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SIMULATION MODELS APPLICATION FOR SAFETY LEVEL MONITORING AND FORECASTING OF WASTES STORAGE PLACE

Abstract: *The main result is improvement of the safety level forecasting method for wastes storage place on the basis of simulation modeling application for safety management system functioning. Parameters needed for safety level assessment of the wastes storage place, which determine extreme situations occurrence risk, and environmental quality indexes are represented as responses on external factors influence. Interrelations of the process taking place on the object and in the environment are stated and represented in formalized way.*

Keywords: *forecasting, safety level, simulation modeling, wastes, extreme situation.*

Problem setting. In February 2015 the Law of Ukraine of 19.06.2003 No. 964-IV "About fundamentals of national security of Ukraine" was added with significant amendments on determination of threats and directions of the state policy in the civil protection. In particular, significant anthropogenic and technogenic overloading of the territory of Ukraine was included into the list of threats for national interests and national security in civil protection sphere as well as occurrence risk of technogenic and natural extreme situations. Thus, the mentioned above law states legislative basis for transition to complex resolution of problems of the environmental safety provision as well as extreme situations occurrence risk decrease for objects which are the source of negative environmental impact, for example, wastes storage places.

Concept of the Ukrainian security and defense development, approved by the Decree of the President of Ukraine of 14.03.2016 No. 92/2016, establishes the improvement of extreme situations monitoring and forecasting mechanism as a priority action for the State Emergency Service of Ukraine. In return, existing today subsystems of the Unified state system of civil protection are organized according to territorial, branch or functional principle. Thus, they perform the monitoring and forecasting tasks in separate areas and are not combined into joint information and analysis complex[1].

Concerning the wastes storage places there were multiple examples of the catastrophes in Ukraine and other countries such as landslides, fires, flooding, etc. Extreme situation occurrence significantly complicates performance of the safety level monitoring and forecasting for such objects. Especially it may be seen on simultaneous realization of several events of different kinds. In return, analysis of the technogenic and natural extreme situations occurring within the limits of the approved and not approved wastes storage places demonstrates presence of interrelations between environmental impact sources and extreme situations risk factors. For example, accumulation of the large amounts of water due to rainfall or fire extinguishing sharply raises risk of the landslide of the collected waste. Then such landslide brings additional

[1] Євдін, О. М., Калиненко Л. В. Моніторинг і прогнозування ризику виникнення надзвичайних ситуацій в Україні – сучасний стан та проблеми // Науковий вісник: Цивільний захист та пожежна безпека. 2016. № 2 (2). С. 75-82.

negative environmental impact because of wastes spreading over the fields not prepared for the safe storage provision. Obviously, for wastes storage places the problems of monitoring and forecasting of both extreme situations occurrence risk and environmental danger level are to be considered taking into account interrelations mentioned above. It means the application of the unified assessment approach including evaluation of the current and forecasted characteristics of the environmental condition of the territories adjoining to such objects.

Additionally we have to take into account practical uselessness of the usual method of the object condition control during extreme situation due to danger level increase. At fire, for example, such danger is represented with increased level of smoke, toxic combustion products concentration in air, raised temperature of burning substances, etc. Therefore, the problem of improvement of mechanism of monitoring and forecasting safety of wastes storage places is topical.

Recent research and publications analysis. Existing today solutions on methodology of the territory environmental condition assessment are generally based on expert or calculating approach. Expert approach may be represented, in particular, by the works of teams of Canadian scientists[2] or World Wild Fund For Nature[3]. Such approach is based on conclusions made by the group of experts after investigation of the large amount of initial data. In return, application of calculating approach means to evaluate certain generalizing index by summation of the assessment on separate characteristics. In most cases, it is achieved with weight coefficients application. Such

[2] Wanda Leung, Bram F. Noble, Jochen A. G. Jaeger, Jill A. E. Gunn. Disparate perceptions about uncertainty consideration and disclosure practices in environmental assessment and opportunities for improvement [Electronic resource] // Environmental Impact Assessment Review. 2016. Vol. 57. Pp. 89-100. URL: http://dx.doi.org/10.1016/j.eiar.2015.11.001 (accessed March 20, 2017).

[3] Living Planet Report 2016. Risk and resilience in a new era. [Electronic resource] / WWF International Gland, Switzerland, 2016. URL: http://wwf.panda.org/ about_our_earth/all_publications/lpr_2016/ (accessed March 20, 2017).

approach is widely used in different fields like landfill danger evaluation[4], environmental territory assessment[5], etc.

Fundamentals of the concept of complex environmental assessment of natural and technogenic objects are described in works on environmental safety problems – G. V. Lisichenko[6], M. S. Maliovanyi[7], H. O. Biliavskyj[8], M. M. Prykhodko[9], and others. General approach to simulation used by the authors in investigation is represented in works of Robert Shannon[10]. What about application of such approach for certain cases in resolution of the safety provision problem both of general and specific type – these results are represented in articles of the authors[11].

Today monitoring and forecasting of extreme situations in Ukraine are actualized on the level of independent systems, which are not combined into unified information and analytical complex. Wide variety of danger factors explains absence of unified criteria for the territory environmental condition assessment. Thus methods based on expert or calculating approach do not provide the opportunity to estimate absolute assessment of the environmental condition and are more suitable for comparison of the territories with each other.

Besides different researches are based on different sets of assessment characteristics. For example, the system of indexes represented in European

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4 Aydi, A, Zairi, M. & Dhia, H. B., etc. Minimization of environmental risk of landfill site using fuzzy logic, analytical hierarchy process, and weighted linear combination methodology in a geographic information system environment [Electronic resource] // Environmental Earth Sciences. 2013. Vol. 68, issue 5. Pp. 1375-1389. URL: http://link.springer.com/article/10.1007/s12665-012-1836-3 (accessed March 20, 2017).

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6 Лисиченко, Г. В., Забулонов, Ю. Л., Хміль, Г. А. Природний, техногенний та екологічний ризики: аналіз, оцінка, управління. К.: Наук. думка, 2008. 543 с.

7 Харламова, Е. В., Малеваный М. С., Пляцук Л. Д. Теоретические основы управления экологической безопасностью техногенно нагруженного региона // Екологічна безпека 2012. № 1 (13). С. 9–12.

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11 Колосков, В. Ю. Моделювання міцності несучих конструкцій будівель під час пожежі // Проблемы пожарной безопасности: Сб. науч. тр. Вып. 38. Х.: НУЦЗУ, 2015.

Guidelines for the Application of Environmental Indicators[12] [14] includes only the most important of them – 36 positions in total. But these indexes are directed on determination of consolidated conclusions about territory environmental condition.

Paper objective. Thereby, modern approaches to resolution of the problem of the territories environmental condition assessment are directed mainly on consolidated evaluation and forecasting, therefore their practical application for dynamic control of environmental safety in conditions connected to possible extreme situation occurrence is significantly complicated. In addition, it is to be taken into account that experiments with full reconstruction of extreme situation events is inadmissible according to safety requirements. Considering everything mentioned above the methodological basis chosen for the represented paper is the method of simulation modeling. Its application allowed us to proceed to analysis of corresponding conditions of the object, evaluation of its functioning mode alternatives and forecasting of its safety level.

The objective of the represented reserach is improvement of extreme situations monitoring and forecasting mechanism for wastes storage places. To achieve the stated objective the task of improvement of safety level forecasting method for wastes storage place on the basis of simulation modeling is resolved.

Paper main body. Application of simulation modeling method allows to achieve stable statistics of events development on condition of replacement of the real safety management system of wastes storage place with its model. The functioning of the safety management system is considered on the time interval (T_0, T_1), which is characterized with the influence of the complex of internal factors $F_i(t) \in \Phi$, $i = 1...n$. To determine extreme situation occurrence risk factors and environmental quality indexes we add parameters $\varepsilon_m^{ES} \in E^{ES}$, $m = 1...R$ and $\varepsilon_l^{EQ} \in E^{EQ}$, $l = 1...P$ respectively. A quantity of values $E = E^{ES} \cup E^{EQ}$ is considered as a complex of responses of object and natural environment on external factors influence taking into account interrelations

[12] Environmental monitoring: Guidelines for the application of environmental indicators in Eastern Europe, Caucasus and central Asia [Electronic resource] / Economic commission for Europe of the United Nations. – 2007. – 75 p.

of them. Result of modeling is represented as a set of dependencies on time Результатом моделювання є залежності від часу $W(t) = K(t), Y(t)$ of safety level evaluation criteria $K(t): K = K^{ES} \cup K^{EQ}$ and control impulse $Y(t)$ expressed as a complex of influences on each of safety factors $Y = \{Y_i\}: Y_i = g_i(K)$.

The task of mentioned above dependencies is formalized in the following way

$$W(t) = M(A(t), B), \quad (1)$$

where A – the set of input parameters of the system it the form of $A = \Phi \cup E$; B – the quantity of regulation limitations defining limits for each safety level evaluation criteria.

The formed set of criteria $K = K^{ES} \cup K^{EQ} = \{K_m^{ES}\} \cup \{K_l^{EQ}\}$ represents formalized requirements of normative documents which regulate conditions of wastes storage place maintenance on allowable level of extreme situation occurrence risk $K_m^{ES}: \chi_m^{ES}(\Phi, E^{ES})$, $m = 1...R$ and environmental safety level $K_l^{EQ}: \chi_l^{EQ}(\Phi, E^{EQ})$, $l = 1...P$, where R and P – the number of criteria used to evaluate safety level on mentioned directions.

So, the process of safety control system functioning on wastes storage place in general may be represented in following formal way:

$$\{A, B\} \to W: \{K \to Y\}. \quad (2)$$

As the real conditions of natural environment processes are characterized with influence of complex set of negative factors, evaluation of their impact must be based on dynamic models of environmental responses appearance. Taking this into account the method of safety level forecasting for wastes storage place is in step-by-step verification of the safe object functioning conditions compliance based on safety criteria in n-measurable space of factors Φ changing according to the program of the object maintenance. The final objective of the method is to provide the generalized conclusion on safety level.

The complex of input data for forecasting is formed on three directions.

1. Forming of the set of factors defining safety level according to the program of the object maintenance taking into account control impulses application in condition

of unallowable mode of action. For unification of safety level evaluation the quantity of reduced factors $\overline{F_i} \in \Phi^{rd} : \varphi_F^{rd} : \Phi \to \Phi^{rd}$ is provided in the form

$$\overline{F_i} = \varphi_F^{rd}(F_i) = \frac{F_i}{[F_i]}, \quad i = 1...n, \tag{3}$$

where $[F_i]$ – maximum allowable limits of acting factors. Such approach allows to proceed to consideration of n-measurable space of reduced values of factors with maximum allowable limits determined by normative criterion as

$$\overline{F_i} = 1, \quad i = 1...n, \tag{4}$$

whereby different on origin factors will be equalized on their value.

2. Forming of the set of investigated object safety level evaluation taking into account defined set of acting factors. In particular it allows to gather up the set of valuable responses maximally corresponding to the object condition.

3. Forming of the set of parameters and initial data defining initial conditions of object and environment including maximum allowable limits of acting factors, object parameters and environmental quality indexes.

Complex of safety level evaluation criteria is implemented for every acting factor and valuable responses of environment and object. Consistent safety level evaluation is accomplished for each set of factors determined according to the object functioning program. Further the generalized conclusion on forecasted object safety level is formed for the given time interval.

Conclusions of the research. The main result of the research is improvement of the safety level forecasting method for wastes storage place on the basis of simulation modeling application for safety management system functioning. The basic advantage of the proposed method in comparison with those used today is in opportunity to take into account the whole complex of acting factors of negative environmental impact with collateral factors of extreme situations occurrence risk. Such approach application allows to combine results of different functional and territorial systems of monitoring of and forecasting of environmental condition and extreme situations. Thereby it gives an opportunity to improve the safety monitoring and forecasting mechanism for wastes

storage places without precision loss of the results achieved by separate monitoring systems.

For practical implementation of proposed method it is needed to make systematic investigations directed on collection of the formalized safety criteria database for as big as possible amount of safety level evaluation indicators for wastes storage places taking into account interrelation between natural environmental processes and object functioning parameters.

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ОПРЕДЕЛЕНИЕ ОСНОВНЫХ ПОКАЗАТЕЛЕЙ ТЯГОВО – СКОРОСТНЫХ СВОЙСТВ ПОЖАРНЫХ АВАРИЙНО-СПАСАТЕЛЬНЫХ АВТОМОБИЛЕЙ В ЗАВИСИМОСТИ ОТ ТЕПЛОВОГО РЕЖИМА АГРЕГАТОВ ДЛЯ ОПЕРАТИВНОГО ЕГО ВЫЕЗДА И ПРИБЫТИЯ НА ЧРЕЗВЫЧАЙНЫЕ СИТУАЦИИ

DETERMINATION OF THE MAIN INDICATORS OF TIGH - SPEED PROPERTIES OF FIRE ALARM-RESCUE AUTOMOBILES DEPENDING ON THE THERMAL REGIME OF UNITS FOR OPERATIONAL ITS DEPARTURE AND ARRIVAL FOR EMERGENCY SITUATIONS

В статье приведены результаты экспериментальных исследований влияния теплового режима агрегатов и механизмов пожарного аварийно-спасательного автомобиля оперативность его выезда и прибытия на чрезвычайные ситуации, на основные показатели тягово – скоростных свойств.

Ключевые слова: *пожарная автоцистерна, удельная мощность автомобиля, скорость движения, тепловая подготовка двигателя внутреннего сгорания, оперативность, надёжность техники, среднее скорость, чрезвычайная ситуация.*