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***Abstract*—**This article is devoted to designing an information management system for the conveyor line of mining enterprises. The analytical design method for the transient mode of the stepped speed control system of the conveyor line was developed. The partial differential equation was used in constructing the conveyor line model. The description of the production system is fulfilled in the single step approximation. A decision was obtained which determines the state of the parameters of the production line for a technological position specified as a function of time. Has been determined the length of the transition period during which the initial condition for the distribution of labor objects along the conveyor affects the parameters of the state of the conveyor line. The method for calculating the current parameters of a conveyor line with the use of partial differential equations allows the design of control systems for production lines of conveyor type for transient modes. The originality of the results obtained is to improve the PDE-models of the conveyor-type production systems used to design highly efficient production control systems operating in transient modes.

***Keywords*—**conveyor, PDE-model, production cycle; mass production; work in progress; balance equations; quasi-static process; stochastic process.

The competitive ability of a modern industrial enterprise is largely determined by the level of optimization of the production process. Reducing the number of mineral reserves with a constant increase in the level of world standards requires the design of more and more effective management systems for the parameters of production of the mining enterprise.

This leads to the emergence of new concepts for the design of effective information systems, whose task is to increase the productivity of the production process in conditions of increasing restrictions on modes and methods of production [1].

One of the main tasks that have to be dealt with in modern mining enterprises are a) reducing the energy costs required to transport a ton of rock from the site of direct production to the place of shipment from the mine; b) increasing the capacity of mine conveyor systems [2-4]. These tasks are especially important when the mining enterprise is operating in transitional regimes, which are the results of constantly acting external and internal disturbances in the parameters of the production system [5], with a constant fluctuation of the global demand for products.

Belt conveyors are one of the main means of continuous transport in mining enterprises. Increasing the productivity of conveyors operating in quarries, their reliability, durability, and at the same time, energy saving are one of the most important conditions for increasing the technical level and efficiency of mining. In this regard, when designing information management systems for mining operations, an important place is given to the construction of efficient models of conveyor lines [2-6].

Conveyor lines of modern coal mines and quarries work for a considerable time when loading below the nominal value. Direct technological connection of prefabricated lines with conveyors of mining areas in the absence of an adjustable conveyor drive excludes the possibility of controlling the intensity of cargo flows on transport lines. The mechanical part of the conveyor has a significant inertia, which is caused by the masses of its moving elements. All this creates technical difficulties in solving the problem.

The conveyor speed is controlled in two ways: discreetly and continuously. Discrete regulation is based on a change in the speed of the conveyor belt when the input freight flow reaches certain threshold values accepted for adaptation values [6]. With continuous regulation, it is proposed to create such a mode of operation of the conveyor, in which the speed of the belt varies in proportion to the freight flow in such a way that the load on the belt remains constant and with the maximum possible design. When discrete control of conveyor speed, first of all, it is necessary to determine the required number of stages of drive speeds. The number of stages of speed regulation is determined based on the range of changes in the productivity of the mining machine, that is, based on a change in the coefficient of unevenness of the cargo flow. Wherein adhere to the recommendations: a) the conveyor should provide the maximum economically feasible and technically possible productivity of the excavating machine; б) the average speed of movement of the traction organ should be minimal. The load on the belt from the rock material distributed along the route is directly proportional to the incoming value of the cargo flow and inversely proportional to the speed of the belt.

Analysis of modes of operation of conveyor transport shows the availability of reserves to improve the performance of transport equipment [1,2,6].

A significant increase in the efficiency of the use of conveyor transport can be achieved by regulating the speed of the conveyors depending on the traffic flow [4,6]. The actual task is the task of developing a informational system for automatic control of the speed of the belt conveyor in order to increase the efficiency of using the conveyor by reducing the length of the run of its traction body, reducing wear of friction parts and saving electricity. Also, the efficiency of production can also be improved if a set of conveyor belts is presented as a graph.

For the design of control systems of transport systems are used as the main models –discrete-event simulation and queuing theory models[3-5]. In this paper, to describe the continuous process of rock movement along the conveyor route, we use the PDE model (Partial differential equation - model). A detailed comparative analysis of discrete-event simulation, queuing model models and PDE-models in the field of application to the description of production systems with a streamlined method of production organization is carried out in [7,8]. PDE-models are most in demand at the time when designing flow control systems that operate in transient modes or with variable capacity [9,10], when the use of discrete-event simulation and the queuing model becomes inefficient. It should also be pointed out that PDE-models have been widely used for the design of highly efficient control systems for industrial production of semiconductor products [8,11]. A general-purpose conveyor line model with a constant belt speed is presented in [12].

In this paper, attention is paid to designing a control system for a conveyor line in a transitional mode, when a conveyor is run on which a rock is distributed along a transport route.

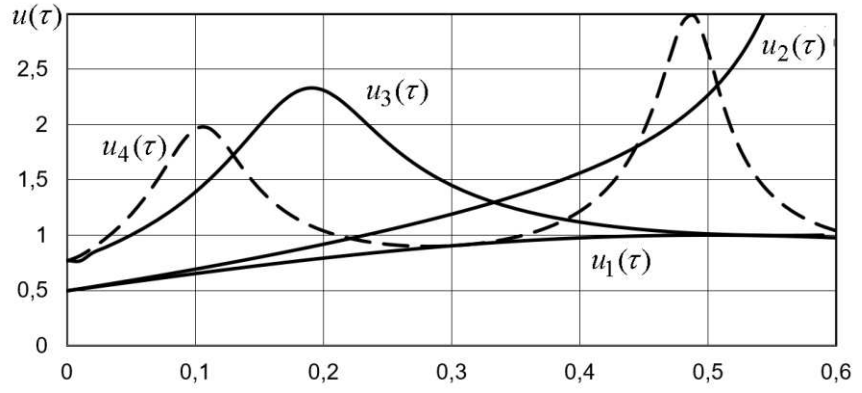

Fig. 1 Optimal control for transient process

The obtained results of the research are basic for the development of control systems for conveyor lines in the transitional regime. The influence of the initial conditions on the rate of rock output from a conveyor-type transport system was considered. An important result of this work is the method of calculating the duration of the transition period, based on the use of the characteristic equation. The dependence of the duration of the transition period on the initial distribution of labor objects along the conveyor line was obtained. The length of the transition period is determined by the selected speed control mode of the conveyor belt. Next perspective of the development of the issue discussed in the paper is the design of a control system for a transport system consisting of a large number of connecting conveyor lines located both in series and in parallel.

REFERENCES

[1] DIN 22101:2002-08. Continous conveyors. Belt conveyors for loose bulk materials. Basics for calculation and dimensioning., Normenausschuss Bergbau (FABERG) im Deutsches Institut fur Normung e.V. Normenausschuss Maschinenbau (NAM) im DIN (2002).

[2] SIMINE for conveyors. Siemens. (2017). https://new.siemens.com/global/en/markets/mining-industry/transport/conveyor-systems.html

[3] Semenchenko A.K. The impact of an uneven loading of a belt conveyor on the loading of drive motors and energy consumption in transportation // A. *Semenchenko*, M. *Stadnik* , P. *Belitsky* , D. Semenchenko , O. *Stepanenko*, // Eastern-European Journal of Eenterprise Technologies. Kharkiv: Scientific-Production Enterprise "TECHNOLOGICAL CENTER". - 2016. – vol. 4. –№ 1 (82). - P. 17 – 22. https://doi.org/10.15587/1729-4061.2016.75936

[4] Kondrakhin, V. P. Statistical Analysis of Mine Belt Conveyor Operating Parameters [Text] / V. Kondrakhin, N. Stadnik, P. Belitsky // Scientific works DonNTU. Electromechanical series. — 2013. — № 2(26). — P. 140–150. http://nbuv.gov.ua/UJRN/Npdntu_gir_2013_2_15

[5] Prokuda, V.N. Research and evaluation of cargo flows on the main conveyor transport of the PSP "Shakhta Pavlogradskaya" PJSC DTEK Pavlogradugol / V.N. Prokuda, Y.O. Mishanskiy, S.M. Procenko // Mountain Electromechanics. – 2012. – № 88. – P. 107-111.

[6] Zalika, M. (2017). Belt conveyors with regulated speed / M. Zalika, M.Kolek, S. Tytko http://www.bartec.kz/files/mining/for-conveyance.pdf.

[7] Pihnastyi O.M. About a new class of dynamic models of production lines of production systems / O.M. Pihnastyi // Scientific bulletins of Belgorod State University. Belgorod: BSU. - 2014. - No. 31/1. - P. 147-157 https://doi.org/10.13140/RG.2.2.30384.05120

[8] Lefeber E. Modeling, Validation and Control of Manufacturing Systems. / E.Lefeber, R.A.Berg, J.E. Rooda — Proceeding of the 2004 American Control Conference, Massachusetts, 2004. – P. 4583 – 4588.

[9] Pihnastyi OM. Overview of models of controlled production processes of production line production lines / O.M. Pihnastyi // Scientific bulletins of the Belgorod State University. Belgorod: BSU. - 2015. - No. 34/1. P.137-152.

[10] Pihnastyi OM Analysis of Models of Transient Controlled Production Processes / O.M. Pihnastyi / Scientific Bulletins of the Belgorod State University. Belgorod: BSU. - 2015. - No. 35/1. - P. 133-144 (In Russ.) http://repository.kpi.kharkov.ua/handle/KhPI-Press/40275

[11] Lefeber E. Aggregate modeling of manufacturing systems. Planning Production and Inventories in the Extended Enterprise: A State of the Art Handbook. International Series in Operations Research and Management Science. / [E.Lefeber, D.Armbruster, eds. K.Kempf P. Keskinocak, R.Uzsoy]. – Springer-Verlag, New York, 2010. – Vol. 151. – P. 509 – 536.

[12] Pihnastyi O.M. The model of the production line of the conveyor type at a constant speed moving subjects of labor / Pihnastyi O.M., Khodusov V.D. // Bulletin of V. Karazin Kharkiv National University, – 2016. –Series «Mathematical Modelling. Information Technology. Automated Control Systems», Issue 32. – P. 60-74

[13] Pihnastyi O.M. Stochastic description of economic-production systems with mass production / V.P.Demutskiy, V.S.Pihnastyi , O.M.Pihnastyi // Reports of the National Academy of Sciences of Ukraine. - Kyiv: PH "Akademperiodyka" . - 2005. - № 7. - P. 66-71. doi.org/10.13140/RG.2.2.31202.32968

[14] Pihnastyi O.M. Statistical theory of control systems of the flow production. / O.M. Pihnastyi LAP LAMBERT Academic Publishing. –2018. – 436 c. –ISBN: 978-613-9-95512-1

[15] Pihnastyi O. M. The task of optimal operational control of macroparameters of a production system with mass production / O. M. Pihnastyi // Reports of the National Academy of Sciences of Ukraine. - Kyiv: PH "Akademperiodyka". - 2006. - №5 - P. 79-85. – http://archive.kpi.kharkov.ua/View/57953/

[16] Pihnastyi O. M. Tasks of the program control of the parameters of the current line using overtime work //O. M. Pihnastyi, V. Y. Zaruba // Information Technologies in Management: Proceedings of the 5th Russian Multiconference on Management Problems (ITU-2012), (St. Petersburg, 09-11 oktober 2012). - St. Petersburg: CRI "Electrical appliance". 2012. - P. 107-114.

[17] Pihnastyi O. M. Calculation of the production cycle using the statistical theory of production and technical systems / O. M Pihnastyi. V. D. Khodusov // Reports of the National Academy of Sciences of Ukraine. - Kyiv: PH "Akademperiodyka". -2009. –№12. –P. 38-44. doi.org/10.13140/RG.2.2.36267.54562

[18] Ageyev D.V. Information streams modeling in multiservice network NGN for parametrical synthesis problem solving / D.V. Ageyev, A.N. Kopyliev // Radio electronics, informatics, control.-2010. -- №2 - P. 48-52. https://cyberleninka.ru/article/n/modelirovanie-informatsionnyh-potokov-v-multiservisnoy-seti-ngn-pri-reshenii-zadach-parametricheskogo-sinteza

[19] Norros I. A storage model with self-similar input / I. Norros // Queueing Systems, 16:387--396, 1994. http://citeseer.ist.psu.edu/norros94storage.html

[20] Bo Du , Xiuguo Lian and Xiwang Cheng. Partial differential equation modeling with Dirichlet boundary conditions on social networks. - Boundary Value Problems 2018(1):50 https://doi.org/10.1186/s13661-018-0964-4