Conveyor Model with Input and Output Accumulating Bunker

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Abstract—In this article, a model of a conveyor-type transport system with an input and output bunker is developed. The transport conveyor is presented in the form of a dynamic distributed system. It is shown that the material flow is proportional to the linear density of material distribution along the transport route. The coefficient of proportionality is the speed of the belt. When constructing the model, the assumption of the absence of oscillatory processes associated with the tension of the conveyor belt is introduced, which corresponds to the case when the function determining the speed of the belt is only a function of time. A solution is given, that determines the state of the flow parameters of the conveyor section for a given point of the transport route at an arbitrary point in time. It is shown that the state of the flow parameters for an arbitrary place in the transport route is determined by the state of the flow parameters at the input of the conveyor section, considering the transport delay. An expression is written that allows to calculate the amount of transport delay. The relationship of the transport delay value with the algorithm for controlling the conveyor belt speed is demonstrated. A system of equations for the model of a conveyor-type transport system with an input and output bunker is obtained. The behavior of the model for several characteristic cases of the functioning of the transport system is analyzed. The constructed model of the control object can be used to design highly efficient control systems for the flow parameters of the transport system with an input and an output bunker.

Keywords—production line, optimal control, distributed system, transport system.

A characteristic feature of Industry 4.0 is fully automated production. The conveyor belt is an integral part of an intelligent industrial automation system. Smart modern factories create transport systems that can improve the efficiency of production process control. The conveyor is the link between the production modules. The modern conveyor includes various intelligent control components and sensors to increase the efficiency of using [1].

Industrial Internet of Things opens a direct path to the creation of fully automated industries. The industrial Internet of things opens a direct path to the creation of fully automated industries, in which conveyor systems play an important role. But that is not enough. For optimal control of the flow parameters of the transport system, it is necessary to build more and more efficient models that allow us to describe the transport system as an object of intelligent control. Of particular importance within the framework of the Industry 4.0 concept is the conveyor transport in the mining industry [2]. There are special reasons for this. A conveyor belt is a universal means of transporting bulk materials due to the low unit cost of the material [3,4]. For normative mode the average share of the cost of transporting a unit mass of material is 20% of the total cost of coal mining [5] and depends on the length of the transport route. For long conveyors, the cost of transportation increases in proportion to the length of the conveyor. Energy costs are especially noticeable for long multi-sectional transport systems and branched transport systems, the characteristics of some of them are given in Table 1. The length of the transport route exceeds 100 km [6] and continues to increase. To increase reliability, the transport route is divided into sections. The technology for transporting material provides a section length of up to 20 km.

The basic result of the article is that a model of the conveyor section with two accumulating bunkers was built. The scientific novelty of the results is that for the first time an analytical model of the conveyor with two bunkers is presented, which takes into account the time-varying transport delay. Using the developed model of the control object, optimal control of the flow parameters of the conveyor-type transport system with an input and an output bunker can be synthesized. The dependence of the flow parameters at the output from the conveyor section on the initial distribution of material along the route is shown. The duration of the transition mode for the conveyor section is determined. The next step in the development of the issue discussed in the article is the design of a control system for the conveyor section with input and output bunkers, which would allow taking into account restrictions on the phase coordinates and transport delay in phase coordinates.

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