Method for Determining Statistical Characteristics of Input Material Flows of Transport Conveyor

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Abstract

This paper is devoted to the study of the statistical characteristics of the experimental values of the material flow entering the input of a conveyor-type transport system. The paper considers the statistical analysis of the input non-stationary stochastic material flow, represented as a superposition of non-stationary deterministic and stationary stochastic material flow with ergodic properties. The problems of typification of the empirical input material flow for modern mining enterprises are considered, taking into account the technical and technological factors that characterize the method of extracting the material. The results of the work are of theoretical and practical interest for building transport conveyor models, considering the stochastic nature of the input material flow, and can be used to improve the efficiency of algorithms for optimal control of the transport conveyor material flow.

Keywords

Conveyor, deterministic material flow, stochastic material flow, deterministic and stochastic material flow

1. Introduction

Conveyor type transport systems are business-critical, especially regarding their performance and availability [1]. The specific cost of transporting material for the standard mode of operation of the transport system is 20% of the total cost of extracting the material [2]. With an increase in the number of sections and the length of the route of the transport system, the cost of transporting the material can make up the bulk of the cost of extracting the material. The cost of electricity that is consumed to transport the material is the main part of the cost of transportation. Existing methods for reducing the specific consumption of electricity are based on the creation of control systems for the flow parameters of the conveyor, the main of which are the speed of the conveyor belt [3, 4] and the value of the input material flow [5, 6, 7]. The value of the input material flow is determined by the mass of rock that enters the input of the conveyor section per unit of time.

Traditionally, models that are used in the synthesis of systems for controlling the speed of a conveyor belt or the amount of material flow entering the conveyor inlet from an accumulating bin consider the input flow as a deterministic flow [8, 9, 10, 11], without substantiating such a decision. To consider the stochastic nature of the input stream, the distribution function of the random variable λ is introduced. The random value is determined by the average value of the flow of material that entered the transport system for a given time interval. The most common law for describing the statistical characteristics of the material flow is the normal distribution law [12, 13] with unbounded left and right tails of the distribution density function. This approach makes it possible to consider the stochastic nature of the material flow, without considering the technical and technological factors that affect the formation of the main characteristics of the flow, which are the cause of its non-stationarity.

The construction of functional empirical relationships between the statistical characteristics of the random value of the material flow λ requires experimental studies, which include a sufficiently large number of conveyors with different characteristics of the input material flow. It is difficult to carry out

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such studies in practice. At the same time, there are works that give a graphical representation of the realizations of a random material flow entering the input of a conveyor system. The analysis of such implementations makes it possible to reveal the functional relationships between the statistical characteristics of the random variable of the material flow λ , which are determined by the technical and technological factors of the functioning of the existing transport system. The existing methods for typification of empirical data [12, 13] are based on the approximation of stochastic material flow data and can be used to a greater extent for stationary material flows. This paper is devoted to the task of typification of a non-stationary random flow of material obtained from the data of the functioning of real transport systems.

2. Statement of the problem

Reducing the unit cost of transporting material with a stochastic input material flow may be achieved using algorithms for controlling the speed of the conveyor belt [12, 14]. In a number of works, the input material flow is presented as a product of random processes [13, 14, 15]

$$\lambda(t) = \lambda_t(t)\lambda_s(t), \tag{1}$$

where $\lambda_t(t)$ is a process representing a discrete sequence of pulses with a random duration of material arrival and with a random interval of its absence, $\lambda_s(t)$ is a directly random process. As a rule, it is assumed that this process is characterized by a distribution function with a normal or logarithmically normal law [12, 13].

The current state of publications devoted to modeling the input flow of a transport conveyor for solving applied and theoretical problems shows that the material flow is considered as a continuous process, the mathematical expectation of which is a periodic function of time. The temporary value of the capacity recorded on the crusher, which feeds the WD-1 conveyor, is presented in Figure 1.a [16]. It can be seen from the figure that the material flow at the conveyor inlet is uneven, and its amount may differ by 1.5-2 times from a relatively stable average value.

The nature and magnitude of changes in the load flow for the belt conveyor 2LU120V (No. 4) of the eastern conveyor line of the Dovzhanska-Capital mine of the LLC DTEK Sverdlovanthracite (Sverdlovsk, Ukraine) is shown in Figure 1.b [17]. This figure presents the conveyor operation from 16:57 on 25 May 2011 till 00:22 on 26 May 2011. The experimental data provided is an example where the material flow value is a periodically changing value over time.

The results of operating the ECS (Excavator-Conveyors-Spreader) system, implemented on the open pit mine “Drmno” of the Public Enterprise “Electric power industries of Serbia”, and comprised of excavator SRs2000, spreader ARs2000, and the system of five belt conveyors with maximum total length of 8 km, are shown in the Figures 1.c and 1.d [18]. The Figure 1.c demonstrates the operation of the conveyor at constant speed 900 min–1 under variable belt loading, the Figure 1.d - the instantaneous volume of the overburden on the belt under the laser-based measurement device. The material flow value also changes periodically over time. This behavior also suggests that the material flow has some deterministic component that can be described by a periodic function of time.

Figures 1.e and 2.f show the change in the input material flow for cargo transportation over time when cutting a coal strip forward and backward motion of the combine obtained for the combine KDK500 [14]. These results were obtained for the situations of transporting broken rock mass at constant speed. These figures show that the loading of a mine face scraper conveyor is non-uniform over time and varies in the range (0...21) t with a coefficient of variation of 0.53.

The analysis of the published experimental results reveals a big unevenness of the load flow. It can be assumed that the uneven load flow occurs due to the technological cycle of material extraction and the combined machine performance. The influence of these factors on the value of the input material flow may be described by some deterministic component of the input flow, which is a characteristic of a particular technological cycle.

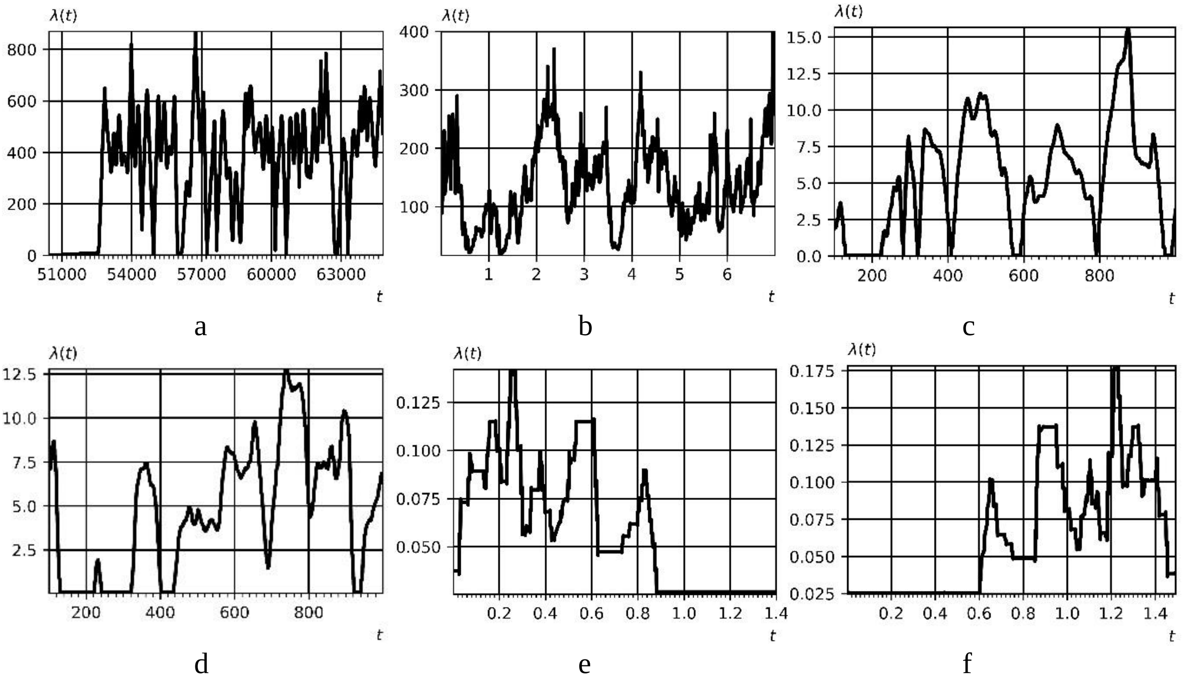

Figure 1: Experimental data of the material flow of the conveyor type transport systems: a - WD-1 conveyor [16]; b - 2LU120V belt conveyor [17]; c - ECS system [18]; d - under the laser-based measurement device of the ECS system [18]; e – with forward motion of the combine KDK500 [14]; f - with backward motion of the combine KDK500 [14]

The data sets (λ_i, t_i) presented in Figure 1 were obtained by scanning graphic images from [14, 16, 17, 18] at the following time points

$$t_i = (t_{\min} + n\Delta t), \ \ \Delta t = \frac{(t_{\max} - t_{\min})}{N}, \ \ n = 0..N, \qquad (2)$$

where $t_{\min}$, $t_{\max}$ are the initial and final values of the time interval for experimental measurements. When scanning images, $N \approx 5 \cdot 10^4$ points along the abscissa axis were used.

This review of the experimental data gives a general idea of the qualitative characteristics of material flows entering the transport system. In most cases, the flow of material is a random continuous flow, characterized by mathematical expectation and standard deviation, the values of which are determined by periodically changing functions of time. This indicates the non-stationarity of the parameters of the input material flow. The amplitude of fluctuations of the input flow is determined by the speed of advancement deep into the material deposit, the rhythm, as well as other technological features of the processes of extracting materials.

Thus, the description of the input material flow by a normal or logarithmically normal distribution law can be justified only in individual cases. In this regard, the development of methods for typification of the input material flow based on experimental data from existing conveyor systems is an urgent task that determines the further development of transport conveyor models.

3. Method for calculating statistical characteristics of input material flow

3.1. General description of input material flow

The analysis of the experimental data on the values of the input material flow of operating conveyor systems [14, 16, 17, 18] shows that the material flow is a random, continuous, and unsteady flow.

To determine the $\lambda(t)$ statistical characteristics, the input material flow may be represented in the following form

$$\lambda(t) = \lambda_d(t) + \lambda_s(t) \tag{3}$$

where $\lambda_d(t)$ is a deterministic function of time t; $\lambda_s(t)$ is a stationary centered ergodic process. The stationary centered stochastic process $\lambda_s(t)$ is defined by a one-dimensional distribution density $f_{\lambda s}(\lambda)$ with mathematical expectation $m_{\lambda s} = 0$ and standard deviation $\sigma_{\lambda s}$ of the random variable λ. To continue it is necessary to extract a deterministic component $\lambda_d(t)$ from the input flow in such a way that the remaining flow $\lambda_s(t)$ is a stationary random flow with ergodic properties.

Publications devoted to the study of material flows entering the transport system [12, 13, 15] suggest that the correlation function for the input material flow has the form

$$K_s(\eta) = \sigma_s{}^2 \exp(-\eta / \eta_{kor}). \tag{4}$$

The value of the correlation time η_{kor} is closely related to the method of organizing the production process and is a characteristic of each individual data set (λ_i, t_i) [14, 16, 17, 18].

For the stationary ergodic process $\lambda_s(t)$, the mathematical expectation $m_{\lambda s}$, standard deviation $\sigma_{\lambda s}$ and correlation function $k_{\lambda s}(\eta)$ may be determined by integrating the implementation of this random process over time

$$m_{\lambda s} = \frac{1}{T}\int_0^T \lambda_s(t)dt, \quad \sigma_{\lambda s}{}^2 = \frac{1}{T}\int_0^T \lambda_s{}^2(t)dt, \quad k_{\lambda s}(\eta) = \frac{1}{T}\int_0^T \lambda_s(t)\lambda_s(t-\eta)dt. \tag{5}$$

To satisfy equalities (5), a sufficient condition is the limiting equality

$$\lim_{\eta \to \infty} k_{\lambda s}(\eta) \to 0. \tag{6}$$

If for the presented data sets [14, 16, 17, 18] the correlation function $k_{\lambda s}(\eta)$ may be represented by a dependence close to dependence (4) and following condition is satisfied

$$\eta_{kor} < (t_{\max} - t_{\min}). \tag{7}$$

then to calculate the mathematical expectation $m_{\lambda s}$, the standard deviation $\sigma_{\lambda s}$ and the correlation function $k_{\lambda s}(\eta)$, following expressions may be used

$$m_{\lambda s} = \frac{1}{t_{\max} - t_{\min}} \int_{t_{\min}}^{t_{\max}} \lambda_s(t)dt, \quad \sigma_{\lambda s}{}^2 = \frac{1}{t_{\max} - t_{\min}} \int_{t_{\min}}^{t_{\max}} \lambda_s{}^2(t)dt, \tag{8}$$

$$k_{\lambda s}(\eta) = \frac{1}{t_{\max} - t_{\min}} \int_{t_{\min}}^{t_{\max}} \lambda_s(t)\lambda_s(t-\eta)dt \tag{9}$$

The periodic function $\lambda_d(t)$ is determined from the quality criterion of the approximation process

$$J = \int_0^{\eta_{kor}} (k_{\lambda s0}(\eta) - k_{\lambda s}(\eta))^2 d\eta = \int_0^{\eta_{kor}} \left(\sigma_{\lambda s}{}^2 \exp(-\eta/\eta_{kor}) - k_{\lambda s}(\eta)\right)^2 d\eta \to 0. \tag{10}$$

The joint solution of equations (8), (9) using the quality criterion of the approximation process (10) makes it possible to determine the approximate form of the function $\lambda_d(t)$ for given values of the correlation time η_{kor} and standard deviation $\sigma_{\lambda s}$.

3.2. Synthesis of deterministic component of input flow

For synthesis of deterministic component of input flow the dimensionless parameters that determine the description of the input material flow may be introduced as following

$$\gamma(\tau)=\frac{\lambda(t)}{m_d},\ \gamma_s(\tau)=\frac{\lambda_s(t)}{m_d},\qquad \gamma_d(\tau)=\frac{\lambda_d(t)}{m_d},\ \tau=\frac{t-t_{\min}}{t_{\max}-t_{\min}},\ \tau_n=\frac{n}{N},\ n=0..N, \tag{11}$$

$$m_d=\frac{1}{t_{\max}-t_{\min}}\int_0^{t_{\max}-t_{\min}}\lambda(t)dt=\frac{1}{N+1}\sum_0^N\lambda(t_n),\ m_s=\frac{m_{\lambda s}}{m_d},\ \sigma_s=\frac{\sigma_{\lambda s}}{m_d},\ \tau_{kor}=\frac{\eta_{kor}}{t_{\max}-t_{\min}}, \tag{12}$$

$$k_s(\eta)=\frac{k_{\lambda s}(\vartheta)}{m_d{}^2},\quad \vartheta=\frac{\eta}{(t_{\max}-t_{\min})}=\frac{(t_i-t_j)}{(t_{\max}-t_{\min})}=(\tau_i-\tau_j). \tag{13}$$

Then the numerical characteristics of the stochastic material flow may be represented in the dimensionless form

$$m_s=\frac{m_{\lambda s}}{m_d}=\frac{1}{m_d\left(t_{\max}-t_{\min}\right)}\int_{t_{\min}}^{t_{\max}}\lambda_s(t)dt=\int_0^1\gamma_s(\tau)d\tau=0, \tag{14}$$

$$\sigma_s{}^2=\frac{\sigma_{\lambda s}{}^2}{m_d{}^2}=\frac{1}{m_d{}^2\left(t_{\max}-t_{\min}\right)}\int_{t_{\min}}^{t_{\max}}\lambda_s{}^2(t)dt=\int_0^1\gamma_s{}^2(\tau)d\tau, \tag{15}$$

$$k_s(\vartheta)=\frac{k_{\lambda s}(\eta)}{\sigma_s{}^2m_d{}^2}=\frac{1}{\sigma_s{}^2m_d{}^2\left(t_{\max}-t_{\min}\right)}\int_{t_{\min}}^{t_{\max}}\lambda_s(t)\lambda_s(t-\eta)dt=\frac{1}{\sigma_s{}^2}\int_0^1\gamma_s(\tau)\gamma_s(\tau+\vartheta)d\tau, \tag{16}$$

$$k_{s0}(\vartheta)=\frac{k_{\lambda s0}(\eta)}{\sigma_s{}^2m_d{}^2}=\frac{\sigma_{\lambda s}{}^2}{\sigma_s{}^2m_d{}^2}\exp\left(-\frac{\vartheta}{\tau_{kor}}\right)=\exp\left(-\frac{\vartheta}{\tau_{cor}}\right), \tag{17}$$

$$\gamma(\tau)=\gamma_d(\tau)+\gamma_s(\tau). \tag{18}$$

The correlation functions $k_s(\eta)$ and $k_{s0}(\vartheta)$ are written in a dimensionless form with the normalization condition $k_s(0)=1$, $k_{s0}(0)=1$. The correlation function of a stationary random process is an even function, i.e. $k_s(\vartheta)=k_s(-\vartheta)$. Then on the interval $[-1;1]$ the correlation function has the form

$$k_s(\vartheta)=\frac{k_s(\vartheta)+k_s(-\vartheta)}{2}=\frac{1}{2\sigma_s{}^2}\int_0^1\gamma(\tau)\big(\gamma(\tau-\vartheta)+\gamma(\tau+\vartheta)\big)d\tau+\frac{-1}{2\sigma_s{}^2}\int_0^1\gamma_d(\tau)\big(\gamma(\tau-\vartheta)+\gamma(\tau+\vartheta)\big)d\tau+ \tag{19}$$

$$+\frac{-1}{2\sigma_s{}^2}\int_0^1\gamma(\tau)\big(\gamma_d(\tau-\vartheta)+\gamma_d(\tau+\vartheta)\big)d\tau+\frac{1}{2\sigma_s{}^2}\int_0^1\gamma_d(\tau)\big(\gamma_d(\tau-\vartheta)+\gamma_d(\tau+\vartheta)\big)d\tau.$$

and may be expanded into a Fourier series in cosines. The graphical representation of the input material flow, shown in Figure 1, suggests the possibility of approximating a deterministic function $\gamma_d(\tau)$ on a time interval $0 \le \tau \le \tau_d = 1$ by a periodic function. The following is representation of this function as an expansion in cosines, redefining it accordingly on the interval $-1 \le \tau \le 0$

$$\gamma_d(\tau) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos\left(\frac{\pi n \tau}{\tau_d}\right) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos(\pi n \tau), \tag{20}$$

with expansion coefficients

$$a_0 = 2\int_0^1 \gamma_d(\tau) d\tau, \quad a_n = 2\int_0^1 \gamma_d(\tau)\cos(\pi n \tau) d\tau. \tag{21}$$

The expansion coefficients are found from the minimum condition of the quality criterion (10). The calculation of the statistical characteristics of the input material flow $\gamma(\tau)$ is based on the fact that the input flow is represented as a superposition of a deterministic process $\gamma_d(\tau)$ and a stochastic stationary centered process $\gamma_s(\tau)$ (18). When separating, hypothesis that the correlation function for the material flow has the form (17) was used. Then, on the time interval of experimental studies, it may be assumed that, with accuracy ε when calculating the quality criterion (10), the stochastic process is ergodic, $\varepsilon > J$. In this case, to calculate the statistical characteristics, the ensemble integration was replaced with time integration (14), (15), (16). This possibility is justified by the fact that the stochastic stationary process proceeds uniformly in time within the interval of the experiment.

4. Analysis of results

Graphs of implementations of the deterministic process $\gamma_d(\tau)$ for the analyzed input material flows in Figure 1 [14, 16, 17, 18] for 50 members of the series (20) are shown in the Figure 2. The presented implementations of the deterministic process have a similar oscillation period and approximately the same number of peak values. Deterministic process implementations $\gamma_d(\tau)$ containing the first six terms of the Fourier series expansion of the deterministic process $\gamma_d(\tau)$ are shown in Figure 3. One of the challenges in synthesizing the deterministic process $\gamma_d(\tau)$ is to determine how many expansion terms to use. The number of expansion terms is primarily determined by the accuracy with which the quality criterion (10) is fulfilled, $\varepsilon > J$. The theoretical correlation function (17) corresponds to an ideal input material flow. When carrying out experimental measurements, it is necessary to estimate the magnitude of the error (in accordance with the given quality criterion), which may arise in determining the expansion coefficients (21) as a result of choosing a certain hypothesis about the form of the theoretical correlation function (17).

Table 1 presents the values of expansion coefficients a_n, which are characterizing the deterministic process $\gamma_d(\tau)$ for the experimental data obtained in [14, 16, 17, 18], and which correspond the hypothesis of the theoretical correlation function (17). Analysis of the expansion coefficients confirms the assumption that the deterministic flow $\gamma_d(\tau)=1$ may be chosen as a zero approximation in determining the expansion coefficients.

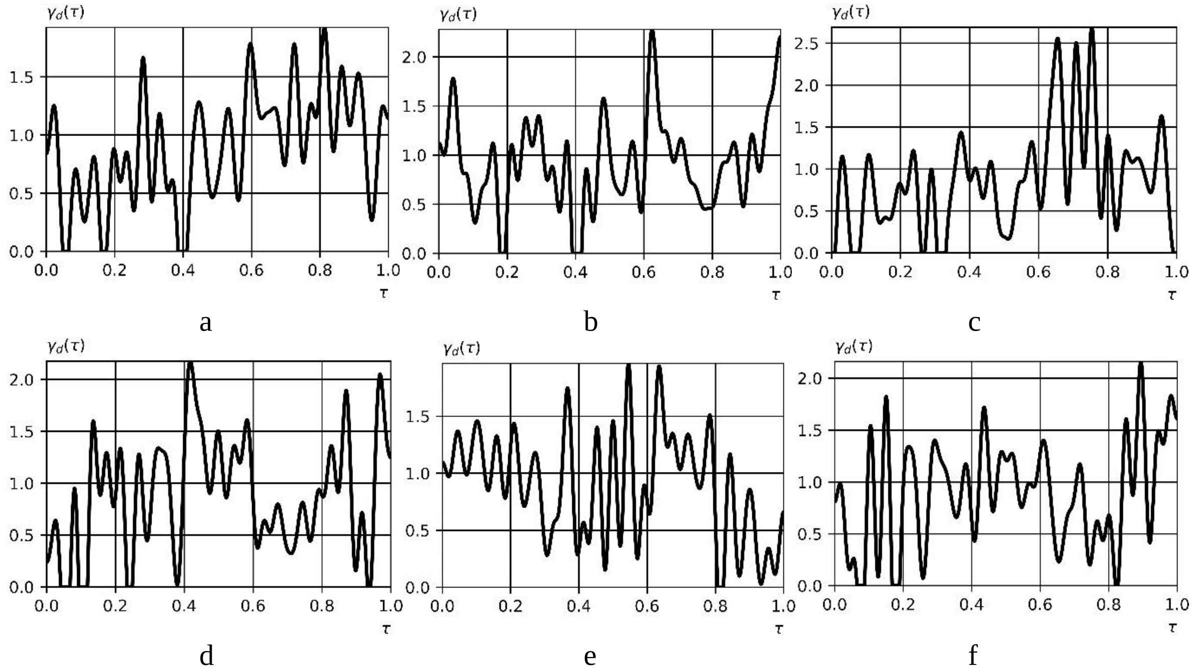

Figure 2: The synthesis of a deterministic material flow: a - for the WD-1 conveyor [16]; b - for the 2LU120V belt conveyor [17]; c - for the ECS system [18]; d - under the laser-based measurement device of the ECS system [18]; e - with forward motion of the combine KDK500 [14]; f - with backward motion of the combine KDK500 [14]

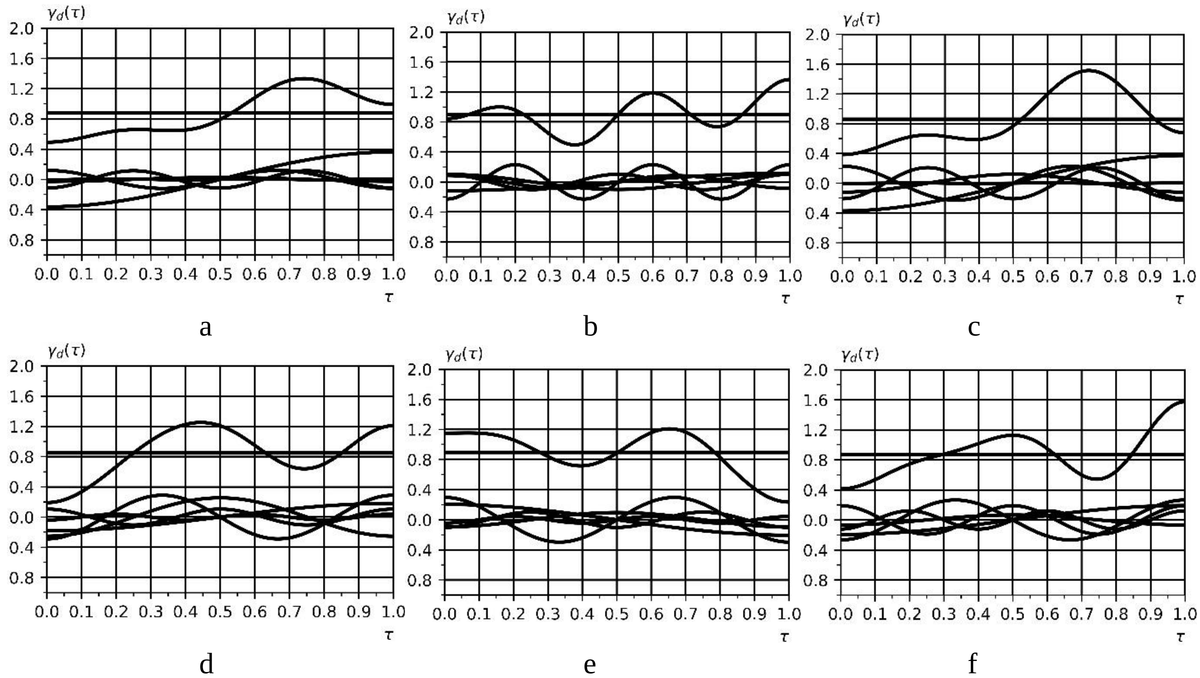

Figure 3: Major harmonics of the deterministic material flow: a - of the WD-1 conveyor [16]; b - of the 2LU120V belt conveyor [17]; c - of the ECS system [18]; d - of the ECS system under the laser-based measurement device[18]; e - with the forward motion of the combine KDK500 [14]; f - with the backward motion of the combine KDK500 [14]

Table 1

The value of the coefficients a_n of the deterministic process $\gamma_d(\tau)$

Dataset	a0	a1	a2	a3	a4	a5
Figure 1.a [16]	1,762176	-0,36328	-0,02584	0,118937	-0,11436	-0,00544
Figure 2.b [17]	1,802211	-0,11728	0,1012	0,084977	0,102737	-0,22924
Figure 3.c [18]	1,718977	-0,37195	-0,11927	0,228462	-0,20923	-0,00341
Figure 4.d [18]	1,697766	-0,18105	-0,25409	-0,28886	0,105013	-0,03882
Figure 5.e [14]	1,781765	0,204809	-0,09617	0,296894	-0,10136	-0,04337
Figure 6.f [14]	1,741747	-0,19316	-0,0665	-0,26558	0,189927	-0,12144
mean	1,750774	-0,17032	-0,07678	0,029139	-0,00455	-0,07362
st.dev.	0,03568	0,192379	0,106454	0,227518	0,144141	0,0798
min	1,697766	-0,37195	-0,25409	-0,28886	-0,20923	-0,22924
max	1,802211	0,204809	0,1012	0,296894	0,189927	-0,00341

The average value of the coefficient a_0 for different sets of experimental data is approximately the same. The range of values a_0 is determined by the mean value $a_0 \approx 1.75$ and the standard deviation $\sigma \approx 0.035$. The value of the coefficients a_1-a_5 is much less than the value of the coefficient a_0, they make up a tenth of the value of the coefficient a_0. The first iteration for calculating the coefficients is characterized by the value of the quality criterion (10) equal to

$$\int_0^1 \left(k_s(\vartheta) - k_{s0}(\vartheta)\right)^2 d\eta = \int_0^1 \Delta k_s(\vartheta)^2 d\vartheta = 0{,}041959\,. \qquad (22)$$

The theoretical correlation function $\Delta k_s(\vartheta)$ and the error $\Delta k_s(\vartheta)$, resulting from its approximation with the calculated coefficients a_n for the first iteration, are shown in Figure 4.

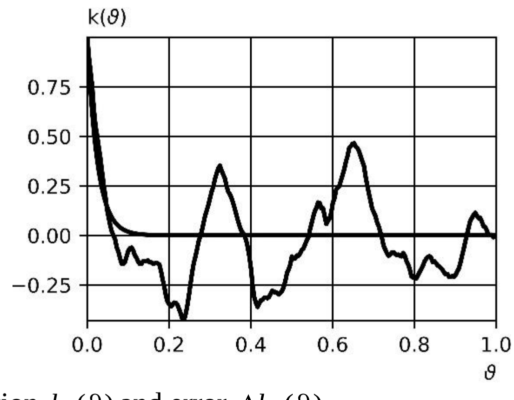

Figure 4: Correlation function $k_s(\vartheta)$ and error $\Delta k_s(\vartheta)$

The error $\Delta k_s(\vartheta)$ occurs because of the fact that the values $\gamma_d(\tau) = 1$ for the interval $\tau \notin [0;1]$ are used to determine the correlation function (16). In the next iteration, the values $\gamma_s(\tau)$ for the interval $\tau \notin [0;1]$ will be determined considering the values of the deterministic process $\gamma_d(\tau)$ and the values of the stochastic stationary process $\gamma_s(\tau)$. The iterative process is repeated for the required number of times, which is determined by the inequality

$$\int_0^1 \left(k_\gamma(\vartheta) - k_{\gamma 0}(\vartheta)\right)^2 d\vartheta < \varepsilon\,. \qquad (23)$$

Thus, each subsequent iteration will reduce the error $\Delta k_s(\vartheta)$ as a result of refining the values of the coefficients a_n, as well as the distribution law of the random process $\gamma_s(\tau)$ and its numerical characteristics. The error function of the correlation function $\Delta k_s(\vartheta)$ gives reason to assume that the correlation function of the stochastic process contains a periodic component. Using the implementation of the deterministic process $\gamma_d(\tau)$ and relation (3), makes it possible to obtain the implementation of the stochastic process $\gamma_s(\tau)$, which is shown in Figure 5.

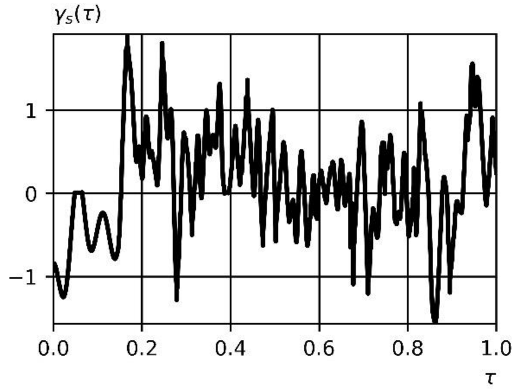

Figure 5: Implementation of a stochastic process $\gamma_s(\tau)$ of the crusher feeding the WD-1 conveyor [16]

To analyze the statistical regularities of a stationary random process $\gamma_s(\tau)$, histograms of the frequencies of the distribution of material flow values for this stationary random process may be constructed. Histograms of the distribution frequencies of realizations of the stationary random flow $\gamma_s(\tau)$ for the corresponding input material flows in Figure 1 [14, 16, 17, 18] are shown in Figure 6. Comparative analysis of the histograms of the distribution frequencies of the material flow values makes it possible to conclude that the stochastic material flow obtained as a result of calculating the expansion coefficients in the first approximation has a normal distribution law.

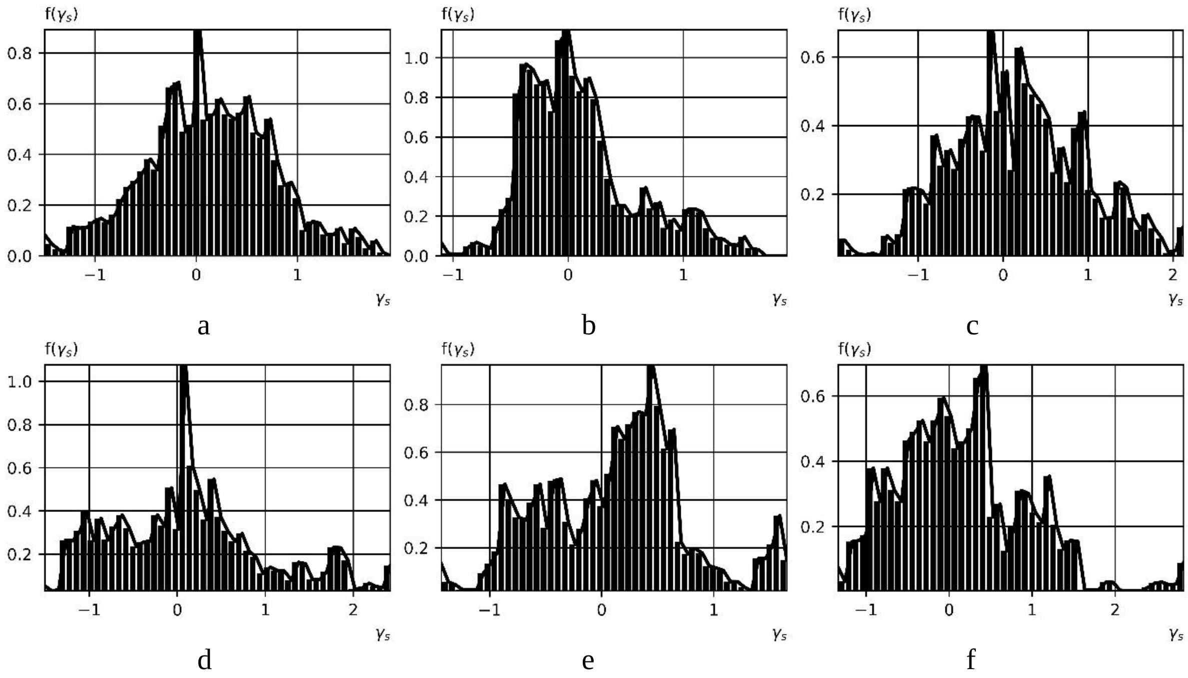

Figure 6: The distribution frequencies histogram of implementations of the stationary random material flow: a – for the WD-1 conveyor [16]; b – for the belt conveyor 2LU120V [17]; c – for the ECS system [18]; d - under the laser-based measurement device of the ECS system [18]; e – with forward motion of the combine KDK500 [14]; f - with backward motion of the combine KDK500 [14]

This makes it also possible to assume that the presented histograms of the distribution frequencies of the values of the material flow for the stationary random process, synthesized as a result of calculating the expansion coefficients in higher approximations, will allow one to formulate the problem of typification of the stationary random component of the input material flow using data from existing transport systems.

When conducting experimental measurements of the values of a input material flow over a period $\tau \in [0;1]$, only one realization of the random process under study is formed. In this regard, the representation of the input material flow as a superposition of a deterministic process and a stochastic ergodic process is important, since it allows one to construct relationships between the distribution function of the stochastic ergodic process and the residence time of the stochastic material flow in a certain range of values, as well as between statistical averages and average over time. The use of the ergodicity property of the stochastic process made it possible to determine the statistical characteristics of the input material flow using its only implementation, obtained as a result of experimental studies.

5. Conclusion

The paper considers a method that makes it possible to carry out a statistical analysis of a non-stationary random material flow entering the input of a conveyor-type transport system. Statistical characteristics are determined during the statistical analysis of experimental data when measuring the material flow for a functioning conveyor system. The existing methods for typification of random material flow entering transport system assume that the input material flow is a stationary flow. In this study, for a non-stationary random flow, an approach is proposed for constructing the statistical characteristics of the input material flow, which is based on the fact that a stochastic component with ergodic properties is extracted from the non-stationary random process. This approach makes it possible to determine statistical characteristics of a random process by one of its implementations, which may be obtained from experimental measurements of the input flow of operating transport system.

As the result of the research described in this paper, implementations of the deterministic and stochastic components of the non-stationary input material flow were obtained, and histograms of the distribution of the values of the stochastic component for the input material flow were constructed. It is assumed that this will allow the typification of the deterministic and stochastic components for input material flow. The results obtained may be used to construct generators of a random input material flow, considering technological features of its formation and stochastic nature of material extraction processes. The construction of these generators of values of random input material flow is a prospect for further research. It is supposed to use the indicated generators of values of random input material flow to improve the algorithms for controlling flow parameters of conveyor transport systems. One of the important areas of application of these generators of values of random input material flow is the construction of transport system models based on a neural network. The sets of input material flow values generated using these generators can be used to train the neural network in a transport pipeline model. Another issue that requires a separate study is the issue of choosing the type of theoretical correlation function for separating deterministic and stochastic components of input material flow.

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