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ORGANIZATIONAL AND TECHNICAL METHODS OF NATURAL AND TECHNOGENIC EMERGENCIES CONSEQUENCES LIQUIDATION

Studies on the processes of dealing with the aftermaths of natural and industrial emergencies, leading to the release of gaseous and dispersed hazardous chemical and radioactive substances into the atmosphere, by artificially initiating precipitation, allowed us to develop two organizational and technical methods for implementing this process. The first method of eliminating the consequences of emergency situations by precipitating gaseous and dispersed hazardous substances from the atmosphere relies on a developed mathematical model of the deposition process of gaseous and dispersed substances artificially initiated by atmospheric precipitation, which is based on the patterns of sedimentation of such substances and the impact of the chosen management decision. This method involves the implementation of five procedures, namely: obtaining monitoring information; calculation of the time of free propagation of the affected area; determining the size of the predicted area of damage; conducting an assessment of the area of emergency of the area of permissible decisions attraction of forces and means for liquidation of consequences of emergency situations. The second method of eliminating the consequences of emergency situations by localizing the centers of intense burning relies on the developed mathematical model of the process of localization and liquidation of artificially induced natural and industrial disasters with intense burning based on the equations of motion of a falling drop of precipitation and its mass and heat balance in the center of burning. This method involves the use of four procedures, namely: collection of monitoring data; forecasting the development of the hearth of combustion; setting targets for performers; influence on atmospheric processes.

Keywords: emergency situations of industrial and natural nature, emission of hazardous substances into the atmosphere, gaseous substances, dispersed substances, deposition of hazardous substances from the atmosphere, localization of the center of intense burning

1. Introduction

The problem of eliminating the consequences of natural and industryal emergencies is an important public function, and its urgency is caused both by manifestations of natural disasters and the exploitation of a wide range of enterprises of the heavy, chemical and atomic-energy industries.

Even with the normal work of industrial enterprises, a large number of hazardous chemicals is released into the environment. Particularly large-scale emissions occur when such objects of large-scale accidents occur. This poses a significant threat to the population, territory and environment, which are the main objects of the civil protection system. Due to the large scale of atmospheric pollutants that can spread up to several kilometers, localization and the elimination of the effects of emergencies present considerable challenges and require the involvement of a large number of forces. Existing methods and means of preventing emergencies that lead to the spread of hazardous substances in the atmosphere, based on the mechanisms of precipitation of harmful substances by spray water, can affect the zone of damage at altitudes not more than a dozen meters.

In addition, as a result of large natural and industrial fires, a large amount of combustion products is thrown into the atmosphere. Due to the intensive movement of air masses, combustion products extend to tens and hundreds of kilometers. Combustion products consist of gaseous components and solid aerosols of soot and ashes. In contact with gaseous atmospheric products, some gases formed during combustion, react with them to form new chemically active compounds capable of condensing under atmospheric conditions. Therefore, practically the only method of air purification from combustion products is the washing of their atmospheric precipitation.

Based on these positions, research aimed at developing methods for the elimination of the consequences of natural and industrial emergencies, characterized by the presence of harmful and radioactive substances in the atmosphere, using methods of artificial precipitation, should be considered relevant.

2. Literature review and problem statement

Among the dangerous emergency factors, the most significant impact on the atmosphere is pollution of various physical and chemical nature [1]. The Ukrainian Research Institute of Environmental Problems regularly monitors the state of the atmosphere over the territory of Ukraine [2]. However, the ecological situation in the region is sharply deteriorating in the event of accidents at chemical enterprises [3]. A separate class of emergencies is the fires. The main factors influencing the speed of the spread of large natural fires are: terrain, wind speed and direction, fire load, air humidity and combustible material [4]. In this case, precipitation over the fire zone significantly increases the humidity of air and combustible material. As a result of the accidental decompression of a nuclear reactor, a large amount of gaseous and aerosol radioactive substances enters into the atmosphere [5]. The radionuclide composition of contamination at accidents at the Chernobyl Nuclear Power Plant and Fukushima-1 NPPs was analyzed in papers [6, 7].

Existing Global Emergency Response (GER) Emergencies, which are characterized by the release of harmful and radioactive substances into the atmosphere, based on the use of liquid curtains with the help of ground emergency and rescue equipment [8]. This method provides a minimization zone with a height not exceeding tens of meters [9]. However, in the case of the emergence of natural and industrial discharges, the zone of damage to the air reaches a height of several meters [10].

To date, the process of purifying the air of the lower atmosphere is carried out only naturally–gravity deposition, reduction of concentration at the expense of wind streams and sedimentation of pollution by atmospheric precipitation. The most effective mechanism is precipitation of pollutants by precipitation [11]. However, the involuntary precipitation of atmospheric precipitation with the required intensity over the pollution zone is extremely rare. Accordingly, one way to solve the problem of natural or industrial disaster consequences is to artificially initiate atmospheric precipitation [12]. At the present stage, the most effective way of artificially initiating precipitation is the sputtering of the active reagent in the precipitation zone [13].

The kinetics of the sorption of dangerous gases by atmospheric precipitation is quite complex and multifactorial. To date, there are two fundamentally different approaches to solving this problem–the kinetic multilayer model for gas-particle (KM-GAP) [14] and the model of molecular dynamics (MD) simulations [15]. The capture of contaminating disperse particles by falling drops is a special case of inertial deposition in the spheres [16]. However, the use of these models to predict the intensity of precipitation of hazardous substances requires consideration of features.

The lack of an integrated approach to solving the problem of eliminating the consequences of the emergency for atmospheric air at altitudes of several kilometers condition the need for research in this direction.

3. The aim and objectives of the study

The conducted research was aimed at the development of new methods for the elimination of the consequences of natural and industrial emergencies that lead to the release of gaseous and dispersed hazardous chemical and radioactive substances into the atmosphere, by artificially initiating precipitation.

To achieve this goal the following tasks were solved:

- to develop a mathematical model of precipitation of artificially initiated atmospheric precipitation of gaseous and dispersed hazardous chemical and radioactive substances released into the atmosphere as a result of emergency natural and industrial disasters;
- to develop a managerial algorithm of the organizational and technical method for the elimination of the consequences of natural and industrial emergencies by depositing from the atmosphere hazardous gaseous and dispersed substances;
- to propose a procedure for the application of the organizational and technical method for the elimination of the consequences of natural and industrial emergencies by depositing from the atmosphere hazardous gaseous and particulate substances;
- to develop a mathematical model of the process of localization and elimination of artificially-induced sediments of cells of natural and industrial disasters with intensive burning;
- to develop a managerial algorithm of the organizational and technical method of elimination of the consequences of emergency situations of a natural and industrial nature by locating the cells of intensive combustion;
- to propose the procedure of application of the organizational and technical method for the elimination of the consequences of natural and industrial emergencies by locating the cells of intensive combustion.

4. Methods of modeling precipitation precipitation of hazardous substances and localization of deposits of cells of natural and industrial disasters with intense combustion

4.1. Modeling of atmospheric precipitation sedimentation process of gaseous and dispersed hazardous substances emitted into the atmosphere due to emergency situations

To solve the problem of prediction of sorption intensity, we proposed a modified and refined version of the model of phase-out gas absorption. Schematically, the stages of sorption are presented in Fig. 1.

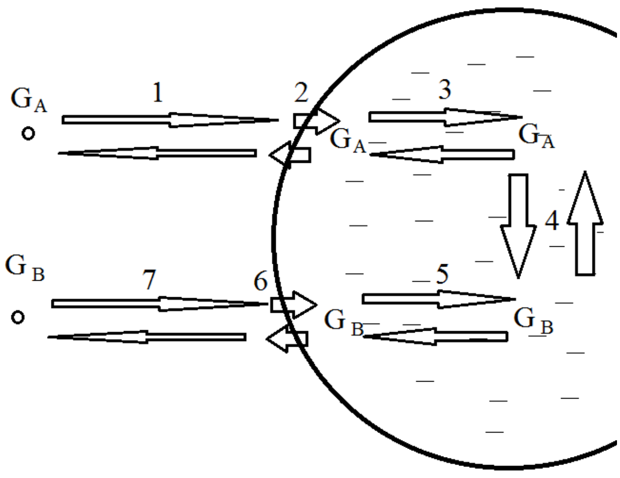


Fig. 1. Scheme of stages of absorption of chemically hazardous gases by drop of atmospheric aerosols

Phase content:

1. Transportation of gas molecules (G_A) to the surface of the drop due to diffusion in the gas phase;

2. Absorption of gas molecules by the surface of a drop and the achievement of equilibrium in the local area of the interface surface due to the desorption of gas;

3. Transportation of absorbed gas molecules (G_A) into the volume of a drop due to diffusion in a liquid;

4. Chemical reactions of the absorbed gas (G_A) and water in the volume of the droplet with the formation of reaction products (G_B);

5. Transport of reaction products (G_B) in volume of drop;

6. Achieve equilibrium in the local volume of the surface of the drop due to the adsorption-desorption of products of the chemical reaction;

7. Transportation of product molecules (G_B) from the surface of the drop to the gas phase due to diffusion.

The rate of absorption of chemically hazardous gas by atmospheric aerosol is determined by the difference in velocity of the V_{des} desorption process and V_{abs} absorption

$$\frac{dC_g}{d\tau} = V_{des} - V_{abs}, \tag{1}$$

where C_g – concentration of gas in the atmosphere; τ – time.

In accordance with steps 1–7, the mathematical expression for the absorption rate is as follows

$$V_{abs} = V_{col} \cdot \alpha \cdot K_{dif} \quad \text{or} \quad V_{abs} = V_{col} \cdot \alpha \cdot K_r, \tag{2}$$

where V_{col} – the rate of interaction of gas molecules with droplets of water; α – coefficient taking into account the probability of absorption of gas molecules by surface of droplets (coefficient of accommodation); K_{dif} – coefficient that takes into account the rate of diffusion of gas inside the drop. In the course of the chemical reaction of the absorbed gas in the volume of the droplet, the coefficient K_{dif} is replaced by K_r – a coefficient that takes into account the diffusion of gas molecules in the drop and the rate of chemical reaction of gas with the liquid.

The modified model of sorption of hazardous gases requires a smaller amount of input parameters, which is a significant advantage in operational forecasting of the consequences of emergences.

The process of washing the dispersed particles with precipitation is carried out by the mechanism of gravitational coagulation. The nature of the interaction of dispersed particles significantly affects the size of aerosol particles. The characteristic parameter for estimating the particle size is the Knudsen number (Kn). Particles with a size $d \approx 0.1$ μm ($Kn >> 1$) are characterized by active Brownian motion and a practical lack of sedimentation process.

$$-\left(\frac{dC_p}{d\tau}\right) = K_{Br} C_d C_p, \tag{3}$$

where C_p – the concentration of disperse particles at time t; C_d – concentration of rain drops; K_{Br} – the rate constant for Brownian coagulation.

With droplets larger than 1 μm (Kn → 0), the collision of dispersed particles with gas molecules does not significantly affect the motion of particles, and they move in space under the influence of airflows.

The essence of the mechanism of gravitational sorption is the capture of a large drop of rain when the fine particles are dispersed. Small aerosol particles with radius rp and the concentration of C_p under the influence of airflows hover in the air ($V_0 \approx 0$). Under the influence of gravitational forces, drop drops of rd size move down a certain velocity V_d. When a large drop of it flows around the flow of air, which captures small aerosol particles. However, since aerosol particles have a mass other than zero, they have inertial forces that seek to maintain a straight-line trajectory. The probability of a collision of a large droplet with a small (capture coefficient K_g) depends on their mutual dimensions, media viscosity (η) and velocity (Fig. 2).

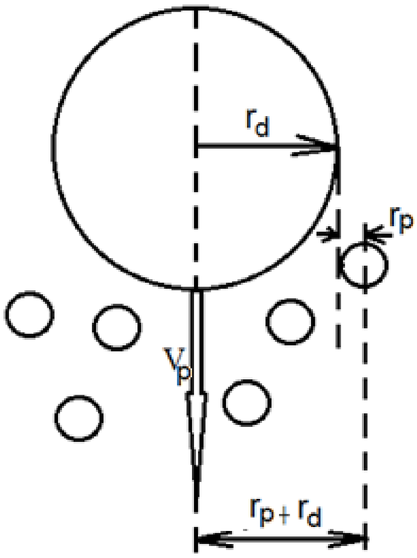


Fig. 2. Scheme of capture of disperse particles by drop drops under gravitational coagulation

The number of small particles that adds one large drop of rain to itself is defined as [16]

$$-\left(\frac{dC_p}{d\tau}\right) = C_d \frac{\pi}{4}\int_0^R K_g \cdot (r_p + r_d)^2 \cdot V_d \cdot C_p dr_p \,. \qquad (4)$$

The theory of similarity (for the construction of semiempirical models) is most commonly used to determine the capture coefficient of K_g.

4.2. Modeling of the process of localization and liquidation of artificially induced sediments of cells of natural and industrial disasters with intense burning

To determine the influence of atmospheric precipitation on the intensity of emission of combustion products, the critical values of the moisture content of combustible plant material and humidity are determined, under which combustion is not possible.

The amount of heat released by precipitation per unit area of combustion is:

$$Q_{ch.} = \left[\tilde{n}_{\eth_w}\left(\grave{O}_{boil.} - \grave{O}_0\right) + \acute{I}_{\ evap.} + \tilde{n}_{\eth_s}\left(\grave{O}_{flam.} - \grave{O}_{boil.}\right)\right] \cdot I \cdot \tau_{\grave{o}}\,, \qquad (5)$$

where c_{pw} – specific mass isobaric heat capacity of water; c_{ps} – specific massive isobaric heat of steam; T_{boil} – boiling point of water; H_{evap} – heat loss on evaporation of water;

T_{flam} – the temperature of the flame; I – the intensity of the flow of water into the combustion zone (rainfall intensity).

For completeness of consideration of the task, the process of removing droplets from the combustion zone by powerful convective flows, which significantly affect large natural fires, is also taken into account. The critical speed is the speed of speech [17]

$$W_{evap.} = \sqrt{\frac{4gd_d(\rho_d - \rho_g)}{3\rho_g Ñ_õ}}, \tag{6}$$

where g – free fall acceleration; d_d – the diameter of the drop; ρ_d – water droplet density; ρ_a – air density; C_x – coefficient of frontal resistance (at $2 \cdot 10^5 > Re > 500$ $C_x = 0{,}44$; at $500 > Re > 2$ $C_x = 18{,}5 \cdot Re^{-0,6}$).

To determine the influence of atmospheric precipitation on the intensity of emission into the atmospheric air of combustion products, a mathematical model for evaporation of a drop of rain when falling in the atmosphere is developed. The model consists of a system of three equations [18]:

1. Equation of the motion of a falling drop

$$\frac{dw_d}{d\tau} = g - \frac{w_d - w_a}{m_d} \cdot \rho_a \cdot \left[6 \cdot \pi \cdot r_d \cdot \nu_a + \frac{C_f}{2} \cdot \pi \cdot r_d^2 \cdot |w_d - w_a| \right], \tag{7}$$

where w_d, w_a – droplet and air velocity; ρ_a – air density; ν_a – coefficient of kinematic air viscosity; C_f – the form factor (for spherical droplets $C_f = 0{,}47$); $m_d = \rho_w \cdot \frac{4 \cdot \pi}{3} \cdot r_d^3$ – mass of drop, where ρ_w – is considered constant water density.

The equilibrium of the mass balance of water in a drop

$$4 \cdot \pi \cdot r_d^2 \cdot \rho_w \cdot \frac{dr_d}{d\tau} = -J_s. \tag{8}$$

The equation that specifies the rate of change in the temperature of the drop:

$$m_d \cdot c_{p.w} \cdot \frac{dT_d}{d\tau} = J_s \cdot \left[-\Delta h + \frac{c_{p.s} \cdot (T_a - T_d)}{\exp(B) - 1} \right], \tag{9}$$

where $\Delta h \equiv h_s(T_d) - h_w(T_d)$ – specific heat of steam generation; $h_s(T)$ and $h_w(T)$ – specific mass enthalpy of formation of steam and water in the liquid phase; $c_{p \cdot w}$ – specific mass isobaric heat capacity of water; B – the characteristic parameter, which is determined taking into account the Nusselt criterion.

5. Results of investigations of methods of liquidation of the consequences of emergency situations with release of dangerous substances into the atmosphere

5.1. Organizational and technical method of liquidation of the consequences of natural and industrial emergencies by depositing dangerous gaseous and dispersed substances from the atmosphere

The mathematical model of precipitation of artificial and initiated atmospheric precipitation of gaseous and dispersed hazardous chemical and radioactive substances discharged into the atmosphere as a result of natural and industrial discharges is developed using the presented models of sorption of gaseous and disperse substances (1) – (4). four dependencies:

$$\left.\begin{aligned} &\frac{dC_g}{d\tau} = V_{des} - V_{abs} \\ &V_{des} - V_{abs} = f_1(K_{chem}, K_{met}, K_{in}) \\ &-\left(\frac{dC_p}{d\tau}\right) = K_{Br}C_pC_d \qquad \text{at} \quad r_p << 0{,}1\mu m \\ &-\left(\frac{dC_p}{d\tau}\right) = C_d\frac{\pi}{4}\int_0^R K_g\cdot(r_p + r_d)^2\cdot V_d\cdot C_p dr_p \qquad \text{at} \quad r_p >> 0{,}1\mu m \end{aligned}\right\}. \qquad (10)$$

The first dependence describes the process of precipitation of gaseous hazardous substances emitted as a result of emergency natural and industrial disasters. The second dependence describes the influence on the process of precipitation of gaseous dangerous substances, the chemical properties of a dangerous gas (K_{chem}), meteorological conditions of the process of sedimentation (K_{met}), and the characteristics of precipitation, which in turn are determined by methods of artificial initiation of precipitation (K_{in}). The third and fourth dependencies describe the process of precipitation of disperse hazardous substances in a wide range of sizes, which are formed in emergency situations of natural and industrial nature, depending on the chosen control influence on atmospheric processes.

With the help of the developed model, the calculation of the rate of precipitation with fine particles (Fig. 3) has been calculated. The measurement error depends on the wide range of dispersion of the dust to be deposited, the low level of chemical purity of the disperse substance, and the error of converting the concentration of dispersed particles from the aerosol capacity data.

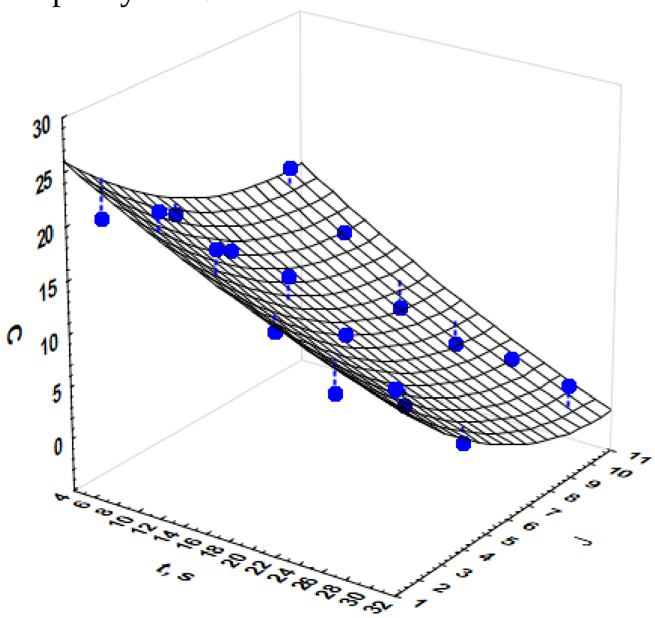


Fig. 3. Dependence of the rate of change of the concentration of fine particles of silicon oxide (C, 10^{-7} m^{-3}) during precipitation with a water aerosol with intensity intensity (J, 10^{-1} $kg\cdot s^{-1}\cdot m^{-2}$): surface – estimated data; dots – experimental data

The scheme of managing the algorithm of the organizational and technical method for the elimination of the consequences of natural and industrial emergencies by depositing dangerous gaseous and dispersed substances from the atmosphere is presented in Fig. 4. It consists of 14 blocks, located on three hierarchical levels, connected by direct and feedback links.

The use of this method involves the following procedures:

1. Receipt of monitoring information.
2. Calculation of the time of free propagation of the zone of damage in the atmosphere.
3. Determination of the size of the predicted zone of atmospheric damage.
4. Conducting an estimation of the membership of the NA area of admissible decisions.
5. Involving contingency forces and means.

Operational information is provided by the state or regional hydrometeorological service. Clarification of received and obtaining additional data on the nature of the accident and meteorological conditions is carried out by conducting intelligence of the zone of emergency and meteorological conditions with the use of satellite, stationary and operational monitoring means.

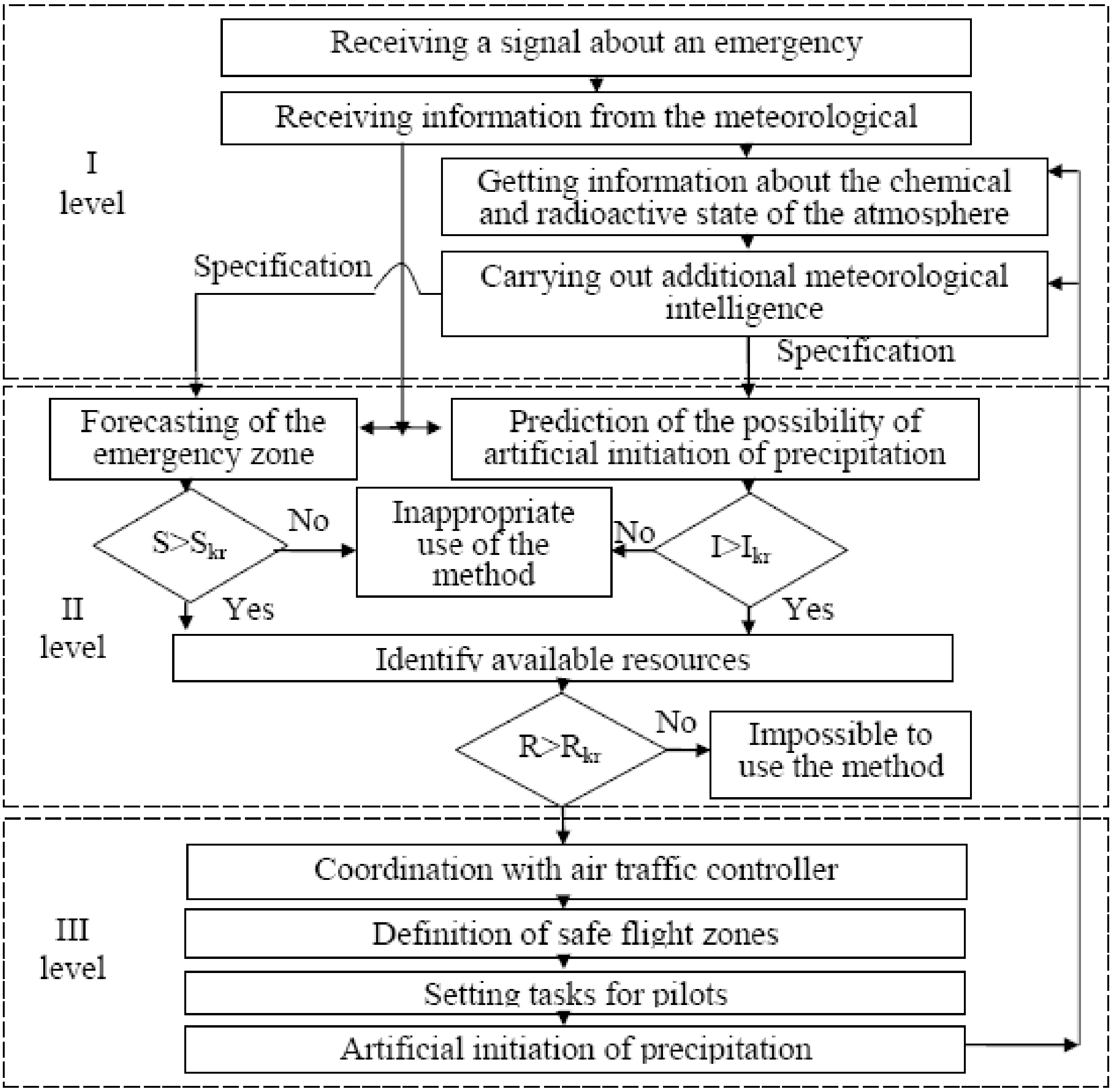


Fig. 4. Management algorithm for the implementation of the organizational and technical method for the elimination of the consequences of natural and industrial emergencies by depositing hazardous gaseous and dispersed substances from the atmosphere

With the data on the nature of the emergency and meteorological conditions, forecasts are made of areas of damage from an emergency and an estimation of the possibility of artificial initiation of precipitation. The next step is a comparative reduction in the results of forecasting to determine the feasibility of using the organizational and technical method for the elimination of the consequences of natural and industrial emergencies by depositing hazardous gaseous and dispersed substances from the atmosphere.

If the use of the method is appropriate, then determine the available resources to use the organizational and technical method of eliminating the consequences. In the presence of the necessary amount of forces and means, we move to the third hierarchical level. In the absence of the necessary resources, the use of the proposed method is impossible.

When obtaining a managerial decision to use the method of organizational and technical method for the elimination of the consequences of natural and industrial emergencies by means of deposition of dangerous gaseous and dispersed substances from the atmosphere, coordination with the air traffic control service of the district is carried out. After that, the zones of safe flight are determined and the tasks of the pilots for sowing the clouds are reagent. Given the inertia of the process, artificial initiation of precipitation is carried out.

The use of this method involves the following procedures:

1. Receipt of monitoring information.
2. Calculation of the time of free propagation of the zone of damage in the atmosphere.
3. Determination of the size of the predicted zone of atmospheric damage.
4. Conducting an estimation of the membership of the NA area of admissible decisions.
5. Involving contingency forces and means.

5.2. Organizational and technical method of liquidation of consequences of natural and industrial emergency situations by localization of intensive burning cells

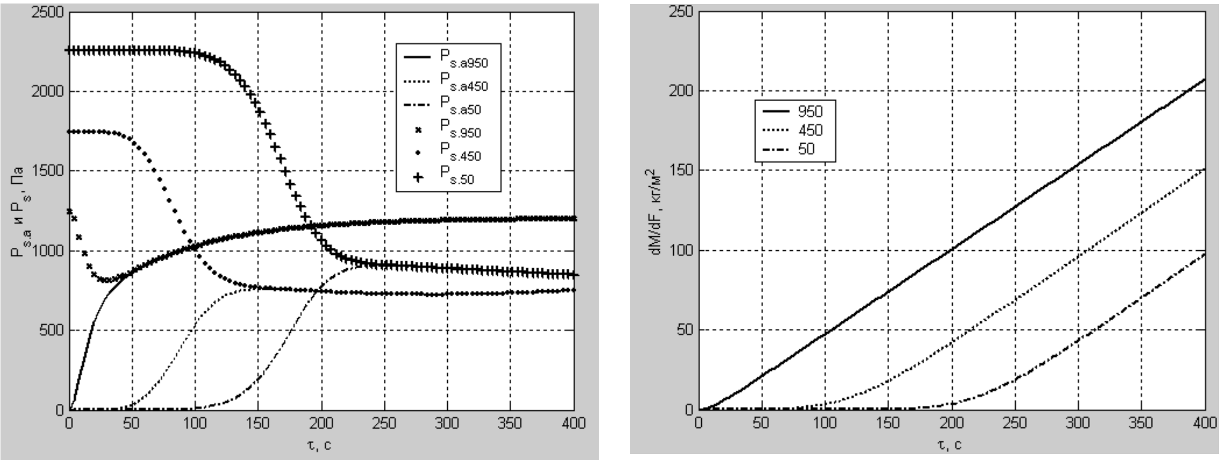
The results of the above research and equations (5)–(9) are the basis for forecasting the dynamics of the zone of damage from an emergency under the influence of artificially induced precipitation.

In the final form a mathematical model of the process of localization and liquidation of artificially initiated sediments of cells of natural and industrial disasters with intense combustion is developed, is a system of five dependencies:

$$\left.\begin{aligned}
&\frac{dw_d}{d\tau} = g - \frac{w_d - w_a}{m_d}\cdot\rho_a\cdot\left[6\cdot\pi\cdot r_d\cdot\nu_a + \frac{C_f}{2}\cdot\pi\cdot r_d^2\cdot\left|w_d - w_a\right|\right]\\
&4\cdot\pi\cdot r_d^2\cdot\rho_w\cdot\frac{dr_d}{d\tau} = -J_s\\
&m_d\cdot c_{p.w}\cdot\frac{dT_d}{d\tau} = J_s\cdot\left[-\Delta h + \frac{c_{p.s}\cdot(T_a - T_d)}{\exp(B)-1}\right]\\
&Q_{\text{â³äâ.}} = \left[\tilde{n}_{\eth_{\text{â}}}\left(\grave{O}_{\text{êèï.}} - \grave{O}_0\right) + \acute{I}_{\text{âèï.}} + \tilde{n}_{\eth_{\text{ï}}}\left(\grave{O}_{\text{ïë.}} - \grave{O}_{\text{êèï.}}\right)\right]\cdot I\cdot\tau_{\text{ò}}\\
&W_{\text{âèò.}} = \sqrt{\frac{4gd_{\text{ê}}\left(\rho_{\text{ê}} - \rho_{\text{ã}}\right)}{3\rho_{\text{ã}}\tilde{N}_{\text{õ}}}}
\end{aligned}\right\}. \quad (11)$$

The first dependence of the model (11) describes the movement of falling drop of precipitation over the center of an emergency. The second and third dependencies describe the mass and thermal balance of the drop in the combustion cell. The fourth dependence describes the process of absorption of heat by atmospheric precipitation from the combustion cell, depending on the management influence on atmospheric processes. The fifth dependence determines the boundary condition, when the elimination of the intensive combustion cell is impossible and only its localization takes place.

The obtained model (11) allows to predict the dynamics of changes in the humidity of atmospheric air (Fig. 5 a) and combustible material (Fig. 5 b) under various weather conditions and parameters of the accident.



a) b)

Fig. 5. The rate of change in humidity of atmospheric air at different altitudes (a) and the amount of water entering the surface of the combustible material (b)

The scheme of managing the algorithm of the organizational and technical method for the elimination of the consequences of natural and industrial emergencies by locating the cells of intensive combustion is presented in Fig. 6. The control algorithm consists of 21 blocks, located on three hierarchical levels, connected by straight lines and back links.

The collection of geographic and geometric data on the combustion zone is based on the data of operational intelligence and satellite control. The collection of the main indicators of combustion is carried out by establishing the type of combustible material and its moisture content.

According to the results of the determination of the area of the combustion cell and the prediction of its development, an assessment is made of the feasibility of using the developed organizational and technical method. Estimation of the possibility of artificial initiation of precipitation with the required intensity is carried out on the basis of monitoring data. Based on the forecasts of the distribution of the intensive combustion cell, the territory of safe placement of personnel and equipment is determined. Taking into account the size of the emergency zone, the calculation of the required number of reagents for artificial initiation of precipitation is carried out.

The calculation of the number of aircraft is based on the required amount of reagent and the tactical and technical characteristics of the aircraft available. Determination of the location of the aircraft is carried out in order to minimize the distance from the cell to the appropriate runways. Definition of sowing zones is carried out taking into account the safety of flights and the inertia of the artificial initiation of precipitation.

The definition of the flight zone is made taking into account the danger of the flight of airplanes by powerful convective flows over the cells of intense combustion.

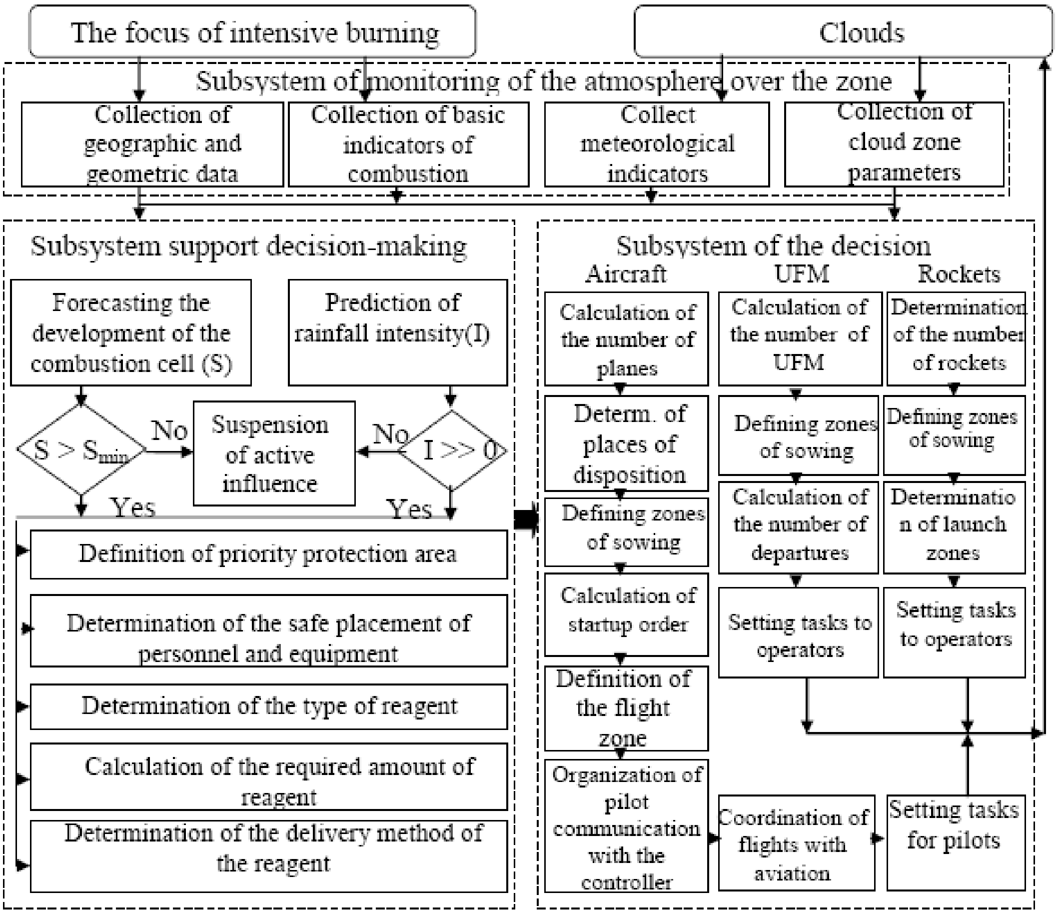


Fig. 6. A management algorithm for implementing the organizational and technical method for the elimination of the consequences of emergency situations of natural and industrial nature by locating the cells of intensive combustion

At the last stage, the tasks are set for pilots.

The use of this method involves the following procedures:

1. Processing and systematization of monitoring data.
2. Forecasting of the burning area and rainfall intensity.
3. Setting specific tasks for performers.
4. Direct influence on atmospheric processes.

6. Discussion of the results of the development of organizational and technical methods for the elimination of the consequences of emergencies of natural and industrial nature

In accordance with the developed organizational and technical methods and procedures for their implementation, an automated workplace (AWP) was created in the form of a software product "FORECASTING ATMOSPHERIC RISKS" (Fig. 7, 8) for automation of the subsystem of support for the management decision making by operational staff involved in the elimination of the consequences of the emergence, which will allow to summarize the monitoring information promptly and to conduct forecasting of the development of events when making certain decisions. The main task, which allows to solve the AWP, is to determine the possibility and effective use of one or another method of artificial precipitation for purification.

The program interface consists of two sections (tabs) – "MONITORING" and "FORECASTING". The "MONITORING" tab (Fig. 7) is designed for convenient processing of information obtained by monitoring the pollution zone and meteorological situation. The developed program is aimed at monitoring the pollution zone using UFM equipped with a device base for automatic monitoring of the required parameters and wireless transmission to the agro-industrial complex.

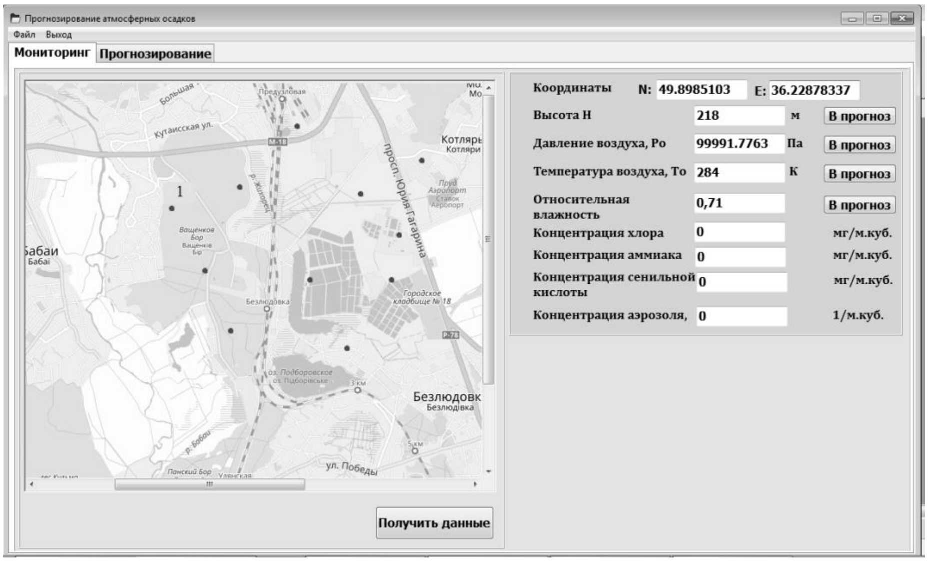


Fig. 7. «MONITORING» tab of the interface of the APC «FORECASTING ATMOSPHERIC RISKS»

In the left part of this tab is a map of the area over which there is pollution of the atmosphere. The specific region and scale of the map is chosen by the operator by moving the corresponding cursors. The UFM data points from the UFM are located on the map on the real-time coordinates transmitted from the UFM.

Directly transmitted from the UFM-reconnaissor, the data attached to the point on the map is displayed on the right side of the tab. The contamination eliminator analyzes the data received and, if necessary, can send them immediately for prediction purposes.

The second tab "FORECASTING" (Fig. 8) consists of the field of input of the initial parameters of calculation and output of the received data.

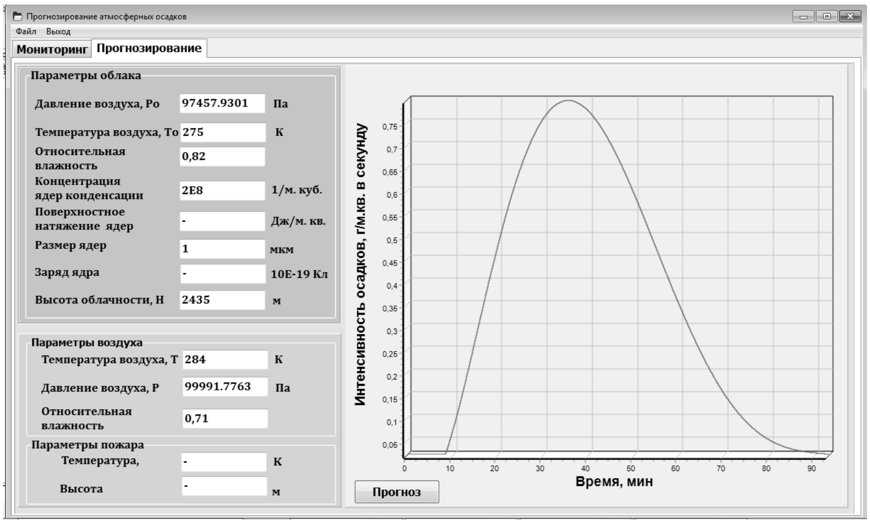


Fig. 8. The tab «FORECASTING» of the interface of the «FORECASTING ATMOSPHERIC RISKS»

The input field of input parameters, in turn, is also divided into two parts, where the parameters of the precipitation zone (I) and the fall zone (II), respectively, are introduced. The data, which failed to receive as a result of monitoring, the operator enters manually, based on the information received in another way. After pressing the button "FORECAST" calculates the intensity of precipitation, the results of which are displayed in the form of a graph or table.

Using the developed APC, the head of the elimination of pollution will be able to quickly obtain information on the possibility of artificial causation of precipitation in one way or another under the existing atmospheric conditions. In the case where the theoretical possibility of artificially initiating precipitation over the pollution zone with the use of APC "PROGNOSIS OF ATMOSPHERIC PROPERTIES" is determined, the most effective way of influence can be determined, the intensity of predicted precipitation in one or another period of time and the total predicted rainfall duration can be estimated.

7. Conclusions

1. The mathematical model of precipitation of artificially initiated atmospheric precipitation of gaseous and dispersed hazardous chemical and radioactive substances released into the atmosphere due to emergency situations of a natural and industrial nature is developed in this work, is a system of four dependencies.

2. The management algorithm of the organizational and technical method for the elimination of the consequences of emergencies of natural and industrial nature by depositing from the atmosphere of dangerous gaseous and disperse substances consists of 14 blocks, located on three hierarchical levels, connected by direct and feedback bonds.

3. The use of the organizational and technical method for the elimination of the consequences of natural and industrial emergencies through the deposition of hazardous gaseous and dispersed substances from the atmosphere involves the receipt of monitoring information; calculation of the time of free propagation of the zone of damage in the atmosphere; determination of the size of the predicted zone of atmospheric damage; carrying out of the assessment of the membership of the emergence area of admissible decisions; attraction of forces and means for the elimination of the consequences of emergencies.

4. The mathematical model of the process of localization and liquidation of artificially induced sediments of cells of natural and industrial disasters with intense combustion is a system of five dependencies.

5. The management algorithm of the organizational and technical method for the elimination of the consequences of emergency situations of a natural and industrial nature by locating the cells of intensive combustion consists of 21 blocks, located on three hierarchical levels, connected by direct and feedback links.

6. The use of the organizational and technical method for the elimination of the consequences of natural and industrial emergencies by locating the cells of intensive combustion involves the collection, processing and systematization of monitoring data; forecasting the development of the combustion cell and the intensity of precipitation; statement of specific tasks to performers; direct influence on atmospheric processes.

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ОРГАНІЗАЦІЙНО-ТЕХНІЧНІ МЕТОДИ ЛІКВІДАЦІЇ НАСЛІДКІВ НАДЗВИЧАЙНИХ СИТУАЦІЙ ПРИРОДНОГО ТА ТЕХНОГЕННОГО ХАРАКТЕРУ

Проведені дослідження процесів ліквідації наслідків надзвичайних ситуацій природного та техногенного характеру, що призводять до викиду газоподібних та дисперсних небезпечних хімічних та радіоактивних речовин в атмосферу, шляхом штучного ініціювання опадів дозволили розробити два організаційно-технічних методи реалізації цього процесу. Перший метод ліквідації наслідків надзвичайних ситуацій шляхом осадження з атмосфери газоподібних та дисперсних небезпечних речовин, спирається на розроблену математичну модель процесу осадження штучно ініційованими атмосферними опадами газоподібних та дисперсних речовин, яка базується на закономірностях осадження таких речовин та впливу обраного управлінського рішення. Цей метод передбачає виконання п'яти процедур: отримання моніторингової інформації; розрахунок часу вільного розповсюдження зони ураження; визначення розмірів прогнозованої зони ураження; проведення оцінки належності площі надзвичайної ситуації області припустимих рішень; залучення сил та засобів для ліквідації наслідків надзвичайних ситуацій. Другий метод ліквідації наслідків надзвичайних ситуацій шляхом локалізації осередків інтенсивного горіння, спирається на розроблену математичну модель процесу локалізації та ліквідації штучно ініційованими опадами осередків природних та техногенних катастроф з інтенсивним горінням, яка базується на рівняннях руху падаючої краплі опадів та її масового та теплового балансу в осередку горіння. Цей метод передбачає використання чотирьох процедур: збір моніторингових даних; прогнозування розвитку осередку горіння; постановка конкретних задач виконавцям; вплив на атмосферні процеси.

Ключові слова: надзвичайні ситуації техногенного та природного характеру, викид в атмосферу небезпечних речовин, газоподібні речовини, дисперсні речовини, осадження небезпечних речовин з атмосфери, локалізація осередку інтенсивного горіння

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