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T. M. Lubenets[1],
orcid.org/0000-0002-3116-2681,
Ye. A. Koroviaka[1],
orcid.org/0000-0002-2675-6610,
V. H. Snigur[2],
orcid.org/0009-0009-1205-5707,
A. V. Tkachuk[2],
orcid.org/0009-0008-9510-1299,
V. O. Rastsvietaiev[*1],
orcid.org/0000-0003-3120-4623

1 – Dnipro University of Technology, Dnipro, Ukraine
2 – PSU Mine "n.a Heroiv Kosmosu" PJSC "DTEK Pavlohradvuhillia", Pavlohrad, Ukraine
[*] Corresponding author e-mail: rastsvietaiev.v.o@nmu.one

THEORETICAL MODEL OF RANDOM FREIGHT FLOW DISTRIBUTION IN THE CONVEYOR TRANSPORT LINE OF THE COAL MINE

Purpose. Increasing the efficiency of the conveyor transport system of the mine due to the application of rational parameters, which are calculated objectively on the basis of the reliable output data of random freight flow in the conveyor transport line, taking into account the velocity of minerals transportation, including a perfect theoretical model application of the freight flow distribution.

Methodology. Complex research:

- statistical studies on the actual distribution of random freight flow in the highly productive stages of the PSU Mine "n.a Heroiv Kosmosu" PJSC "DTEK Pavlohradvuhillia";
- description of histograms of the distribution of random freight flow by various indicative algebraic functions, normal and gamma distribution of a random variable and a specially constructed function with separately defined parameters of its branches;
- analysis of research results regarding the correctness of the theoretical model of the distribution of random freight flow according to various criteria of genuineness, a center of grouping, amplitude, velocity of rise and fall, and deviation.

Findings. A perfect theoretical model was built in the form of an indicative algebraic function, whose branches are described by the normal distribution law of a random variable with separately determined parameters. It describes well the distribution of random freight flow in the conveyor transport line of the mine and ensures the determination of its parameters by the methods of probability theory.

Originality. A theoretical model of the distribution of random freight flow in the conveyor transport line of the mine has been obtained for the first time, which describes well various cases of its distribution, including symmetric and asymmetric ones, and provides the determination of the freight flow parameters by the methods of probability theory.

Practical value. The actual value of the coefficient of nonuniformity of the freight flow in the conveyor transport line of the mine, which was determined by a perfect theoretical model, exceeds, by almost a quarter, the value inherent in the model accepted in practice, the normal law of the distribution of a random variable. The coefficient of nonuniformity of the freight flow in the highly productive longwalls of only the specified mine reaches a value of 2.012, which already exceeds the normative value limit for conveyor transport lines along horizontal and inclined preparatory workings of mining areas (2.0). Reliable initial data on the variation of the random freight flow in the conveyor transport line of the mine, which is substantiated by a perfect theoretical model of its distribution, have a positive effect on the calculation of its parameters and contribute to increasing the efficiency and reliability of the functioning of the conveyor transport system.

Keywords: *conveyor transport line, random freight flow, distribution of freight flow, bar chart, theoretical model, normal distribution law of a random variable, coefficient of nonuniformity*

Introduction. In the conditions of the energy crisis in the world [1, 2], developing the mining industry [3] and increasing the rate of coal production [4, 5] remain relevant in Ukraine.

The intensification of mining operations in coal mines is associated with the introduction of high-performance longwalls [6, 7], in which, as a rule, productive conveyor transport systems are applied [8].

Analysis of the operation of conveyor transport systems of mines in Ukraine [9, 10] shows their significant branching [11, 12] and the presence of conveyor transport lines with varying freight flow [13, 14]. The freight flows of coal mines have been quite well-researched by R. V. Mertsalov, V. O. Ponomarenko, O. M. Zaretskyi, L. H. Shakhmeister, N. M. Hung, M. Ya. Bilichenko, and others [15, 16].

However, there are complications with ensuring the necessary capacity of conveyor transport lines during periods of large freight flows, which negatively affects the efficiency and reliability of the transport system and the productivity of the mine.

In particular, one of the ways to increase the capacity of conveyor transport lines and the efficiency of the mine transport system [17, 18] is to control the velocity of the conveyor belt [19, 20].

Obviously, the effective and reliable functioning of the conveyor transport system of the mine is ensured by rational parameters, which, in particular, should be determined by the actual parameters of random freight flow in it [21, 22].

However, the calculation of the parameters of the mine's conveyor transport line is based on unreliable initial data from the variation of the random freight flow and is simplified without taking into account the influence of the mineral transportation velocity [23, 24].

These circumstances lead to the application of irrational parameters of conveyor transport lines, which negatively affects the efficiency and reliability of the transport conveyor system and mine's productivity.

Therefore, to increase the efficiency and reliability of the mine's conveyor transport system, it is necessary to use rational parameters that should be determined based on reliable initial data of random freight flow in conveyor lines and objectively taking into account the minerals transportation velocity [25, 26].

The study on the actual distribution of the random freight flow in the conveyor transport line of the mine will allow us to find a perfect theoretical model of its distribution and, based on it, to prepare reliable initial data from the variation of the random freight flow for the objective calculation of its parameters.

Main part. Transport freight flows are one of the main elements of logistics.

In general, the freight flow of minerals $Q(t)$ is represented as the product of a continuous random process (continuous component) and a flow of pulses of unit height (discrete component – correlation function), which characterizes the intervals of progress and absence of freight

$$Q(t) = Q'(t) \cdot \varphi(t).$$

The continuous component of the random freight flow $Q'(t)$ is considered to be a Gaussian-and-Markivskyi process with an amplitude distribution close to the normal law.

The discrete component of the freight flow $\varphi(t)$ is considered as a simple Poisson process. According to experimental research, the distribution of the interval of progress and absence of freight flow over time is well approximated by an exponent.

The main characteristics of random freight flow are:
- mathematical expectation;
- deviation variance;
- freight flow correlation function $\varphi(t)$.

To calculate the parameters of the conveyor transport line of the mine, the following characteristics are usually applied:

- the freight flow variation coefficient, as the ratio of the maximum freight flow to the mathematical expectation (the average value for the accepted theoretical model of the distribution of random freight flow – the normal law of the distribution of a random variable) for the observation period;

- the coefficient of machine time, which is equal to the share of the time of progress of the freight during the observation period $k_m = t_m / t$.

In particular, the indicated characteristics of the freight flow were used by I. E. Atlas and V. O. Sysoev during the research of the second half of the *20th* century on the distribution of random freight flow in the longwalls and conveyor transport lines of the mines of the Central District of Donbas. At that time, outdated mechanized complexes, narrow-cut shearers with individual supporting, wide-cut shearers and mining ploughs have been applied in the mines.

The distribution of the random freight flow in the mines according to this research seems to be satisfactorily described by a theoretical model, the normal law of the distribution of a random variable (Gauss's law)

$$f(x) = \frac{1}{\sqrt{2\pi} \cdot \sigma} \cdot e^{-\frac{(x-x_0)^2}{2 \cdot \sigma^2}},$$

where $f(x)$ is normal density of the distribution of a random variable; σ^2 – deviation variance of a random variable; x – random variable; x_0 – mathematical expectation.

However, does the calculation of the parameters of the mine's conveyor transport line take into account the actual distribution of the freight flow coming from the high-performance longwalls that are equipped by mechanized complexes of the new generation in real working conditions?

Including the mines of Western Donbas, which will obviously allow a balanced approach to the choice of a theoretical model for the distribution of random freight flow in the conveyor transport line during the preparation of the initial data from the calculation of its parameters.

Moreover, there are well-known cases of asymmetric distribution of random freight flow in collective conveyor transport lines of mines [27], which differ from the symmetrical theoretical model accepted in practice, the normal law of distribution of a random variable [28, 29].

For instance, Fig. 1 illustrates a bar chart of the distribution of freight flow in the main conveyor transport line of "Dovzhanska-Kapitalna" LLC DTEK "Sverdlovskantracit" mine.

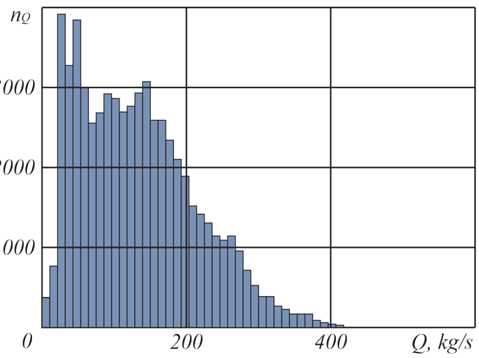

Fig. 1. A bar chart of freight flow distribution in eastern railroad line of "Dovzhanska-Kapitalna" LLC DTEK "Sverdlovskantracit" mine:

Q – freight flow, kg/s; n_Q *– the number of instantaneous values of the freight flow (mathematical expectation according to the normal distribution law is 134 kg/s)*

The given bar chart has a clearly asymmetric nature of the distribution of random freight flow relative to the center of its grouping (probable value or mathematical expectation).

In addition, different rates of increase and decrease in the number of instantaneous values of the random freight flow are observed, which is strikingly different from the theoretical model of its distribution applied in practice.

It is also observed that the center of random freight flow grouping in the transport line according to the bar chart does not coincide with the mathematical expectation of the theoretical model – 134 kg/s.

Therefore, according to the accepted theoretical model (normal law) of the distribution of a random variable, its parameters will be erroneously determined: the center of grouping (probable value or mathematical expectation), the variance of the deviation, the probable maximum value and the coefficient of nonuniformity of the random freight flow, which is calculated in accordance with the theory of probability and mathematical statistics [30].

These circumstances lead to the application in the calculations of the conveyor transport line parameters of erroneous initial data from the variation of the random freight flow.

Thus, the accepted procedure for determining the parameters of the random freight flow in the transport line of the mine is questionable, since it is based on an imperfect theoretical model, the normal law of random variable distribution.

Overcoming these shortcomings is possible in the case of applying a perfect theoretical model of the distribution of random freight flow in the conveyor transport line of the mine.

The search for a perfect theoretical model was conducted by means of statistical research on the distribution of freight flow in the ranks and its description by various models, followed by the analysis of its results.

Statistical research has been conducted in highly productive longwalls of the mine "n.a Heroiv Kosmosu" PJSC "DTEK Pavlohradvuhillia", which are equipped with mechanized complexes KD-90.

The distribution of the freight flow in the longwalls was determined based on the data of the minute feed velocity of the shearer, which were collected from the dispatching reports of the longwalls.

The distribution of freight flow was determined as follows:

- the real axis of the freight flow was divided into a finite number of intervals bordering each other;

- the number of freight flow sampling values (group sampling frequency) within these intervals was calculated;

- a Table was compiled of statistical distribution of consecutive intervals of instantaneous freight flow by group frequency;

- a bar chart was built – a diagram of the distribution of freight flow according to the frequency of falling into these intervals.

The bar charts of freight flow distribution obtained from statistical research are a component of the results presented later regarding their description by various models.

The analysis of the obtained and well-known bar charts of the distribution of freight flow indicates their extreme nature.

However, the shape of the bar charts significantly differs from each other.

The distribution of the freight flow according to the bar chart is observed to be mostly asymmetrical with respect to the center of its grouping, and, on the contrary, symmetrical or close to it.

Also, the rates of increase and decrease in the instantaneous freight flow for different branches of the bar chart usually differ from each other, which also indicates their asymmetry.

Therefore, the results of statistical research testify to the imperfection of the symmetric theoretical model accepted in practice, the normal law of distribution of random freight flow, since the bar charts are usually asymmetric.

Obtaining a perfect theoretical model of freight flow distribution was conducted by analyzing the results of describing bar charts with various algebraic functions.

At the same time, well-known and specially constructed indicative algebraic functions based on the results of statistical research were applied.

Let us consider them separately.

1. *Symmetric display function* of the form

$$y = a \cdot e^{-c \cdot (x - x_0)^2},$$

where x is an independent variable ($-\infty < x \leq x_0$); a and c – function parameters; x_0 – the value of the independent variable for which the extremum is observed; e – const (the basis of the natural logarithm).

Fig. 2 shows the diagram of the specified symmetric exponential function.

Function properties:

- the range of function existence is within from $-\infty$ to $+\infty$;
- the function has one extreme value;
- the function is symmetric with respect to the extremum.

It is rational to use another form of the function proposed above, the normal law of the distribution of a random variable (Gauss's law) for practical application, with a well-developed mathematical apparatus for determining the parameters of a random variable

$$y = \frac{S}{\sqrt{2\pi\sigma}} \cdot e^{-\frac{(x - x_0)^2}{2 \cdot \sigma^2}},$$

where S is the square of the figure bounded by the function; σ – average square deviation of a random variable.

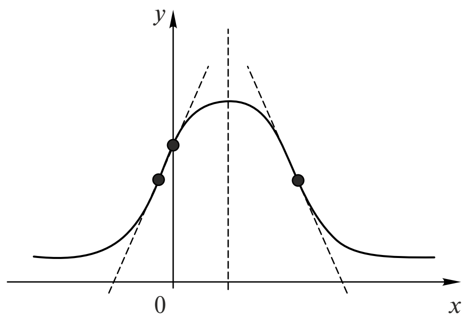

Fig. 2. Diagram of the symmetric exponential function

At present moment, as was mentioned earlier, it is used as an accepted theoretical model of freight flow distribution in the transport line.

Therefore, the parameters of the random freight flow are determined by the methods of probability theory and mathematical statistics.

2. *Asymmetric indicator exponential*

$$y = a \cdot (x - d)^b \cdot e^{-c \cdot (x - d)},$$

where x is an independent variable ($x \geq d$); a, b, c and d – function parameters.

Properties of an asymmetric exponential function:

- the range of function existence is within from $-\infty$ to $+\infty$;
- the function has one extreme value;
- the function is asymmetric relative to the extremum (Figs. 3, *a, b* and *c*);
- the probable value and variance of the deviation of a random variable are determined by the expressions

$$x_0 = -b/c \quad \text{and} \quad \sigma^2 = b/c^2.$$

The specified function is based on the well-known (parameter $d = 0$) asymmetric indicator function

$$y = a \cdot x^b \cdot e^{-c \cdot x}.$$

Fig. 3 shows the "basic" (parameter $d = 0$) diagrams of the asymmetric exponential function.

In practice, the following laws of random variable distribution are based on the application of a well-known exponential algebraic function:

- gamma distribution of a random variable a, b and c;
- exponential distribution of a random variable d.

3. *The specially built indicative* algebraic function based on the results of statistical research, whose rising and falling branches are described by the corresponding branches of the symmetric indicative function given above with separately defined parameters, of the form

$$y = a \cdot e^{-c_k \cdot (x - x_0)^2},$$

where x is an independent variable ($-\infty < x \leq x_0$); a – the maximum value of the function; x_0 – the value of the independent variable for which the extremum is observed; c_k – parameter that describes the rate of rise and fall of the branches of the function (c_1 for the rise branch at $x \leq x_0$; c_2 for the fall branch at $x \geq x_0$).

In practice, it is rational to apply another form of the continuous function proposed above, which is described by the

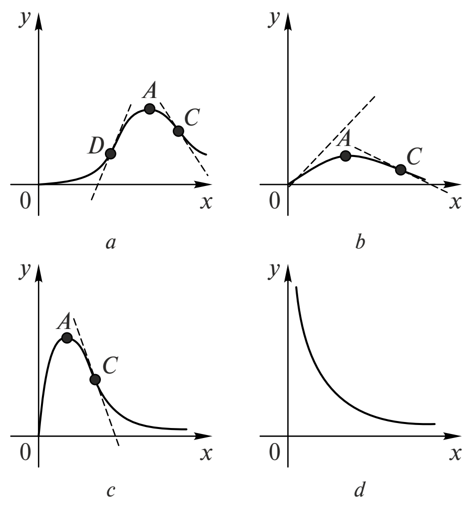

Fig. 3. Diagrams of the asymmetric exponential function $y = a \times x^b \cdot e^{-c \cdot x}$:

a – parameters $c < 0$, $b > 1$; b – parameters $c < 0$, $b = 1$; c – parameters $c < 0$, $0 < b < 1$; d – parameters. $c < 0$, $b = 0$

branches of the normal law of the distribution of a random variable with separately defined parameters, hence there is a well-known technique for determining its parameters

$$y = a \cdot e^{-c_k \cdot (x-x_0)^2} = \frac{2 \cdot S_k}{\sqrt{2\pi} \cdot \sigma_k} e^{-\frac{(x-x_0)^2}{2 \cdot \sigma_k^2}},$$

where x is a random variable; x_0 – probable value (grouping center, mathematical expectation); S_k – the square of the figure bounded by the function within a uniform change (S_1 within $-\infty < x \le x_0$; S_2 within $x_0 \le x < \infty$); σ_k – average square deviation of a random variable (σ_1 at $x \le x_0$; σ_2 at $x \ge x_0$).

Fig. 4 illustrates a qualitative diagram of a specially constructed continuous exponential algebraic function.

The density of the distribution of a random variable for this function has the following form

$$f(x) = \frac{1}{\sqrt{2\pi} \cdot \sigma_k} \cdot e^{-\frac{(x-x_0)^2}{2 \cdot \sigma_k^2}}.$$

Fig. 5 shows a diagram of the density of a random variable distribution, whose branches are described by the normal law of its distribution.

Properties of the specified indicative function:

- the range of function existence is within from $-\infty$ to $+\infty$.
- the function has one extreme value;
- the function can be both asymmetric and symmetric with respect to the extremum;
- the rate of rise and fall of function branches is determined by parameters c_1 and c_2 or deviation variance σ_1^2 and σ_2^2 of a random variable from mathematical expectation.

The parameters of a random freight flow with its distribution according to a specially constructed indicator function are determined by the methods of probability theory and mathematical statistics, as its branches are described by the normal law of random variable distribution.

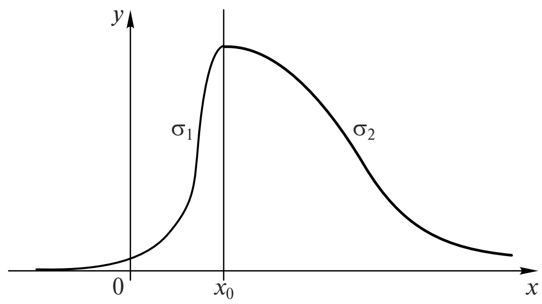

Fig. 4. The diagram of the specially constructed continuous exponential function, whose rising and falling branches are described by the corresponding branches of the normal distribution law of a random variable with separately defined parameters

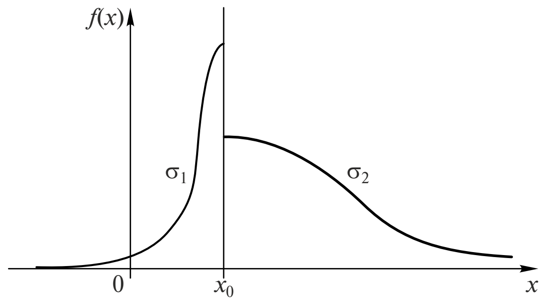

Fig. 5. The diagram of the density of a random variable distribution according to the exponential function, whose branches are described by the normal law of its distribution

However, this is done after the mandatory preliminary determination of the valid value of the grouping center (probable value or mathematical expectation) of the random freight flow and separately for each branch of the theoretical model.

The actual value of the freight flow grouping center is determined step by step:

- first, the parameters of the model are calculated based on the visual assessment of the center of the freight flow grouping of the bar chart, and an intermediate diagram of the expected theoretical model is constructed;
- then, if necessary, the value of the center of the freight flow grouping is refined by iteration, by calculating the model parameters at each step of the iteration according to a value close to the true value, and building the model diagram again until the best description of the bar chart is obtained;
- the criterion for determining the valid value of the center of a grouping of the freight flow and its other parameters is the coincidence of the extremes of the rising and falling branches of the model in the next iteration;
- the calculation of the model branches parameters at each step of the iteration is performed with the application of instantaneous values of the random freight flow that exceed or, on the contrary, do not exceed the intermediate value of the grouping center.

Let us consider the obtained research results.

The Table shows the parameters of theoretical models of the distribution of random freight flow in the longwalls of the Mine "n.a Heroiv Kosmosu" PJSC "DTEK Pavlohradvuhillia", which were described by the obtained bar charts.

Figs. 6, 7 and 8 show bar charts and models of the distribution of freight flow in the longwalls of the Mine "n.a Heroiv Kosmosu" PJSC "DTEK Pavlohradvuhillia".

A comparative analysis of the results of the bar charts models description shows the following:

- a better match between a specially constructed theoretical model and bar charts of different levels, both with an asymmetric distribution of freight flow and, on the contrary, close to symmetric according to various criteria of genuineness, the center of grouping, amplitude, velocity of rise and fall, and deviation of the freight flow is observed with the naked eye;
- therefore, a specially constructed indicative algebraic function, whose branches are described by the normal law of the distribution of a random variable with separately defined parameters, is recognized as a "perfect" theoretical model of the distribution of random freight flow in the conveyor transport lines of mines, since it has the ability to correctly describe various cases of distribution;
- the correctness of determining the parameters of the freight flow under a perfect theoretical model is guaranteed by the application of the methods of probability theory and mathematical statistics, since the branches of the model are described by Gauss's law, but after the mandatory preliminary determination of the valid value of the center of its grouping;
- the calculated parameters of the nonuniformity of the freight flow in the longwalls of the mine with the application of different theoretical models of its distribution are significantly different from each other;
- the values of the parameters of the freight flow in the longwalls according to different theoretical models are both larger and smaller than the actual values determined according to the perfect theoretical model of its distribution;
- the actual value of the coefficient of nonuniformity of the freight flow in the longwalls under a perfect theoretical model usually exceeds the value corresponding to the theoretical model accepted in practice, the normal law of random variable distribution;
- also, the actual coefficient of nonuniformity of the freight flow in the highly productive longwalls of only one analyzed mine reaches a value of 2.012, which already exceeds the limit

Table

Parameters of theoretical models of random freight flow distribution in longwalls of Mine “n.a Heroiv Kosmosu”

Theoretical model	Model parameters	Longwall No		
		983	1060	1100
Normal distribution law	mathematical expectation, x_0, m/min	2.714	2.980	1.877
	average square deviation, σ, m/min	0.352	0.560	0.454
	coefficient of variation, *v*	0.130	0.188	0.242
	coefficient of nonuniformity, k_n	1.334	1.484	1.623
Gamma distribution	*ln a* *b* *c* *d*	15.841 7.726 –6.748 1.400	14.398 8.017 –6.039 1.500	10.632 1.209 –2.338 0.950
	mathematical expectation, x_0, m/min	2.545	2.828	1.465
	average square deviation, σ, m/min	0.412	0.469	0.468
	coefficient of variation, *v*	0.162	0.166	0.319
	coefficient of nonuniformity, k_n	1.417	1.427	1.823
Specially built display function	mathematical expectation, x_0, m/min	2.650	2.900	1.575
	average square deviation, σ, m/min	0.206/0.432	0.498/0.580	0.193/0.619
	coefficient of variation, *v*	0.163	0.200	0.393
	coefficient of nonuniformity, k_n	1.420	1.515	2.012

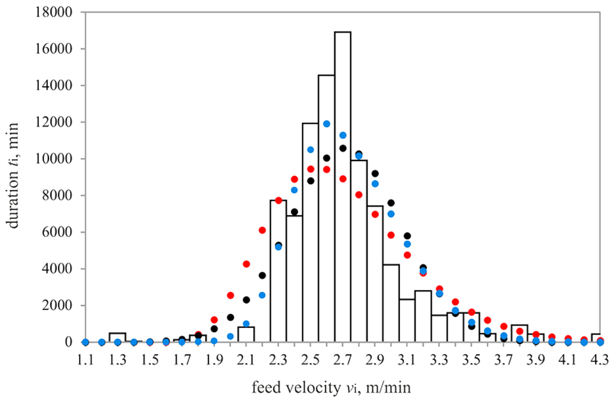

Fig. 6. A bar chart and models of the distribution of feed velocity of the V shearer over time in longwall No. 983 of the Mine “n.a Heroiv Kosmosu” PJSC “DTEK Pavlohrad-vuhillia”:

a specially built display function – blue dots; normal distribution law – black dots; gamma distribution – red dots

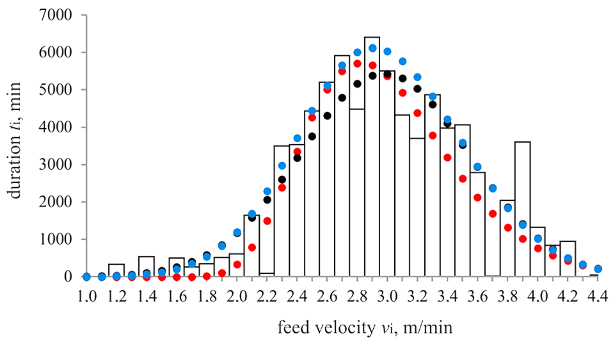

Fig. 7. A bar chart and models of the distribution of feed velocity of the V shearer over time in longwall No. 1060 of the Mine “n.a Heroiv Kosmosu” PJSC “DTEK Pavlohrad-vuhillia”:

a specially built display function – blue dots; normal distribution law – black dots; gamma distribution – red dots

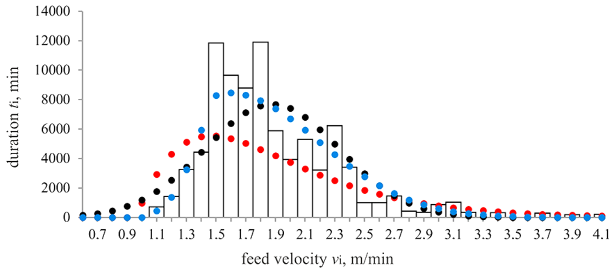

Fig. 8. A bar chart and models of the distribution of feed velocity of the V shearer over time in longwall No. 1100 of the Mine “n.a Heroiv Kosmosu” PJSC “DTEK Pavlohrad-vuhillia”:

a specially built display function – blue dots; normal distribution law – black dots; gamma distribution – red dots

normative value for conveyor transport lines along horizontal and inclined preparatory workings of mining areas – 2.0;

- at the same time, the established value of the coefficient of nonuniformity of the freight flow in the longwalls of the only analyzed mine is not at all the maximum, since there are cases when in some conveyor transport lines of other mines, it reaches a value of 2.5 or more, according to the theoretical model accepted in practice.

Conclusions. Therefore, we have built a perfect theoretical model that describes well various cases of distribution of random freight flow in the conveyor transport line of the mine, including both predominantly asymmetric and symmetric or close to its distribution.

A perfect theoretical model is represented by an indicative algebraic function, whose branches are described by the normal distribution law of a random variable with separately defined parameters. Therefore, the calculation of the parameters of the random freight flow is conducted with the application of the methods of probability theory and mathematical statistics, but after the preliminary determination of the actual value of the center of its grouping.

The coefficient of nonuniformity of freight flow in the longwalls of analyzed mine exceeds the value inherent in the theoretical model applied in practice by almost a quarter.

The coefficient of nonuniformity of the freight flow in the highly productive longwalls of only analyzed mine reaches a value of 2.012, which already exceeds the limit for the corresponding conveyor transport lines – 2.0.

The initial data from the nonuniformity of the random freight flow in the conveyor transport line of the mine, which is substantiated by the application of a perfect theoretical model of its distribution, in the case of an objective calculation of its parameters, including taking into account the influence of the minerals transportation velocity, increase the efficiency and reliability of the operation of the conveyor transport system and mine's productivity.

Acknowledgments. *The work was conducted at the TST (transport systems and technologies) department with the aim of improving the efficiency of the conveyor transport system of the mine due to the application of rational parameters that were calculated objectively and based on reliable initial data from the nonuniformity of the random freight flow in it.*

The authors express strong gratitude to the staff of the TST department of the NTU "Dnipro University of Technology" for the formation of a scientific direction for the development of conveyor transport systems of mines and ways to increase the efficiency and reliability of their operation and the creation of test equipment for conveyor transport of mining enterprises.

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Теоретична модель розподілу випадкового вантажопотоку в конвеєрній транспортній лінії вугільної шахти

Т. М. Лубенець[1], *Є. А. Коровяка*[1], *В. Г. Снігур*[2], *А. В. Ткачук*[2], *В. О. Расцвєтаєв**[1]

1 – Національний технічний університет «Дніпровська політехніка», м. Дніпро, Україна

2 – Шахтоуправління «Імені Героїв космосу» ПрАТ «ДТЕК Павлоградвугілля», м. Павлоград, Україна

* Автор-кореспондент e-mail: rastsvietaiev.v.o@nmu.one

Мета. Підвищення ефективності роботи конвеєрної транспортної системи шахти за рахунок використання раціональних параметрів, що розраховуються об'єктивно за достовірними вихідними даними випадкового вантажопотоку в конвеєрній транспортній лінії з урахуванням швидкості транспортування корисних копалин, у тому числі з використанням досконалої теоретичної моделі розподілу вантажопотоку.

Методика. Комплексні дослідження:

- статистичні дослідження фактичного розподілу випадкового вантажопотоку в високопродуктивних лавах ВСП шахта «Імені Героїв Космосу» ПрАТ «ДТЕК Павлоградвугілля»;

- опис гістограм розподілу випадкового вантажопотоку різноманітними показовими алгебраїчними функціями – нормальним і гама розподілом випадкової величини та спеціально збудованою функцією з окремо визначеними параметрами її гілок;

- аналіз результатів досліджень щодо правильності теоретичної моделі розподілу випадкового вантажопотоку за різними критеріями істинності – центром групування, амплітудою, швидкістю зростання й падіння та відхиленням.

Результати. Збудована досконала теоретична модель у вигляді показової алгебраїчної функції, гілки якої описуються нормальним законом розподілу випадкової величини з окремо визначеними параметрами, що добре описує розподіл випадкового вантажопотоку в конвеєрній транспортній лінії шахти й забезпечує визначення його параметрів методами теорії ймовірностей.

Наукова новизна. Уперше отримана теоретична модель розподілу випадкового вантажопотоку в конвеєрній транспортній лінії шахти, що добре описує різноманітні випадки його розподілу, у тому числі симетричний і несиметричний, та забезпечує визначення параметрів вантажопотоку методами теорії ймовірностей.

Практична значимість. Дійсне значення коефіцієнта нерівномірності вантажопотоку в конвеєрній транспортній лінії шахти, яке визначене за використання досконалої теоретичної моделі, майже до чверті перевищує значення, що притаманне прийнятій у практиці моделі – нормальному закону розподілу випадкової величини. Коефіцієнт нерівномірності вантажопотоку в високопродуктивних лавах тільки вказаної шахти досягає значення 2,012, що вже перевищує граничне нормативне значення для конвеєрних транспортних ліній по горизонтальним й похилим підготовчим виробкам виїмкових полів – 2,0. Достовірні вихідні данні з нерівномірності випадкового вантажопотоку в конвеєрній транспортній лінії шахти, що обґрунтовані за використання досконалої теоретичної моделі його розподілу, позитивно впливають на розрахунок її параметрів і сприяють підвищенню ефективності й надійності функціонування конвеєрної транспортної системи.

Ключові слова: *конвеєрна транспортна лінія, випадковий вантажопотік, розподіл вантажопотоку, гістограма, теоретична модель, нормальний закон розподілу випадкової величини, коефіцієнт нерівномірності*

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