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DETERMINATION OF DYNAMIC PARAMETERS OF DUST EMISSION FROM A COAL MINE FANG

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ВИЗНАЧЕННЯ ДИНАМІЧНИХ ПОКАЗНИКІВ ПИЛОВОГО ВИКИДУ З ВЕНТИЛЯЦІЙНОГО СТВОЛА ВУГІЛЬНОЇ ШАХТИ

Purpose. To prepare the method of dynamic parameters prediction for dust emission from a coal mine fang.

Methodology. The methodology is based on the stochastic nature of mine capacity. That is why we suggested determining the dynamic parameters for dust emission from coal mine fang according to the random process of mine capacity in a one-month period. The common solutions of mathematic the problem of the overshoot of the random process above a set level were applied.

Findings. It was stated that the volumes of dust emission from a fang are proportional to one-hour capacity of skip hoisting. The probabilistic assessment of capacity dynamics and dust emission was carried out; it can be applied for the prediction of ecological danger level of dust emission from a coal mine fang.

As a result of integration of problem of the overshoot of the random process above a set level, the following average values were determined: the time of the definite level exceeding in a definite period; number of cases of the definite level overriding; the duration of the process overriding the normalized level. The probabilistic assessment of dust emission dynamics from coal mine fang enables confidence increase for the prediction of pollution level of atmospheric air and its danger rate compared with the existing assessment of annual average emission volumes.

Originality. The methodology of dynamic parameters assessment for solid particles (dust) emission from coal mine fang was prepared as based on the data of mine capacity changes in one-month period.

Practical value. The obtained regularities of dust emission formation of coal mine allow the prediction of the level of environmental objects pollution in the adjacent territories and to take timely measures for protection of the environment.

Keywords: *dust emission of a mine, ecological danger of emission, emission dynamics*

Introduction. Running continuously, coal mines emit large volumes of polluted air form fangs into the atmosphere; the air contains coal and rock dust, which consists of silicon dioxide (dangerous for human health) and other harmful substances from adjacent rocks of underground horizons of a mine. The dust is dispersed in the bottom layer and can cover large territories, polluting the air, soil, and water bodies decreasing the environmental safety in the region [1].

Deep-mined output causes considerable pollution of environmental components and requires the development of methods of emission dynamics prediction for taking timely measures of nature protection [2–4]. It should be also considered that the emission and dust load rate in the territories adjacent to mines depends on a range of factors affecting the effectiveness and reliability of predictable indices [5]. We should point out that the emissions of mining enterprises increase the dust load on environmental objects, especially when other industrial enterprises operate in the local area [6, 7].

The dust emission rate from fangs varies from 20 to 100 grams per second for different coal mines. Rough estimates show that about 5.2 tons of dust is emitted per day whereas the average emission rate is 60 grams per second. Taking into account the ash-content, the dust can contain up to 3 tons of nonfuel minerals (about 1900 and 1000 tons per year respectively). Thus, apart from coal about 1000 tons of rock is emitted from fangs into the atmosphere; the rock contains sulphides and some heavy metals which cause worsening of life conditions for population.

Analysis of the recent research and publications. To estimate the level of atmospheric air pollution the calculated value of gross emission is used to calculate ground dust concentration according to the standardized procedure of OND-86 (All-Union normative document – 86) [8]. The obtained ground concentrations are, in turn, applied to estimate the level of atmospheric air pollution according to the working sanitary regulation [9]. It is appraised as based on the ratio of the pollution index (PI) excess compared to their standard values (SV) and implies determination of the pollution level and its danger level according to the Table.

Table

Estimation of the level of the atmospheric air pollution according to the working sanitary regulation [9]

Level of pollution	Danger level	PI excess ratio	SV excess percentage
Allowable	Safe	<1	0
Unallowable	Insignificantly hazardous	>1–2	>0–4
Unallowable	Moderately hazardous	>2–4.4	>4–10
Unallowable	Hazardous	>4.4–8	>10–25
Unallowable	Very hazardous	>8	>25

To identify the abovementioned ratio, the virtual ground level concentration values (C) are divided into their maximum permissible values (MPV); either maximum single or daily average MPV can be considered depending on the concentration assessment conditions and pollutant type. Thus, in case of assessment of dust with undifferentiated composition (aerosol), the following MPV are allowed: maximum-single – 0.5 mg per m^3, daily average – 0.15 mg per m^3 (3rd hazard class).

Unsolved aspects of the problem. Gross dust emission into the atmosphere form the main fang should be estimated in tons per year according to the branch methodology [10]. The methodology is applied for the preparation of the state statistical report on the atmospheric air protection; it is also used to calculate the amount of damages caused by the ventilation systems of underground mine workings of coal mines as well as to estimate the atmospheric air pollution and to plan nature protection measures. It is appropriate to note here that the practice of the emission estimation mentioned as based on the results of actual measuring of dust concentration for the output of main ventilation fan, which should be conducted regularly, is not entirely appropriate. It is reasoned by the fact that the measurements are often obtained during the period of time or shift when minimum emission occurs. As a result, the rated annual or quarterly emissions are underestimated in the reports.

It should be noted that the assessments using the methods [9] based on the average annual values of dust concentration calculated according to [8, 10] appear to be of low reliability and do not meet the requirements of the methodology [9] as the actual average daily concentration of dust emitted from fangs is changed day by day. Correspondingly, the SV excess ratio will be varied so will the level of danger of the atmospheric air pollution caused by dust (columns 2 and 3 in the Table). In addition, the column 4 provides the indicator regulating the SV excess percentage, which cannot be estimated without the data of actual 24-hour dynamics of dust emission.

It is obvious that regular data organization requires establishing standing observational stations for dust emissions monitoring, particularly from fangs, which is not economically feasible. That is the reason why the authors set a problem to determine the missing dynamic indicators on the base of an alternative parameter in comparison to the dust emission parameter, which can be applied to calculate the dynamic indicators during at least a one-month period of time.

Objectives. The objectives of the work include the development of methods of estimating and forecasting emission dynamic parameters of dust emission from a coal mine fang based on the data of its daily output.

Main research. To solve the defined problem, let us analyse the possibility of application of permanently changing mine output for the future assessment of the dynamics indicators for dust emission from a coal mine fang into the atmosphere.

In accordance with the methodology [10] the gross emission of solid particles can be calculated using the formula

$$E_j = 8,64 \cdot 10^{-5} \cdot \bar{V}_j \cdot D_f \times$$
$$\times \left[\left(\bar{C}_{\hat{\imath}} + 0,28 K_1 q \frac{A_p}{Q_{ind}} \right) K_2 + 0,28 K_1 q Q_n \frac{A_p}{Q_{ind} V_j} \right], \quad (1)$$

where D_f is the time of actual operation of a mine during a year, days; $\bar{V}_j$ is an average flow rate of the air which is emitted from the fang, m^3 per second; $\bar{C}_o$ is an average dust content of the air around the fang on the return horizon, mg per m^3; K_1 is an index accounting for the availability of mined rock in the fang (0 indicates absence or lifting of mined rock by means of tilting-deck cages and 1 indicates lifting of mined rocks by means of charging ladles); K_2 is an index accounting for dust fall in the fang; q is the specific dust emission while loading or unloading mined rock, gram per ton; A_p is intensity of loading or unloading of mined rock, tons per hour, Q_{ind} is the quantity of induced air, m^3 per second; Q_n is the quantity of suction air in the pit head, m^3 per second (the parameters are detected according to Chapter 7 of the methodology [10]).

In case of dust emission from the fang with charging ladles, $K_1 = 1$; thus, for the future analysis it is convenient to show the (1) as follows

$$E_j = 8,64 \cdot 10^{-5} \cdot \bar{V}_j \cdot D_f \times$$
$$\times \left[\bar{C}_o K_2 + 0,28 A_p \frac{q}{Q_{ind}} \left(K_2 + \frac{Q_n}{\bar{V}_j} \right) \right]. \quad (2)$$

According to this pattern, the dust emission is conventionally assumed to consist of two components. The first one is conditioned by dust ejection from mine workings located on the operating underground horizons; the other is conditioned by intensity of loading or unloading of coal and rock in the mine shaft bottom and head frame. The square brackets contain the sum of the components of dust content of the air emitted immediately from the fang into the atmosphere.

Gross emission variability E_j is conditioned by variability of the parameters in the (2). Thus, the average flow rate of the air $\overline{V}_j$ through a fang does not practically change daily and monthly since the main ventilation fan operates uninterruptedly. The fan delivery fluctuates insignificantly in the range of the average value responding to mine aerodynamic resistance changes and is rarely regulated by means of guide vanes. The time of actual operation of a mine during a year in days D_f is also stable, with the exception of emergency situations and other forced outage.

As for the components of dust content of the air (which is described in the square brackets), they change proportionally to the mine capacity. The value of $\overline{C}_o$ is implicitly, though directly dependent on mining equipment capacity in work faces and longwall faces, while the other component is pro-portional to the intensity of loading or unloading of mined rock A_p, and is dependent on the values of q/Q_{ind} and $\left(K_2+\frac{Q_n}{\overline{V}_j}\right)$ in different ways.

The value of q/Q_{ind}, expressing the ratio of specific dust emission and quantity of the induced air, caused by loading and unloading equipment operation, also depends on rank of coal, its humidity, reduction range and rock content (q parameter) as well as on the device design (Q_{ind} parameter). It is obvious that the clean air ejection decreases the quantity of dust emitted during loading and unloading of coal and rock. However, regarding the definite loading and unloading equipment, the ratio is only dependent on dust production capacity of transferred rock, so it is almost stable for a single mine.

K_2 index, which is described by fang geometry and water inflow, can vary over a wide range because of different water inflow in different seasons, but it can be considered as stable in a one-month period.

The Q_n/V_j ratio rarely exceeds 0.2, since reliable ventilation of mines is often provided by decreasing the suction air Q_n in the pit head (head frame) by means of its capsulation. The value only changes at the moment of charging ladles passing through the head frame, as it increases both Q_n and dust emission in the short run. It is obvious that the number of charging ladles moves is proportional to mine capacity regarding the mined rock.

Research results. To demonstrate the analysis carried out, let us adduce the speculative calculations of gross emission of two mines from different mining regions based on priori data.

For instance, under the conditions of a mine from the Lviv-Volyn Coal Basin with $\overline{V}_j = 315$ m^3 per second; $K_2 = 0.246$; $q = 80.5$ grams per ton; $A_p = 115$ tons per hour; $Q_{ind} = 5.7$ m^3 per second; $Q_n = 60.8$ m^3 per second; $C_o = 4.5$ mg per m^3, the annual average dust emission according to (2) is

$$E_j = 8,64\cdot10^{-5}\cdot315\cdot365\times$$

$$\times\left[0,246\cdot\overline{C}_o + 0,28\times115\frac{80,5}{5,7}\left(0,246+\frac{60,8}{315}\right)\right]=$$

=1994 tons per year (63.2 grams per second),

where $q/Q_{ind} = 80.5/5.7 = 14.2$; $Q_n/V_j = 0.193$.

Under conditions of a Donbass mine with $\overline{V}_j = 164.2$ m^3 per second; $K_2 = 0.264$; $q = 68.8$ grams per ton; $A_p = 95$ ton per hour; $Q_{ind} = 4.7$ m^3 per second; $Q_n = 30.8$ m^3 per second; $\overline{C}_o = 2.5$ mg per m^3

$$E_j = 8,64\cdot10^{-5}\cdot164,2\cdot365\times$$

$$\times\left[0,246\cdot\overline{C}_o + 0,28\times95\frac{68,8}{4,7}\left(0,246+\frac{30,8}{164,2}\right)\right]=$$

= 1753 tons per year (55.9 grams per second),

where $q/Q_{ind} = 14.2$; $Q_n/V_j = 0.1875$.

As it is obvious, q/Q_{ind} and Q_n/V_j ratios do not differ for mines in different regions, and dust emission is generally defined according to the operation of skip hoisting in a groove, i. e. it hardly depends on $\overline{C}_o$ if the values of the latter are small.

Thus, under conditions of a definite mine, particularly of one equipped with skip hoisting, it is only the dynamically changing parameter A_p that is proportional to dust emission from a fang, and it is monitored and recorded on a daily basis. That is the reason why its relative daily changes in a one-month period enable to assess dust emission variation in comparison to its average value which is calculated using formulas (1) or (2).

To give an example, let us analyse the typical time series (Fig. 1), characterizing daily coal mining (published in *Vuhillya Ukrajiny* (*Coal of Ukraine*) journal*,* June 2003, p. 40).

The time series in Fig. 1 demonstrate that the mine capacity is significantly dependent on random factors, i. e. it is stochastic. The average values of capacity are often 1.5–2 times higher; so are dust emissions into the atmosphere from a fang compared to the average design values.

The series given is the selective realization of the random process of capacity in a one-month period. The availability of this process allows determining the missing dynamic parameters of dust emission from a coal mine fang using the known solution of mathematical *problem of the overshoot of the random process above a set level* by A. A. Sveshnikov (first solved by Reis in 1944–1945). The integrals of the problem make it possible to calculate the probabilistic characteristic of random process overrunning the specific value.

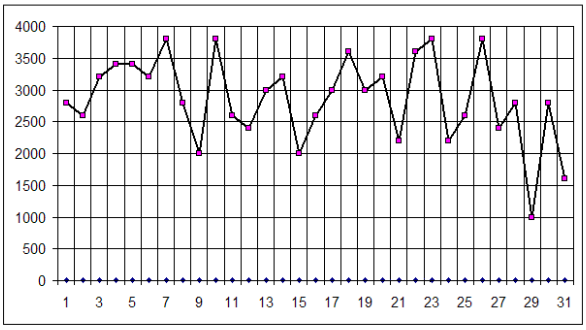

Fig. 1. Typical time series of daily coal mine capacity in a one-month period

While solving the problem, let us consider that the random function of the change process of mine capacity in time and, thus, of dust emission is stationary with distribution density which is close to normal law. It is quite permissible as the capacity irregularly varies (fluctuates) within the range conditioned by the designed value or plan, provided there are no explicit factors, particularly breakdowns and lengthy downtime, among accidental mining and technical ones, which can lead to significant deviations from the normal process.

Let us consider the sequence of integration for the stationary random process with the normal distribution law by A. A. Sveshnikov. Thus, we can obtain the average value time of stationary random function stay above the definite level a at T period of time

$$\overline{t}_a = T\int_a^\infty f(x)\,dx. \qquad (3)$$

The average excess value above the set level within the same period of time is determined as follows

$$\overline{n}_a = T\int_0^\infty vf(a,v)\,dv, \qquad (4)$$

while the average time of the process being above the set level is

$$\overline{\tau} = \frac{\int_a^\infty f(x)\,dx}{\int_0^\infty vf(a,v)\,dv}. \qquad (5)$$

As it is obvious from (3–5), the values of $\overline{t}_a$ and $\overline{n}_a$ are proportional to the considered period of time T, $\overline{\tau}$ does not depend on the period of time. That is why the average value of emissions per time unit $\overline{v}_a$ can be defined for steady-flow processes; $\overline{v}_a$ does not depend on T, as it is obvious from $\overline{v}_a = \frac{\overline{n}_a}{T}$.

As a result, we obtain the integral which is the component of (4) and (5)

$$\overline{v}_a = \int_0^\infty vf(a,v)\,dv. \qquad (6)$$

Since the formulas contain probability density for steady-flow process $f(x)$ and $f(x, v)$, we need the densities to find the value of the integrals.

In the formulas, x and v are current ordinates of the random function and its change rate respectively, while $f(x)$, $f(x,v)$ are probability densities which do not depend on time for steady-flow processes.

Regarding the normal law of ordinates distribution for the random function, their distribution density is unambiguously expressed through the expectation value ($\overline{x}$) of the random function and its value dispersion

$$f(x) = \frac{1}{\sigma_x\sqrt{2\pi}}e^{-\frac{(x-\overline{x})^2}{2\sigma_x^2}}. \qquad (7)$$

The value of dispersion is equal to the value of the autocorrelation function of the random process at the point of (0), i. e. $\sigma_x^2 = K_x(0)$.

The two-dimensional density of probability distribution $f(x,v)$ determined by A. A. Sveshnikov splits into the product of standard distribution densities for random values $X(t)$ and $V(t)$, which can be expressed as

$$f(x,v) = \frac{1}{\sigma_x\sqrt{2\pi}}e^{-\frac{(x-\overline{x})}{2\sigma_x^2}\,2} \times \frac{1}{\sigma_v\sqrt{2\pi}}e^{-\frac{v^2}{2\sigma_v^2}}, \qquad (8)$$

where the dispersion of the rate of change of the ordinate of the random function σ_v^2 is equal to the value of the correlation function of the random process speed at zero point, namely

$$\sigma_v^2 = K_v(0) = -\frac{d^2}{d\tau^2}K_x(\tau)\big|_{\tau=0}. \qquad (9)$$

The mathematical expectation $V(t)$ is 0 as a result of steady flow of the random process.

The substitution of (8) into (6) gives

$$\overline{v}_a = \frac{\sigma_v}{2\pi\sigma_x}e^{-\frac{(a-\overline{x})^2}{2\sigma_x^2}}. \qquad (10)$$

In a similar way, the substitution into (5) results in obtaining the average duration value of the random process over-shoot above a set level a

$$\overline{\tau} = \pi\frac{\sigma_x}{\sigma_v}e^{\frac{(a-\overline{x})^2}{2\sigma_x^2}}\left[1 - F\left(\frac{a-\overline{x}}{\sigma_x}\right)\right], \qquad (11)$$

where $F(x)$ is the integral Laplace function.

In a special case, when $a = \overline{x}$, i. e. the average duration of the average value excess for the random function is determined, the latter function is simplified

$$\overline{\tau} = \pi\frac{\sigma_x}{\sigma_v} = \pi\sqrt{-\frac{K_x(\tau)}{\ddot{K}_x(\tau)}}_{\tau=0}, \qquad (12)$$

where the values of the random process dispersion and its speed, i. e. in fact the values of the autocorrelation function of $K_x(\tau)$ process and its second derivative $\ddot{K}_x(\tau)$ at zero point.

Finally, after the substitution of (7) into (3) we obtain the integral to determine the average time of the definite function being above the set level a within T time period

$$\overline{t}_a = T\frac{1}{2}\left[1 - \Phi\left(\frac{a-\overline{x}}{\sigma_x}\right)\right]. \qquad (13)$$

It is notable that the interval may be obtained by multiplication of (10) to (11) and T.

Let us turn to the practical application of the given formulas. We shall obtain the statistical values describing the dynamics of mine capacity and, thus, dust emission above the set level.

Let us find the autocorrelation function of the process using the assessment formula and data from the graph (Fig. 1)

$$K_x(\tau) = \frac{1}{n-\tau}\sum_{i=1}^{n-\tau}(x_i - \overline{x})(x_{i-\tau} - \overline{x}), \qquad (14)$$

where τ is a time shift equal to 1, 2, 3,…; x_i is daily mine capacity, tons per day.

The initial fragment of the normalized autocorrelation function is shown in Fig. 2.

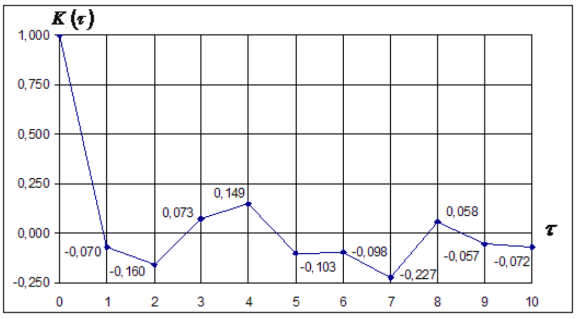

Fig. 2. Normalized autocorrelation function of mine capacity distribution and dust emission

To solve the problem we need the most exact analytical expression of the autocorrelation function of the process at its initial interval. The requirement is conditioned by the need to determine the dispersion of change rate for the random function using the second derivative of $K_x(\tau)$ at zero point. So, considering the type of the normalized graph, let us approximate the initial decreasing section of the autocorrelation function *for its values in* 0, 1 and 2 points; we shall use the general exponential equation. As a result, we obtain the following expression of the autocorrelation function *of the random process of mine capacity*

$$K_x(\tau)=\sigma_x^2\left(b_0+b_1e^{b_2\tau}\right), \qquad (15)$$

where σ_x^2 is dispersion; $b_0=-0.168$; $b_1=1.168$; $b_2=-2.48$ are index values obtained with the east-squares method with b_2 index selection for approximation errors minimization in the decrease section.

In this case

$$\ddot{K}_x(\tau)=K_v(\tau)=-\sigma_x^2 b_1\left(b_2\right)^2\cdot e^{b_2\tau}. \qquad (16)$$

Now, considering the process of mine capacity change as a normalized one, let us define the dynamic parameters of its slipover for the period of $T=30$ days, e.g.: $a=$ $=3500$ tons per day, if the average value of the capacity is $\bar{x}=2893.3$ tons per day, and the dispersion is $\sigma_x^2=$ $=407\,288.9$ ($\sigma_x=638.19$ tons per day), according to the data from Fig. 2.

Calculating the dispersion of the change rate for the random function considering (9) and (14), we obtain

$$\sigma_v^2=K_v(0)=-\frac{d^2}{d\tau^2}K_x(\tau)\,|_{\tau=0}=\sigma_x^2\left(b_1b_2^2\right)=$$

$$=407\,288.9(1.168(2.48)^2)=2\,925\,828\ (\sigma_v=1710.5).$$

Let us calculate the average value for number of level excess cases per day, using the (10), day^{-1}

$$\bar{\nu}_a=\frac{\sigma_v}{2\pi\sigma_x}e^{-\frac{(a-\bar{x})^2}{2\sigma_x^2}}=$$

$$=\frac{1710.5}{2\cdot 3.14\cdot 638.192}e^{-\frac{(3500-2893.3)^2}{2\cdot 407\,288.9}}=0.2716.$$

Considering the value, the number of the random process excess above the level of 3500 tons per day is: $\bar{n}_a=T\bar{\nu}_a=30\cdot 0.2716=8.148$ times (in 30 days).

The average duration of capacity level excess can be determined by means of the (11), days.

$$\bar{\tau}=3.14\frac{638.192}{1710.5}e^{\frac{(3500-2893.3)^2}{2\cdot 407\,288.9}}\times$$

$$\times\left[1-F\left(\frac{3500-2893.3}{638.192}\right)\right]=1.3376.$$

As a result, the average time for the random capacity process being above the level of 3500 tons per day for 30-days period is $\bar{t}_a=\bar{n}_a\bar{\nu}_a=8.148\cdot 1.3376=10.9$ days.

To compare, we can obtain the same value from the integral (3), using the formula (13), i.e., days.

$$\bar{t}_a=\frac{30}{2}\left[1-F\left(\frac{3500-2893.3}{638.192}\right)\right]=10.1.$$

The close result obtained indicates that the calculations are reliable. However, the number of random process excess cases above the level of 3500 tons per day is overvalued (8 times vs. 5 times on the graph). It can be explained by the deviation of the random process from the stationary normalized law of distribution, as well as the errors of the assessment of the correlation function and defining of the indexes for its analytical modes using the data selected.

In general, regarding the probabilistic nature of the results, they can be used for the assessment of dust emission dynamics. Particularly, the average dust emission of 60 grams per second the production level of 3500 tons per day will correspond to the dust emission rate of 72.6 grams per second. The level will be 6 times higher per month; the total excess time will be approximately 10 days, i.e., about 33 % of mine operation time.

We can carry out the similar calculations for $a=\bar{x}=$ $=2893.3$ tons per day or 60 grams per second for dust emission, i.e. we can define the dynamic parameters of excess of the average capacity level rate.

The number of the average capacity level excess cases per 24 hours, day^{-1}.

$$\bar{\nu}_a=\frac{1710.5}{2\cdot 3.14\cdot 638.192}=0.4268.$$

An average number of excess cases per month is, times.

$$\bar{n}_a=T\bar{\nu}_a=30\cdot 0.4268=12.804.$$

The average duration of each excess is, days.

$$\bar{\tau}=3.14\frac{638.192}{1710.5}=1.17.$$

And average time of excess per month is $\bar{t}_a=$ $=12.804\cdot 1.1715=15$ days, i.e. half of a month or 50 % of mine operation time, as expected.

In conclusion, we should note that the calculations of probabilistic characteristic can be used to forecast ecological danger rate for dust emission from a coal mine fang which changes dynamically.

Conclusions. In addition to the standard assessment of gross emission of solid particles (dust) from coal mine fangs, which is the basis for the assessment of the atmospheric air pollution rate and its danger rate, the frequency of standard values excess as well as other dynamic parameters of dust emission, should be determined; the process requires additional daily information on its changing.

Under conditions of a coal mine, particularly the one equipped with skip hoisting, it is only the dynamically changing parameter of skip hoisting hourly capacity that is proportional to dust emission from a fang, and it is monitored and recorded on a daily basis. That is the reason why relative changes of mine capacity in a one-month period allow assessing the relative variation of dust emission from a fang.

The analysis of time series of coal mine capacity in a one-month period has demonstrated its stochastic nature. The availability of such series enables us to determine the missing dynamic parameters of dust emission from a coal mine fang using the known solutions of mathematical problem of the overshoot of the random process above a set level.

The solution of the problem is based on the idea that the random function of the change process of mine capacity in time and, thus, of dust emission, is stationary with distribution density which is close to the normal law provided there are no explicit factors, particularly breakdowns and lengthy downtime, among accidental mining factors.

As a result of calculating acquainted integrals of the abovementioned problem using the definite example, the following average values were obtained:

- Response time of the random function of mine capacity exceeding the set rate within the definite period.
- Number of excess cases above the set level.
- The duration of the process overshooting the level.
- Number of cases of the set level excess.
- Number of cases of the set level overshooting per unit of time.

Thus, the developed methodology enables quite comprehensive and reliable assessment of dust emission dynamics, which can be put into practice to forecast the level of environmental danger of dynamic dust emissions from coal mines fangs.

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СОУ 10.00174125.004-2004. Стандарт Мінпаливенерго України. Концентрація і об’єми шкідливих забруднюючих речовин (у тому числі газу метану), що викидається в атмосферу вугільними шахтами. Методика розрахунку. – К: Мінпаливенерго, 2004. – 28 с.

Мета. Розробка методики прогнозування динамічних показників пилового викиду з вентиляційного ствола вугільної шахти.

Методика. Методика базується на тому, що показник продуктивності вугільної шахти носить стохастичний характер. Тому за вибірковою реалізацією випадкового процесу продуктивності шахти на місячному інтервалі запропоновано визначати динамічні показники пилового викиду з вентиляційного ствола. Для цього використані відомі рішення математичної „задачі про викиди випадкового процесу за встановлений рівень“.

Результати. Встановлено, що обсяги пилового викиду з вентиляційного ствола шахти пропорційні продуктивності скіпового підйому за годину. Виконана ймовірнісна оцінка динаміки продуктивності та пилового викиду, що може бути використана для прогнозу ступеня екологічної небезпеки пилового викиду з вентиляційного ствола вугільної шахти. У результаті обчислення інтегралів „задачі про викиди випадкового процесу за встановлений рівень“ визначені середні значення: часу перевищення заданого рівня продуктивності шахти на заданому інтервалі часу; числа викидів за заданий рівень; тривалості перебування процесу вище нормованого рівня. Імовірнісні оцінки динаміки пилового викиду з вентиляційного ствола вугільної шахти дозволяють підвищити достовірність прогнозу рівня забруднення атмосферного повітря й ступеня його небезпеки у порівнянні з існуючою оцінкою за середньорічним значенням викидів.

Наукова новизна. Розроблена методика оцінки динамічних показників викиду твердих частинок (пилу) з вентиляційного ствола вугільної шахти за інформацією про мінливість продуктивності шахти на місячному інтервалі.

Практична значимість. Отримані закономірності формування пилового викиду вугільної шахти дозволяють прогнозувати рівні забруднення об'єктів навколишнього середовища на прилеглих територіях і своєчасно запроваджувати природоохоронні заходи.

Ключові слова: *пиловий викид шахти, екологічна небезпека викиду, динаміка викиду*

Цель. Разработка методики прогнозирования динамических показателей пылевого выброса из вентиляционного ствола угольной шахты.

Методика. Методика базируется на том, что показатель производительности угольной шахты носит стохастический характер. Поэтому по выборочной реализации случайного процесса производительности шахты на месячном интервале предложено определять динамические показатели пылевого выброса из вентиляционного ствола. Для этого использованы известные решения математической „задачи о выбросах случайного процесса за установленный уровень“.

Результаты. Установлено, что объемы пылевого выброса из вентиляционного ствола шахты пропорциональны часовой производительности скипового подъема. Выполнена вероятностная оценка динамики производительности и пылевого выброса, которая может быть использована для прогноза степени экологической опасности пылевого выброса из вентиляционного ствола угольной шахты. В результате вычисления интегралов „задачи о выбросах случайного процесса за установленный уровень“ определены средние значения: времени превышения заданного уровня производительности шахты на заданном интервале времени; числа выбросов за заданный уровень; длительности пребывания процесса выше нормируемого уровня. Вероятностные оценки динамики пылевого выброса из вентиляционного ствола угольной шахты позволяют повысить достоверность прогноза уровня загрязнения атмосферного воздуха и степени его опасности в сравнении с существующей оценкой по среднегодовым значениям выбросов.

Научная новизна. Разработана методика оценки динамических показателей выброса твердых частиц (пыли) из вентиляционного ствола угольной шахты по информации об изменчивости производительности шахты на месячном интервале.

Практическая значимость. Полученные закономерности формирования пылевого выброса угольной шахты позволяют прогнозировать уровни загрязнения объектов окружающей среды на прилегающих территориях и своевременно внедрять природоохранные мероприятия.

Ключевые слова: *пылевой выброс шахты, экологическая опасность выброса, динамика выброса*

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