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DEVELOPMENT OF A MECHATRONIC MODULE FOR PNEUMATIC CONVEYING OF SMALL-PIECE MATERIALS

Summary. *The model has been developed for calculating the coordinates of a product particle in a collision with the inner surface of the product pipeline, as well as changing its kinematic characteristics. The developed model makes it possible to determine rational modes of pneumatic transportation and possible energy costs in the processing of various small-piece materials. Rational modes of pneumatic transportation and possible energy costs in the processing of small-piece materials are determined. The maximum pulse frequency in pneumatic transport was up to 1.5 ... 20 Hz, at a pressure of up to 2.5 bar. As the time of compressed air supply to the product pipeline increases, the number of product particles reaches a maximum in the range of 0.1 ... 0.2 s.*

Key words: *pneumatic transport, adaptronic, mechatronic module model, modes, boundary conditions.*

Aim. The existing control models and mathematical models for the dynamics of the process of pneumatic conveying of food products are simplified. Most often, their description does not correspond to real phenomena that occur in process equipment [1, p. 15]. Therefore, the processes of work in the pneumatic network were selected for consideration, taking into account the dynamic mode. The task of creating flexible pneumatic transport automation systems to increase productivity by three to five times and simultaneously reduce actual costs by 30–50% is also considered [2, p. 21].

The issues of development and implementation of the principles of transportation of loose, small-piece materials through pipelines using compressed air in a dense layer without congestion are also raised [3, p. 57], in [4, p. 111]. A mathematical model of a two-phase flow of a granular medium in a pressure pneumatic pipeline is proposed. Narrowing, expansions, turns of the pneumatic line due to various types of hydraulic resistance coefficients are taken into account. However, the particle was accepted as a material point, without taking into account changes in the environment [5, p. 25].

It is shown that the concentration of particles near the wall decreases with a decrease in the channel width and an increase in the particle size, but there is no mathematical modeling of the process [6, p. 651]. The dependence of the resistance coefficients, which significantly affect the processes of movement of two-phase media in various sections of the pipeline, are described and determined [7, p. 18]. The results of the experiments showed that the pneumatic conveying mechanism obeys hydrodynamic laws, however, it requires additional theoretical justification when using products and materials with different properties [8, p. 125].

The purpose of this study is mathematical and physical modeling of the process of pneumatic transportation of small-piece products with elements of adaptronics, as well as critical modes to provide calculations and design product pipelines with continuous supply.

Materials and methods. The experimental and theoretical studies carried out are based on the application of the fundamental laws of theoretical mechanics, hydrodynamics of multiphase media, and the theory of solutions to ordinary differential equations (Fig. 1).

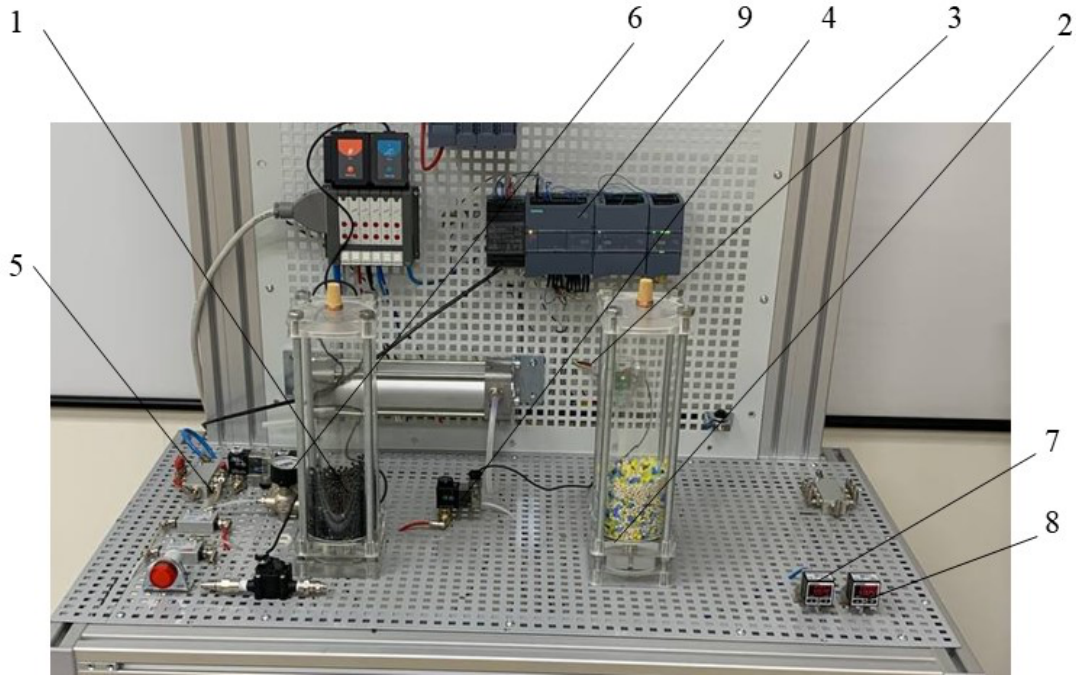

Fig. 1. Type of experimental stand for the study of pneumatic transport of bulk and small-piece products: 1,2 - vertical channels; 3.5 - drivers for controlling the proportional supply of compressed air; 4.6 - proportional electromagnetic distributors of direct action 2/2; 7,8 - electronic vacuum / pressure relays with analog output; 9 - programming device for setting the law of signal change 4… 20mA

The mechanism of the process of pneumotransportation, typical of most technological processes, is illustrated by a photograph of the experimental stand, using different types of small and artificial products (for a better representation of the transportation process is presented frame-by-frame site formation and stabilization.

Dried black pepper peas were chosen for the research, as well as one of the most common dry granulated breakfast cereals. The photo shows that in the vertical zone of transport of the channel, there is a division of the product into areas of acceleration and stabilization.

In a vertical pipe, the gas flow moves at an average fictitious speed. The speed of movement of solid particles relative to the flow is easy to estimate, as in vertical pneumatic transport it is close to the speed of soaring.

The process of pneumotransportation controlled by compressed air pulses, which determine the operating modes, is investigated.

The air flow is formed at the entrance to the channel with the product, by means of a pneumatic valve, which is controlled by the generation of current by the Heaviside function (single step function). The measured value of current in mA (from 0.001 mA) relative to the standard scale Imax, Imin = 4..20 mA, recorded in the ranges of 4.1 mA ... 19.9 mA; 12mA ... 19.9mA. Consumption characteristics of the pneumatic valve in the installation = 180 Nl / min The duration of the function period is taken up to 0.3 s.

Conclusions. The process of control of critical modes at pneumotransport on the basis of proportional elements and feedback (current loop of 4-20 mA) is theoretically investigated; study of the process of destruction of the cluster of products by air waves and controlled decompression.

The results of the study showed that the use of the developed model allows taking into account the speed and control the pressure at the inlet to the product line. A generalized physical model of the process was developed, and the results of changes in pressure regimes and their influence on product distribution during transportation were tested by comparing the results.

Studies have been conducted for certain types of products - dried black pepper peas, as well as one of the most common dry granulated breakfast cereals.

Control current values, relative to the standard scale, Imax..Imin = 4.1..19.9 mA, the frequency of formation of compressed air pulses in the product line - 0.1 ... 1.3s. Preliminary values of the control signal, formed the maximum pressure in the pipe 1.7 ... 2.5 bar.

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