

# On the Characteristics of the Input Material Flow of the Transport Conveyor

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**Abstract**— In this paper, the statistical characteristics of the flow of material entering the input of a conveyor-type transport system are studied. For a set of data obtained as a result of experimental measurements of the input flow of material, the law of distribution of a random variable and the correlation function is investigated. Theoretical assumptions about the law of change of the correlation function for the input flow of material are confirmed.

**Keywords**—*Transport Conveyor, Incoming Flow Model, Data Set, Stochastic Process, Neural Network.*

## I. INTRODUCTION

Belt conveyors are widely used in the mining industry, as they have relatively specific low costs for transporting rock [1]. Despite its apparent simplicity, a transport conveyor is a complex dynamic distributed system Fig.1, Fig.2. The operation of such systems is associated with high energy costs. The total length of the modern transport system exceeds 100 km, and the length of a separate section is up to 20 km. The main characteristics of modern conveyor-type transport systems are presented in [2, 3, 4].

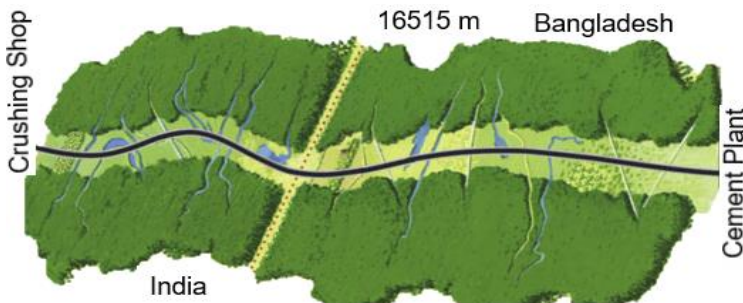


Fig.1. The long conveyor from India to Bangladesh (16.5 km)



Fig. 2. The longest belt conveyor system (Western Sahara), more than 100 km conveying length (11 flights of up to 11.7 km) [2]

Optimal control of the flow parameters of the transport system makes it possible to reduce specific transport costs by up to 30% [5]. To reduce specific transportation costs, belt speed control systems [6, 7], material consumption at the output of the bunker [8, 9], and energy management methodology [10, 11] are used. In this regard, the further development and synthesis of new algorithms for optimal control of the flow parameters of a conveyor-type transport system is an actual problem [12]. Of particular interest to researchers of transport systems are models based on neural networks [13, 14, 15]. One of the key issues in building such models is the availability of data sets for neural network training.

## II. RELATED WORK

The main models that are usually used to design optimal control systems for the transport conveyor flow parameters are numerical models. The foundation of these models is the finite element method, finite difference method, Lagrange method, system dynamics method. A detailed review of the conveyor systems models shows that these models are used to determine the dynamics of changes in the individual conveyor section flow parameters [5]. It is necessary to note that the use of numerical models for the development of algorithms for optimal control of the transport system flow parameters causes significant difficulties and requires significant computational resources. The analytical PiKh-model [16] is a successful tool for describing transport systems consisting of dozens conveyor sections. The model of an individual section consists, as a rule, of two basic equations. Projected, a transport system which contains one hundred separate sections is described by a model of two hundred equations. As a result, the analytical model requires significant computational, and most importantly, time resources. The reaction time of the control system, which is based on an analytical model for such number of sections, may exceed the maximum allowable. Therefore, the analytical model did not solve the problems that occurred when using numerical models but moved the applicability of the model to a much larger number of conveyor sections.

Along with the numerical models considered above, there are many studies devoted to the use of neural networks [13, 14]. The studies demonstrate that the most important advantage of control systems based on models using a neural network is that the response time of a control system is much smaller than for numerical models. With a significant increase in the number of sections, the duration of the calculation of the output parameters can be significantly shorter than for a conveyor system analytical multi-section model. The model using a neural network can be successfully applied to describe multi-section conveyor systems if there are data to train the neural network.

## III. METHODOLOGY

To build a transport system model based on a neural network, data sets for training the neural network is needed. A set of data in the form of a set of input and output flow parameters can be obtained for functioning conveyor systems. However, this set of data corresponds to a rather narrow mode of operating parameters of the production system, and it can be used to improve the existing transport conveyor control system and is not suitable for designing control systems for new transport systems. This circumstance is connected not only with the presence of different operating modes for the conveyor systems operation, but also with the structure conveyor system: the sections amount and the interactions between them. In addition to that, in many cases, collecting data for training is not possible.

One of the ways to solve this problem is to build input flow generators, which are based on the analysis of experimental data. The data sets required for training the neural network must be built in accordance with a certain law of distribution of the input material flow value. If this condition is not met, the use of these data sets for training a neural network is inefficient. For that, there is a necessity to support or decline some assumptions made in publications, in particular, assumptions about correlation function and the distribution law of the input material flow of working transport conveyor.

The statistical data of the input material flow was taken for the bucket-wheel excavator SRs 2000 [17] (Fig. 3, Fig. 4).

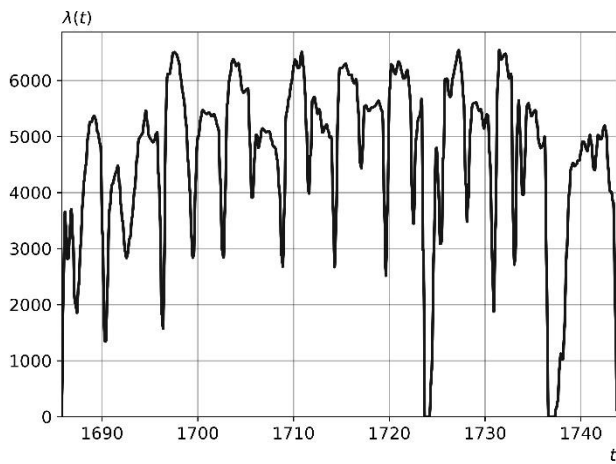


Fig. 3. Input material flow for the SRs 2000 bucket-wheel excavator [17]

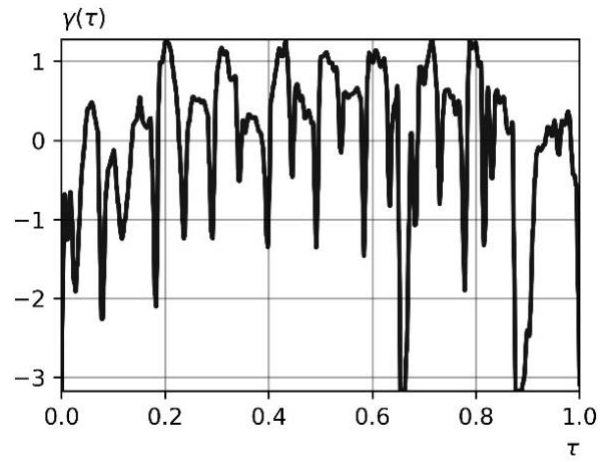


Fig. 4. Dimensionless input material flow for the SRs 2000 bucket-wheel excavator

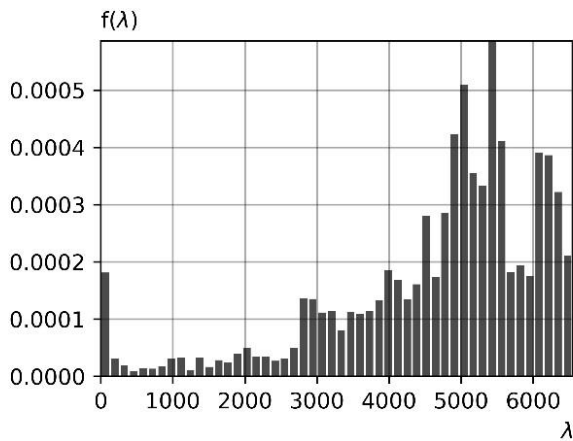


Fig. 5. Capacity distribution density for the SRs 2000 bucket-wheel excavator

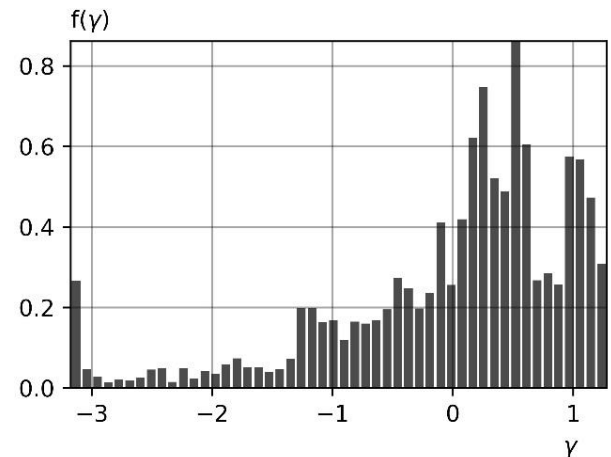


Fig. 6. Dimensionless capacity distribution density for the SRs 2000 bucket-wheel excavator

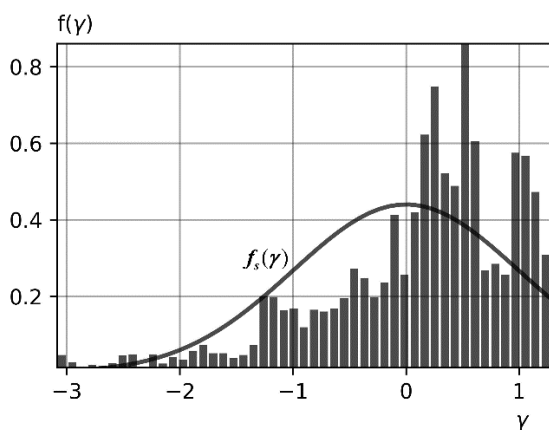


Fig. 7. Statistical and theoretical distribution of the input material flow

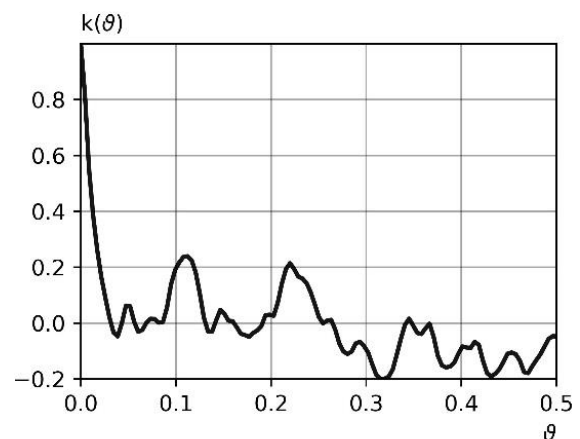


Fig. 8. Correlation function

There is an assumption that the transport conveyor input material flow random variable has a normal distribution law [18, 19, 20]. In terms of correlation function there are recommendations

that the correlation functions of the material incoming input flow value can be approximately represented in exponential form. To test these assumptions histograms for an input material flow random variable were construct (Fig. 5, Fig. 6).

Obtained in this way statistical distribution of the transport conveyor input material flow value was compared with theoretical distribution using Pearson's goodness-of-fit test  $\chi^2$ .

#### IV. RESULTS

Comparative analysis of the discrepancy between the statistical and theoretical distribution of the input material flow does not confirm the assumption that the transport conveyor input material flow random variable has a normal distribution law. On the other hand, the correlation function (Fig.8) has a dependence that is quite closely characterized by the theoretical correlation function. Thus, recommendations that the correlation functions of the material incoming input flow value can be approximately represented in exponential form are confirmed.

#### V. DISCUSSION

As a result, the implementation of a random process is analyzed. Theoretical assumptions were tested using experimental data. These results can be used to construct a generator of the input material flow based on production data. A transport system model based on a neural network trained by generated in this way data sets can be used in the synthesis of algorithms for optimal control of the conveyor type transport systems flow parameters. Additional studies are required of works that present experimental data on the magnitude of the input material flow for modern transport conveyors.

#### VI. FUTURE RESEARCH

The present work is the first step in such experimental data multifaceted study. Additionally, to improve the accuracy of the approximation, it is required to analyze the input material flow represented by a non-stationary random process, which is considered as a prospect for further research. An additional problem is to determine the law of distribution of the value of the input cargo material flow entering the transport system input per time unit.

#### VII. CONCLUSION

To reduce the specific energy consumption of material transportation using conveyor type transport systems, algorithms for optimal control of the transport system flow parameters are required. Using neural network is the contemporary and perspective approach to synthesize such algorithms. The data sets required for training the neural network must be generated. This data sets must be generated in accordance with an experimental data. If this condition is not met, the use of these data sets for training a neural network is inefficient. In this paper, experimental data of the material input flow is analyzed. It is revealed that the hypothesis put forward about the normal law of distribution of the material input flow value does not correspond to the experimental data.

The existing recommendations that the correlation functions can be approximately represented in exponential form are confirmed. Additional studies are required of works that present experimental data on the magnitude of the input material flow for modern transport conveyors. The analysis and generalization of the obtained results will make it possible to form a countable number of relevant data sets which can be used to train neural network.

#### VIII. DISCLOSURES

The authors declare that there are no conflicts of interest related to this paper.

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