic detergent, which has been confirmed by experimentally.

We have investigated the efficiency of the obtained result under actual industrial conditions. It was established that the decrease in the magnetic field intensity of industrial frequency and its inter-harmonics by a single layer of the impregnated material without magnetic treatment is 1.4, with a magnetic treatment – 2. In this case, there is no significant decrease in the level of the natural geomagnetic field. We have modeled the distribution of a magnetic field in the human body for the case of manufacturing a protective suit from the developed material. Under the conditions of a warranted reduction in the magnetic field intensity by 2 times in critical places, an increase in the field level is observed in the cervical region due to the increase in the magnetic resistance in this region. This should be considered when designing the protective suit configuration.

Keywords: electromagnetic field, nanoparticles, textile material, shielding coefficient, magnetic treatment.

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IMPROVING THE MATHEMATICAL MODEL OF CHANGE IN THE BODY STATE OF AN EMPLOYEE (p. 32–42)

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Current models of labor safety management at enterprises have several drawbacks. The main drawback of such models consists in their focus on the analysis of the accidents that have already occurred at the enterprise. In addition, the existing models poorly take into account the mutual influence of several production factors on each other during their combined effect on the employee's body.

To eliminate these shortcomings, the task of improving the mathematical model of change in the employee body state was set. The Hammerstein model was considered as the initial model of change in the employee's body state. In the course of this model improvement, an individual component of the model that describes the employee's state immediately before the start of the work shift was chosen for situations of impossibility or severe limitation of applying technologies for monitoring the employee's body state. To assess the mutual impact of various production factors, instead of a vector function that describes the cumulative effect of factors on the employee's body, a set of multiple regression equations that describe the mutual impact of factors on individual employee's body state parameters was introduced into the model.

The improved model was tested at an industrial enterprise using the example of a team of welders (5 persons). To assess their body state, systolic and diastolic blood pressure, heart rate and reaction time to a light stimulus were used. The results presented in the article make it possible to draw a general conclusion about the adequacy of the proposed model to the observed results of the impact of production factors on employee organisms. It was pointed out that the results of modeling slightly exceeded the results of direct measurements in most cases.

Keywords: labor safety, production factor, employee's body condition, Hammerstein model, functional module.

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RESULTS OF RESEARCH OF THE REDUCED EMISSIONS OF POLLUTANTS BY ROAD VEHICLES OF VARIOUS ENVIRONMENTAL CLASSES «EURO» AS THE BASIS OF ENVIRONMENTAL HAZARD LABELING (p. 43–52)

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This study analyzes the change in the calculated reduced emissions of pollutants by all major categories of road vehicles of European environmental classes from «Euro-0» to «Euro-6». It covers cars, light commercial vehicles, trucks, buses, and category L vehicles (mopeds and motorcycles). The reduced mass emissions of pollutants are defined in a common coordinate system, from both traditional internal combustion engines and electric vehicles. Emissions in atmospheric air by wearing products of a pneumatic tire, road pavement, and brake pad are also taken into account. The methodology for calculation of reduced mass operational emissions includes 64 types of major pollutants, grouped into eight specific groups. Carbon monoxide, carbon dioxide, nitrogen oxides, nitrous oxide, ammonia, light hydrocarbons, aldehydes, ketones, aromatic hydrocarbons, polycyclic aromatic hydrocarbons, persistent organic pollutants, particles, sulfur compounds, metals, are covered. Particulate matter emissions from engine exhaust, pneumatic tire wear, road pavement, and brake pads are taken into account. Particulate matter emissions include both elemental carbon and individually adsorbed and absorbed carcinogens in their composition. The average operational mass emissions of pollutants were determined using the methodology of the European Environment Agency. For each of the 64 pollutants, a relative toxicity (aggressiveness) factor is proposed. It is based on available data on the maximum permissible concentrations of substances in ambient air. It is determined as the ratio of the maximum permissible concentrations of carbon monoxide to a known pollutant. It was found that the reduced emissions by cars of level «Euro-5» and «Euro-6» with gasoline engines are only about four times higher than the reduced emissions of electric vehicles; the reduced emissions of «Euro-6++» cars with diesel engines are twice as high as those of «Euro-5» or «Euro-6» cars with gasoline engines; the reduced emissions of trucks and city buses of «Euro-6» level are on average only about five times greater than the reduced emissions of electric transport; the reduced emissions by vehicles of category L (mopeds and motorcycles) can significantly exceed the emissions of cars and even buses and trucks. The results obtained could be the basis for the development of environmental (ecological) classification and labeling of road vehicles. It provides opportunities for the introduction of fiscal and other mechanisms to encourage the use of more environmentally friendly vehicles in line with the practice of EU Member States, using the «polluter pays» principle. General principles of the introduction of the universal system of road vehicles' environmental hazard labeling are proposed. It is suggested to set discrete baseline levels of environmental hazard in increments of 1.259 times the reduced emissions, which is equal to an increase by $10^{0.1}$ times in the specific energy value, that is, 1 dB.

Keywords: road vehicles, pollutants, reduced emissions, environmental hazard labeling.

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IMPROVING THE ENERGY EFFICIENCY OF CYCLONE DUST COLLECTORS (p. 53–62)

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Our study, aimed at assessing the impact exerted by the inclusion to a low-efficiency cyclone of an additional «bypass» pipe connecting the cyclone's inlet branch pipe and the exhaust pipe, has been established the mechanisms to improve the energy efficiency and the process of purifying air from dust. It has been proven that the increase in the degree of purification is explained by a decrease in the radial flow rate under the exhaust pipe of the cyclone. The decrease in hydraulic resistance is due to a decrease in the flow rate along the inlet branch pipe when the air is fed separately to the body through the inlet branch pipe and the «bypass» pipe. Our experimental study has confirmed that when the cyclone design is supplemented with a «bypass» pipe in the most dangerous area of the cyclone in terms of dust release (under the exhaust pipe), the radial rate of the gas flow that negatively affects purification is reduced. This leads to an increase in the overall degree of purification from dust. The result of analytical calculations and computer simulation by the SolidWorks-2009 software were experimentally confirmed when investigating the effectiveness of dust capture from powdered skimmed milk in an industrial cyclone (a 630-mm diameter) with a «bypass» pipe. Such a cyclone is installed in the system of pneumatical transportation at the spray dryer «CT-500» at Ichnya Milk Powder and Butter Plant (Ukraine). Specifically, it has been established that the removal of dust is reduced almost twice, hydraulic resistance – by 15 %, and the energy efficiency of the cyclone with a «bypass» pipe increases by 2.43 times.

Thus, there is a reason to argue about the possibility of significant energy efficiency improvement of the cyclone with a «bypass» pipe.

This makes it possible to assess the energy efficiency of the cyclone in the early stages of design.

Keywords: cyclone dust collector, «bypass» pipe, CFD simulation, degree of purification, hydraulic resistance, energy efficiency.

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EXPERT-ANALYTICAL ESTIMATION OF ENVIRONMENTAL SAFETY OF SOLID HOUSEHOLD WASTE HANDLING PROCESSES (p. 63–76)

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One of the key indicators of regional development is environmentally safe handling of waste including household waste. Solving the problems in this domain requires the creation of an efficient household waste management system. A mechanism for solving this problem was proposed in this study. In contrast to the existing ones, it comprehensively takes into account the formation of environmental hazards at all stages of the waste handling life cycle and substantiates and identifies priorities of obligatory management measures to be taken at local, regional and national levels with their qualitative and quantitative expert estimation.

The study of waste hierarchy performed according to the Directive 2008/98/EC by the hierarchy analysis method has made it possible to determine not only the priorities of the measures ensuring environmental safety of SHW handling process but also the significance of measures at each stage. According to the calculations, contributions to the overall risk amounted to 46.15 % for disposal, 24.02 % for recycling, 10.95 % for neutralization, 10.95 % for generation, 5.14 % for collection and 2.79 % for transportation.

Assessment of the factor characteristics has made it possible to find out that the handling conditions whose contribution is 54.95 % of all factors require the greatest attention during danger generation.

Effectiveness of implementation of the measures ensuring normative environmental safety can be ranked as follows: 60.22 % for the local level, 22.55 % for the regional level and 17.23 % for the national level.

The study has found that the formation of awareness, conscientiousness, and rational consumption is the most effective measure of ensuring environmental safety making up 27.55 % among the thirteen measures assessed.

Application of the proposed method will ensure making grounded managerial decisions not only for the whole system of household waste handling but also for each of its stages: from waste generation to its operation.

This method is quite simple to use and can be applied at the national, regional or local levels.

Keywords: environmental safety, systems analysis, waste handling, hierarchy analysis method.

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