

metrics will be crucial for comparing different simulators and validating simulation results. UAV simulation platforms are at the forefront of enabling the next generation of autonomous aerial systems. By addressing current limitations and capitalizing on emerging technologies, the field can unlock the full potential of UAV technology, fostering innovation and ensuring safe and efficient deployment across an ever-expanding array of applications. Collaboration, standardization, and innovation are key to developing the next generation of simulation tools.

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**ПРО ПОБУДОВУ СТОХАСТИЧНОЇ МОДЕЛІ ВХІДНОГО  
ПОТОКУ ДЛЯ ТРАНСПОРТНИХ КОНВЕЙЕРНИХ СИСТЕМ**

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**ON CONSTRUCTING A STOCHASTIC INPUT-FLOW MODEL  
FOR TRANSPORT CONVEYOR SYSTEMS**

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***Анотація.** Досліджено роботу транспортної системи конвеєрного типу за умов стохастичного характеру вхідного потоку сипкого матеріалу. Запропоновано математичну модель із канонічним поданням стаціонарного випадкового процесу для вхідного потоку, безрозмірним описом ланцюга конвеєрів та оцінкою ймовірності перевищення критичних порогів, що спричиняють розсип. Чисельні приклади для схеми з реверсивним конвеєром демонструють залежність коефіцієнта завантаження й втрат від статистичних характеристик потоку та обґрунтовують режими керування швидкістю.*

***Ключові слова:** стрічковий конвеєр, стохастичний вхідний потік, нормальний розподіл, кореляційна функція, ймовірність розсипу, реверсивний конвеєр.*

***Abstract.** The paper examines the operation of a conveyor-type transport system under a stochastic inflow of bulk material. The authors propose a mathematical model that employs a canonical representation of a stationary random process for the input flow, a dimensionless description of the conveyor chain, and an assessment*

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*of the probability of exceeding critical thresholds that cause spillage. Numerical examples for a scheme with a reversible conveyor demonstrate how the load factor and losses depend on the statistical characteristics of the flow and substantiate appropriate speed-control regimes.*

**Keywords:** *belt conveyor, stochastic input flow, normal distribution, correlation function, spillage probability, reversible conveyor.*

Introduction. Belt conveyors provide continuous transportation of bulk materials in mining and related industries, where energy efficiency and stable loading are key requirements. In real operations the incoming flow exhibits random fluctuations, causing uneven loading, additional energy losses, and spillage risk [1]. This calls for models that explicitly account for the stochastic nature of inputs and support decisions on belt speed and routing control. Aim and methods. The aim is to build a generalized model of a transport system with multiple sequential conveyors (including a reversible one) that (i) describes the deterministic transport dynamics in dimensionless coordinates; (ii) represents the input flow as a stationary random process via a canonical expansion; (iii) evaluates the probability of exceeding critical density/flow thresholds that lead to spillage at the inlet of the next conveyor. The approach relies on the mass-transport equation with delay and on the relation between density and volumetric flow at a constant belt speed [2, 3]. Mathematical formulation. A conveyor with constant speed is modeled as a transport problem with initial–boundary conditions in dimensionless variables; for a conveyor chain we introduce compatible length, speed, and boundary-density parameters. The stochastic input is given by a canonical expansion in orthogonal basis functions with uncorrelated coefficients, yielding closed-form expressions for the mean, variance, and correlation function of the inflow process. Based on this, we compute the critical flow value, the probability of exceedance, and the minimal belt speed needed to limit spillage. Results and application example. For a seven-conveyor test scheme reproducing a section of a real mine transport system we show that (a) measured inflow values are well approximated by a normal distribution with short correlation memory; (b) the no-spillage critical threshold is determined as the distribution quintile for a target reliability level; (c) the reversible conveyor redistributes flow between routes and reduces peak loads [4, 5]. Comparative estimates demonstrate how the loading factor and required speed margin depend on the mean and variance of the input process.

Conclusions. The proposed model reconciles deterministic mass-transport equations with a probabilistic description of the incoming flow, providing engineering criteria for selecting belt speeds and route configurations to prevent spillage and reduce energy consumption. Practically, it enables the design of adaptive speed-control strategies based on online estimates of input statistics and exceedance forecasts.

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**РОЗПІЗНАВАННЯ КЛАВІАТУРНОГО ПОЧЕРКУ ЗА  
ДОПОМОГОЮ ВОСЬМИВИМІРНОГО ЕЛІПСОЇДА  
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